PW 7947988

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

December 03, 2013

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: *09/006,073*
FILING DATE: *January 12, 1998*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

M Bassford
M. BASSFORD
Certifying Officer

PART (1) OF (2) PARTS

01/12/98

ISSUE CLASSIFICATION	
Class	Subclass

[redacted]

PATENT NUMBER

U.S. UTILITY PATENT APPLICATION

RG O.I.P.E. SCANNED CK Q.A.	PATENT DATE

SECTOR	CLASS	SUBCLASS	ART UNIT	EXAMINER
	358	468	2722	~~K. VU~~ POKRZYWA

FILED WITH: ☐ DISK (CRF) ☐ FICHE
(Attached in pocket on right inside flap)

[redacted]

PREPARED AND APPROVED FOR ISSUE

ISSUING CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)						
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					
INTERNATIONAL CLASSIFICATION								
/								
/								
/								
/								
/								

☐ Continued on Issue Slip Inside File Jacket

☐ **TERMINAL DISCLAIMER**	DRAWINGS			CLAIMS ALLOWED	
	Sheets Drwg.	Figs. Drwg.	Print Fig.	Total Claims	Print Claim for O.G.

☐ a) The term of this patent subsequent to ________ (date) has been disclaimed.

☐ b) The term of this patent shall not extend beyond the expiration date of U.S Patent. No. ________

☐ c) The terminal ____months of this patent have been disclaimed.

________ ________
(Assistant Examiner) (Date)

________ ________
(Primary Examiner) (Date)

________ ________
(Legal Instruments Examiner) (Date)

NOTICE OF ALLOWANCE MAILED

ISSUE FEE

Amount Due	Date Paid

ISSUE BATCH NUMBER

WARNING:
The information disclosed herein may be restricted. Unauthorized disclosure may be prohibited by the United States Code Title 35, Sections 122, 181 and 368. Possession outside the U.S. Patent & Trademark Office is restricted to authorized employees and contractors only.

Form PTO-436A
(Rev. 10/97)

(LABEL AREA)

(FACE)

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/006,073	01/12/98	358	2722	58959.12

APPLICANT

DAVID A. MONROE, SAN ANTONIO, TX.

CONTINUING DOMESTIC DATA*******************
VERIFIED NONE

JP

371 (NAT'L STAGE) DATA*******************
VERIFIED NONE

JP

FOREIGN APPLICATIONS**********
VERIFIED NONE

JP

IF REQUIRED, FOREIGN FILING LICENSE GRANTED 04/06/98

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐yes ☒no 35 USC 119 (a-d) conditions met ☐yes ☒no ☐Met after Allowance Verified and Acknowledged JP Examiner's Initials ______ Initials	TX	8	266	11

ADDRESS

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

TITLE

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

FILING FEE RECEIVED $6,988	FEES: Authority has been given in Paper No. _______ to charge/credit DEPOSIT ACCOUNT NO. _____________ for the following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ____________ ☐ Credit

PATENT APPLICATION SERIAL NO. ____________________

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

```
13/1998 AGRAY1    00000042 09006073
FC:101                        790.00 OP
FC:103                       5412.00 OP
FC:102                        656.00 OP
```

PTO-1556
(5/87)

A

PATENT APPLICATION TRANSMITTAL LETTER

ATTORNEY DOCKET NO.: 58959.012

THE COMMISSIONER OF PATENTS AND TRADEMARKS:

Transmitted herewith for filing is the patent application of David A. Monroe for **APPARATUS FOR CAPTURING, CONVERTING AND TRNASMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRNASMISSION SYSTEM.**

Enclosed are:

[X] Twenty-one (21) sheets of drawings.

[ ] a certified copy of a __________ application.

[ ] combined declaration and power of attorney.

[ ] verified statement to establish small entity status under 37 CFR 1.9 and 1.27.

[ ] Information Disclosure Statement with references.

[ ] Supplemental Transmittal Letter

CLAIMS AS FILED			**SMALL ENTITY**			**OTHER THAN A SMALL ENTITY**	
For	**No. Filed**	**No. Extra**	**Rate**	**Fee**	**OR**	**Rate**	**Fee**
Basic Fee				$395.00	OR		$790.00
Total Claims	266 - 20	246	x $22 =	$ .00	OR	x $ 22=	$5,412.00
Indep Claims	11 - 3	8	x $41 =	$ 0.00	OR	x $ 82=	$ 656.00
Multiple Dependent Claim Present			+ $135	$ 0.00	OR	+ $270 =	$
			Total	**$* .00**	**OR**	**Total**	**$6,858.00**

[ ] Please charge my Deposit Account No. 50-0259 in the amount of $.
A duplicate copy of this sheet is enclosed.

[x] A check in the amount of **$6,858.00** to cover the filing fee is enclosed.

[X] The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 50-0259. A duplicate copy of this sheet is enclosed.

- [X] Any additional filing fees required under 37 CFR 1.16.
- [X] Any patent application processing fees under 37 CFR 1.17.

[X] The Commissioner is hereby authorized to charge payment of the following fees during the pendency of this application or credit any overpayment to Deposit Account No. 50-0259. A duplicate copy of this sheet is enclosed.

- [X] Any filing fees under 37 CFR 1.16 for presentation of extra claims.
- [X] Any patent application processing fees under 37 CFR 1.17.
- [ ] The issue fee set in 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

Date: 1/12/98

Mark Tidwell

Mark A. Tidwell
Reg. No. 37,456

BRACEWELL & PATTERSON, L.L.P.
SOUTH TOWER PENNZOIL PLACE
711 LOUISIANA STREET, SUITE 2900
HOUSTON, TEXAS 77002-2781
(713) 221-1529
Attorney Docket No. 58959.012

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service as EXPRESS MAIL - POST OFFICE TO ADDRESSEE, in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on 1/12/98. The Express Label No. is EM018601734US.

Judy Kruger

SIGNATURE

IP\DMA012\PATAPPTRN

KRUGJ\058959\007011
HOUSTON\797832.1
1/12/98–4:09 pm

09006073.011298

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

Inventor: **David A. Monroe**

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The invention is generally related to image capture and transmission systems and is specifically directed to an image capture, compression and transmission system for use in connection with land line and wireless telephone systems.

DISCUSSION OF THE PRIOR ART

Industry has developed and continues to develop and enhance techniques for scanning, compressing, transmitting, receiving, decompressing, viewing and printing documents. This technology, encompassing the full body of facsimile transmission and reception, is currently in widespread use. The current standards, CCITT Group III and Group IV, define methods to scan and transmit high quality, bi-level images with a high degree of success and has become commercially acceptable throughout the world. However, gray scale documents are not easily transmitted because the scanners and algorithms are not tailored to the function. Three dimensional objects will not fit into the flat document scanners and cannot be transmitted.

Examples of systems that have addressed some of these issues are shown in U.S. Patent No. 5,193,012 which shows a video to facsimile signal converter, and U.S. Patent No. 3,251,937 which discloses a system for transmitting still television pictures over a telephone line.

Wire photography, and its extension , radio photography, have long been used by the news media. The most common form involves an input device that converts photographs into encoded signals for communication over telecommunications facilities or radio. At the receiving end, reproducing equipment reconverts the encoded image signals by exposing photographic film or other sensitized paper. The term facsimile is often use with these products.

Still video equipment has recently become available from vendors such as Kodak, Canon and Sony, and is again primarily used by the television and print media, although applications are expanding rapidly in such areas as insurance investigations and real estate transactions. A still video camera captures a full color still video image that can be reproduced using a special video printer that converts the still video image data into hard copy form. For applications requiring communication of the still video image, transmit/receive units are available wherein the image begins and ends as a video image.

The Photophone from Image Data Corporation is an example of a specialty product that combines a video camera, display and storage facility in a terminal package. One terminal can send a real time or stored still video image to another for display or storage, or printing on special video printers. Again, the signal begins and ends as a video image.

Another example of a specialty product is peripheral equipment available for personal computers that enables the input/output, storage and processing of still video images in digitized formats. For instance, the Canon PV-540 is a floppy disk drive that uses conventional still video disks, digitizing and a still video image using a conventional format, and communicates with the computer through a standard communications I/O port.

U.S. Patent No. 5,193,012 discloses a still-video to facsimile conversion system for converting the still-video image frame into a half-tone facsimile reproduction without having to store an entire intermediated gray scale image frame by repeatedly transmitting the still-video image frame from a still-video source to an input circuit with a virtual facsimile page synchronization module . This system permits image to facsimile conversion by utilizing a half tone conversion technique.

While the various prior art systems and techniques provide limited solutions to the problem of transmitting visual images via a facsimile transmission system, all fall short of providing a reliable and convenient method and apparatus for readily capturing, storing, transmitting and printing visual images in a practical manner.

SUMMARY OF THE INVENTION

The subject invention is an image capture, compression and transmission system that is specifically designed to permit reliable visual image transmission over land line or wireless communications using commercially available facsimile transmission techniques. The invention incorporates a camera and signal converter into an integrated unit wherein the converted signal may be transmitted on a real time basis or may be stored in memory for later recall and transmission. The design of the invention permits maximum flexibility, with the camera/converter/telephone or other transmission device being designed in a modular configuration wherein any or all of the devices may exist as integrated or independent units.

The preferred embodiment permits capture of a video image using a digital camera, an analog camera, or a video camera such as a camcorder. The captured video image is then converted into still frame digitized format for transmission over any of a variety of transmission systems ranging from Group-III facsimile to computer, or to a like device at a remote location, in any protocol desired. The invention recognizes that once the signal is digitized, the transmission protocols are virtually endless.

For example, the present invention, permits a still frame visual image to be captured at a remote location and sent immediately, over wireless communication systems, to a remote location such as, by way of example, a computer system wherein the image could be merged directly into newsprint. The image may also be sent to and printed as a hard copy using any Group-III facsimile machine, anywhere in the world. Where desired, the images may be stored in memory for later recall, and may be archived on a portable medium such as a memory card or the like.

The system of the subject invention is particularly useful for applications where immediate transmission of visual images of scenes, people and objects is desirable and sophisticated equipment is not always available for receiving the information. The system also provides a unique and reliable means for transmitting visual data to and from remote locations, such as, by way of example, law enforcement and emergency vehicles and the like.

In the preferred embodiment of the invention, the system includes a video camera and an integral cellular telephone, wherein the telephone using the standard audio mode or future digital modes, can be used to transmit and receive visual image signals. A desk model is also disclosed and permits connection to a standard land line telephonic system. A mobile console model is disclosed for use in law enforcement vehicles, and the like. Other communication systems are also supported by the subject invention, including hardwired networks, radio and satellite transmission and the like.

A local facsimile machine may be incorporated with the unit and can serve as a printer for providing hard copy of the captured image at the point of capture, as well as being adapted for receiving facsimile transmissions in the standard fashion.

The circuitry is disclosed for supporting any of the preferred configurations from a basic real time transmission system via Group-III fax to a comprehensive system supporting both land line and wireless transmission of image, audio and documentary data at both a local and remote station.

The subject invention also permits digitized collection of audio signals through the use of an internal microphone, and external input device, a cellular telephone, land line telephone, wireless radio or other communication system, and digitized audio playback, as well. The playback can be via an internal speaker, out an external out jack to a remote device or via a cellular telephone, land line telephone, wireless radio or other communication system.

The digitized image and audio capture features permit association of audio with an image, as well as data with the image. Useful data associated with the image includes GPS from either internal or external GPS devices, range information from ranging devices, date and time, and text which may be input from an integrated keyboard or from a remote device.

It is an important feature of the invention that the system supports storage of images in an interim storage format including raw video, compressed video, interim gray scale format and/or half tone format. The image can also be stored in the selected output mode, such as by way of example, a Group III facsimile mode. The versatile capability of the system permits transmission of captured data to a standard bi-level facsimile machine such as Group III, to gray scale facsimile systems or full color facsimile systems, as well as to other remote receiving devices such as, by way of example, personal computers and network servers. The data may be transferred in any of a variety of formats and protocols including JPEG, FAX, wavelets, emerging imagery formats, FAX and computer data protocols. The invention is adapted to operate in multiple modes, with a unitary capture and send mode or separate capture and store, and send modes.

In the preferred embodiment, the system is adapted for tagging a collected image, video, audio, and other data such as a GPS information, with geospatial information and real time clock and added text. This permits the complete historical data to be transmitted simultaneously with the image signal.

It is contemplated that the system of the invention would be self-contained with an integral power unit such as a disposable battery, rechargeable battery source or the like. Therefore, the system is adapted to power up when in use and power down or "sleep" when not activated, preserving power during idle time. The power systems for the video camera, the video input circuits and converters, the modem or other transmission devices and other high drain components may be isolated and only powered when needed. This also permits use of ancillary functions, such as use as a cellular telephone, to proceed without draining the power source by powering idle components. The processor clock rate may also be slowed down during idle mode to further conserve power.

Where desired, the system also includes camera operation control capability through the use of a digital/analog circuits for converting digital commands to analog signals for controlling the gain, pedestal, setup, white clip, lens focus, white balance, lens iris, lens zoom and other functions of the camera from a local input device, a remote device or as automatic or programmed functions. The central processor may also be used to control camera shutter rate. Other camera features and parameters which may be controlled in this manner are compressor resolution (such as high, medium, low user settings) corresponding to compression rate parameters, field/frame mode, color or monochrome, image spatial resolution (640x420 pixels, 320x240 pixels, for example), lens and camera adjustments, input selection where multiple cameras or video sources are used and the like.

When an integrated communications device is used, such as by way of example, a cellular telephone, the telephone can be isolated from the rest of the system to permit independent use, and independent power up and power off and other cellular phone functions.

In operation, the system permits not only the manual capture, dial (select) and send of images, but may also be fully automated to capture, dial and send, for example, on a timed sequence or in response to a sensor such as a motion sensor, video motion detection, or from a remote trigger device. The remote trigger also may be activated by an incoming telephone signal, for example.

The remote device may also be use for remote loading and downloading of firmware, and for setting of the programmable parameters such as to provide remote configuration of sampling modes during capture, compression rates, triggering methods and the like.

The triggering function permits a multitude of sampling schemes for a simple triggered activation for capturing an image upon initiation to a trigger signal to more complicated schemes for capturing and transmitting images prior to and after receipt of the trigger signal. The trigger function can be set to operate, for example, on a time per sample and number of sample basis, or time per sample and total sample time basis, or number of samples and total time basis. Depending on application, the trigger can sample in a prior to and after signal mode, using in combination the time per sample and number of samples prior and after signal basis, a total time basis, a percent prior versus percent after trigger basis, time per sample basis, time prior to and time after trigger basis, and other combination. For example, if the image capture device is positioned to monitor traffic accidents at a specific location, and an audio signal sensor identifying a crash were used as the trigger, it would be desirable to collect image sample both prior to and after the trigger signal. The number of samples, total sample time, and percentage of samples prior to and after trigger would be controlled by the specific application.

Circular sampling techniques are supported by the data capture system of the present invention. This is particularly useful when triggering events are used to initiate transmission of collected image data over the communications system. For example, if a triggering event is motion detected at a motion sensor, it may be useful to look at the images captured for a period of time both prior to and after the actual event. The circuitry of the subject invention permits any circular sampling technique to be utilized depending upon application, such as prior to an after trigger, only after trigger or only before trigger or prior to and after the trigger point. Again, as an example, it may desirable to look primarily at images captured before a triggering event if the event is a catastrophic event such as an explosion or the like. Other circular sampling techniques may be employed, as well, incorporating multiple cameras, for example, wherein different fields are sampled depending upon the time frame in a sequence of events.

It is, therefore, an object and feature of the invention to provide an apparatus for capturing, converting and transmitting a visual image via standard facsimile transmissions systems.

It is another object and feature of the invention to provide an apparatus for compressing the visual image data in order to minimize the capacity requirements of the data capture and storage system.

It is an additional object and feature of the invention to provide an apparatus for capturing and storing a visual image for later recall and review and/or transmission.

It is yet another object and feature of the invention to provide an apparatus for storing a captured video image in digital format on a portable storage medium.

It is an additional object and feature of the invention to provide an apparatus capable of sending and receiving telephonic audio messages, facsimile documents and captured visual images to and from standard, readily available remote stations.

It is a further object and feature of the invention to provide the means and method for capturing images prior to, prior to and after, or after a triggering event.

It is also an object and feature of the invention to provide for multiple triggering events and/or optional viewing or review of the captured images prior to printing or transmission.

It is another object and feature of the invention to provide an apparatus which may be activated from a remote location for initiating the capture of images by the device.

Other objects and features will be readily apparent from the drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a basic facsimile camera configuration for capturing an image via a camera and transmitting it via Group-III facsimile transmission to a standard hard copy medium.

Fig. 2 is similar to Fig. 1, but incorporates a memory storage capability, permitting storage and optional review or viewing of the image prior to transmission.

Fig. 3 is similar to Figs. 1 and 2, but incorporates a data compression scheme for increasing the capacity of the memory and for increasing efficiency of transmission.

Fig. 4 includes the capture and transmission configuration of Fig. 2, with multiple transmission format capability including Group-III facsimile, personal computer, modem, parallel and serial transmission schemes.

Fig. 5 is an exemplary schematic diagram supporting the configurations shown in each of Figs. 1-4.

Figs. 6A, 6B, and 6C, are block diagrams of the physical components of desktop, portable and comprehensive console embodiments of the invention, respectively.

Fig. 7A and 7B are perspective drawings of a hand held device for capturing, storing and transmitting an image in accordance with the invention (new drawings to replace Frassinito design.

Figs. 8A-8L (Formerly Fig. 12) comprises a schematic diagram for an exemplary embodiment of the circuit for supporting the subject invention.

Fig. 9 is a diagram of the various triggering sequence options.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The image capture and transmission system of the subject invention is suited for capturing one or more single frame analog image or a digital image data signal and transmitting the captured signal via any of a plurality of transmission schemes to a remote receiving station where the image is downloaded in a suitable format for viewing and printing on hard paper copy, a CRT screen image, or other medium. The system is particularly well suited for sending and/or receiving images via a standard Group III facsimile transmission system and permits capture of the image at a remote location using an analog or digital camera. Two generic configurations are shown and described, the first, where each image is transmitted as it is captured, and the second, which permits capture, storage, and selective recall of captured images for transmission. The invention also contemplates a portable storage medium, wherein the captured stored medium may be removed from the capture device and archived for later use. While a system for black and white (gray tones) for Group-III facsimile transmission is described in detail herein, the invention could be readily adapted to transmission of color images utilizing the teachings of the present invention using industry standard color video standards and circuits. Both portable, or hand held, and stationary, or desktop, units are described. The circuitry utilized for both is configurations is identical , but stationary configurations do not need a battery.

Figs. 1-5 are circuit configuration diagrams for the various capture, storage and transmission schemes. The physical embodiments utilized to employ the teachings of the schemes taught in Figs. 1-5 are not limited. Figs. 6-10 are exemplary physical embodiments of the subject invention.

Turning now to Fig. 1, the simplest embodiment of the invention incorporates a standard analog or digital camera device 10 for capturing a visual image in the typical fashion. The camera 10 may be operator activated as indicated at 12, or may be programmed to be activated at selected intervals or in response to certain conditions. For example, a motion detector may be utilized to activate the camera 10 in a surveillance installation. Once activated, the camera 10 captures a visual image in typical fashion through a lens (see lens 192, for example, in Fig. 7A). In the illustrated embodiment, the captured image is then transmitted to a gray scale bit map memory device 16, from which it is output to a half-tone conversion scheme 18 to be input into a binary bit map 20 for formatting the captured image in a configuration suitable for transmission via a Group-III facsimile system. The signal generated at 22 by the binary bit map 20 is input into a Group-III encoding and compression network 24 for generating an output signal at 26 which is introduced into a Group-III protocol transmission device 28. The output at 30 of the transmission device 28 is then transmitted into any standard transmission interface such as, by way of example, hard line telephonic transmission, cellular transmission, radio signal, satellite transmission or other transmission system 32 via a modem or similar device, as needed(as diagrammatically illustrated at 29), to be received via a compatible interface by a remote Group-III receiving system 34. The Group-III receiving system 34 is a typical Group-III facsimile system comprising a Group-III receiver 36, decoder and decompressor 38 and binary bit map 40, from which a facsimile hard copy such as plain paper copy 42 may be generated.

This configuration is particularly well suited where real near time transmission is desired, for example when the system is operator controlled and a "real time" image is desired at a remote location. An example of such a system may be a photo-identification confirmation of an apprehended suspect in law enforcement use, or transmission of images of damaged assets for insurance purposes, or transmission of images of construction job site conditions. This configuration is also well suited for use in those applications where a sensor activates the system and real time transmission of the sensed condition is desired. An example of such a system would be a motion activated camera in a surveillance location, where the image is immediately transmitted to a remote monitoring station. Of course, it will be readily understood by those who are skilled in the art that tagging a transmitted image with information such as, by way of example, date, time and location, can be incorporated in the transmitted signal so that a receiving station could monitor a plurality of remote image data capture systems. This is also useful for reviewing a body of previously stored or printed images to determine the time and location of such image.

The embodiment of Fig. 2 is similar to Fig. 1, but incorporates a memory and optional operator viewer system. The image is captured by the camera 10 and conditioned by the gray scale bit map 16, as in Fig. 1. In this embodiment, the output 44 of the bit map 16 is input into a standard digital memory device 46 for later recall. This configuration is particularly well suited for applications where near real time transmission of the image either is not required or is not desirable. It will be noted that with the exception of the insertion of the memory device 46 and the optional viewer device 48, the capture and transmission system of Fig. 2 is identical to that shown and described in Fig. 1. Once the image is captured by the camera 10 and is presented at 44 to the memory device 46, it is stored for later recall and transmission. The specific type of memory device is optional and may include, for example, an SRAM device, a DRAM, Flash RAM, hard drive, floppy disk, PCMCIA format removable memory (see, for example, the PCMCIA card ~~50~~ 72 in Fig. 7A), writeable optical media or other storage device. The memory may selectively capture images, as indicated by the operator interface/capture interface 52, or may be programmed to selectively capture periodic images or all images. In the embodiment shown in Fig. 2, an optional viewer device 48 is provided. This permits the operator to recall and view all or selective images before transmission, as indicated by the operator interface/recall interface 54. This permits the operator to review all images retained in the memory 46 and transmit selective images, as desired, to the Group-III transmission system. The remainder of the system of Fig. 2 operates in the same manner as the configuration shown and described in Fig. 1.

The configuration of Fig. 3 incorporates all of the features of Figs. 1 and 2, and additionally, includes an interim data compression and decompression scheme to permit increased utilization of the memory or storage medium 46. As shown in Fig. 3, an interim format compressor 56 is inserted between the gray scale bit map 16 and the memory device 46. This permits compression and reduction of the data required to store the image, effectively increasing the capacity of the storage device. It is an objective of the storage device to preserve the gray scale quality of the image for viewing at the location of capture. An interim format decompression device 58 is inserted between the output of the memory device 46 and the rest of the system, whether the optional viewer 48 is utilized, or the output is entered directly into the half-tone convertor 18. The interim compression/decompression scheme is particularly useful when all of the image data is to be permanently archived, or when limited capacity portable media are used, such as, by way of example, floppy disks or a portable PCMCIA card. It will be noted that the remainder of the system shown in Fig. 3 is identical to the system shown and described in Fig. 2.

Fig. 4 illustrates the use of the image capture and/or retention configured in any of the optional embodiments of Figs. 1-3 and adapted for use in combination with any of a variety of transmitting and receiving schemes such as, by way of example, the Group-III system shown in Figs. 1-3, a modem, direct connection to a personal computer, serial or parallel transmission, or any selected transmitting/receiving protocol. This illustration demonstrates the versatility of the system once the image has been captured, converted and conditioned by the image capture device of the subject invention. Specifically, once the image is captured by the camera 10 and conditioned by the gray scale bit map 16, it may be stored and transmitted, or transmitted "real time" via any transmitting and receiving scheme. As shown in Fig. 4 the image capture device includes the memory device 46 and the optional viewer 48 for incorporating maximum capability. However, any of the schemes of Figs. 1-3 would be suitable for producing a transmittable signal. In the embodiment shown, a format select interface switch 60 is positioned to receive the fully conditioned signal on line 59. This would permit either automated or manual selection of the transmitting protocol, including the Group-III facsimile system previously described in connection with Figs. 1-3, as indicated by selecting format select switch 60 position A; or PC modem protocol as illustrated by the JPEG compressor 62 and protocol generator 64, as indicated by selecting format select switch position B; or the wavelet compressor and PC modem protocol, as illustrated by the wavelet compressor 66 and PC modem protocol generator 68 by selecting switch position C; or any selected conversion network 65, (if needed) with a compatible compressor 67 (if needed) and compatible protocol generator 75 (if needed), as indicated by switch position D; or a serial protocol scheme 77, with serial drivers 79 directly to a hardwired personal computer 81 by selecting switch position E. Of course, it will be readily understood by those skilled in the art that one or a plurality of transmitting protocols may be simultaneously selected. Depending on the protocol selected, the signal output is generated at the selected output module and introduced to a communications interface module 83 via a modem or other device, as needed, for transmission via a transmission system to a compatible receiving station such as the Group-III facsimile device 34, the personal computer 85, the video telephone 89, and/or other server or receiving device 91 for distribution.

An exemplary circuit supporting the configurations of Figs. 1-4 is shown in Fig. 5. With specific reference to Fig. 5, an analog camera is indicated by the "video in" signal at 70. Typically, the video signal is a composite video/sync signal. The diagram shows all of the signal processing necessary to sync up to an NTSC signal 70 coming out of the analog camera and processed for introduction into an integral RAM memory 71 and/or a portable RAM memory via interface 73. An analog to digital (A/D) converter 74 converts the video portion of the analog signal from the camera and produces the digital signal for output at line 76. The digital output data on path 76 is introduced into a data multiplexer circuit 81 and into the RAM memory unit(s) 71, 72. In the exemplary embodiment, the portable RAM memory 72 is an image card such as, by way of example, a PCMCIA SRAM card or a PCMCIA Flash RAM card. However, it will be readily understood that any suitable RAM memory configuration can be used within the teachings of the invention. It is desirable to store compressed rather than raw data in card 72 because of space and transmission speed factors.

As the signal at 70 is introduced into the circuit, the sync detector 78 strips the sync signal portion off of the video signal. The sync signal drives the video address generator 80 for providing a signal used to generate an address signal at the address multiplexer circuit 82 for synchronizing the scanned in video signal with the locations in RAM to define each frame to be captured. The read/write control 84 controls the coordination of the sync signal 83 with the video signal to define a full frame. Basically, when the camera is activated either by the operator or by automation, the system processor 86 detects the initiation of the camera and capture sequence and sends a signal via line 88 to the read/write control 84. The read/write control then monitors the incoming video signal 83 to find the horizontal and vertical sync pulse to identify the beginning of a frame. The read/write control then initiates writing to memory at the RAM devices to initiate capture of the frame. The read/write control continues to "write" to memory until the appropriate sync signal is received, indicating the end of the frame. At this point a single frame is captured in RAM 71 and/or on the portable medium RAM 72.

This frame may now be output from the system via any of the available transmitting schemes. In the exemplary embodiment, the processor 86 may be any processor or such as a microprocessoror DSP, with sufficient capability to perform the described functions. The processor bus is indicated at 87. The circuitry supporting the processor comprises the processor chip 86 and the control store memory (ROM, Flash RAM, PROM, EPROM or the like) 92 for storing the software program executed by the processor. It will be understood that other memory devices could be utilized without departing from the spirit of the invention. For example, a Flash RAM would permit flexibility and replacement of the program for upgrades and enhancements. The user interface commands are generated and interpreted by the software that is being executed by the processor 86.

The display unit 94 is connected through a typical interface 96, and provides visual user interface at the camera body to give the operator a visual read-out of the status of the collection and transmission of a selected frame. In the exemplary embodiment, the display unit is a two line, multi-character LCD display, but other sizes or technology displays could be readily incorporated, depending, for example, on the amount of graphics desired in the display module. The bank of operator buttons and/or switches 98 are connected to the system through the button interface 100.

The general purpose control register 102 serves as a latch and permits control bits to be introduced from the processor 86 to the transmitting systems or to transfer status bits from the transmitting systems back to the processor in the well known manner. The modem 104 may be any of a variety of widely available modems or modem chip sets currently in commercial use. The modem should support CCITT

Group III fax format for transmission to Group III fax machines. Once the signal is introduced into the modem 104, it is handled in typical fashion to provide input/output transmissions: (1) from the subject device to a hardwired telephonic line as indicated at 114, (2) from the subject device to the external facsimile machine as indicated at 116, or (3) from the subject device to an external wireless device telephone as indicated at 130. The specific selection is controlled by the user at button module 98 in conjunction with the processor 86.

An isolation transformer 110 is provided to isolate the circuitry connected to external communications circuit from the circuitry of the subject device. The relays at 108 and 112 permit patching directly into the hardwired telephonic line and to the telephone company system as indicated at 114, to an external handset or fax machine at 116, or to the modem 104, whereby facsimile data can be sent and received via the modem. These relays could be mechanical or solid state. The relay 118 is connected to a tone source 120 for providing an audible tone signaling to the user that the system is being used for transmitting or receiving a captured image.

With specific reference to the circuitry associated with relay 112, it will be noted that when the handset is switched away from the phone line to the tone source, the modem transformer 110 is switched to the telephone line 114. This blocks normal audio telephone service and permits the transmission of an image signal from the RAM devices 71 or 72, through the modem 104, and to the telephone line 114.

In the exemplary embodiment, a stand alone facsimile machine can be connected through the external handset jack at 116. With relay 112 set to activate telephone service and the tone generator 120 disconnected, the relay 108 can be set in either of two positions. The first position, as drawn, connects the facsimile machine at jack 116 to the telephone line, permitting standard facsimile transmission. The second or alternative position permits the modem 104 to transmit the image data signal directly to the facsimile machine at jack 116, for providing an archive copy or the like. In this configuration, the facsimile machine will operate as a local printer for printing the captured images. Signal source 120 may be used as a ringing voltage generator for signaling such facsimile machine prior to connection.

The system of the present invention also contemplates wireless transmission over a cellular telephone, radio frequency, satellite transmission or the like. In the exemplary embodiment, the specific configuration for a cellular telephone interface is shown in detail. The amplifiers 122, 124 amplify the input of the modem 104 and are controlled by the FETs 126, 128, respectively. The FETs are controlled by the control register 102 and allow selection of the audio either coming in from the cellular interface 130 or from the telephone line 104 to the modem. This permits the cellular phone to be used for three distinct functions: (1) as an audio telephone, (2) as a transmitting system for transmitting the captured image and related signals via a cellular system, and (3) for receiving incoming transmissions to the processor such as remote control, remote configuration, or images.

In the exemplary embodiment, the image card 72 is a DRAM card or non-volatile storage card such as a Flash RAM or the like and provides a removable medium for storing the image data as either raw or compressed data. The card can also be used to store compressed data sent into the system via external facsimile transmission. As illustrated, the system is capable of both sending and receiving image data via Group-III fax or other protocol. By incorporating the digital to analog (D/A) converter into the system and pulling the signal from the RAM 71 (or portable RAM 72), the signal can be displayed right at the camera viewfinder 134 or other display device connected at port 138. A sync generator 136 is incorporated to provide synchronization of incoming data in the same manner. The sync detector 78 is utilized to define a frame-by-frame correlation of the data generated by the camera at the video input 70 for storage to memory 71 or 72.

Any standard power source may be utilized, including replaceable or rechargeable batteries 141, or an AC adapter 142. The AC adapter is particularly suitable for desktop applications.

The exemplary embodiment includes a speaker or other audio transducer 144 for emitting a detectable signal whenever the user interface merits its use, such as user induced errors, system errors, user attention getting and the like.

In order to send a facsimile transmission over a typical Group-III Facsimile system, the multiplexer 82 is switched to the processor 86 such that the RAM address is generated by the processor 82 instead of the video address generator signal. In the facsimile transmitting mode, the processor accesses the RAM and manipulates the data representing each frame image. For example, the processor will perform the gray scale to half tone conversions described in connection with Figs. 1-4 to prepare the signal for facsimile transmission. The processor can also perform image compression and output the image as a gray scale. In the facsimile transmission mode, once the half tone conversion is completed, the processor executes a code for performing a bi-level compression of the data and the signal representing the frame data is output over line 90, through the multiplexer 81 and over the processor bus 87 to the processor 86, then to modem 104 for transmission. Other memory and processor configurations could be used without departing from the scope and spirit of the invention, as will be recognized by those skilled in the art.

Various physical configurations of the invention are shown in Figs.7A & 7B. Figs. 6A, 6B and 6C are block diagrams for desktop and portable units. Figs. 7A and 7B iillustrate the subject invention as incorporated in a standard 35 millimeter type camera housing.

A basic desktop system is shown in Fig. 6A, and includes a console unit having a telephone jack 152, an external telephone connection 154 and a video input/camera power jack 156 for connecting the analog camera 10. A facsimile machine may be also connected at jack 154 to provide local printer capability. The configuration shown in Fig. 6B is a basic portable system, with a battery powered portable module 160 having a self-contained power source 162. The system may include an integral RAM and/or the removable memory module as indicated by the image card 72. The camera 10 may be an integral feature of the portable module 160, or may be a detached unit, as desired. In this embodiment, a cellular telephone 164 is provided with a data jack 166 for connecting to the output jack 168 of the module, whereby the image data signal may be transmitted via the cellular telephone to a remote facsimile machine over standard cellular and telephone company facilities. When incorporating the circuitry of Fig. 5, the cellular phone may be used as both an input and an output device, and incoming data or stored images may be viewed through the viewfinder 170.

Fig. 6C shows a comprehensive desk or stationary configuration incorporating all of the features supported by the circuitry of Fig. 5. As there shown, the control module 172 is adapted for receiving the image card 72 and is powered by an AC power adapter as indicated at 142. The camera 10 is connected to the module via a hardwired connection at jack 174. A monitor 176 is provided for viewing data images. A video cassette recorder 178 is provided and may be used as an auxiliary input device for the images transmitted from the system. The facsimile machine 180 can be used as a local printer, or can be used to send facsimiles transmissions in the well-known manner. Direct connections to the telephone line system are provided at jack 182. The FAX/phone jack 186 can be connected to a facsimile machine 180 and/or a standard telephone 184, where the public telephone system can be accessed. A data jack 188 is used to connect to a cellular telephone or the cellular modem, or other wireless device for transmission or reception of image data.

Turning now to Figs. 7A and 7B, the camera body 190 is similar to a standard 35 millimeter camera housing and is adapted to receive a standard lens 192 with a viewfinder 194. The electronics are housed in the casing in the area normally occupied by the film and film advancing implements. The operator interface button keys 98 are housed within the housing and may be positioned on the back plate 196 of the body. A ~~Fig. 8~~. The LCD unit may be positioned to be visible through the viewfinder 194 or may be in a separate back window 198. The memory card 72 is positioned in a slot 200 provided in a sidewall of the camera body. This camera has the appearance of a standard SLR 35 millimeter camera. In addition, where desired, an integral cellular phone can be incorporated in the camera housing and transmission can be sent directly from the camera housing to a remote receiving station. The keypad for the telephone is indicated at 202.

Fig. 8 is an illustration of an exemplary schematic diagram for the circuit of a system according to the teaching of the invention as specifically taught in the diagram of Fig. 5. Pin numbers, wiring harnesses and components are as shown on the drawing. Fig. 8, part A, is the system interconnect and shows the central processor board 300, the video board 302, the power board 304 and the CRT electronic interconnect board 306. The telephone interface is provided at 307. Board 308 is the audio connector board. Board 310 is the serial connector board and board 312 is the video connector board. Fig. 8, part B contains the audio logic, with audio I/O at 314. The audio amplifiers are designated 316 and 318. A microphone connector is provided at 320, with preamplifier circuit 322. Audio switches are provided at 324 and 326. Summing circuit 328 provides audio summing. The serial RAM for audio is designated 330. Fig. 8, part C includes the camera module 332 and the camera control digital to analog convertor 334. Amplifier 336 is the video buffer. Module 338 is the camera shutter control resistor.

Fig. 8, part D contains the central processor unit 340. Voltage in is at 342, with the power switch at FET 344. Power shutdown is provided at the video shutdown bit 346. The video connector is designated at 348. Pin 1 is switched five volts out to video logic. Pins 2-9 are connected to the video data bus and pins 10-22 are video control signals. Buffers 350 and 352 are the video board I/O isolation buffers. As shown, pin 19 of buffer 352 is the output enable and is connected to the video shutdown bit 346. Line 354 is bus enable. Pin A0 of buffer 350 is the direction control signal and pins A1-A7 are connected to the processor data bus. Pins I0-I7 of buffer 352 are also connected to the processor bus.

The system DRAM memory is designated 356. The processor I/O module is designated 358 and the I/O decoder is provided at 360. A non-volatile RAM 362 provides system parameters. The processor oscillator is shown at 364 and a real time clock at 366. Controller 368 is the RAM card controller. The PCMCIA socket for the RAM card is shown at 370a and 370b. The modem is designated 372. The serial controller is shown at 374 with serial controller oscillator 376. Module 378 is a memory module. A signal buffer is provided at 380, and an address decoder at 382. Connectors are designated at 384, 386 and 388.

Fig. 8, part E shows the modem board connector at 390, the glue logic PLD at 392 and the glue logic module at 394. Module 396 is the synchronous/asynchronous serial controller. Circuit 398 is the signal multiplex relay and circuit 400 is the transmit/PTT relay. Bypass relays are shown at 402. Relay 404 is the digital mode relay. Transformer 406 is the audio isolation transformer. Circuit 408 provides a low speed data filter. The line drivers are designated 410 and the line rectifiers are designated 412, respectively. Connector 414 provides radio/serial data connection.

Fig. 8, part F shows the status LED's 416 and the PCMCIA door open switch 418. Fig. 8, part G shows the power switches 420. Fig. 8, part H is the battery pack 422.

Fig. 8, part I is the power supply. The rechargeable battery connection is shown at 424, with DC power input at 426. An internal battery/external DC input transfer relay is provided at 430. The signal for the power switch on the removable disk drive access door is on pins 3,4 of connector 428. The voltage IN regulator is designated at 432, with the processor voltage regulator designated 434. The processor power control bit is at 436. The system power control bit is at 438, with the system voltage regulator at 440. The video power control bits are at 442 and 444, with the video voltage regulators at 446 and 448, respectively. Battery 450 is the real time clock battery. Connector 452 is the battery charger connector. Connector 454 connects processor power, system power, regulated battery power and real time clock power, as shown. Connector 456 connects video power. The power sequencer circuit is at 458.

Fig. 8, part J shows the direct access arrangement to a land line telephone at 460 and the video viewfinder circuitry (CRT electronics) at 462.

Fig. 8, part K is the video control circuitry. The video input amplifier is designated at 464. The composite video sync stripper is designated at 466. The video H/V timing pulse generator is at 468 and the video phase lock loop at 470. The register 472 is the video control register. Circuit 474 provide programmable video filters--edge enhancers, with the FET switch designated at 476. The video filter circuit is at 478 and the video filter is at 480. The video reference digital to analog circuit is shown at 482, with the video analog to digital circuit at 484 and the video analog to digital data out buffer at 486. The voltage reference circuit is designated at 488.

Fig. 8, part L shows the push button control switches as 490 and 492. The keyboard display is designated 494, and the microcontroller 496 is the keyboard and keyboard display microcontroller. The backlight circuitry is designated at 498, with the back light control at 500. Module 502 is the LCD module.

The circuitry supports any of the preferred configurations from a basic real time transmission system via Group-III fax to a comprehensive system supporting both land line and wireless transmission of image, audio and documentary data at both a local and remote station.

The subject invention also permits digitized collection of audio signals through the use of an internal microphone, and external input device, a cellular telephone, land line telephone, wireless radio or other communication system, and digitized audio playback, as well. The playback can be via an internal speaker, out an external out jack to a remote device or via a cellular telephone, land line telephone, wireless radio or other communication system.

The digitized image and audio capture features permit association of audio with an image, as well as data with the image. Useful data associated with the image includes GPS from either internal or external GPS devices, date and time, and text which may be input from an integrated keyboard or from a remote location.

It is an important feature of the invention that the system supports storage of images in an interim storage format including raw video, interim gray scale format and/or half tone format. The image can also be stored in the selected output mode, such as by way of example, a Group III facsimile mode. The versatile capability of the system permits transmission of captured data to a standard bi-level facsimile machine such as Group III, to gray scale facsimile systems or full color facsimile systems, as well as to other remote receiving devices such as, by way of example, personal computers and network servers. The data may be transferred in any of a variety of formats and protocols including JPEG, FAX, emerging ~~ne~~ new imagery formats, wavelets and data protocols. The invention is adapted to operate in multiple modes, with a unitary capture and send mode or separate capture and store, and send modes.

In the preferred embodiment, the system is adapted for tagging a collected image, video, audio, and other data such as a GPS signal, with a real time clock and added text. This permits the complete historical data to be transmitted simultaneously with the image signal.

It is contemplated that the system of the invention would be self-contained with an integral power unit such as a rechargeable battery source or the like. Therefore, the system is adapted to power up when in use and power down when not activated, preserving power during idle time. The power systems for the video camera, the video input circuits and converters, the modem or other transmission devices and other high drain components may be isolated and only powered when needed. This also permits use of ancillary functions, such as use as a cellular telephone, to proceed without draining the power source by powering idle components. The processor clock rate may also be slowed down during idle mode to further conserve power.

Where desired, the system also includes camera operation control capability through the use of a digital/analog network for converting digital commands to analog signals for controlling the gain, pedestal, setup, white clip, lens focus, and other functions of the camera from a local input device, a remote device or as programmed functions. The central processor may also be used to control camera shutter rate. Other camera features and parameters which may be controlled in this manner are compressor resolution (high, medium, low), field/frame mode, color or monochrome, image spatial resolution (640x430, 320x240, for example), lens and camera adjustments, input selection where multiple cameras are used and the like.

When an integrated communications device is used, such as by way of example, a cellular telephone, the telephone can be isolated from the rest of the system to permit independent use, and independent power up and power off and other cellular phone functions.

In operation, the system permits not only the manual capture, dial (select) and send of images, but may also be fully automated to capture, dial and send, for example, on a timed sequence or in response to a sensor such as a motion sensor or from a remote trigger device. The remote trigger may be activated by an incoming telephone signal, for example. The remote device may also be use for remote loading and downloading of firmware, and of the programmable devices, as well as to provide remote configuration of sampling modes during both the capture and the send functions.

Circular sampling techniques are supported by the data capture system of the present invention. Fig. 9 is a diagram illustrating exemplary sampling techniques in accordance with the teachings of the invention. As shown in Fig. 9, the time sequence is indicated by the Time Line: t1, t2...tn, with a sample at each time interval, as indicated by S1...Sn. For purposes of illustration, the triggering event occurs at time interval t10. Based on the predetermined programming of the system, images will start to be collected upon triggering event, as shown at 210, for a predetermined period prior to and after trigger, as shown at 212, or immediately preceding the trigger, as shown at 214. This permits "circular image storage" without requiring that all images be collected and stored in order to look at events surrounding a triggering event. The technique is also very useful when multiple overlapping zones are monitored by multiple devices and it is desirable to sequence from device to device without losing any critical images.

This is particularly useful when triggering events are used to initiate transmission of collected image data over the communications system. For example, if a triggering event is motion detected at a motion sensor, it may be useful to look at the images captured for a period of time both prior to and after the actual event. The circuitry of the subject invention permits any circular sampling technique to be utilized depending upon application, such as prior to an after trigger, only after trigger or only before trigger. Again, as an example, it may desirable to look primarily at images captured before a triggering event if the event is a catastrophic event such as an explosion or the like. Other circular sampling techniques may be employed, as well, incorporating multiple cameras, for example, wherein different fields are sampled depending upon the time frame in a sequence of events.

Other configurations are contemplated and are within the teachings of the invention. While specific embodiments have been shown and described herein, it will be understood that the invention includes all modifications and enhancements within the scope and spirit of the claims.

CLAIMS

What is claimed is:

Sub A1)

1. ~~An self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:~~
   - a. ~~An image capture device;~~
   - b. ~~A processor for generating a data signal representing the image;~~
   - c. ~~A communications device adapted for transmitting the data signal to the remote receiving station~~
   - d. ~~a subprocessor for generating a Group-III facsimile compatible signal representing the digital signal.~~

2. The image processing system of claim 1, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

3. The image processing system of claim 1, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

4. The image processing system of claim 1, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

5. ~~The image processing system of claim 3, wherein the subprocessor comprises:~~
   - a. ~~A gray scale bit map;~~
   - b. ~~A half tone converter; and~~
   - c. ~~A binary bit map.~~

~~6. The image processing system of claim 1, wherein there is further included an integrated wireless telephone associated with the communications device.~~

~~7. The image processing system of claim 1, further comprising a housing for housing all of the elements of the system in an integrated body.~~

~~8. The image processing system of claim 1, wherein said image capture device is a digital camera.~~

A

9. The image processing system of claim 2, wherein the cellular device includes ~~further including~~ a view screen for viewing the captured and stored image.

10. The image processing system of claim 1, further including a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy.

11. The image processing system of claim 1, wherein the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

12. The image processing system of claim 1, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

13. The image processing system of claim 1, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

14. The image processing system of claim 1, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

15. The image processing system of claim 1, further comprising a data processor for creating a text data signal associated with said image data signal.

16. The image processing system of claim 2, wherein said image data signal is stored in a raw video format.

17. The image processing system of claim 2, wherein said image data signal is stored in a compressed format.

18. The image processing system of claim 2, wherein said image data signal is stored in a half-tone format.

19. The image processing system of claim 1, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

20. The image processing system of claim 1, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

21. The image processing system of claim 1, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

22. The image processing system of claim 1, wherein the remote receiving station is a digital device and the image data is digital.

23. The image processing system of claim 1, further comprising an self-contained power source for powering the system.

24. The image processing system of claim 1, further including control apparatus for remotely controlling operating functions of the image capture device.

A 25. The image processing system of claim 24, wherein said image capture device is a camera with a shuttered lens and where said control apparatus controls any combination of lens direction, iris, focus and shutter speed.

26. The image processing system of claim 1, further comprising an input device for controlling the processor configuration from a remote location.

A 27. The image processing system of claim 1, wherein said image capture device may be controlled to capture a plurality of images in controlled order.

28. The image processing system of claim 26, wherein said image capture device may be controlled to capture a plurality of images in a controlled order.

29. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

30. The image processing system of claim 29, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

31. The image processing system of claim 29, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

32. The image processing system of claim 29, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

33. The image processing system of claim 29, further including a subprocessor for generating a Group-III facsimile compatible signal representing the digital signal.

34. The image processing system of claim 29, wherein the subprocessor comprises:

a. A gray scale bit map;
b. A half tone converter; and
c. A binary bit map.

09006073 .011298

35. The image processing system of claim 29, wherein there is further included an integrated wireless telephone associated with the communications device.

36. The image processing system of claim 29, further comprising a housing for housing all of the elements of the system in an integrated body.

37. The image processing system of claim 29, wherein said image capture device is a digital camera.

38. The image processing system of claim 30, further including a view screen for viewing the captured and stored image.

39. The image processing system of claim 29, wherein the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

40. The image processing system of claim 29, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

41. The image processing system of claim 29, wherein the processor routine converts the signals to a Group-III facsimile protocol, the system further including a facsimile modem for accepting the signal and transmitting to the compatible receiving station.

42. The image processing system of claim 29, further including a hardwired transmission system and a wireless transmission system associated with the modem and a switching device for selecting in the alternative either the hardwired or the wireless transmission system.

43. The image processing system of claim 40, further including a local facsimile receiving system associated with the modem for providing local hard copy of the stored image signals in the memory.

44. The image processing system of claim 43, further including a switching device for selectively activating and deactivating the local facsimile receiving system.

45. The image processing system of claim 40, wherein the wireless transmission system is a cellular telephone system and wherein the wired transmission system is a land line telephone system, and wherein the processing system further includes and integral cellular telephone and/or and integral land line telephone, and wherein each of said telephones is capable of operating in a standard telephonic format for receiving incoming and transmitting outgoing audio calls.

46. The image processing system of claim 45, further including an interrupt device to prohibit use of the telephones in a standard telephonic mode whenever image data signals are being transmitted.

47. The image processing system of claim 45, wherein the interrupt device further includes a tone generator for generating an audible signal when in the interrupt mode.

48. The image processing system of claim 40, further including an integral viewer for viewing the images stored in the memory.

49. The image processing system of claim 40, wherein the memory is a removable memory medium which may be selectively removed from the system.

50. The image processing system of claim 49, wherein the removable memory medium comprises a PCMCIA card memory.

51. The image processing system of claim 29, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

52. The image processing system of claim 29, further comprising a data processor for creating a text data signal associated with said image data signal.

53. The image processing system of claim 30, wherein said image data signal is stored in a raw video format.

54. The image processing system of claim 30, wherein said image data signal is stored in a compressed format.

55. The image processing system of claim 30, wherein said image data signal is stored in a half-tone format.

56. The image processing system of claim 30, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

57. The image processing system of claim 29, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

58. The image processing system of claim 29, further comprising an self-contained power source for powering the system.

59. The image processing system of claim 58, wherein said communications device is adapted to be used independently of the image capture device and the processor, and wherein the power supply is adapted for isolating the power to the communications device from the power to the image capture device and processor.

60. The image processing system of claim 59, further including a power initiation device associated with the image capture device and the processor, wherein the power to the image capture device and the processor is off when the initiation device is not activated.

61. The image processing system of claim 59, wherein the power initiation device is user controlled.

62. The image processing system of claim 59, further including a trigger device for activating the power initiation device.

63. The image processing system of claim 62, wherein the trigger device is a timer.

64. The image processing system of claim 62, wherein said trigger device is triggered by the presence of an image to be captured.

65. The image processing system of claim 64, wherein said trigger device is a motion sensor.

66. The image processing system of claim 29, further including control apparatus for remotely controlling operating functions of the image capture device.

67. The image processing system of claim 66, wherein said image capture device is a camera with a shuttered lens and where said control apparatus any combination of lens direction, iris, focus and shutter speed.

68. The image processing system of claim 29, further comprising an input device for controlling the processor configuration from a remote location.

69. The image processing system of claim 29, wherein said image capture device may be controlled to capture a plurality images in controlled order.

70. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station;

d. A wireless transmission system between the communications device and the compatible receiving station.

71. The image processing system of claim 70, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

72. The image processing system of claim 70, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

73. The image processing system of claim 70, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

74. The image processing system of claim 70, further including a subprocessor for generating a Group-III facsimile compatible signal representing the digital signal.

75. The image processing system of claim 70, wherein the subprocessor comprises:

a. A gray scale bit map;

b. A half tone converter; and

c. A binary bit map.

76. The image processing system of claim 70, wherein there is further included an integrated wireless telephone associated with the communications device.

77. The image processing system of claim 70, further comprising a housing for housing all of the elements of the system in an integrated body.

78. The image processing system of claim 70, wherein said image capture device is a digital camera.

79. The image processing system of claim 71, further including a view screen for viewing the captured and stored image.

80. The image processing system of claim 74, further including a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy.

81. The image processing system of claim 70, wherein the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

82. The image processing system of claim 70, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

83. The image processing system of claim 82, wherein the processor routine converts the signals to a Group-III facsimile protocol, the system further including a facsimile modem for accepting the signal and transmitting to the compatible receiving station.

84. The image processing system of claim 82, further including a hardwired transmission system and a wireless transmission system associated with the modem and a switching device for selecting in the alternative either the hardwired or the wireless transmission system.

85. The image processing system of claim 82, further including a local facsimile receiving system associated with the modem for providing local hard copy of the stored image signals in the memory.

86. The image processing system of claim 85, further including a switching device for selectively activating and deactivating the local facsimile receiving system.

87. The image processing system of claim 82, further including an integral viewer for viewing the images stored in the memory.

88. The image processing system of claim 82, wherein the memory is a removable memory medium which may be selectively removed from the system.

89. The image processing system of claim 88, wherein the removable memory medium comprises a PCMCIA card memory.

90. The image processing system of claim 70, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

91. The image processing system of claim 70, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

92. The image processing system of claim 70, further comprising a data processor for creating a text data signal associated with said image data signal.

93. The image processing system of claim 92, further including an input device for providing text data to the data processor.

94. The image processing system of claim 93, wherein said input device is user controlled.

95. The image processing system of claim 94, wherein said user controlled input device is an integral keyboard.

96. The image processing system of claim 93, said input device comprising a real time clock.

97. The image processing system of claim 93, said input device comprising a global positioning system.

98. The image processing system of claim 71, wherein said image data signal is stored in a raw video format.

99. The image processing system of claim 71, wherein said image data signal is stored in a compressed format.

100. The image processing system of claim 71, wherein said image data signal is stored in a half-tone format.

101. The image processing system of claim 70, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

102. The image processing system of claim 70, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

103. The image processing system of claim 70, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

104. The image processing system of claim 70, wherein the remote receiving station is a digital device and the image data is digital.

105. The image processing system of claim 70, further comprising an self-contained power source for powering the system.

106. The image processing system of claim 105, wherein said communications device is adapted to be used independently of the image capture device and the processor, and wherein the power supply is adapted for isolating the power to the communications device from the power to the image capture device and processor.

107. The image processing system of claim 106, further including a power initiation device associated with the image capture device and the processor, wherein the power to the image capture device and the processor is off when the initiation device is not activated.

108. The image processing system of claim 107, wherein the power initiation device is user controlled.

109. The image processing system of claim 107, further including a trigger device for activating the power initiation device.

110. The image processing system of claim 109, wherein the trigger device is a timer.

111. The image processing system of claim 109, wherein the trigger device is triggered by the presence of an image to be captured.

112. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station;

d. A remote trigger device for activating the processing system to initiate image capture.

113. The image processing system of claim 112, wherein the remote receiving station is a digital device and the image data is digital.

114. The image processing system of claim 112, further comprising an self-contained power source for powering the system.

115. The image processing system of claim 114, wherein said communications device is adapted to be used independently of the image capture device and the processor, and wherein the power supply is adapted for isolating the power to the communications device from the power to the image capture device and processor.

116. The image processing system of claim 115, further including a power initiation device associated with the image capture device and the processor, wherein the power to the image capture device and the processor is off when the initiation device is not activated.

117. The image processing system of claim 116, wherein the power initiation device is user controlled.

118. The image processing system of claim 116, further including a trigger device for activating the power initiation device.

119. The image processing system of claim 118, wherein the trigger device is a timer.

120. The image processing system of claim 118, wherein said trigger device is triggered by the presence of an image to be captured.

121. The image processing system of claim 119, wherein said trigger device is a motion sensor.

122. The image processing system of claim 112, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

123. The image processing system of claim 112, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

124. The image processing system of claim 112, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

125. The image processing system of claim 112, further including a subprocessor for generating a Group-III facsimile compatible signal representing the digital signal.

126. The image processing system of claim 125, wherein the subprocessor comprises:

a. A gray scale bit map;
b. A half tone converter; and
c. A binary bit map.

127. The image processing system of claim 112, wherein there is further included an integrated wireless telephone associated with the communications device.

128. The image processing system of claim 112, further comprising a housing for housing all of the elements of the system in an integrated body.

129. The image processing system of claim 112, wherein said image capture device is a digital camera.

130. The image processing system of claim 112, further including a view screen for viewing the captured and stored image.

131. The image processing system of claim 112, wherein the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

132. The image processing system of claim 112, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

133. The image processing system of claim 112, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

134. The image processing system of claim 112, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

135. The image processing system of claim 134, wherein said audio signal capture device is an input device for receiving an externally generated audio signal.

136. The image processing system of claim 112, further comprising a data processor for creating a text data signal associated with said image data signal.

137. The image processing system of claim 121, wherein said image data signal is stored in a raw video format.

138. The image processing system of claim 121, wherein said image data signal is stored in a compressed format.

139. The image processing system of claim 121, wherein said image data signal is stored in a half-tone format.

140. The image processing system of claim 112, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

141. The image processing system of claim 112, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

142. The image processing system of claim 112, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

143. The image processing system of claim 112, further including control apparatus for remotely controlling operating functions of the image capture device.

144. A modular image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. A camera component for capturing an image;

b. A processor component for generating a digital signal representing the image;

c. A communications component adapted for transmitting the digital image to the remote receiving station; and

d. A unit for housing each of the separate components for forming an assembled system.

145. The system of claim 144, wherein the camera is a hand held system.

146. The system of claim 148, wherein the communications component comprises a wireless communications device.

147. The system of claim 144, wherein the base unit is a housing incorporating a standard hand held video camera and is adapted receiving the processor component and the communications component.

148. The image processing system of claim 144, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

149. The image processing system of claim 144, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

150. The image processing system of claim 144, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

151. The image processing system of claim 144, further including a subprocess or for generating a Group-III facsimile compatible signal representing the digital signal.

152. The image processing system of claim 144, wherein there is further included an integrated wireless telephone associated with the communications device.

153. The image processing system of claim 144, further including a view screen for viewing the captured and stored image.

154. The image processing system of claim 144, including a hardwired interface between the communications device and the compatible receiving station.

155. The image processing system of claim 144, including a wireless transmission system between the communications device and the compatible receiving station.

156. The image processing system of claim 144, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

157. The image processing system of claim 144, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

158. The image processing system of claim 144, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

159. The image processing system of claim 144, further comprising a data processor for creating a text data signal associated with said image data signal.

160. The image processing system of claim 144, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is

generated in a standard bi-level facsimile machine format and protocol.

161. The image processing system of claim 144, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

162. The image processing system of claim 144, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

163. The image processing system of claim 144, wherein the remote receiving station is a digital device and the image data is digital.

164. The image processing system of claim 144, further comprising an self-contained power source for powering the system.

165. The image processing system of claim 144, further including control apparatus for remotely controlling operating functions of the image capture device.

166. The image processing system of claim 165, wherein said image capture device is a camera with a shuttered lens and where said control apparatus any combination of lens direction, iris, focus and shutter speed.

167. The image processing system of claim 144, further comprising an input device for controlling the processor configuration from a remote location.

168. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station;

d. An audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

169. The image processing system of claim 168, wherein said audio signal capture device is an integral microphone.

170. The image processing system of claim 168, wherein said audio signal capture device is an input device for receiving an externally generated audio signal.

171. The image processing system of claim 168, further comprising a device for outputting processed captured audio signal.

172. The image processing system of claim 168, wherein said audio processor system is adapted for associating an audio signal with an image signal.

173. The image processing system of claim 168, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

174. The image processing system of claim 168, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

175. The image processing system of claim 168, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

176. The image processing system of claim 168, further including a subprocess or for generating a Group-III facsimile compatible signal representing the digital signal.

177. The image processing system of claim 168, wherein there is further included an integrated wireless telephone associated with the communications device.

178. The image processing system of claim 168, further comprising a housing for housing all of the elements of the system in an integrated body.

179. The image processing system of claim 168, wherein said image capture device is a digital camera.

180. The image processing system of claim 168, wherein the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

~~181. The image processing system of claim 1, wherein:~~

~~a. The image capture device is an analog video camera for generating a video signal;~~

~~b. The processor further comprises:~~

~~i. An analog to digital converter;~~

~~ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;~~

~~iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;~~

~~iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol~~

receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

182. The image processing system of claim 168, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

183. The image processing system of claim 168, further comprising a data processor for creating a text data signal associated with said image data signal.

184. The image processing system of claim 168, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

185. The image processing system of claim 168, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

186. The image processing system of claim 168, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

187. The image processing system of claim 168, wherein the remote receiving station is a digital device and the image data is digital.

188. The image processing system of claim 168, further comprising an self-contained power source for powering the system.

189. The image processing system of claim 168, further including control apparatus for remotely controlling operating functions of the image capture device.

190. The image processing system of claim 1, further comprising an input device for controlling the processor configuration from a remote location.

191. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station, the processor is adapted for generating a signal in any of a plurality of selected protocols and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station.

192. The image processing system of claim 191, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

193. The image processing system of claim 191, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

194. The image processing system of claim 191, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

195. The image processing system of claim 191, further including a subprocess or for generating a Group-III facsimile compatible signal representing the digital signal.

196. The image processing system of claim 191, wherein there is further included an integrated wireless telephone associated with the communications device.

197. The image processing system of claim 191, further comprising a housing for housing all of the elements of the system in an integrated body.

198. The image processing system of claim 191, wherein said image capture device is a digital camera.

199. The image processing system of claim 191, further including a view screen for viewing the captured and stored image.

200. The image processing system of claim 195, further including a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy.

201. The image processing system of claim 191, including a hardwired interface between the communications device and the compatible receiving station.

202. The image processing system of claim 191, including a wireless transmission system between the communications device and the compatible receiving station.

203. The image processing system of claim 191, wherein:

a. The image capture device is an analog video camera for generating a video signal;

b. The processor further comprises:

i. An analog to digital converter;

ii. A sync detector and a video address generator for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame;

iii. A random access memory for receiving and storing the converted, synchronized signal frame-by-frame;

iv. A processor routine for converting the signals stored in the memory to a protocol adapted for transmission to a remote, compatible protocol receiving station;

c. A communications device for transmitting the signal in the proper protocol to the compatible receiving station.

204. The image processing system of claim 203, wherein the processor routine converts the signals to a Group-III facsimile protocol, the system further including a facsimile modem for accepting the signal and transmitting to the compatible receiving station.

205. The image processing system of claim 203, further including a hardwired transmission system and a wireless transmission system associated with the modem and a switching device for selecting in the alternative either the hardwired or the wireless transmission system.

206. The image processing system of claim 203, further including a local facsimile receiving system associated with the modem for providing local hard copy of the stored image signals in the memory.

207. The image processing system of claim 203, further including a switching device for selectively activating and deactivating the local facsimile receiving system.

208. The image processing system of claim 204, wherein the wireless transmission system is a cellular telephone system and wherein the wired transmission system is a land line telephone system, and wherein the processing system further includes and integral cellular telephone and/or and integral land line telephone, and wherein each of said telephones is capable of operating in a standard telephonic format for receiving incoming and transmitting outgoing audio calls.

209. The image processing system of claim 208, further including an interrupt device to prohibit use of the telephones in a standard telephonic mode whenever image data signals are being transmitted.

210. The image processing system of claim 208, wherein the interrupt device further includes a tone generator for generating an audible signal when in the interrupt mode.

211. The image processing system of claim 203, further including an integral viewer for viewing the images stored in the memory.

212. The image processing system of claim 203, wherein the memory is a removable memory medium which may be selectively removed from the system.

213. The image processing system of claim 212, wherein the removable memory medium comprises a PCMCIA card memory.

214. The image processing system of claim 191, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

215. The image processing system of claim 191, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

216. The image processing system of claim 191, further comprising a data processor for creating a text data signal associated with said image data signal.

217. The image processing system of claim 216, further including an input device for providing text data to the data processor.

218. The image processing system of claim 217, wherein said input device is user controlled.

219. The image processing system of claim 218, wherein said user controlled input device is an integral keyboard.

220. The image processing system of claim 216, said input device comprising a real time clock.

221. The image processing system of claim 217, said input device comprising a global positioning system.

222. The image processing system of claim 191, wherein the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a standard bi-level facsimile machine format and protocol.

223. The image processing system of claim 191, wherein the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol.

224. The image processing system of claim 191, wherein the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol.

225. The image processing system of claim 191, wherein the remote receiving station is a digital device and the image data is digital.

226. The image processing system of claim 191, further comprising an self-contained power source for powering the system.

227. The image processing system of claim 191, further including control apparatus for remotely controlling operating functions of the image capture device.

228. The image processing system of claim 227, wherein said image capture device is a camera with a shuttered lens and where said control apparatus any combination of lens direction, iris, focus and shutter speed.

229. The image processing system of claim 227, further comprising an input device for controlling the processor configuration from a remote location.

230. A self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. An image capture device;

b. A processor for generating a data signal representing the image;

c. A communications device adapted for transmitting the data signal to the remote receiving station;

d. A self-contained power source for powering the system.

231. The image processing system of claim 230, wherein said communications device is adapted to be used independently of the image capture device and the processor, and wherein the power supply is adapted for isolating the power to the communications device from the power to the image capture device and processor.

232. The image processing system of claim 231, further including a power initiation device associated with the image capture device and the processor, wherein the power to the image capture device and the processor is off when the initiation device is not activated.

233. The image processing system of claim 232, wherein the power initiation device is user controlled.

234. The image processing system of claim 232, further including a trigger device for activating the power initiation device.

235. The image processing system of claim 234, wherein the trigger device is a timer.

236. The image processing system of claim 234, wherein said trigger device is triggered by the presence of an image to be captured.

237. The image processing system of claim 236, wherein said trigger device is a motion sensor.

238. The image processing system of claim 230, further including a memory for receiving and storing the data signal, and wherein the communications device is adapted for recalling the stored data signal from memory.

239. The image processing system of claim 230, wherein said memory is a removable random access medium and wherein the system is adapted for selectively charging and discharging the memory.

240. The image processing system of claim 230, wherein the image capture device is an analog camera for generating an analog image signal and there is further included an analog to digital converter for converting the analog image signal to a digital signal.

241. The image processing system of claim 230 further including a subprocess or for generating a Group-III facsimile compatible signal representing the digital signal.

09006023.011298

242 The image processing system of claim 230, wherein there is further included an integrated wireless telephone associated with the communications device.

243. The image processing system of claim 230, further comprising a housing for housing all of the elements of the system in an integrated body.

244. The image processing system of claim 230, wherein said image capture device is a digital camera.

245. The image processing system of claim 230, further including a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy.

246. The image processing system of claim 230, wherein the system is of modular construction, and the camera, the processor and the communications device are each independent, functional units which may be coupled to one another for defining the assembled system.

247. The image processing system of claim 230, further comprising an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

248. A method for capturing an analog image signal and converting it to a digital signal for transmission over a telephone system, the method comprising the steps of:

a. capturing the image as an analog image signal with a standard analog image capture device;

b. converting the analog image signal to a digital data signal;

c. defining a beginning of frame and an end of frame portion of the signal;

d. storing a complete frame; and

e. transmitting the stored frame over a telephone system to a remote receiving device.

249. The method of claim 248, wherein the transmitting step further included transmitting the stored frame of a cellular telephone.

250. The method of claim 249, further including the step of selectively transmitting the stored frame over a land line telephone.

251. The method of claim 250, further including the step of isolating the cellular telephone whenever the land line telephone transmitting step is selected.

252. The method of claim 248, further including the step of automatically activating steps 248b, 248c, 248d and 248e whenever an image is present to be captured.

253. A sampling method for capturing for retrieval a visual image record of an incident, comprising the steps of:

a. monitoring a zone wherein images will appear;

b. activating a capture device in response to a trigger signal;

c. capturing the images in the zone in response to a predetermined set of conditions ranging from a period of time preceding the trigger signal to a period of time following the trigger signal;

d. utilizing the captured images to reconstruct the events occurring in the zone.

254. The sampling method of claim 253, wherein utilization includes the step of storing the captured images for archival purposes.

255. The sampling method of claim 253, wherein utilization includes the step of transmitting the captured images to a remote location for monitoring purposes.

256. The sampling method of claim 255, wherein said transmission occurs on a near real time basis.

257. The method of claim 253, wherein said trigger signal is a timer.

258. The method of claim 253, further including the step of monitoring the audio conditions in the zone and wherein said triggering signal is an audio sensor.

259, The method of claim 253, further including the step of monitoring the motion conditions in the zone and wherein said triggering signal is a motion sensor.

260. The method of claim 253, wherein said capturing step includes capturing a predetermined set of images preceding the trigger signal.

261. The method of claim 253, wherein said capturing step includes capturing a predetermined set of images following the trigger signal.

262. The method of claim 253, wherein said capturing step includes capturing a predetermined set of images both preceding and following the trigger signal.

263. An portable, self-contained handheld image processing system for capturing a visual image and transmitting it to a remote receiving station, the image processing system comprising:

a. a camera for capturing an image;

b. a processor for generating a digital signal representing the image;

c. a communications device adapted for transmitting the digital image to the remote receiving station.

264. The system of claim 263, further including an integral cellular telephone for defining the communications device.

265. The system of claim 263, wherein all of the components of the system are housed in a single housing.

266. The system of claim 265, wherein said housing resembles a standard 35 millimeter camera body.

ABSTRACT

An image capture, conversion, compression, storage and transmission system provides a data signal representing the image in a format and protocol capable of being transmitted over any of a plurality of readily available transmission systems and received by readily available, standard equipment receiving stations. In its most comprehensive form, the system is capable of sending and receiving audio, documentary and visual image data to and from standard remote stations readily available throughout the world.

United States Patent & Trademark Office

Office of Initial Patent Examination – Scanning Division

Application deficiencies found during scanning:

1. Application papers are not suitable for scanning and are not in compliance with 37 CFR 1.52 because:
   - ☐ All sheets must be the same size and either A4 (21 cm x 29.7 cm) or 8-1/2"x 11". Pages ____________________ do not meet these requirements.
   - ☐ Papers are not flexible, strong, smooth, non-shiny, durable, and white.
   - ☐ Papers are not typewritten or mechanically printed in permanent ink on one side.
   - ☐ Papers contain improper margins. Each sheet must have a left margin of at least 2.5 cm (1") and top, bottom and right margins of at least 2.0 cm (3/4").
   - ☐ Papers contain hand lettering.

2. Drawings are not in compliance and were not scanned because:
   - ☐ The drawings or copy of drawings are not suitable for electronic reproduction.
   - ☐ All drawings sheets are not the same size. Pages must be either A4 (21 cm x 29.7 cm) or 8-1/2" x 11".
   - ☐ Each sheet must include a top and left margin of at least 2.5 cm (1"), a right margin of at least 1.5 cm (9/16") and a bottom margin of at least 1.0 cm (3/8").

3. Page(s)________________ are not of sufficient clarity, contrast and quality for electronic reproduction.

4. Page(s)________________ are missing.

5. OTHER: No Declaration

FIG. 1

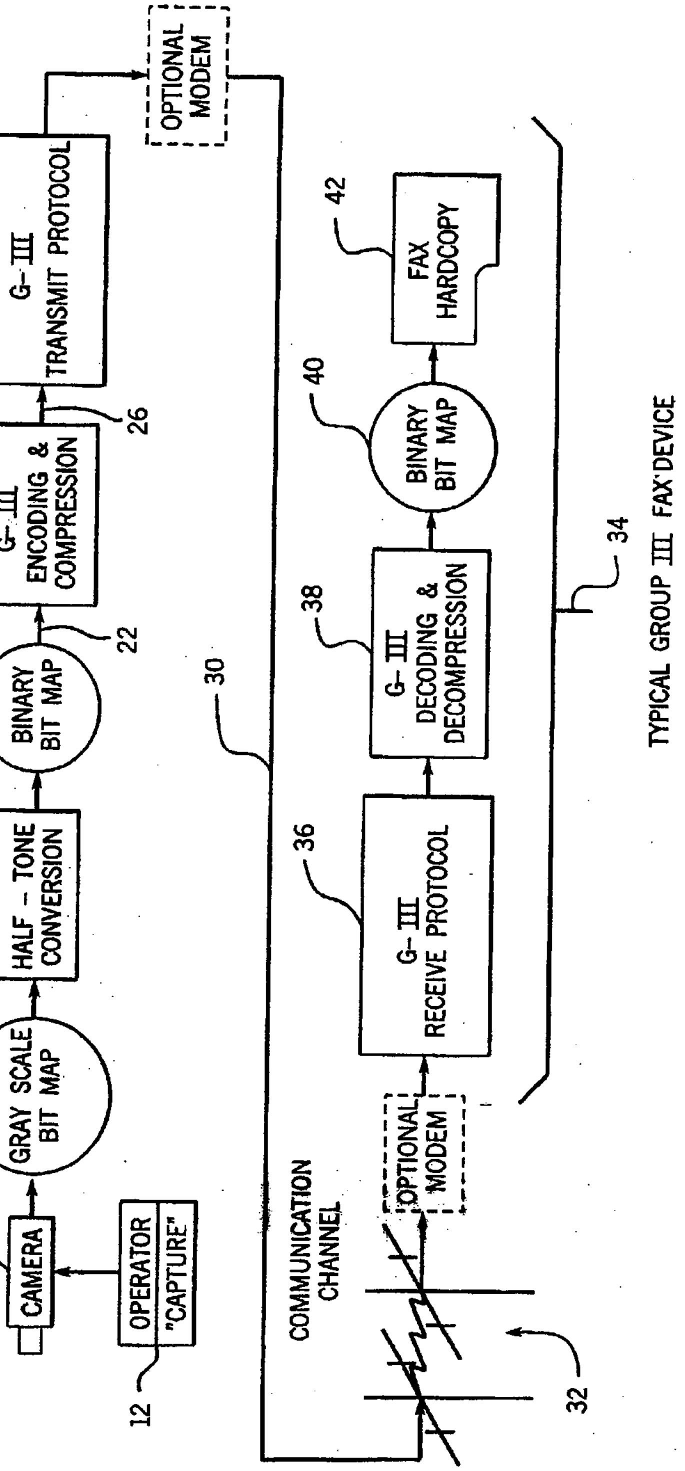

10
CAMERA
12
OPERATOR "CAPTURE"
16
GRAY SCALE BIT MAP
18
HALF - TONE CONVERSION
20
BINARY BIT MAP
22
24
G-III ENCODING & COMPRESSION
26
28
G-III TRANSMIT PROTOCOL
OPTIONAL MODEM
30
COMMUNICATION CHANNEL
32
OPTIONAL MODEM
36
G-III RECEIVE PROTOCOL
38
G-III DECODING & DECOMPRESSION
40
BINARY BIT MAP
42
FAX HARDCOPY
34
TYPICAL GROUP III FAX DEVICE

FIG. 2

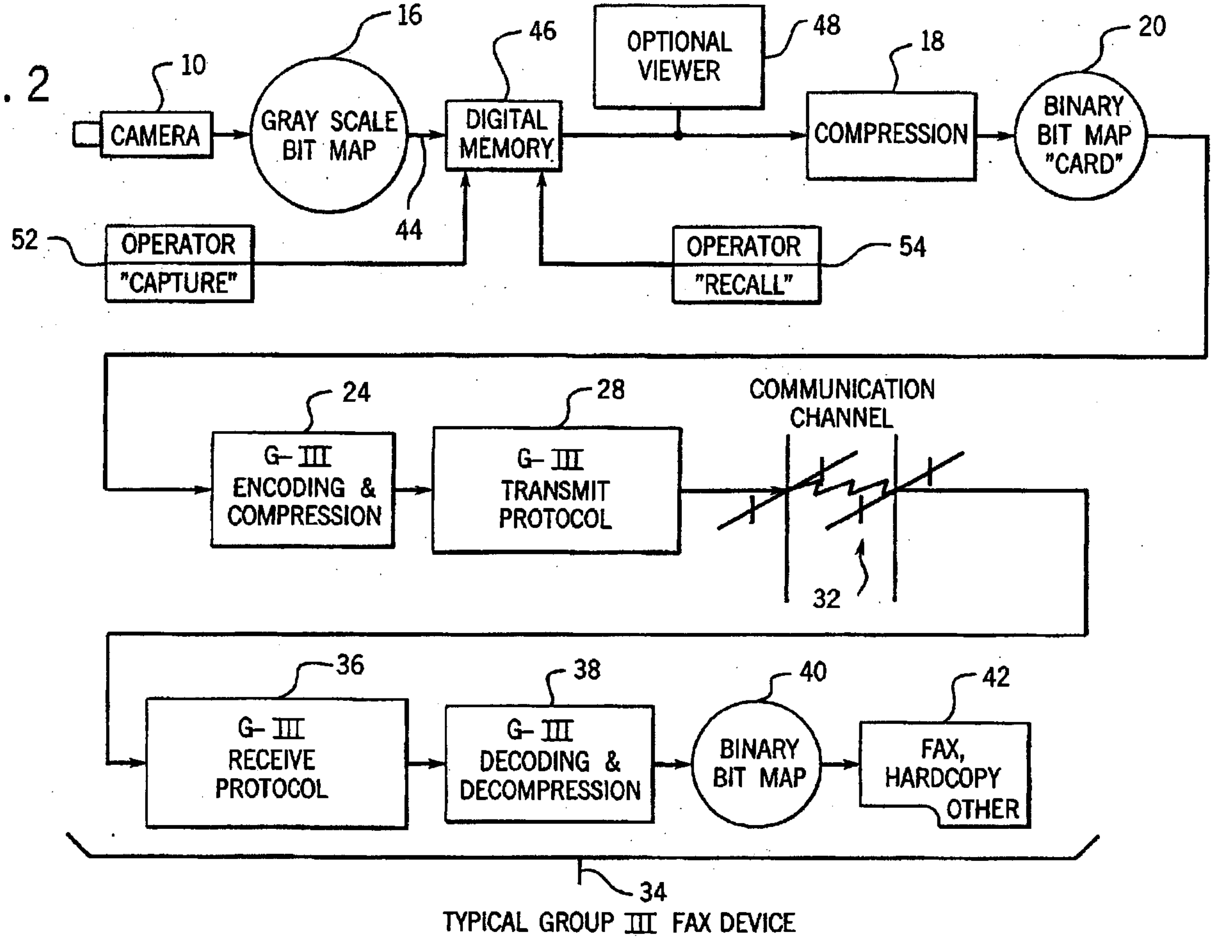
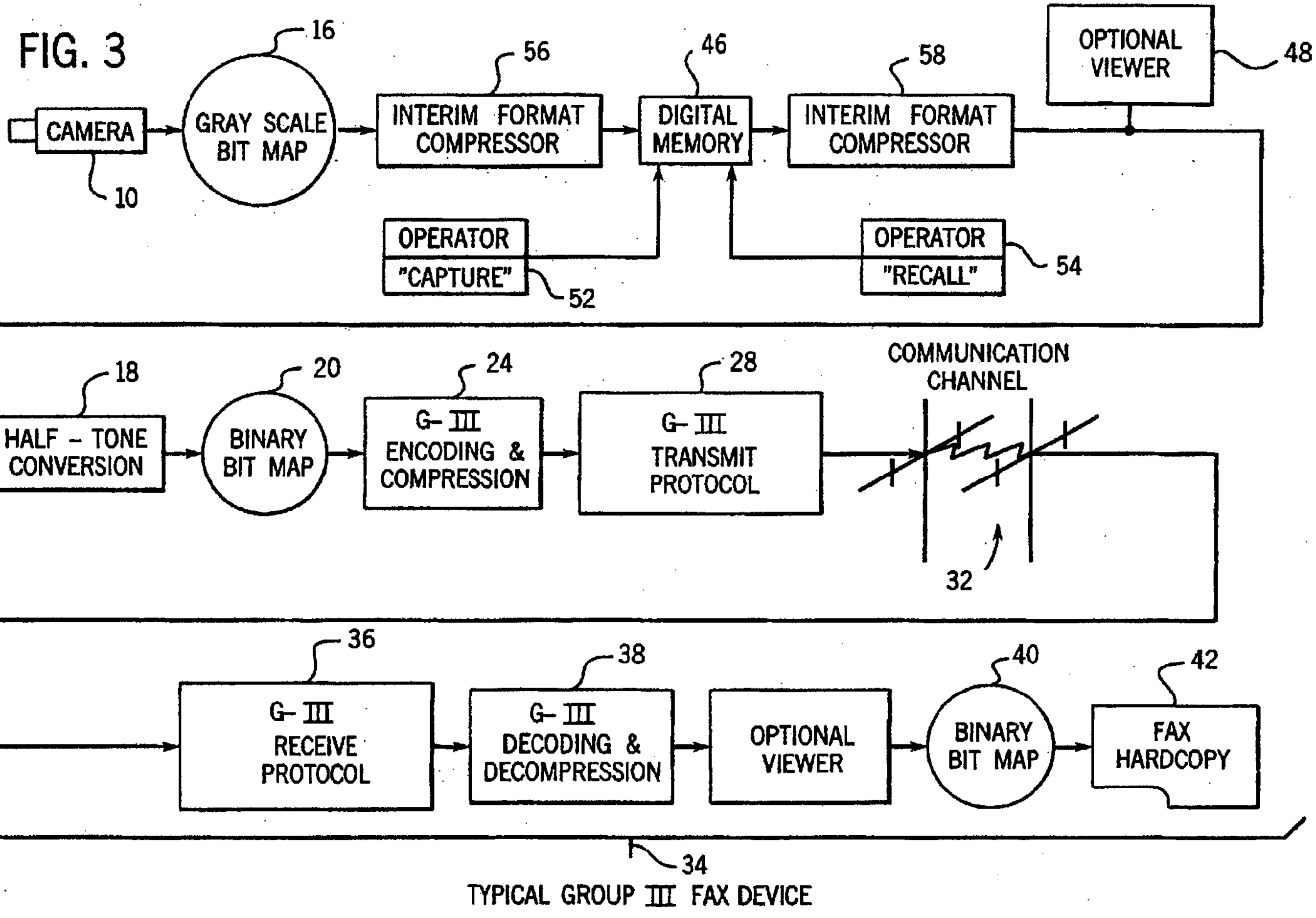
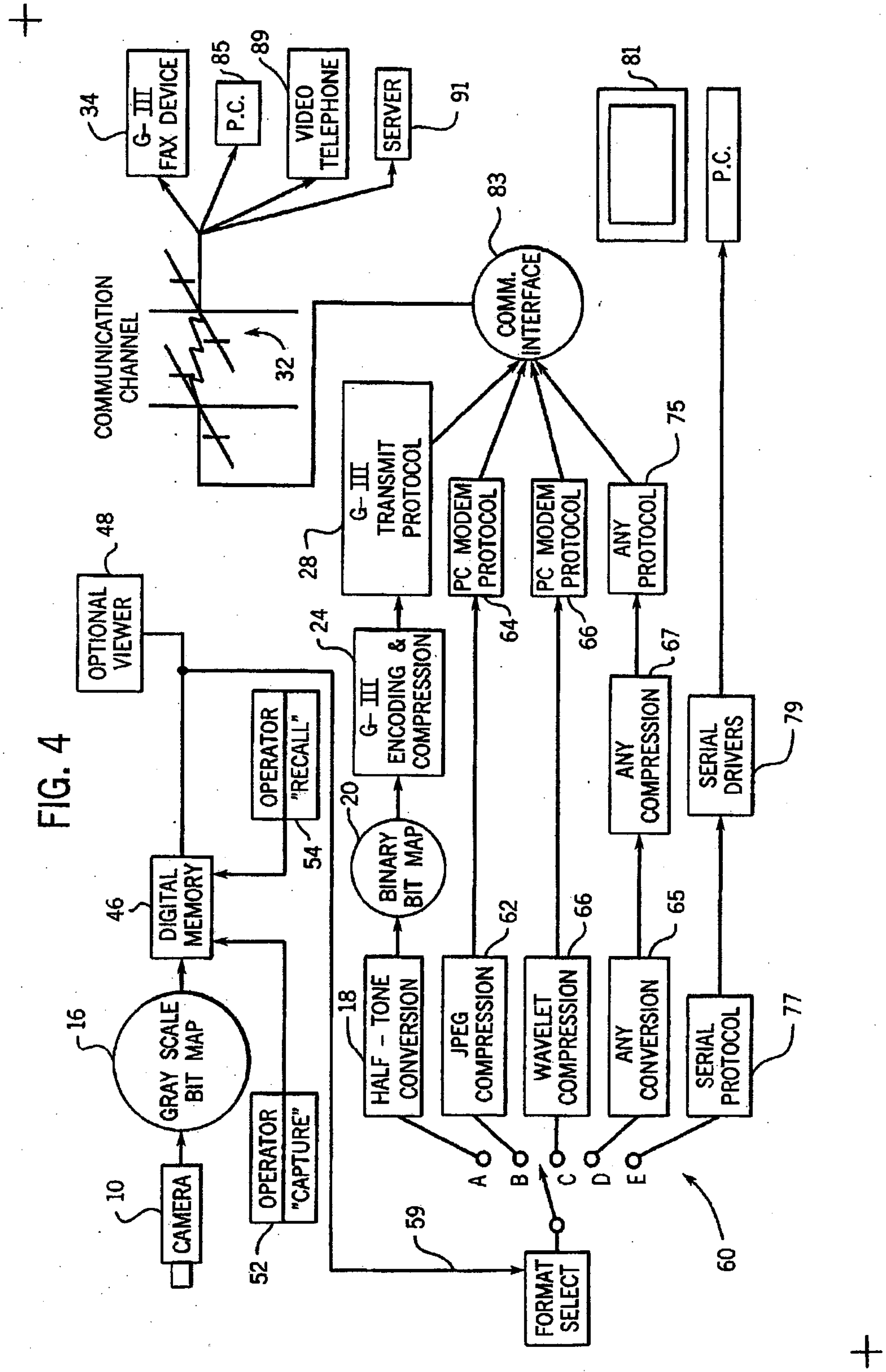

10
CAMERA
16
GRAY SCALE BIT MAP
44
46
DIGITAL MEMORY
48
OPTIONAL VIEWER
18
COMPRESSION
20
BINARY BIT MAP "CARD"
52
OPERATOR "CAPTURE"
54
OPERATOR "RECALL"
24
G-III ENCODING & COMPRESSION
28
G-III TRANSMIT PROTOCOL
COMMUNICATION CHANNEL
32
36
G-III RECEIVE PROTOCOL
38
G-III DECODING & DECOMPRESSION
40
BINARY BIT MAP
42
FAX, HARDCOPY OTHER
34
TYPICAL GROUP III FAX DEVICE

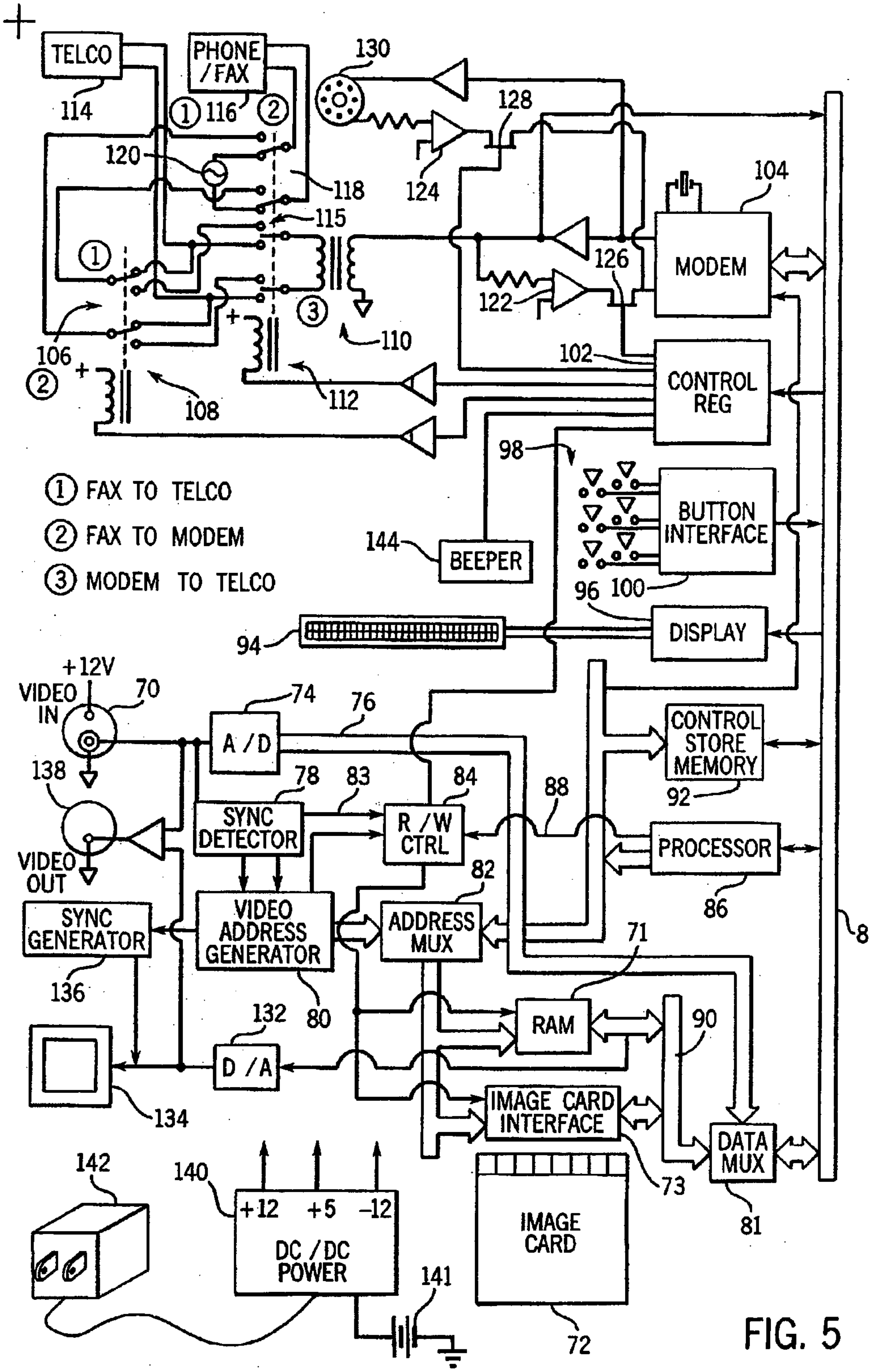
FIG. 3


CAMERA
10
GRAY SCALE BIT MAP
16
INTERIM FORMAT COMPRESSOR
56
DIGITAL MEMORY
46
INTERIM FORMAT COMPRESSOR
58
OPTIONAL VIEWER
48
OPERATOR "CAPTURE"
52
OPERATOR "RECALL"
54
HALF - TONE CONVERSION
18
BINARY BIT MAP
20
G- III ENCODING & COMPRESSION
24
G- III TRANSMIT PROTOCOL
28
COMMUNICATION CHANNEL
32
G- III RECEIVE PROTOCOL
36
G- III DECODING & DECOMPRESSION
38
OPTIONAL VIEWER
BINARY BIT MAP
40
FAX HARDCOPY
42
34
TYPICAL GROUP III FAX DEVICE

09006309.011298

FIG. 4





① FAX TO TELCO
② FAX TO MODEM
③ MODEM TO TELCO

FIG. 5

09006023.011298

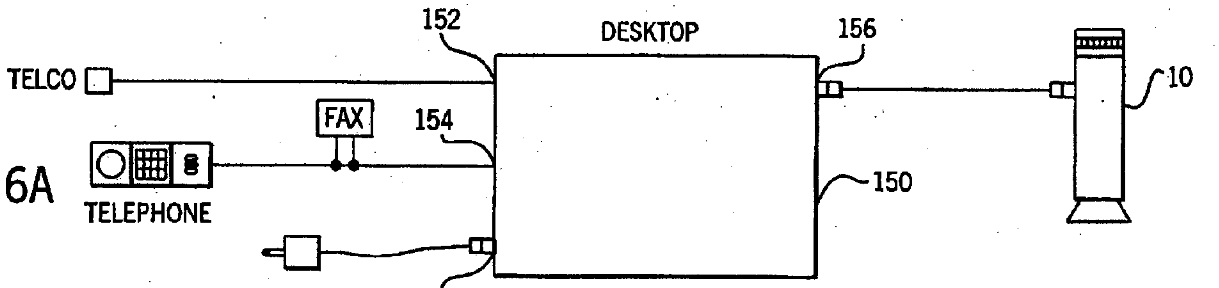


FIG. 6A

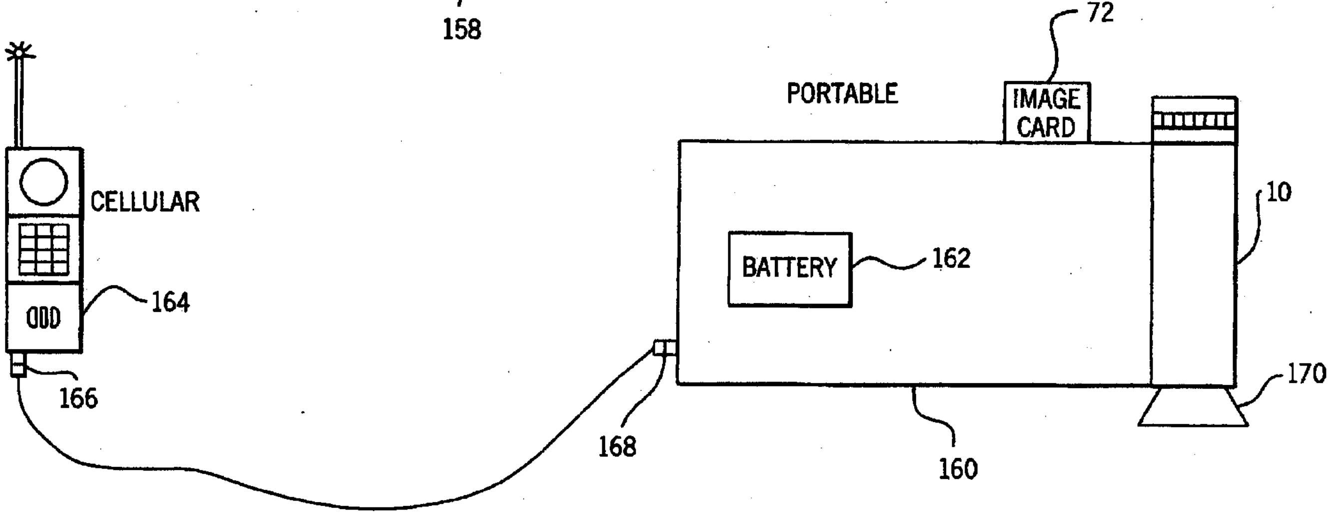


FIG. 6B

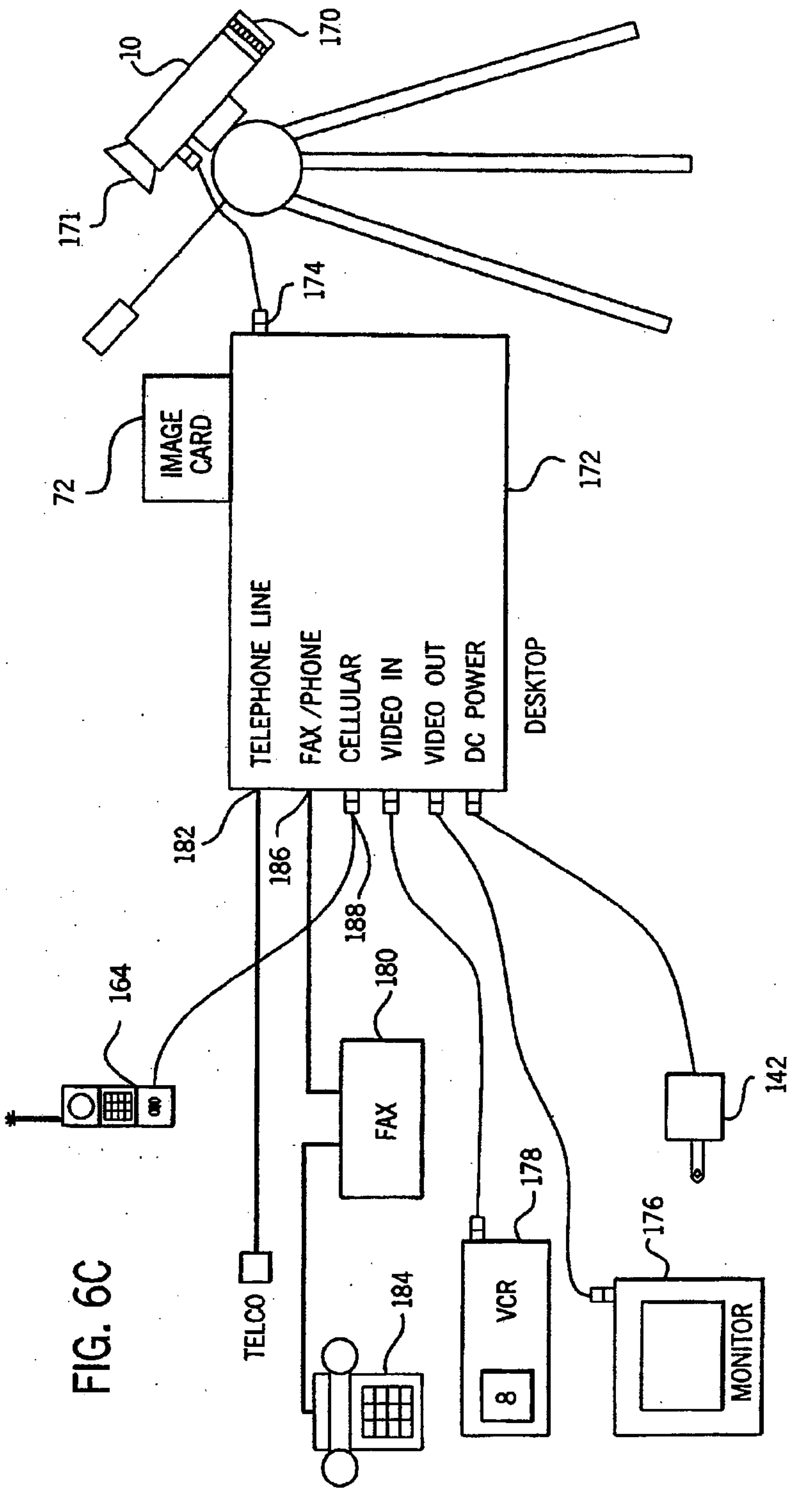

10
170
171
174
IMAGE CARD
72
172
TELEPHONE LINE
FAX /PHONE
CELLULAR
VIDEO IN
VIDEO OUT
DC POWER
DESKTOP
182
186
188
164
180
FAX
142
178
176
184
TELCO
VCR
8
MONITOR

FIG. 6C

FIG. 7A

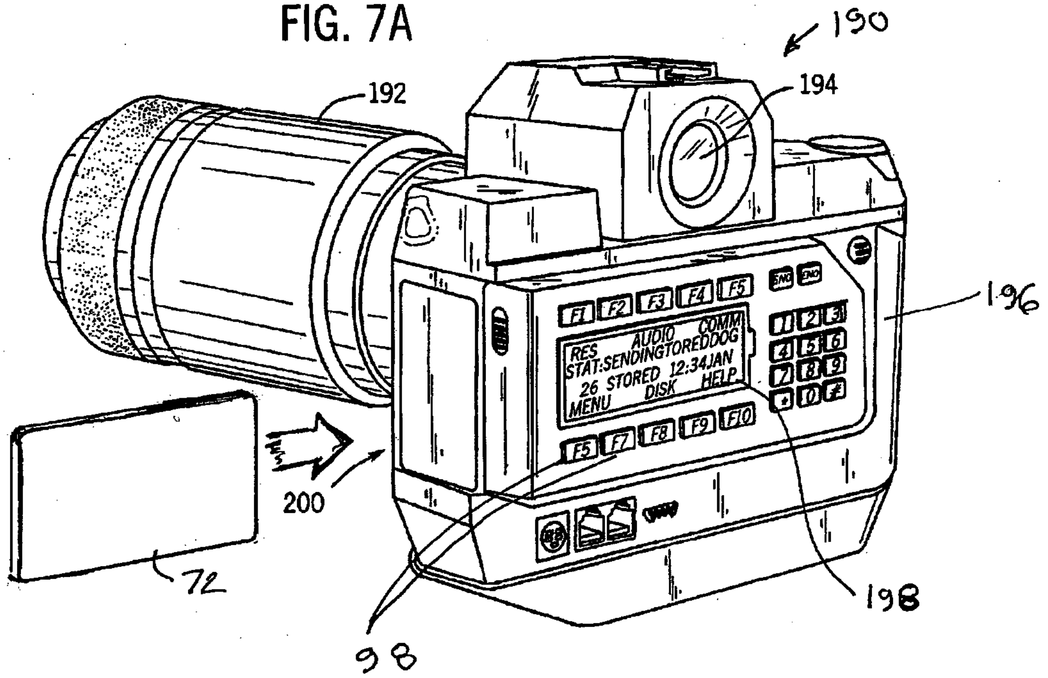
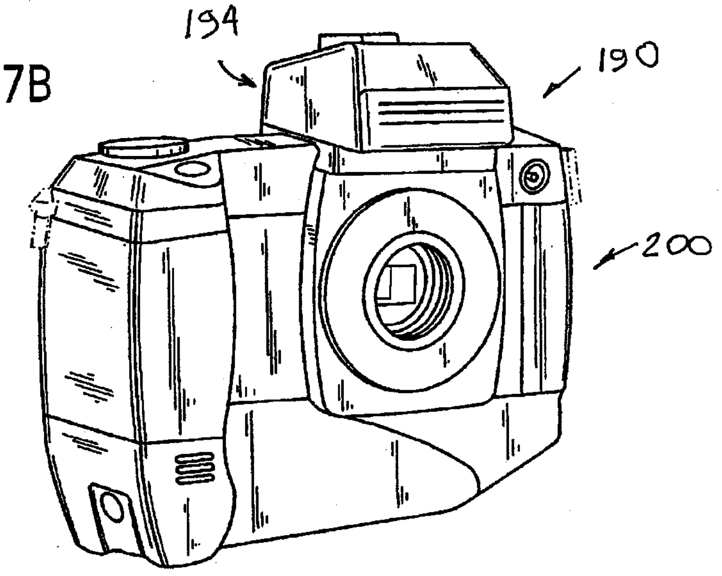

190
192
194
196
F1 F2 F3 F4 F5
END END
RES AUDIO COMM
STAT:SENDINGTOREDDOG
26 STORED 12:34JAN
MENU DISK HELP
1 2 3
4 5 6
7 8 9
* 0 #
F5 F7 F8 F9 F10
200
72
198
98

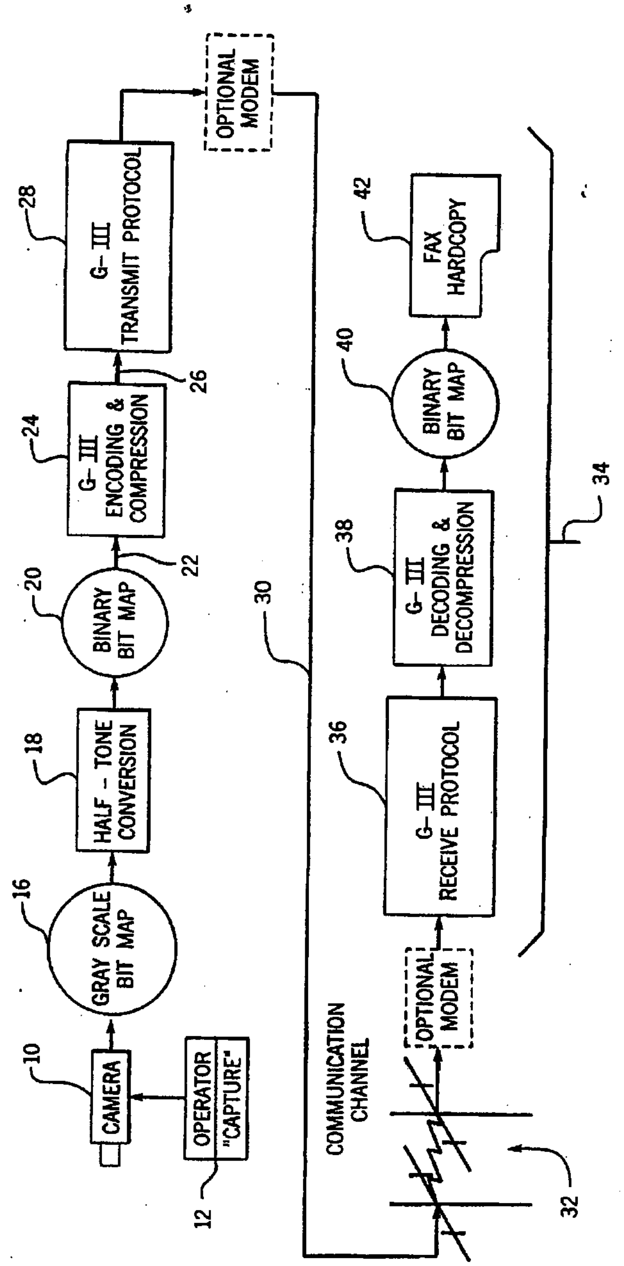
FIG. 7B


194
190
200

PRINT OF DRAWINGS
AS ORIGINALLY FI

09006073.011298

FIG. 1



09006073.011298

FIG. 2

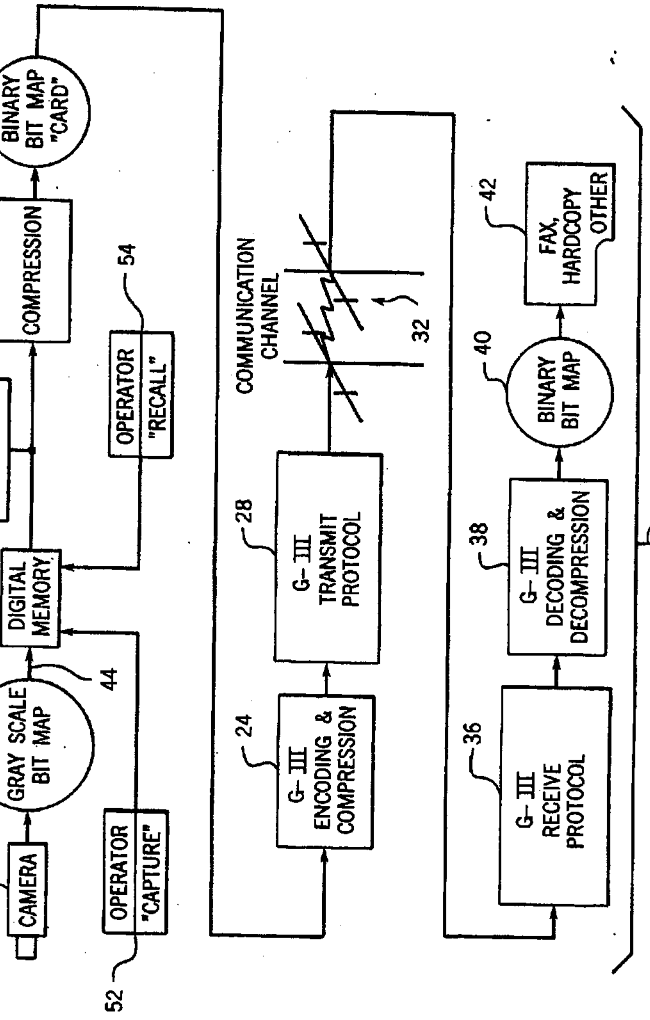
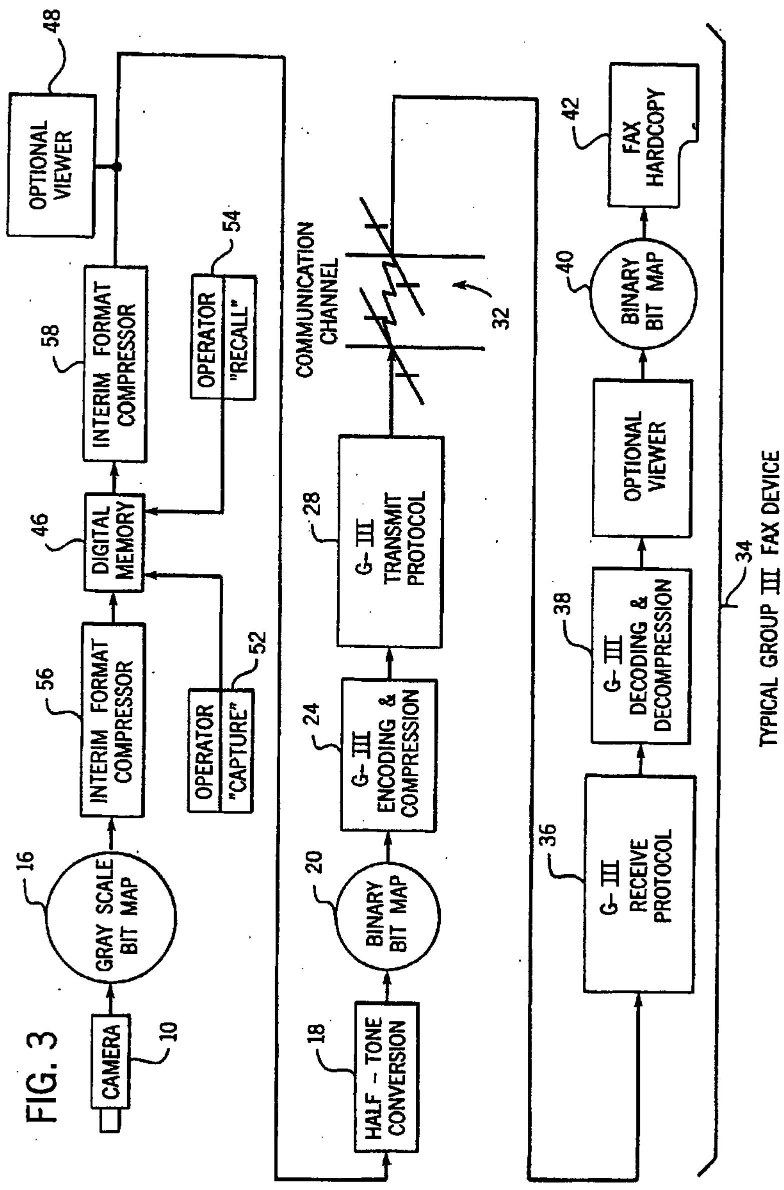


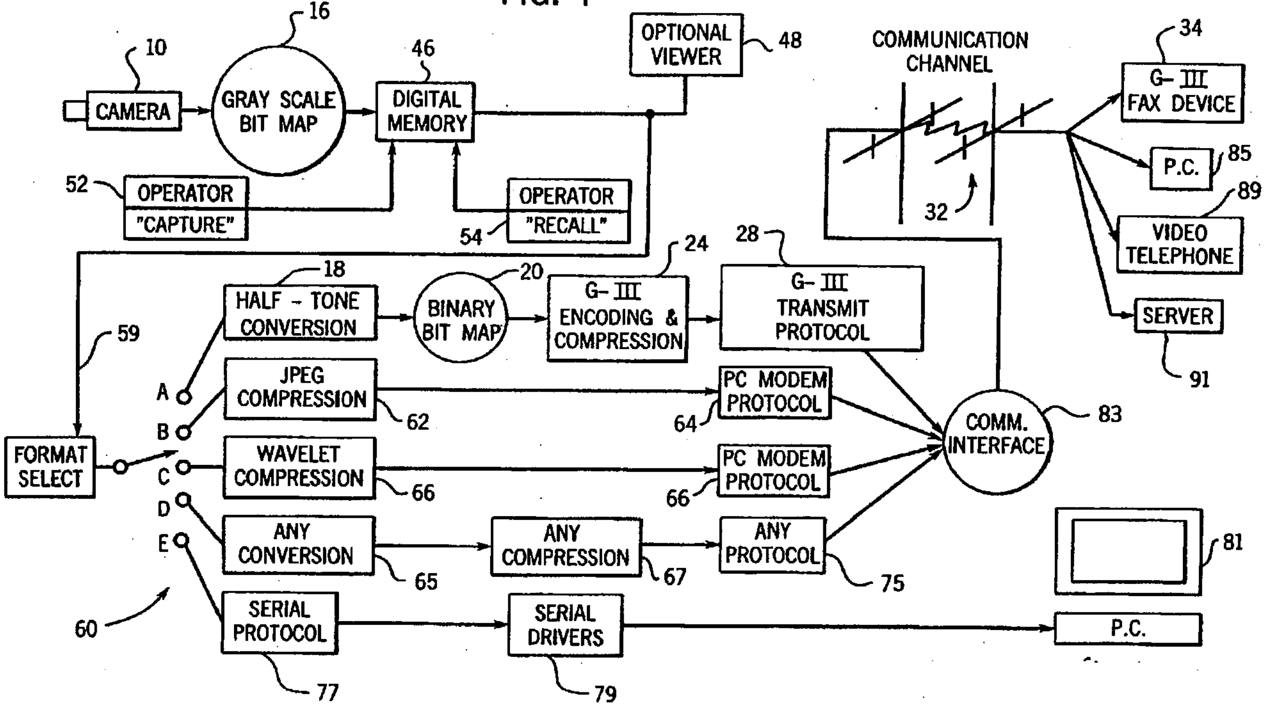
FIG. 3


CAMERA
10
GRAY SCALE BIT MAP
16
INTERIM FORMAT COMPRESSOR
56
DIGITAL MEMORY
46
INTERIM FORMAT COMPRESSOR
58
OPTIONAL VIEWER
48
OPERATOR "CAPTURE"
52
OPERATOR "RECALL"
54
HALF - TONE CONVERSION
18
BINARY BIT MAP
20
G-III ENCODING & COMPRESSION
24
G-III TRANSMIT PROTOCOL
28
COMMUNICATION CHANNEL
32
G-III RECEIVE PROTOCOL
36
G-III DECODING & DECOMPRESSION
38
OPTIONAL VIEWER
BINARY BIT MAP
40
FAX HARDCOPY
42
TYPICAL GROUP III FAX DEVICE
34

]

PRINT OF DRAWINGS AS ORIGINALLY FI

FIG. 4



PRINT OF DRAWINGS
AS ORIGINALLY FI

09006073.011298

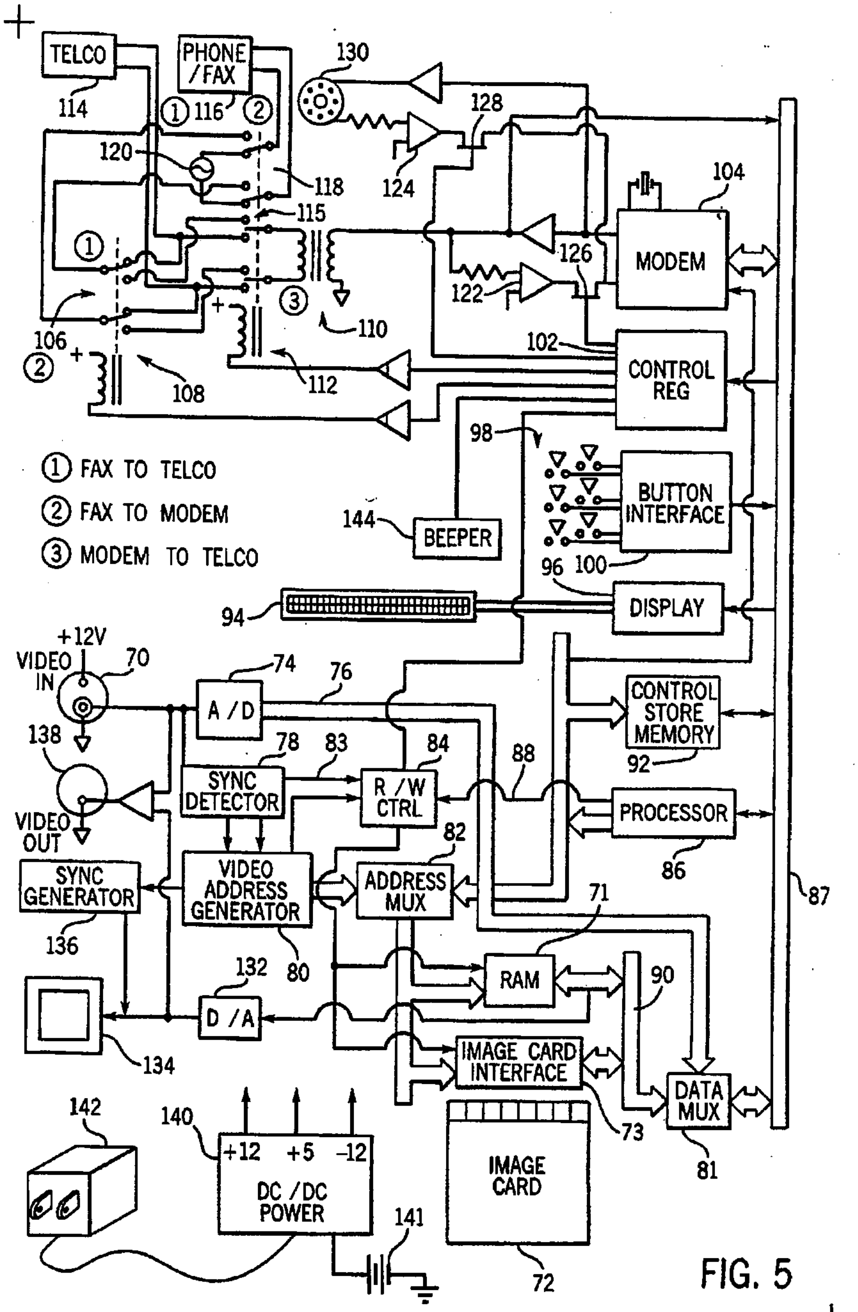


FIG. 5

PRINT OF DRAWINGS
AS ORIGINALLY FI

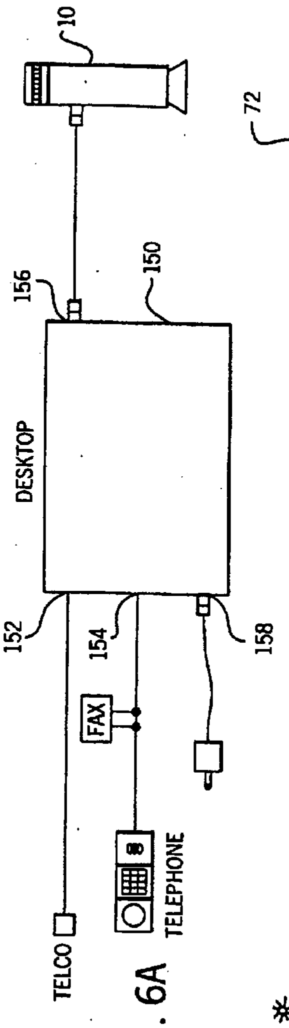


FIG. 6A

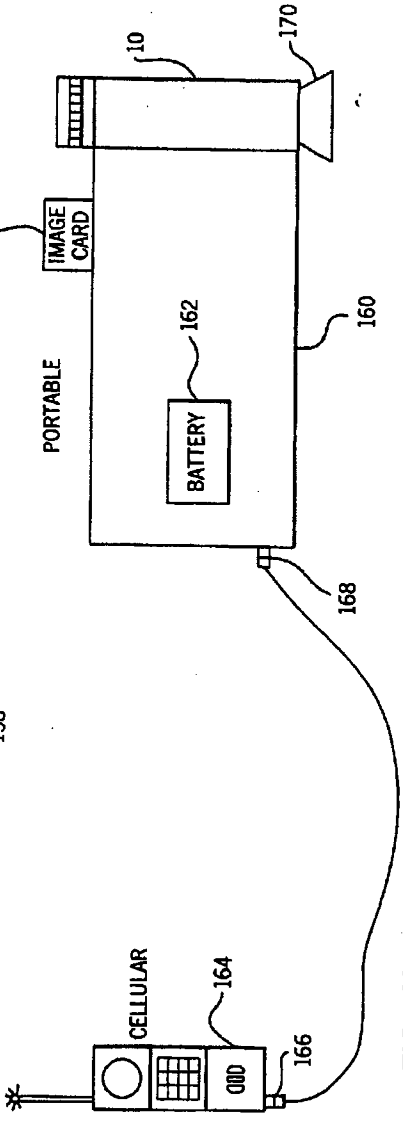


FIG. 6B

PRINT OF DRAWINGS
AS ORIGINALLY FI

09005073 .011298

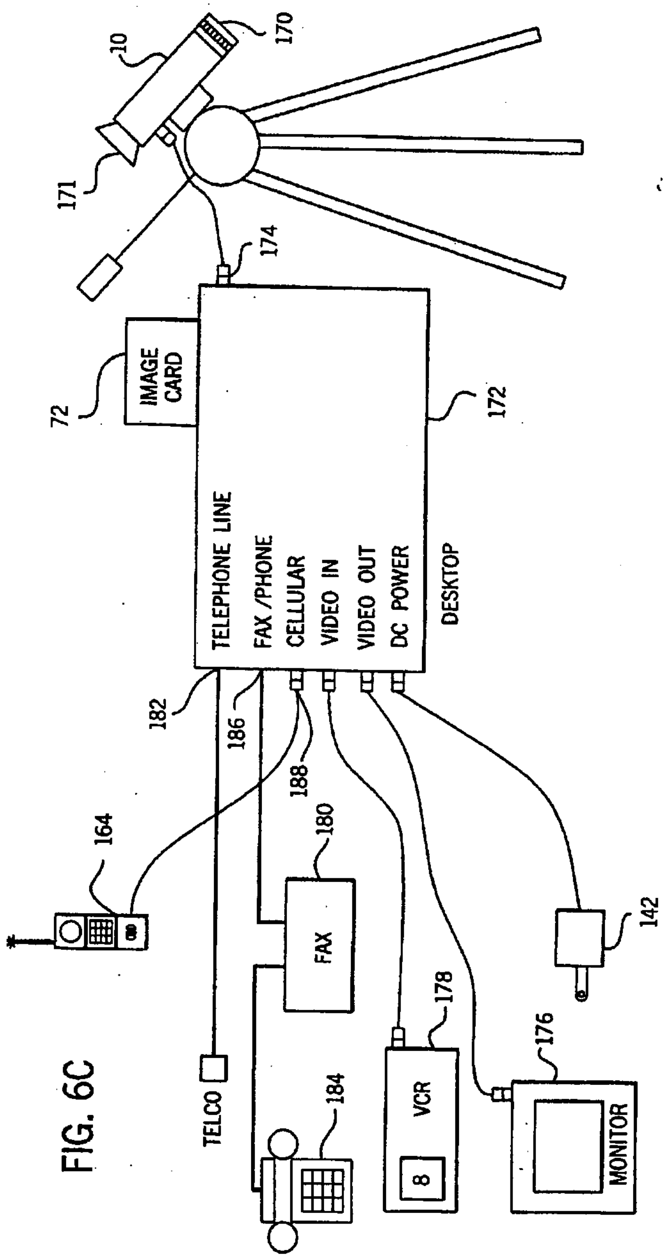


FIG. 6C

09060723.011298

FIG. 7A

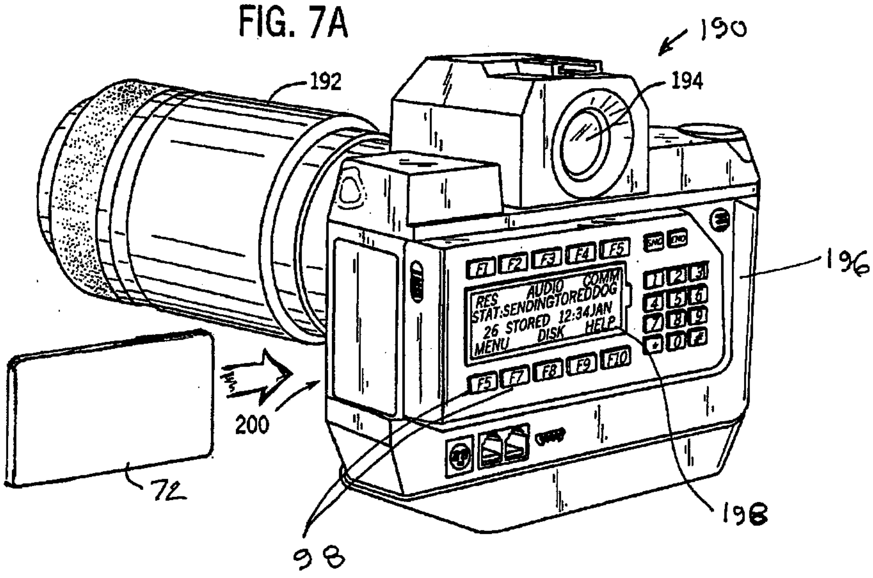
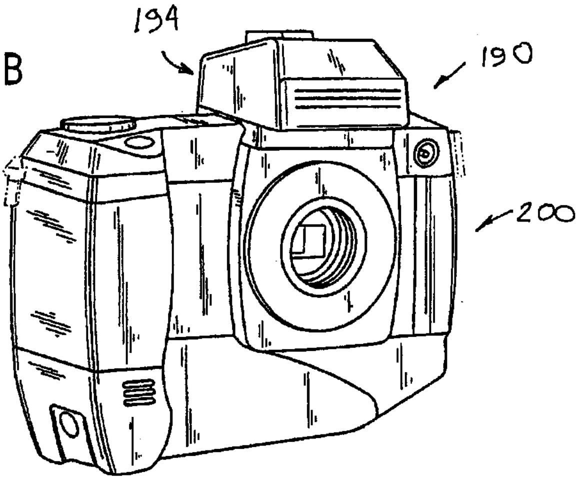


FIG. 7B



PATENT APPLICATION FEE DETERMINATION RECORD

Effective October 1, 1997

Application or Docket Number
09/006873

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE	FEE		RATE	FEE
BASIC FEE				395.00	OR		790.00
TOTAL CLAIMS 266	minus 20 =	* 246	x$11=		OR	x$22=	5412
INDEPENDENT CLAIMS 11	minus 3 =	* 8	x41=		OR	x82=	656
MULTIPLE DEPENDENT CLAIM PRESENT			+135=		OR	+270=	—
			TOTAL		OR	TOTAL	6858

* If the difference in column 1 is less than zero, enter "0" in column 2

589591.012

CLAIMS AS AMENDED - PART II

AMENDMENT A

		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
Total		* 260	Minus	** 266	= —	x$11=		OR	x$22=	—
Independent		* 11	Minus	*** 11	= —	x41=		OR	x82=	—
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM						+135=		OR	+270=	—
						TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	—

AMENDMENT B

	(Column 1)		(Column 2)	(Column 3)					
	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x41=		OR	x82=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+135=		OR	+270=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1)		(Column 2)	(Column 3)					
	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x41=		OR	x82=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+135=		OR	+270=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 8/97)

*U.S. Government Printing Office: 1997 - 430-571/69194

Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

Staple issue Slip Here

POSITION		ID NO.	DATE
CLASSIFIER		55	09/18/97
EXAMINER		69652	11/18/97
TYPIST			
VERIFIER			
CORPS CORR.			
SPEC. HAND			
FILE MAINT.			
DRAFTING			

RESTRICTION

INDEX OF CLAIMS

Claim		Date							
Final	Original	11/29/99							
	151	N							
	152	N							
	153	N							
	154	N							
	155	N							
	156	N							
	157	N							
	158	N							
	159	N							
	160	N							
	161	N							
	162	N							
	163	N							
	164	N							
	165	N							
	166	N							
	167	N							
	⑱ 168	N							
	169	N							
	170	N							
	171	N							
	172	N							
	173	N							
	174	N							
	175	N							
	176	N							
	177	N							
	178	N							
	179	N							
	180	N							
	181	✓							
	182	N							
	183	N							
	184	N							
	185	N							
	186	N							
	187	N							
	188	N							
	189	N							
	190	✓							
	(191)	N							
	192	N							
	193	N							
	194	N							
	195	✓							
	196	N							
	197	N							
	198	N							
	199	N							
	200	N							

SYMBOLS

✓ .... Rejected
= .... Allowed
- (Through numberal) Canceled
÷ .... Restricted
N .... Non-elected
I .... Interference
A .... Appeal
O .... Objected

Claim		Date							
Final	Original	11/29/99							
	201	N							
	202	N							
	203	N							
	204	N							
	205	N							
	206	N							
	207	N							
	208	N							
	209	N							
	210	N							
	211	N							
	212	N							
	213	N							
	214	N							
	215	N							
	216	N							
	217	N							
	218	N							
	219	N							
	220	N							
	221	N							
	222	N							
	223	N							
	224	N							
	225	N							
	226	N							
	227	N							
	228	N							
	229	N							
	(230)	N							
	231	N							
	232	N							
	233	N							
	234	N							
	235	N							
	236	N							
	237	N							
	238	N							
	239	N							
	240	N							
	241	N							
	242	N							
	243	N							
	244	N							
	245	N							
	246	N							
	247	N							
	(248)	N							
	249	N							
	250	N							

Staple Issue Slip Here

POSITION		ID NO.	DATE
CLASSIFIER		55	09/18/97
EXAMINER		69652	11/18/97
TYPIST			
VERIFIER			
CORPS CORR.			
SPEC. HAND			
FILE MAINT.			
DRAFTING			

RESTRICTION

INDEX OF CLAIMS

Claim		Date							
Final	Original	11/29/98							
	251	N							
	252	N							
	253	N							
	254	N							
	255	N							
	256	N							
	257	N							
	258	N							
	259	N							
	260	N							
	261	N							
	262	N							
	263	N							
	264	N							
	265	N							
	266	N							
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								
	26								
	27								
	28								
	29								
	30								
	31								
	32								
	33								
	34								
	35								
	36								
	37								
	38								
	39								
	40								
	41								
	42								
	43								
	44								
	45								
	46								
	47								
	48								
	49								
	50								

SYMBOLS

✓	Rejected
=	Allowed
÷ (Through numberal)	Canceled
+	Restricted
N	Non-elected
I	Interference
A	Appeal
O	Objected

Claim		Date							
Final	Original								
	51								
	52								
	53								
	54								
	55								
	56								
	57								
	58								
	59								
	60								
	61								
	62								
	63								
	64								
	65								
	66								
	67								
	68								
	69								
	70								
	71								
	72								
	73								
	74								
	75								
	76								
	77								
	78								
	79								
	80								
	81								
	82								
	83								
	84								
	85								
	86								
	87								
	88								
	89								
	90								
	91								
	92								
	93								
	94								
	95								
	96								
	97								
	98								
	99								
	100								

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/006,073	01/12/98	358	2722	58959.12

APPLICANT

DAVID A. MONROE, SAN ANTONIO, TX.

CONTINUING DOMESTIC DATA********************
VERIFIED

____

371 (NAT'L STAGE) DATA********************
VERIFIED

____

FOREIGN APPLICATIONS**********
VERIFIED

____

FOREIGN FILING LICENSE GRANTED 04/06/98

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐yes ☐no 35 USC 119 (a-d) conditions met ☐yes ☐no ☐Met after Allowance Verified and Acknowledged ________ Examiner's Initials ________ Initials	TX	8	266	11

ADDRESS

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

TITLE

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

FILING FEE RECEIVED $6,988	FEES: Authority has been given in Paper No. ______ to charge/credit DEPOSIT ACCOUNT NO. __________ for the following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________ ☐ Credit

JC561 U.S. PTO
09/006073
01/12/98

PATENT APPLICATION TRANSMITTAL LETTER

ATTORNEY DOCKET NO.: 58959.012

TO THE COMMISSIONER OF PATENTS AND TRADEMARKS:

Transmitted herewith for filing is the patent application of David A. Monroe for **APPARATUS FOR CAPTURING, CONVERTING AND TRNASMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRNASMISSION SYSTEM.**

Enclosed are:

[X] Twenty-one (21) sheets of drawings.

[ ] a certified copy of a __________ application.

[ ] combined declaration and power of attorney.

[ ] verified statement to establish small entity status under 37 CFR 1.9 and 1.27.

[ ] Information Disclosure Statement with references.

[ ] Supplemental Transmittal Letter

CLAIMS AS FILED			**SMALL ENTITY**			**OTHER THAN A SMALL ENTITY**	
For	**No. Filed**	**No. Extra**	**Rate**	**Fee**	**OR**	**Rate**	**Fee**
Basic Fee				$395.00	OR		$790.00
Total Claims	266 - 20	246	x $22 =	$ .00	OR	x $ 22=	$5,412.00
Indep Claims	11 - 3	8	x $41 =	$ 0.00	OR	x $ 82=	$ 656.00
Multiple Dependent Claim Present			+ $135	$ 0.00	OR	+ $270 =	$
			Total	**$* .00**	**OR**	**Total**	**$6,858.00**

[ ] Please charge my Deposit Account No. 50-0259 in the amount of $.
A duplicate copy of this sheet is enclosed.

[x] A check in the amount of **$6,858.00** to cover the filing fee is enclosed.

[X] The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 50-0259. A duplicate copy of this sheet is enclosed.

- [X] Any additional filing fees required under 37 CFR 1.16.
- [X] Any patent application processing fees under 37 CFR 1.17.

[X] The Commissioner is hereby authorized to charge payment of the following fees during the pendency of this application or credit any overpayment to Deposit Account No. 50-0259. A duplicate copy of this sheet is enclosed.

- [X] Any filing fees under 37 CFR 1.16 for presentation of extra claims.
- [X] Any patent application processing fees under 37 CFR 1.17.
- [ ] The issue fee set in 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

Date: 1/12/98

Mark Tidwell

Mark A. Tidwell
Reg. No. 37,456

BRACEWELL & PATTERSON, L.L.P.
SOUTH TOWER PENNZOIL PLACE
711 LOUISIANA STREET, SUITE 2900
HOUSTON, TEXAS 77002-2781
(713) 221-1529
Attorney Docket No. 58959.012

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service as EXPRESS MAIL - POST OFFICE TO ADDRESSEE, in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on 1/12/98. The Express Label No. is EM018601734US.

Judy Kruger
SIGNATURE

IP\DMA012\PATAPPTRN

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO./TITLE
09/006,073	01/12/98	MONROE D	58959.12

0222/0419

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

NOT ASSIGNED

2722

DATE MAILED: 04/13/98

NOTICE TO FILE MISSING PARTS OF APPLICATION

Filing Date Granted

An Application Number and Filing Date have been assigned to this application. The items indicated below, however, are missing. Applicant is given TWO MONTHS FROM THE DATE OF THIS NOTICE within which to file all required items and pay fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a). **If any of items 1 or 3 through 5 are indicated as missing, the SURCHARGE set forth in 37 CFR 1.16(e) of ☐ $65.00 for a small entity in compliance with 37 CFR 1.27, or ☑ $130.00 for a non-small entity, must also be timely submitted in reply to this NOTICE to avoid abandonment.**

If all required items on this form are filed within the period set above, the total amount owed by applicant as a ☐ small entity (statement filed) ☑ non-small entity is $ 130 .

☐ 1. The statutory basic filing fee is:
  ☐ missing.
  ☐ insufficient.
  Applicant must submit $________ to complete the basic filing fee and/or file a small entity statement claiming such status (37 CFR 1.27).

☐ 2. Additional claim fees of $________, including any multiple dependent claim fees, are required.
  $________ for ________ independent claims over 3.
  $________ for ________ dependent claims over 20.
  $________ for multiple dependent claim surcharge.
  Applicant must either submit the additional claim fees or cancel additional claims for which fees are due.

☑ 3. The oath or declaration:
  ☑ is missing or unexecuted.
  ☐ does not cover the newly submitted items.
  ☐ does not identify the application to which it applies.
  ☐ does not include the city and state or foreign country of applicant's residence.
  An oath or declaration in compliance with 37 CFR 1. 63, including residence information and identifying the application by the above Application Number and Filing Date is required.

☐ 4. The signature(s) to the oath or declaration is/are by a person other than inventor or person qualified under 37 CFR 1.42, 1.43 or 1.47.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.

☐ 5. The signature of the following joint inventor(s) is missing from the oath or declaration:
  ____
  An oath or declaration in compliance with 37 CFR 1.63 listing the names of all inventors and signed by the omitted inventor(s), identifying this application by the above Application Number and Filing Date, is required.

☐ 6. A $50.00 processing fee is required since your check was returned without payment (37 CFR 1.21(m)).

☐ 7. Your filing receipt was mailed in error because your check was returned without payment.

☐ 8. The application does not comply with the Sequence Rules.
  See attached "Notice to Comply with Sequence Rules 37 CFR 1.821-1.825."

☐ 9. OTHER: ________________

Direct the reply and any questions about this notice to "Attention: Box Missing Parts."

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 3 - OFFICE COPY

FORM PTO-1533 (REV.9/97)

SECTOR / $

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of

DAVID A. MONROE

Serial No.: 09/006,073

Filed: January 12, 1998

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION DEVICE

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail addressed to: COMMISSIONER OF PATENTS AND TRADEMARKS, Washington, D.C. 20231, this 8th day of July, 1998. The Express Mail No. is EL080487139US.

Judy Kruger
Judy Kruger

#3

SUBMISSION OF MISSING PARTS

Commissioner of Patents and Trademarks
Box: APPLICATION BRANCH
Washington, D.C. 20231

Dear Sir:

Responsive to the Notice of Missing Parts dated April 13, 1998, (copy enclosed) enclosed is the Declaration for the above-identified application. Also enclosed is a check covering the $130.00 fee for the surcharge. A one-month extension of time is also enclosed along with the fee of $110.00. The Commissioner is authorized to charge Deposit Account 50-0259 for any deficiencies in this filing.

Respectfully submitted,

BRACEWELL & PATTERSON, L.L.P.

7/8/98
DATE

BY: Robert C. Curfiss
Robert C. Curfiss
Reg. No. 26.540

BRACEWELL & PATTERSON, L.L.P.
South Tower Pennzoil Place
711 Louisiana Street, Suite 2900
Houston, Texas 77002-2781
(713) 221-1430
ATTORNEY DOCKET NO. 058959.007010.0012

/14/1998 DNASH1 00000068 09006073

! FC:115 110.00 OP

KRUGJ\058959\007010
HOUSTON\867058.1
7/8/98--2:35 pm

Docket No. 058959.007010.012

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe that I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

the specification of which: (check one)
[ ] is attached hereto;
[x] was filed on 01/12/98 as Application Serial No. 09/006073

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulation, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S) PRIORITY CLAIMED

(Number)	(Country)	(Day/Month/Year Filed)	[ ] Yes	[] No
(Number)	(Country)	(Day/Month/Year Filed)	[] Yes	[] No
(Number)	(Country)	(Day/Month/Year Filed)	[] Yes	[] No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

____

(Application Serial No.) (Filing Date) (Status - Patented, Pending, or Abandoned)

____

(Application Serial No.) (Filing Date) (Status - Patented, Pending, or Abandoned)

____

(Application Serial No.) (Filing Date) (Status - Patented, Pending, or Abandoned)

I hereby appoint the following attorney(s) and/or agents, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Robert C. Curfiss	Reg. No. 26,540
Mark A. Tidwell	Reg. No. 37,456

Address all Telephone Calls to: ROBERT C. CURFISS
(713) 221-1430

Address all correspondence to
BRACEWELL & PATTERSON, L.L.P.
SOUTH TOWER PENNZOIL PLACE
711 Louisiana Street, Suite 2900
Houston, Texas 77002-2781

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title

18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF FIRST OR SOLE INVENTOR DAVID A. MONROE

INVENTOR'S SIGNATURE DATE 7/3/1998

Citizenship UNITED STATES
Address P. O. BOX 780907, SAN ANTONIO, TEXAS 78278-0907

KRUGJ\058959\007010
HOUSTON\795555.5
7/2/98--4:00 pm

OIPE JC49
JUL 07 1998
PATENT & TRADEMARK OFFICE

OIPE JC49
JUL 08 1998
PATENT & TRADEMARK OFFICE

OIPE JC49
JUL 08 1998
PATENT & TRADEMARK OFFICE

CANCELLED

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO./TITLE
09/0[illegible],07[illegible]	01/12/98	MONROE	D 58959.12

0222/0413

BRACEWELL PATTERSON
SOUTH TOWER [illegible]IL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

NOT ASSIGNED

2722

DATE MAILED: 04/13/98

NOTICE TO FILE MISSING PARTS OF APPLICATION

Filing Date Granted

An Application Number and Filing Date have been assigned to this application. The items indicated below, however, are missing. Applicant is given TWO MONTHS FROM THE DATE OF THIS NOTICE within which to file all required items and pay fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a). **If any of items 1 or 3 through 5 are indicated as missing, the SURCHARGE set forth in 37 CFR 1.16(e) of ☐ $65.00 for a small entity in compliance with 37 CFR 1.27, or ☑ $130.00 for a non-small entity, must also be timely submitted in reply to this NOTICE to avoid abandonment.**

If all required items on this form are filed within the period set above, the total amount owed by applicant as a ☐ small entity (statement filed) ☑ non-small entity is $ 130 .

☐ 1. The statutory basic filing fee is:
  - ☐ missing.
  - ☐ insufficient.

  Applicant must submit $________ to complete the basic filing fee and/or file a small entity statement claiming such status (37 CFR 1.27).

☐ 2. Additional claim fees of $________, including any multiple dependent claim fees, are required.

$______ for ______ independent claims over 3.
$______ for ______ dependent claims over 20.
$______ for multiple dependent claim surcharge.

Applicant must either submit the additional claim fees or cancel additional claims for which fees are due.

☑ 3. The oath or declaration:
  - ☑ is missing or unexecuted.
  - ☐ does not cover the newly submitted items.
  - ☐ does not identify the application to which it applies.
  - ☐ does not include the city and state or foreign country of applicant's residence.

  An oath or declaration in compliance with 37 CFR 1. 63, including residence information and identifying the application by the above Application Number and Filing Date is required.

☐ 4. The signature(s) to the oath or declaration is/are by a person other than inventor or person qualified under 37 CFR 1.42, 1.43 or 1.47.
A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.

☐ 5. The signature of the following joint inventor(s) is missing from the oath or declaration:
____
An oath or declaration in compliance with 37 CFR 1.63 listing the names of all inventors and signed by the omitted inventor(s), identifying this application by the above Application Number and Filing Date, is required.

☐ 6. A $50.00 processing fee is required since your check was returned without payment (37 CFR 1.21(m)).

☐ 7. Your filing receipt was mailed in error because your check was returned without payment.

☐ 8. The application does not comply with the Sequence Rules.
See attached "Notice to Comply with Sequence Rules 37 CFR 1.821-1.825."

07/14/1998 [illegible] 00000068 [illegible]

☐ 9. OTHER: ________

01 FC:105 130.00 OP

Direct the reply and any questions about this notice to "Attention: Box Missing Parts."

A copy of this notice MUST be returned with the reply.

D Martin 7-4

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 2 - COPY TO BE RETURNED WITH RESPONSE

FORM PTO-1533 (REV.9-97)

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

A4

Application of:

DAVID A. MONROE

Serial No. 09/005,931

Filed: January 12, 1998

Group Art Unit:

Examiner:

APPARATUS FOR CAPTURING,
CONVERTING AND TRANSMITTING
A VISUAL IMAGE SIGNAL VIA A
DIGITAL TRANSMISSION SYSTEM

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail, Express Mail No. EL080487139US, in an Express Mail envelope addressed to: COMMISSIONER OF PATENTS AND TRADEMARKS, Washington, D.C. 20231, this 8th day of July, 1998.

Judy Kruger
Judy Kruger

REQUEST FOR ONE-MONTH EXTENSION OF TIME

HONORABLE COMMISSIONER
OF PATENTS AND TRADEMARKS
Box: Fee
Washington, D.C. 20231

Sir:

Responsive to the Notice of Missing Parts dated April 13, 1998, a one-month extension of time is hereby requested in the above-identified application. The requisite extension fee of $110.00 is attached.

The Commissioner is hereby authorized to charge any additional fees in this application under 35 C.F.R. §1.16 or §1.17 to **Deposit Account No. 50-0259**. An additional copy of this Request for Extension of Time is attached.

Respectfully submitted,

Robert C. Curfiss
Registration No. 26,540

BRACEWELL & PATTERSON, L.L.P.
711 Louisiana, Suite 2900
Houston, Texas 77002
(713) 221-1430
Attorney Docket No. 058959.007010.0012

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO./TITLE
09/006,073	01/12/98	MONROE	D 58959.12

0242/0806

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

NOT ASSIGNED

2722

DATE MAILED: 08/06/98

NOTICE TO FILE CORRECTED APPLICATION PAPERS
Filing Date Granted

This application has been accorded an Application Number and Filing Date. The application, however, is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS FROM THE DATE OF THIS NOTICE within which to correct the informalities indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

☐ 1. An Abstract, commencing on a separate sheet *(37 CFR 1.72(b))*.

☐ 2. The Claim(s) commencing on a separate sheet *(37 CFR 1.75(h))*.

☐ 3. A substitute specification in compliance with 37 CFR 1.52 because:
  - ☐ All sheets must be the same size and either A4 (21 cm x 29.7 cm) or 8-1/2" x 11".
  - ☐ Papers are not flexible, strong, smooth, non-shiny, durable, and white.
  - ☐ Papers are not typewritten or mechanically printed in permanent dark ink on one side.
  - ☐ Papers contain hand lettering.
  - ☐ Papers contain improper margins. *Each sheet must have a left margin of at least 2.5 cm (1") and top, bottom and right margins of at least 2.0 cm (3/4").*
  - ☐ Line spacing on the sheets is not 1-1/2 or double-spaced.
  - ☐ The pages of specification including the abstract and claims are not consecutively numbered starting with the number "1."
  - ☐ The pages of specification do not contain page numbers centrally located within the top or, preferably, bottom margin.

☑ 4. Substitute drawings in compliance with 37 CFR 1.84 because:
  - ☐ The drawings or copy of drawings are not suitable for electronic reproduction.
  - ☑ All drawing sheets must be the same size and either A4 (21cm x 29.7 cm) or 8-1/2" x 11". FIG- 8A-9
  - ☐ Each sheet must include a top and left margin of at least 2.5 cm (1"), a right margin of at least 1.5 cm (9/16") and a bottom margin of at least 1.0 cm (3/8").

☐ 5. Page(s)__________ are not of sufficient clarity, contrast and quality for electronic reproduction. *New typewritten or mechanically printed pages of sufficient clarity, contrast and quality for electronic reproduction, together with a statement that the new pages contain the same material as those on deposit are required.*

☐ 6. A new oath or declaration in compliance with 37 CFR 1.63 setting forth the residence (city and state or foreign country) of each applicant (or legal representative under 37 CFR 1.42 or 1.43 of each applicant).

☐ 7. An English translation of the non-English language application, the $130.00 fee set forth in 37 CFR 1.17(k), unless previously submitted, and a statement that the translation is accurate *(37 CFR 1.52(d))*.

☐ 8. OTHER:______________________________

Direct the reply and any questions about this notice to "Attention: Box Missing Parts."

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

FORM PTO-1660 (REV.9-97)

PART 3 - OFFICE COPY

*U.S. GPO: 1997-434-203/60163

09/006,073

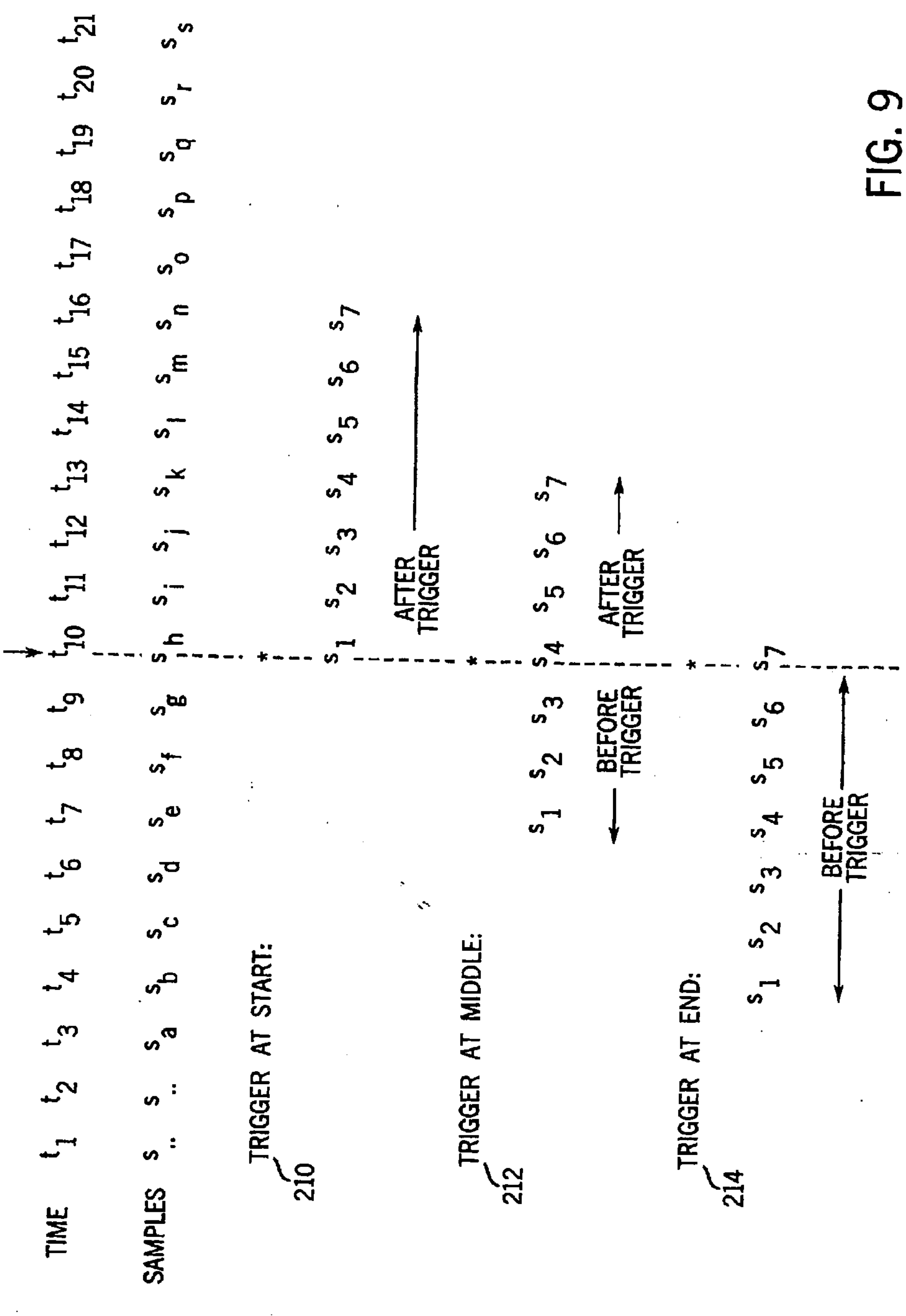


FIG. 9

OIPE
MAY 26 1998
JC34
PATENT & TRADEMARK OFFICE

GAU 2722
Not assigned at 358

PATENT #5
[illegible]
12-29-98

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of

DAVID A. MONROE

Serial No.: 09/006,073

Filed: JANUARY 12, 1998

APPARATUS FOR CAPTURING,
CONVERTING AND TRANSMITTING
A VISUAL IMAGE SIGNAL VIA A
DIGITAL TRANSMISSION SYSTEM

CERTIFICATE OF EXPRESS MAIL

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail addressed to: COMMISSIONER OF PATENTS AND TRADEMARKS, Washington, D.C. 20231, this 26th day of MAY, 1998. The Express Mail No. is EL080486972US.

Judy Kruger
Judy Kruger

INFORMATION DISCLOSURE STATEMENT

RECEIVED
JUN 01 1998
GROUP 2100

HONORABLE COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Sir:

Applicant desires to bring to the attention of the Examiner the following U.S. Patents listed on the attached form PTO 1449. A copy of each of the patents is enclosed in compliance with Rules 97 and 98 of the Rules of Practice.

RECEIVED
98 JUN -3 PM 12:26
GROUP 2700

U.S. PATENT NO.	ISSUE DATE	INVENTOR
2,642,492	JUNE, 1953	HAMMOND, JR.
3,251,937	MAY, 1966	HOAG
3,751,159	AUGUST, 1973	FISHER
3,864,514	FEBRUARY, 1975	LEMELSON
4,074,324	FEBRUARY, 1978	BARRETT
4,530,014	JULY, 1985	D'ALAYER DE COSTEMORE D'ARC
4,652,926	MARCH, 1987	WITHERS ET AL
4,884,132	NOVEMBER, 1989	MORRIS ET AL
4,937,676	JUNE, 1990	FINELLI ET AL
4,942,477	JULY, 1990	NAKAMURA
5,032,911	JULY, 1991	TAKIMOTO

5,047,870	SEPTEMBER, 1991	FILO
5,193,012	MARCH, 1993	SCHMIDT
5,235,432	AUGUST, 1993	CREEDON ET AL

Respectfully submitted,

BRACEWELL & PATTERSON, L.L.P.

5/26/1998
DATE

BY:
ROBERT C. CURFISS
Reg. No. 26,540

BRACEWELL & PATTERSON, L.L.P.
South Tower Pennzoil Place
711 Louisiana Street, Suite 2900
Houston, Texas 77002-2781
(713) 221-1430
ATTORNEY DOCKET NO. 058959.007010.0012

KRUGJ\058959\007010
HOUSTON\850282.1
5/26/98--9:23 am

Sheet 1 of 2

orm PTO-1449 U.S. Department of Commerce
Patent and Trademark Office

NFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Use several sheets if necessary)

Atty Docket No. 058959.007010.0012	Serial No. 09/006,073
Applicant DAVID A. MONROE	
Filing Date January 12, 1998	Group Art Unit 2722

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
JP	A	2642492	6/1953	HAMMOND, JR.			
JP	B	3251937	5/1966	HOAG			
JP	C	3751159	8/1973	FISHER			
JP	D	3864514	2/1975	LEMELSON			
JP	E	4074324	2/1978	BARRETT			
JP	F	4530014	7/1985	D'ALAYER DE COSTEMORE D'ARC			
JP	G	4652926	3/1987	WITHERS ET AL			
JP	H	4884132	11/1989	MORRIS ET AL			
JP	I	4937676	6/1990	FINELLI ET AL			

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	NO

OTHER PREFERENCES (Including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER Joseph R [illegible]	DATE CONSIDERED 11/15/99

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to client.

KRUGJ\058959\007010
HOUSTON\850301.1
5/26/98--9:30 am

OIPE
MAY 26 1998
PATENT & TRADEMARK OFFICE

Sheet 2 of 2

Form PTO-1449	U.S. Department of Commerce Patent and Trademark Office	Atty Docket No. 058959.007010.0012	Serial No. 09/006,073
INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Use several sheets if necessary)**		Applicant DAVID A. MONROE	
		Filing Date January 12, 1998	Group Art Unit 2722

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
JP	J	4 9 4 2 4 7 7	7/1991	NAKAMURA			
JP	K	5 0 3 2 9 1 1	7/1991	TAKIMOTO			
JP	L	5 0 4 7 8 7 0	9/1991	FILO			
JP	M	5 1 9 3 0 1 2	3/1993	SCHMIDT			
JP	N	5 2 3 5 4 3 2	8/1993	CREEDON ET AL			

RECEIVED
JUN 01 1998
GROUP 2100

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	NO

RECEIVED
98 JUN -3 PM 12:26
GROUP 2700

OTHER PREFERENCES (Including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER Joseph R	DATE CONSIDERED 11/15/99

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to client.

KRUGJ\058959\007010
HOUSTON\850301.2
5/26/98--9:29 am

E9595 XR 2,642,492

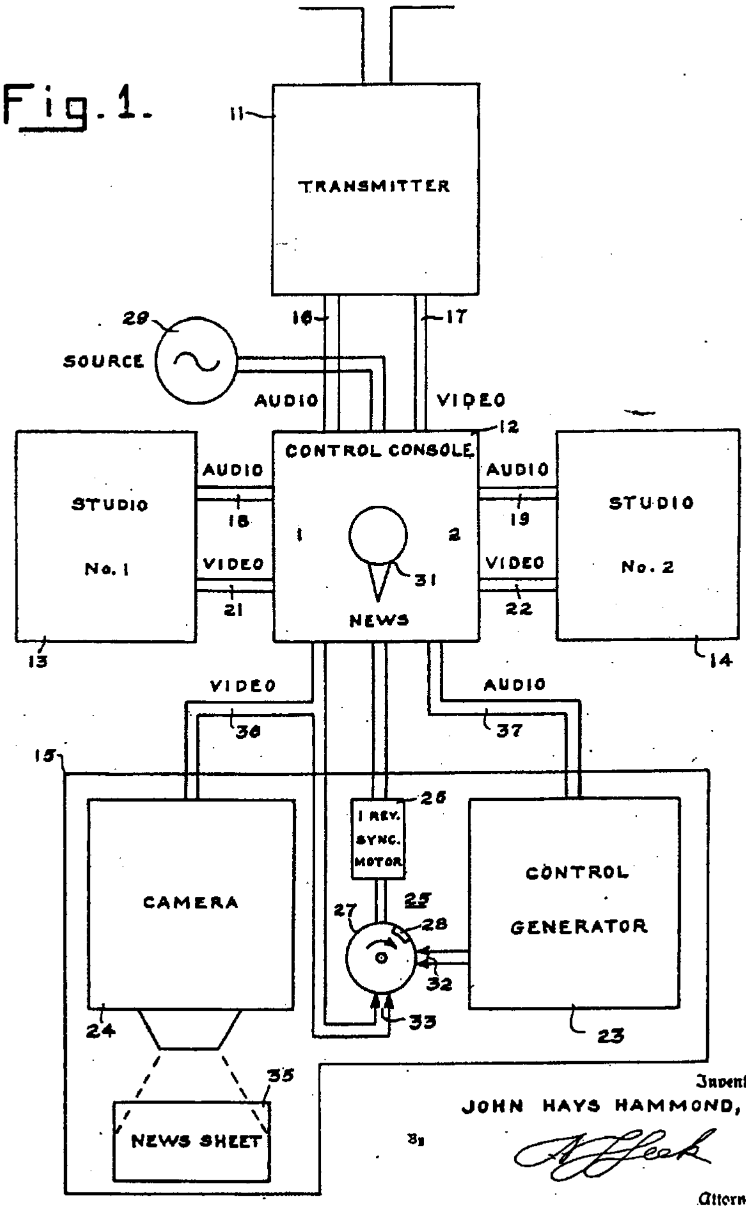
[redacted]

June 16, 1953 J. H. HAMMOND, JR 2,642,492

TELEVISION TYPE FACSIMILE TRANSMISSION SYSTEM

Filed Dec. 11, 1948 3 Sheets-Sheet 1

Fig. 1.



Inventor
JOHN HAYS HAMMOND, JR.

By

Attorney

A

June 16, 1953 J. H. HAMMOND, JR **2,642,492**

TELEVISION TYPE FACSIMILE TRANSMISSION SYSTEM

Filed Dec. 11, 1948 3 Sheets-Sheet 2

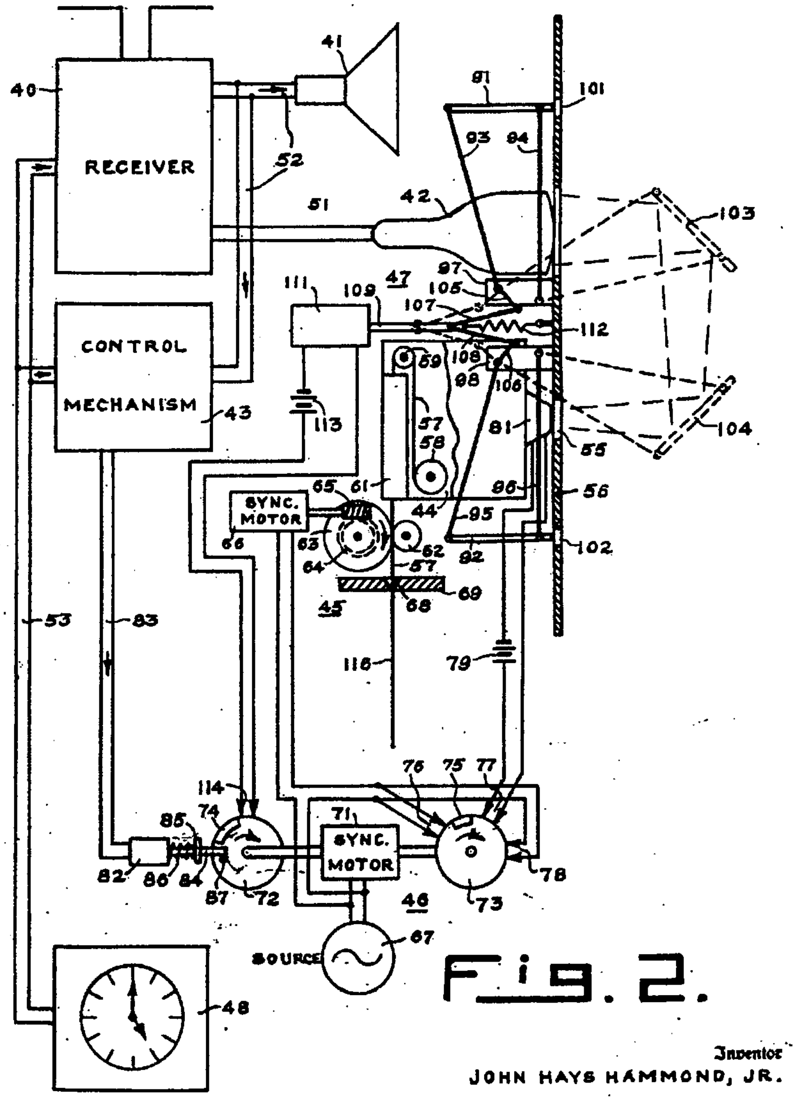


Fig. 2.

Inventor
JOHN HAYS HAMMOND, JR.

By

Attorney

June 16, 1953 J. H. HAMMOND, JR 2,642,492

TELEVISION TYPE FACSIMILE TRANSMISSION SYSTEM

Filed Dec. 11, 1948 3 Sheets-Sheet 3

FIG. 3.

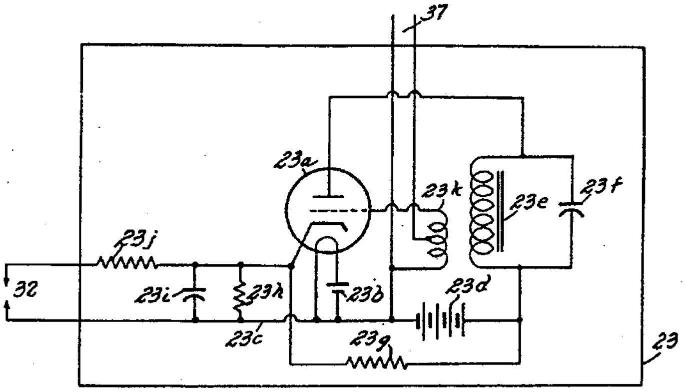
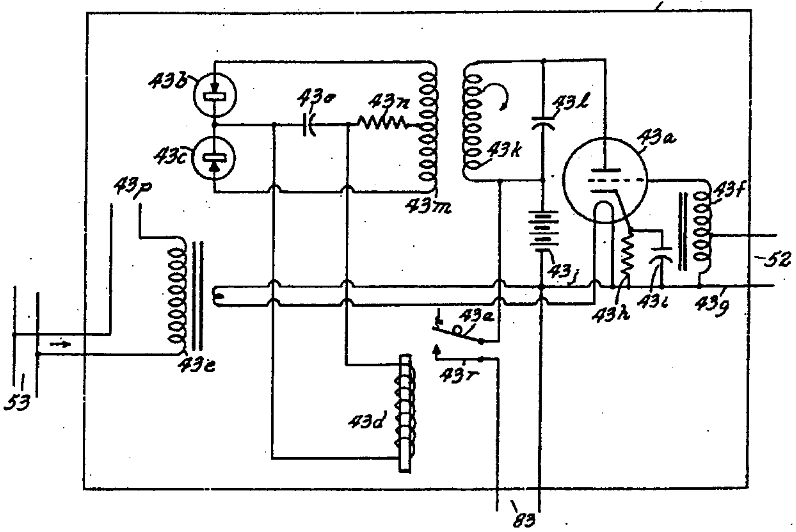


FIG. 4.



INVENTOR

JOHN HAYS HAMMOND, JR.

BY Alvin A. Mitchell

ATTORNEY

Patented June 16, 1953

2,642,492

UNITED STATES PATENT OFFICE

2,642,492

TELEVISION TYPE FACSIMILE TRANSMISSION SYSTEM

John Hays Hammond, Jr., Gloucester, Mass.

Application December 11, 1948, Serial No. 64,808

5 Claims. (Cl. 178—6.7)

1

This invention relates to television and more specifically to a system for transmitting news on any desired schedule.

The invention comprises means in connection with a standard television system for scanning and transmitting a news sheet and transmitting a characteristic control signal which operates means at the receiver causing a set of mirrors to be moved into position between the kinescope and a camera and to photograph the news sheet when it appears on the kinescope subsequent to which the film is processed and is placed in position to be torn off and used as a news sheet.

The invention also consists in certain new and original features of construction and combinations of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Fig. 1 is a diagrammatic view of a television transmitting system constructed in accordance with the invention,

Fig. 2 is a diagrammatic view of a television receiving system used in connection with the transmitting system shown in Fig. 1,

Fig. 3 is a diagrammatic showing of a control generator suitable for use with the invention, and

Fig. 4 is a diagrammatic showing of a control mechanism suitable for use in practicing the invention.

In the following description parts will be identified by specific names for convenience, but they are intended to be generic in their application to similar parts.

Referring to the drawings and more particularly to Fig. 1, the transmitting system consists of a standard television transmitter 11, a control console 12, two studios 13 and 14 and a news room 15. The control console is connected to the transmitter 11 by an audio channel 16 and a video channel 17, to the two studios 13 and 14 by two audio channels 18 and 19 and two video channels 21 and 22 respectively.

The news room 15 comprises a control generator 23, a television camera 24 and a timing mechanism 25.

Control generator 23 is a simple electronic audio oscillator with single frequency, which is so connected that the oscillation can be switched

2

on by external shorting of the contacts 32, as by commutator 28 of the application. This reduces the positive voltage on the cathode to permit current to flow and the tube to oscillate. Signal is delivered to line 37. The tuned plate inductive feedback oscillator with cathode keying selected for illustrative purposes is disclosed in Fig. 7 of the U. S. patent to Chaffee No. 1,610,425. A similar keying system is disclosed on page 225 of the 1944 edition of "The Radio Amateurs' Handbook" of the American Radio Relay League.

A distinctive signal is to be delivered to line 37 during the external closure of contacts 32. For this purpose there is provided an audio oscillator triode 23a, the filament of which is heated by a battery 23b connected to one end of the filament, the other end of which is connected to ground line 23c and the negative of the battery. The plate circuit is powerized by the battery 23d, the negative end of which is connected to ground line 23c, and the positive end of which is connected through inductor 23e paralleled by capacitor 23f to the plate anode of triode 23a. The positive end of battery 23d is also connected through resistor 23g to the cathode of the triode 23a, which in turn is connected through resistor 23h paralleled by capacitor 23i to ground line 23c. The cathode is also connected through resistor 23j to one side of the contacts 32, the other side of which is connected to ground line 23c. The grid of 23a is connected through inductor 23k to ground line 23c, with the inductor suitably coupled to inductor 23e. One side of output line 37 is connected to ground line 23c and the other to a suitable tap on the inductor 23k.

Circuit constants are such that normally the cathode of the triode is positively biased sufficiently by the current flowing through resistors 23g and 23h so that no current flows through the triode tube, and no oscillations can occur. When, however, the connection is made externally across the contacts 32 by operation of the commutator segment 28, resistor 23j is placed in parallel with resistor 23h. This lowers the positive bias on the cathode so that oscillations start in the plate circuit elements 23e, 23f, and are sustained by the feedback to the grid by coil 23k. The frequency of these oscillations may be in the high audio range, such as 10000 cycles. Energy of this frequency is delivered over line 27, thence, through the switching circuit 12 to the transmitter. When the external connection is broken at contacts 32, the cathode bias increases to cut off the oscillations. The elements 23g and 23h may be omitted, but the operation of the system is more positive if they are included.

The timing mechanism **25** consists of a self-starting synchronous motor **26** on the shaft of which is mounted a commutator **27** which is made of insulating material and is provided with a contact segment **28**. The synchronous motor **26** and other similarly described motors may have speed reducing gears built into the motors so that the shaft rotates at a suitably low speed. A 60 cycle or other suitable A. C. generator **29** is provided which is connected through the control console **12** to the motor **26** in such a way that when the control console indicator **31** is turned to "News" the motor **26** will cause the commutator **27** to make one complete revolution in a clockwise direction and come to rest in its initial position. Engaging the commutator **27** are two sets of contacts **32** and **33**, the former being connected to the control generator **23** and the latter being connected in the video output circuit **36** of the camera **24** which is connected to the control console. A news sheet **35** is shown as placed in position to be viewed by the camera **24**. The control generator **23** is connected to the control console **12** by an audio channel **37**.

Referring to Fig. 2 the receiving system comprises a television receiver **40**, a loud speaker **41** and a kinescope **42**. For recording and printing the news flashes a control mechanism **43** is provided together with a camera **44**, a feeding mechanism **45**, a timing mechanism **46**, a mirror system **47** and a time clock **48**.

Control mechanism **43** is a simple circuit in which the clock controlled line **53** turns on the filament of a selective amplifier tube. This drives a rectifier and a relay in an obvious manner to put D. C. power on line **83** to operate solenoid **86**. The control mechanism **43** includes, illustratively, an electron tube with an untuned plate circuit, which drives a rectifier circuit to operate a relay and thereby powerize line **83**. A similar circuit is shown, for example, in Fig. 1 of U. S. Patent No. 1,522,883. The use of diode or crystal rectifiers driven from the output of an amplifier is shown in Fig. 1 of U. S. Patent 1,998,617 where elements 31 and 32 correspond to elements **43*b*** and **43*c*** of Fig. 4; and where the system 33, 34, 35, 36 and 37 is an electromagnetic system driven from the rectifier output corresponding to **43*d*** of Fig. 4.

Control mechanism **43** is constructed to develop a D. C. voltage across line **83** for actuating solenoid **82**, in response to a signal of suitable strength and suitable characteristics impressed upon line **52**. Preliminary to functioning, the system is rendered operative by external shorting of the clock controlled line **53**. The circuit includes a selective amplifier triode **43*a***, a pair of rectifiers **43*b***, **43*c***, a relay **43*d*** and a filament transformer **43*e***. The grid of amplifier **43*a*** is connected to ground line **43*g*** through autotransformer **43*f***, a tap on which is connected to one side of line **52**, the other side of which is connected to ground line **43*g***. The cathode is connected to ground line **43*g*** by resistor **43*h*** paralleled by capacitor **43*i***. Plate power is provided by battery **43*j***, the negative end of which is connected to ground and the positive end of which is connected through inductor **43*k*** paralleled by capacitor **43L** to the plate anode of triode **43*a***. This circuit **43*k***, **43L** is tuned to the operating frequency corresponding to that supplied by block **23** above described. Coupled to inductor **43*k*** is a secondary inductor **43*m***, the ends of which are connected to the anodes of rectifiers **43*b*** and **43*c***. The cathodes are connected through the winding of relay **43*d*** and a resistor **43*n*** to a center tap on inductor **43*m***. The relay winding is shunted by capacitor **43*o***. The filament transformer is connected to a power source **43*p*** when the circuit **53** is closed, and this then supplies current to the filament of triode **43*a*** to render it operative. The moving blade **43*q*** of relay **43*d*** is connected to the positive end of battery **43*j***, the negative grounded end of which is connected to one side of output line **83**. The fixed contact **43*r*** of the relay is connected to the other end of line **83**.

In operation, after the time clock has connected the filament transformer **43*e*** to the power source, the system becomes responsive to a control signal of suitable frequency and strength impressed from line **52**, such as the 10,000 cycle signal transmitted over the audio channel from block **23**. This signal is amplified by tube **43*a***, and by resonance in the plate circuit energizes the rectifiers in push-pull manner to produce direct current through the winding of relay **43*d***. Upon closure, the battery **43*j*** is connected across the output line to operate solenoid **82**. It will be understood that normal audio sound signals will not have sufficient components in the vicinity of 10,000 cycles to cause actuation of the relay. It will be further understood that the circuit can be improved, if necessary, by use of further audio and D. C. amplifiers, and by use of circuits which are more sharply responsive to the desired signal.

The receiver **40** is connected to the kinescope **42** by a video channel **51** and to the loud speaker **41** and control mechanism **43** by an audio channel **52**. The time clock **48** is connected by a circuit **53** to both the receiver **40** and the control mechanism **43**.

The camera **44** is mounted behind an opening **55** in a panel **56** which forms part of the casing of the receiving system. The camera **44** is provided with a film **57** which is initially wound on a spool **58** and then passes over a roller **59** and through a processing chamber **61**. After emerging from the processing chamber **61** the film **57** passes between two rollers **62** and **63** in the feeding mechanism **45** and through a V-shaped slot **68** in a member **69**. Mounted on the shaft of the roller **63** is a worm wheel **64** which meshes with a worm gear **65** mounted on the shaft of a synchronous motor **66**, which at suitable times is supplied with current from an A. C. source **67**.

The timing mechanism **46** comprises a synchronous motor **71** on the shaft of which are mounted two commutators **72** and **73**. The commutators **72** and **73** are made of insulating material and are provided with contact segments **74** and **75** respectively. The motor **71** is connected to the source of A. C. **67**. Engaging the commutator **73** are three sets of contacts **76**, **77** and **78**. The contacts **76** and **78** are connected in parallel and are in a circuit including the motor **66** and the A. C. source **67**. The contacts **77** are in a circuit including a battery **79** and the shutter mechanism **81** of the camera **44**. Mounted adjacent to the commutator **72** is a solenoid **82** which is connected by a circuit **83** to the control mechanism **43**. The solenoid **82** is provided with a core **84** to which is secured a collar **85** between which and the solenoid **82** is mounted a coil spring **86**. When the core **84** is extended it engages or is in the path of a pin **87** mounted on the commutator **72**.

The mirror system **47** comprises two plane mirrors **91** and **92** which are pivotally connected to two sets of arms **93**—**94** and **95**—**96**, the other ends of which are pivoted to two brackets **97** and **98** mounted on the back of the panel **56**. Suitable slots such as 101 and 102 are provided in the panel 56 to allow the mirrors and arms to move into the positions shown in dotted lines at 103 and 104. Secured to one end of the arms 93 and 95 are two short arms 105 and 106 the ends of which are connected by two links 107 and 108 to the core 109 of a solenoid 111. To the core 109 is attached one end of a tension spring 112 the other end of which is secured to the panel 56. The winding of the solenoid 111 is connected through a battery 113 to a pair of contacts 114 which engage the commutator 72.

Operation

The news sheet 35 is placed in position in front of the television camera 24 and control generator 23, and transmitter 11 are turned on. At the receiver, shown in Fig. 2, the time clock 48, which may have been set at 5 a. m. the night before, operates at that time to close the circuit through channel 53, which turns on the receiver 40 and control mechanism 43. After waiting a few minutes the operator at the control console 12 turns the indicator 31 to the "News" position, as shown in Fig. 1. This closes a circuit from the A. C. source 29 to the synchronous motor 26 which starts rotating the commutator 27 in the direction of the arrow. As the commutator 27 rotates the segment 28 will engage the contacts 32 thus causing the control generator 23 to send out a distinctive signal on the audio channels 37 and 16 to the transmitter 11 which sends it as a radio signal for a brief interval of time.

This distinctive audio signal is picked up at the receiver 40, Fig. 2, and passes to the control mechanism 43, the circuits of which are responsive to this particular type of signal. After a predetermined time interval, depending upon the characteristics of the audio circuits, a control signal will be sent out over the circuit 83 which will energize the solenoid 82 causing the core 84 to be retracted, which will free the pin 87. The two commutators 72 and 73 then start rotating in the directions of the arrows under the action of the synchronous motor 71.

As the commutator 72 rotates the segment 74 will engage the contacts 114 thus closing a circuit through the solenoid 111. This will cause the core 109 to be moved to the left, which by means of the links 107 and 108 and the arms 93–96 will cause the mirrors 91 and 92 to be moved into the positions shown in dotted lines at 103 and 104. In this position the light from the screen of the kinescope 42 is reflected onto the shutter of the camera 44.

After this operation has taken place the segment 28, Fig. 1, will engage the contacts 33 which causes the video output circuit 36 to operate. This will cause a telecast of the news sheet to be transmitted by the transmitter 11. This telecast will be received by the receiver 40 and will be reproduced on the screen of the kinescope 42 in the usual manner. At this instant the commutator 73 will have rotated so that the segment 75 will engage the contacts 77 which will operate the shutter mechanism 81 of the camera 44, to take a picture of the news sheet on the film 57.

As the commutator 72 continues to rotate the segment 74 will disengage the contacts 114 thus deenergizing the solenoid 111. This will allow the core 109, links 107 and 108, arms 93–96 and mirrors 91 and 92 to return to their initial positions under the action of the spring 112. As the commutator 73 rotates the segment 75 will engage the contacts 78 closing a circuit through the synchronous motor 66, which by means of the worm 65 and gear 64 will rotate the roller 63 in the direction of the arrow. This will cause the exposed portion of the film 57 to be drawn into the processing chamber 61 where it will remain, as by this time the segment 75 will have moved out of engagement with the contacts 78 thus stopping the motor 66.

The film 57 remains in the processing chamber 61 a predetermined time depending on the nature of the process. At the end of this time interval the segment 75 will engage the contacts 76 thus starting the motor 66 which again will rotate the roller 63 in the direction of the arrow to move the exposed and printed film 57 from the processing chamber 61, through the V-shaped slot 68 and into the position indicated at 116 from which it may be torn off and used as a news sheet whenever desired. The commutators 72 and 73 continue to rotate until the pin 87 engages the core 84 of the solenoid 82 which became deenergized at the cessation of the control signal.

After a sufficient interval of time has elapsed to complete these operations the time clock 48 will break the circuit 53 thus turning off the receiver 40 and control mechanism 43. The system will then be in the inoperative condition and will be ready to receive a second telecast of news at some future time as determined by the setting of the time clock 48.

If it is desired to use the system for straight television the indicator 31 of the control console 12 is turned to either studio 1 or 2, the receiver 40 is turned on and a regular television program is transmitted and reproduced on the screen of the kinescope 42 in the usual manner.

Although only a few of the various forms in which this invention may be embodied have been shown herein, it is to be understood that the invention is not limited to any specific construction but might be embodied in various forms without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A system for utilizing television type transmission for the facsimile transmission of a still picture during a time pause in the transmission of a television program, comprising a television transmitter including a television camera adapted to scan an image for transmission to a remote point, a television receiver including a kinescope having a screen on which the image is reproduced, a photographic camera containing a sensitized film normally disposed out of the path of the rays from said screen, a normally inoperative optical system, means at said transmitter to produce a predetermined control signal, means at the receiver responsive to said control signal to shift said optical system into a position to direct the rays from said screen onto said photographic camera, shutter control means for said photographic camera, timed means responsive to said control signal to actuate said shutter control means for photographing the image on said screen onto said sensitized film, processing means for said film and timed means for advancing the exposed film from said camera through said processing means.

2. A system, as set forth in claim 1, in which said optical system comprises mirrors mounted for movement between inoperative and operative positions and shiftable in response to said control signal.

3. A system, as set forth in claim 1, including timed means synchronized by the transmitter control signal for actuating the shutter control

means while the desired image is being received on the kinescope screen, and while the optical system is making the image on the kinescope screen available for the photographic camera.

4. A system, as set forth in claim 1, in which said processing means includes a chamber and said timed means is adapted to advance the exposed film to said chamber and, after a predetermined time, to feed the processed film from said chamber.

5. A system, as set forth in claim 1, having means to cause said receiver to complete a cycle

for the facsimile reproduction of said image in response to each transmission of said control signal.

JOHN HAYS HAMMOND, Jr.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,174,490	Somers	Sept. 26, 1939
2,420,029	Brady	May 6, 1947

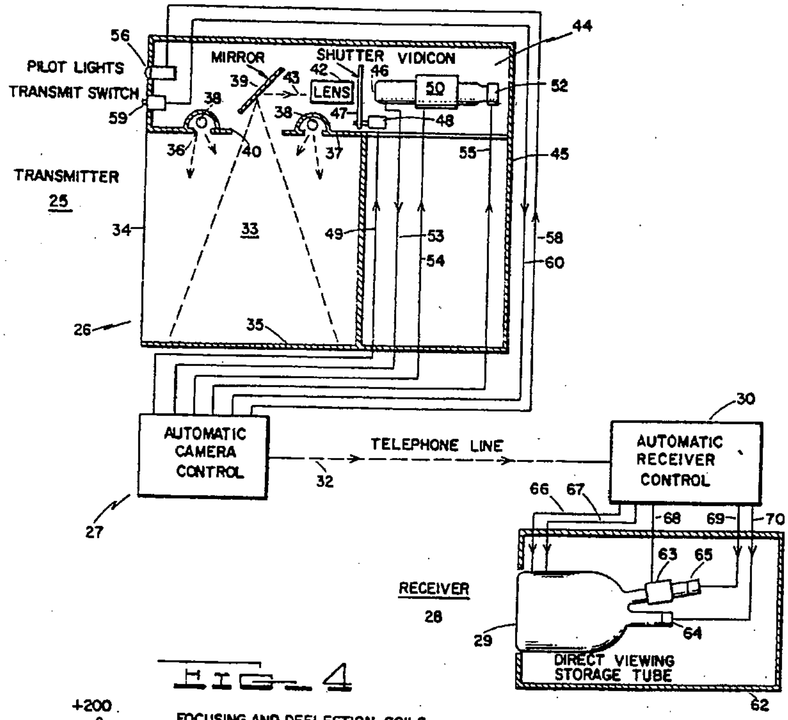
E9595 XR 3,251,937

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

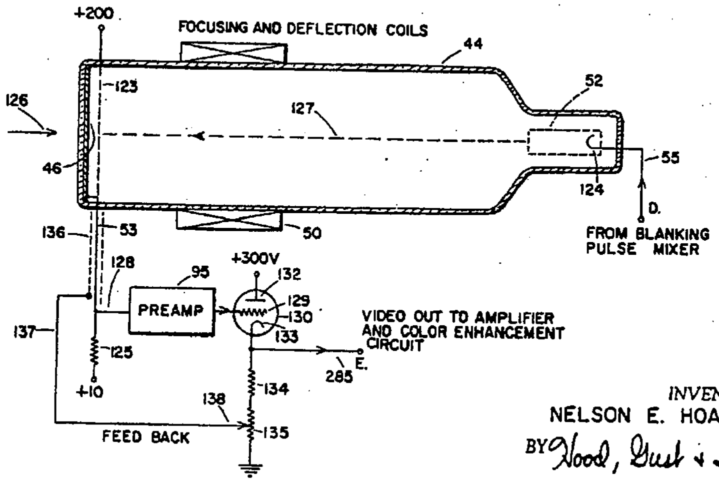
Filed Dec. 20, 1962 15 Sheets-Sheet 1

FIG. 1



T51
X513
.503
X511
X51

FIG. 4



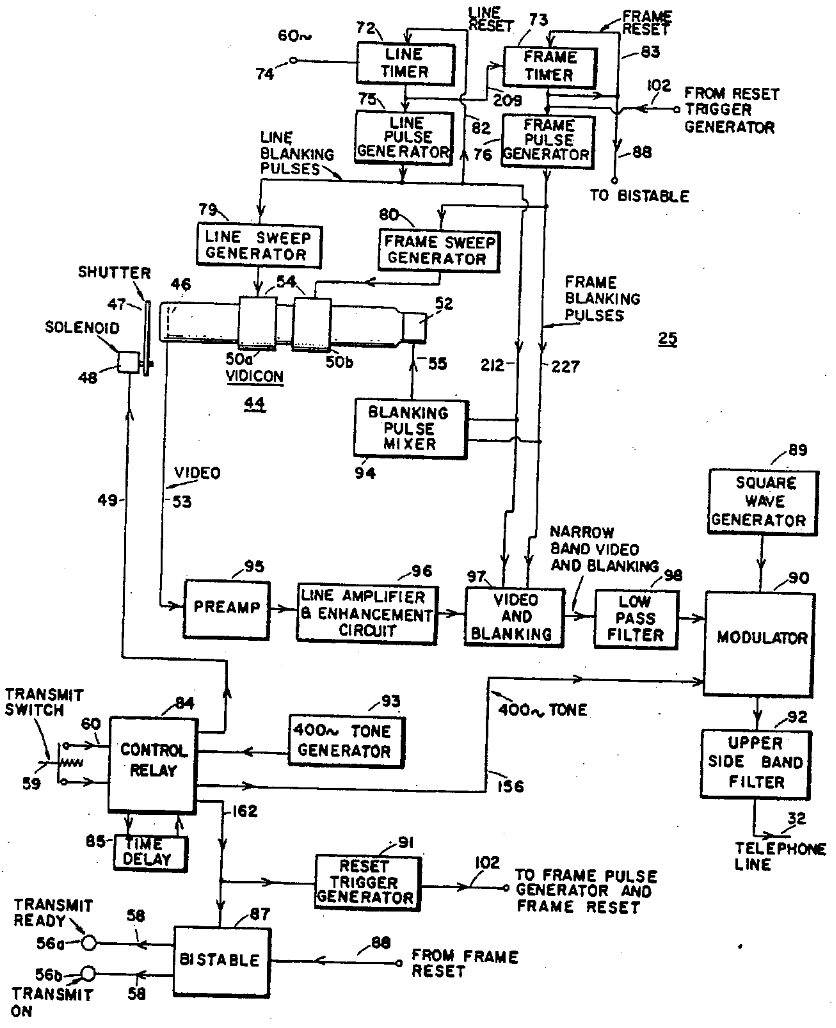
INVENTOR
NELSON E. HOAG

BY Wood, Gust & Irish

ATTORNEYS

B

FIG. 2



INVENTOR.
NELSON E. HOAG
BY Hood, Gust & Irish
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 3

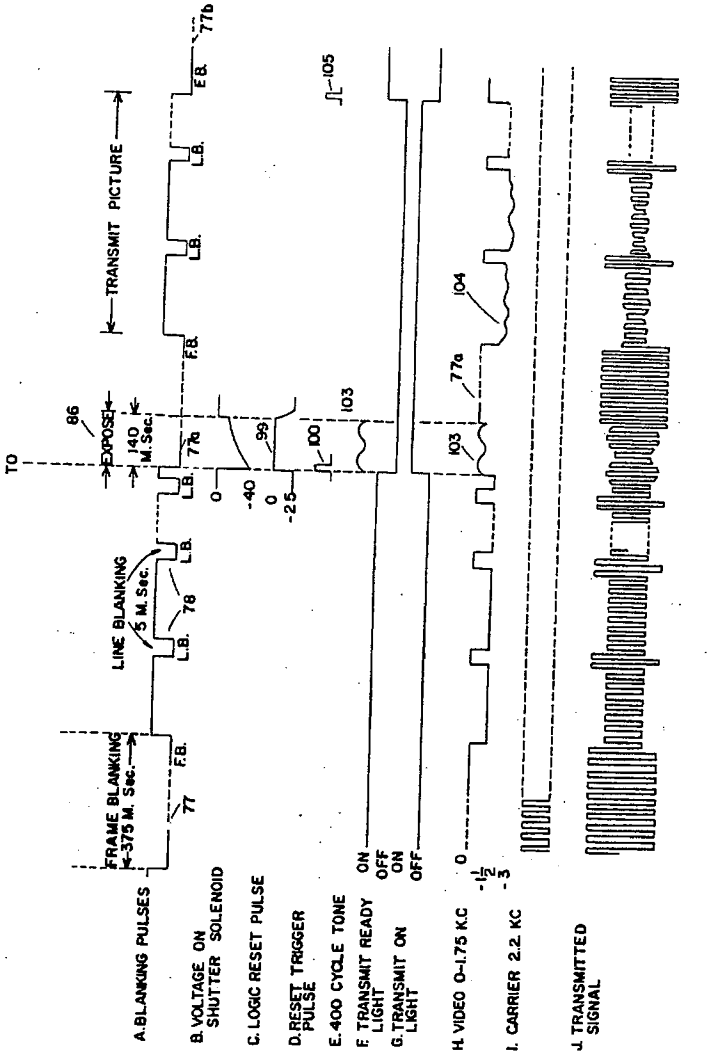


FIG. 3

INVENTOR.
NELSON E. HOAG

BY Wood, Gust & Irish

ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 4

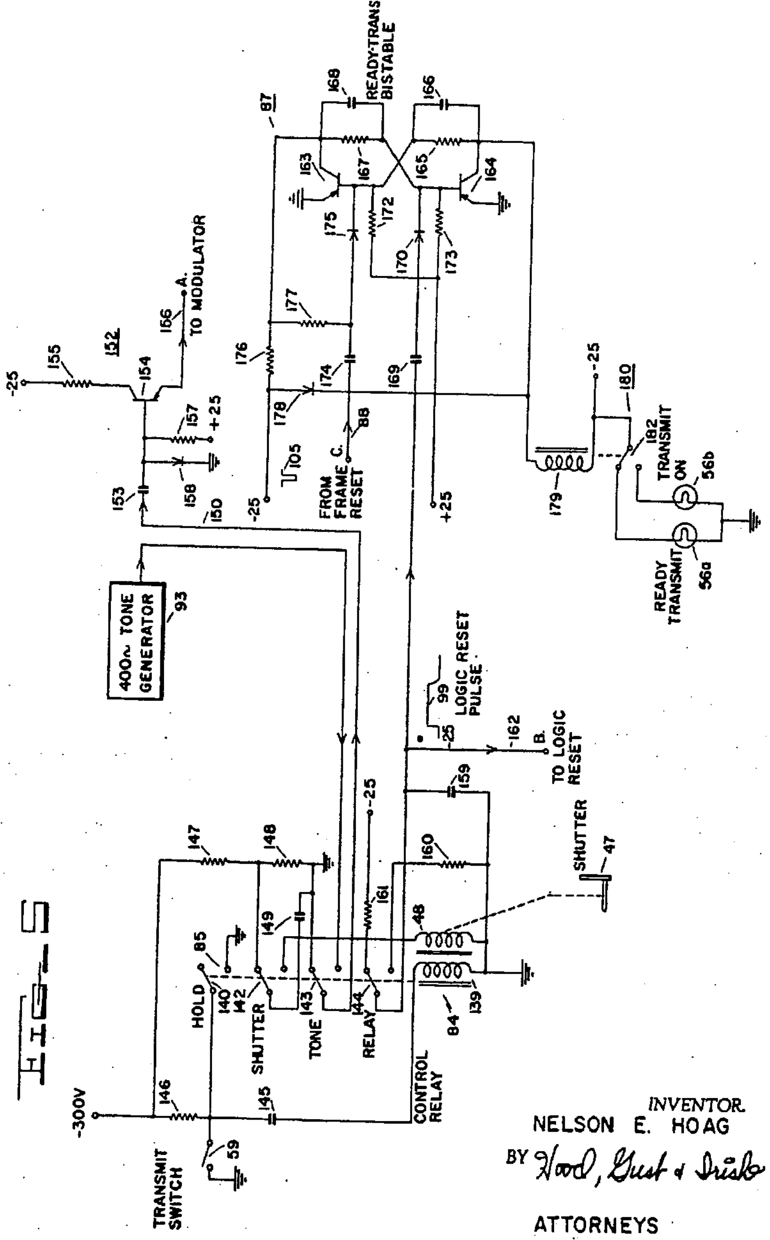


FIG. 5

INVENTOR.
NELSON E. HOAG

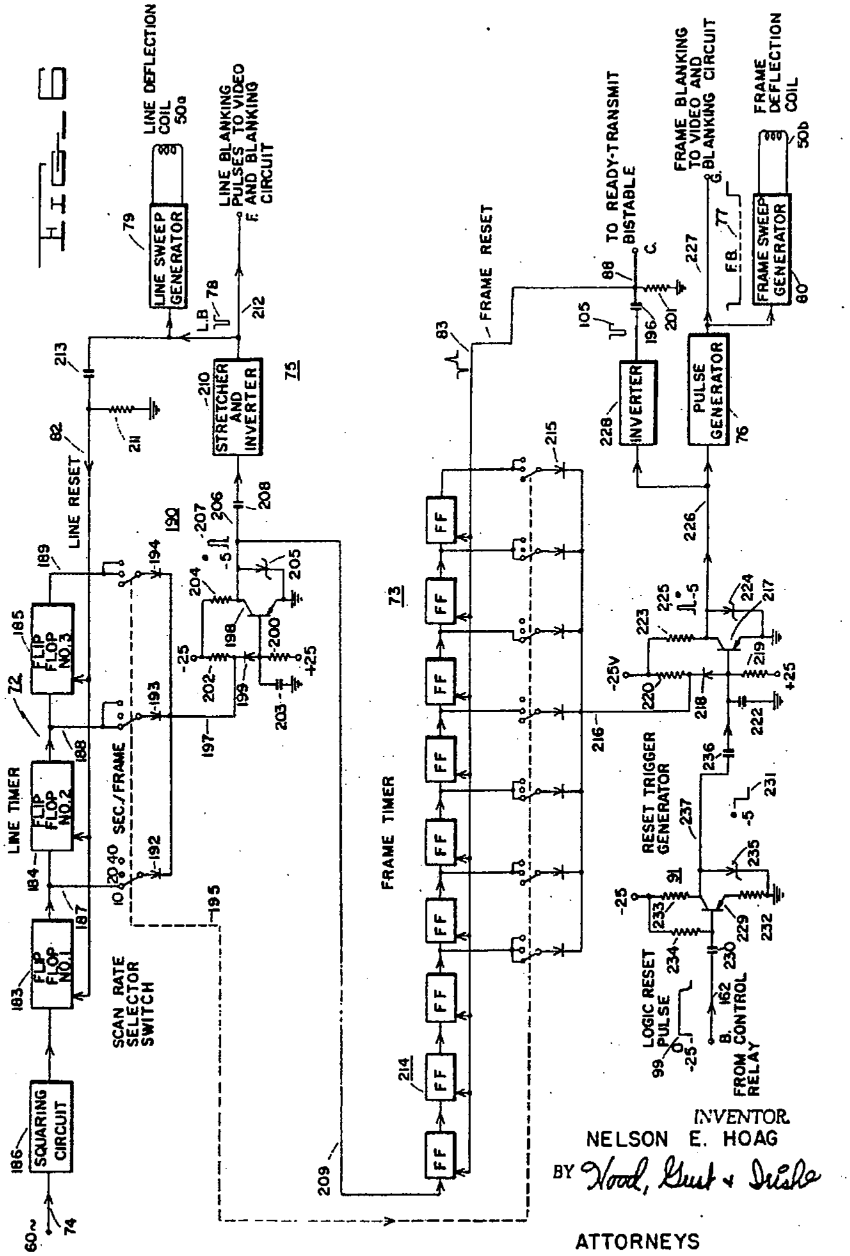
BY Hood, Gust & Irish

ATTORNEYS

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 5

FIG. 5



INVENTOR
NELSON E. HOAG
BY Wood, Gust & Irish
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 6

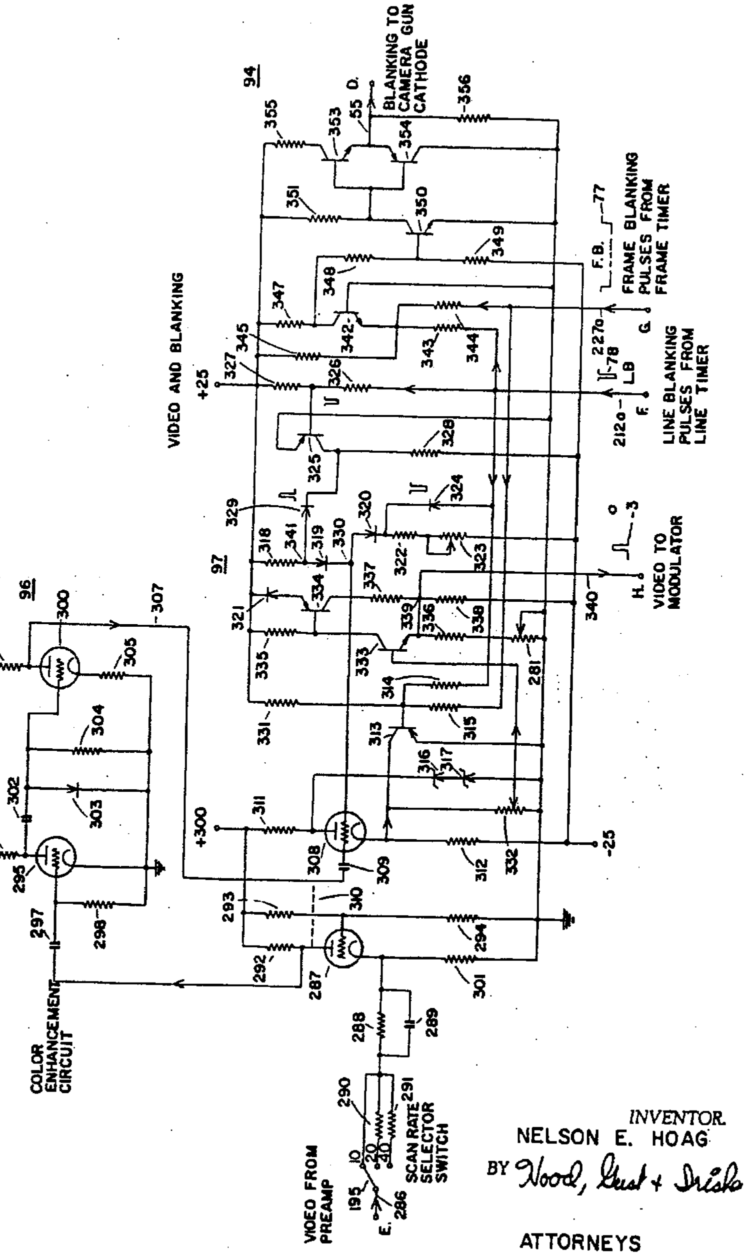


FIG. 7

INVENTOR.
NELSON E. HOAG
BY Wood, Gust + Drisko
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 7

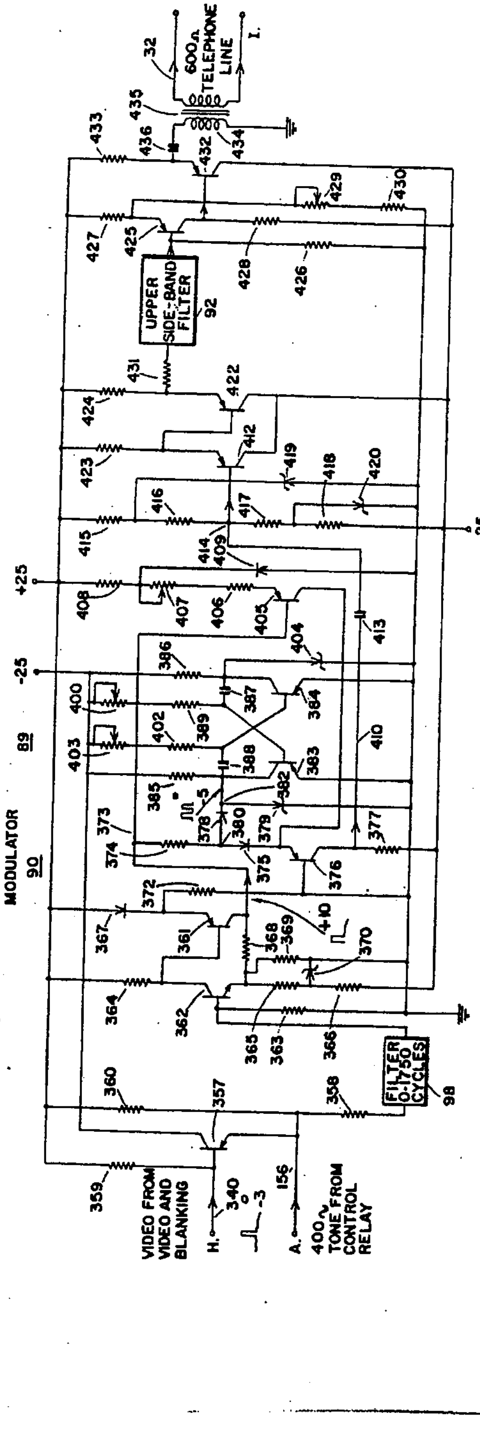


FIG. 11

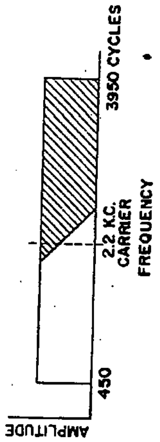


FIG. 12

INVENTOR.
NELSON E. HOAG
BY Wood, Gust & Irish
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 8

VIDICON SWEEP CIRCUIT

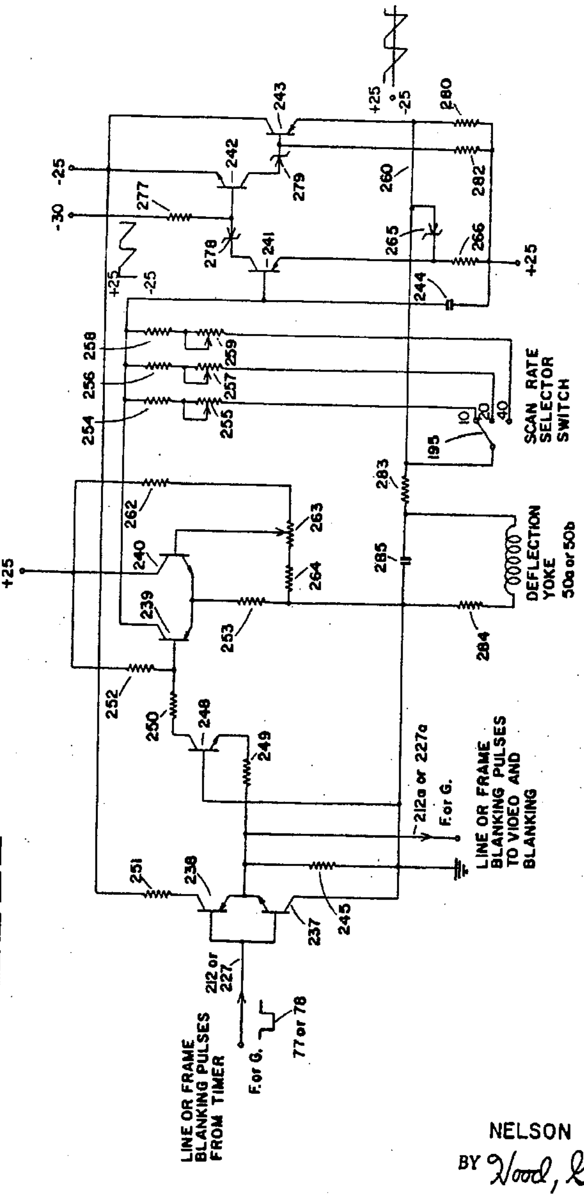


FIG. 10

INVENTOR.
NELSON E. HOAG

BY Wood, Gust & Irish

ATTORNEYS

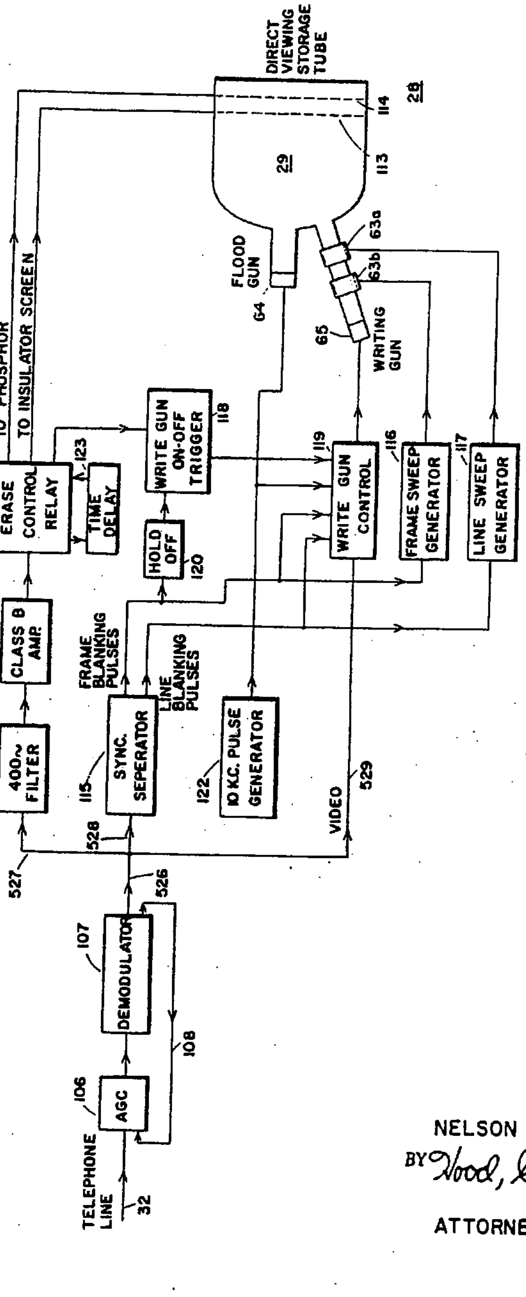


FIG. 11

INVENTOR.
NELSON E. HOAG
BY Wood, Gust + Drisk
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962

15 Sheets-Sheet 10

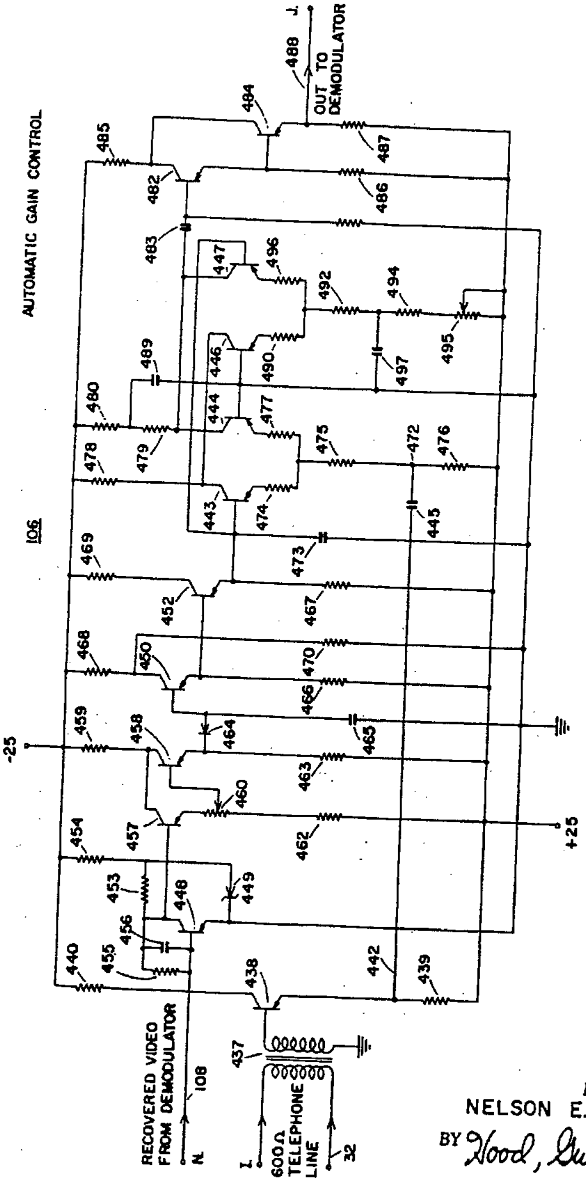


FIG_12

INVENTOR
NELSON E. HOAG
BY Hood, Gust & Irish
ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 11

FIG. 13

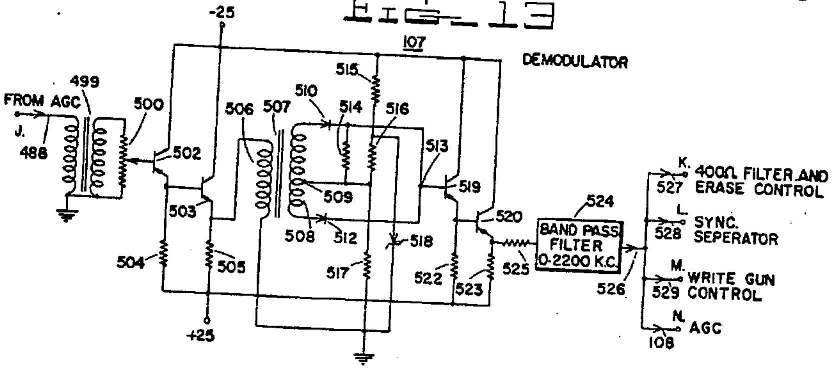
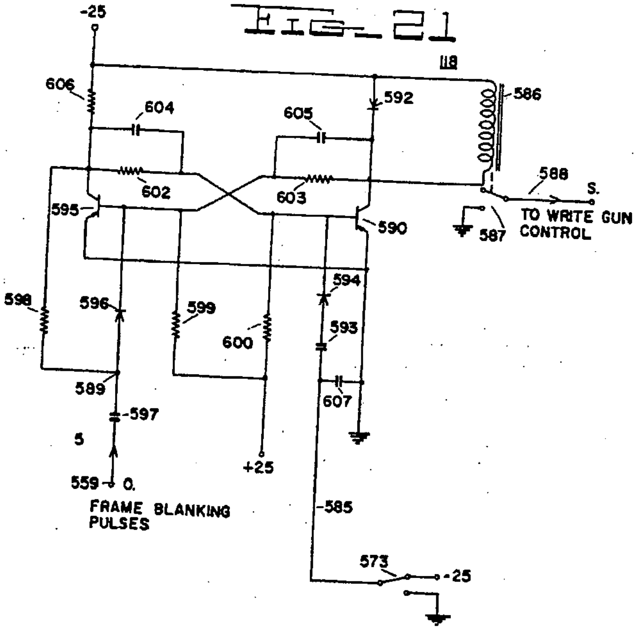


FIG. 21



INVENTOR
NELSON E. HOAG
BY Wood, Gust & Irish
ATTORNEYS

FIG. 14

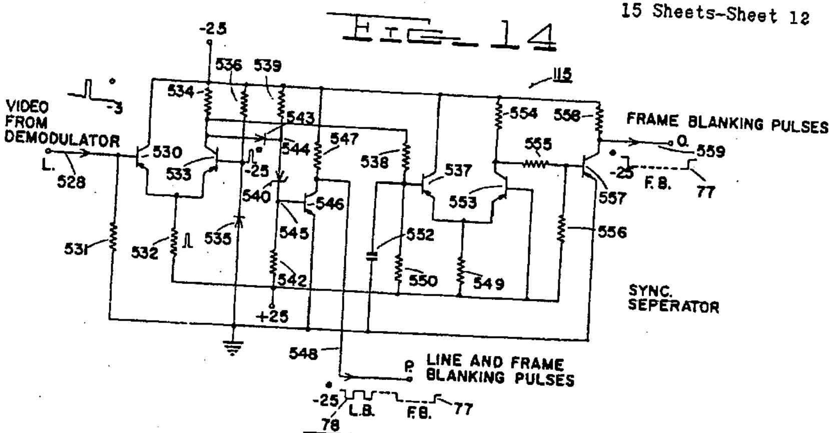
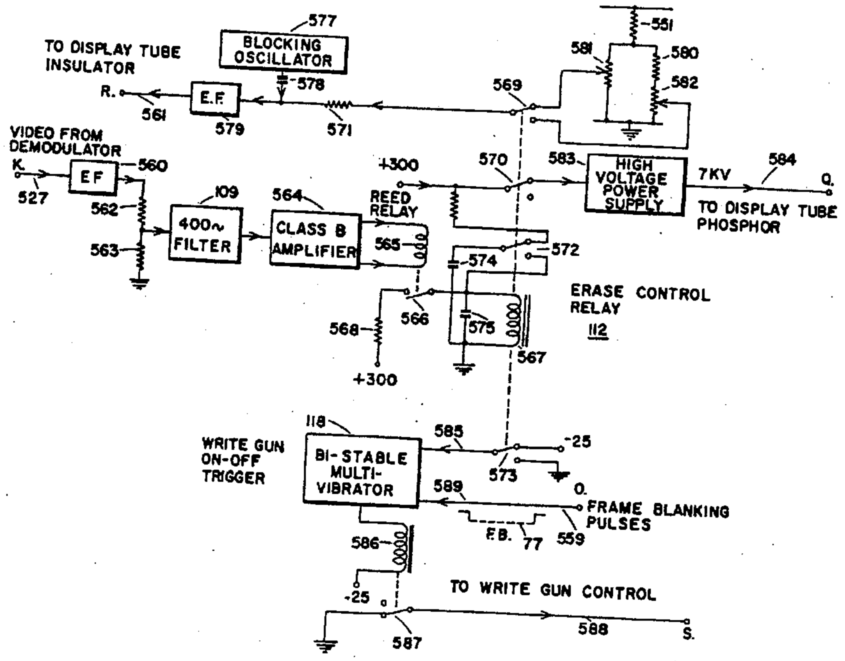


FIG. 15



INVENTOR.
NELSON E. HOAG

BY Hood, Gust & Irish

ATTORNEYS

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962

15 Sheets-Sheet 13

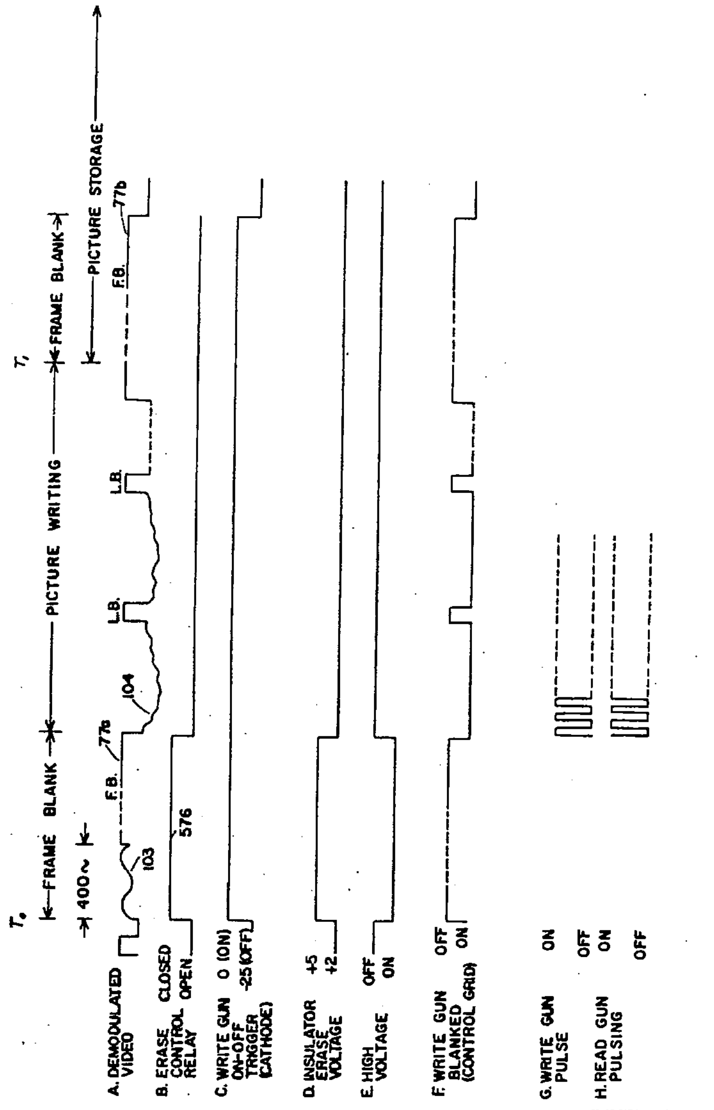


FIG. 15

INVENTOR.
NELSON E. HOAG

BY Wood, Gust & Irish

ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962 15 Sheets-Sheet 14

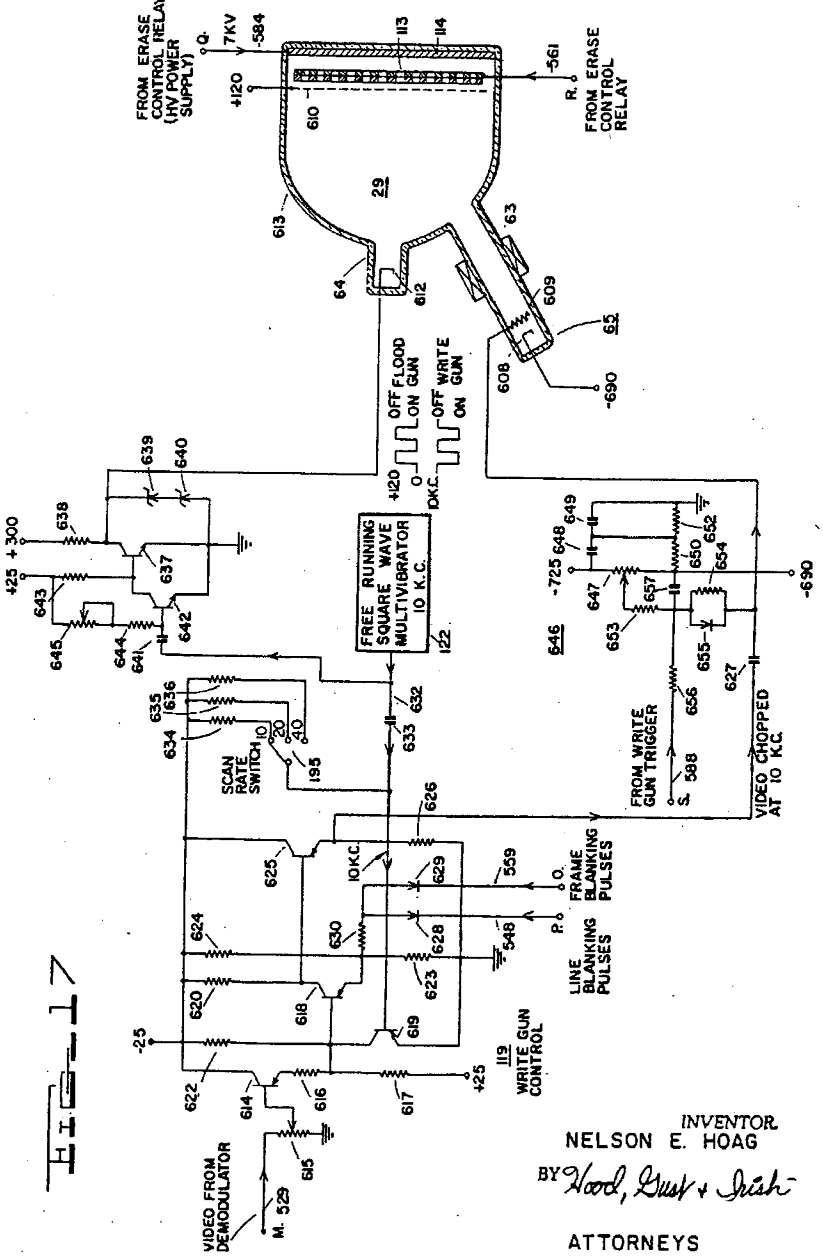


FIG. 17

INVENTOR.
NELSON E. HOAG

BY Hood, Gust + Irish

ATTORNEYS

May 17, 1966 N. E. HOAG 3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Filed Dec. 20, 1962

15 Sheets-Sheet 15

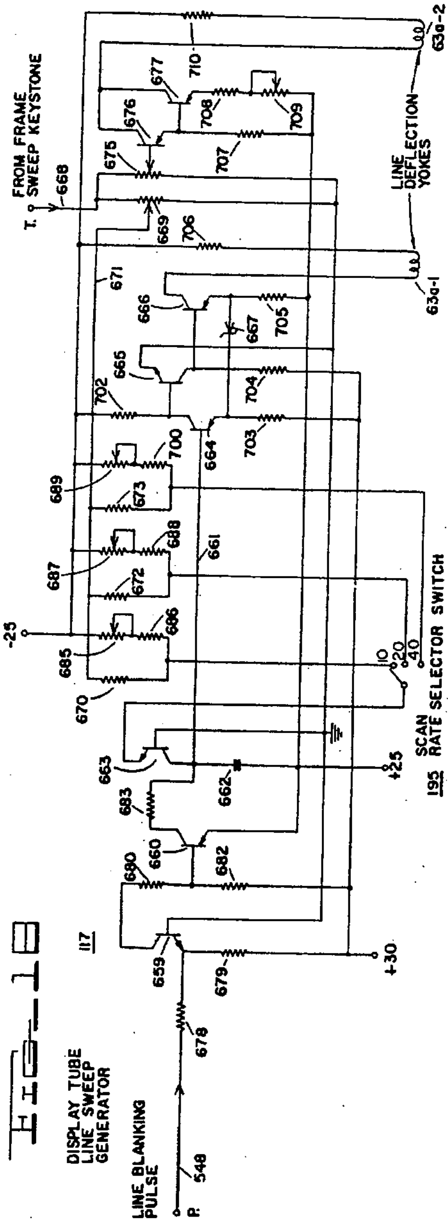
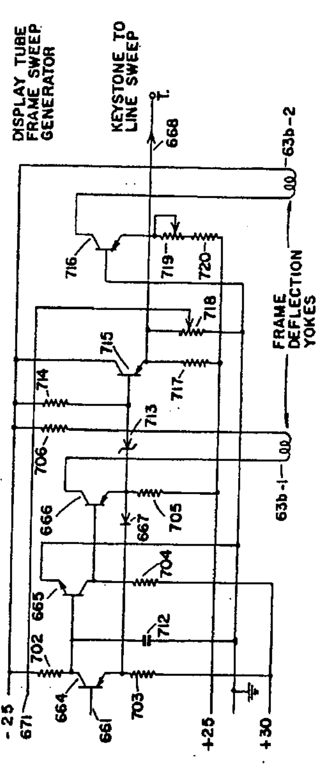


FIG. 18



116

FIG. 19

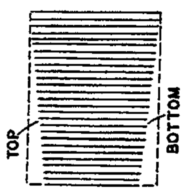


FIG. 20

INVENTOR.
NELSON E. HOAG

BY Hood, Gust + Irish

ATTORNEYS

United States Patent Office 3,251,937
Patented May 17, 1966

3,251,937

IMAGE TRANSMISSION SYSTEM AND METHOD

Nelson E. Hoag, Fort Wayne, Ind., assignor to International Telephone and Telegraph Corporation, Nutley, N.J., a corporation of Maryland

Filed Dec. 20, 1962, Ser. No. 246,103
34 Claims. (Cl. 178—6.8)

This invention relates to a television system and method for transmitting images, and more particularly to an automated narrow band television system for transmitting still pictures over a voice band transmission facility, such as a telephone line.

Conventional television systems, by virtue of their fast scanning rates which are required in order to transmit moving images, require an extremely wide band transmission facility. There are numerous instances, however, where it is not necessary to transmit a moving image, but on the contrary it is only desired to transmit a still picture rapidly, either from previously prepared flat copy, or from a moving scene. It is highly desirable that a system for transmitting still pictures be capable of operation over ordinary voice band telephone lines, even at great distances, and that appreciable viewing time be provided at the receiving station. Applications for such a system for the rapid transmission of still pictures over ordinary telephone channels include signature verification, the transmission of printed or written documents, photographs, drawings, and the like, and the transmission of still pictures from moving scenes such as in news picture gathering, traffic control, and the like.

Conventional closed circuit television systems have been employed for the above purposes, however, as indicated, a wide band transmission facility such as coaxial cable or a microwave link is required, and furthermore, unless a photograph is taken of the image on the display screen at the receiving station, there is no storage of the transmitted picture to permit viewing of the same after transmission has been terminated. Conventional facsimile systems have been employed for the transmission of previously prepared flat copy pictures, however, such systems are limited to flat copy of limited size and the transmission of a single picture requires appreciable time, i.e., ordinarily from 3 to 10 minutes. Furthermore, a facsimile system is not capable of instantaneously transmitting a still picture from a moving scene.

It is further desirable that such a system for still picture transmission be automated to the extent that actuation of a single "transmit" switch button will expose the picture to be transmitted to the image tube, cause erasure of a previously stored picture and restoration of the apparatus at the receiving station to a condition for reception of a new picture, cause transmission of the new picture, and provide an indication at the transmitting station that the picture has been transmitted and that the system is now capable of transmitting another picture.

It is accordingly an object of the invention to provide an improved image transmission system.

Another object of the invention is to provide an improved television system for transmitting still pictures.

A further object of the invention is to provide an improved narrow band television system for transmitting still pictures.

Yet another object of the invention is to provide an automated television system for transmitting still pictures.

A still further object of the invention is to provide an improved television system for transmitting still pictures over a voice band transmission facility.

A still further object of the invention is to provide an improved method of transmitting a still picture.

In accordance with the broader aspects of the system of the invention, image tube means are provided having target means for converting an optical image exposed thereto into a corresponding electrical characteristic pattern and for storing the same for a finite time. Selectively actuable shutter means are provided for exposing the target means to an optical image and the image tube means includes selectively actuable means for converting the stored pattern into a time-based video signal. Means are provided for generating a control signal and means are provided for modulating an input signal to provide an output transmission signal. Control means are provided for actuating the shutter means for a predetermined period thereby to expose the optical image to the target means, the control means including means for coupling the control signal to the modulating means for a predetermined period thereby to modulate the transmission signal. The control means further includes means for actuating the image tube converting means following termination of the exposing and control signal periods and means are provided for coupling the video signal to the modulating means thereby to modulate the transmission signal. Means are provided for demodulating the transmission signal to recover the control and video signals, respectively, and signal-to-image converting means are provided for converting the recovered video signal into an optical image. The converting means includes storage means for maintaining the optical image for a finite time following termination of the video signal, and means are provided for coupling the control signal to the storage means for erasing a previously stored optical image.

In accordance with the method of the invention, an optical image is exposed to the target means of an image tube for a predetermined period and a control signal is transmitted during the same period. The image stored on the target means is then converted into a time-based video signal and transmitted during an interval following the exposing period. The control signal is received and applied to storage signal-to-image converting means for erasing a previously stored image, and the video signal is received and converted into an optical image on the converting means.

More particularly, in accordance with the method of the invention, recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses are generated. In order to transmit a new picture, a new sequence of pulses is initiated and an optical image is exposed to the target means of the image tube for a predetermined period during the first frame pulse of the new sequence of pulses. A tone signal is generated for a predetermined period during the first pulse of a new sequence and the tone is amplitude modulated onto a carrier and the resultant signal transmitted. The target means of the image tube is rectilinearly scanned once with an electron beam in synchronism with the synchronizing pulses during the new sequence following the first frame pulse thereof to convert the optical image on the target means into a video signal, and the carrier is modulated with the video signal and the resultant signal is transmitted. The transmitted signals are received and the tone and video signals are recovered, the tone signal being converted into a control signal which is supplied to the storage means of direct viewing storage cathode ray tube means for erasing a previously stored image. The video signal is converted into an electron beam in the storage tube means that is scanned once over the storage means in synchronism with the synchronizing pulses during the new sequence of pulses following the first frame pulse thereof.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a diagram schematically showing the transmitting and receiving stations of a system incorporating the invention;

FIG. 2 is a schematic diagram generally showing the system of the transmitting station;

FIG. 3 is a diagram showing the wave forms employed in the transmitting portion of the system;

FIG. 4 is a diagram schematically showing the image tube and associated circuitry of the system of FIG. 2;

FIG. 5 is a diagram schematically illustrating the control relay and associated circuitry of the system of FIG. 2;

FIG 6 is a diagram schematically illustrating the line and frame blanking pulse timing and generating portions of the system of FIG. 2;

FIG. 7 is a schematic illustration of the color enhancement circuit and the video and blanking circuit of the transmitting system;

FIG. 8 is a schematic diagram of the modulator portion of the system of FIG. 2;

FIG. 9 is a diagram showing the action of the upper sideband filter of the modulator of FIG. 8;

FIG. 10 is the schematic illustration of a sweep generating circuit of FIG. 2;

FIG. 11 is a schematic diagram generally illustrating the system of the receiving station of FIG. 1;

FIG. 12 is a schematic diagram of the automatic gain control circuit of the system of FIG. 11;

FIG. 13 is a schematic diagram of the demodulator portion of the receiving system;

FIG. 14 is a schematic diagram of the synchronizing pulse separator circuit of FIG. 11;

FIG. 15 is a schematic diagram illustrating the erase control relay and associated circuitry of the receiving system;

FIG. 16 is a diagram showing wave forms employed in the receiving system;

FIG. 17 is a schematic diagram showing the storage tube and the reading and writing gun circuitry associated therewith;

FIG. 18 is a schematic diagram of the line sweep generating circuit of the display tube;

FIG. 19 is a fragmetary schematic diagram of the frame sweep generating circuit for the display tube;

FIG. 20 is a diagram showing the line and frame scanning employed in the invention and the keystone correction provided in the display tube; and

FIG. 21 is a schematic diagram of the writing gun trigger circuit for the system of FIG. 11.

Referring now to FIG. 1 of the drawings, the system of the invention includes a transmitting station 25 comprising a camera unit 26 and a control unit 27, and a receiving station 28 comprising a direct viewing storage cathode ray tube 29 and the control circuitry 30 thereof. The transmitting station 25 and the receiving station 28 may, in accordance with the invention, be connected by an ordinary voice band telephone line, shown by the dashed line 32, or may be interconnected by any radio link.

The transmitting station 25 shown in the drawing is adapted for transmitting still pictures of flat copy and also three-dimensional objects, as opposed to pictures "snapped" from a moving scene. Here the camera unit 26 comprises a picture-taking enclosure 33 open at its end 34 and having a flat copying surface 35. Thus, the photograph, document, or object, a picture of which is to be transmitted, is inserted in the enclosure 33 through opening 34 and placed on the copying surface 35. The document or object is illuminated through openings 36 in the top wall 37 of enclosure 33 by suitable lamps such as fluorescent tubes 38. A suitable mirror 39 views the object on the copying surface 35 through opening 40 in the top wall 37 and reflects the image thereof onto a suitable lens 42, as shown by the dashed line 43.

A suitable camera or image tube 44, such as a vidicon tube No. WL7290 is disposed within the housing 45 so that its target 46 receives the optical image from lens 42. A mechanical shutter 47 is normally disposed between the lens 42 and the target 46 of the image tube 44 to prevent exposure of the target 46 to light, so that the target is normally dark, as will be hereinafter more fully described. Shutter 47 is actuated by solenoid 48 to expose target 46 to the image from lens 42 for a predetermined period, as will hereinafter be described. Solenoid 48 is connected to the camera control unit 27 by connection 49 and is energized thereby as will be hereinafter described. Target 46, deflection coils 50 and the electron gun 52 of image tube 44 are likewise connected to the camera control unit 27 by connections 53, 54 and 55, as will be hereinafter more fully described. Suitable pilot lights 56 mounted on the front of housing 45 are connected to the camera control unit 27 by connection 58 and indicate when the system is ready to transmit a new picture, and when a picture is in the process of transmission, as will be hereinafter described. Transmission of a new picture is initiated, as will be described, by transmit switch 59 on the front of housing 45 connected to the camera control unit by connection 60.

The direct viewing storage cathode ray tube 29, such as No. FW-245 manufactured by the assignee of this application, is mounted in housing 62 and has its display screen, storage electrode 113, deflection coils 63, writing gun 65, and flood gun 64 connected to the receiver control unit 30 by connections 66, 67, 68, 69 and 70, as will be hereinafter described.

In the system of this invention, the storage capability of the vidicon camera tube is substantially increased by the employment of selenium for the photoconductive surface of the target electrode rather than antimony trisulfide as is customarily employed. This permits the image to be stored on the photoconductive surface by means of the lens 42 and shutter 47 for a sufficient length of time to permit scanning of the target electrode in the slow scan parameters necessary to produce a narrow band video signal for transmission over voice band facilities. In a specific embodiment of this system, the scanning rates are such as to provide a narrow band video signal from 0 to 1.7 kc. which is amplitude modulated onto a 2.2 kc. carrier, the modulating signal and upper sideband components being eliminated so as to transmit only the lower side band and carrier components in a vistigal sideband manner.

At the receiving station, the transmitted signal is detected in a manner which permits the highest video frequency to approach .9 of the carrier frequency, as will be hereinafter more fully described. The detected narrow band and video signal is then written into the direct viewing storage cathode ray tube 29 for display, the circuitry at the receiving station providing storage of the displayed image for periods from six to eight minutes following transmission of the picture; a single picture is completely transmitted in one frame, the frame time being selectively adjustable at 10, 20 or to 40 seconds, depending on the resolution desired.

The system is completely automated so that the operator at the transmitting station need only place the document in position in the enclosure 33 and momentarily press the transmit switch button 59, the camera control 27 then automatically actuating the shutter 47 to expose the image to the vidicon 44, causing transmission of a control signal to erase a previously stored image from the display screen of the storage tube 29 at the receiving station and to restore the storage tube to a condition to receive a new image, causing transmission of the new picture following exposure of the vidicon thereto, and finally terminating transmission at the end of one frame and providing an indication on the pilot lights 56 that the system is now ready to transmit yet another picture.

The system further includes circuitry to be hereinafter more fully described, to improve the contrast and readability of documents having different background colors thus to compensate for the variation in sensitivity of the vidicon tube 44 to different colors.

Referring now to FIGS. 2 and 3, there is shown a simplified block diagram of the transmitting station 25 together with the wave forms therein. Line and frame timers 72, 73, coupled to a suitable source of master timing signals, such as a 60-cycle source 74, are coupled respectively to line and frame pulse generators 75, 76 and normally continuously generate recurrent sequences of frame blanking pulses 77 and intervening line blanking pulses 78; in the illustrated embodiment, the frame blanking pulses have a duration of 375 millisecond and the line blanking pulses have a duration of 5 millisecond. As will be hereinafter described, the line and frame timers 72, 73 are arranged selectively to provide frame times of 10, 20, or 40 seconds respectively. The line and frame pulse generators 75, 76 are respectively coupled to line and frame sweep generators 79 and 80 which in turn are coupled to the deflection coils 50 and the vidicon 44.

A resetting circuit 82 couples the output of the line pulse generator 75 back to the line timer 72 in order to reset the same to count-down a new sequence of timing signals to provide a new line timing pulse. The frame timer 73 is coupled to the output circuit of the line timer 72 and thus the line timing pulses from the line timer 72 are counted-down by the frame timer 73 to provide the frame timing pulses. A resetting circuit 83 is provided for the frame timer 73 to reset the same so as to count down a new sequence of line timing pulses in response to the appearance of a frame timing pulse in the output circuit of the frame timer.

The operator, after placing the copy to be transmitted on the surface 35 of the enclosure 33, momentarily actuates the transmit switch 59 which energizes control relay 84. Control relay 84 includes a time delay or holding circuit 85 which maintains the relay energized for a predetermined period 86 (FIG. 3) which, in the specific embodiment, has a duration of 140 milliseconds. Relay 84, when energized, energizes solenoid 48 to actuate shutter 47 thereby to expose target electrode 46 of the vidicon 44 to the image of the copy reflected by mirror 39 through the lens 42. Thus, the target electrode of the vidicon is exposed to the optical image for the period 86 during which the control relay 84 is energized. The target electrode 46 of the vidicon 44 has storage capability and will thus retain the exposed image on the photoconductive surface until it is subsequently scanned off by the electron beam of the tube in the slow scan parameters as will be hereinafter described.

Control relay 84 is coupled to a reset trigger generator 91 which in turn is coupled to the frame pulse generator 76 and the frame reset circuit 83 by line 102. Energization of control relay 84 in response to momentary closing of transmit switch 59 thus causes the reset trigger generator 91 to generate a reset trigger pulse (in essence simulating a frame timing pulse from frame timer 73) which actuates frame pulse generator 76 to generate a new frame blanking pulse 77a (FIG. 3) and also resets the frame timer 73 to initiate a new count-down of line timing pulses from the line timer 72. Thus, momentary actuation of transmit switch 59 initiates a new sequence of frame and line blanking pulses.

Control relay 84 is also coupled to a bistable multivibrator 87 which alternately energizes the "transmit ready" pilot light 56a and the "transmit on" pilot light 56b. When the system is in a condition to receive and transmit a new picture, bistable multivibrator 87 is in one stable condition and energizes the "transmit ready" pilot light 56a. When control relay 84 is energized in response to momentary closing of transmit switch 59, bistable multivibrator 87 is switched to its other stable condition thereby turning off the "transmit ready" light 56a and turning on the "transmit on" light 56b, thus to indicate that transmission of a new picture is in process. Frame reset circuit 83 is coupled to the bistable multivibrator 87 by connection 88 so that the leading edge of the next frame blanking pulse 77b following the first frame blanking pulse 77a of the new sequence switches the bistable multivibrator 87 back to its first stable position thereby extinguishing the "transmit on" light 56b and again illuminating the "transmit ready" light 56a to indicate that a complete picture has been transmitted and that the system is now in condition to receive and transmit still another new picture.

A square wave generator 89 is provided for generating the square wave carrier signal, which in the specific embodiment has a frequency of 2.2 kc. A modulator 90, to be hereinafter more fully described, is provided for modulating the square wave carrier provided by the generator 89, the modulator 90 including means for cancelling the modulating signal component. The output circuit of the modulator is coupled to band pass filter 92 which removes the upper sideband component from the output of the modulator 90. The resultant transmission signal comprising the carrier and lower sideband components is coupled to a conventional 600 ohm voice band telephone line 32 for transmission to the receiving station 28. With this system, the telephone line 32 may be of any length from a few feet to thousands of miles.

A tone generator 93 is provided which, in the specific embodiment, provides a 400 cycle tone; the only requirement as to the frequency of the tone is that it be below the upper frequency of the video signal. Energization of control relay 84 couples the tone generator 93 to the modulator 90 during the period 86 so that the square wave carrier during that period is modulated by the 400 cycle tone.

The frame and line blanking pulses 77, 78 are non-additively mixed in mixer 94 and coupled to the electron gun 52 of the vidicon tube 44 for blanking the electron beam therein in response to each frame and line blanking pulse. The target electrode 46 of the vidicon tube 44 is coupled by connection 53 to a preamplifier circuit 95 which in turn is coupled to a color enhancement circuit 96 to be hereinafter more fully described. The frame and blanking pulses 77, 78 are inserted in the video signal by the video and blanking circuit 97 and the resulting narrow band viedo and blanking signal is passed through low pass filter 98 which passes the video frequency, i.e., 0 to 1.7 kc. to the exclusion of higher frequencies.

Referring specifically to FIG. 3A it will be seen that the recurrent sequences of frame blanking pulses 77 and intervening line blanking pulses 78 are continuously generated by the line and frame timers 72, 73 and the line and frame pulse generators 75, 76, however, that actuation of the transmit switch 59 at T_0 initiates period 86 and a new sequence of frame and line blanking pulses, the period 86 being shorter than a frame blanking pulse. FIG. 3B shows the voltage applied to the shutter solenoid 48 thereby actuating the same to expose the image to the target electrode 46 of the vidicon 44 during the period 86. FIG. 3C shows the logic reset pulse 99 applied to the reset trigger generator 91 by the control relay 84 during the period 86. The logic reset pulse 99 triggers the reset trigger generator 91 to generate reset trigger pulse 100 which is applied to frame pulse generator 76 by connection 102 thereby to initiate the new frame blanking pulse 77a, and to the frame reset circuit 83 to reset the frame timer 73.

In FIG. 3E, it is seen that the 400 cycle tone 103 is transmitted during the period 86 and in FIGS. 3F and G it is seen that the logic reset pulse 99 provided by the control relay 84 during the period 86 switches the bistable multivibrator **87** to turn the "transmit ready" light **56a** OFF and the "transmit on" light **56b** ON.

As will be hereinafter more fully described, the level of the video signal applied to the modulator **90** when no image is stored on the target electrode **46** of vidicon **44** which is being scanned by the electron beam thereof, is set by the video and blanking circuit **97** to 0 volts in the presence of a blanking pulse and minus 1½ volts in the absence of blanking pulses. Since the blanking pulses have been inserted in the video signal by the video and blanking circuit **97**, and since the 400 cycle tone **103** is coupled to the modulator **90** during the first frame blanking pulse **77a** of the new sequence, it will be seen in FIG. 3H that the 400 cycle tone is superimposed on the first frame blanking pulse **77a**.

It will be seen that at the end of the period **86** provided by the time delay **85** of the control relay **84**, an image is stored on the target electrode **46** of the vidicon **44**, however, the scanning-off of the image by the electron beam does not start until the end of the first frame blanking pulse **77a** since it will be recalled that the electron beam of the vidicon **44** is blanked-off by the frame blanking pulse **77a**. It will also be understood that the line and frame sweeps for the electron beam of the vidicon tube **44** have been reset to their original positions during the first frame blanking pulse **77a** of the new sequence initiated at T_0 so that scanning-off of the image stored on the target electrode **46** by the electron beam begins at the end of the first frame blanking pulse **77a**. This provides a time-based video signal **104** in the intervals between line-blanking pulses **78** having a dark level of −1½ volts and a white level of −3 volts as set by the video and blanking circuit **97**.

At the end of the new sequence of frame and line blanking pulses initiated at T_0, the frame timer **73** provides timing pulse **105** which is applied to the frame pulse generator **76** to generate the next frame blanking pulse **77b** and is also applied to the frame reset circuit **83** to reset the frame timer **73**. Frame reset pulse **105** is also applied by connection **88** to the bistable multivibrator **87** to switch the same to its initial stable position thereby to turn ON the "transmit ready" light **56a** and to turn OFF the "transmit ON" light **56b** as shown in FIGS. 3D, F, G, and H.

Referring now to FIGS. 3I and J, the square wave carrier provided by the square wave generator **89** is amplitude modulated by the balanced modulator **90** as shown in FIG. 3J, a 0 level video signal during the blanking pulses providing no modulation and the −3 volt white level video signal providing 100% modulation. Normal white level modulation is preferably held to 35% to minimize 2nd order distortion in the output.

Turning now to FIG. 11 which is a simplified block diagram of the receiver **28**, and to FIG. 16 which shows the wave forms in the receiver, an automatic gain control circuit **106** is provided which receives the signal transmitted over the telephone line **32**. The AGC circuit **106** is coupled to the demodulator **107**, a portion of the recovered signal being fed back to the AGC circuit **106** by connection **108**; the AGC circuit **106** and demodulator **107** will be hereinafter more fully described.

The 400 cycle tone, after being detected as a part of the narrow band video in the receiver, is filtered out by a very narrow band pass filter **109**, is amplified in amplifier **110**, and employed to energize erase control relay **112**. Erase control relay **112** is coupled to the storage electrode or insulator **113** of storage tube **29** and when energized, applies the proper potential to the insulator **113** to erase a previously stored image therefrom. Erase control relay **112** is also coupled to the display screen or phosphor **114** of storage tube **29** and when energized, disconnects the high voltage power supply therefrom.

A synchronizing pulse separator circuit **115** receives the frame and line blanking pulses after detection as a part of the narrow band video signal and separates the blanking pulses therefrom, as will be hereinafter described. The sync. separator **115** is coupled to the frame and line sweep generators **116**, **117**, which in turn are coupled to the deflection coils **63** for the writing gun **65** of the storage tube **29**. The erase control relay **112** is coupled to trigger a bistable multivibrator **118** to one of its stable conditions in response to energization of the relay **112**. The bistable multivibrator or "write gun ON-OFF trigger" **118** is in turn coupled to the writing gun control circuit **119** to actuate the writing gun **65** of the storage tube **29**. The frame blanking pulses separated by the sync. separator **115** are coupled to the ON-OFF trigger **118** through a hold-off circuit **120** so that the trailing edge of frame blanking pulse **77b** following the first frame blanking pulse **77a** of the new sequence initiated at T_0 switches the ON-OFF trigger **118** to its other stable condition thereby to actuate the writing gun control **119** to turn off the writing gun **65**. The frame and line blanking pulses from the sync. separator **115** are also coupled to the writing gun control **119** to turn off the writing electron beam during each blanking pulse.

In order to provide for storage of the transmitted picture on the display screen **114** of the storage tube **29** for an appreciable length of time following completion of the transmission of a picture, i.e., one frame, a pulse generator **122** is provided coupled respectively to the flood gun **64** of the storage tube **29** and to the write gun control **119** to pulse the writing electron beam and the flood electron beam alternately on and off at a frequency substantially higher than any other frequency employed in the system; in this specific embodiment, pulse generator **122** provides pulses having a frequency of 10 kc.

It will now be seen that the 400 cycle tone **103** is transmitted at the beginning of a new picture transmission, i.e., is superimposed upon the first frame blanking pulse **77a** of the new sequence of frame and line blanking pulses initiated by actuation of transmit switch **59**, whereas actual picture transmission does not begin until the end of the first frame blanking pulse **77a**, erasure of a previously stored picture being accomplished just prior to transmission of a new picture and writing the same onto the insulator **113** of the storage tube **29**. It will also be understood that since the first frame blanking pulse **77a** of the new sequence is received simultaneously with the 400 cycle tone **103**, the sweep circuits **116** and **117** of the storage tube **29** are returned to their respective starting positions so that at the end of the first frame blanking pulse **77a** of the new sequence, the sweep circuits of both the vidicon **44** and the storage tube **29** are in their starting positions for respectively scanning-off the video signal of the target electrode **46** of the vidicon **44** and for simultaneously writing the same onto the insulator **113** of the storage tube **29** during the remainder of the frame initiated at T_0.

Erase control relay **112** is provided with a time delay **123** for maintaining the same energized for a period longer than the duration of the 400 cycle tone but less than the duration of the first blanking pulse **77a** and thus, the erase control relay **112** is energized for the period **576** shown in FIG. 16B. As indicated, energization of the erase control relay **112** actuates the write gun ON-OFF trigger **118** to in turn actuate the writing gun control **119** to turn on the writing gun **65** whereas the trailing edge of the frame blanking pulse **77b** following the first frame blanking pulse **77a** actuates the trigger circuit **118** and the writing gun control **119** to turn off the writing gun **65** as shown in FIG. 16C. It will be seen in FIG. 16D that an erasing potential of +5 volts is applied to the insulator **113** of the storage tube **29** during the period when the erase control relay **112** is energized. It will likewise be seen in FIG. 16E that the high voltage applied to the display screen **114** of the storage tube **29** is disconnected therefrom during the period **576** when the erase control relay **112** is energized in order to prevent a momentary flash of light on the screen when the reading gun **64** is turned on. The blanking of the writing gun **65** by the frame and line blanking pulses is shown in FIG. 16F. The alternate ON and OFF pulsing of the reading or flood gun **64** and the writing gun **65** of the storage tube **29** by the pulse generator **122** is shown in FIGS. 16G and H.

It will now be seen that when the transmit switch **59** at the transmitting station **25** is actuated at T_0, if a previously stored picture is still persisting, it is erased from the storage tube **29** at the receiving station **28**, and that a new picture is written into the storage tube during one frame, the writing gun **65** being turned off at the end of the one picture-transmitting and writing frame, but the picture being stored and thus displayed on the display screen **114** for a period as long as 8 minutes following the one frame in which it was transmitted and written into the storage tube. However, immediately upon completion of the one frame transmission and writing period initiated at T_0, i.e., at T_1, the "transmit ready" light **56***a* at the transmitting station **25** is illuminated and a new picture may be transmitted at any time thereafter; if, as above described, the transmit switch **59** is actuated to transmit a new picture during the 6 to 8 minutes persistence period of a previously transmitted picture, that picture is erased to permit writing in of the new transmitted picture in the storage tube **29**.

Turning now to FIG. 4, the vidicon tube **44** includes a collector screen **123** adjacent the photoconductive target electrode **46** and connected to a suitable source of potential such as +200 volts. Electron gun **52** includes a cathode **124** coupled to the blanking pulse mixer **94** by lead **55** for receiving the frame and line blanking pulses therefrom, and also conventional beam forming and accelerating electrodes (not shown), for providing the electron beam **127** which is scanned over the target electrode **46** by the deflection coils **50**. The photoconductive target electrode **46** is connected to a suitable source of potential, such as +10 volts by load resistor **125** and lead **53**. As indicated, employing selenium for the photoconductive surface of the target electrode **46** instead of the conventional antimony trisulphide, increases the storage time of the target electrode sufficiently to permit scanning-off of the stored image with the slow scan paramater employed in the system. It will be understood that the target electrode **46** is normally dark except during the period **86** when the solenoid **48** is energized to actuate shutter **47** thus exposing target electrode **46** to an image from lens **42** as indicated by arrow **126**. It will be observed that the electron beam **127** provided by the electron gun **52** is continuously scanned over the surface of the target electrode **46** thus bringing the surface of the photoconductor to cathode potential, i.e., to ground.

When the target electrode **46** is exposed to light by the shutter **47**, the electron beam **127** being blanked off during the period of exposure as above described, the areas of the target electrode which are exposed to light discharge toward the target voltage. Thus, when scanning of the target electrode by the electron beam **127** is resumed following the end of the first frame blanking pulse **77***a* of the new sequence, the amount of beam current flowing in the load resistor **125** to restore the potential of the photoconductive surface to cathode potential provides the time-based video signal. The employment of the conventional antimony trisulphide for the photoconductive surface **46** would provide an excessive "dark current," i.e., leakage current with the target electrode dark, with the result that no signal would remain at the slow scanning rates employed in this system.

Preamplifier **95** which may have any conventional circuit configuration, has its input circuit **128** coupled to the end of load resistor **125** to which the lead **53** is connected. The output circuit of preamplifier circuit **95** is coupled to the control grid **129** of a triode tube **130** having its plate **132** coupled to a suitable source of potential, such as +300 volts and having its cathode **133** coupled to ground by resistor **134** and potentiometer **135**. Cathode **133** of tube **130** is coupled to the input circuit of the line amplifier and color enhancement circuit **96**, thus providing a conventional cathode-follower connection.

A metalic shield **136** surrounds the target electrode lead **53** in order to prevent pickup of stray signals, however, the distributed capacitance of the shield **136**, the target electrode **46**, and elsewhere in the circuit, shunts the load resistor **125** thus reducing the high frequency response of the system. Since it is desirable that the response of this portion of the system be flat to a frequency of 2 kc., i.e., above the maximum video frequency of 1.75 kc., it is necessary to compensate for this distributed capacitance. This is accomplished by providing a feed-back connection **137** from the end of the shield **136** adjacent the load resistor **125** to the movable element **138** of the potentiometer **135**. Thus, by providing a positive feedback connection from the shield **136**, the high frequency end of the video pass band may be controlled.

Referring now to FIG. 5, control relay **84** comprises an operating coil **139** and four contacts **140**, **142**, **143**, and **144** actuated thereby between first positions when coil **139** is de-energized, as shown in FIG. 5, and second positions when the coil is energized. Operating coil **139** has one end connected to ground and its other end connected to a suitable source of potential, such as −300 volts by capacitor **145** and resistor **146**. It will thus be seen that capacitor **145** is normally charged to −300 volts through resistor **146** at a rate insufficient to pull in control relay **84**. Transmit switch **59**, when momentarily actuated, shorts capacitor **145** to ground thus causing it to discharge through coil **139** to energize the same thus moving contacts **140**, **142**, **143**, **144** to their second positions. Contact **140** is a holding contact which, in its second position, connects capacitor **145** to ground despite release of transmit switch **59**. Capacitor **145** thus continues to discharge until coil **139** is de-energized restoring the contacts **140**–**144** to their first positions, thus establishing the period **86**. It will thus be seen that capacitor **145**, the resistance of control relay **84** and the holding contacts **140** comprise the time delay circuit **85** for the control relay **84**.

The shutter actuating solenoid coil **48** has one end connected to ground and its other end connected to the normally open side of contact **142** of control relay **84**. Resistors **147** and **148** are connected between the −300 volt source and ground. Contact **142** in its normally closed position, i.e., when operating coil **139** of control relay **84** is de-energized, couples capacitor **149** across resistor **148** so that capacitor **149** is normally charged to the voltage drop across resistor **148**. When coil **139** of control relay **84** is energized as above-described, contact **142** connects capacitor **149** to discharge through shutter actuating solenoid coil **48** thus energizing the solenoid coil and actuating shutter **47**, the voltage provided on the solenoid coil **48** by discharge of capacitor **149** therethrough being shown in FIG. 3B. This arrangement is provided in the illustrated embodiment in order to provide the heavy current necessary for energizing the solenoid coil **48** to provide the requisite fast operation of the shutter **47**.

The 400 cycle tone generator **93**, which may comprise a conventional reed relay with suitable amplification, is coupled to the normally open position of contact **143** of control relay **84**. Contact **143** in its normally closed position grounds the input circuit **150** of emitter follower **152** and when operating coil **139** is energized, couples the 400 cycle tone generator **93** thereto. Emitter follower **152** comprises capacitor **153** coupling the input circuit **150** to the base of transistor **154** which has its collector coupled to a suitable source of potential, such as −25 volts by resistor **155** and which has its emitter coupled to low pass filter **98** by connection **156** as will be hereinafter described; resistor **358** (FIG. 8) is the emitter resistor. The base of transistor 154 is also connected to a source of +25 volt potential by resistor 157 and a diode 158 is connected between the base and ground, as shown. Diode 158 and resistor 157 normally bias transistor 154 OFF in the absence of the input 400 cycle tone, diode 158 clamping the most positive excursion of the 400 cycle wave form to ground causing it to swing negative from ground so that the output signal in line 156 goes negative and is thus at the proper direct current potential level for the modulator.

Contact 144 of control relay 84 in its normally closed position couples capacitor 159 to a source of −25 volts through resistor 161. Capacitor 159 thus is charged to −25 volts when operating coil 139 of relay 84 is de-energized. When coil 139 is energized, contact 144 connects line 162 to ground through resistor 160. Capacitor 159 is a relatively large capacitor and is thus immediately discharged so that the potential of line 162 immediately rises to 0 to provide the logic reset pulse 99.

The ready-transmit bistable multivibrator 87 comprises transistors 163 and 164 with the base of transistor 163 connected to the collector of transistor 164 by resistor 165 and capacitor 166 and with the base of transistor 164 connected to the collector of transistor 163 by resistor 167 and capacitor 168. Line 162 from the reset contact 144 of relay 84 is coupled to the base of transistor 164 by capacitor 169 and diode 170. A source of +25 volt potential is connected to the base of transistor 163 and the base of transistor 164 by resistors 172 and 173 respectively. Frame reset pulses 105 from the frame reset circuit 83 are connected by line 88 to the base of transistor 163 through capacitor 174 and diode 175. The collector of transistor 163 is connected to a source of −25 volt potential by resistor 176 and resistor 177 is connected between the collector of transistor 163 and a point between capacitor 174 and diode 175. Diode 178 protects transistor 164 from switching transients due to relay coil 179. The emitters of both transistors are grounded, as shown.

The above described circuit of bistable multivibrator 87 is conventional, and other conventional bistable multivibrator circuits may be substituted therefor, however, it will be observed that the collector of transistor 164 is coupled to a source of −25 volt potential through operating coil 179 of relay 180. Contact 182 of relay 180 in its closed position, i.e., with coil 179 energized, energizes "ready transmit" pilot light *56a* and when coil 179 is de-energized, contact 182 energizes "transmit ON" pilot light *56b*.

It will be readily seen that in the normal stable or stand-by state of bistable multivibrator 87, coil 179 of relay 180 is energized so that contact 182 energizes "ready transmit" pilot light *56a*. When coil 139 of relay 84 is de-energized, responsive to momentary actuation of transmit switch 59, as above-described, the positive-going leading edge of the logic reset pulse 99 switches the bistable multivibrator 87 to its other stable condition de-energizing coil 179 of relay 180 and causing contact 182 to extinguish pilot light *56a* and to illuminate the "transmit ON" pilot light *56b*. It will further be seen that timing pulse 105 from frame timer 73 which initiates the next frame blanking pulse *77b* will again switch bistable multivibrator 87 back to its first stable position thus energizing operating coil 179 of relay 180 and causing contact 182 to extinguish the "transmit ON" pilot light *56b* and again to illuminate the "ready-transmit" pilot light *56a*.

Referring now to FIG. 6, line timer 72 comprises a bistable counting chain having three conventional bistable multivibrator or flip-flop circuits 183, 184 and 185, flip-flop circuit 183 being connected to the 60 cycle source of timing signals 74 by a conventional squaring circuit 186. The flip-flops 183, 184, and 185 are serially connected so as to count-down the squared 60 cycle timing signal, as is well known.

Each of the three flip-flops 183, 184, and 185 has a timing pulse pick-off circuit 187, 188, and 189 selectively coupled to diode logic circuit 190 comprising diodes 192, 193, and 194 by a scan rate selector switch 195 for selectively providing the 10, 20, or 40 second frame rate.

The output circuit 197 of the logic circuit 190 is coupled to the base of transistor 198 by diode 199. The base of transistor 198 is connected to a source of +25 volt potential by resistor 200 and to a source of −25 volt potential by resistor 202 and diode 199. A capacitor 203 couples the base of transistor 198 to ground. The collector of transistor 198 is connected to the source of −25 volt potential by resistor 204 and to ground by a zener diode 205, the emitter being grounded as shown.

When the flip-flops 183, 184, 185 are initially reset to initiate a new count-down operation, those of the diodes 192, 193, and 194 which are connected in the logic circuit by the particular position of scan rate selector switch 195 are grounded thus placing the base of transistor 198 slightly positive so that transistor 198 is cut-off. Therefore, the potential level in the output circuit 206 connected to the collector of transistor 198 will, by virtue of the zener diode 205 be −5 volts. As the count in the respective output circuits 187, 188, and 189 of the flip-flops 183, 184, 185 is impressed upon the diodes 192, 193, 194, depending upon the position of switch 195, the desired predetermined pulse count is reached when the connected logic diodes are back-biased negatively thereby opening the connection 197 so that the base of transistor 198 assumes the potential provided by the voltage divider formed of resistor 200, diode 199 and resistor 202. Under these conditions, the base of transistor 198 goes sufficiently negative to turn on transistor 198 thus providing ground or 0 voltage potential at the collector to provide the positive-going line timing pulse 207 in the output circuit 206. Capacitor 203 is provided in order to short-circuit any switching transients involved in the operation of the logic diodes 192, 193, 194.

The positive-going line timing pulses 207 are coupled to the frame timer 73 by connection 209 and also to a conventional stretching and inverting circuit 210 by capacitor 208. Stretching and inverting circuit 210 provides the negative-going 5 millisecond line blanking pulses 78 in its output circuit 212. Output circuit 212 of the stretching and inverting circuit 210 is coupled to the video and blanking circuit 97, to the line sweep generator 79, and to the line reset circuit 82 for the flip-flops 183, 184, and 185 by differentiating circuit 211, 213 which provides the requisite positive-going pulse to reset the line timer flip-flops.

The line timing pulses 207 in line 209 are coupled to a bistable counting chain 214 of frame timer 73 which, in the illustrated embodiment, comprises ten conventional flip-flop circuits for counting-down the line timing pulses 207. The pulse pick-off circuits of all but the first two flip-flops 214 are selectively coupled to diode logic circuit 215 by scan rate selector switch 195 to provide the desired 10, 20 or 40 second frame rates. The output circuit 216 of the diode logic circuit 215 is coupled to the base of transistor 217 by diode 218, the base of transistor 217 being connected to a source of +25 volt potential by resistor 219 and to a source of −25 volt potential by diode 218 and resistor 220. Capacitor 222 couples the base of transistor 217 to ground. The collector of transistor 217 is coupled to the source of −25 volt potential by resistor 223 and to ground by zener diode 224, the emitter being grounded as shown.

The operation of the circuit of transistor 217 is identical to that of the circuit of transistor 198, above described. Thus with one of more of the diodes 215 coupled to ground, the potential level in the output circuit 226 of transistor 217 is at a potential of −5 volts, however, when the predetermined pulse count is reached, as determined by the position of scan rate selector switch 195, all of the diodes 215 are either negatively back-biased or floating, so that transistor 217 is turned on to provide the positive-going frame timing pulse 225 in the output circuit 226.

The positive-going frame timing pulse 225 is coupled to the frame blanking pulse generator 76 which generates the negative-going 375 millisecond frame-blanking pulse 77 in its output circuit 227. The output circuit 227 of the frame-blanking pulse generator 76 is coupled to the frame sweep generator 80 and to the video and blanking circuit 97.

The frame timing pulse 225 is also inverted in conventional inverting circuit 228 to provide the negative-going frame reset pulse 105. After differentiation, the output circuit 88 of the inverting circuit 228 is coupled to the frame reset circuit 83 for the flip-flops of the counting chain 214 and also by line 88 to the ready-transmit bistable multivibrator 87 (FIG. 5).

Line 162 from the reset contacts 144 of the control relay 84 is coupled to the base of transistor 229 by a coupling capacitor 230. Transistor 229 has its emitter connected to ground by resistor 232 and its collector is connected to a −25 volt potential by resistor 233, the base being likewise connected to the source of −25 volt potential by resistor 234. The collector of transistor 229 is connected to ground by zener diode 235 and to the base of transistor 217 by coupling capacitor 236.

Transistor 229 is normally conducting thus providing a potential level in its output circuit 237 of approximately 0 volts. However, the application of the positive-going logic reset pulse 99 on the base of transistor 229 from line 162 turns transistor 229 OFF thus providing a potential level of −5 volts at its output circuit 237 by virtue of the zener diode 235, in turn providing the negative-going pulse 231 which is applied to the base of transistor 217 through coupling capacitor 236 which turns transistor 217 ON as above described, to provide a new frame timing pulse 225. It is thus seen that the frame timing pulse 225 which initiates the new frame blanking pulse 77a and also resets the flip-flops of the bistable counting chain 214 of the frame timer 73 is provided either in response to completion of a predetermined count-down of line timing pulses by the counting chain 214, or by the application of a logic reset pulse 99 to reset trigger generator 91 comprising the transistor 229 and its associated circuitry.

Referring now to FIG. 10, there is shown the circuit of the line and frame sweep generators, 79, 80, the two circuits differing essentially only in the resistance and capacitance values necessary to provide the two different sweep rates. Here, output circuit 212 or 227 from the line or frame pulse generator 75 or 76, as the case may be, is coupled to the bases of transistors 237 and 238 connected in a complementary emitter follower configuration. The emitters of transistors 237, 238 are connected together and to ground by load resistor 245, the collector of transistor 237 is connected to ground and the collector of transistor 238 is connected to a source of −25 volt potential. It will be seen that the occurrence of the negative-going line or frame blanking pulse 77 or 78 will turn transistor 237 OFF and turn transistor 238 ON to provide a negative-going pulse across resistor 245. Output circuit 212a in the case of line blanking pulses, or 227a in the case of frame blanking pulses is connected to the emitters of transistors 237, 238 and to the video and blanking circuit 97, as will be hereinafter described.

The emitters of transistors 237, 238 are connected to the emitter of transistor 248 by resistor 249, transistor 248 having its base connected to ground and its collector connected to a source of +25 volt potential by resistors 250 and 252. The negative-going pulse across resistor 245 thus turns transistor 248 ON to impress a negative-going pulse upon the base of transistor 239 in turn turning it ON. The emitter of transistor 239 is connected to ground by resistor 253 and its collector is connected to the base of transistor 241 and to one side of sweep capacitor 244, which has its other side connected to a source

of +25 volt potential. The collector of transistor 239 is also connected to the serially connected pairs of charging resistors 254 and 255, 256 and 257, and 258 and 259 which are selectively connected to line 260 by scan rate selector switch 195.

Transistor 240 has its emitter connected to the emitter of transistor 239 and its base connected to a voltage divider comprising a resistor 262, potentiometer 263 and resistor 264 connected between the source of +25 volt potential and ground. The conduction through transistor 240, and thus the potential of its emitter and the emitter of transistor 239 is established by adjustment of potentiometer 263 which provides the centering control for the resultant sweep.

Assuming that the sweep capacitor 244 is fully charged to a potential more negative than +25 volts as will hereinafter be described, impression of the negative-going pulse upon the base of transistor 239 turns that transistor ON and connects sweep capacitor 244 to the potential established at the emitter of transistor 239, which will approach the +12 volt potential, and sweep capacitor 244 will thus immediately be discharged to that potential. Upon termination of the line or frame blanking pulse as the case may be, transistor 239 is turned OFF.

It will be observed that line 260 is connected to the +25 volt potential by zener diode 265 and resistor 266 thus establishing a potential level on line 260 at the end of a blanking pulse which is approximately 5 volts below the +12 volt potential. Upon termination of the blanking pulse, capacitor 244 charges through the particular pair of charging resistors selected by scan rate selector switch 195 to the potential thus established on line 260, thus impressing a negative-going saw-tooth potential on the base of transistor 241 which is thus rendered increasingly more conductive. The emitter of transistor 241 is connected to the +25 volt source of potential by resistor 266 and its collector is connected to a source of −30 volt potential by resistor 277 and zener diode 278 which also connects the collector of transistor 241 to the base of transistor 242. Likewise, the potential of approximately −25 volts established by zener diode 278 is impressed upon the base of transistor 242 during a blanking pulse. Increase conduction of transistor 241 responsive to charging of capacitor 244 increases the potential applied to the base of transistor 242 in saw-tooth fashion thus causing that transistor to conduct more current. The emitter of transistor 242 is connected to the source of −25 volt potential while the selector is connected to the base of transistor 243 by zener diode 279. The collector of transistor 243 is connected to the source of −25 volt potential and its emitter is connected to line 260 and to the source of +25 volt potential by resistor 280. The base of transistor 243 is also connected to the source of +25 volt potential by resistor 282.

Thus it can be seen that transistors 241, 242, and 243 with their associated resistors and diodes form a direct coupled feed back amplifier. As a negative-going saw-tooth potential is applied to the base of transistor 243 responsive to charging of capacitor 244, the conduction of transistor 243 increases thus reducing the potential of its emitter in line 260 in saw-tooth fashion toward −25 volts. At this point, it will again be observed that the charging resistors 254–259 for capacitor 244 are connected by scan rate selector switch 195 to line 260 and thus the potential to which capacitor 244 is charged is bootstrapped at a constant charging voltage of 5 volts due to zener diode 265.

Line 260 is connected to the respective deflection yoke 50A or 50B by resistor 283 and the deflection yoke is then connected to ground by resistor 284 with capacitor 285 coupled across resistor 284 and the deflection yoke.

It will be observed that during blanking, substantially all of the deflection yoke current flows through resistor 280, the electron beam of the vidicon tube 44 dwelling at one side of the tube in this condition. As the current flowing through transistor 243 and resistor 280 increases as capacitor 244 charges, the potential of line 260 decreases linearly to 0 and continues to increase linearly toward —25 volts, the deflection yoke current thus in turn decreasing linearly toward 0 and increasing linearly to its opposite maximum before the next blanking pulse. Potentiometer 263 sets the discharge level of the charging capacitor 244 and therefore the resultant deflection yoke current at the beginning of the sweep. Potentiometer 263 thus sets the position of the sweep start and is used as the beam centering control.

It will be observed that direct-coupled sweep amplifiers are used by virtue of the very low sweep rates employed, thus accurately controlling the resulting operating point drift. It will be seen that the maximum amount of exponential charge of the sweep capacitor 244 is employed, followed with minimum over-all gain and maximum over-all feed-back to provide maximum linearity and drift stability.

Turning now to FIG. 7, the video signal from the preamplifier 95 on line 286 as applied by scanning rate selector switch 195 to the cathode of tube 287 through resistor 288 and capacitor 289, and also through either resistor 290 or resistor 291 in the 20 or 40 second frame rate positions of switch 195. The cathode of tube 287 is grounded and the plate is connected to a source of +300 volt potential by load resistor 292, bias for its control grid being provided by a voltage divider comprising resistors 293 and 294. The plate of amplifier tube 287 is coupled to the control grid of triode 295 of the color enhancement circuit 96 by coupling capacitor 297.

All vidicon image tubes are sensitive to variations in background color. For example, the WL7290 vidicon employed in the specific embodiment has a peak sensitivity in the blue region (4000 to 5000 A.), and the relative response outside of these limits drops off rapidly. For example, for yellow (6000 A.) the relative response is only about 5%. Since the information to be transmitted by the system of the invention may be recorded on cards or papers of different color and also since the color of the ink used on different documents varies, the color enhancement circuit 96 is provided in order to overcome the deficiencies of the vidicon 44 to provide a readable display.

Tube 295 is a high gain amplifier and inverter and has its cathode connected to ground and its grid connected to ground by resistor 298 with its plate being connected to a source of +25 volt potential by resistor 299. The plate of tube 295 is coupled to the grid of triode 300 by coupling capacitor 302. The video signal which appears at the grid of tube 300 thus has a positive polarity for "white" and a negative polarity for "black"; the white level of the video signal is assumed to be the background color of the image being transmitted. Diode 303 clamps the grid of tube 300 to ground. Resistor 304 also couples the grid of tube 300 to ground, its cathode is connected to ground by resistor 305 and its plate is connected to the +25 volt potential source by resistor 306. The output circuit 307 of the enhancement circuit 96 is coupled to the plate of tube 300.

With the "white" level video signal thus clamped to ground by diode 303, the bias on the grid of tube 300 is set so that the negative-going video signal is clipped at about —1 volt level. The cathode and plate resistors 305 and 306 are equal in value thereby making the gain of the stage one, and the desired video signal thus appears as a negative-going signal from ground on line 307.

The enhancement circuit 96 is more fully described in application Serial No. 246,198 filed December 20, 1962, now Patent No. 3,204,027, of L. E. Clements, assigned to the assignee of the present application.

Output circuit 307 from the enhancement circuit 96 is coupled to the grid of tube 308 by coupling capacitor 309. At this point it is to be observed that in the event that color enhancement is not required, enhancement circuit 96 may be eliminated and the plate of tube 287 directly coupled to the grid of tube 308 by coupling capacitor 309, as indicated by the dashed line 310. It is further observed that scan rate selector switch 195 inserts either zero resistance or the resistances of resistor 290 or 291 in the input circuit in order to provide a constant amplitude input video signal since the video signal level from the vidicon tube 44 increases with increased scan rates.

The cathode of tube 308 is coupled to a source of —25 volt potential by resistor 312 and its plate is coupled to a source of positive 300 volt potential by resistor 311. Tube 308 is a cathode follower with its output taken from its cathode, its grid also providing the clamp of a direct current-coupled driven clamp during blanking. The cathode of tube 308 is thus connected to the collector of transistor 313 which has its emitter connected to ground. Line and frame blanking pulses received in lines 212a and 227a from the respective sweep circuits 75, 76 (FIG. 10) are mixed in resistors 314, 315 and applied to the base of transistor 313. Thus, during a line or frame blanking pulse, transistor 313 grounds the cathode of tube 308 shorting the signal to ground. Zener diodes 316, 317 connect the plate of tube 308 to ground and set the plate voltage thereof.

Resistor 318, diode 319, diode 320, and resistors 322 and 323 are serially connected between the source of +25 volt potential and a source of —25 volt potential, the grid of tube 308 being connected to point 330 between diodes 319, 320. Diode 324 connects line blanking pulse input line 246 to a point between diode 320 and resistor 322. The negative-going line blanking pulses 78 are thus applied non-inverted to diode 324. The line blanking pulse input line 246 is also coupled to the base of transistor 325 by resistor 326, the base of transistor 325 also connected to the source of +25 volt potential by resistor 327. The emitter of transistor 325 is connected to ground and its collector is connected to a source of —25 volt potential by resistor 328. Transistor 325 thus inverts the line blanking pulse 78 and applies the thus inverted line blanking pulses to diode 329 which is coupled to the point 341 between diode 319 and resistor 318.

In the absence of a line blanking pulse 78, diode 329 conducts to —25 volts through resistors 318 and 328 thus back-biasing diode 319 to cut it off so that point 330 to which the grid of tube 308 is connected is floating, i.e., no clamp is applied to the grid of tube 308. In this condition, the grid of tube 308 follows the instantaneous input video signal wave form applied thereto to provide a resulting video signal across cathode resistor 312. It will be observed that transistor 325 is normally biased off by the voltage drop across resistors 326 and 327 thus permitting diode 329 to conduct so that point 341 between diode 319 and resistor 318 is below ground thus back-biasing diode 319. Application of a non-inverted and inverted line blanking pulse 78, respectively, to diodes 324 and 329 back-biases both diodes. Under this condition, the series circuit comprising resistor 318, diode 319, diode 320, and resistors 322, 323 conducts from +25 volts to —25 volts thus clamping point 330 and the grid of tube 308 with a direct current-driven clamp. This clamping action sets the direct current level for the pedestal of the blanking pulses in the video signal at 0 volts. It will be observed that the turning ON of transistor 313 by a blanking pulse thus grounding the video signal in tube 308 effectively prevents video signal leakage during blanking.

It will be observed as a description proceeds that from this point, the entire circuit is direct current-coupled to the modulator 90 thus providing direct current restoration which in turn provides the gray scale. It will further be observed that transistor 313 provides current for charging capacitor 309 during blanking so that any charge lost during a line time is restored maintaining the bias on the grid of tube **308** between blanking pulses and providing a flat base line.

Gain control potentiometer **332** connects the cathode of tube **308** to ground and its movable element is coupled to the base of transistor **333**. Thus, during the absence of blanking when the grid of tube **308** is unclamped, the video signal passes through the gain control **332** to the base of transistor **333**. Transistors **333** and **334** constitute a feed-back amplifier, the collector of transistor **333** being connected to +25 volts by resistor **335** and its emitter being connected to ground by resistor **336** and potentiometer **281**. The collector of transistor **333** is connected to the base of transistor **334** which has its emitter connected to +25 volts by zener diode **321** and its collector connected to −25 volts by resistors **337** and **338**. The emitter of transistor **333** is connected to point **339** between resistors **337** and **338** to which video signal output circuit **340** is connected, output circuit **340** being coupled to the modulator **90** as hereinafter described. In the specific embodiment, the pedestals of the blanking pulses are clamped to 0 volts with the maximum negative excursion of the video signal (white level) being −3 volts, potentiometer **281** setting the clip point on the maximum excursion of the video signal.

To provide composite blanking to the vidicon camera tube **44**, the non-additive blanking pulse mixer circuit **94** is provided. Here, the line blanking pulse input line **212*a*** and the frame blanking pulse input line **227*a*** are respectively connected to the emitter of transistor **342** by resistors **343** and **344**. The emitter is also connected to +25 volts through resistor **345**, the base is connected to ground, and the collector is connected to +25 volts by resistor **347** and to −25 volts by resistors **348** and **349**. The midpoint between resistors **348** and **349** is connected to the base of transistor **350** which has its emitter connected to ground and its collector connected to +25 volts by resistor **351**. The collector of transistor **350** is connected to the bases of complementary emitter follower transistors **353**, **354**; the collector of transistor **354** being connected to ground and the collector of transistor **353** being coupled to +25 volts by resistor **355**. The emitter of transistor **353** and the emitter of transistor **354** are connected to line **55** which is connected to the cathode **124** of the vidicon tube **44** (FIG. 4) and to ground by resistor **356**.

The potential drop provided by the voltage divider formed of resistors **347**, **348**, **349** normally biases transistor **350** ON and transistor **342** is normally biased OFF. Application of the negative-going blanking pulses to the emitter of transistor **342** turns that transistor ON thus turning transistor **350** OFF to provide an inverted positive-going pulse at its collector. With the transistor **350** normally conducting, i.e., in the absence of a blanking pulse, transistor **354** is biased ON and transistor **353** biased OFF thus short circuiting resistor **356** and coupling the cathode **124** of vidicon tube **44** directly to ground. The appearance of the inverted positive-going blanking pulse at the collector of transistor **350** biases transistor **354** OFF and transistor **353** ON thus developing across resistor **356** a positive-going blanking signal approaching +25 volts with reference to ground for driving the cathode of the vidicon.

Turning now to FIG. 8, the video and blanking signal is received from the video and blanking circuit on line **340**, as previously indicated, and has its level set with the pedestals of the blanking pulses at 0 and the maximum extremity of the video signal, i.e., the "white" level at −3 volts. The 400 cycle tone from the control relay is received on line **156**. The video line **340** is connected to the base of emitter follower transistor **357** which has its collector connected to −25 volts and its emitter connected by resistor **358** to the input of low pass filter **98**. The base and emitter of transistor **357** are respectively connected to +25 volts by resistors **359** and **360**. The 400 cycle tone line **156** is connected to the emitter of transistor **357**.

Filter **98** is a constant delay low pass filter limiting the video signal to 0–1750 cycles, thus eliminating any high frequencies from the modulator **90**.

Transistors **362** and **361** form a D.C. coupled feedback amplifier which sets the level of the video signal between +10 volts and 0 volts, i.e., the pedestals of the blanking pulses are clamped at +10 volts and the extremity of the video signal is at 0 volts. The output of filter **98** is connected to the base of transistor **362** which is also connected to ground by resistor **363**. Transistor **362** has its collector connected to +25 volts by resistor **364** and its emitter connected to −25 volts by resistors **365** and **366**. The collector of transistor **362** is connected to the base of transistor **361** which has its emitter connected to +25 volts by diode **367**. The emitter of transistor **362** is connected to the collector of transistor **361** by resistor **368** and to ground by resistor **369**. Zener diode **370** connects the midpoint between resistors **365** and **366** to a potential −5 volts from ground. The emitter of transistor **361** is also connected to ground by resistor **372** and the collector is connected to line **373**.

It is thus seen that the modulating video signal having a level of from +10 volts at the peak of a blanking pulse to 0 volts at the maximum extremity, i.e., the "white" level of the video signal appears on line **373** which is the output of the feed-back amplifier of transistors **361**, **362**. The actual modulation is accomplished in the voltage divider and switching circuit comprising resistor **374**, diode **375**, the emitter-collector circuit of transistor **376** and resistor **377** connected between line **373** and −25 volts.

Base of transistor **376** is connected to ground. Diode **378** and zener diode **379** serially connect point **380** between resistor **374** and diode **375** to ground. Transistor **376** is normally conducting, and with a potential of 0 volts applied to point **382** between diodes **378** and **379**, i.e., in the absence of a negative-going carrier signal pulse from square wave generator **89**, diode **378** will be back-biased and current responsive to the video signal appearing on line **373** will flow in the voltage divider-switching circuit to provide the video signal at the collector of transistor **376**.

The square wave carrier generator **89** is formed of transistors **383** and **384** which form a free-running multivibrator. Transistors **383** and **384** have their emitters respectively connected to ground and their collectors connected to −25 volts by resistors **385** and **386**. The base of transistor **383** is connected to the collector of transistor **384** by capacitor **387** while the base of transistor **384** is connected to the collector of transistor **383** by capacitor **388**. The base of transistor **383** is connected to a −25 volt source by resistor **389** and potentiometer **400** while the base of transistor **384** is connected to −25 volts by resistor **402** and potentiometer **403**; potentiometers **400** and **403** are provided for symmetry adjustment. The collector of transistor **384** is connected to ground by zener diode **404** and the collector of transistor **383** is connected to point **382** between diode **378** and zener diode **379**. In the specific embodiment, a square wave signal pulsed from 0 to −5 volts at 2.2 kc. is provided at the collector of transistor **383** and at point **382**.

It will be seen that when the −5 volt potential from the square wave generator **89** is applied to point **382** the back-bias on diode **378** is removed and diodes **378** and **379** conduct the video signal to ground thus back-biasing diode **375** to turn it OFF and in essence, short circuiting resistor **374** so that current flow into transistor **376** is zero allowing the collector of transistor **376** to reach −25 volts. The result is pulsing or chopping of the video signal at a 2.2 kc. rate, as seen in FIG. 3J.

In this transmission system, it is desired to cancel the video or modulating signal component. It can be demonstrated mathematically that this may be accomplished by inverting the modulating signal and feeding it back at half amplitude to be mixed with the modulated signal. Thus, the video signal line **373** is connected to the base of transistor **405** which has its collector coupled back to the emitter of transistor **376** and which has its emitter connected to +25 volts by resistor **406**, potentiometer **407** and resistor **408**. The point between potentiometer **407** and resistor **408** is connected to ground by diode **409**. In this manner, a video signal on line **373** is inverted, its amplitude reduced by one-half, and the resulting half-amplitude inverted video signal appearing at the collector of transistor **405** is applied to the emitter of transistor **376** to be mixed with the modulated signal in the voltage divider-switching network with the result that the signal appearing in line **410** connected to the collector of transistor **376** comprises the carrier and upper and lower side band components with the modulating signal component eliminated.

It will be observed that by virtue of the employment of a symmetrical square wave carrier signal, there are no second harmonics in the resulting modulated signal, only the odd harmonics being strong.

The output circuit **410** from the modulator **90** is coupled to the base of transistor **412** by capacitor **413**. The base of transistor **412** is connected to point **414** of a voltage divider comprising resistors **415**, **416**, **417**, and **418** connected across +25 volts and −25 volts. The point between resistors **415** and **416** is connected to ground by zener diode **419** while a point between resistors **417** and **418** is connected to ground by zener diode **420**. This network sets the base of transistor **412** at a direct current level of 0 volts. Transistors **412** and **422** form a double emitter follower, the collectors of transistors **412** and **422** being connected to −25 volts, the emitters being connected to +25 volts by resistors **423** and **424**, and the emitter of transistor **412** being connected to the base of transistor **422**. As previously indicated, it is desired to filter out the upper side band component from the modulated signal and thus, the emitter of transistor **422** is coupled to the input circuit of upper side band filter **92**.

The action of filter **92** is shown diagrammatically in FIG. 9. Assuming a modulating or video signal frequency of 1750 c.p.s. and a carrier frequency of 2200 c.p.s. it will be seen that the lower side band frequency is 450 cycles and the upper side band frequency 3950 c.p.s. Filter **92** is designed to pass the lower side band and to eliminate the upper side band, the carrier frequency being down by 6 db.

The resulting modulated signal comprising only the lower side band and carrier components appearing in the output circuit of filter **92** is applied to the base of transistor **425**, the base of transistor **425** being connected to ground by resistor **426**. Transistor **425** forms an amplifier with its emitter connected to +25 volts by resistor **427** and its collector connected to −25 volts by resistor **428**. The emitter of transistor **425** is also connected to ground by potentiometer **429** and resistor **430**. The output of amplifier **425** appearing on the collector is coupled to the base of emitter follower transistor **432** having its collector connected to −25 volts and its emitter connected to +25 volts by resistor **433**. The emitter of transistor **432** is connected to ground by the primary winding **434** of coupling transformer **435** which has its secondary winding connected to the 600 ohm voice frequency band telephone line **32**. The modulation system described above is further described and illustrated in application Serial No. 247,186, filed December 26, 1962, of Nelson E. Hoag and Jerry L. Holsinger, and assigned to the assignee of the present application.

In this connection, it will be understood that a normal voice band telephone line has a reasonable flat frequency response from 300 to 2800 cycles, however, that the term "voice band" generally is considered to refer to frequencies which may be as high as 5000 cycles. It will further be observed that the output of filter **92** is a sine wave thus eliminating the odd harmonics of the square wave carrier signal.

Referring now to FIG. 12, automatic gain control **106** is required when the telephone line **32** interconnecting the transmitting and receiving stations is of any appreciable length. Telephone line **32** is connected to the primary winding of isolation transformer **437** which has its secondary connected to the base of emitter follower transistor **438** having its emitter connected to +25 volts by resistor **439** and its collector connected to −25 volts by resistor **440**. The output circuit **442** from emitter follower **438** carrying the received video signal is coupled to the emitter circuits of transistors **443** and **444** by coupling capacitor **445**. A direct current gain-control voltage is provided for gain control of transistors **443**, **444**, **446** and **447** by transistors **448**, **450**, **452**, **457** and **458**.

The recovered video signal from the demodulator **107** is fed over line **108** to the base of transistor **448** which forms a high gain feedback amplifier. The emitter of transistor **448** is connected to ground and its collector is connected to −25 volts by resistors **453** and **454**. Resistor **455** and capacitor **456** connect the collector of transistor **448** to its own base. Zener diode **449** and resistor **454** provide the proper voltage for the collector resistor **453** of transistor **448**.

The collector of transistor **448** is connected to the base of transistor **457** which with transistor **458** forms a double emitter follower. The collectors of transistors **457** and **458** are connected to −25 volts by resistor **459**. The emitter of transistor **457** is connected to +25 volts by potentiometer **460** and resistor **462**, the adjustable element of potentiometer **460** being connected to the base of transistor **458** which has its emitter connected to +25 volts by resistor **463**.

Diode **464** connects the emitter of transistor **458** to the base of the transistor **450** with capacitor **465** connecting the base of transistor **450** to ground, as shown. Diode **464** functions as a peak detector to detect and pass current only in response to the negative-going peaks of the recovered video signal, i.e., the pedestals of the negative-going blanking pulses. Capacitor **465** in conjunction with diode **464** functions as a long time constant integrating circuit to integrate the blanking pulses detected by the diode **464**, the resulting integrated direct current level being applied to the base of transistor **450**. It is thus seen that a direct current control voltage is provided at the base of transistor **450** which is responsive to the amplitude of the sync. pulses in the recovered video signal.

Transistors **450** and **452** form a double emitter follower with their emitters respectively connected to +25 volts by resistors **466** and **467** and their collectors are respectively connected to −25 volts by resistors **468** and **469**. The resulting negative polarity direct current control voltage appearing at the emitter of transistor **452** is applied to the base of transistor **443** and to the base of transistor **447**, which are also connected to ground by capacitor **473**.

The collector of transistor **443** is connected to −25 volts by resistor **478** and its emitter is connected to +25 volts by resistors **474**, **475**, and **476**. The output circuit **442** from emitter follower **438** which carries the incoming video signal is coupled to point **472** between resistors **475** and **476**. The collector of transistor **444** is connected to −25 volts by resistors **479** and **480** while its emitter is connected to resistor **475** by resistor **477**. Transistors **443** and **444** thus form a variable current divider, the video signal current respectively flowing therethrough dividing between transistor **443** and transistor **444** in accordance with the direct current control which is applied to the base of transistor **443**. The resulting output signal appearing at the collector of transistor **444** is coupled to the base of emiter follower transistor **482** by coupling capacitor **483**. Transistors **482** and **484** form a double emitter follower, their collectors being connected to −25 volts by resistors **485** and their emitters being respectively connected to —25 volts by resistors **486** and **487**. The emitter of transistor **482** is connected to the base of transistor **484** and its emitter is connected to the demodulator **107** by line **488**.

Transistors **446** and **447** provide direct current balance for the collectors of transistors **443** and **444**. The base of transistor **444** is connected to the base of transistor **446**, to ground, and to the midpoint between resistors **479** and **480** by capacitor **489**. The collector of transistor **446** on the other hand is cross-connected to the collector of transistor **443** while the collector of transistor **47** is cross-connected to the collector of transistor **444**. The emitter of transistor **446** is connected to +25 volts by resistors **490**, **492**, **494**, and potentiometer **495** while the emitter of transistor **447** is connected to resistor **492** by resistor **496**. A capacitor **497** connects the midpoint between resistors **492** and **494** to ground, as shown. By virtue of this cross-connection of the collectors of transistors **446** and **447** to the collectors of transistors **443** and **444**, the collectors of those transistors are held at a constant potential level.

The variable current divider and direct current balancing portion of the automatic gain control circuit **106** is further described in application Serial No. 189,071 filed April 20, 1962, of W. W. Greutman assigned to the assignee of the present application.

Referring now to FIG. 13, the video signal received from the automatic gain control circuit **106** on line **488** is applied to the primary winding of transformer **499** having gain control potentiometer **500** connected across its secondary winding. The movable element of potentiometer **500** is connected to the base of transistor **502** which, with transistor **503**, forms a double emitter follower, the collectors being connected to —25 volts and the emitters being respectively connected to +25 volts by resistors **504** and **505**.

The emitter of transistor **503** is coupled to one side of primary winding **506** of transformer **507**, the other side being connected to ground. Secondary winding **508** is center tapped at **509** with its two ends being connected together by diodes **510** and **512** to form a full-wave rectifier. Resistor **514** connects midpoint **513** between the diodes **510**, **512** to center tap **509** and a voltage divider comprising resistors **515**, **516**, and **517** as connected across —25 volts and ground with center tap **509** being connected between resistors **516** and **517**. Zener diode **518** connects a point between resistors **516** and **517** to ground. Point **513** is connected to the base of transistor **519** which with transistor **520** forms another double emitter follower, the collectors being connected to —25 volts and the emitters being connected to ground by resistors **522** and **523**. The emitter of transistor **520** is coupled to band pass filter **524** by resistor **525**. Band pass filter **524** is tuned to pass only the modulating, i.e., the video signal component of the transmitted signal, i.e., to pass frequencies from 0 to 2200 c.p.s. and to reject higher frequencies.

It will be recalled that in the modulation process, the modulating and upper sideband components were cancelled with the result that the transmitted signal contains only the lower side band and carrier signal components. In the demodulation process, the effect of the full wave rectification provided by diodes **510**, **512** is to double the frequency of the carrier; the modulating or video signal component reappearing at the output of the band pass filter **524**. The modulation and demodulation process employed in this system is described in application Serial No. 802,233 filed March 26, 1959, of A. Gatfield assigned to the assignee of the present application.

With the carrier frequency component being doubled, i.e., increased to 4.4 kc., this doubled carrier frequency component is eliminated by filter **524**.

The recovered video signal (from 0 to 1750 c.p.s.) thus appears on the output circuit **526** of filter **524** and is coupled to the 400 cycle filter **109** and the erase control relay **112** by line **527**, to the sync. separator **115** by line **528**, to the writing gun control **119** by line **529** and to the automatic gain control **106** by line **108**.

Referring now to FIG. 14, the recovered video signal is received by the sync. separator circuit **115** from the demodulator **107** on line **528** and applied to the base of emitter follower transistor **530** which has its collector connected to —25 volts and its emitter connected to +25 volts by resistor **532**. The base of transistor **530** is connected to ground by resistor **531**. The recovered video signal from the demodulator has approximately 0 voltage at the peaks of the synchronizing pulses with the extremities of the video signal being —3 volts. Transistor **530** is normally on and is turned OFF by the positive-going synchronizing pulses in the recovered video signal. Transistor **533** has its emitter connected to the emitter of transistor **530**, its collector connected to —25 volts by resistor **534** and its base connected to ground by diode **535**. Transistor **533** is normally OFF, however, the positive-going pulse provided at the emitter of transistor **530** in response to the positive going synchronizing pulse applied to its base turns transistor **533** ON to provide a positive-going pulse at its collector.

The base of transistor **533** is connected to —25 volts by resistor **536** and its collector is connected to the base of transistor **537** by resistor **538**. A voltage dividing-switching network formed of resistor **539**, zener diode **540** and resistor **542** is connected between —25 volts and +25 volts. Diode **543** connects the collector of transistor **533** to point **544** between resistor **539** and zener diode **540**. Point **545** between zener diode **540** and resistor **542** is connected to the base of transistor **546** which has its emitter connected to ground and its collector connected to —25 volts by resistor **547**. In the absence of a synchronizing pulse in the recovered video signal applied to the base of transistor **530**, the current flow through the voltage divider-switching network back-biases diode **543**. Transistor **546** is normally ON thus providing a 0 voltage level at its collector to which the line and frame blanking pulse output circuit **548** is coupled. Appearance of the positive-going pulse at the collector of transistor **533** in response to the positive-going synchronizing pulse in the recovered video signal causes diode **543** to conduct thus turning transistor **546** OFF and lowering the potential of its collector to essentially —25 volts thus to provide the negative-going separated line blanking pulses **78** and frame blanking pulses **77** in output circuit **548**.

Transistor **537** is an emitter follower having its collector connected to —25 volts and emitter connected to +25 volts by resistor **549**. Its base is also connected to +25 volts by resistor **550** and to ground by capacitor **552**.

Assuming now that a positive-going pulse has appeared at the collector of transistor **533** in response to a frame synchronizing pulse in the input video signal, this positive-going pulse will provide a potential which may be +5 volts on the base of transistor **537** thus turning it OFF and the capacitor **552** will have been charged to the base potential of transistor **537**, i.e., +5 volts. Under these conditions, the potential at the emitter of transistor **537** will be essentially +5 volts and transistor **553** which has its base connected to +25 volts and its collector connected to —25 volts by resistor **554** will be turned ON so that its collector potential is essentially at 0 volts. Now, termination of the frame synchronizing pulse in the input video signal and thus of the positive-going pulse on the collector of transistor **533** will restore the potential of the base of transistor **537** to that established by the voltage divider formed by resistors **534**, **538**, and **550**, which may be —12 volts. This immediately discharges capacitor **552** and turns transistor **537** ON decreasing the potential of its emitter essentially to —12 volts in turn turning transistor **553** OFF so that its collector potential falls to the level established by the voltage divider formed of resistors 554, 555 and 556 which may be on the order of −23 volts.

Assuming now that the first line synchronizing pulse following the above-referred to frame synchronizing pulse appears on the video signal, a corresponding positive-going pulse will again appear at the collector of transistor 533 and capacitor 552 will now begin to charge toward the +5 volt level of that pulse through resistor 538, however, the time constant of the charging circuit is such that the potential level of the base of transistor 537 established by the charge on capacitor 552 does not increase sufficiently rapidly to a point to turn OFF transistor 537 before termination of the line synchronizing pulse and the consequent discharge of capacitor 552. Thus, transistor 537 is not turned OFF in response to line synchronizing pulses in the input video signal, but on the contrary remains ON during the entire sequence of line synchronizing pulses so that the voltage at its emitter remains at essentially −12 volts. Thus, transistor 553 remains turned OFF during this period so that the −23 volt potential remains at its collector.

Upon the occurrence of a frame synchronizing pulse in the input video signal, capacitor 552 has time to become fully charged to the +5 volt level of the positive-going pulse on the collector of transistor 533 thus turning transistor 537 OFF and increasing the potential at its emitter to essentially +5 volts. This increase in the emitter potential of transistor 537 turns transistor 553 ON increasing its collector potential to essentially 0 volts at which it remains during the remainder of the frame synchronizing pulse. Thus it is seen that positive-going frame synchronizing pulses only are provided at the collector of transistor 553.

The collector of transistor 553 is coupled to the base of transistor 557 by resistor 555, transistor 557 having its emitter connected to ground and its collector connected to −25 volts by resistor 558. The positive-going frame pulse appearing at the collector of the transistor 553 is thus inverted and appears as the desired negative-going frame blanking pulse at the collector of transistor 557 to which the frame blanking pulse output circuit 559 is connected.

Referring now to FIG. 15, the recovered video, including the 400 cycle tone, is received from the demodulator 107 on line 527, passed through a conventional emitter follower 560 and applied to the input circuit of 400 cycle filter 109 from voltage divider formed of resistors 562 and 563. Filter 109 is a narrow band pass filter passing only the 400 cycle tone to the exclusion of lower and higher frequencies (thus excluding the subsequent picture-responsive video signal). The output circuit of filter 109 is coupled to a conventional class B amplifier 564, the output of which energizes the coil of reed relay 565. The contact 566 of reed relay 565 connects capacitor 575 to a +300 volt source of energizing potential through resistor 568. The potential on capacitor 575 thus charges toward +300 volts each time reed relay contacts 566 close. When the voltage across capacitor 575 reaches 60 volts, operating coil 567 closes.

Erase control relay 112 is provided with contacts 569, 570, 572, and 573, which are in the positions shown in FIG. 15 when coil 567 is de-energized. Energization of coil 567 by closing of the reed relay contacts 566 actuates contact 572 to its second position to couple capacitor 574 across coil 567 in shunt with capacitor 575 thus to maintain coil 567 energized despite chattering of the relay contacts 566 and further for the period 576 (FIG. 16) which is longer than the exposure period 86 (FIG. 3) in which the 400 cycle tone is provided, but which is shorter than the duration of the first frame blanking pulse 77*a* of the new sequence.

Capacitor 574 thus provides the time delay 123 for the erase control relay 112.

When erase control relay coil 567 is de-energized, i.e., prior to occurrence of the 400 cycle tone and after termination of the holding period 576 of the relay, relay contact 569 couples the insulator screen 113 of the storage tube 29 to a suitable source of potential, such as +2 volts by resistor 571 and emitter follower 579 lead 561. This normal insulator potential is established by a voltage divider comprising resistor 551 and potentiometer 581. The insulator 113 is pulsed in known fashion by one microsecond pulses provided by conventional free running blocking oscillator 577 coupled to emitter follower 579 by capacitor 578.

Energization of erase control relay coil 567 in response to the 400 cycle tone actuates contact 569 to a second position to couple a source of erasing potential, such as +5 volts to the insulator 113 of the display tube 29, this erase potential being established by the voltage divider comprising resistor 551, resistor 580 and potentiometer 582.

Erase control relay 112 thus applies the +5 volt erase potential to the insulator 113 during the period 576 during which erase control relay 112 is energized, as shown in FIG. 16B.

Contact 570 of erase control relay 112 in its normally closed position, i.e., with coil 567 de-energized, couples a +300 volts to high voltage power supply 583 which in turn supplies a suitable high potential, such as 7 kv., to the display screen or phosphor 114 of the storage tube 29 by high voltage lead 584. Energization of erase control relay coil 567 responsive to the occurence of the 400 cycle tone actuates contact 570 to its normally open position thereby breaking the connection of the +300 volt energizing potential to the high voltage power supply 583, thus removing the high voltage from the display screen 114 during the period 576 during which erase control relay 112 is energized, as shown in FIG. 16E.

Contact 573 of erase control relay 112 in its normally closed position, i.e., with coil 567 de-energized, couples one of the input circuits 585 of bistable multivibrator 118, which forms the write gun ON-OFF trigger, to a source of −25 volt potential. As will be be hereinafter described in connection with FIG. 21 which shows the circuit of the bistable multivibrator 118, under these conditions, multivibrator 118 is in one stable state to energize relay coil 586. This normal energization of coil 586 actuates its contact 587 to its closed position, as shown, to connect lead 588 to ground. As will be described in connection with FIG. 17, connection of lead 588 to ground turns OFF writing gun 65 of storage tube 29.

When coil 567 of erase control relay 112 is energized in response to the occurrence of the 400 cycle tone, contact 573 is actuated to connect input circuit 585 of multivibrator 118 to ground which, as will be hereinafter described, switches multivibrator 118 to its second stable condition in which relay coil 586 is de-energized thus actuating its contact 587 to the open position to disconnect line 588 from ground. Disconnection of line 588 from ground turns ON writing gun 65 of storage tube 29, as shown in FIG. 16C.

Frame blanking pulse output circuit 559 from the sync. separator circuit is coupled to the other input circuit 589 of multivibrator 118 for impressing the frame blanking pulses 77 thereon. The trailing edge of a frame blanking pulse switches bistable multivibrator 118 back to its first stable position, i.e., with coil 586 energized, however as will be described in connection with FIG. 21, input circuit 589 of multivibrator 118 is provided with a hold-off circuit so that the trailing edge of the first frame blanking pulse 77*a* of the new sequence does not switch the multivibrator 118, but on the contrary, the multivibrator is not switched to its first stable position until the trailing edge of the second frame blanking pulse 77*b*. Thus, the trailing edge of the second frame blanking pulse 77*b* of the new sequence switches the multivibrator **118** back to its initial stable condition energizing coil **586** and actuating contact **587** to its closed position to ground lead **588** and thus turning off the writing gun **65** of the storage tube **29**, as shown in FIG. 16C.

Referring now briefly to FIG. 21 in which a suitable circuit for the bistable multivibrator write gun ON-OFF trigger **118** is shown, transistor **590** is normally turned ON thereby energizing relay coil **586** connected to its collector, diode **592** being connected across relay coil **586** to prevent an inductive kick when transistor **590** is turned OFF. Input circuit **585** is coupled to the base of transistor **590** through capacitor **593** and diode **594** and thus actuation of contact **573** of control relay **112** to switch the connection of input line **585** from —25 volts to ground turns OFF transistor **590**, thus de-energizing relay coil **586** and turning ON transistor **595**.

Input circuit **589** is coupled to the base of transistor **595** by diode **596** and with the exception now to be pointed out, the remaining circuitry of multivibrator **118** is conventional so that application of a positive-going pulse to the input circuit **589**, i.e., a pulse from a negative voltage level to ground would turn OFF transistor **595**, turn ON transistor **590** and again energize relay coil **586**. However, in this circuit, capacitor **597** couples line **559** from the sync. separator **115** to input circuit **589** and resistor **598** is connected from the point between the capacitor **597** and diode **596** to the collector of the transistor **595**. Capacitor **597** and resistor **598** form a hold-off circuit with a time constant sufficiently long to prevent transistor **595** from being turned OFF by the trailing edge of the first blanking pulse **77a** of the new sequence with the result that transistor **595** is turned OFF only by the trailing edge of the second frame blanking pulse **77b**.

Thus, as above described, bistable multivibrator write gun ON-OFF trigger **118** is switched from one of its stable conditions to the other at T_0 by the erase control relay **112** in response to the 400 cycle tone thereby turning the writing gun **65** of the storage tube **29** ON and is switched back to its first stable condition in response to the trailing edge of the second frame blanking pulse **77b**, thereby turning the writing gun **65** OFF, as shown in FIG. 16C.

Referring now to FIG. 17, writing gun **65** of storage tube **29** includes a cathode **608** coupled to a suitable source of potential, such as —690 volts, control grid **609**, and other conventional beam forming and accelerating elements, as is well known to those skilled in the art. A suitable collector electrode **610** is provided in front of storage electrode **113** and is connected to a suitable source of potential, such as +120 volts. The high velocity writing electron beam provided by writing gun **65**, modulated by the video signal applied to grid **609** as will be hereinafter described, is rectilinearly scanned by the deflection coils **63** over the storage electrode **113** thereby providing a charge pattern thereon corresponding to the video signal and in turn to the optical image impressed upon the vidicon camera tube **44**.

The reading or flood gun **64** includes a cathode **612** and other conventional elements for providing a low velocity electron beam which floods the entire area of the storage electrode **113**. As is well known, the low velocity electrons of the flood beam pass through the openings in the storage electrode **113**, being modulated by the incremental charges thereon, and impinge upon the phosphor display screen **114** to provide the resulting optical image. The interior wall of the envelope **613** of storage tube **29** may have conventional conducting wall coatings thereon connected to suitable sources of potential for columnating the flood beam, as is well known to those skilled in the art.

The write gun control unit **119** includes transistor **614** having the video signal from the demodulator received in line **529** applied to its base by gain control potentiometer **615**. Transistor **614** has its collector connected to —25 volts and emitter connected to +25 volts by resistors **616** and **617**. The midpoint between resistors **616** and **617** is connected to the base of an amplifier transistor **618** and to the collector of a switching transistor **619**. The collector of transistor **618** and its base are respectively connected to —25 volts by resistors **620** and **622**, the emitter of transistor **619** is connected to ground and the emitter of transistor **618** is connected to ground by resistor **623** and to —25 volts by resistor **624**. Transistor **618** operates as a normal video amplifier when switching transistor **619** is turned OFF. The video signal appearing at the collector of transistor **618** is applied to the base of emitter follower transistor **625** having its collector connected to —25 volts and emitter connected to ground by resistor **626**. The video signal thus appearing at the emitter of transistor **625** is coupled to the control grid **609** of writing gun **625** of the storage tube **29** by coupling capacitor **627**.

As previously indicated, the writing beam of the storage tube is turned OFF by the frame and line blanking pulses **77, 78** and to accomplish this, the line and frame blanking pulses received on lines **548** and **559**, respectively from the sync. separator **115** are added by diodes **628** and **629** and resistor **630** and applied to the emitter of transistor **618**. Thus, the negative-going line and frame blanking pulses, respectively turn OFF transistor **618** thus disconnecting the control grid **609** of the writing gun **65** from the demodulator during the blanking pulses.

As also previously indicated, in order to increase the storage time and thus the display period of storage tube **29**, the writing beam and the flood beam are pulsed ON and OFF alternately, at a rate substantially higher than the frequency of the carrier signal. To accomplish this pulsing of the writing and flood beams, a conventional free-running square wave multivibrator **122** is provided, having a frequency of 10 kc. in the specific embodiment. The output circuit **632** of the multivibrator **122** is coupled to the base of switching transistor **619** by coupling capacitor **633**. Resistors **634, 635**, and **636** are selectively coupled between —25 volts and the base of transistor **619** by scan rate selector switch **195** in order to adjust the ON time of transistor **619** for the 10, 20, or 40 second per frame scanning rate. It will now be seen that a negative-going pulse applied to the base of transistor **619** from the multivibrator **122** will turn transistor **619** ON thereby shorting the video signal on the base of transistor **618** to ground. Multivibrator **122** and switching transistor **619** thus chop the video signal received from the demodulator at the 10 kc. rate.

In order to pulse the flood beam ON and OFF at the 10 kc. rate, the cathode **612** of the reading or flood gun **64** is connnected to the collector of transistor **637** which has its emitter connected to ground and its collector connected to a source of +300 volt potential by resistor **638**. Zener diodes **639** and **640** connect the collector of transistor **637** to ground. It will be seen that when transistor **637** is turned ON, cathode **612** of the reading gun **64** is directly connected to ground, thereby to provide the flood electron beam.

The output circuit **632** of the 10 kc. multivibrator **122** is coupled to the base of switching transistor **642** by coupling capacitor **641**. Transistor **642** has its emitter connected to ground and its collector connected to the base of transistor **637** and to a source of +25 volt potential by resistor **643**. Resistor **644** and potentiometer **645** connect the base of transistor **642** to +25 volts. It will be seen that when transistor **642** is turned ON, transistor **637** will be turned OFF thus impressing the +120 volt potential established by diodes **639, 640** onto the flood cathode **612** to turn OFF the flood electron beam. It will further be seen that a positive-going pulse from the multivibrator **122** impressed upon the base of transistor **642** will turn ON the same thus alternately pulsing the flood cathode **612** between 0 and +120 volts. It will be recalled by reference to FIG. 15 that contact **587** of relay **586** of write gun ON-OFF trigger **118** grounded lead **588** to turn the writing gun **165** of the storage tube **29** OFF. A biasing, intensity control, and direct current restoring circuit **646** is provided having intensity control potentiometer **647** connected between a source of −725 volts and a source of −690 volts. Capacitors **648** and **649** and resistors **650** and **652**, connected as shown, provide a filter for the power supply, the movable element on the potentiometer **647** is connected to the control grid **609** of the writing gun **65** by resistor **653** and resistor **654** having diode **655** connected in shunt therewith. Lead **588** of the write gun ON-OFF trigger **118** is connected to the midpoint between resistors **653** and **654** by resistor **656**. Capacitor **657** couples this point to a source of −690 volts.

It will be seen that potentiometer **647** provides the requisite negative direct current bias on the control grid **609** of writing gun **65** of the storage tube **29**, this bias being selectively variable to provide the desired gain intensity. By virtue of the 10 kc. chopping of the video signal, it is possible to couple the video signal to the control grid **609** of the writing gun **65** which is at a potential on the order of −700 volts, with a relatively small capacitor **627**. It will further be seen that grounding of the lead **588** by contacts **587** of relay **586** biases the control grid **609** to turn OFF the writing beam without jeopardizing the direct current levels provided by the circuit **646** when lead **588** is not grounded. It also will be seen that diode **655** provides the direct current restoration by clamping on the negative pedestals of the blanking pulses.

Referring now to FIGS. 18 and 19, FIG. 18 is a schematic diagram of the line sweep generator circuit **117** for the storage tube **29** while FIG. 19 is a fragmentary schematic diagram showing the respects in which the frame sweep generator **116** for the storage tube **29** differs from the line sweep generator **117**.

It will be recognized that the line and frame sweep generators **117**, **116** for the storage tube **29** are similar in circuit configuration to the line and frame sweep generators **75**, **76** for the vidicon camera tube **44**, as shown in FIG. 10 and described above, and these circuits will therefore be described only to the extent that they functionally differ from the line and frame sweep generators for the vidicon camera tube.

Referring additionally to FIG. 20, in the specific embodiment of the invention illustrated and described, the line scanning is vertical, and is viewed on the display screen of the storage tube **29** with the frame scanning being horizontal from left to right, i.e., the picture is written onto the display screen of the storage tube from left to right during the 10, 20, or 40 second frame scanning time, there being no interlace. The reading and writing guns **64**, **65** of the storage tube **29** are disclosed in a horizontal plane in the specific embodiment and, by virtue of the provisions of the offset writing gun, keystone distortion appears in the image on the display screen as shown in FIG. 20.

The line blanking pulses **78** (and also the frame blanking pulses **77**) are supplied to the line sweep generator **117** from the sync. separator **115** on line **548** and applied to the emitter of transistor **659** which is normaly off. The resultant negative-going pulses are applied to the base of transistor **660** which turns it ON to discharge the sweep voltage generating capacitor **662**. Upon termination of the blanking pulse, the capacitor **662** charges through constant current transistor **663** and the particular resistance network selected by the scan rate selector switch **195**. The resulting saw-tooth wave form signal is applied to transistors **664**, **665**, and **666** with line deflection yoke **63*a*–1** being supplied from the collector of transistor **666**. Feed-back is provided, as in the case of the vidicon sweep circuits, by zener diode **667**.

It will be observed that a frame sweep voltage from the frame sweep generator **116** is supplied to the line sweep generator **117** by line **668**. Potentiometer **669** applies a portion of the frame sweep voltage to the scan rate selector resistors **670**, **672**, and **673** thereby to vary the amplitude of the line sweep voltage in accordance with the frame sweep voltage and thus to correct the bottom portion of the keystone distortion, as shown in FIG. 20. Another portion of the frame sweep voltage on line **668** is supplied by potentiometer **675** to the base of transistor **676** which with transistor **677** drives line deflection yoke **63*a*–2** which in turn corrects the top portion of the keystone distortion as shown in FIG. 20.

In the frame sweep genertnor **116**, capacitor **712** is coupled across the base of transistor **665** and ground and the frame sweep voltage from emitter follower **666** is coupled to the base of emitter follower transistor **715** by zener diode **713**, the resulting frame sweep signal voltage for keystone distortion correction in the line sweep generator **117** being taken from the emitter of line **668**, as shown. Here, the keystone distortion correction voltage for line **671** is taken from potentiometer **718** connected across line **668** and ground as shown. Centering control for the frame sweep is provided by transistor **716** which drives frame deflection yoke **63*b*–2** from its collector as shown. In the frame sweep generator **116**, resistor **683**, of the line sweep circuit **117** is eliminated.

The pulsing of the flood beam at a relatively high rate in order substantially to increase the storage time together with the alternate pulsing of the writing beam in a time-sharing arrangement is described in application Serial No. 109,082 filed May 10, 1961, of J. H. Holsinger and the present inventor, and assigned to the assignee of the present application. If shorter storage times, i.e., on the order of two minutes, are permissible, pulsing of the flood beam may be eliminated, the writing beam, however, is still preferably pulsed in order to permit coupling the video signal to the writing gun with a relatively small capacitor.

It will be readily seen that the vidicon tube **44** together with shutter **47** and a suitable lens **42** may be mounted in a portable camera unit to permit the system to be used for transmitting a still picture "snapped" from a moving scene. The system may thus be employed for transmitting any picture which could ordinarily be taken with a conventional photographic camera with comparable exposure time.

It will now be seen that in the above-described system, control relay **84** initiates a frame blanking pulse which automatically resets the sweeps of the vidicon back to the beginning of a frame and blanks the vidicon beam. The control relay simultaneously actuates the mechanical shutter to expose the vidicon to whatever image the lens is viewing and transmits the 400 cycle tone to the receiver where it is employed to erase a previously stored picture from the display tube. The newly initiated frame blanking pulse is also transmitted to the receiver and automatically resets the sweeps of the display tube back to the beginning of a frame. At the end of the newly initiated frame blanking pulse, the vidicon scans the picture in one frame, the resulting video signal being transmitted to the receiver and written into the storage tube for display for a period following transmission of the picture.

In order to permit transmission of the video signal over ordinary voice frequency band telephone lines, unusually low scanning rates are employed, the video signal being modulated and demodulated in a system which allows the highest video frequency to approach .9 of the carrier frequency.

In a specific embodiment of the system of the invention employing the specific vidicon and storage tube as indicated and with the scanning rates and frequencies indicated, the following component values were employed:

Preamp 95

R125	meg	8.2
R134		180K
R135		20K
Tube 130		6112

Control relay 84 and bistable 81

C145	mf	4
R146		470K
R147		20K
R148		3900
C149	mf	500
C153	mf	.47
Trans. 154		2N1377
R155		1K
R157		510K
Diode 158		1N277
C159	mf	1
R160		100K
R161		100K
Trans. 163		2N1377
Trans. 164		2N1377
R165		82K
C166	mmf	47
R167		82K
C168	mmf	47
Diode 170		1N277
Diode 175		1N277
Diode 178		1N277
C169	mmf	470
C174	mf	.47
R172		470K
R173		470K
R176	ohms	68,000
R177		470K

Line and frame timers 72, 73 and reset trigger 91

Diode 192		1N277
Diode 193		1N277
Diode 194		1N277
Diode 199		1N459
Diode 205		1N751
C196	mf	.004
R201		220K
Trans. 198		2N1377
R200		470K
R202		100K
R204		10K
C203	mf	.01
C208	mf	.47
Trans. 229		2N1377
R232	ohms	47
R233		10K
R234		100K
Diode 235		1N759
C230	mf	.015
C236	mf	.1
C213	mf	.004
R211		220K
Diode 218		1N459
R219		470K
R220		100K
R223		10K
Diode 224		1N751
C222	mf	.01

Sweep generators 79, 80

	Line	Frame
Trans. 237	2N358A	
Trans. 238	2N1377	
Trans. 248	2N358A	
Trans. 239	2N1377	
Trans. 240	2N358A	
Trans. 241	2N1377	
Trans. 242	2N358A	
Trans. 243	2N1039	
R251	2,200 ohms	
R245	47K	
R249, 22K		10K.
R250, 10K		4,700 ohms.
R252	100K	
R253	100K	
R262	4,700 ohms	
R263	10K	
R264, 1,000 ohms		470 ohms.
C285	01mf	
R283, 47 ohms		100 ohms.
R254, 36K		100K.
R255, 20K		50K.
R256, 27K		56K.
R257, 10K		20K.
R258, 15K		33K.
R259, 10K		10K.
C244, .47mf.		100mf.
R277, 47K		15K.
Diode, 278	1N1316	
Diode, 265	1N751	
Diode, 279	1N1314	
R266	10K	
R282	27K	
R280	1,300 ohms	
R284, 1,000 ohms		470.

Enhancement circuit 96, video and blanking 97, and blanking pulse mixer 94

R290	ohms	4000
R291	do	8200
R288		18K
C289	mf	.022
Tube 287		6112
Tube 308		6112
R293		470K
R292		220K
R301		120K
R294		150K
Tube 295		6112
Tube 300		6112
R298	meg	2.2
R299		39K
C302	mf	.01
Diode 303		1N277
R304	meg	2.2
R305		22K
R306		22K
C309	mf	.022
R312		33K
R311		100K
R332		25K
Diode 316		1N1323
Diode 317		1N1323
Trans. 313		2N1377
R331		180K
R315		47K
R314		47K
Trans. 333		2N358A
R335		47K
R336	ohms	1200
R281	do	1000
Trans. 334		2N1377
Diode 321		1N751
R337		12K
R338		11K
R318		33K
Diode 319		1N459
Diode 320		1N459
R322		22K
R323		10K

Diode 324	1N277
Diode 329	1N277
Trans. 325	2N1377
R328	10K
R327	100K
R326	10K
R345	100K
Trans. 342	2N358A
R347	22K
R343	10K
R344	10K
R348	10K
R349	100K
Trans. 350	2N358A
R351	2.2K
Trans. 353	2N358A
Trans. 354	2N1377
R355	2.2K
R356	47K

Square wave generator 89 and modulator 90

Trans. 357	2N1039
R359	47K
R358	ohms 82
R360	3.9K
Filter 98	Burnell S-60105
Trans. 362	2N358A
R363	ohms 620
R364	10K
R365	4.7K
R366	4.7K
R368	10K
R369	8.2K
Diode 370	1N751
Trans. 361	2N1377
Diode 367	1N459
R372	27K
R374	10K
Diode 375	1N277
Trans. 376	2N526
R377	27K
Diode 378	1N459
Diode 379	1N751
Trans. 383	2N1377
Trans. 384	2N1377
R385	10K
R386	10K
C387	mf .01
C388	mf .01
R389	100K
R402	100K
R400	50K
R403	50K
Diode 404	1N751
Trans. 405	2N1377
Diode 409	1N759
R408	4.7K
R407	50K
R406	10K
C413	mf 10
R415	10K
R418	10K
R416	27K
R417	27K
Diode 419	1N751
Diode 420	1N751
Trans. 412	2N1377
Trans. 422	2N1039
R423	47K
R424	3.9K
R426	ohms 620
Filter 92	Burnell S-60106
R431	ohms 560
Trans. 425	2N1377
Trans. 432	2N1377
R427	47K
R428	27K
R433	39K
R429	10K
R430	1.3K
C436	mf 10

AGC 106

Trans. 438	2N1377
R440	ohms 4700
R439	10K
R455	100K
C456	mf .01
Trans. 448	2N1377
R453	18K
R454	6.8K
Diode 449	1N751
Trans. 457	2N1377
Trans. 458	2N1377
R459	5.6K
R460	5K
R462	18K
R463	10K
Diode 464	1N277
C465	mf 100
Trans. 450	2N329A
Trans. 452	2N1377
R468	22K
R470	1K
R466	470K
R469	1.2K
R467	10K
Trans. 443	2N1377
Trans. 444	2N1377
Trans. 446	2N1377
Trans. 447	2N1377
C445	mf 1
C473	mf 1
R474	ohms 56
R477	do 56
R475	10K
R476	47K
R480	4.7K
R479	27K
C489	mf 100
C497	mf 1
R490	ohms 56
R496	do 56
R492	10K
R494	33K
R495	25K
C483	mf 1
Trans. 482	2N1377
Trans. 484	2N1377
R485	2.7K
R486	47K
R487	3.9K
R478	33K

Demodulator 107

R500	50K
Trans. 502	2N1377
Trans. 503	2N1039
R504	47K
R505	ohms 3900
R515	do 4700
R516	do 1000
R517	do 1500
Diode 518	1N751
Trans. 519	2N1377
Trans. 520	2N1039
R514	47K
R522	47K

R523	ohms 3900
R525	do 82
Filter 524	Burnell S-60106
Diode 510	1W277
Diode 512	1W277

Sync. separator 115

Trans. 530	2N1377
R532	ohms 6800
R531	do 620
Trans. 533	2N1377
R534	10K
Diode 543	1N277
Diode 535	1N277
R536	15K
R539	100K
Diode 540	1N751
R 542	220K
Trans. 546	2N1377
R547	10K
R538	47K
C552	mf .22
R550	180K
Trans. 537	2N1377
Trans. 553	2N1377
R549	ohms 8200
R554	10K
R555	47K
R556	180K
Trans. 557	2N1377
R558	10K
R562	3.3K
R563	ohms 560
C578	mf .001
R551	10K
R581	20K
R580	10K
R582	10K
R571	10K
R568	ohms 1200
C574	mf 8
C575	mf .022

Write gun ON-OFF Trigger 118

Trans. 590	2N1377
Trans. 595	2N1377
Diode 592	1N277
Diode 594	1N277
Diode 596	1N277
C593	mf .47
C597	mf 4.0
R598	570K
R602	82K
R603	82K
C604	mmf 47
C605	mmf 47
R606	ohms 6800
C607	mf .1

Write Gun Control 119

Trans. 614	2N1377
Trans. 619	2N1377
Trans. 625	2N1377
R615	25K
R616	ohms 1000
R617	47K
R620	68K
R623	ohms 2200
R624	470K
R622	430K
R630	150K
Diode 628	N277
Diode 629	N277
R626	10K
R634	43K
R635	62K
R636	82K
C627	mf .001
C633	mf .002
Trans. 637	2N341
R638	100K
Diode 639	1N1323
Diode 640	1N1323
Trans. 642	2N358A
R643	22K
R644	22K
R645	100K
C641	mf .01
R647	100K
C648	mf 4
C649	mf 4
R650	meg 1
R652	meg 1
R653	68K
R654	meg 2.2
Diode 655	1N277
R656	meg 4.7
C657	mf .1

Display tube line and sweep Generators 116, 117

	Line	Frame
Trans. 659	2N358A	
Trans. 665	2N358A	
Trans. 660	2N358A	
Trans. 664	2N358A	
Trans. 676	2N1377	
Trans. 677	2N1377	
Trans. 715	2N1377	
Trans. 716	2N1377	
Trans. 663	2N341	
Trans. 666	2N1039	
R678	10K	
R679	100K	
R680	10K	
R682	100K	
R683, 350 ohms		
C662, 1.0 mf		100 mf.
R670, 270K		180K.
R672, 470K		470K.
R673, 680K		1.2 Meg.
R685, 20K		50K.
R686, 51K		120K.
R687, 50K		100K.
R688, 51K		240K.
R689, 50K		200K.
R700, 150K		510K.
R702	150K	
R703	10K	
Diode, 667	1N751	
R704	15K	
R705, 2,200 ohms		1,800 ohms.
R706	100 ohms	
R669	50K	
R675	50K	
R708	3,300 ohms	
R709	2,000 ohms	
C712		.01 mf.
R707	220K	
Diode, 713		1N1314.
R714		47K.
R717		15K.
R718		50K.
R719		3,300 ohms.
R720		2,000 ohms.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What is claimed is:

1. A television system for transmitting a still picture comprising: image tube means including target means for converting an optical image into a corresponding electrical characteristic pattern, and means for scanning an electron beam thereby to convert said pattern into a time-based video signal; means for generating recurrent sequences of periodic frame synchronizing signals and

4157

intervening line synchronizing signals for said scanning means; means for generating a control signal; means for modulating an input signal to provide an output transmission signal; selectively actuable control means coupled to said pulse generating means for initiating a new sequence of said synchronizing signals, said control means including means for coupling said control signal generating means to said modulating means for a predetermined period during the first frame synchronizing signal of said new sequence thereby to modulate said transmission signal with said control signal; ~~means for coupling said~~ image tube ~~means to said~~ modulating means thereby to modulate said transmission signal with said video signal during said new sequence of said synchronizing signals following said first frame synchronizing signal thereof; means for demodulating said transmission signal to recover said control and video signals; means for separating said control signal from said recovered signals; means for separating said synchronizing signals from said recovered signals; direct viewing storage cathrode ray tube means having display screen means and selectively actuable means for converting said separated video signal into an optical image on said display screen means, said cathrode ray tube means including storage means for maintaining said optical image on said display screen means for a finite time following deactuation of said storage tube converting means; first means coupling said control signal separating means to said storage means for erasing a previously stored image from said display screen means responsive to said control signal; second means coupling said control signal separating means to said cathode ray tube converting means for actuating the same responsive to said control signal thereby to convert said separated video signal into a new optical image on said display screen means; and third means coupling said synchronizing signal separating means to said cathode ray tube converting means for de-actuating the same responsive to the next said frame synchronizing signal following said first frame synchronizing signal of said new sequence.

2. The system of claim 1 wherein said modulating means comprises means for amplitude modulating said input signal onto a square wave carrier having a frequency in the voice band range, wherein said control signal is a tone relatively low in frequency with respect to the highest frequency of said video signal, and wherein said separating means comprises band pass filter means for passing only said tone to the exclusion of other frequencies.

3. The system of claim 2 wherein said demodulator means comprises full-wave rectifier means coupled to receive said transmission signal, and band pass filter means coupled to said rectifier means for passing only the frequencies of said video signal to the exclusion of higher frequencies.

4. The system of claim 1 wherein said cathode ray tube means includes means for generating a writing electron beam responsive to said video signal, means for generating a reading electron beam, means for generating pulses having a frequency relatively high with respect to the frequencies of said video signal, and means for coupling said pulse generating means to said writing and reading beam generating means for alternating disabling the same, respectively.

5. The system of claim 1 wherein said image tube target means is photoconductive; said image tube converting means compising means for generating an electron beam and means for scanning the same over said target means; and further comprising a load resistor connected to a source of potential, an electrical lead connecting said resistor to said target means, and a conductive shield for said lead; said video signal coupling means comprising an amplifier having an input circuit coupled to said lead adjacent said resistor and having an output circuit coupled to said modulating means for supplying said video signal thereto; and feedback means coupling said output circuit to said shield for feeding-back a portion of the video signal in said output circuit in phase to said shield thereby to vary the potential of said shield in response to the amplitude of said video signal.

6. The system of claim 1 wherein said image tube target means is photoconductive and includes a signal output circuit coupled thereto; said image tube converting means comprising means for generating an electron beam and means for scanning the same over said target means thereby to develop said video signal in said output circuit, said target means including means for providing said video signal with one level extremity responsive to large area background colors on said optical image and its other level extermity responsive to black areas on said optical image; said video signal coupling means including means for amplifying said video signal, means for clipping said other extremity to a predetermined level, and means for clamping said one extremity to a reference potential level thereby to flatten the response of said image tube to different background colors in said optical image.

7. The system of claim 1 wherein said modulating means comprises oscillator means for generating space wave carrier signal pulses, an input circuit for receiving said video and control signals, an output circuit for said transmission signal, switching means coupling said input and output circuits, and means coupling said oscillator means to said switching means for actuating the same in response to said carrier signal pulses thereby to pulse said video and control signals on and off at the frequency of said carrier pulses to provide said transmission signal.

8. The system of claim 7 further comprising means coupled to said signal input circuit for inverting said video and control signals and for reducing the amplitude thereof by one-half, and means for mixing said inverted half-amplitude signals with said pulsed signals whereby the modulating signal component is cancelled from said transmission signal.

9. The system of claim 1 further comprising degenerative automatic gain control means coupling said modulating and demodulating means.

10. The system of claim 9 wherein said automatic gain control means comprises a first input circuit for receiving said transmission signal from said modulating means, a second input circuit coupled to receive said recovered video signal from said demodulating means, means for detecting the peaks of said synchronizing signals in said recovered video signal, means for integrating said detected peaks to provide a direct current control signal responsive to the amplitude of said peaks, and means coupled to said first input circuit for varying the level of said transmission signal responsive to said control signal.

11. A television system for transmitting a still picture comprising: image tube means having photosensitive target means for converting an optical image exposed thereto into a a corresponding electrical characteristic pattern and for storing the same for a finite time, said image tube means including means for generating an electron beam and means for scanning the same over said target means for converting said pattern into a time-based video signal; selectively actuable shutter means for exposing said target means to an optical image; means for generating recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses; means coupling said pulse generating means to said beam generating means for disabling the same during a pulse; means coupling said pulse generating means to said scanning means for actuating the same to scan said beam over said target means in raster fashion; means for providing a regularly pulsating signal; means for modulating an input signal to provide an output transmission signal; control means coupled to said pulse generating means for initiating a

new sequence of said pulses, said control means including means for actuating said shutter means for a predetermined period during the first frame pulse of said new sequence to expose said optical image to said target means whereby a video signal responsive to said image is provided during said new sequence following said first frame pulse thereof, said control means including means for coupling said pulsating signal to said modulating means for a predetermined period during said first frame pulse thereby to modulate said transmission signal, means for coupling said video signal to said modulating means thereby to modulate said transmission signal; means for demodulating said transmission signal to recover said pulsating and video signals; means coupled to said demodulator means for separating said pulsating signal; means coupled to said demodulator means for separating said frame and line pulses from said video signal; direct viewing storage cathode ray tube means having display screen means, said cathode ray tube means including selectively actuable means coupled to said demodulating means for converting a video signal into an optical image on said display screen means, said cathode ray tube means including storage means for maintaining said optical image on said display screen means for a finite time following deactuation of said stoarge tube converting means; first means coupling said pulsating signal separating means to said storage means for erasing a previously stored optical image from said display screen means responsive to said pulsating signal; second means coupling said pulsating signal separating means to said storage tube converting means for actuating the same responsive to said pulsating signal thereby to convert said video signal into a new optical image on said display screen means; and third means coupling said pulse separating means to said storage tube converting means for deactuating the same responsive to the next frame pulse following said first frame pulse.

12. The system of claim **11** wherein said modulating means comprises means for amplitude modulating said input signal onto a square wave carrier having a frequency in the voice band range; said pulsating signal being a tone relatively low in frequency with respect to the highest frequency of said video signal; said demodulator means comprising full-wave rectifier means coupled to receive said transmission signal, and fisrt band pass filter means for passing only the frequencies of said video signal to the exclusion of higher frequencies; said pulsating signal separating means comprising second band pass filter means for passing only said tone to the exclusion of other frequencies; said storage tube stor-means comprising storage electrode means; said storage means comprising storage elcertode means; said storage tube converting means comprising means coupled to said demodulator means for generating a writing electron beam responsive to said video signal, means for scanning said writing beam over said storage electrode means, means coupling said pulse separating means to said scanning means whereby said writing beam is scanned over said storage electrode in raster fashion and said video signal is converted into an electrical characteristic pattern on said storage electrode means corresponding to said optical image, means for generating a reading electron beam, and means for flooding said storage electrode means with said reading beam thereby to convert the pattern thereon into an optical image on said display screen means; said first coupling means comprising first switching means actuated in response to said tone for applying an erasing potential to said storage electrode means; said second coupling means comprising second switching means actuated in response to said tone for enabling said writing beam generating means; said third coupling means coupling said puse separating means to said second switching means for actuating the same to disable said writing beam means in response to the next frame pulse following said first frame pulse.

13. The system of claim **11** wherein said modulator means includes means for cancelling the video signal component of said transmission signal; and further comprising band pass filter means for passing only the carrier and lower side band components to the exclusion of the upper side band component.

14. The system of claim **11** wherein said control means comprises switching means having two positions, manually actuated means for actuating said switching means to said first position thereof, means coupling said switching means to said shutter means for actuating the same responsive to actuation of said switching means to said first position thereof, said switching means in said first position thereof coupling said pulsating signal to said modulating means, means coupling said switching means to said pulse generating means for intitiating said new sequence of pulses responsive to actuation of said switching means to said first position thereof, said switching means including time delay means for actuating said switching means to said second position thereof thereby establishing said periods, said periods being shorter than a said frame synchronizing pulse.

15. The system of claim **14** further comprising first means for indicating when said system is in a condition to transmit a picture and second means for indicating when said system is transmitting a picture, and second switching means having two positions, said second switching means in said first position thereof actuating said first indicating means and in said second position thereof actuating said second indicating means, means coupling said first-named switching means to said second switching means for actuating the same to said second position thereof in response to actuation of said first-named switching means to said first position thereof; and means coupling said pulse generating means to said second switching means for actuating the same to said first position thereof responsive to the next frame pulse following said first frame pulse of said new sequence.

16. The system of claim **11** wherein said control means comprises a relay having an operating coil, a capacitor normally coupling said coil to a source of energizing potential, manually actuated switch means for momentarily short-circuiting said coil and caparitor whereby said capacitor discharges through said coil to energize the same, said relay having first contacts for maintaining said short-circuit when said coil is enregized whereby said capacitor fully discharges through said coil thereby establishing said periods, said shutter means including solenoid means for actuating the same, said relay having second contacts coupled to energize said solenoid when said coil is energized, said relay having third contacts coupling said pulsating signal to said modulating means when said coil is energized, said pulse generating means including means for initiating another sequence of pulses responsive to completion of a previous sequence, said relay having fourth contacts coupled to said initiating means when said said coil is energized for actuating the same to initiate said new sequence prior to completion of a previous sequence.

17. The system of claim **11** wherein said frame synchronizing pulses are substantially longer than said line synchronizing pulses; wherein said frame and line synchronizing pulse separating means comprises first amplifier means having an input circuit coupled to said demodulator means for receiving the recovered video signal therefrom, said first amplifier means having an output circuit, said first amplifier means including means for rendering the same substantially non-conductive in the absence of a synchronizing pulse and conductive in response to a synchronizing pulse thereby providing said line and frame synchronizing pulses only in said output circuit, time constant means coupled to said output circuit for providing a predetermined potential level only in response to said frame synchronizing pulses, and second amplifier means having an input circuit coupled to

said time constant means, said second amplifier means having an output circuit, said second amplifier means including means for rendering the same substantially non-conductive in the absence of said predetermined potential level and conductive in response to said predetermined potential level thereby providing said frame synchronizing pulses only in said second amplifier means output circuit; and wherein said storage tube converting means includes means coupled to said demodulating means for generating an electron beam responsive to said recovered video signal, and means for rectilinearly scanning said beam coupled to said frame and line synchronizing pulse separating means and actuated by said frame and line synchronizing pulses, respectively.

18. A television system for transmitting a still picture comprising: image tube means having photosensitive target means for converting an optical image exposed thereto into a corresponding electrical characteristic pattern and for storing the same for a finite time, a signal output circuit coupled to said target means, means for generating an electron beam, and means for rectilinearly scanning said beam over said target means thereby to provide a time-based video signal in said output circuit responsive to said pattern; line and frame sweep generating means respectively coupled to said scanning means; means for generating frame blanking pulses coupled to said frame sweep generating means; means for generating line blanking pulses which are relatively short with respect to said frame blanking pulses coupled to said line sweep generating means; timing means coupled to said pulse generating means for actuating the same, respectively, to provide recurrent sequences of frame pulses and intervening line pulses; means coupled to said pulse generating means for non-additively mixing said frame and line pulses and for coupling the same to said beam generating means thereby to disable the same during each pulse; means for generating a regularly pulsating signal; means for modulating an input signal to provide an output transmission signal; control means coupled to said timing means for initiating a new sequence of pulses, said control means including means for actuating said shutter means for a predetermined period during the first frame pulse of said new sequence to expose said optical image to said target means whereby a video signal responsive to said image is provided during said new sequence following said first frame pulse thereof, said control means including means for coupling said pulsating signal to said modulating means for a predetermined period during said first frame pulse thereby to modulate said transmission signal, means for coupling said video signal to said modulating means thereby to modulate said transmission signal; means for demodulating said transmission signal to recover said pulsating and video signals; means coupled to said demodulator means for separating said pulsating signal; means coupled to said demodulator means for separating said frame and line pulses from said video signal; direct viewing storage cathode ray tube means having display screen means, said cathode ray tube means including selectively actuable means coupled to said demodulating means for converting a video signal into an optical image on said display screen means, said cathode ray tube means including storage means for maintaining said optical image on said display screen means for a finite time following deactuation of said storage tube converting means; first means coupling said pulsating signal separating means to said storage means for erasing a previously stored optical image from said display screen means responsive to said pulsating signal; second means coupling said pulsating signal separating means to said storage tube converting means for actuating the same responsive to said pulsating signal thereby to convert said video signal into a new optical image on said display screen means; and third means coupling said pulse separating means to said storage tube converting means for deactuating the same responsive to the next frame pulse following said first frame pulse.

19. The system of claim 18 wherein said timing means comprises a source of timing pulses, first pulse counting means coupled to said source for counting down said timing pulses, first pulse output means coupled to said first counting means for providing a first output pulse in response to a predetermined pulse count thereby, said first pulse output means being coupled to said line blanking pulse generating means for actuating the same to provide a line blanking pulse in response to each said first output pulse, first means for resetting said first counting means in response to each said first output pulse, second pulse counting means coupled to said first pulse output means for counting down said first output pulses, second pulse output means coupled to said second counting means for providing a second output pulse in response to a predetermined pulse count thereby, said second pulse output means being coupled to said frame blanking pulse generating means for actuating the same to provide a frame blanking pulse in response to each said second output pulse, and second means for resetting said second counting means in response to said second output pulses; and wherein said control means is coupled to said second resetting means for actuating the same to reset said second counting means thereby to initiate said new sequence of blanking pulses.

20. The system of claim 18 wherein said timing means comprises a source of timing pulses, a first pulse counting chain coupled to said source for counting-down said timing pulses and comprising a first plurality of bistable multivibrators each having a pulse output circuit and a resetting circuit, a first diode logic circuit, first switching means for selectively coupling said first logic circuit to said pulse output circuits of said first plurality of multivibrators thereby to provide a first output pulse in response to a predetermined pulse count by said first counting chain, said first logic circuit being coupled to said line blanking pulse generating means for actuating the same to provide a line blanking pulse in response to each said first output pulse, means coupling said first logic circuit to said resetting circuits of said first plurality of multivibrators for actuating the same to initiate a new count in response to each said first output pulse; a second pulse counting chain coupled to said first logic circuit for counting-down said first output pulses and comprising a second plurality of bistable multivibrators each having a pulse output circuit and a resetting circuit, a second diode logic circuit, second switching means for selectively coupling said second logic circuit to said pulse output circuits of said second plurality of multivibrators thereby to provide a second output pulse in response to a predetermined pulse count by said second counting chain, said second logic circuit being coupled to said frame blanking pulse generating means for actuating the same to provide a frame blanking pulse in response to each said second output pulse, means coupling said second logic circuit to said resetting circuits of said second plurality of multivibrators for actuating the same to initiate a new count in response to each said second output pulse; and wherein said control means is coupled to trigger pulse generating means, said trigger pulse generating means being coupled to last-named coupling means for actuating said resetting circuits of said second plurality of multivibrators thereby to initiate said new sequence of blanking pulses.

21. The system of claim 18 wherein said video signal coupling means comprises means coupled to said blanking pulse generating means for inserting said blanking pulses in said video signal, and means for clamping the pedestals of said blanking pulses to a predetermined direct current level thereby establishing a direct current level for said video signal.

22. The system of claim **18** wherein said modulating means comprises first and second input circuits for respectively receiving said video and pulsating signals, means coupled to said input circuits for non-additively mixing said video and pulsating signals to provide a modulating signal, band pass filter means coupled to said mixing means for passing only the frequencies of said video signal to the exclusion of higher frequencies, the frequency of said pulsating signal being below the highest frequency of said video signal, amplifier means coupled to said filter means and including means for setting a predetermined direct current level for said modulating signal, said amplifier means having an output circuit for the modulating signal resulting therefrom, oscillator means for generating square wave carrier signal pulses having a frequency in the voice band range and having an output circuit; a diode resistor switch network coupled across said amplifier output circuit and comprising means including first and second resistors serially coupled by a first diode, and means including a second diode coupled across said first diode and second resistor, said oscillator means output circuit being coupled to said second diode, said second diode being normally back-biased whereby current flows in said first diode and second resistor responsive to said modulating signal in the absence of a carrier pulse, said second diode being rendered conductive responsive to a carrier pulse thereby back-biasing said first diode to cut off current flow therein and in said second resistor in the presence of a carrier pulse whereby an output signal is developed across said second resistor responsive to said modulating signal which is pulsed on and off at the frequency of said carrier pulses; means coupled to said amplifier output circuit for inverting said modulating signal and for reducing the amplitude thereof by one-half, said inverting means being coupled to said second resistor for mixing said inverted half-amplitude signals therein with said pulsed modulating signal whereby the modulating signal component is cancelled from said output signal; and band pass filter means coupled to said second resistor for passing the carrier and lower side band frequency components to the exclusion of the upper side band frequency component in said output signal thereby to provide said transmission signal.

23. The system of claim **18** wherein said scanning means comprises vertical and horizontal deflection yokes, wherein said modulating means includes means for amplitude modulating said input signal onto a carrier signal having a frequency in the voice band range; and wherein each of said sweep generating means comprises an input circuit coupled to the respective blanking pulse generating means, first amplifying means coupled to said input circuit, capacitor-discharge saw-tooth wave form generating means, switching means coupling said first amplifying means to said saw-tooth generating means for discharging the same responsive to a blanking pulse, second amplifying means coupled to said saw-tooth generating means for amplifying the saw tooth wave form signals produced thereby, and means for feeding-back the amplified saw-tooth signals to said saw-tooth generating means, said second amplifying means being coupled to energize the respective deflection yoke; said sweep generating means, second amplifier means and deflection yoke being direct current coupled.

24. A television system for transmitting a still picture comprising: image tube means having photosensitive target means for converting an optical image exposed thereto into a corresponding electrical characteristic pattern and for storing the same for a finite time, said image tube means including means for generating an electron beam and means for rectilinearly scanning the same over said target means for converting said pattern into a time-based video signal; selectively actuable shutter means for exposing said target means to an optical image; means for generating recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses which are relatively short with respect to said frame synchronizing pulses; means coupling said pulse generating means to said beam generating means for disabling the same during a pulse; means coupling said pulse generating means to said scanning means for actuating the same to scan said beam over said target means in raster fashion; means for generating a tone having a frequency relatively low with respect to the frequencies of said video signal; means for inserting said synchronizing pulses in said video signal to provide a modulating signal; means for amplitude modulating said modulating signal onto a carrier signal to provide a transmission signal; control means coupled to said pulse generating means for initiating a new sequence of said pulses, said control means including means for actuating said shutter means for a predetermined period during the first frame pulse of said new sequence to expose said optical image to said target means whereby a video signal responsive to said image is provided during said new sequence following said first frame pulse thereof, said control means including means for coupling said tone generating means to said modulating means for a predetermined period during said first frame pulse whereby said tone is superimposed on said modulating signal; means for demodulating said transmission signal to recover said video signal; band pass filter means coupled to said demodulating means for passing only said tone to the exclusion of other frequencies; means coupled to said demodulating means for separating said frame and line synchronizing pulses from said modulating signal; a storage cathode ray tube having charge storage electrode means, display screen means, means for generating a writing electron beam, selectively actuable means for coupling said writing beam generating means to said demodulating means whereby said writing beam is responsive to said video signal, means for rectilinearly scanning said writing beam over said storage electrode means, means coupling said pulse separating means to said scanning means whereby said writing beam is scanned over said storage electrode means in raster fashion to convert said video signal into a charge pattern on said storage electrode means corresponding to said optical image, means for generating a reading electron beam, and means for flooding said storage electrode means with said reading beam thereby to convert said charge pattern into an optical image on said display screen means; first switching means having first and second positions, said first switching means being coupled to said filter means and actuated to said second position thereof responsive to said tone, said first switching means including means for actuating the same to said first position thereof in the absence of said tone and prior to termination of said first frame pulse of said new sequence, said first switching means in said second position thereof coupling said storage electrode to a source of erasing potential for erasing said charge pattern therefrom, said first switching means in said first position thereof coupling said display screen to a source of anode potential and decoupling the same in in said second position; second switching means having first and second positions, means coupling said first switching means to said second switching means for actuating the same to said second position thereof responsive to actuation of said first switching means to said second position thereof; means coupling said pulse separating means to said second switching means for actuating the same to said first position thereof responsive to termination of the next said frame pulse following said first frame pulse of said new sequence; means coupling said second switching means to said writing beam coupling means for actuating the same to couple said writing beam generating means to said demodulating means responsive to actuation of said second switching means to said second position thereof and to decouple the same responsive to actuation of said second switch-

ing means to said first position thereof whereby a new charge pattern is written onto said storage electrode during the first frame of said new sequence; and means coupling said pulse separating means to said writing beam coupling means for deactuating the same to decouple said writing beam generating means from said demodulating means during said synchronizing pulses.

25. The system of claim 24 further comprising means for generating pulses having a frequency relatively high with respect to said carrier; and means coupling said last-named pulse generating means to said writing beam coupling means and to said reading beam generating means for alternately pulsing said reading and writing beams on and off respectively.

26. The system of claim 24 wherein said first switching means comprises reed relay means tuned to the frequency of said tone and having a first operating coil coupled to said filter means for energization responsive to said tone, said reed relay having contacts actuated in response to energization of the operating coil thereof, and a second relay having a second operating coil coupled for energization by said reed relay contacts responsive to actuation thereof, means including first contacts on said second relay for maintaining said second coil energized for a predetermined time longer than the period of said tone and shorter than the duration of said first frame pulse, said second relay having second contacts coupling said storage electrode means to said source of erasing potential in response to energization of said second coil and to a source of writing potential in response to de-energization of said second coil, said second relay having third contacts coupling said display screen to a source of anode potential when said second coil is de-energized and decoupling the same in response to energization of said second coil; said second switching means comprising bistable multivibrator means having first input circuit means for switching the same to one stable condition in response to application of a first signal, said second relay having fourth contacts coupling said first input circuit means to a source of potential in response to energization of said second coil thereby to provide said first input signal, said bistable means having second input circuit means for switching the same to the other stable condition thereof in response to application of a second signal, said second input circuit means being coupled to said synchronizing pulse separating means for impressing said frame synchronizing pulses thereon, said second input circuit means including time delay means for providing said second input signal in response to the trailing edge of the next frame synchronizing pulse following said first synchronizing pulse of said new sequence, and third relay means having a third operating coil coupled to said bistable means and energized thereby when said bistable means is in said other stable condition, said third relay having contacts coupled to actuate said writing beam control means responsive to de-energization of said third coil.

27. The method of transmitting a still picture comprising the steps of: exposing an optical image to the target means of an image tube for a predetermined period, transmitting a control signal for a predetermined period, converting the image on said target means into a time-based video signal and transmitting the same during an interval following said periods, receiving said control signal and applying the same to storage signal-to-image converting means for erasing a previously stored image, and receiving said video signal and converting the same into an optical image on said converting means.

28. The method of transmitting a still picture comprising the steps of: generating recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses, initiating a new sequence of pulses, exposing an optical image to the target means of an image tube for a predetermined period during the first frame pulse of said new sequence, generating a tone signal for a predetermined period during said first pulse, amplitude modulating said tone signal onto a carrier and transmitting the resultant signal, rectilinearly scanning said target means once with an electron beam in synchronism with said pulses during said new sequence following said first pulse to convert the optical image on said target means into a video signal, modulating said carrier with said video signal and transmitting the resultant signal, receiving the transmittal signals and recovering said tone and video signals, converting said tone signal into a control signal, applying said control signal to the storage means of direct viewing storage cathode ray tube means for erasing a previously stored image, and converting said video signal into an electron beam in said storage tube means and scanning the same once over said storage means in synchronism with said pulse during said new sequence following said first pulse.

29. The method of claim 28 comprising the further steps of combining said pulses, video signal and tone signal to provide a modulating signal whereby said tone signal is superimposed upon said first frame pulse, and separating said pulses from said recovered signal.

30. The method of transmitting a still picture comprising the steps of: generating recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses, initiating a new sequence of pulses, exposing an optical image to the target means of an image tube for a predetermined period during the first frame pulse of said new sequence, generating a square wave carrier signal, generating a tone signal for a predetermined period during said first pulse, amplitude modulating said tone signal onto said carrier, rectilinearly scanning said target means once with an electron beam in synchronism with said pulses during said new sequence following said first pulse to convert the optical image on said target means into a video signal, amplitude modulating said video signal onto said carrier, cancelling the modulating signal and upper sideband components from the modulated signal and transmitting the resultant signal receiving said resultant signal and recovering said tone and video signals, converting said tone signal into a control signal, applying said control signal to the storage means of direct viewing storage cathode ray tube means for erasing a previously stored image, and converting said video signal into an electron beam in said storage tube means and scanning the same once over said storage means in synchronism with said pulses during said new sequence following said first pulse.

31. The method of claim 30 wherein said recovering comprises the stesp of doubling the frequency of said resultant signal and filtering out all frequencies above the frequency of said video signal.

32. The method of claim 30 wherein said square wave carrier signal has a frequency in the voice band range and said tone signal has a frequency substantially lower than said carrier.

33. The method of transmitting a still picture comprising the steps of: generating recurrent sequences of frame synchronizing pulses and intervening line synchronizing pulses, initiating a new sequence of pulses, exposing an optical image to the target means of an image tube for a predetermined period during the first frame pulse of said new sequence, generating a control signal for a predetermined period during said first pulse, rectilinearly scanning said target means once with an electron beam in synchronism with said pulses during said new sequence following said first pulse to convert the optical image on said target means into a video signal, combining said pulses, control signal and video signal to provide a modulating signal, amplitude modulating said modulating signal onto a carrier signal and transmitting the resultant signal, receiving the transmitted signal and recovering said modulating signal, separating said control signal and said pulses from said modulating signal, respectively, converting said control signal into an erasing potential and

applying the same to the storage electrode means of a direct viewing storage cathode ray tube to erase a previously stored image therefrom, initiating a writing electron beam simultaneously with said control signal, modulating said writing beam with said modulating signal, rectilinearly scanning said writting beam once over said storage electrode means in synchronism with said pulses during said new sequence following said first pulse, flooding said storage electrode means with a reading electron beam, and terminating said writing beam simultaneously with the end of said new sequence.

34. The method of claim 33 comprising the additional step of pulsing said writing and reading beams alternately on and off, respectively, at a frequency substantially higher than the frequency of said carrier signal.

References Cited by the Examiner

UNITED STATES PATENTS

2,879,442	3/1959	Kompfner et al.	315—12
2,929,869	3/1960	Hines	178—6.8
3,061,670	10/1962	Oster et al.	178—6.8
3,084,213	4/1963	Lemelson	178—5.6

DAVID G. REDINBAUGH, *Primary Examiner.*

J. O'BRIEN, *Assistant Examiner.*

358-479

E9595 XR 3,751,159

United States Patent [19]

Fisher

[11] **3,751,159**

[45] **Aug. 7, 1973**

[54] **REPRODUCTION SYSTEM**

[76] Inventor: **William G. Fisher,** 1619 E. John Wesley Ave., College Park, Ga.

[22] Filed: **May 19, 1971**

[21] Appl. No.: **144,743**

[52] **U.S. Cl.** .... **355/20,** 178/7.8, 355/8, 355/84, 346/74 CR

[51] **Int. Cl.** **G01d 15/06,** G11b 5/30

[58] **Field of Search** .... 355/20, 8, 81, 84; 313/329; 346/74 CR; 178/7.8

[56] **References Cited**

UNITED STATES PATENTS

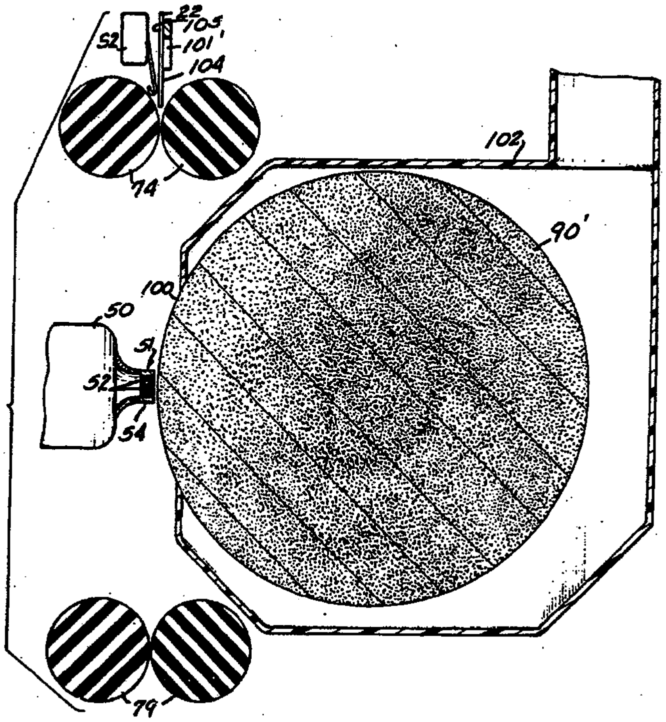
2,928,973	3/1960	Crews	313/329 X
3,608,452	9/1971	Conrad	95/12
2,771,336	11/1956	MacGriff	346/74 CR
3,041,932	7/1962	Kliminster	355/20
2,297,398	9/1942	Fries	346/74 CR
2,212,249	8/1940	Schroter	346/74 CR

Primary Examiner—Samuel S. Matthews
Assistant Examiner—Michael D. Harris
Attorney—B. J. Powerll

[57] **ABSTRACT**

A machine for reproducing the visual image on documents onto a paper substrate including a television camera for scanning the visual image on a document and converting the visual image into a corresponding electrical video signal; a cathode ray printing tube having a wire matrix; a control circuit electrically connecting the camera to the cathode ray tube to cause the wire matrix to be electrically charged in a pattern corresponding to the mirror image of the visual image on the document, a conveyor for selectively moving the paper substrate by and closely adjacent to the wire matrix to impose the electrical charge pattern from the wire matrix thereon, and a developer applying toner particles to that side of the paper substrate opposite the wire matrix to convert the electrical charge pattern imposed on the paper substrate into a visual image. The developer may include a cylindrical roll defining a driving surface for engaging the paper substrate at the wire matrix and forcing same across the wire matrix in contact with the wires of the matrix. A plurality of cameras with a corresponding number of printing cathode ray tubes may be used for reproducing multi-color copies. The control circuit may include microwave transmitting and receiving station to produce a facsimile system.

18 Claims, 13 Drawing Figures



1TX5184
1 X5212
X5206

C

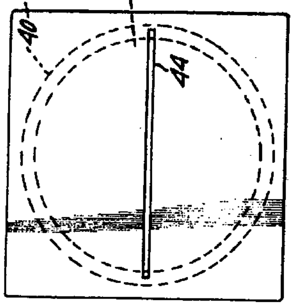


Fig 3

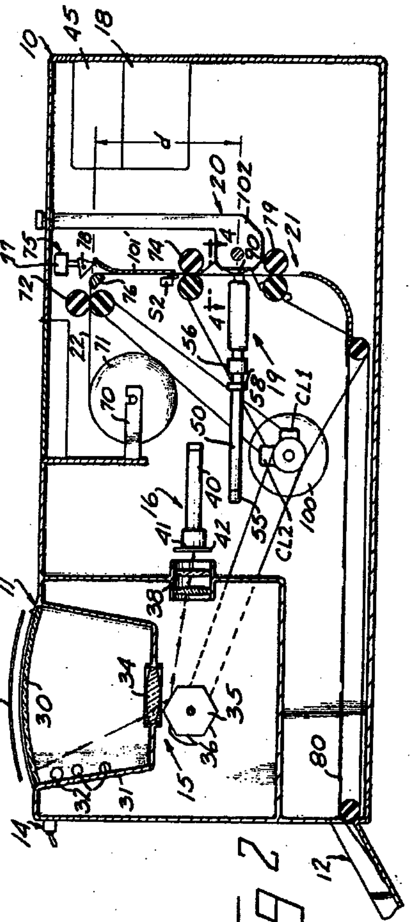


Fig 2

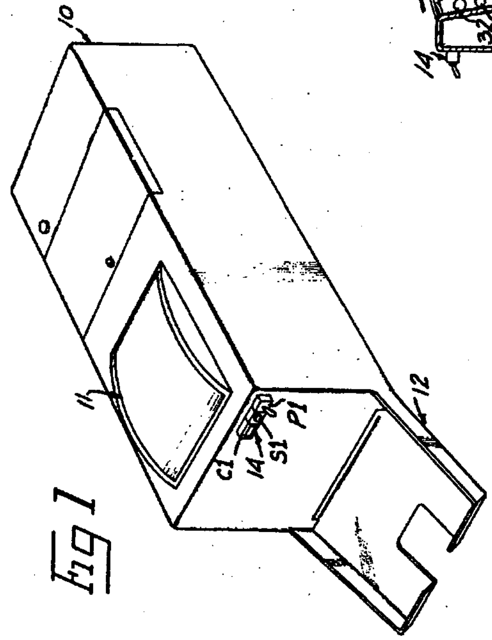
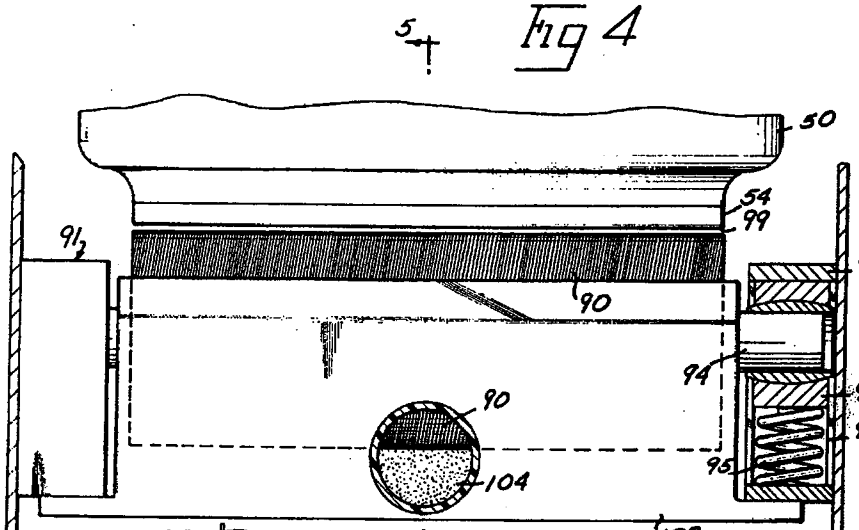


Fig 1

INVENTOR
WILLIAM G. FISHER
BY: BJPowell
ATTORNEY

Fig 4


5
50
54
99
91
98
90
94
90
92
96
95
104
102
5

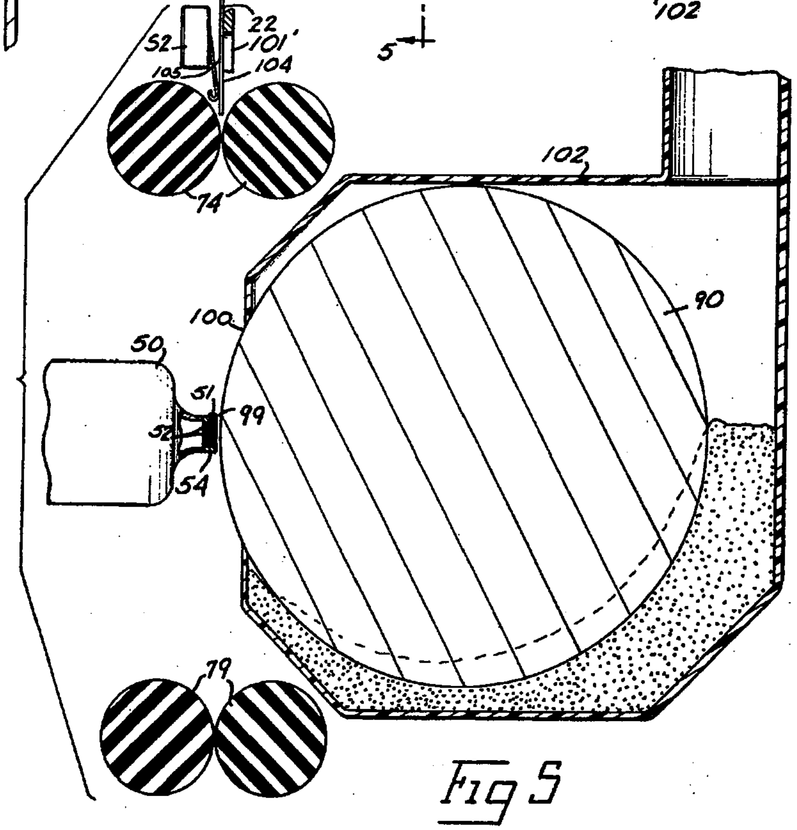

22
52
101'
105
104
74
102
100
90
50
51
52
99
54
79

Fig 5

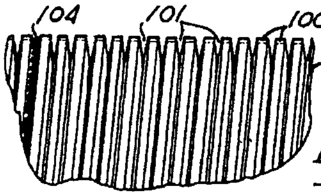


Fig 6

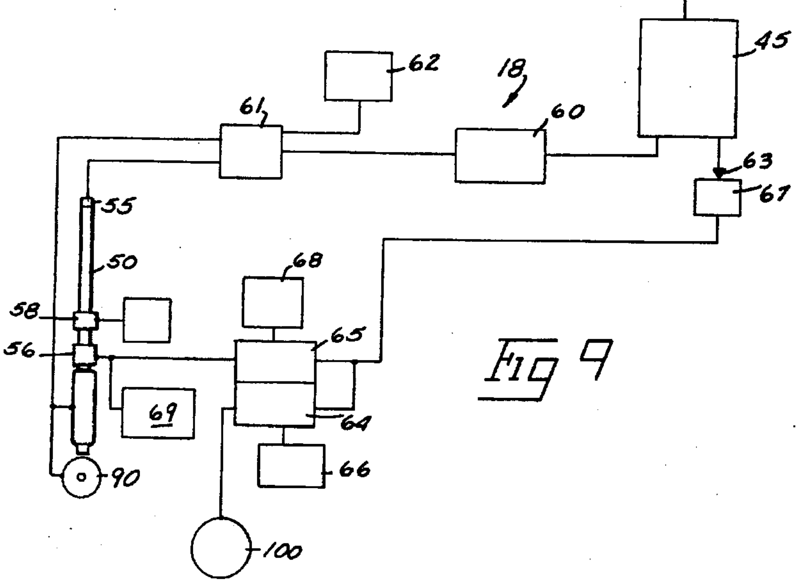


Fig 9

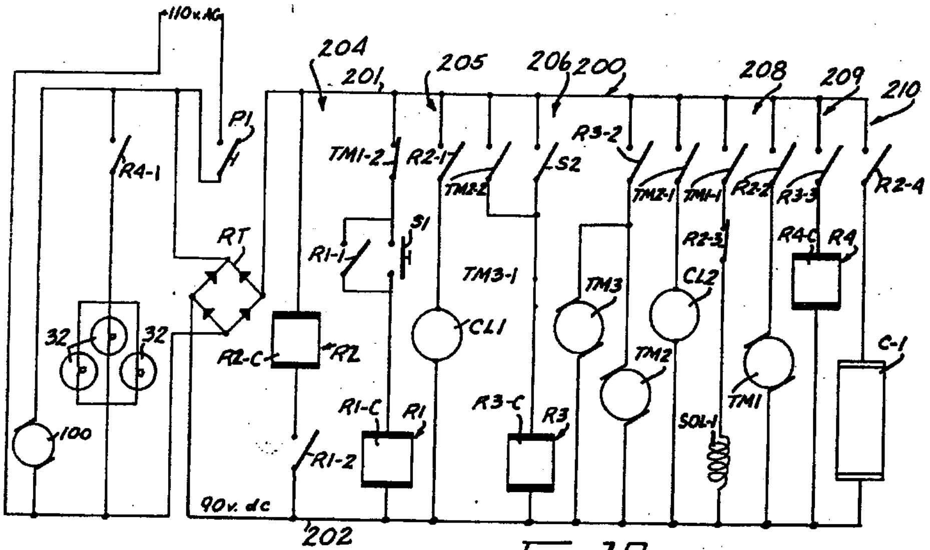
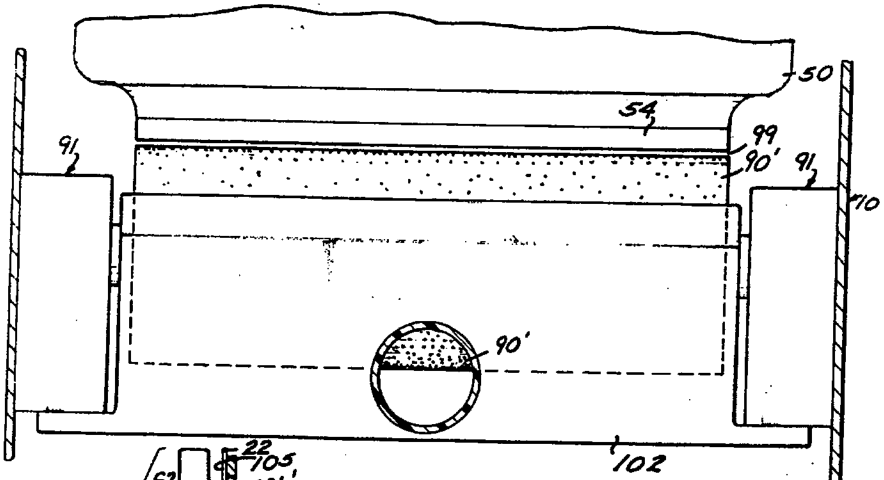


Fig 10

Fig 8


50
54
99
90'
91
91
10
90'
102

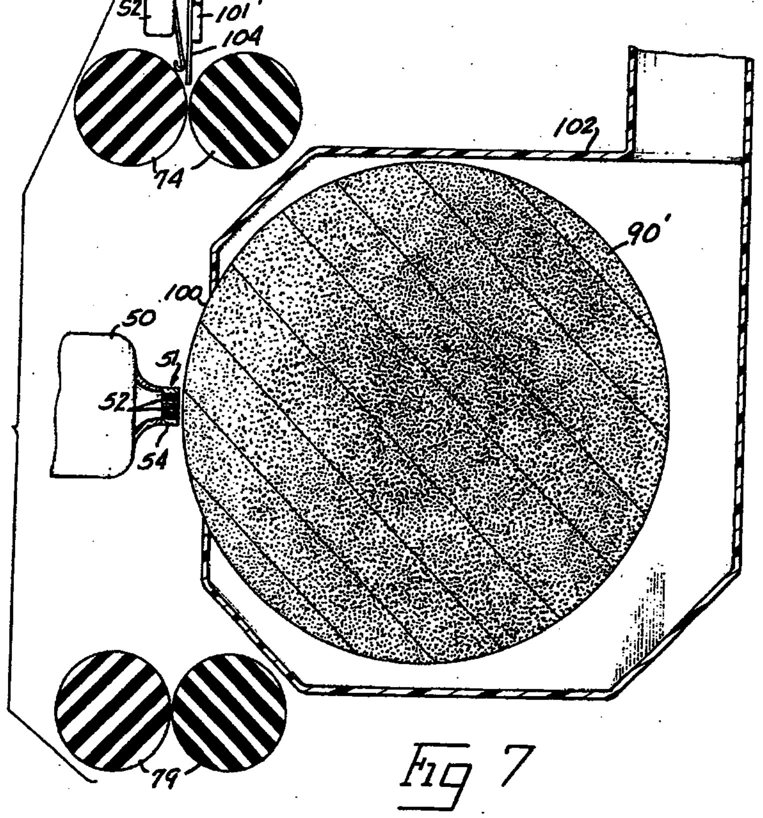

22
105
52
101'
104
74
102
90'
100
50
51
52
54
79

Fig 7

Fig 11

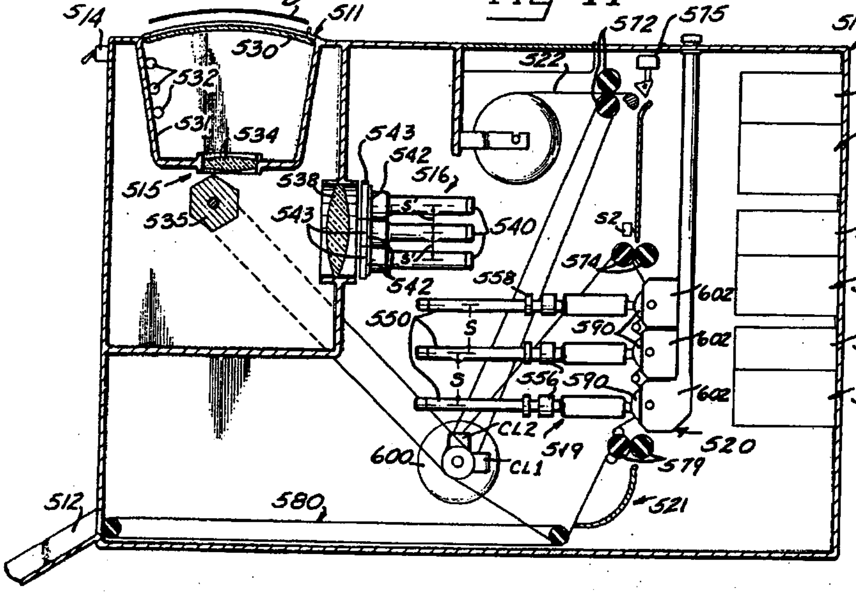
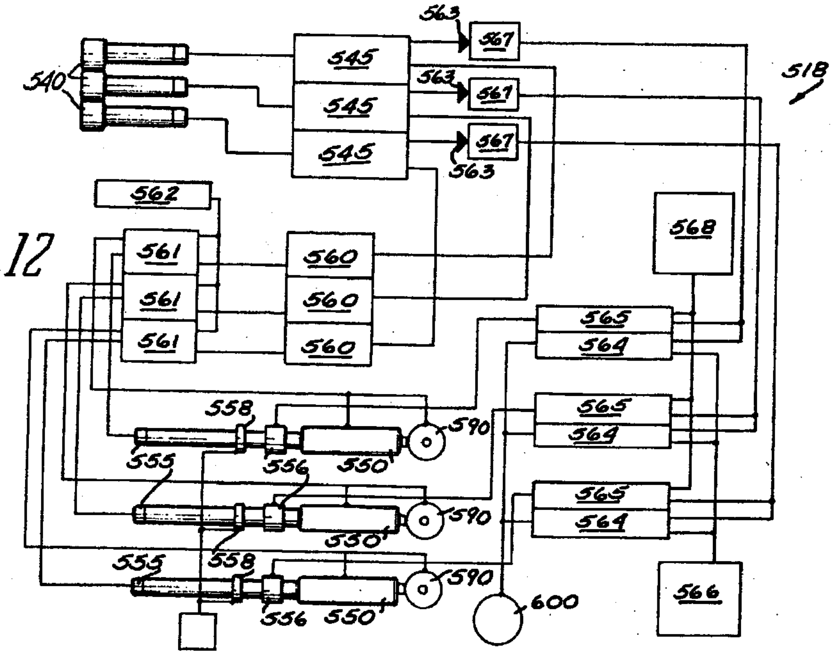

514
D
511
530
532
531
534
515
535
543
542
516
538
543
540
542
S
S'
510
572
575
322
545
518
545
518
545
518
52
574
558
602
550
S
590
602
S
556
590
602
CL2
519
520
600
CL1
579
512
580
521

Fig 12


563
567
545
563
567
540
545
518
545
567
563
562
568
561
560
561
560
561
560
565
564
558
565
590
564
555
556
550
565
590
564
550
555
558
590
600
566
556
550

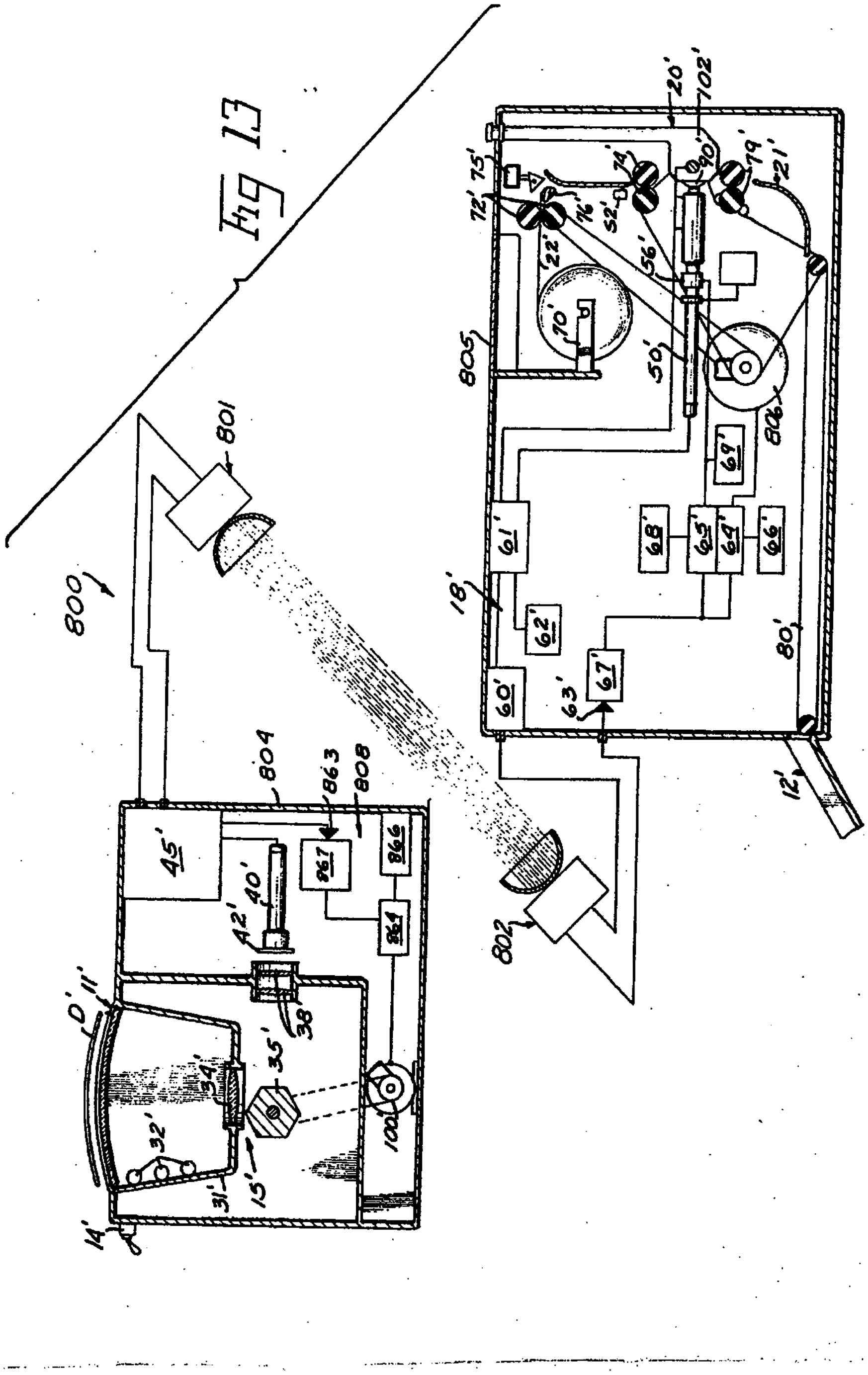

800
801
802
804
805
806
808
863
864
866
867
45'
40'
42'
38'
D'
11'
32'
34'
35'
31'
15'
14'
100'
12'
18'
60'
61'
62'
63'
64'
65'
66'
67'
68'
69'
80'
50'
56'
70'
22'
72'
75'
76'
52'
74'
90'
102'
20'
79'
21'

Fig 13

REPRODUCTION SYSTEM

BACKGROUND OF THE INVENTION

Many copying machines are available today which copy the visual image of a document onto a paper substrate. One widely used system is commonly known as the "Xerox" process and uses a charged selenium drum which is exposed to the document visual image to drain off the charge In those areas having no visual image but leaves a charge where there is a visual image. This drum is then dusted with a charged powder which adheres to the charged portions of the drum and the adhereing powder then transferred to a plain bond paper substrate onto which the powder is fused to develop a copy.

Another widely used process uses a photoconductive paper substrate which is charged and exposed to the visual image of the document in a manner similar to the selenium drum. The charged image left on the paper is then dusted with a charged powder to develop the image on the paper substrate.

Another system uses an electrostatic paper substrate which is electrically charged with the visual image and then dusted with charged powder to develop the image as described above.

Each of these above processes have the inherent disadvantage of being relatively slow because of the several steps necessary to properly place the charge on the paper substrate and develop same. Also, none of the systems have been successful in providing a simple and efficient system of transferring the visual image onto the paper substrate with high resolution. Moreover, those systems using a specially treated paper substrate have had difficulty in producing a copy of sufficient longevity for permanent records and in keeping the paper substrate cost to the consumer at a minimum. Also, those prior art processes have required complex and expensive equipment to properly orient and move the paper substrate to create the necessary copy outputs.

SUMMARY OF THE INVENTION

These and other problems associated with the prior art are overcome by the invention disclosed herein by providing a simple and relatively inexpensive reproduction process. The invention can copy on a plain bond paper substrate and combine the charging, exposure, developing and fusing steps of the prior art into a single step. Moreover, the system is compact and allows the document copying section to be remotely located with respect to the copy formation section. This system also eliminates all photoconductive requirements associated with most prior art copying machines. Also, the invention lends itself to full color copying without excessive alteration of operation.

The apparatus of the invention includes a high resolution television camera electrically connected to a cathode ray printing tube with a wire matrix. The document is exposed to the camera through an imaging section and a paper substrate is moved across the wire matrix in the cathode ray tube at the same rate as the document is exposed to the camera.

The toner is applied with a grooved roller which picks up the toner particles from a dry or wet toner mixture and transfers same to the vicinity of the paper substrate at the wire matrix on the cathode ray tube. The charges on the wire matrix cause the entrapped toner particles in the grooves of the roller to be transferred to the paper substrate to form the visual image on the copy. The roller also serves to positively feed the paper substrate past the wire matrix of the cathode ray tube.

In that embodiment of the invention having full color copying capabilities, a camera is provided for each color to be copied along with an appropriate filtering system to expose each camera to those colors of the visual image to be reproduced. A cathode ray tube is connected to each camera and an appropriately colored toner with a separate roller for each toner color is associated therewith to reproduce the image color on the copy. The scan of the document by the cameras and the rate of movement of the paper substrate by the cathode ray tubes are synchronized to re-create the full color image of the document on the copy.

Alternately, a roll composed of compressed toner particles may be placed adjacent the paper substrate on that side opposite the wire matrix and in alignment therewith rather than the roller. The toner bar is charged with a voltage just below its ionization potential so that the charged image on the wire matrix causes the toner bar to ionize in those portions corresponding to the charged image and the ionized particles accelerated toward the matrix to be trapped by the paper substrate and be fused therein to form the visual image.

These and other features and advantages of the invention will become more fully understood upon consideration of the following specification and accompanying drawings wherein like characters of reference designate corresponding parts throughout the several views and wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a copying machine embodying the invention;

FIG. 2 is a schematic drawing showing the internal layout of the machine of FIG. 1;

FIG. 3 is an enlarged view of the light receptive face of the scanning section;

FIG. 4 is an elevational view taken along line 4—4 in FIG. 2 showing the cathode ray printing tube and the developing section;

FIG. 5 is an enlarged cross-sectional view taken along line 5—5 in FIG. 4;

FIG. 6 is an enlarged view of a portion of the developing roll shown in FIGS. 4 and 5;

FIG. 7 is an enlarged cross-sectional view taken substantially along line 5-5 but showing an alternate developing system;

FIG. 8 is an elevational view of the cathode ray tube and developing system shown in FIG. 7;

FIG. 9 is a schematic diagram for electronic control circuit of the invention illustrated in FIGS. 1–8;

FIG. 10 is a schematic diagram for the mechanical control circuit of the invention;

FIG. 11 is a schematic drawing showing the internal layout for a full color copying machine;

FIG. 12 is a schematic electrical diagram for that embodiment of the invention shown in FIG. 11; and,

FIG. 13 is a schematic drawing showing the application of the invention to a facsimile sending device.

These figures and the following detailed description disclose specific embodiments of the invention, however, it is to be understood that the inventive concept is not limited thereto since it may be embodied in other forms.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Referring to FIG. 1, it will be seen that the invention is mounted in a housing 10 with a document exposure section 11 and a copy receiving tray 12. Suitable controls 14 are provided to control the copying-duplicating process.

Referring now to FIG. 2, the invention includes generally an imaging section 15, a scanning section 16, a control section 18, a printing section 19, a developing section 20, and a paper transport section 21. The document to be copied is placed on the document exposure section 11 and the imaging section 15 directs the image on the document into the receptive area of the scanning section 16 successively one line at a time. The scanning section 16 converts the visual image received thereby into an electrical charge image which is transmitted to the printing section 19 through the control section 18. The printing section 19 transfers the electrical charge image to a paper substrate or web 22 whereupon the developing section 20 applies toner particles to the web 22 to change the electrical charge image into a visual image and fuse the toner particles into the web to make the visual image permanent. The transport section 21 moves the paper web 22 past the printing section 19 and developing section 20 synchronously with the scan rate of the original document and also cuts the paper web to the desired length.

The document exposure section 11 includes a curved document exposure glass 30 onto which the document D is placed so that the visual image thereon is on the bottom surface of the document facing glass 30. An enclosure 31 is provided inside housing 10 around glass 30 and is lighted by lamps 32 while the document is being copied.

The imaging section 15 includes a lens 34 is located centrally of the glass in the bottom of enclosure 31. A multifaceted mirror 35 is located below lens 34 so as to be in visual communication with the image on the document D. Each facet 36 of mirror 35 is constructed and arranged to project the visual image into the scanning section 16 without distortion through lens 38 as the mirror is rotated about its axis in conventional manner such as that disclosed in U. S. Pat. No. 3,051,044.

The scanning section 16 includes a television receiver tube 40 having a light sensitive face 41. Any number of receiver tube constructions may be used, however, one such tube 40 that has been found adequate is a tube manufactured by Sylvania Electric Products, Inc. of New York, N.Y., and designated 7735A Vidicon. Tube 40 is located on that side of lens 38 opposite mirror 35 so that the reflected visual image from mirror 35 will be directed against the face 41 of tube 40. As the mirror 35 is rotated, it will move the visual image across the face of the tube 40. A mask 42 is positioned on the face 41 and is provided with a slot 44 therethrough to admit light to face 41. The size of slot 44 is such that it admits the same amount of the visual image from the document therethrough as will be printed by the printing section 19 as explained hereinafter.

The printing section 19 includes a cathode ray printing tube 50 of the type disclosed in U. S. Pat. No. 2,928,973. Such printing tube has a wire matrix 51 formed by an array of fine, closely spaced wires 52 as best seen in FIG. 5 extending through the bulb face 54 of the tube. These wires 52 serve as targets for the electron beam emitted from the cathode 55 of the tube as seen in FIGS. 2 and 8. Such a tube is manufactured by Sylvania Electronic Components of Seneco Falls, N.Y., under their designation SC-4070 and SC-4071 Electrostatic Charge Printing Type Cathode Ray Tube. Tube 50 has a video input connected to the cathode 55, a sweep deflection coil 56, and a focusing coil 58.

As best seen in FIG. 8, the tube 40 is connected to a scanner control circuit 45 as is conventional. The circuit 45 produces a video output and a sweep output in response to the exposure of the face 41 of tube 40 to the visual image which are connected to control circuit 18.

The video output is connected to the video amplifier 60 of circuit 18, thence to modulator 61 driven by power supply 62 and thence to the video input of the cathode 55 of tube 50. The sweep output of from the scanner control circuit 45 is connected through gate 63 and sweep oscillator 67 to the vertical sweep amplifier 64 and the horizontal sweep amplifier 65 of control circuit 18. The vertical amplifier 64 is powered by a power supply 66 and the output of amplifier 64 is connected to the main drive motor 100. The horizontal amplifier 65 is powered by power supplies 68 and 69 and the output therefrom is connected to the sweep deflection coil 56 around tube 50. The positive output of modulator 61 is connected to the anode outside tube 50 opposite the wire matrix 51. Portions of the developing section 20 are illustrated as the anode as will be explained.

The paper web 22 is carried by the transport section 21 which is in turn driven by the main drive motor 100. The transport section 21 is shown for dispensing the paper web from a roll, however, it is to be understood that the section 21 could be used for other types of dispensing such as sheet dispensing.

Section 21 includes a cradle 70 for rotatably supporting the roll 71 of paper web 22, a pair of feed rolls 72, and a pair of guide rolls 74 as seen in FIGS. 2. The feed rolls 72 and guide rolls 74 are positioned on opposite sides of a paper knife assembly 75 between the paper roll 71 and the bulb face 54 of tube 50. The feed rolls 72 receive the paper web 22 from roll 71 and move it over anvil 76 and under the rotary knife 78 of assembly 75 to guide rolls 74 as seen in FIG. 2. The guide rolls 74 engage and drive web 22 toward the bulb face 54 as seen in FIG. 5.

Section 21 also includes a pair of drawing rolls 79 for receiving the paper web 22 after it passes the wire matrix 51 in bulb face 54 to complete the passage of web 22 across the wire matrix as seen in FIGS. 2 and 5. The web 22 with the copy thereon is deposited onto a conveyor 80 for moving same to the copy receiving tray 12.

The developing section 20 includes a roll 90 positioned directly opposite the bulb face 54 for developing the copy on the web 22 and for driving same across the wire matrix 51 in bulb face 54. Roll 90 is carried by a spring assembly 91 at each end thereof as seen in FIG. 4 and is driven at the same speed as rolls 72, 74 and 79 by the main drive motor 100. Each spring assembly 91 includes a slide block 92 which rotatably journals the shaft 94 of roll 90 and a spring 95 which urges the block 92 in its guide 96 toward the bulb face 54 along a path perpendicular to the bulb face. A stop 98 is provided in guide 96 for limiting the movement of roll 90 toward bulb face 54 to a position such that the clearance 99 between the outer surface 100 of roll 90 and the ends of wires 52 flush with the bulb face 54 is less than the thickness of the paper web 22 as best seen in FIG. 5.

The diameter of roll 90 is such that that portion of the outer peripheral surface 100 directly opposite the wire matrix 51 is substantially parallel thereto as seen in FIG. 5. The peripheral surface 100 of roll 90 is helically grooved at 101, the grooves 101 being V-shaped in cross-section as seen in FIG. 6. A toner bin 102 is provided under and partially around the roll 90 leaving that portion of the peripheral surface 100 opposite wire matrix 51 exposed. The bin 102 is adapted to receive toner 104 in a dry or wet form. As the roll 90 is rotated within bin 102, the toner 104 is entrapped in the grooves 101 in the surface 100 of roll 90 and moved past the wire matrix 52 and in juxtaposition with that surface 104 of the paper web 22 opposite the surface 105 of web 22 in contact with wires 52. As the web 22 is moved past the wire matrix 51, the surface 105 will contact the ends of wires 52 while surface 100 will be in contact with surface 104.

The roll 90 serves as the anode for tube 50 with the positive output from the modulator 61 being connected thereto. A base negative voltage of a magnitude substantially equal to the positive voltage on anode or roll 90 is also imposed on the wire matrix 51 of tube 50 by the modulator 61. The magnitude of these voltages are just below that potential necessary to cause the toner 104 carried in grooves 101 to be ionized and accelerated toward the wire matrix 51. When the video signal is imposed on the particular wires 52 of matrix 51 from the cathode 55 of tube 50, the imposed voltage will create a potential difference greater than the ionization potential in those wires 52 onto which a charge from cathode 55 is imposed. This causes those toner particles trapped in grooves 101 substantially opposite the additionally charged wires 52 to be ionized and accelerated toward these wires 52. Since the web 22 is interposed between the wire matrix 51 and roll 90, such ionized toner particles will impinge on the web 22 in the same pattern as the charged image imposed on the wire matrix 51 by cathode 55 to develop a visual image on surface 104 of paper web 22. By generating sufficient kinetic energy in the toner particles as they are accelerated toward the surface 104, enough heat will be generated when the particle is arrested by surface 104 to cause the particle to fuse to the web 22, especially if each particle is coated with a thermoplastic. Thus, the heater normally used in fusing can be eliminated and since the electrical charge does not need to be retained on web 22, a plain bond paper web can be used.

Referring back to FIG. 2, it will be seen that knife 78 has three equally spaced cutting edges thereon which extend across the width of the web 22. As knife 78 is rotated, each cutting edge will engage and cut web 22 against anvil 76. A solenoid actuated ratchet drive 77 selectively rotates knife 78 so that the web 22 will be cut each time the drive 77 is actuated. The distance d as seen in FIG. 2 between the knife 78 and the beginning of wire matrix 51 is equal to the length of the paper web 22 to be cut and supplied to tube 50 as will be explained.

The main drive motor 100 is directly connected to guide rolls 74, roll 90, drawing rolls 79 and conveyor 80 to drive same at a constant speed. The drive motor 100 is connected to the feed rolls 72 through a solenoid actuated clutch CL1 as seen in FIG. 2 and to the mirror 35 through a solenoid actuated clutch CL2 to drive same. A paper sensing switch S2 is engaged by paper web 22 before it reaches the guide rolls 74 and a guide plate 101' is used therewith to insure that the web 22 activates same as seen in FIG. 5.

Referring now to FIGS. 7 and 8, it will be seen that the roll 90 of the first embodiment of the invention has been replaced by a roll 90'. Roll 90' is made of a cylindrical bar of compressed toner particles held together by a suitable binder so as to have an ionization potential of a predetermined value. The roll 90' serves to force the paper web 22 past the wire matrix 51 of tube 50 similarly to roll 90 and is mounted by spring assemblies 91 to be driven by motor 100.

The roll 90', like roll 90, is connected to the positive output of modulator 61 and charged with a potential just below its ionization potential. When the wires 52 are charged as described above, the toner particles of the roll 90' will be ionized similarly to those in the grooves on roll 90 and driven into the paper web 22 to form the visual image.

The paper web or substrate 22 may be of any of a variety of paper types now used in reproductive processes. Plain bond paper may be used when the developing section 20 applies the toner to web 22 at the wire matrix 51. On the other hand, an electrostatic paper may be used which holds the charged pattern thereon after passage by the wire matrix 51. If an electrostatic web 22 is used, the developing section 20 may apply the toner particles to the web 22 after or during passage of the web 22 past the wire matrix 51. Also, an electrofax paper normally used in facsimile systems may be used as web 22. This paper has a dark sublayer with a white top layer that is responsive to an electrical charge to be burned or evaporated in the area of the electrical charge to expose the darker sublayer and produce a visual image. The electrofax web 22 would thus eliminate the need for a toner.

MECHANICAL CONTROL CIRCUIT

Referring now to FIG. 10, a control circuit 200 for the mechanical components of the machine is illustrated, it being understood that other circuits could be used therefor.

The circuit 200 is connected to a 110 v. A-C source and includes a rectifier RT converting the 110 v. A-C to 90 v. d-c. The positive side of rectifier RT is connected to a common hot wire 201 and the negative side to common ground wire 202. A start control circuit branch 204, a paper feed control circuit branch 205, an imaging control circuit branch 206, a knife control circuit branch 208, a lamp control circuit branch 209, and a counter control circuit branch 210 are connected between hot wire 201 and ground wire 202 in parallel with each other.

The start control circuit branch 204 includes a coil R1-C of relay R1 and normally closed contacts TM1-2 of timer motor TM1 connected between wires 201 and 202 in series with each other and the parallel circuit of normally open start switch S1 and normally open holding contacts R1-1 of relay R1. Branch 204 also includes the coil R2-C of relay R2 and normally open contacts R1-2 of relay R1 in series between wires 201 and 202.

The paper feed control circuit branch 205 includes the normally open contacts R2-1 of relay R2 and the paper feed clutch coil CL1 connected in series between wires 201 and 202.

The imaging control circuit branch 206 includes the parallel circuit of normally open sensing switch S2 and normally open contacts TM2-2 of timer motor TM2 connected between wires 201 and 202 in series with normally closed contacts TM3-1 of timer motor TM3 and coil R3-C of relay R3. Branch 206 also includes normally open contacts R3-2 of relay R3 in series with timer motors TM2 and TM3 and connected between wires 201 and 202. Also included in branch 206 is the series circuit of normally open contacts TM2-1 of timer motor TM2 and scan clutch CL2 connected between wires 201 and 202.

The knife control circuit branch 208 includes normally open contacts TM1-1 of timer motor TM1, normally closed contacts R2-3 of relay R2 and solenoid SOL-1 of knife drive 77 connected between wires 201 and 202 in series. Branch 208 also includes normally open contacts R2-2 and timer motor TM1 in series between wires 201 and 202.

The lamp control circuit branch 209 includes normally open contacts R3-3 of relay R3 in series with coil R4-C of the lamp relay R4 between wires 201 and 202. The counter control circuit 210 includes normally open contacts R2-4 of relay R2 in series with counter C-1 and connected between wires 201 and 202.

The 110 v. A-C source is connected to rectifier RT through power switch P1. The lamp circuit 220 is connected across the 110 v. A-C source through switch P1 and includes normally open contacts R4-1 of relay R4 in series with lamps 32. The main drive motor 100 is also connected to the 110 v. A-C source through switch P1.

OPERATION

From the foregoing, it will be seen that the power switch P1 is closed to start the machine. When this occurs, the motor 100 is energized to drive rolls 74, 79 and 90 and the conveyor 80. Power is also connected to the power supplies 62, 66, 68 and 69 as well as the control circuit 45 to actuate the scanning and printing sections 16 and 19. The document D is then placed on the exposure glass 30 and print start switch S1 is depressed to start the copying operation.

As seen in FIG. 8, closing switch S1 energizes coil R1-C to close contacts R1-1 to keep coil R1-C energized and to close contacts R1-2 to energize coil R2-C. This closes contacts R2-1 to engage clutch CL1 and drive feed rolls 72 and feed the paper web 22 from the paper roll 71 to already moving rolls 74. When coil R2-C is energized, contacts R2-2 are closed to energize timer motor TM1 to start the paper feed timing cycle. Contacts R2-3 are opened to prevent energization of solenoid SOL-1 of the knife assembly 75 and contacts R2-4 are closed to activate counter C-1.

As the paper web 22 approaches guide rolls 74, switch S2 is closed by the leading edge of web 22 to energize coil R3-C. This closes contacts R3-2 to energize timer motors TM2 and TM3 to start the scanning timing cycle and closes contacts R3-3 to energize coil R4-C and close contacts R4-1 to energize lights 32 and illuminate the document D to be copied.

As the web 22 reaches registration with the nearest edge of the wire matrix 51, timer motors TM1 and TM2 time out and respectively close contacts TM1-1, TM2-1 and TM2-2 and open contacts TM1-2. Closing contacts TM1-1 and opening contacts TM1-2 de-energizes coils R1-C and R2-C to stop the feeding of web 22 and simultaneously activate solenoid SOL-1 to cut the web 22 to length. Closing contacts TM2-1 energize clutch CL2 to rotate mirror 35 and project the visual image of the document D into the face of tube 40. Since both the web 22 and mirror 35 are driven from motor 100, synchronization is insured.

As the mirror 35 presents the visual image to the tube 40, this image is supplied to the printing tube 50 as an electrical charge image and imposed on wires 52. The toner particles from roll 90 or 90' are ionized and impinged on web 22 to form the visual image on the web. Since the image is formed on the back side of web 22, the image is electrically reversed in known manner as it passes through the control circuit 18 so that the image on the copy is intelligible.

The timer motor TM3 is set to time out at the end of the proper scan distance on the mirror 35. This opens contacts TM3-1 to de-energize coil R3-C and stop the scanning of mirror 35. The finished copy on web 22 is transported from tube 50 to the copy receiving tray 12 to complete the copying operation.

FULL COLOR EMBODIMENT

Referring now to FIGS. 11 and 12, the full color embodiment of the invention is housed in the housing 510 with the document exposure section 511 and a copy receiving tray 512. Controls 514 are used to control the copying-duplicating process.

An imaging section 515, scanning section 516, control section 518, printing section 519, developing section 520 and paper transport section 521 is provided similar to that shown in FIG. 2. The copying process is similar to FIG. 2 except that three receiver tubes 540 are provided in alignment with the image projected from mirror 535 so that the face of each tube 540 will be successively exposed to the image. Masks 542 are provided for each tube 540 similarly to tube 40. A filter 543 is provided over the face of each tube 540. One filter 543 is effective to allow one primary color light to expose its associated tube 540, another to allow another primary color light to expose its associated tube 540, and the other to allow the other primary color light to expose its associated tube 540. Thus, each portion of the image on document D will be exposed successively to the tubes 540 so that the image will be separated into its primary colors.

The printing section 519 includes three printing tubes 550. each printing tube 550 has the same construction as tube 50 and the output of one of the receiver tubes 540 is connected a corresponding printing tube 550. Therefore, by ordering the arrangement of tubes 550 the same as tubes 540, taking into consideration the difference in dimensions of the tubes, it will be seen that the electrical charged image of each color component of the image on document D will be applied to the paper web 522 so as to recreate the visual image as seen on the document D.

The developing section 520 includes a developing roll 590 associated with each tube 550 and operates in the same manner roll 90 in conjunction with tube 50. A toner bin 602 is provided around roll 590 and carries a primary color toner 604 corresponding to the electrical color component image received by tube 550. Thus, each tube 550 and roll 590 in conjunction with toner 604 reproduces one primary color component of the visual image onto the paper web 522. Since the spacing *s* between tubes 550 corresponds to the spacing *s'* between tubes 540, the primary color components produced by each tube 550 will be in registration to recreate the full color image on paper web 522.

Since most of the components of the first embodiment of the invention are virtually the same as the full color embodiment of the invention corresponding parts of the full color embodiment have the same numbers increased by 500 applied thereto.

Referring more particularly to FIG. 12, there are three control sections 518 corresponding to section 18, with one section 518 connecting one receiver tube 540 with its associated printing tube 550.

In operation, the full color embodiment of the invention is similar to the first embodiment thereof except that the scan cycle is greater in duration. This is to allow each selected line of the visual image on document D to be sequentially exposed to each tube 540 and the paper web 522 to be sequentially developed by each printing tube 550 to recreate the full color image.

FACSIMILE SYSTEM

Referring to FIG. 13, it will be seen that the facsimile system 800 includes the same components as that embodiment of the invention shown in FIGS. 2 and 9, however, a microwave transmission device 801 and a microwave receiving device 802 have been interposed therein. For simplicity, those portions of the system 800 common to that embodiment shown in FIGS. 2 and 9 will be designated by primes of the reference numerals used in FIGS. 2 and 9. This allows the document exposure section 11', imaging section 15', scanning section 16' and scanner control circuit 45' to be located in a first housing 804; and the printing section 19', control section 18', developing section 20' and paper transport section 21' to be remotely located in a second housing 805. The output from scanner control circuit 45' is connected to the transmitting device 801 through a special telephone hookup now available in the telephone systems capable of transmitting a video signal. The transmitting device 801 then transmits this video signal output on its microwave band to the receiving device 802 which then transmits this signal through the special telephone hookup to the control section 18' for reproducing the original visual image on the paper web 22'.

Because the scanning and receiving sections 16' and 19' are separated the main drive motor 100' is used to power the imaging section 15' and a second drive motor 806 is used to power the paper transport section 21' and developing section 20'. The sweep output from circuit 45' is also connected to motor 100' through gate 863, sweep oscillator 867, vertical sweep amplifier 864 powered by power supply 866 of the second vertical sweep control circuit 808. The output from vertical sweep amplifier 64' is connected to motor 806 to synchronize the speeds of motors 100' and 806.

In operation, then, the facsimile system is readied for transmission by establishing a microwave link between the devices 801 and 802. A document D' is placed in the document exposure section 11' and activating the controls 14'. This transmits the electrical charge pattern to the printing section 19' to produce a copy of the visual image on the web 22'.

While specific embodiments of the invention have been disclosed herein, it is to be understood that full use of modifications, substitutions and equivalents may be made without departing from the scope of the inventive concept.

I claim:

1. A machine for reproducing the visual image on documents onto a paper substrate comprising:

support means;

display means carried by said support means for selectively displaying said document;

camera means for scanning said document and for converting the visual image on said document onto a corresponding electrical video signal;

imaging means for selectively exposing said visual image on said document to said camera means;

a cathode ray printing tube means having a wire matrix;

circuit means electrically connecting said camera means to said cathode ray tube means to cause said wire matrix to be electrically charged in a pattern corresponding to the visual image exposed to said camera means; and, including means for reversing the electrical image produced by said camera means;

transport means for selectively moving the paper substrate by and closely adjacent to said wire matrix at a rate corresponding to the exposure rate of the visual image to said camera means; and

developing means for converting said electrically charged image imposed on said paper substrate into a visual image including a member for positively forcing said paper substrate across said wire matrix at a rate corresponding to the exposure rate of the visual image to said camera means, toner particles, and means for applying said toner particles to the electrically charged image imposed on said paper substrate on that side of said paper substrate opposite said wire matrix.

2. The machine of claim 1 wherein said means for applying said toner particles to said paper and said member for positively forcing said paper substrate include roll means having a driving surface engaging said paper substrate at said wire matrix to force same by said wire matrix and for transporting said toner particles into close proximity to that side of said paper substrate opposite said wire matrix and wherein said developing means includes drive means for rotating said driving surface of said roll means at the same rate as the exposure rate of the visual image to said camera means.

3. The machine of claim 2 wherein said roll means includes forcing means for resiliently urging said driving surface toward said wire matrix and into engagement with said paper substrate.

4. The machine of claim 3 wherein said roll means includes a cylindrical roll defining said driving surface, said roll composed of said toner particles and having an emission threshold potential of a predetermined value.

5. The machine of claim 3 wherein said roll means includes a cylindrical roll defining said driving surface, said roll defining grooves at said surface to entrap toner particles; and wherein said developing means includes a storage bin for receiving and storing said toner particles in contact with said surface of said roll.

6. The machine of claim 1 wherein said transport means includes means for feeding said paper substrate

from a roll and means for selectively cutting said paper substrate into predetermined lengths.

7. The machine of claim 1 wherein said camera means includes a Vidicon television receiver tube having a receptive surface for converting said visual image into a corresponding electrical image.

8. The machine of claim 7 wherein said camera means includes masking means for exposing selected portions of said receptive surface of said Vidicon television receiver tube to said visual image.

9. The machine is set forth in claim 1 wherein said cathode ray printing tube means includes a plurality of cathode ray printing tubes, each having a wire matrix; wherein said camera means includes color separation means for separating the colors of the visual image on said document into selected color portions and converting each color portion of said visual image into a corresponding electrical video signal; wherein said circuit means connects one of said electrical video signals corresponding to a color portion of the visual image to each of said printing tubes; and wherein said transport means selectively moves said paper substrate by said wire matrix of each of said printing tubes at the same rate and in the same order as said visual image is exposed to said camera means.

10. The machine of claim 9 wherein said developing means includes a plurality of rolls means, one roll means being associated with said wire matrix of each of said printing tubes for forcing said paper substrate across its associated wire matrix and toner particles operatively associated with each of said roll means, the toner particles having the color to reproduce that color portion of the visual image to which its associated printing tube is supplied as an electrical video signal.

11. The machine of claim 10 wherein said camera means includes a plurality of television receiver tubes, one of said receiver tubes corresponding to each of said printing tubes and a color separation means associated with each of said receiver tubes.

12. The machine of claim 11 wherein said receiver tubes are spaced from each other a first predetermined distance and wherein said printing tubes are spaced from each other a second predetermined distance related to said first predetermined distance to cause each color portion of the visual image to be reproduced on said paper substrate in the same relative position as the color portion on said original document.

13. The machine as set forth in claim 1 wherein said circuit means include microwave transmitting and receiving means.

14. In a machine for printing a visual image onto a paper substrate which includes a cathode ray printing tube having a selectively charged wire matrix; drive means for positively forcing said paper substrate across said wire matrix including a cylindrical roll member positioned closely adjacent said wire matrix and having a driving surface for engaging said paper substrate and forcing said substrate across said wire matrix while maintaining said substrate in contact with said wire matrix; support means for resiliently urging said dirving surface of said roll member toward said wire matrix to insure positive engagement between said substrate and said driving surface; and means for selectively rotating said roll member, and wherein said roll member is composed of carbon toner particles pressed together and having an emission threshold potential of a predetermined value to deposit said particles on said paper substrate in the electrical charge pattern imposed on said paper substrate by said wire matrix.

15. In a machine for printing a visual image onto a paper substrate which includes a cathode ray printing tube having a selectively charged wire matrix; drive means for positively forcing said paper substrate across said wire matrix including a cylindrical roll member positioned closely adjacent said wire matrix and having a driving surface for engaging said paper substrate and forcing said substrate across said wire matrix while maintaining said substrate in contact with said wire matrix; support means for resiliently urging said driving surface of said roll member toward said wire matrix to insure positive engagement between said substrate and said driving surface; and means for selectively rotating said roll member, and wherein said roll member defines grooves at said driving surface, and further including carbon toner particles and bin means for supporting said particles in contact with said driving surface and said grooves so that said grooves entrap said particles and move same into the vicinity of said wire matrix so that said particles will be deposited on said paper substrate in the electrical charge pattern imposed on said substrate by said wire matrix.

16. In a machine as set forth in claim 15 wherein said grooves are sufficiently close together to present a substantially solid surface of toner particles to said paper substrate.

17. A method of duplicating the visual image on a document onto a paper substrate including the steps of:

a. converting the visual image on the document into an electrical charge pattern;

b. reversing the charge pattern thus formed so that the resulting charge pattern corresponds to a mirror image of the visual image on the document;

c. imposing the reversed electrical charge pattern on one side of the paper substrate; and,

d. positioning toner particles in the vicinity of the opposite side of the paper substrate to cause the particles to adhere to said opposite side of the paper substrate to reproduce the visual image.

18. In a machine for printing a visual image onto individual sheets of paper substrate having a leading edge using a cathode ray printing tube having a selectively charged wire matrix mounted in the tube face with a prescribed height, the improvement comprising drive means operatively associated with the tube face for driving the leading edge of the sheets of paper substrate individually across the tube face and in close proximity to with the wire matrix, said drive means including a cylindrical roll member defining a driving surface of a radius substantially greater than the presecribed height of the tube face for engaging the leading edge of each sheet of paper substrate and forcing said sheet across the tube face, support means rotatably mounting said roll and constantly urging said roll member toward the tube face so that one side of the leading edge of the sheet of substrate will be engaged by said driving surface and the opposite side will be slidably supported on the tube face so that said roll member will drivingly engage the leading edge of the sheet of paper substrate to drive same across the tube face in close proximity to the wire matrix as said roll member is rotated; means for selectively rotating said roll member at a presecribed speed; and, feed means for selectively feeding the leading edge of the sheet of paper substrate into engagement with said driving surface of said roll member and the tube face, said support means including a resilient spring urging said roll member toward said tube face and a stop for arresting movement of said roll member so that said driving surface does not contact the tube face but is spaced therefrom a distance less than the thickness of the sheet of paper substrate.

* * * * *

E9595 XR 3,864,514

United States Patent [19]

Lemelson

[11] **3,864,514**

[45] **Feb. 4, 1975**

[54] **FACSIMILE SYSTEM AND METHOD**

[76] Inventor: **Jerome H. Lemelson**, 85 Rector St., Metuchen, N.J. 08840

[22] Filed: **Oct. 24, 1972**

[21] Appl. No.: **300,424**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 225,172, Aug. 27, 1962, , which is a continuation-in-part of Ser. No. 668,348, June 27, 1957, Pat. No. 3,051,777, which is a continuation-in-part of Ser. No. 823,600, May 12, 1969, which is a continuation-in-part of Ser. Nos. 279,030, April 1, 1963, abandoned, and Ser. No. 723,075, Feb. 28, 1958, Pat. No. 3,084,213.

[52] **U.S. Cl.** .... **178/6.8,** 178/6, 178/6.7 R
[51] **Int. Cl.** **H04n 1/32**
[58] **Field of Search** .... 178/6.7 R, 6, 6.8

[56] **References Cited**

UNITED STATES PATENTS

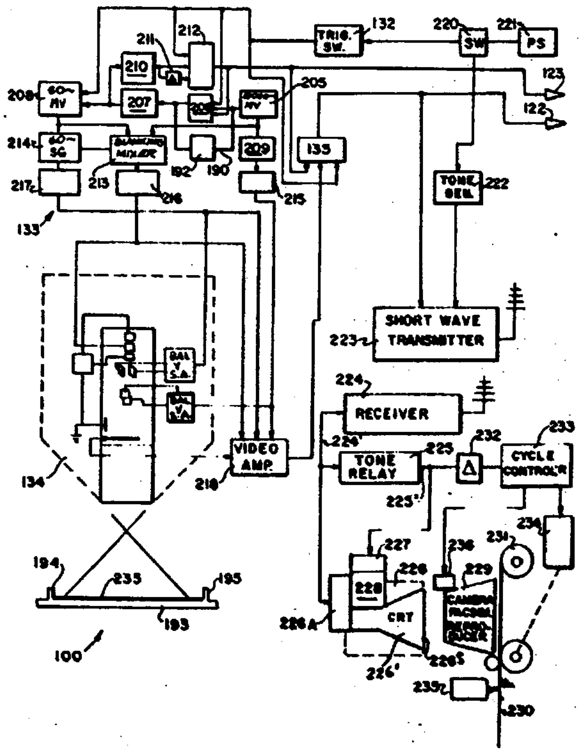
2,611,027 9/1952 Hammond .... 178/6.7 R
2,889,399 6/1959 Hammond .... 178/6.7 R

Primary Examiner—Howard W. Britton

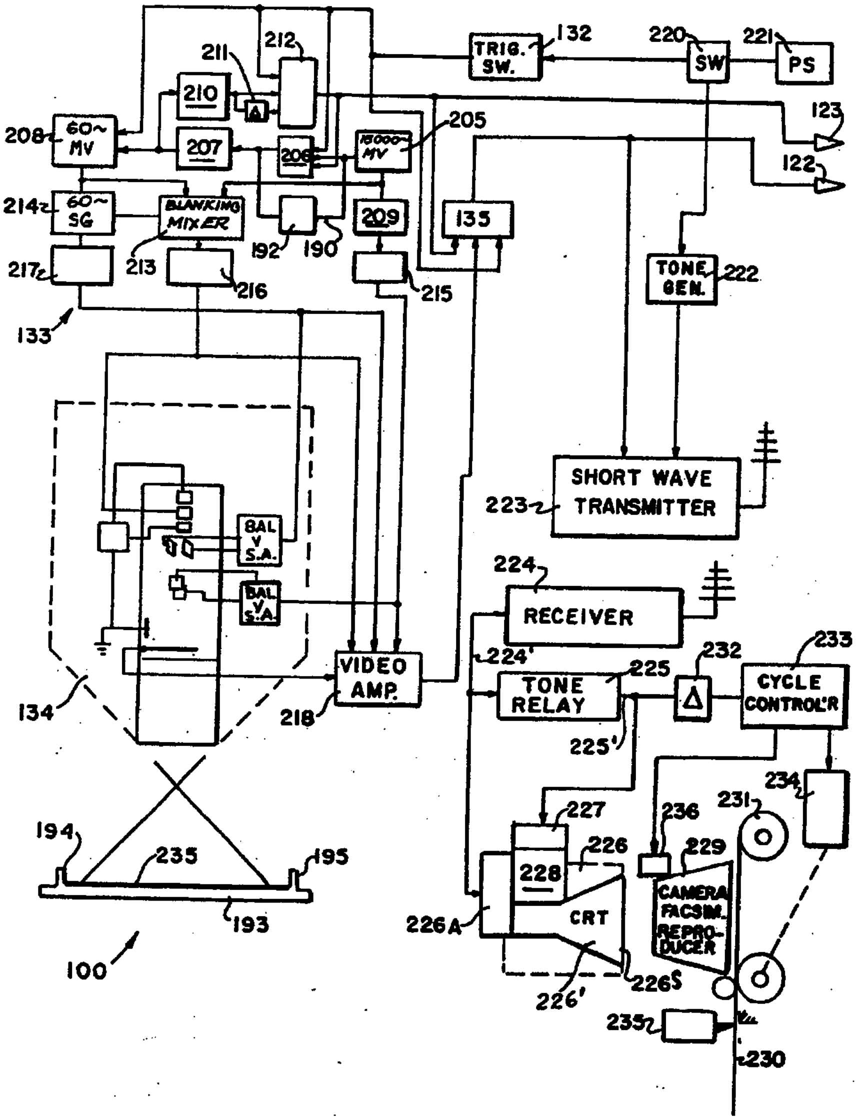
[57] **ABSTRACT**

An apparatus and method are provided for generating, transmitting, receiving and recording video information such as page document information employing a modified television camera and receiver. The television camera is controlled in its operation so as to generate a full-frame video picture signal on its output when a trigger input thereto is energized after placing a flat document in the scanning field of the camera. The full frame video signal is automatically transmitted to a receiving station where it is applied to intensity modulate and deflection control the write beam of a video receiver. Hard copy generating means is optically coupled to the display screen of the receiver and is automatically controlled to generate a print of each image generated on said display screen.

7 Claims, 1 Drawing Figure



D


132
TRIG. SW.
220
SW
221
PS
123
122
211
212
210
207
206
205
18000~ MV
208
60~ MV
214
60~ SG
BLANKING MIXER
213
192
190
209
135
TONE GEN.
222
217
216
215
133
SHORT WAVE TRANSMITTER
223
BAL V S.A.
BAL V S.A.
224
RECEIVER
224'
232
233
VIDEO AMP.
218
134
TONE RELAY
225
225'
CYCLE CONTROL'R
234
231
236
227
226
229
228
CRT
CAMERA FACSIM. REPRODUCER
226A
226S
226'
235
230
194
235
195
193
100

FACSIMILE SYSTEM AND METHOD

RELATED APPLICATIONS

This is a continuation-in-part of application Ser. No. 225,172 filed Aug. 27, 1962, for Videotape Recording which was filed as a continuation-in-part of Ser. No. 668,348 filed June 27, 1957, now U.S. Pat. No. 3,051,777. This is also a continuation-in-part of Ser. No. 823,600 filed May 12, 1969 for Automatic Communication System, which was a continuation-in-part of Ser. No. 279,030 filed Apr. 1, 1963 now abandoned and having as a parent application Ser. No. 723,075 filed Feb. 28, 1958 for Facsimile Apparatus, now U.S. Pat. No. 3,084,213.

SUMMARY OF THE INVENTION

This invention relates to a facsimile apparatus and method for generating, transmitting and recording facsimile information by short wave, microwave link, cable or telephone lines.

Prior to the making of the instant invention, it was the practice to generate and transmit facsimile information by scanning a document, photograph or drawing disposed against a drum and electromechanically causing a photo electric cell to be driven in a path close to the drun above the cylindrical record member as it is rotated. Such a procedure is not only time consuming but requires the physical manipulation of the document or photograph and its adjustment on the drum so that it may be properly scanned. In other words, the document or photograph must be so dimensioned that it will completely wrap around the drum and must be positioned accurately thereon a procedure which requires considerable effort on the part of the operator.

The instant invention employs a conventional cathode ray tube television camera, the deflection control circuits for which and their controls have been modified to permit the initiation and completion of a so called full-frame image field scan upon receipt of a trigger pulse. Depending upon the communication channel employed, scanning may be effected at conventional television signal generating frequency or at so called slow-scanning rate. The document need only be disposed within the scanning field after which scanning may be effected by simply generating a trigger-pulse. Accordingly it is a primary object of this invention to provide a new and improved facsimile apparatus and a method of generating, transmitting and recording facsimile information without the need for substantial human effort, if any at the signal generating station and without requiring human attendance at the receiving station.

Another object is to provide a new and improved apparatus and method for transmitting document information at a high transmission rate and without the delays experienced in conventional facsmilie systems.

Another object is to provide a facsimile apparatus which is substantially totally electronic at the sending station and is void of electro mechanical apparatus at the receiving station, thereby reducing maintainance requirements.

Another object is to provide a facsimile apparatus wherein a plurality of documents may be transmitted, received and recorded without complex procedures.

Another object is to provide an apparatus and method for transmitting facsimile information on conventional telephone lines without the need for human attendance.

With the above and such other objects in view as may hereafter more fully appear, the inventions consists of the novel constructions, combinations and arrangements of parts as will be more fully described and illustrated in the accompanying drawings, but it is to be understood that changes, variations and modifications may be resorted to which fall within the invention as claimed.

In the drawing:

FIG. 1 is a schematic diagram showing the basic components and sub-systems of the apparatus defined in the instant invention.

The single drawing illustrates the components and subsystems which comprise the facsimile system of the instant invention in block diagram notation. Where not illustrated, it is assumed that the correct power supplies are provided on the correct sides of all amplifiers, switches, relays, motors, motor controls, delays, signal generators, transmitter and receivers. Such power supplies have been eliminated in order to simplify the drawings.

Also it is noted that while short wave communication means is provided in the drawing to transmit full-frame video picture signals of documents scanning by a video camera to a remote location whereit it is recorded, other forms of communication may also be employed such as cable, wire pairs, laser beam communication, microwave links and telephone lines.

FIG. 1 illustrates a facsimile apparatus **100** which employs a conventional television camera **134** to scan documents **235** disposed in its scanning field and to generate at the final stage **218** of video amplification a composite video picture signal after a trigger input is energized. The composite picture signal is then transmitted to a receiving station where it is applied to intensity modulate the write-beam of the a modified television receiver to generate an image on the screen of the cathode ray tube thereof which is then applied to form hard copy. The entire procedure may be effected automatically after a start cycle switch **220** is closed, momentarily gating a pulse from a power supply **221** to energize a start switch **132** which is operable to initiate control of the deflection control circuits **133** for the camera **134** which controls the read-beam thereof to execute a full-frame scan of the image field thereafter.

The deflection control circuitry which contains multivibrator circuits **205** and **208**, signal generators **209** and **214**, a blanking mixer **213** and sync signal amplifiers **215**, **216** and **217**, is described in U.S. Pat. NO. 3,051,777 and is designed such as to cause the read—beam of camera **134** to be deflection controlled in effecting a full-frame scanning of the image field thereof upon activation of switch **132**, after which full-frame scanning the beam ceases to be controlled and is blanked until switch **132** is again energized.

The output of switch **220** also extends to a tone signal generator **222**, the output of which is connected to the transmitter **223** which also receives the composite video picture signal. The transmitter **223** may comprise a short wave transmitter, the output signals of which are transmitted to and received by a short wave receiver **224** having an output **224'** which is connected both to a tone responsive relay **225** and the input circuits **226A** for a television receiver **226** which includes a cathode ray tube **226'**, vertical and horizontal beam deflection means 228, a signal activated control switch 227 for gating suitable electrical energy for conditioning the receiver 226 and the recording means of the cathode ray tube to record information on its image screen 226S and input circuitry 226A for the composite video signals generated by camera 134, which circuitry includes conventional means for separating the sync signals from the picture signals and applying same respectively to the deflection plates or coils of the deflection means 228 and the beam mudulation input for the cathode ray tube 226'. The tone responsive relay 225 is operable to become activated upon receiving a tone signal generated by generator 222 and transmitted to receiver 224. Output 225' of relay 225 is connected through a suitable time delay relay 232 to a printer controller 233, a self-recycling multicircuit timer adapted to control operation of a hard copy printer to be described. Tone relay 225 is also shown connected to close control switch 227 to condition television receiver 226 for recording. The composite video picture signal which is received by receiver 224 after tone relay 225 is energized by the signal generated by tone generator 222, is then applied to input circuitry 226A and is operable to control the write-beam of the tube 226' and generate an image of the document scanned by camera 134 on the display screen 226S of tube 226'. In another form of the invention requiring less bandwidth for transmission, the video camera may be modified to generate only the video picture signal and the signal generated by tone generator 222 and regenerated as the output signal of tone relay 225 may be applied to suitable vertical and horizontal synchronizing signal generators at the receiving station for deflection controlling the beam of the cathode ray tube in synchronization with the received video picture signal so that the required picture information will be properly generated on the display screen of the tube 226'.

Thus the video picture signal generated by camera 134 is transmitted to and generates an image on the screen if the cathode ray tube 226' which image is photographed by a camera or facsimile reproduction device 229 at a predetermined time interval after the switch 220 is closed as determined by the time delay relay 232. The camera shutter or printer control 236 is activated by a signal generated by the print cycle controller 233 to cause a print of the image of the face of the cathode ray tube 226' to be effected on reproduction paper 230 which is driven from a supply roll 231 by a motor 234 which is controlled in its operation by the controller 233.

A motorized cutting knife 235 is also controlled by the print cycle controller 233 to cut off just that length of sheet 230 which has been exposed and printd with the image of the cathode ray tube 226'.

The switch 220 may be a manual switch closed by an operator after he has manually disposed a document of photograph 235 on a receiving table 193 between guides 194 and 195 thereof to position said document in the scanning field of the camera 134. The switch 220 may also be automatically closed when a document is fed to the table 193 and its position has been sensed by a limit switch which defines switch 220 or is connected thereto.

In the event it is desired to locally record the full-frame video picture signals generated each time the read-beam of the television camera 134 scans the image of a document for record keeping purposes, the magnetic tape recording arrangements disclosed in U.S. Pat. No. 3,051,77 may be employed which include the use of a video picture signal recording head 122 and a frame marker pulse recording head 123 shown in the drawing as connected to the respective output circuits on which such signals are generated. Reference is particularly made to FIG. 4' of U.S. Pat. No. 3,051,777 for further details of such a recording arrangement taken in consideration with the other disclosures found in said patent. Further descriptive details of the deflection control circuits 133 which are not fully described herein, may be found in application Ser. No. 225,173 and in U.S. Pat. No. 3,051,777.

I claim:

1. Facsimile apparatus for transmitting and recording full-frame video picture information comprising in combination:

a television camera,

means for positioning a document containing a pictorial representation of information to be transmitted to a location remote from said camera, in the scanning field of said camera,

said camera having a reading electron beam and deflection control circuits for causing the reading-beam of the camera to rpedeterminately scan the image field presented to the camera,

signal generating means for generating a sequence of deflection control signals and applying said signals to energize said deflection control circuits of said camera to cause said camera reading beam to full-frame scan its image field,

control means for said signal generating means including a control switch, an input circuit energized by closing said control switch for initiating operation of said signal generating means to generate and apply the signals generated thereby to said deflection control circuits whereby said reading beam is caused to full-frame scan the complete image field presented to the camera and to terminate the scanning action of said reading beam when the complete image field has been scanned thereby,

means including said reading beam for generating a composite video picture signal on the output of said camera including separable picture and synchronizing signal elements,

a receiving station,

means for effecting a communication link between the output of said camera and said receiving station,

receiving means at said receiving station operable for receiving the signals generated by said transmitting means, and including a video receiver having a cathode ray tube and write-beam generating means for generating an image on a display screen of said tube,

horizontal and vertical deflection control means for the write-beam of said receiving station cathode ray tube connected to receive signals from said receiving means,

means at said receiving station for separating said synchronizing signal elements from the picture signal elements from each composite video picture signal received thereby and applying said synchronizing elements to said horizontal and vertical deflection control means for said write-beam of said receiving station cathode ray tube and for simultaneously applying the separated picture signal elements to intensity modulate said write-beam of said cathode ray tube to cause said beam to full-frame scan and generate an image on the display screen of said tube which image is representative of the document scanned by said television camera,

relay means connected to said receiving means of said receiving station and responsive to the code signal generated when said control switch is closed for conditioning said receiving means of said receiving station to receive signals generated by said sending station transmitting means,

means optically coupled to said display screen of said receiving station cathode ray tube for generating a hard copy reproduction of images generated by said display screen, and

means at said receiving station connected to said receiving means and responsive to the control signal received from said sending station for controlling the operation of said hard copy generating means to generate a hard copy print of the image displayed on the display screen of said cathode ray tube.

2. Facsimile apparatus in accordance with claim 1 wherein said means for establishing a communication link between the output of said camera and said receiving station comprises a short wave transmitter connected to the output of said camera and said receiving means at said receiving station comprises a short wave receiver having its output connected to said means at said receiving station for separating said synchronizing signal elements from the picture signal elements, said short wave receiver being operable to receive signals transmitted by said transmitter.

3. Facsimile apparatus in accordance with claim 1 wherein said code signal generating means at said sending station comprises means for generating a tone signal, said relay means connected to said receiving means at said receiving station being tone responsive and operable to generate a control signal on its output for conditioning said receiving means of said receiving station to receive signals from said sending station upon receipt of a tone signal generated by said tone generating means of said sending station.

4. Facsimile apparatus in accordance with claim 1 wherein said control switch is a manually operable electrical switch connected to initiate the operation of said television camera to cause its read-beam to full-frame scan its image field and to energize said code signal generating means.

5. Facsimile apparatus in accordance with claim 1 including means for prepositioning the document in the scanning field of said television camera, said control swtich being operable to sense the presence of a document presented to said prepositioning means and to become activated for operating said signal generating means.

6. Facsimile apparatus in accordance with claim 1, said automatic control means including cycle control means for said hard copy generating means operable to control the operation of said hard copy generating means to generate said hard copy print of the image appearing on the face of said display screen of said cathode ray tube at said receiving station.

7. Facsimile apparatus in accordance with claim 6 wherein said code signal generating means comprises a tone signal generator and said means at said receiving station responsive to the control signal received from said sending station comprises a tone responsive relay which relay is operable to control said automatic cycle control means for said hard copy generating means each time it initially receives a tone signal from said sending station.

* * * * *

United States Patent [19]

Barrett

[11] **4,074,324**

[45] **Feb. 14, 1978**

[54] **INSTANT ELECTRONIC CAMERA**

[76] Inventor: **Jon S. Barrett**, 715 Dona St.,
Sunnyvale, Calif. 94087

[21] Appl. No.: **595,628**

[22] Filed: **July 14, 1975**

[51] **Int. Cl.**^{2} **H04N 1/04**

[52] **U.S. Cl.** **358/296**; 358/280

[58] **Field of Search** .... 178/6.6 R; 358/296

[56] **References Cited**

U.S. PATENT DOCUMENTS

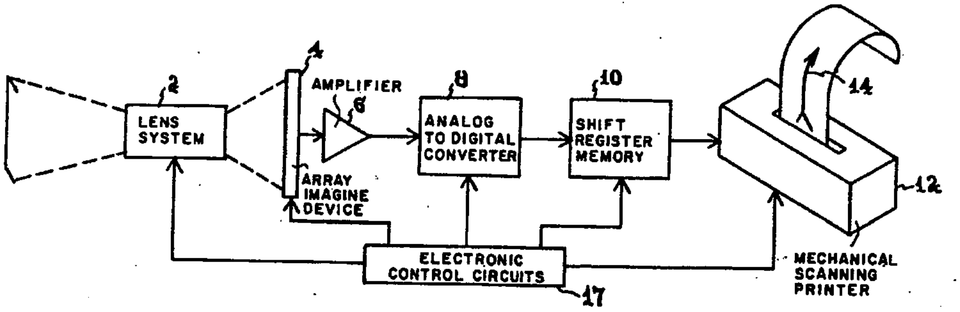
2,779,654	1/1957	Williamson	178/6.6 R
3,409,904	11/1968	Maiershofer	178/6.6 R
3,418,427	12/1968	Jones	178/6.6 R
3,723,646	3/1973	Behane	178/6.6 R

Primary Examiner—Thomas B. Habecker

[57] **ABSTRACT**

A conventional lens system projects an image on a planar array of light sensitive elements of a charge coupled device from which digital signals containing the picture information are produced and stored for reproduction by a mechanical printer.

4 Claims, 2 Drawing Figures



E

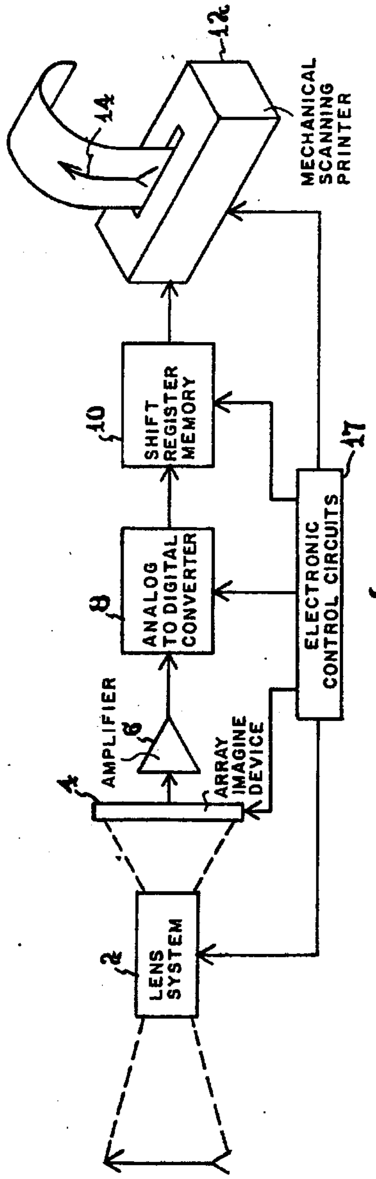

2
LENS SYSTEM
4
ARRAY IMAGINE DEVICE
6
AMPLIFIER
8
ANALOG TO DIGITAL CONVERTER
10
SHIFT REGISTER MEMORY
12
MECHANICAL SCANNING PRINTER
14
17
ELECTRONIC CONTROL CIRCUITS

Fig. 1

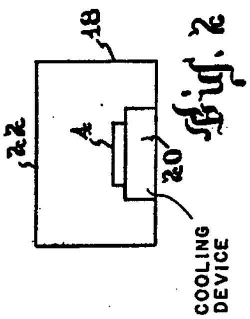

18
22
4
20
COOLING DEVICE

Fig. 2

INSTANT ELECTRONIC CAMERA

This invention relates to an instantaneous camera capable of producing an immediate and permanent image on non-photographic paper. More particularly, it relates to such a camera in which a series of pulses is generated as a function of the light intensity at discrete points on an imaging device, which pulses are fed sequentially to a printer.

It is an object of this invention to provide a compact and economical camera capable of producing immediate images without the use of chemical or other development processes.

It is another object of the invention to provide a method and apparatus for producing images rapidly and economically.

It is another object to provide an instantaneous camera with greater light sensitivity than that provided by the usual photographic film.

It is still another object of the invention to provide a camera capable of the immediate production of multiple copies of the same image.

These and other objects of the invention will be apparent from the following description of a preferred embodiment of the invention considered together with the following drawings, in which:

FIG. 1 is a block diagram of a camera embodying the invention; and

FIG. 2 is a diagrammatic representation of an alternative embodiment of the invention.

A conventional lens system 2, equipped with any desired shutter, exposure, and focusing arrangement, is arranged to project an image on the surface of a solid state array imaging device 4, which may be a CCD (charge-coupled device) having a planar array of light sensitive elements. The device 4 delivers a series of pulses, each of which has an amplitude that is a function of the light-induced charge on a small discrete area on the surface of the device 4, which is coupled through a conventional amplifier 6 to an analog-to-digital converter 8.

The digital signals from the converter 8 are stored in a CCD shift register memory 10. The data from the memory are fed into a mechanical scanning printer 12 capable of printing one or more discrete dots or lines in response to each of said digital signals to produce directly a visible reproduction 14 of the image projected onto the surface of the array imaging device 4.

The operation of the various sections of the camera is controlled by conventional electronic circuits 17, which may be arranged to synchronize the operation of the shutter in the lens assembly 2.

The array imaging device 4 may be a conventional CCD equipped with known scanning circuits whereby pulses are produced in sequential form, each pulse having an amplitude that is a function of the light incident at one predetermined area of the device 4 so that the entire sequence of pulses represents the distribution and intensity of the light falling on the surface of the device 4. Such devices are well known and are described, for example, in an article entitled "Charge-Coupled Devices" in the February 1974 issue of Scientific American.

Other forms of solid state imaging devices may be used, such as a CID (charge-injection device), the construction and operation of which is well known in the art.

The retention time of the charge induced on the imaging array by the projection of an image thereon is a function of the dark current in the device, and in a typical CCD is of the order of one-half second. If the printer is capable of producing an entire image within the retention period of the imaging array, the analog-to-digital converter 8 and the memory 10 can be eliminated and the printer 12 coupled directly to the imaging device 4. However, the construction of a high speed printer or a CCD with a substantially lower dark current adds to the cost of the system, thereby obviating one of the advantages. The preferred system is therefore to provide a memory 10 having a retention time sufficient to permit the use of a lower speed, and therefore more economical, printer. The printer may be one capable of printing dots on low cost paper. For example, one using a heat-sensitive paper, such as the ones coated with white pigmented wax (or wax otherwise treated to render it opaque) over a dark background paper, permits control of the dot size either by controlling the length of time the heat is applied to the surface or by controlling the power applied to the marking element, to produce a half tone effect in the image. The cost of the paper, and therefore the cost per image, is substantially less than that of any photographic paper or light sensitive film.

An alternative type of printing is one using paper having either a voltage or current sensitive coating which may be arranged to move at constant speed across a rotating drum having a projecting spiral marking element.

The camera described here has unique advantages when the retention time of the memory significantly exceeds the time to produce an image on the printer. Such an arrangement permits multiple prints of the image stored in the memory without re-exposing the imaging device 4. For example, the operator can examine a completed print and decide whether additional prints are required. If he wishes one or more additional images, he merely requests additional read-outs from the memory 10.

As pointed out above, there are, under certain conditions, advantages in using an imaging array 4 with the capability of increased retention time. The dark current can be substantially reduced, and the retention time correspondingly increased, by operating the imaging device 4 at a reduced temperature. The imaging device may, for example as shown in FIG. 2, be supported within an evacuated housing 18 and in thermal contact with a cooling device 20 which may, by way of example, be a thermoelectric cooler. The housing 18 is provided with a transparent wall, as at 22, or other means for permitting the image to be projected onto the surface of the device 4. It should be noted that with sufficient cooling the CID type of device may be read out repeatedly and non-destructively to produce multiple copies of the same image.

The resolution of the camera is dependent upon the number of light sensitive areas in the imaging device 4, but even a relatively low resolution image has many useful applications. When greater resolution is desired, imaging devices with greater numbers of light sensing areas must be employed.

This type of electronic camera has an additional advantage over conventional photography in that the solid state devices presently available have a higher quantum efficiency than film, and have significantly better low light performance than can be achieved with photographic film.

From the foregoing it will be seen that my invention is well adapted to attain the ends and objects herein set forth and to be economically manufactured and practical in application.

I claim:

1. An instantaneous camera comprising a lens system; a solid state array imaging device having discrete light sensitive points whose accumulated charge is a function of the incident light; means for positioning said imaging device in predetermined relationship with said lens system; means for sensing charges at said points and generating in predetermined order a sequence of pulses whose amplitudes are a function of the respective instantaneous charges at said points; a printer responsive to said pulses and having means for direct production of visible marks; and means coupling said last-said means to said printer.

2. A camera as described in claim 1 including means maintaining the said imaging device substantially below ambient temperature.

3. A camera as described in claim 1 wherein said coupling means includes an analog-to-digital converter and a solid state memory device whereby said pulses are stored as digital data for a time sufficient to permit effective recording of said data by said printer.

4. A camera as described in claim 3 wherein said memory has a retention time significantly in excess of the printing time of said printer for one complete image.

* * * * *

United States Patent [19]

d'Alayer de Costemore d'Arc

[11] **Patent Number: 4,530,014**
[45] **Date of Patent: Jul. 16, 1985**

[54] **ELECTRONIC CAMERA**

[75] Inventor: **Stéphane M. d'Alayer de Costemore d'Arc**, Genappe, Belgium

[73] Assignee: **Staar S. A.**, Brussels, Belgium

[21] Appl. No.: **466,065**

[22] Filed: **Feb. 14, 1983**

[30] **Foreign Application Priority Data**

Feb. 16, 1982 [BE] Belgium 892.155

[51] **Int. Cl.**^{3} **H04N 5/782**
[52] **U.S. Cl.** **360/33.1**; 358/906; 360/35.1
[58] **Field of Search** 360/33.1, 35.1, 79; 358/335, 906

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,130,834	12/1978	Mender et al.	360/35.1
4,163,256	7/1979	Adcock	360/35.1
4,280,151	7/1981	Tsunekawa et al.	360/33.1
4,442,462	4/1984	Kimura	358/906

FOREIGN PATENT DOCUMENTS

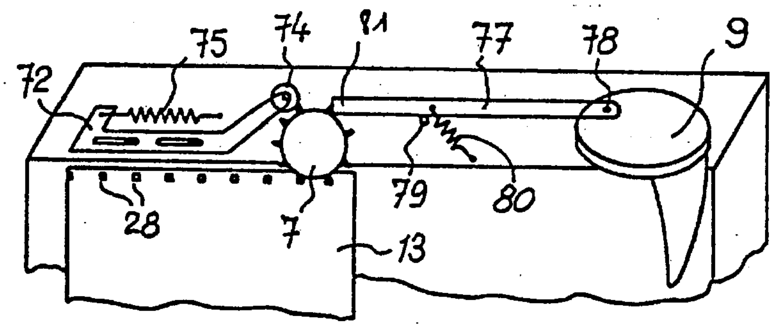
2802670	7/1979	Fed. Rep. of Germany	358/906

Primary Examiner—Donald McElheny, Jr.
Attorney, Agent, or Firm—Leydig, Voit, Osann, Mayer and Holt, Ltd.

[57] **ABSTRACT**

A photographic camera converting a captured optical image to a series of electronic signals is disclosed comprising a recording mechanism to record these signals including a recording head which executes transverse scanning movements with reference to a magnetic record medium so that at least one scanning movement corresponds to each image. The magnetic record medium is contained within a cassette that is removable from the camera body.

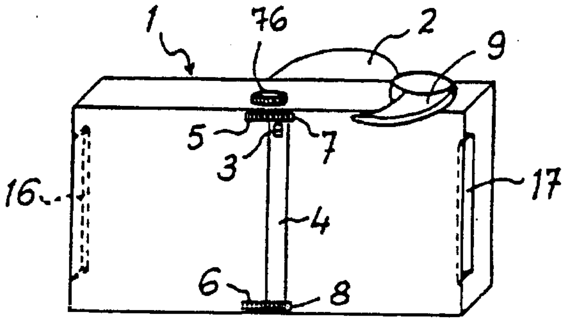
13 Claims, 25 Drawing Figures



XP

F

FIG. 1



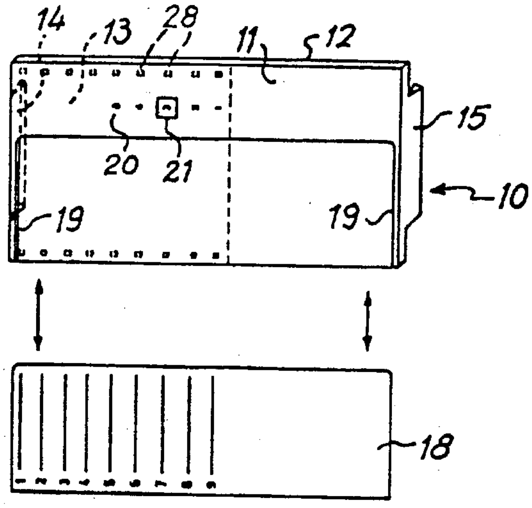


FIG. 2

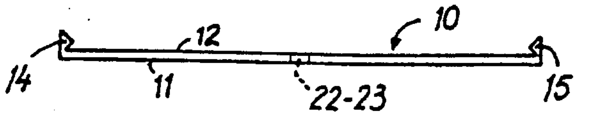
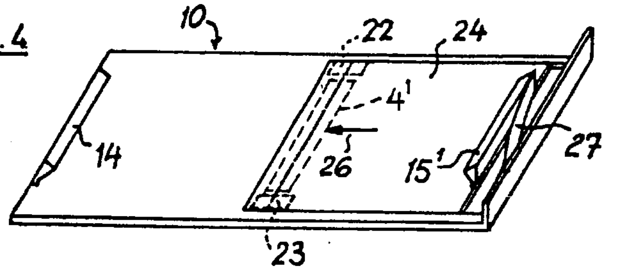


FIG. 3

FIG. 4



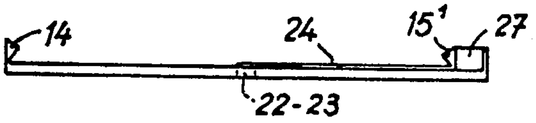


FIG. 4A

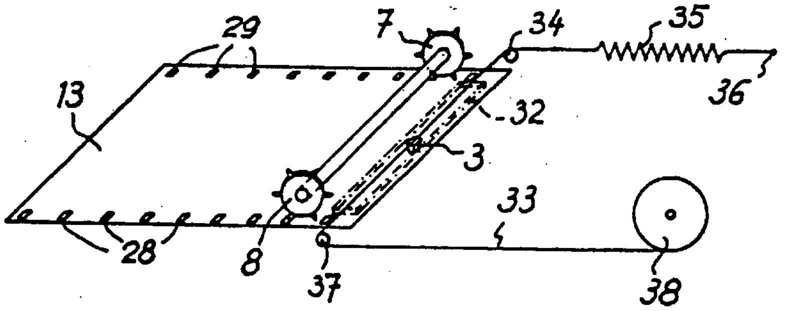


FIG. 5

FIG. 6

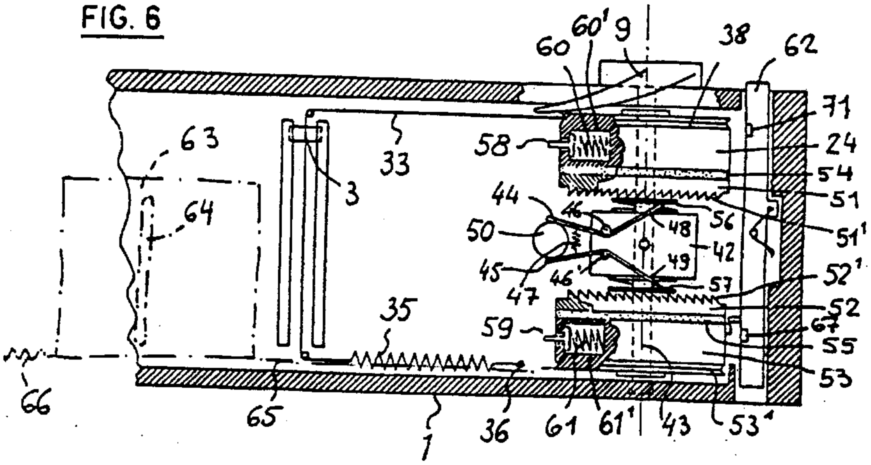
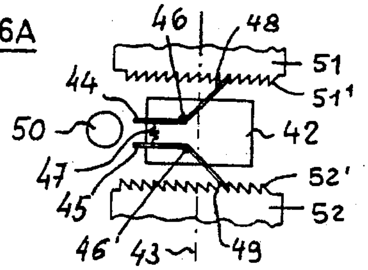


FIG. 6A



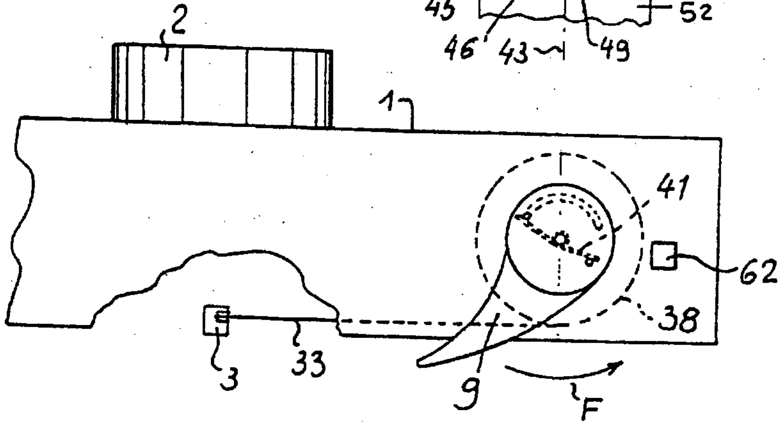


FIG. 7

FIG. 8

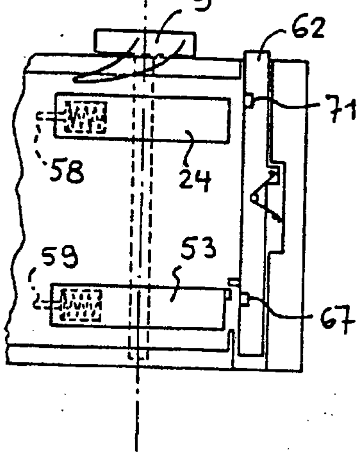


FIG. 9

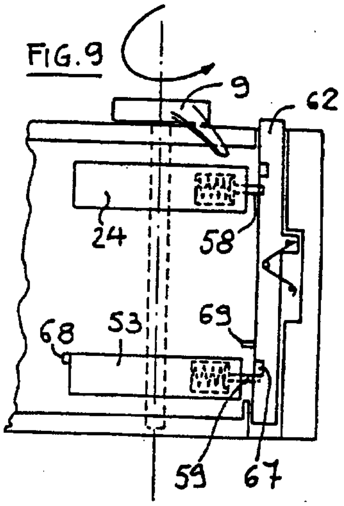


FIG. 10

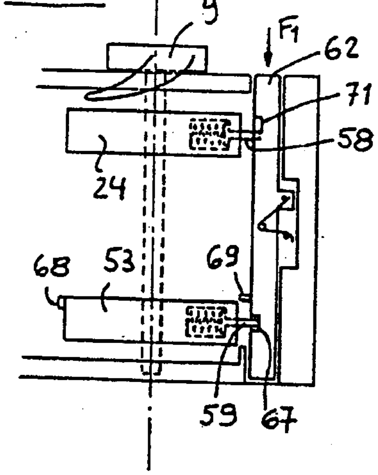


FIG. 11

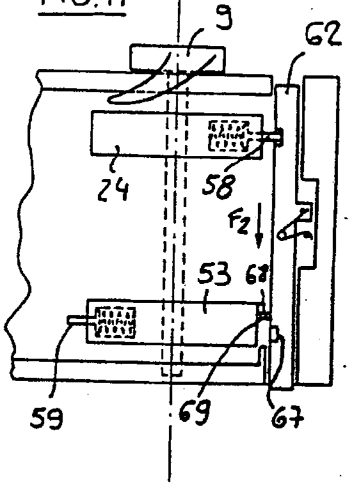


FIG. 12A

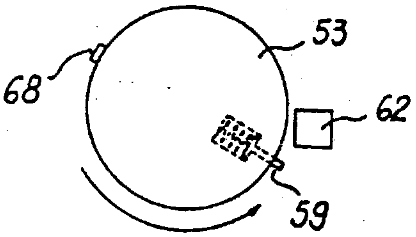


FIG. 12B

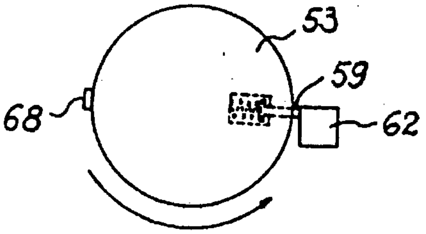


FIG. 12C

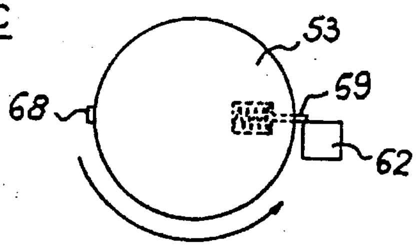


FIG. 12D

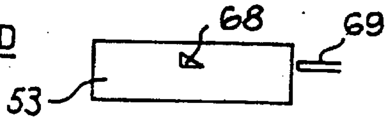


FIG. 13

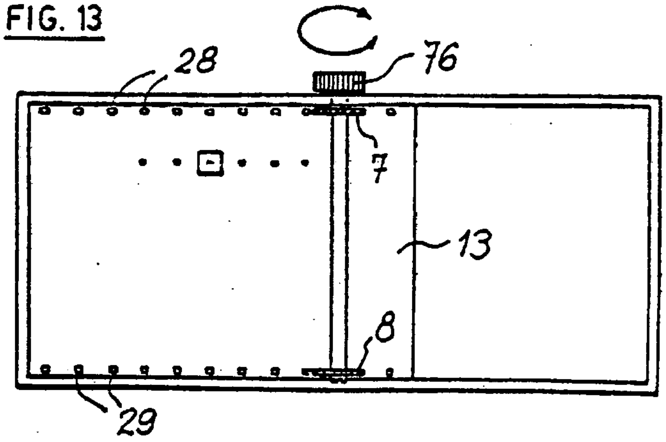


FIG. 14

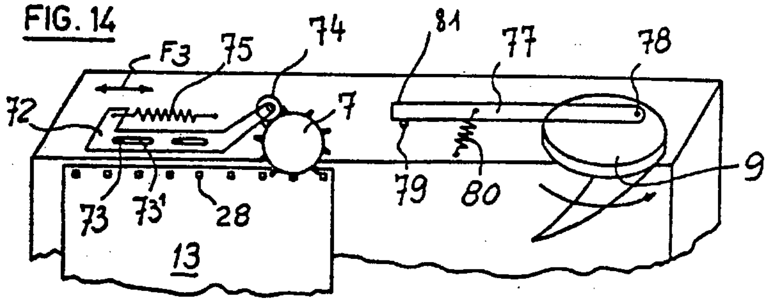


FIG. 15

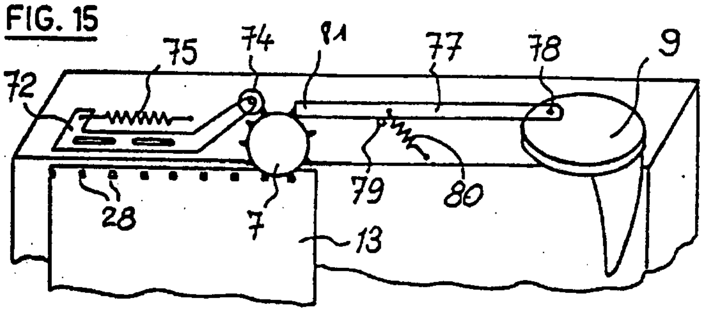
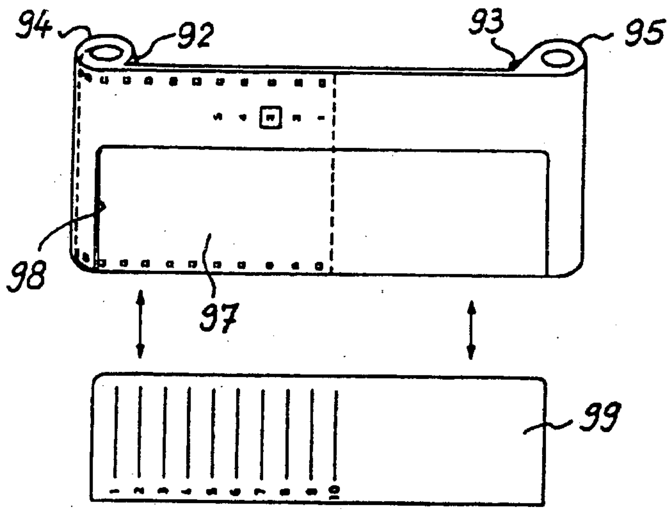


FIG. 16



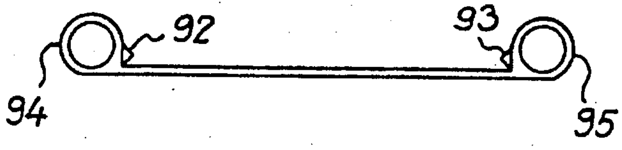


FIG. 16A

FIG. 17

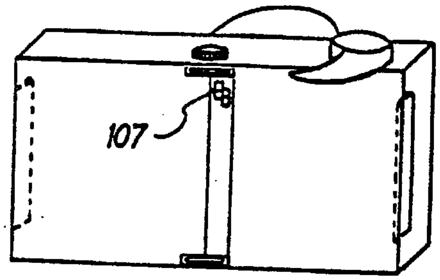


FIG. 18

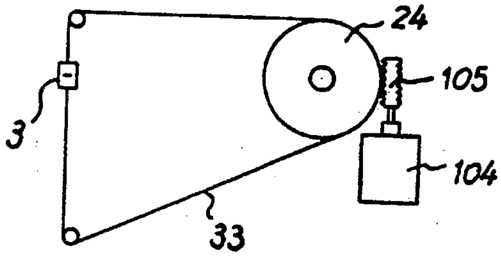
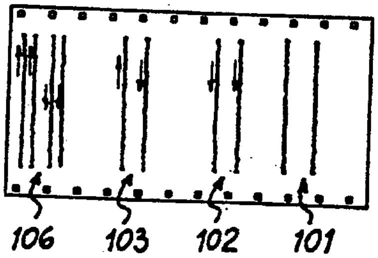


FIG. 19



ELECTRONIC CAMERA

TECHNICAL FIELD

This invention relates to a photographic camera having means for recording images electronically by converting a captured optical image into a series of electronic signals and recording these signals on a magnetic record medium.

BACKGROUND ART

Cameras of this type have been developed recently which have a magnetic record medium in the form of a disc driven by an electric motor. Each image is recorded on a concentric track.

Such an image recording system has a number of drawbacks, e.g., poor recorded images due to vibrations caused by the driving parts in motion during the shooting, high weight due to the motor components necessary for driving the disc, and large-capacity electric batteries or cells, and large external dimensions of the housing required for the various components.

DISCLOSURE OF THE INVENTION

The principal object of this invention is to provide a photographic camera in which images are converted to electronic signals and recorded on a magnetic medium which is very simple, very light, low cost to manufacture, and comparable in size to a conventional photographic camera.

Another object is to provide for such a camera a cassette containing a magnetic record medium on which electronic signals may be recorded corresponding to optical images.

A further object is to provide a camera having a magnetic head or heads which are movable to execute a transverse scanning movement for recording electronic signals on a magnetic record medium corresponding to optical images, the magnetic record medium being fixed during the recording step and moved between recording operations so that a single scanning movement and recording trace corresponds to each image.

Another object is to provide a camera in which the magnetic record medium is moved between recordings by the same mechanism used for setting or cocking the shutter of the camera.

Another important object is to provide a cassette for containing a magnetic record medium which is removable from the camera and has provision for access of driving means to position the magnetic record medium within the cassette.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects will become clear from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a rear perspective view of a camera embodying the invention;

FIG. 2 is a view of a cassette with magnetic record medium for the camera of FIG. 1;

FIGS. 3, 4 and 4A are detailed views of the cassette;

FIG. 5 is a schematic view showing the mechanism for operating the magnetic record medium and the recording head;

FIG. 6 is a schematic view with parts in section showing the operating mechanism for the recording head;

FIGS. 6A to 12D are detailed views of the operating mechanism for the recording head and the shutter;

FIGS. 13 to 15 are schematic views showing the operating mechanism for the magnetic record medium;

FIGS. 16 and 16A show an alternative cassette construction for a large-capacity magnetic record medium; and

FIGS. 17 to 19 relate to alternative mechanisms for recording on magnetic record medium.

BEST MODE FOR CARRYING OUT THE INVENTION

Turning to FIG. 1 of the drawings, a photographic camera has a housing 1 and a lens 2. The image passing through the lens 2 is projected onto charge coupled devices for converting each optical image into a series of electronic signals. This operation being known, per se, will not be described further here.

According to this invention, the camera is provided with a record medium 13, preferably a rectangular plastic sheet with a magnetic coating, housed in a cassette 10 (FIG. 2) for recording electronic signals derived from the converting means. The camera also is provided with a recording means, herein shown as a recording head 3, movable along a path transverse to the magnetic record medium 13 and extending substantially the full height of the housing 1. The recording head 3 is visible In FIG. 1 through an elongated window 4 in the rear of the camera housing 1, which is shown open and the mechanism exposed without the cassette 10 and magnetic record medium 13 (FIG. 2) mounted in the camera.

While the recording head 3 is mounted for transverse scanning movement, the magnetic record medium 13 is movable lengthwise of the cassette 10 and camera housing 1 in a direction from left to right in FIG. 2 by an operating mechanism including toothed wheels 7, 8 which are mounted in the housing and are engagable in holes 28 in the magnetic record medium 13.

In carrying out the invention, the cassette 10 for the magnetic record medium 13 is formed by two casing halves 11, 12 between which the magnetic record medium 13 is captive and is movable by means of the toothed wheels 7, 8 which are accessible through apertures 22, 23 in the walls of the cassette.

The cassette 10 is adapted to be mounted on and removable from the housing 1 and, for this purpose, has at each of its ends a projection 14, 15 intended to cooperate with notches 16, 17 in the housing 1, which permits the insertion and the locking of the cassette in position.

The walls of the cassette casing are sufficiently flexible for the projections 14, 15 to be able to penetrate by pressure into the notches 16, 17 to retain the cassette 10 firmly in the housing 1.

The recording head 3 records electronic signals corresponding to each image upon the magnetic record medium 13 while the latter is in fixed position, the movement of the magnetic record medium being carried out between recording steps to allow separate recording of a plurality of images.

A label 18 (FIG. 2) which may be removable or fixed and which, in the example illustrated, is slid into a groove 19 provided in the cassette 10 permits the writing of data (numbering and/or titles) to identify the images photographed with the camera and corresponding to marks 20 printed on the magnetic record medium

13 and visible through a window 21 formed in the rear wall of the cassette 10.

Transverse apertures 22, 23 (FIG. 3) which are provided in the cassette to provide access to the magnetic record medium 13 in order to position it for recording also permit access for positioning it for reading the recordings on the magnetic record medium 13. An elongated transverse aperture 4' is also shown in FIG. 4 in the cassette 10 opposite the path of the recording head 3 to permit access by the head to the magnetic record medium 13.

A slidable door or shutter 24 (FIG. 4) is also provided in the cassette 10 and serves to block automatically the access apertures 4', 22, 23 to the magnetic record medium 13 when the cassette is removed from the photographic camera in order to protect the accessible portions of the magnetic record medium.

When the projection 14 is introduced into the notch 16 of the camera housing 1, the shutter 24 must be pushed against a leaf spring 27 (FIG. 4) so that the projection 15 may be introduced into the notch 17.

The cassette 10 is thus guided and retained in position in the camera housing. Also, after sliding, the shutter 24 exposes the apertures in the cassette.

When the cassette is inserted in the camera housing 1, the magnetic record medium 13 is correctly positioned with reference to the recording head 3 and the perforations 28, 29 provided on the edges of the magnetic record medium 13 are accessible to and engaged by the teeth of the toothed wheels 7, 8 (FIG. 5).

Turning again to FIG. 5, the operating mechanism for the magnetic head 3 is illustrated schematically. As shown, the head 3 slides in a slideway 32 on the chassis of the camera and is driven in its cocking or setting and scanning movements by the cable 33.

This cable 33 is guided by rollers 34, 37, also mounted on the camera chassis. One of the ends of the cable 33 is fixed at 36 to the chassis of the camera through the intermediary of a spring 35. The other end is wound on a pulley 38 forming part of the setting device.

It is necessary that the camera operations of exposing images, converting the images to corresponding electronic signals and recording the signals upon the magnetic record medium be correctly synchronized.

In an entirely electronic embodiment, the "clock" circuit contained in the charge coupled devices and effecting the conversion of the photographed image into electronic signals may advantageously be used to control the succession of the above-mentioned operations.

However, for low-cost photographic cameras, it is more economical to use mechanical means to effect this synchronization.

In carrying out the invention, a mechanical means is shown for synchronizing the operation of the recording head and the conventional lens shutter of the camera, herein shown in FIGS. 6–14 as a mechanical setting and release device for the camera. Means are also provided for synchronizing the movement of the magnetic record medium 13 so that occurs between recordings as an incident to setting the shutter and recording head into a set condition.

The setting is accomplished by a cocking or setting lever 9 mounted to pivot around the axis of the shaft 43 in the direction of the arrow F counter to a return spring 41 (FIGS. 6 and 7). This lever 9 is operative to cock or set both the recording mechanism and the lens shutter. To set the recording head 3, the lever 9 is connected to wind the cable 33 on the pulley 38. To rotate the pulley 38, a plate or hub 42 fixed the shaft 43 carries on its circumference two small levers 44, 45 which pivot about axes 46, 46^1 carried by the hub 42 and engage facing teeth 51^1, 52^1 provided on two spaced circular plates 51, 52 rotatable on the shaft 43.

A spring 47 tends to separate one of the ends 48, 49 of the levers 44, 45 to urge them into engagement with the teeth 51^1 and 52^1, as shown in FIG. 6A. At their other ends, the levers 44, 45 come into contact with a fixed stop 50 so that normally they are separated from engagement with the teeth 51^1, 52^1 as shown in FIG. 6.

The plates 51, 52 are operable when rotated through friction clutches 54, 55 to drive two reels 24, 53 at opposite ends of the shaft 43. The clutches 54, 55 are engaged by the action of springs 56, 67 bearing against the hub 42. The pulley 38 for the cable 33 is integral with the reel means 24.

For cocking or setting the recording mechanism and the conventional shutter of the camera, the lever 9 is actuated in the counterclockwise direction of the arrow F (FIG. 7) which rotates the hub 42. The rear arms of the levers 44, 45 move away from the fixed stop 50 and, under the action of the spring 47, as shown in FIG. 6A, the ends 48, 49 of the levers 44, 45 engage the teeth 51^1, 52^1 of the two plates 51, 52. The plates 51, 52 are caused to rotate and the reels 24, 53 are thus rotated by the friction clutches 54, 55.

Housings on the circumference of the reels 24, 53 contain rods or pawls 58, 59 subject to the action of springs 60, 61 housed in circumferential cavities 60^1, 61^1 formed in the reels 24, 53.

During the setting operation achieved with the lever 9, the cable 33 is wound onto the pulley 38 and moves the magnetic head into its set or cocked position shown in FIG. 6, stretching the spring 35.

By virtue of a cable 65 winding onto a pulley 53^1 integral with the reel means 53, the setting operation likewise sets a conventional shutter, schematically indicated by a shutter curtain 63 (FIG. 6), equipped with a slot 64 and subject to the influence of a spring 66.

A common pawl device is provided for both pawls 58, 59 of the reel 24 for the recording head and the reel 53 for their shutter, which pawl device comprises a rod 62 extending parallel to the axis of the shaft 43 and projecting from the housing 1 to provide an actuating knob.

In the set position, the reels 24, 53 are held by the pawls 58, 59 which are retained by the rod 62. The shutter 63 and the recording head 3 are, therefore, maintained in set position. To set or cock the reels 24, 53, the lever 9 is rotated counterclockwise, as indicated in FIGS. 8, 9, 12A–12C, to rotate the hub 42, which carries the levers 44, 45 and the rear arms of these levers leave the fixed stop 50. Under the action of the spring 47, the ends 48, 49 of the levers 44, 45 engage the teeth of the plates 51, 52. The latter, as they rotate, drive the reels 24, 53 through the friction clutches 54, 55 which are maintained engaged by the pressure of the two springs 56, 57 bearing against the hub 42. After a rotation of approximately 180 degrees, the pawls 58, 59 pass the rod 62 and come into abutment against the back edges of the rod 62, as shown in FIG. 9 and as illustrated in FIG. 12C for the pawl 59 of the lower reel 53, which latches both reels 24, 53. The actuating lever 9 can then be released and returned without releasing the reels 24, 53, which are held by the pawls 58, 59.

The actuating lever 9 is returned to its starting position by the action of the return spring 41 (FIG. 7). During return of the lever 9 and the hub 42, the ends 48, 49 of the levers 44, 45 slide on the teeth of the plates 51, 52 and are then separated from the teeth by the levers 44, 45 coming against the stop 50.

To release the conventional lens shutter 63 and the recording head 3 and thereby operate the camera, pressure is applied to the top of rod 62 which projects from the surface of the housing 1 to move the rod 62 in the direction F_1 (FIG. 10). Upon movement of the rod 62, the notch 67, which is initially in the position of FIG. 9, is moved abreast of the pawl 59 in the position of FIG. 10, which releases the pawl 59 to enter the notch 67 and releases the reel 53, which is no longer retained by the pawl 59. The reel 53 rotates clockwise when released, which releases the shutter for return by the spring 66.

When the reel 53 has returned to its starting position (FIG. 8), the shutter has completed its stroke. The reel 24 and the recording head 3 remain cocked during the period the shutter is open. The circuits of the camera convert the image into signals and store the signals temporarily in electronic memory means.

To release the recording head, an inclined projection 68 (FIG. 12D) carried by the reel 53 comes, at the end of the rotational stroke of the reel 53, into engagement with a projection 69 fixed to the rod 62. The projection 68 on the reel 53 cams the rod 62 in the direction of the arrow F_2 (FIG. 11).

The downward movement of the rod 62 moves the notch 71 abreast of the pawl 58 to release the pawl 58 and the the reel 24 (FIG. 11), and releasing the recording head 3 which is moved by the spring 35 (FIG. 6) in its transverse scanning movement, to record the signals corresponding to the photographed image upon the magnetic record medium 13.

The scanning movement of the head, like that of the shutter, may be braked so as to obtain a transverse scanning of the recording head in a finite time.

Further in keeping with the invention, means are provided for moving the magnetic record medium 13 between recording steps in a direction to locate fresh portions of the magnetic record medium in the path of scanning movement of the head 3. For this purpose, referring to FIGS. 13–15, the toothed wheel 7 is maintained in successive angular positions by an escapement device comprising a lug 72 which is slidable in the direction of the arrow F_3, being guided by pegs 73 sliding in slots 73^1 and which carries a centering roller 74 which, under the action of a spring 75, fits between the teeth of the wheel 7 to regulate the movement of the wheel in discrete steps.

For moving the magnetic record medium 13 manually, a knob 76 may be fixed to the wheels 7, 8, as shown in FIG. 13.

Alternatively, the wheels 7, 8 may be moved automatically each time the lever 9 is actuated to place the operating mechanisms for the recording head and the shutter in set condition. To this end, a lever 77 connected to the setting lever 9 by a pin 78 and guided by a stop 79 is movable in an operating stroke upon actuation of the lever 9 against the force of the spring 80 (FIGS. 14, 15). Towards the end of the stroke of the lever 9 and the lever 77, as shown in FIG. 15, the end 81 of the lever 77 comes into abutment against a tooth of the wheel 7 and rotates this reel counterclockwise by one notch counter to the centering roller 74 which completes the positioning movement of the wheel 7 under the action of the spring 75.

As an alternative construction, FIGS. 16 and 16A show a large capacity cassette comprising cylindrical sections 94, 95 provided to permit the unwinding and winding respectively of a flexible magnetic record medium 97 to move successive portions of the record medium adjacent the path of their recording head.

A groove 98 forming a frame serves to receive one or more program labels 99.

The process of recording signals corresponding to a photographic shot may be varied according to requirements, e.g., in order to make prints of greater definition or to provide a sound recording corresponding to each image recording. As specific examples, referring to FIG. 19, recording tracks as hereinbefore described are in the form of single parallel tracks 101 made by a single magnetic head, such as that illustrated at 3 (FIG. 5). Double tracks 102 are made by a double magnetic head 107 (FIG. 17) operated in the same manner as the single head 3. Two-way tracks 103 are produced by a magnetic head 3' on an endless belt 33 driven by a reversible electric motor 104 via a screw 105 coupled to the reel 24 to advance and return the head 3' (FIG. 18). Double two-way tracks are produced by a double magnetic head 107 (FIG. 17) when operated by a mechanism of the type shown in FIG. 18 having a reversible electric motor 104.

I claim:

1. A photographic camera having means for converting an optical image into a series of electronic signals comprising:
   - means for recording signals on a magnetic record medium including a recording head movable in transverse scanning movements relative to said record medium so that one scanning movement corresponds to each image;
   - a camera shutter;
   - an operating mechanism for opening and closing said shutter, said camera being adapted to transmit an optical image to said converting means when said shutter is open;
   - a removable cassette containing said magnetic record medium;
   - an operating mechanism mounted in said camera for moving said magnetic record medium in discrete steps lengthwise relative to said transverse scanning movements of said recording head, said cassette having an aperture permitting access for moving said magnetic record medium contained in said cassette and a transverse aperture permitting access of said recording head for recording while tape is confined within the cassette; and
   - means for synchronizing the operation of said recording head, shutter and magnetic recording medium.

2. A photographic camera according to claim 1, said cassette having a shutter for blocking said apertures and access to the magnetic record medium when the cassette is removed from the photographic camera.

3. A photographic camera having means for converting an optical image into a series of electronic signals comprising:
   - means for recording signals on a magnetic record medium including a recording head movable in transverse scanning movements relative to said record medium so that one scanning movement corresponds to each image;
   - an operating mechanism for said recording head;

a camera shutter;

an operating mechanism for opening and closing said shutter, said camera being adapted to transmit an optical image to said converting means when said shutter is open;

common means to place said operating mechanisms for said shutter and said recording head in set condition whereby said shutter is prepared to open and said recording head is prepared to effect a scanning movement;

a removable cassette containing said magnetic record medium;

an operating mechanism mounted in said camera for moving said magnetic record medium in discrete steps lengthwise relative to said transverse scanning movements of said recording head;

said operating mechanism for moving said magnetic record medium including a toothed driving member and said magnetic recording medium including holes cooperating with teeth of said driving member.

4. A photographic camera according to claim 3 in which said operating mechanism for said recording head includes a spring, lever means to place said head operating mechanism in set condition, and means for releasing said head operating mechanism so that said spring effects the transverse scanning movement of said recording head.

5. A photographic camera according to claim 4 in which said lever means is connected to place said operating mechanisms for said shutter and said recording means in said condition.

6. A photographic camera having means for converting an optical image into a series of electronic signals comprising:

means for recording signals on a magnetic record medium including a recording head movable in transverse scanning movements relative to said record medium so that one scanning movement corresponds to each image;

an operating mechanism for said recording head;

a camera shutter;

an operating mechanism for opening and closing said shutter, said camera being adapted to transmit an optical image to said converting means when said shutter is open;

common means to place said operating mechanisms for said shutter and said recording head in set condition whereby said shutter is prepared to open and said recording head is prepared to effect a scanning movement;

a removable cassette containing said magnetic record medium;

an operating mechanism mounted in said camera for moving said magnetic record medium in discrete steps lengthwise relative to said transverse scanning movements of said recording head, said cassette having apertures permitting access for moving said magnetic record medium contained in said cassette;

said cassette including a shutter for blocking said apertures and access to the magnetic record medium when the cassette is removed from the photographic camera.

7. A photographic camera according to claim 6 in which said operating mechanism for said magnetic record medium includes an escapement device to feed the magnetic record medium in discrete steps to regulate the spacing of the recording tracks.

8. A photographic camera having means for converting an optical image into a series of electronic signals comprising:

means for recording signals on a magnetic record medium including a recording head movable in transverse scanning movements relative to said record medium so that one scanning movement corresponds to each image;

a camera shutter;

operating mechanisms for said shutter, said recording means and said magnetic record medium; and

means to place said operating mechanisms for said shutter and recording means in said condition whereby said shutter is prepared to open and said recording head is prepared to effect a scanning movement and for synchronizing the release thereof.

9. A photographic camera according to claim 8 in which said operating mechanism for said shutter is movable through an operating stroke and including means for releasing said recording means from set condition at the end of the shutter mechanism operating stroke.

10. A photographic camera according to claim 8 in which said operating mechanisms include independent reel means, setting lever means for rotating said reel means and placing the same in set condition, a cable connected to said recording head and wound on one of said reel means and a cable connected to said shutter and wound on the other of said reel means and springs associated with said cables for moving said head and shutter through an operating stroke.

11. A photographic camera according to claim 10 in which friction clutches are included in said reel means for transmitting movement of said setting lever means to place said reel means in set condition.

12. A photographic camera according to claim 10 in which said operating mechanisms include pawl devices carried by the reel means cooperating with a manual control rod for operating the camera having notches to release the pawl devices.

13. A photographic camera according to claim 12 in which said pawl devices cause sequential release of said shutter and recording head and synchronize the operation thereof.

* * * * *

C1421 XR 4,652,926

United States Patent [19]

Withers et al.

[11] **Patent Number: 4,652,926**

[45] **Date of Patent: Mar. 24, 1987**

[54] **SOLID STATE IMAGING TECHNIQUE**

[75] Inventors: **Richard S. Withers; Richard W. Ralston**, both of Bedford; **Ernest R. Stern**, Concord, all of Mass.

[73] Assignee: **Massachusetts Institute of Technology**, Cambridge, Mass.

[21] Appl. No.: **602,938**

[22] Filed: **Apr. 23, 1984**

[51] **Int. Cl.⁴** **H04N 3/14**

[52] **U.S. Cl.** **358/213**; 358/909; 358/209

[58] **Field of Search** .... 358/213, 212, 209, 906, 358/909, 335, 338; 250/578, 213 A; 357/24 LR, 23.5; 365/215, 234, 114, 112, 106, 115

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,145,368	8/1964	Hoover, Jr.	365/215
3,763,476	10/1973	Wilson et al.	365/115
3,855,583	12/1974	Gudmunosen	365/114
4,022,968	5/1977	Keizer	358/338
4,128,897	12/1978	Norton et al.	365/118
4,213,148	7/1980	Clemens	358/338
4,224,481	9/1980	Russell	365/215
4,296,478	10/1981	Kiess et al.	365/112
4,326,282	4/1982	Verboom et al.	369/48
4,396,996	8/1983	Oldham	365/95
4,420,773	12/1983	Toyoda et al.	358/335
4,489,351	12/1984	D'Alayer de Costemore	358/213
4,498,156	2/1985	Pizzarello	365/215
4,527,259	7/1985	Watanabe	365/189

Primary Examiner—Robert G. Lev
Attorney, Agent, or Firm—Robert F. O'Connell

[57] **ABSTRACT**

An optical imaging system for use as a solid-state camera, for example, which includes a plurality of solid-state elements for providing long-term storage of images, such elements being, for example, MNOS chips having a plurality of storage cells, which chips when exposed to an image focussed thereon can store a representation thereof. The chips are at a later time optically addressed, as by a scanning-light beam, to read out the stored image so as to provide an electrical output representing the stored image, such output being usable to provide a visual representation of the image such as on a display screen or in hard copy form.

14 Claims, 10 Drawing Figures

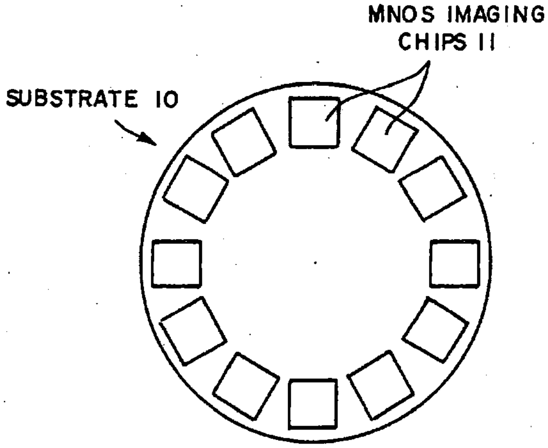


FIG. 1

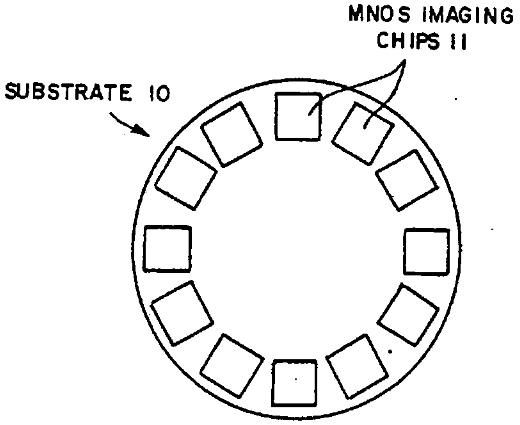
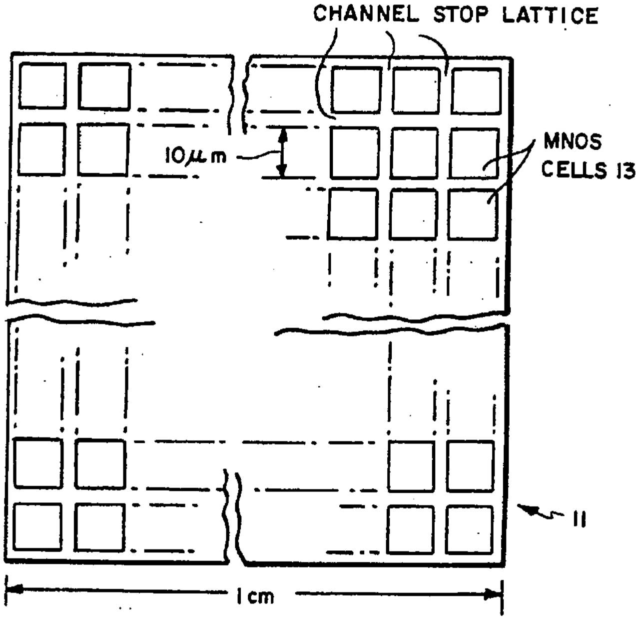

MNOS IMAGING CHIPS 11
SUBSTRATE 10

FIG. 2


CHANNEL STOP LATTICE
10μm
MNOS CELLS 13
11
1 cm

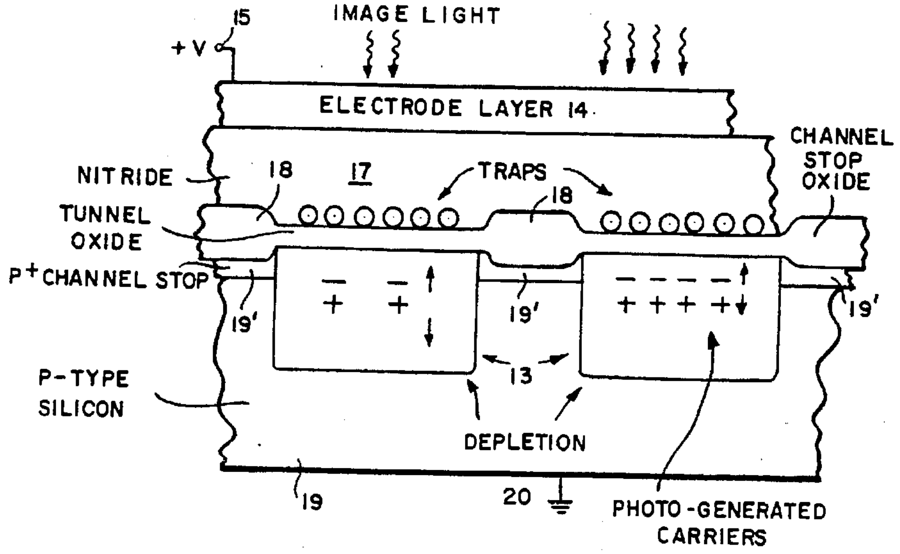

15
+V
IMAGE LIGHT
ELECTRODE LAYER 14
CHANNEL STOP OXIDE
NITRIDE
18
17
TRAPS
18
TUNNEL OXIDE
P+CHANNEL STOP
19'
19'
19'
P-TYPE SILICON
13
DEPLETION
19
20
PHOTO-GENERATED CARRIERS

FIG.3

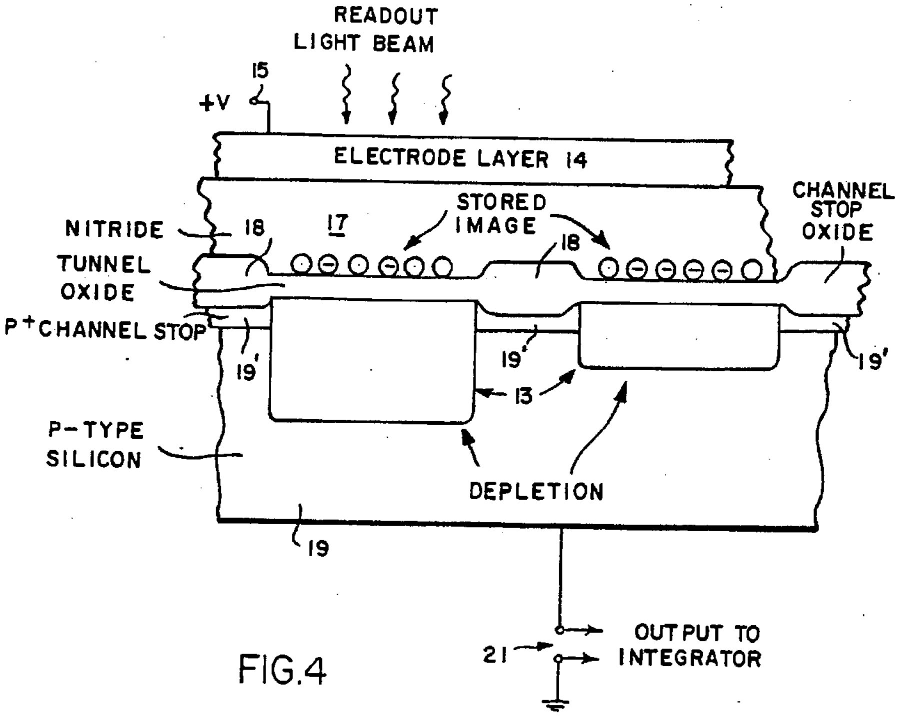

READOUT LIGHT BEAM
15
+V
ELECTRODE LAYER 14
STORED IMAGE
CHANNEL STOP OXIDE
NITRIDE
18
17
18
TUNNEL OXIDE
P+CHANNEL STOP
19'
19'
19'
13
P-TYPE SILICON
DEPLETION
19
OUTPUT TO INTEGRATOR
21

FIG.4

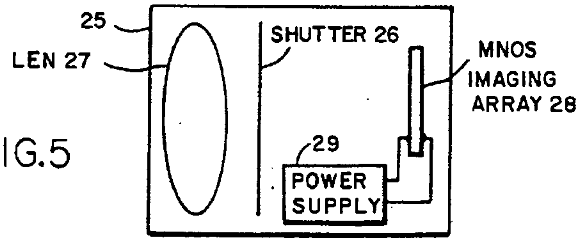
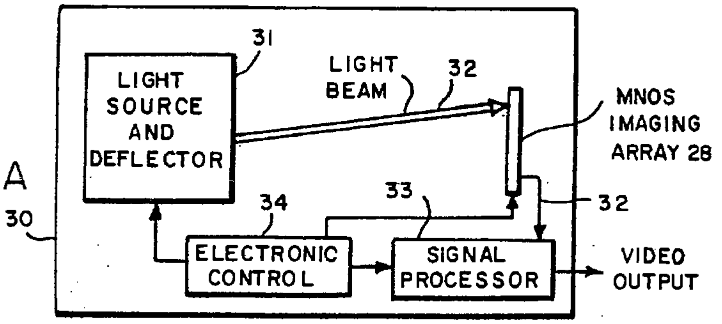


FIG.5

FIG.5A



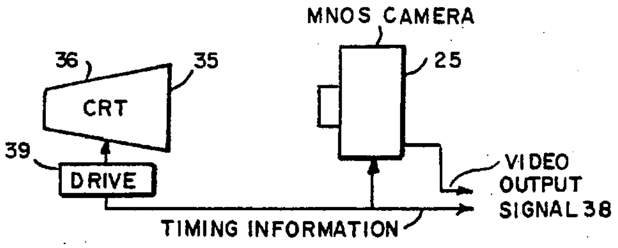


FIG.5B

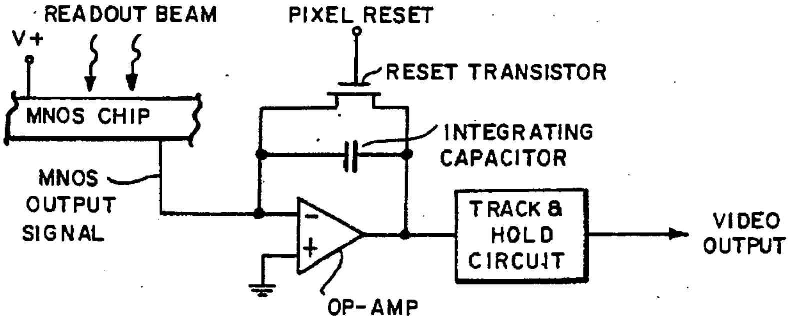


FIG.6

FIG. 7

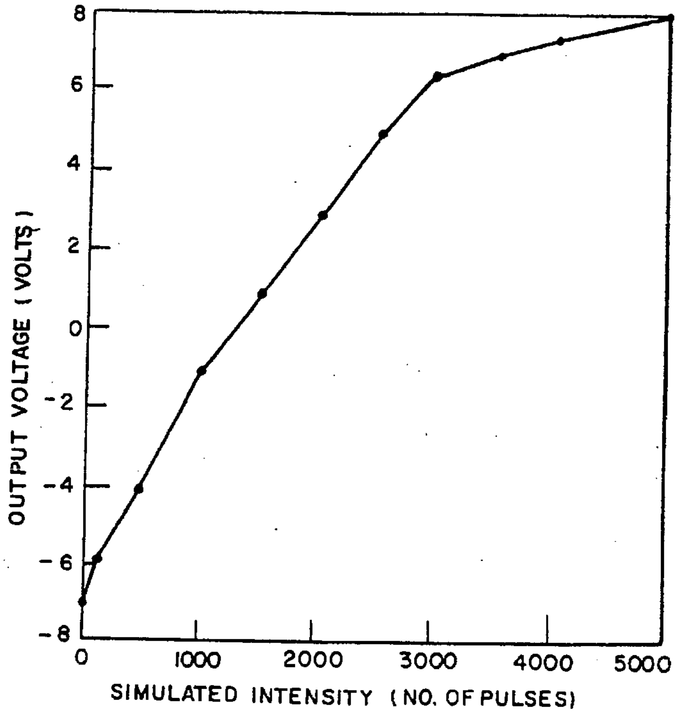
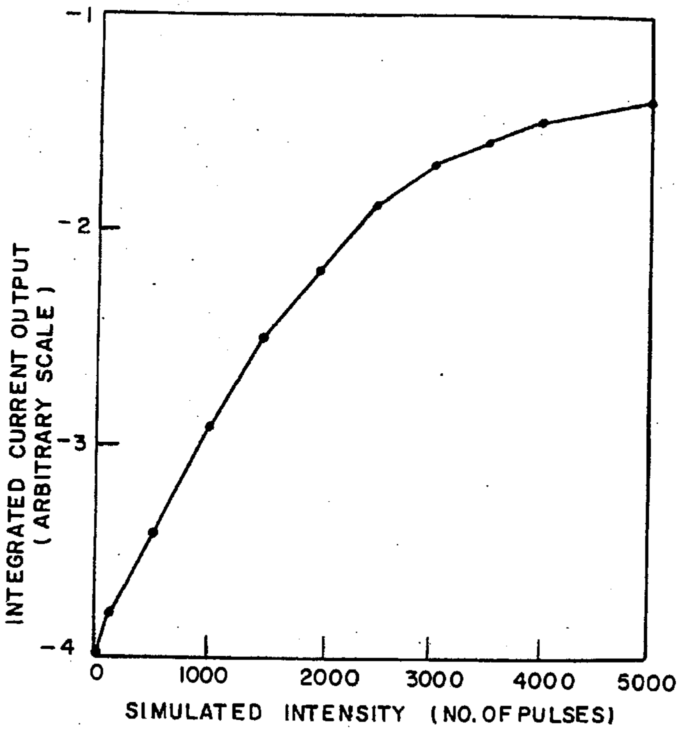

8
6
4
2
0
-2
-4
-6
-8
OUTPUT VOLTAGE (VOLTS)
0
1000
2000
3000
4000
5000
SIMULATED INTENSITY (NO. OF PULSES)

FIG.7A


-1
-2
-3
-4
INTEGRATED CURRENT OUTPUT
(ARBITRARY SCALE)
0
1000
2000
3000
4000
5000
SIMULATED INTENSITY (NO. OF PULSES)

SOLID STATE IMAGING TECHNIQUE

The Government has rights in this invention pursuant to Contract Number AF19628-80-C-0002 awarded by the Air Force.

INTRODUCTION

This invention relates generally to the storing and retrieval for subsequent reproduction of optical images and, more particularly, to techniques for performing such operations utilizing solid state devices.

BACKGROUND OF THE INVENTION

The use of solid state devices has been suggested for storing and for subsequent retrieval and reproduction of optical images as in a solid state camera. One such proposed system utilizes a miniaturized electronic camera and a magnetic disk or tape storage unit which can be packaged as a hand-held or shoulder-supported apparatus. The electronic camera utilizes a conventional charge-coupled device (CCD) imaging chip, the CCD thereon containing an array of pixels and the chip being located in the focal plane of the camera optics. The chip is exposed to the image and photocarriers are produced in each pixel. For reading the image, special electronic shifting circuits are used to shift the photocarriers on a line-by-line, and subsequently a pixel-by-pixel, basis to an output detector. The output detector signal is then stored on a video disk or video tape, for example, and the camera is then ready for the next imaging process. Because CCDs provide only very short term storage, the shifting process must begin substantially immediately after the image has been stored and must be completed within a relatively short time interval, i.e., one which is much less than one second if the quality of the image is to be preserved. If the shifting takes longer the quality of the image stored in the CCD device gradually diminishes and the image ultimately disappears.

Such an approach requires relatively elaborate electronic switching and shifting circuitry and the attachment of a magnetic recording device to the hand-held camera. Accordingly the device becomes relatively bulky and heavy and inconvenient to carry. As mentioned above, because the image that is stored in the CCD chip has a very short storage life, each image must be read out and stored in the magnetic recording device within a very short time after the chip has been exposed to the external image, in practice almost immediately, and the next image cannot be obtained until the overall switching, shifting and permanent storage recording process for a previous image has been completed.

In contrast it would be preferable to provide for solid state imaging in which images can be stored for much longer periods of time so that each image need not be accessed immediately for processing but rather many images can be stored in an array of solid state chips and then processed at a later time. Moreover, it would be desirable to avoid the need for an on-site magnetic storage device and for the elaborate electronic switching and shifting circuitry within the camera for reading out the image which has been formed and is to be stored. Currently there is no known solid state camera which provides such advantages.

BRIEF SUMMARY OF THE INVENTION

This invention provides a solid state camera in which several images can be stored for an extended period of time in an array of solid state devices so that the processing of images need not be performed in the field at the time when the image has originally been stored but can be processed at a much later and more convenient time period when all of the images in an array thereof can be processed together. Moreover, in accordance with the invention the system utilizes a read-out mechanism which permits the stored image to be read out optically so that complex electronic switching and shifting circuitry conventionally required is eliminated. In a particular embodiment, for example, the read-out process can be performed by utilizing a scanning optical beam which utilizes known, reliable electronic or mechanical scanning techniques.

Each of the solid state devices, or imaging chips, of the array thereof can be suitably moved sequentially into the camera's focal plane so that the image can be projected onto the focal plane for storage in the particular chip which has been moved into position. In a preferred embodiment, when all the chips of an array have been exposed to images, the substrate containing the array of chips can be appropriately read out by a device which is separate from the camera itself and which is capable of providing output image information for any appropriate use, such as to produce a print thereof or to store such output in the form of electrical signals on a video recording medium which can be appropriately displayed on a TV display system, for example. The imaging chips may be erased, either singly or collectively, by the application of a voltage pulse at some convenient time, e.g. just prior to exposure.

DESCRIPTION OF THE INVENTION

The invention can be described in more detail with the help of the accompanying drawings wherein

FIG. 1 shows a plan view of an exemplary substrate containing an array of appropriate solid state imaging chips;

FIG. 2 shows a plan view of an exemplary chip having a plurality of appropriate solid state cells for forming each of the pixels of a complete image;

FIG. 3 shows a diagrammatic view in cross-section of a pair of adjacent solid state cells useful in explaining the image storing operation therein;

FIG. 4,shows a diagrammatic view in cross-section of a pair of adjacent solid state cells useful in explaining the optical readout operation thereof; and

FIGS. 5 and 5A show diagrammatic views of an exemplary embodiment of an overall camera apparatus and readout apparatus, respectively, of the invention depicting the locations of significant portions thereof;

FIG. 5B shows a block diagram of an alternative readout apparatus using a cathode ray tube;

FIG. 6 shows an exemplary electrical integrating circuit for providing an output signal from an optically scanned imaging chip; and

FIGS. 7 and 7A show curves representing outputs from an exemplary imaging cell read by known electrical readout techniques and read by the optical readout technique of the invention, respectively.

In one exemplary embodiment of the invention, as can be seen in FIG. 1, a substrate 10 carries a plurality of adjacent MNOS imaging chips 11 formed therein, each of said chips being utilized for storing a separate image as explained in more detail below. In a particular embodiment the substrate 10 may be circular in its plan view with adjacent chips 11 arranged near the outer periphery thereof. The substrate can then be mechanically rotated, for example, so that each chip can be sequentially placed in the focal plane of an optical imaging system. Alternatively, imaging chips may be arrayed in rows and columns on a rectangular substrate, for example, and a bidirectional (X-Y) drive circuit can be used to place the chips in the focal plane of an optical imaging system so as to more efficiently utilize all portions of the substrate.

In accordance with a preferred embodiment of the invention, each of the chips may be formed of metal-nitride-oxide-silicon (MNOS) cells which are formed in a suitable array thereof on each chip. Such cells may be formed in rows and columns on each chip, for example, each cell representing a pixel of the overall image stored on the chip.

MNOS cells of the type proposed for use in the invention have been described in U.S. Pat. No. 4,313,178, issued on Jan. 26, 1982 to E. Stern et al. Briefly, as described in such patent, an MNOS cell is a solid state device which is capable of providing long-term storage of analog signals. Thus, input analog signals (e.g., optical images) can effectively be permanently stored in the array of MNOS cells for subsequent readout and processing. In such MNOS devices analog signals can be stored for time periods up to several days and even a week or more in contrast to storage time of about 100 milliseconds, or less, with CCD devices.

An exemplary chip, for example, is formed as an array of rows and columns of MNOS cells **13** as shown in FIG. 2. In contrast with the use of arrays of charge-coupled devices (CCDs) a minimum of two electrical leads are required for operation of the MNOS cells. One electrical contact provides an appropriate excitation voltage (V) while the other provides an effective ground contact to the cells as can be seen more clearly in FIG. 3 discussed below. The voltage may be applied to each of the cells via an optically transparent, electrically conductive electrode layer which may be formed of a very thin layer of metal (e.g., chromium) or a layer of electrically conductive polysilicon on the upper surface of the chip. The transparent electrode layers of each of the chips of the substrate can be appropriately interconnected to each other and thence to an electrical contact terminal suitably placed on one surface of the substrate **10**. Such contact can be connected to a suitable voltage source (not shown in FIG. 2 but shown in FIG. 3, for example). A ground contact can also be formed on the opposite surface of the chips and interconnected on the substrate in contact with the lower surface of each of the MNOS cells and connected via a suitable terminal to electrical ground, (not shown in FIG. 2 but shown in FIG. 3, for example). To provide a practical idea of the chip dimensions, for example, in the exemplary embodiment depicted in FIG. 3 the chips can be 1.0 cm. square, each of the solid state cells being about 10 micrometers square.

FIG. 3 shows in diagrammatic (and idealized) form a pair of exemplary adjacent MNOS cells **13**, the metal contact terminal **15** providing a voltage V which is supplied to an electrode layer **14** associated with the cells. The electrode layer is in turn in contact with a nitride layer **17** which is above an oxide layer **18** which is above a silicon layer **19** (e.g. a p-type silicon) to form an MNOS image storage cell, as discussed in detail in the above-mentioned Stern et al. patent. Suitable P+ channel stop regions **19'** can be formed in the silicon layer between cells in order to isolate the cells and to prevent migration of charges between cells as discussed in the Stern et al. patent. The silicon layer is shown as p-type although operation with n-type silicon is possible. While the device in the patent utilizes a chromium-gold electrode **14**, such electrode layer may also be in the form of a transparent electrode layer of electrically conductive polysilicon material, the thickness thereof being designed to pass a selected primary color for use in storing color images. Color images may also be formed by the use of a color filter mask which passes the primary colors to appropriate groups of storage cells or by the use of separate chips for each primary color. A suitable ground connection **20** is made to the silicon layer.

The process for storing photocarriers so as to store a representation of an image is described in detail in the Stern et al. patent. Briefly, the positive potential (+V) applied to each electrode layer depletes the region beneath the electrode of majority carriers. Input image light, as from a scene, for example, is permitted to fall on the overall MNOS chip array (FIG. 3) and photons absorbed in the depleted region of each cell create pairs of photo-carriers. The holes are swept into the bulk material and the electrons accumulate beneath the surface, causing the electric field in the oxide layer to increase and consequently causing the electrons to tunnel through the oxide layer into the trap sites shown within the nitride layer near the oxide-nitride interface where they can remain for a relatively long period of time. Accordingly, an image of the scene is effectively stored on a substantially permanent basis in the solid state dual dielectric structure. Such storage process is essentially a solid state equivalent of a photographic film.

Once an image has been so stored, the image can be optically read out in accordance with the invention by the use of an optical (light) beam (e.g., such as supplied by a flying spot scanner) as illustrated in FIG. 4, in contrast with the electrical read-out technique disclosed in the Stern et al. patent. The positive potential(+V) is applied as in the imaging storage process. As indicated in the Stern et al. patent, and as illustrated diagrammatically in the figures, the depth of the depleted region is inversely proportional to the stored charge (i.e., the lower the charge in the stored image the larger the depletion depth).

In accordance with the invention, it has been found that when the readout light beam, e.g., light from the scanner, falls upon a particular cell, photocarriers are created, as in the storage process, and the so generated electrons accumulate at the surface and screen the silicon substrate from the applied potential, thereby causing the depleted region to collapse. Blue light is preferred for this purpose as it is absorbed at a shallower depth and causes less discharge of adjacent cells. The intensity of the readout beam is of little importance as long as it is of sufficient intensity to completely discharge any cell, regardless of the stored charge, within the allotted dwell time. Collapse of a depleted region causes charge to flow into the base electrode in order to neutralize the acceptors in the collapsed depleted region. Accordingly, a read-out signal is now available at the output electrodes **21**, the signal being inversely proportional to the charge due to the image portion stored in each cell. The output signal from each cell can be supplied to an integrator to produce an output which is linearly related to the total charge (i.e., the image intensity) in each cell. Suitable electrical integrator circuitry therefor is shown in FIG. 6 and is of essentially a well-known design. Such signal can then be utilized in a variety of ways in order to recreate the stored image. For example, the signal can be stored on a magnetic disk or tape and later supplied to a cathode ray tube or television imaging tube via appropriate circuitry or it can be used to produce hard copy images (prints).

After a time period on the order of 10 to 1000 milliseconds, dark currents in the MNOS chip cause significant collapse of the depletion layers. At this time the readout process may be halted temporarily, a negative pulse used to discharge the accumulated dark currents, and then the positive potential restored and readout resumed.

Such process and structure represents a novel imaging storage and readout technique in that it utilizes optical addressing of the stored image via, for example, an optical spot scanning beam in order to provide a charge from the electrically stored information which has been stored on a long term basis within each imaging cell. The electrical output which is obtained from such optical addressing process is linearly related to the stored input and can be used to provide a re-creation of the image in any of several well-known ways. Because the long term storage elements are of the type shown by the long-term MNOS image storage cells, for example, rather than short-term CCD storage elements suggested in prior image storage processes, this relatively slow optically-addressed readout method may be used. Only two electrical connections are required for each cell, the leads from each of the cells being appropriately interconnected as shown in FIG. 3, for example, so that only two electrical leads need to be utilized for the overall array of the chips. Furthermore, the patterns on the chip surface are few and simple. Such structure can be contrasted with a device using the CCDs which requires electrical readout techniques in which a larger number of separate leads and more numerous and complex patterns of metals, dielectrics, and doped regions are required for each chip in order to implement the more rapid signal readout with the complex switching and shifting operations utilized therein. The large number of metal lines required in such latter devices prevents the use of closely spaced CCD elements so that the density thereof, and the overall imaging resolution, is relatively low. In the invention, however, because of the need for only two electrical leads and simple patterns for each cell, the cells can be placed much closer together, the resulting high cell density on each chip providing an ultimate image which has much higher resolution.

It will be evident to those skilled in the art that the optically addressed output technique described may suffer to some extent from a degraded signal-to-noise ratio. Specifically, (1) dark current is collected from the entire chip, and (2) the large output capacitance reduces the signal energy with respect to thermal noise energy. If necessary for a given implementation, a compromise may be struck between noise performance and chip simplicity by dividing the chip area into rows, each of which is addressed sequentially during readout. Row address may be achieved electrically using field-effect-transistors (FETs) and associated decoding circuitry or optically using optoelectronic switches and a second readout beam. Pixel (or column) address is as described above.

As discussed above, MNOS devices can store images for relatively long periods of time, e.g., for several days or more. Other devices which are being developed can also be used. For example, floating gate devices as described in the article, R. S. Withers et al., "Nonvolatile Analog Memory: Floating-Gate Devices," *Solid State Research Quarterly Technical Summary*, Aug. 1 to Oct. 31, 1982, Lincoln Laboratory, M.I.T., ESD-TR-82-105, Nov. 15, 1982, pp 75–77, can also provide long term storage up to several weeks and even up to many months or more and can be optically addressed for read-out purposes. Accordingly, any suitable device for providing storage over an extended period of time which, as used herein, can mean a period of time ranging from several seconds to several months or more, can be used in the invention.

FIGS. 5 and 5A depict in diagrammatic form exemplary embodiments of an arrangement of elements required in exemplary solid state camera and readout devices, respectively, made in accordance with the invention. As can be seen therein, a camera enclosure **25** has an appropriate shutter mechanism **26** which supplies an image of an object via a suitable lens system **27** to an MNOS imaging storage chip array **28**. A suitable power supply **29** supplies the desired voltage V. During the image storage operation when the shutter is open an image of the object is stored in an MNOS chip of the overall array thereof. The array of chips can be removed from the camera enclosure following storage of all the images thereon and placed in a separate read-out device which provides for the optical addressing and read-out of the images stored therein.

During the read-out operation, for example, an appropriate optical read-out illuminator **31** utilizing a light source and deflector to provide suitable flying spot scanning operation, the structure of which would be well known to those in the art, supplies a light beam **32** which is used to scan, i.e. to optically address, each of the MNOS chips of the array **28** for readout purposes. The output electrical signal **32** which results can then be utilized in whatever manner is desired, e.g., for storage on a video disk or tape, for supply to the image display circuitry of a cathode ray tube or for use in providing a hard copy of the image. The MNOS chip may be electrically erased, as described in the above Stern et al. patent, and reused. In FIG. 5A the signal **32** can be suitably processed via signal processor circuitry **33**, in accordance with techniques well known to the art, to format the output into a standard video output signal format, for example. Appropriate and well-known electronic control circuitry **34** is used to coordinate the operation of the light beam source and the MNOS array, as would also be well known to the art.

The function of the optical scanning beam may be relatively inexpensively achieved in a particular embodiment by using the camera optics itself to project a spot from a cathode ray tube onto the MNOS chip to be read out. If the screen **35** of a CRT **36** is placed in the focal plane of the MNOS camera **25**, as shown in FIG. 5B, and if a single bright spot is made, by simple electronic means, to scan in a raster across the screen, a corresponding spot will scan the MNOS chip. The resulting video output signal **38** from the chip, along with appropriate timing information from the CRT drive circuitry **39**, may be supplied to an image storage, image display, or other image reproduction device.

Thus a single optical read-out device can be used with an unlimited number of separate image storage cameras. The read-out device, for example, may be located at a store where the camera user takes the exposed substrate and receives appropriate hard copy prints, for example. Alternatively, each user may have his own separate optical read-out device which permits him to read out the chips at his convenience to provide an optical display thereof on a cathode ray tube (TV tube), for example, or to make his own hard copy prints. In accordance with such embodiments the camera itself can have a very compact structure and can be easy to carry and to use.

The use of an optical light beam for optically addressing each MNOS chip has not been suggested by any previously proposed imaging systems. However, it has been found that such optical addressing technique in accordance with the invention provides accurate read out results comparable to those obtained through the use of previously proposed more complex electrical read-out techniques, as shown by FIGS. 7 and 7A. In FIG. 7, a typical curve is shown demonstrating the relationship between the voltage readout from an MNOS cell utilizing an electrical addressing and readout process as described, for example, in the above Stern et al. patent, as a function of the input image intensity thereto. Such a curve can be obtained for testing purposes, for example, by simulating the image intensity in an MNOS cell in accordance with the number of input optical pulses of light which are applied thereto (i.e., the greater the number of such pulses, the greater the simulated intensity). The output voltage, which is proportional to the charge stored, is shown as a function of different intensities (i.e., different numbers of pulses) applied to the cell.

FIG. 7A shows the output as a function of simulated image intensity (i.e. numbers of pulses) wherein the output represents the integrated current output for the cell when utilizing optical addressing of an optical light beam to read out the stored charge in accordance with the invention. Such process provides a current output as discussed above which is then integrated to produce a voltage output once the entire charge stored therein has been discharged. As can be seen, the curve in FIG. 7A essentially matches the curve in FIG. 7, the scaling of the current integrated output being arbitrary depending on whatever scale factor is used. Thus FIG. 7A shows that the use of an optical scanning beam to address the MNOS cells in order to read out the stored information provides as accurate a representation of the stored charge representing the input image as does the more complex and cumbersome electrical read-out process described in the previously issued Stern et al. patent.

While the particular embodiments of the invention described above represent preferred embodiments thereof, modifications thereof may occur to those in the art within the spirit and scope of the invention. For example, although the camera and read-out devices are described as normally being physically separate units, it may be desirable in some applications to integrate them into a single physical unit in which they are either inseparably constructed or in which they can be separated or joined, as desired. Hence, the invention is not to be construed as limited to the particular embodiments disclosed herein except as defined by the appended claims.

What is claimed is:

1. An optical imaging system comprising

at least one solid state element comprising an electrode, one or more dielectric regions, and one or more semiconductor regions each of which has the same conductivity type and one of which can be depleted of mobile charges, said solid state element further having a plurality of storage cell for storing an optical image as a charge in each of said plurality of storage cells;

means for focusing an optical image on said solid state element, said optical image thereby being stored therein;

means which includes an integrating means for optically scanning said solid state element to read out said stored image so as to provide an electrical output which is linearly related to the total charge in each said storage cell and represents said stored image.

2. An optical imaging system in accordance with claim 1 wherein said system includes

a plurality of said solid solid state elements, each capable of storing an optical image; and further wherein

said focusing means sequentially focuses separate optical images on separate ones of said plurality of solid state elements, said separate optical images thereby being separately stored in said separate ones of said solid state elements; and

said optical scanning means sequentially scans each of said solid state elements to read out the separately stored images therein so as to provide a plurality of electrical outputs each representing one of said separate stored images.

3. An optical imaging system in accordance with claim 1 and further including means responsive to said electrical output for providing a visual reproduction of said optical image.

4. An optical imaging system in accordance with claim 1 and further including

means for storing said electrical output;

means for retrieving said stored electrical output from said storing means; and

means responsive to said retrieved electrical output for providing a visual reproduction of said optical image.

5. An optical imaging system in accordance with claim 1 wherein said solid state element comprises a MNOS chip having a plurality of storage cells.

6. A system in accordance with claim 1 wherein said optical scanning means includes an electron beam scanning means.

7. An optical imaging system in accordance with claim 6 wherein said electron beam scanning means comprises means for providing a scanning electron beam for producing an optical output on the screen of a cathode ray tube and means for focusing said optical output from said cathode ray tube on said at least one solid state element.

8. An optical imaging system in accordance with claim 4 wherein said electrical output storing means is a magnetic storage means.

9. An optical imaging system in accordance with claim 1 wherein said at least one solid state element is capable of storing an optical image for an extended period of time.

10. An optical imaging system in accordance with claim 9 wherein said extended period of time can extend up to many months.

11. An optical imaging system in accordance with claim 1 wherein said optically scanning means includes

means for providing a signal from each said storage cell which is inversely proportional to the charge stored therein; and means, which includes said integrating means, responsive to the signal from each said cell for providing said electrical output.

12. An optical imaging system in accordance with claim 1 wherein said intergrating means is an electrical integrator circuit.

13. An optical imaging system in accordance with claim 1 wherein said optical scanning means is a light scanning means.

14. An optical imaging system in accordance with claim 13 wherein the light from said light scanning means is blue light.

* * * * *

C1421 OR 4,884,132

United States Patent [19]

Morris et al.

[11] **Patent Number:** **4,884,132**

[45] **Date of Patent:** **Nov. 28, 1989**

[54] **PERSONAL SECURITY SYSTEM**

[76] Inventors: **James A. Morris**, P.O. Box 4002, Charlottesville, Va. 22903; **Terry F. Morris**, 1405 Chandler Rd., Huntsville, Ala. 35801; **Frank O. Birdsall**, Rte. 1, Box 16, Afton, Va. 22920

[21] Appl. No.: **291,342**

[22] Filed: **Dec. 28, 1988**

Related U.S. Application Data

[63] Continuation of Ser. No. 934,836, Nov. 25, 1986, abandoned.

[51] Int. Cl.⁴ H04N 7/18

[52] U.S. Cl. **358/93**; 358/108; 358/906; 455/33; 455/100

[58] Field of Search 358/83, 93, 108, 228, 358/224, 161, 229, 211, 134, 213.23, 209, 906; 360/69; 455/33, 53–56, 100; 379/59, 60

[56] **References Cited**

U.S. PATENT DOCUMENTS

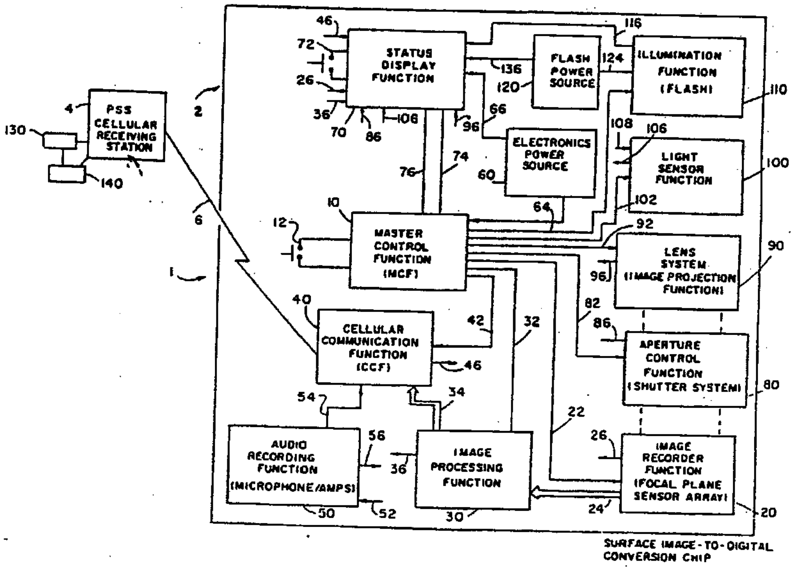
4,083,003	4/1978	Haemming	455/100 X
4,097,893	6/1978	Camras	358/83
4,162,449	7/1979	Bouyssounouse et al.	455/100 X
4,249,206	2/1981	Roscoe	358/108 X
4,293,876	10/1981	Williams	358/108 X
4,317,130	2/1982	Brown	358/108
4,492,978	1/1985	Thomas	358/134
4,511,886	4/1985	Rodriguez	358/108 X
4,516,157	5/1985	Campbell	358/209 X
4,574,319	3/1986	Konishi	358/209 X
4,605,959	8/1986	Colbaugh	358/93
4,606,073	8/1986	Moore	455/100 X
4,630,110	12/1986	Cotton et al.	358/108
4,644,351	2/1987	Zabarsky et al.	455/33 X
4,651,143	3/1987	Yamanaka	358/108 X

Primary Examiner—James J. Groody
Assistant Examiner—Victor R. Kostak
Attorney, Agent, or Firm—James C. Wray

[57] **ABSTRACT**

The personal security system transmits a picture of an object, such as a criminal suspect, and the identification of a portable transmitter, such as the social security number of the user, to a receiver at a remote location. Time of transmission is recorded. If a crime occurs, the time, picture of the suspect, and identification of the victim are obtained from a recorder at the receiver. A potential victim of a crime points his portable personal security unit at a criminal suspect and presses an activating switch. The unit senses available light on the object and provides a flash if required. At the same time focusing an aperture control is performed and an image of the object is admitted to an image recorder which is a focal plane sensor array. Image data from the focal plane sensor array is processed in an image data processor and the processed image data is fed to a cellular communication transmitter for transmitting to the remote receiving station. An audio pickup at the portable unit is connected to the receiver for transmitting voice communications over the transmitter. By pointing the device at a suspect and pressing a button, a person makes a permanent record of an image.

15 Claims, 1 Drawing Sheet



H

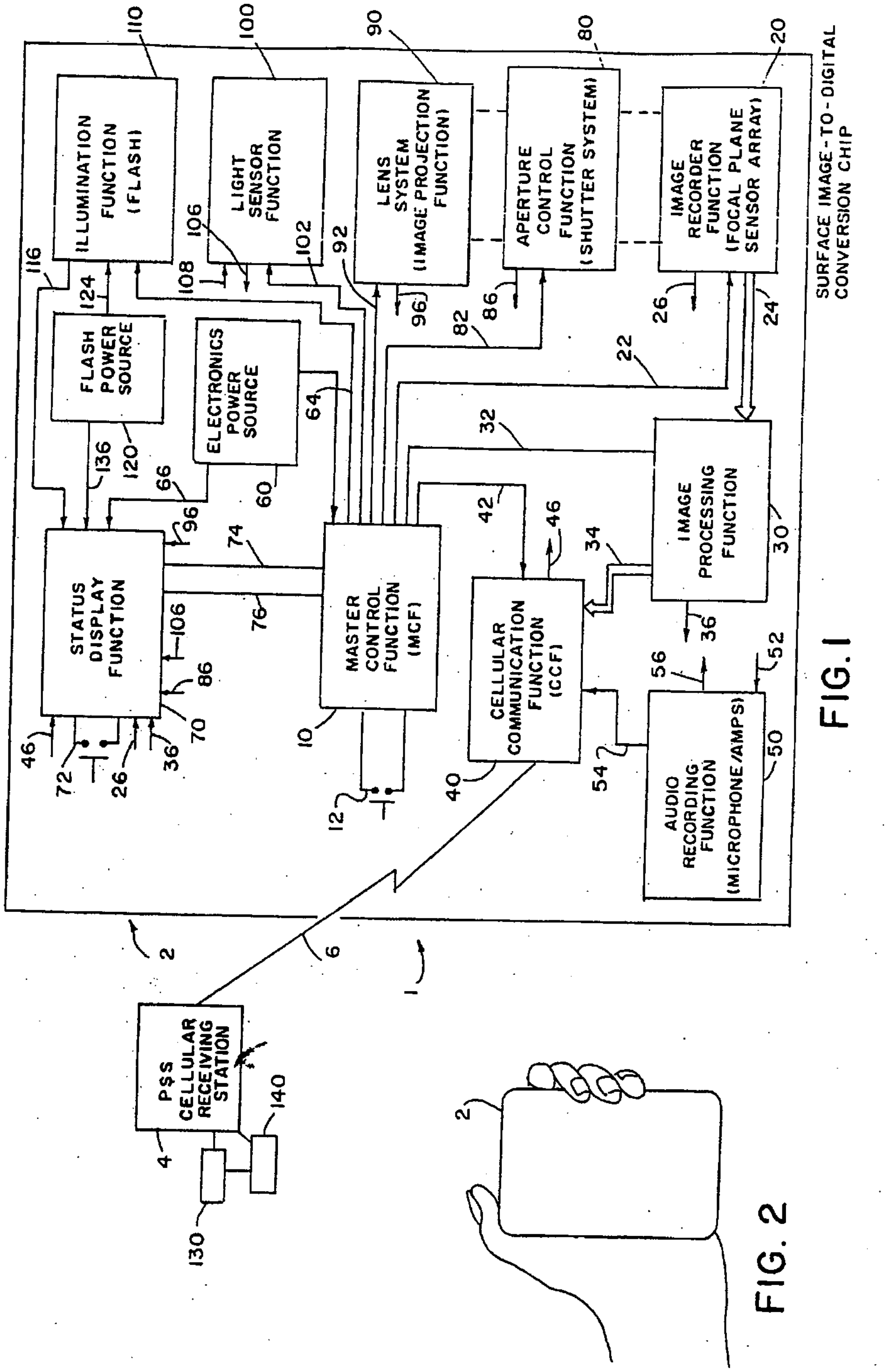

SURFACE IMAGE-TO-DIGITAL CONVERSION CHIP
ILLUMINATION FUNCTION (FLASH)
LIGHT SENSOR FUNCTION
LENS SYSTEM (IMAGE PROJECTION FUNCTION)
APERTURE CONTROL FUNCTION (SHUTTER SYSTEM)
IMAGE RECORDER FUNCTION (FOCAL PLANE SENSOR ARRAY)
FLASH POWER SOURCE
ELECTRONICS POWER SOURCE
IMAGE PROCESSING FUNCTION
STATUS DISPLAY FUNCTION
MASTER CONTROL FUNCTION (MCF)
CELLULAR COMMUNICATION FUNCTION (CCF)
AUDIO RECORDING FUNCTION (MICROPHONE/AMPS)
P$S CELLULAR RECEIVING STATION
110
100
90
80
20
116
124
106
108
102
92
96
86
26
24
82
22
64
136
120
66
60
96
74
32
42
46
34
30
106
76
36
86
70
56
52
46
72
26
36
10
12
40
54
50
2
6
1
4
130
140

FIG. 1

2

FIG. 2

PERSONAL SECURITY SYSTEM

This application is a continuation of application Ser. No. 934,836 filed Nov. 25, 1986, now abandoned.

BACKGROUND OF THE INVENTION

Personal security systems are increasingly in demand. Passive systems which do not directly threaten a suspected potential assailant or place the victim at additional risk are needed. Particularly, passive systems are needed which would record information concerning the potential assailant or the location of a potential crime or victim at the time of the crime. Of particular need is a system which renders the records of the suspected potential criminal and place and time of a crime safe from destruction by a criminal. The present invention provides these needs.

SUMMARY OF THE INVENTION

The personal security system transmits a picture of an object, such as a criminal suspect, and the identification of a portable transmitter, such as the social security number of the user, to a receiver at a remote location. Time of transmission is recorded. If a crime occurs, the time, picture of the suspect, and identification of the victim are obtained from a recorder at the receiver. A potential victim of a crime points his portable personal security unit at a criminal suspect and presses an activating switch. The unit senses available light on the object and provides a flash if required. At the same time focusing an aperture control is performed and an image of the object is admitted to an image recorder which is a focal plane sensor array. Image data from the focal plane sensor array is processed in an image data processor and the processed image data is fed to a cellular communication transmitter for transmitting to the remote receiving station. An audio pickup at the portable unit is connected to the receiver for transmitting voice communications over the transmitter. By pointing the device at a suspect and pressing a button, a person makes a permanent record of an image.

A preferred personal security system has a hand-held unit having a digital image sensor and transmitter for transmitting a digital image and digital information to a remote location.

The preferred personal security system further has an aperture optically aligned with the sensor for permitting an image to pass through to the sensor.

Preferably, the hand-held unit includes a cellular transmitter and the image sensor is a surface image to digital signal conversion chip.

The preferred hand-held unit comprises a start button, a master control function unit connected to the start button, and an electronic power source, an illumination unit, a light sensor unit, a projection lens control unit, an aperture control unit, an image recording unit having a focal plane sensor array, an image processing unit connected to the image recording unit and a cellular communication unit. All of the units are connected to the master control unit and connected to the image processing unit for broadcasting signals from the image processing unit to a distant cellular receiving station.

The preferred personal security system further comprises an audio recording unit connected to the cellular communication unit for providing a digital audio signal to the cellular communication unit.

A status display unit is connected to the master control unit, the status display unit connected to the illumination unit, to the light sensor unit, to the lens unit, to the aperture control unit, and to the image recording unit for displaying status and function of those units. The status display unit is also connected to the image processing unit for displaying status of the image processing unit.

A preferred personal security system has a portable unit having a cellular communication transmitter and a remote unit having a cellular communication receiver. The portable unit further comprises an image recording unit for recording an image of a person or place. An image processing unit connected to the image recording unit converts signals from the image recording unit to signals transmittable by the cellular communication transmitter. A master control unit is connected to the image recording unit and the image processing unit and to the cellular communication transmitter for starting the recording unit and the processing unit and the transmitter.

The portable unit further comprises an aperture control unit mounted adjacent the image recording unit for permitting an image to fall upon the image recording unit.

The preferred portable unit further comprises an illumination source for illuminating an object for image recording and a light sensor unit for sensing illumination of the object of which an image is to be recorded. A power source is connected to the illumination unit and to the light sensor unit, to the aperture control unit and to the image recording unit and to the image processing unit and to the transmitter for providing power thereto.

A personal security system preferably includes the steps of transmitting an image of an object near a portable unit to a remote receiving station and preserving the image of the object and an identification of the portable transmitting unit and time at the receiving station.

The transmitting preferably comprises placing an image of the object upon an image receiving unit, converting an image of the object into electronic signals and transmitting electronic signals containing information signals of the image to the remote receiving station.

The image receiving preferably comprises recording an image on a focal plane sensor array and producing image data from the focal plane sensor array, processing the image data into processed image data signals and transmitting the processed image data signals.

The preferred personal security system further comprises steps of admitting an image of a nearby object to the focal plane sensor array and controlling admission of the image of the object to the focal plane sensor array and focusing the image of the object upon the focal plane sensor array.

An object near the portable unit is illuminated with a flash, and the image on the focal plane sensor array is recorded during the illumination of the object from which the image is formed.

Light level of the object is sensed by the personal security system.

The preferred sensing of the image comprises recording of the image and further comprising the steps of controlling an aperture to the image recorder and controlling a lens focusing system, sensing illumination of an object of which the image is to be recorded and flash illuminating the object upon sensing low light upon the object. Functional readiness is displayed for the image recording, the aperture controlling, the lens controlling, the light sensor, and the flash illumination steps upon pushing a status button. The light sensing, the flash illumination, the lens control, the aperture control, and the image recording function, the image processing function, and the transmitting function operate upon pushing a start button.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a personal security system with schematic showing of elements within a portable hand-held unit and its cellular communication link to a remote cellular receiving station.

FIG. 2 shows that portable hand-held unit 2 in a hand.

DETAILED DESCRIPTION OF THE DRAWINGS

A personal security system is generally indicated by the numeral 1. The system comprises a portable hand-held unit generally indicated by the numeral 2 and a remote cellular receiving station 4 which may be connected by a radio link 6. A master control function unit 10 in the portable unit has a start button 12. The master control function unit is connected to an image recording function unit 20 which is preferably a focal plane sensor array via control line 22. Output of the image recording unit 20 appears on the image data line 24. Line 26 connects the image recording unit to a status display function check. An image processing function unit 30 is connected to the image data line 24 and line 32 from the master control unit starts the image processing unit 30. The image processing unit is preprogrammed with the unit identification, such as the social security number of the owner, and converts the image data from line 24 in a processed digital image data signal on output line 34 which is supplied to the cellular communication function transmitter 40. Line 42 connects the transmitter to the master control unit to provide a start signal and power to the transmitter. An audio recording unit 50 which has a microphone and amplifier is connected to the transmitter 40 by output line 54 by which a digital audio signal is provided to the cellular communication transmitter 40. An input line 52 from the master control unit 10 supplies power and a start signal to the audio unit 50. Electronic power source 60 provides power over line 64 to the master control unit 10 which in turn supplies power to the other units. Line 66 is connected from the power source 60 to a status display 70.

An aperture control unit 80 receives power and start instruction from master control unit 10 over line 82. Line 86 provides status of the aperture control unit to the status display 70.

Lens system unit 90 supplies the image projection function. Power and start control to the lens system 90 are provided from the master control unit 10 over line 92. Line 96 provides a status signal to the status display unit 70. The light sensor unit 100 senses illumination on an object when a start signal is provided over line 102. A status signal of the light sensor is provided over line 106. Power is separately supplied to the light sensor unit from power line 108 from the power source 60.

The flash illumination unit 110 receives a start signal over line 112 from the master control unit 10. Line 116 provides a status check of the flash illumination unit 110 to the status display 70. A flash power source 120 supplies flash power over line 124 to the flash illumination unit 110. Status of the flash power unit is provided over line 126 to the status display unit 70.

Unit 70 has a status check switch 72 and has a status report line 74 and a status request line 76 to and from the master control unit 10. The cellular receiving station 4 has a clock 130 and recorder 140 to record all cellular communications received from all hand-held units 2. One cellular receiving station 4 may support several hand-held units 2.

Power source 60 supplies power to the master control function unit 10. Power also may be supplied from the power source 60 to capacitors in the flash power source 120. Power is also supplied over line 108 to the light sensor function unit 100.

When a status check button 72 is pushed, status report line 74 causes the master control function unit 10 to supply power as needed for checks to the image recorder 20, the image processor 30, the transmitter 40 and the audio system 50 through the power and start lines 22, 32, 42, and 52, respectively. Status signals are provided from those units over lines 26, 36, 46, and 56, respectively. During the status check the master control function unit 10 also energizes the aperture control function unit 80, the lens control system unit 90 and the light sensor function unit 100 over lines 82, 92, and 102, respectively. Status of those units is reported to the status display function unit over lines 86, 96, and 106, respectively. The master control function unit 10 status is reported over line 76 to the status display function. Concurrently line 116 checks the status of illumination function flash unit 110. The status display function unit 70 has go, no go LED lamps for each unit.

The master control function unit requires periodic status display function unit checks via line 76. Unit 70 includes a periodic beeper to indicate malfunction.

We claim:

1. A personal security system comprising a hand-held unit having a digital image sensor, wherein the image sensor comprises a surface image to digital signal conversion chip, a cellular transmitter for transmitting a digital image, a window, wherein the window is optically aligned with the sensor for permitting an image to pass through the window to the sensor, and digital preprogrammed information identifying the hand-held unit to a remote location.

2. The personal security system of claim 1 wherein the portable unit further comprises an aperture control unit mounted adjacent the image recording unit for permitting an image to fall upon a image recording unit.

3. The apparatus of claim 1 wherein the hand-held unit comprises a start button, a master control function unit connected to the start button, an electronic power source connected to the master control unit, an illumination unit connected to the master control unit, a light sensor unit connected to the master control unit, a projection lens control unit connected to the master control unit, an aperture control unit connected to the master control unit, an image recording unit having a focal plane sensor array connected to the master control unit, an image processing unit connected to the master control unit and connected to the image recording unit and a cellular communication unit connected to the master control unit and connected to the image processing unit for broadcasting signals from the image processing unit to a distant cellular receiving station.

4. The personal security system of claim 3 further comprising an audio recording unit connected to the

cellular communication unit for providing a digital audio signal to the cellular communication unit.

5. The personal security system of claim 3 further comprising a status display unit connected to the master control unit, the status display unit connected to the illumination unit, to the light sensor unit, to the lens unit, to the aperture control unit, and to the image recording unit for displaying status and function of those units.

6. The apparatus of claim 5 wherein the status display unit is connected to the image processing unit for displaying status of the image processing unit.

7. A personal security system comprising a portable unit having a cellular communication transmitter and a remote unit having a cellular communication receiver, the portable unit further comprising an image recording unit for recording an image of a person or place and an image processing unit preprogrammed with an identification of the portable unit and connected to the image recording unit for converting signals from the image recording unit to signals transmittable by the cellular communication transmitter and the image processing unit being connected to the cellular communication transmitter, and a master control unit connected to the image recording unit and the image processing unit and to the cellular communication transmitter for starting the recording unit and the processing unit and the transmitter.

8. The personal security system of claim 7 wherein the portable unit further comprises an illumination source for illuminating an object for image recording and a light sensor unit for sensing illumination of the object of which an image is to be recorded and a power source connected to the illumination unit and to the light sensor unit, to the aperture control unit and to the image recording unit and to the image processing unit and to the transmitter for providing power thereto.

9. A personal security system comprising the steps of recording an image of an object near a portable hand-held unit, wherein the image is received by an image recording unit within the portable hand-held unit;

processing the image of the object into electronic signals, wherein the image is processed by an image processing unit within the portable hand-held unit, the image processing unit being preprogrammed with an electronic identification signal unique to the portable hand-held unit;

controlling an aperture to the image recorder;

controlling a lens focusing system, sensing illumination of an object of which the image is to be recorded and flash illuminating the object upon sensing low light upon the object;

transmitting the electronic signals containing information of the image and identification of the unit to a remote receiving station; and

preserving the electronic signal by the remote receiving station, wherein the remote receiving station records the time of day when the electronic signals are received.

10. The personal security system of claim 9 further comprising the steps of displaying functional readiness of the image recording, the aperture controlling, the lens controlling, the light sensor, and the flash illumination steps upon pushing a status button, and starting the light sensing, the flash illumination, the less control, the aperture control, and the image recording function, the image processing function, and the transmitting function upon pushing a start button.

11. The personal security system of a claim 9 wherein the recording comprises recording an image on a focal plane sensor array and producing image data from the focal plane sensor array.

12. The personal security system of claim 11 further comprising admitting an image of a nearby object to the focal plane sensor array and controlling admission of the image of the object to the focal plane sensor array.

13. The method of claim 12 further comprising focusing the image of the object upon the focal plane sensor array.

14. The method of claim 12 further comprising illuminating an object near the portable unit with a flash and recording the image on the focal plane sensor array during the illumination of the object from which the image is formed.

15. The personal security system of claim 14 further comprising sensing light upon the object near the personal security system.

* * * * *

6/26/90 XR 4,937,676

United States Patent [19]

Finelli et al.

[11] **Patent Number: 4,937,676**

[45] **Date of Patent: Jun. 26, 1990**

[54] ELECTRONIC CAMERA SYSTEM WITH DETACHABLE PRINTER

[75] Inventors: **Patrick L. Finelli**, Sudbury; **Hugh R. MacKenzie**, Belmont; **William J. McCune, Jr.**, South Lincoln, all of Mass.

[73] Assignee: **Polariod Corporation**, Cambridge, Mass.

[21] Appl. No.: **308,644**

[22] Filed: **Feb. 10, 1989**

[51] **Int. Cl.⁵** **H04N 5/30**

[52] **U.S. Cl.** **358/229**; 358/906; 358/909

[58] **Field of Search** 358/229, 906, 909; 360/33.1, 35.1; 354/75, 76, 85, 86

[56] **References Cited**

U.S. PATENT DOCUMENTS

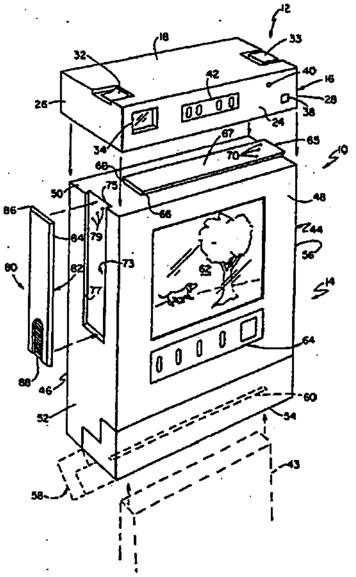
4,097,893	6/1978	Camras	358/83
4,130,834	12/1978	Mender et al.	358/127
4,163,256	7/1979	Adcock	358/127
4,262,301	4/1981	Erlichman	358/6
4,420,773	12/1983	Toyoda et al.	358/335
4,456,931	6/1984	Toyoda et al.	358/335
4,489,351	12/1984	d'Alayer de Costemore d'Arc	358/213
4,507,689	3/1985	Kozuki et al.	360/33.1
4,525,729	6/1985	Agulnek et al.	346/154
4,541,704	9/1985	Freeman	354/432
4,547,815	10/1985	Kimura	358/335
4,827,347	5/1989	Bell	358/224

Primary Examiner—Jin F. Ng
Assistant Examiner—Magdy Shehata
Attorney, Agent, or Firm—Edward S. Roman

[57] ABSTRACT

A compact, handheld portable electronic imaging system including both an electronic imaging camera and hard copy printer are separately housed with respect to each other and readily interconnectable with respect to each other for use either in combination or apart. Means for storing electronic images may be connected to the camera and/or printer housings so that when used apart image defining electronic image information signals may be initially directed for storage by the electronic imaging camera and the storage device thereafter connected to the printer for the making of hard copies therefrom. Alternatively, the electronic imaging camera and printer may be used in combination to provide an immediate hard copy of the image sensed in a manner analogous to that of an instant photographic camera of the self-processing type.

14 Claims, 4 Drawing Sheets



I

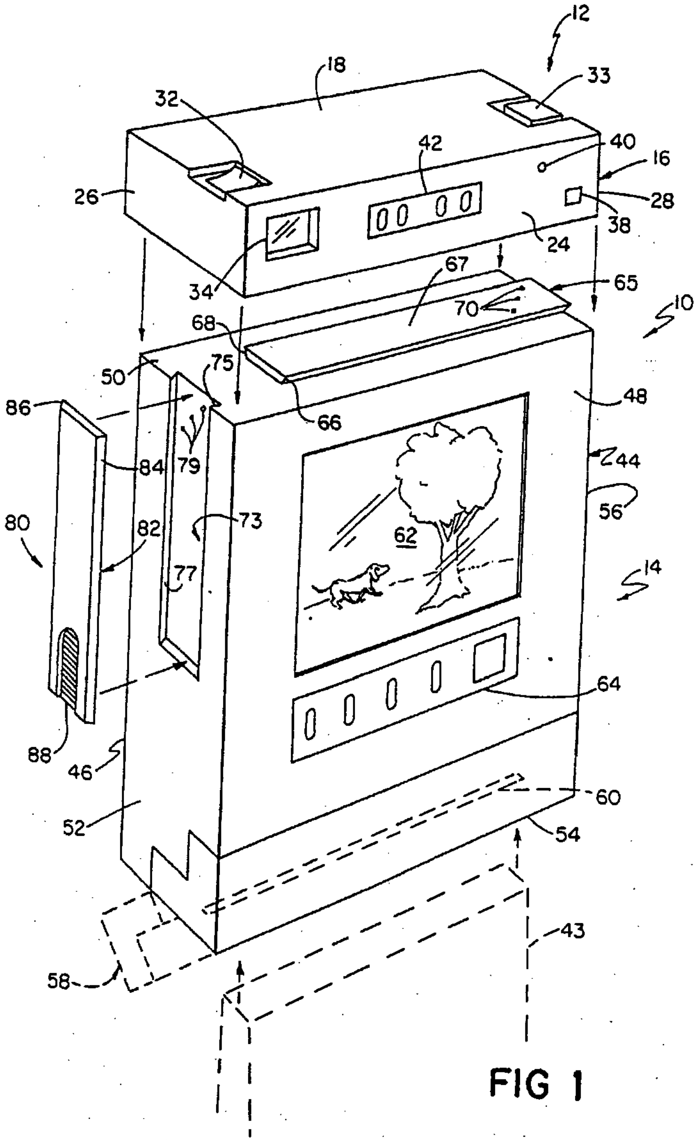

12
18
33
32
42
40
16
26
28
38
24
34
67
65
70
10
68
50
75
66
48
86
84
79
44
80
82
73
56
62
77
14
64
88
46
60
52
54
43
58

FIG 1

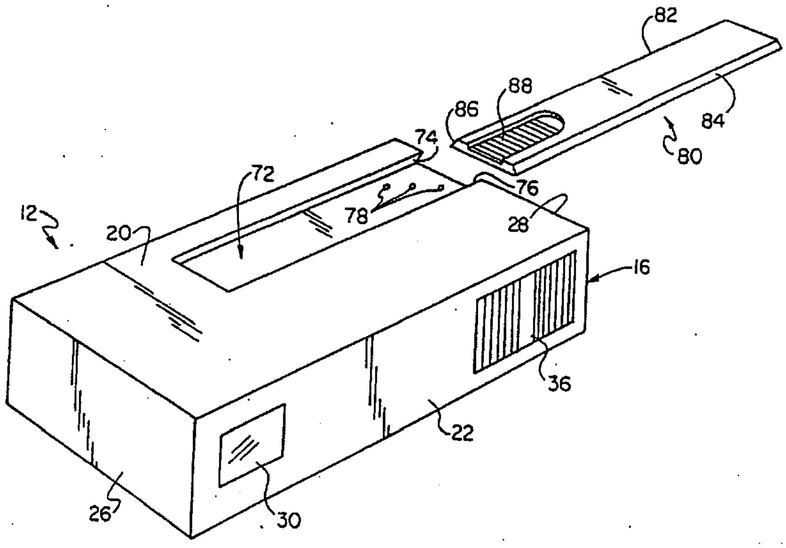


FIG 2

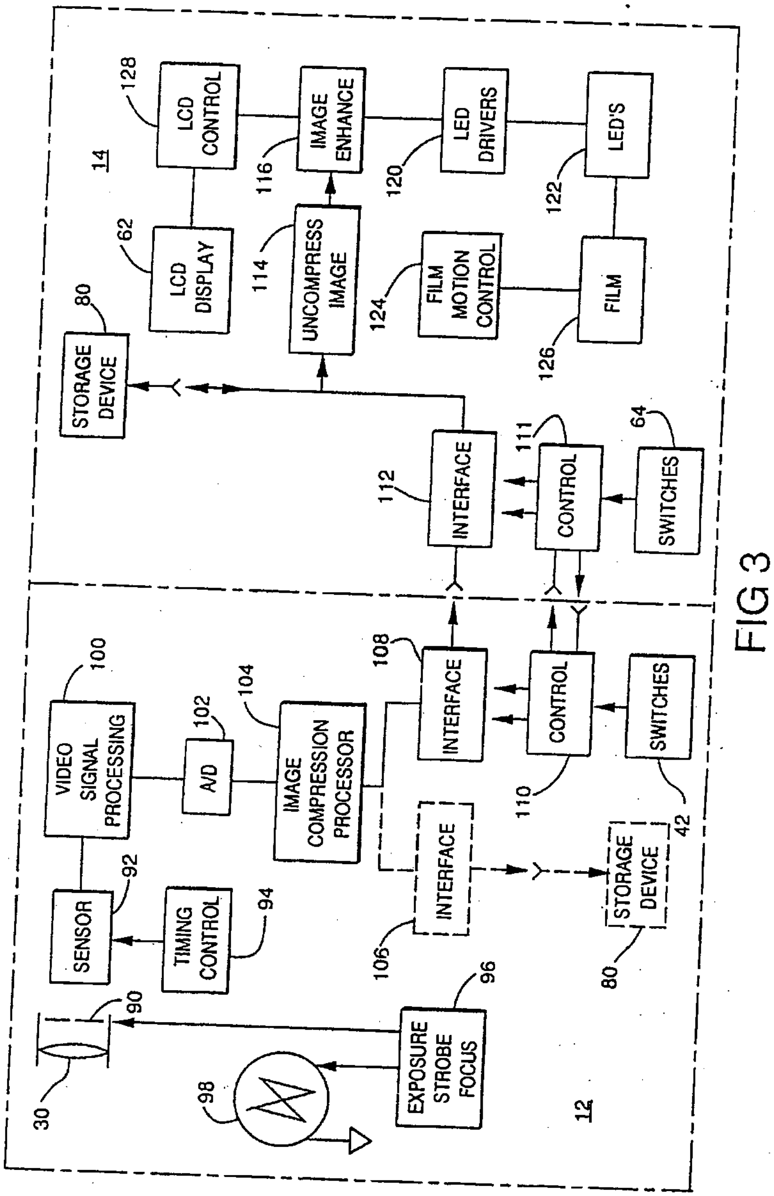

14
128
LCD CONTROL
116
IMAGE ENHANCE
120
LED DRIVERS
122
LED'S
62
LCD DISPLAY
114
UNCOMPRESS IMAGE
124
FILM MOTION CONTROL
126
FILM
80
STORAGE DEVICE
112
INTERFACE
111
CONTROL
64
SWITCHES
100
VIDEO SIGNAL PROCESSING
102
A/D
104
IMAGE COMPRESSION PROCESSOR
108
INTERFACE
110
CONTROL
SWITCHES
42
STORAGE DEVICE
80
INTERFACE
106
92
SENSOR
94
TIMING CONTROL
90
30
96
EXPOSURE STROBE FOCUS
98
12

FIG 3

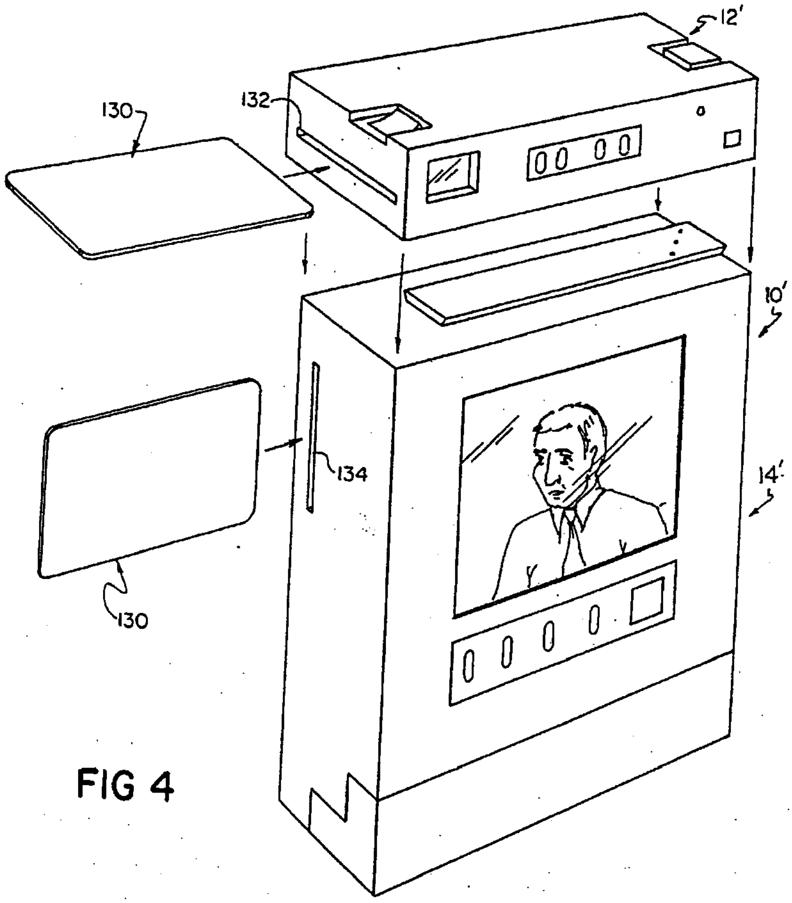


FIG 4

ELECTRONIC CAMERA SYSTEM WITH DETACHABLE PRINTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a readily portable electronic imaging system for use in the field and, more particularly, to an electronic imaging system comprising both a camera and printer separately housed and readily connectable with respect to each other in the field and also readily connectable to an electronic image storage device

2. Description of the Prior Art

Handheld electronic imaging cameras that can electronically record an image of a scene and thereafter print out a hard copy print of the recorded image on a nonphotosensitive image receiving sheet such as that disclosed in U.S. Pat. No. 4,262,301, entitled "Electronic Imaging Camera", by I. Erlichman, issued Apr. 14, 1981, in common assignment herewith, are now known to the art. The electronic camera and printer are built as an integral unit and must both be carried into the field together whenever the camera is used even though the camera user may not actually desire hard copy prints in the field. In addition, a hard copy print of the recorded image is provided by a nonphotographic process onto a nonphotosensitive image receiving sheet. Such printer systems although providing a highly satisfactory copy for many purposes nevertheless do not provide photographic quality hard copy prints.

Therefore, it is a primary object of this invention to provide a compact, handheld electronic imaging system comprising both a camera and printer separately housed and readily interconnectable for selective use either together or apart.

It is a further object of this invention to provide a compact, handheld electronic imaging system comprising an electronic camera and printer usable either apart or in connection with respect to each other wherein the printer can provide a photographic quality hard copy print of the image recorded by the camera.

Other objects of the invention will be, in part, obvious and will, in part, appear hereinafter. The invention accordingly comprises a mechanism and system possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure.

DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with other objects and advantages thereof will be best understood from the following description of the illustrated embodiment when read in connection with the accompanying drawings wherein

FIG. 1 is an exploded perspective view of the electronic imaging system of this invention;

FIG. 2 is a perspective view of the electronic imaging camera and image storage portions of the electronic imaging system of FIG. 1;

FIG. 3 is a circuit block diagram of the electronic imaging system of FIG. 1; and

FIG. 4 is an exploded perspective view for an alternate embodiment of the electronic imaging system of FIG. 1.

SUMMARY OF THE INVENTION

A readily portable electronic imaging system for use in the field comprises a camera housing of a size that may be conveniently carried by hand and a printer housing distinct from the camera housing that is also of a size that may be conveniently carried by hand. An objective lens is operatively disposed with respect to the camera housing to receive and focus incident light defining scene light. A solid state light responsive array is disposed within the camera housing for receiving incident scene light by way of the objective lens and converting the scene light into an image defining electronic information signal. Means for storing the image defining electronic information signals are provided for releasable and operative connection to the camera and printer housings.

Complementary releasable connecting means operatively associated with respect to the camera and printer housings are provided for effecting a releasable fixed connection between the camera and printer housings. The fixed connection also operates to effect an electrical connection between the camera and printer housings. Hard copy printing means are disposed within the printer housing for making a hard copy of select images from the image defining electronic information signals.

Signal control and processing means have portions thereof disposed respectively within the camera and printer housings. The signal control and processing means responds to user selection to effect an exposure interval and thereafter process the image defining electronic information signals to effect a select transformation thereof. The signal control means thereafter responds to user selection to direct the transformed electronic information signals to either the storage means for storage therein or to the hard copy printing means for printing the hard copy. The portion of the signal control and processing means disposed within the printer housing is responsive to user selection when the printer housing is disconnected from the camera housing and the storage means is operatively connected to the printer housing for directing image defining electronic information signals from the storage means to the hard copy printing means in order to print hard copies of select stored images. In addition, the portion of the signal control means disposed within the camera housing is responsive to user selection when the camera housing is disconnected from the printer housing and the storage means is operatively connected to the camera housing for directing image defining electronic information signals from the light responsive array to the storage means immediately subsequent to the exposure interval.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown at **10** the electronic imaging system of this invention comprising an electronic imaging camera **12** and a hard copy printer **14**. The electronic imaging camera **12** comprises a substantially parallelepiped housing structure **16** defined by a substantially planar major top wall member **18** spaced apart in parallel relation to a substantially planar major bottom wall member **20** as best viewed in FIG. **2**. The top and bottom wall members **18** and **20** are interconnected by substantially planar parallel front and back wall members 22 and 24 and substantially parallel planar side wall members 26 and 28. The front wall 22 of the camera housing 16 contains an opening for admitting scene light to an objective lens 30 disposed therein. The wall 22 also contains an electronic strobe discharge window 36 through which artificial light is provided to illuminate a scene in a well-known manner. The objective lens 30 may include a manually actuable telephoto feature as is well known in the art actuable by way of a user select button 32 disposed on the top wall member 18. Use of the electronic strobe built into the camera 12 may be commenced at the discretion of the user upon the actuation of a strobe select charge switch 38 disposed on the back wall member 24. Complete charging of the electronic strobe is signified by the turning on of a strobe ready light 40 also preferably disposed on the back wall member 24. The back wall 24 of the electronic imaging camera 12 also preferably comprises a control panel 42 having a plurality of user actuatable switches that operate in the manner of this invention to be subsequently described. The camera housing is of a size that can be easily held by hand and is readily portable for field use.

The printer housing 44 comprises a substantially planar major bottom wall member 46 spaced apart in parallel relation to a substantially planar major top wall member 48. The wall members 46, 48 are described as bottom and top wall members despite their showing in FIG. 1 in an upstanding position for reasons that will become more fully appreciated by the following discussion. The wall members 46, 48 are interconnected by substantially planar minor side wall members 50, 52, 54, 56 to form a parallelepiped structure as shown. The side wall member 54 forms the major portion of a pivotal door assembly as shown in phantom at 58 in its open position to accommodate the insertion of a film cassette 43 comprising a stack of integral self-developing film units of a type manufactured by the Polaroid Corporation and well known in the art. Side wall member 54 in the pivotal door assembly 58 includes a film exit slot 60 to accommodate the exit of individual ones of the integral self-developing film units as they are exposed by the hard copy printer 14 in a manner as will be more fully described herein. The wall member 48 includes a liquid crystal display panel 62 for displaying recorded images in the manner of this invention. The wall member 48 is also provided with a control panel 64 comprising a plurality of user actuatable switches which can be operated in the manner of this invention to be subsequently described. The printer housing 44 is also of a size that can be easily held by hand and is also readily portable for field use even when connected to the camera housing in the manner of this invention.

Complementary releasable connecting means operatively associated with respect to the camera and printer housings 16, 44 are provided for effecting a releasable fixed connection between the camera and the printer housings so that both the electronic imaging camera 12 and the hard copy printer 14 can be operated together in the manner of this invention. The releasable connecting means preferably comprises a raised elongated tongue member 65 extending outwardly from the side wall member 50 and comprising a pair of spaced apart substantially parallel beveled side walls 66 and 68. The tongue member 65 also comprises a substantially planar top surface portion 67 upon which are disposed a plurality of electrical contacts as shown at 70.

That portion of the releasable connecting means operatively associated with the electronic camera 12 is best shown in FIG. 2 as comprising an elongated recessed groove 72 having substantially parallel bevelled side walls 74, 76. Within the groove 72 there are provided a plurality of electrical contacts as shown at 78. Physical and electrical interconnection between the camera housing 16 and the printer housing 44 is effected by longitudinally sliding the elongated tongue member 65 of the printer housing 44 into the recessed groove 72 in the camera housing 16. As is readily apparent the bevelled side walls 66, 68 of the raised tongue member 65 engage the complimentary bevelled side walls 74, 76, respectively, to maintain the camera and printer housings 16, 44 in fixed connection with respect to each other. In addition, electrical connection is established between the camera and printer housings 16, 44 by the electrical contacts 70 engaging respective corresponding ones of the electrical contacts 78. It will be readily understood that the sliding motion of the electrical contacts 70, 78 over each other which occurs in concert with the sliding movement of the complementary tongue and groove members during camera and printer connection and disconnection respectively operates to wipe clean the electrical contacts thereby insuring a reliable positive electrical connection each time the camera and printer are connected.

The electronic imaging system 10 of this invention further includes an electronic information storage device 80 housed in an elongated substantially parallelepiped housing 82. The information storage device 80 preferably comprises a solid state memory such as an electronically programmable read only memory (EPROM) as fully disclosed in U.S. patent application Ser. No. 102,859, entitled "Electronic Imaging Camera Utilizing EPROM Memory", by David D. Pape, filed in common assignment herewith. The elongated housing 82 of the storage device 80 includes spaced apart substantially parallel bevelled side walls as shown at 84, 86 to accommodate its retention upon insertion into the recessed groove member 72 of the camera 12. As is now readily apparent, the bevelled side walls 86, 84 engage corresponding bevelled side walls 74, 76 respectively of the recessed groove 72 so as to be fixedly connected with respect to the camera housing 16 in the same manner by which the printer housing 44 can be physically connected to the camera housing 16. Also, as will be readily understood, the information storage device 80 also comprises a plurality of electrical contacts (not shown) that make corresponding electrical connection to the plurality of electrical contacts 78 in the recessed groove 72.

The side wall member 52 of the printer housing 44 also includes an elongated recessed groove as shown at 73 defined by two substantially parallel bevelled side walls 75 and 77. A plurality of electrical connectors 79 are also disposed on the face of the groove 73. The information storage device 80 may also be inserted in the aforementioned manner into the recessed groove 73 in the side wall 52 of the printer housing 44 to establish a fixed structural connection therebetween. As is readily apparent, the plurality of electrical contacts (not shown) on the storage device 80 connect to respective ones of the electrical contacts 79 in the aforementioned manner so as to also establish an electrical connection from the hard copy printer 14 to the storage device 80 for reasons which will become more apparent from the following discussion. The information storage device 80 includes a recessed area as shown at 88 in order to enable the camera user to better engage the storage device during insertion into or removal from the recessed grooves in either the camera or printer housings.

Referring now to FIG. 3, there is shown a circuit block diagram for the electronic imaging system 10 of this invention. The electronic imaging camera 12 comprises the objective taking lens 30 for viewing the scene to be electronically recorded and directing the image defining scene light rays to a two-dimensional photoresponsive area array as shown at 92 preferably comprising a high resolution charge coupled device (CCD) or alternatively a charge injection device (CID). The photoresponsive array 92 comprises a plurality of image sensing elements or pixels arranged in a two dimensional area array wherein each image sensing pixel converts the incident image defining scene light rays into a corresponding analog voltage value. The transmission of scene light by way of the objective taking lens 30 to the photoresponsive array 92 is controlled by a shutter as shown at 90. The duration of each still image exposure interval is controlled in a conventional manner by way of an exposure, strobe, and focus control circuit 96. As is readily apparent, the circuit 96 may also operate to automatically control the focus of the objective taking lens 30 in any well-known manner such as by way of sonar or infrared rangefinders. In addition, the control circuit 96 also operates to effect the discharge of an electronic strobe flashtube 98 at the precise moment during the exposure interval.

After the exposure interval, the analog values of the individual pixels of the photoresponsive array 92 are transferred out in a conventional manner by timing clock pulses provided from a timing and control circuit 94. The electronic information signals output from the photoresponsive array 92 are serially transferred to a video signal processing circuit 100 in which the electronic information signals are amplified and filtered in a well-known manner. In addition, a black or dark current reference voltage may also be clamped to a select reference voltage level in a manner as is well known in the art. The electronic information output signals from the video signal processing circuit 100 are thereafter directed to an analog-to-digital converter 102 for conversion from an analog format to a digital format again in a manner as is well known in the art. The digitally formatted electronic information signals are thereafter directed to an image compression processor circuit 104 for compression again in any well-known manner.

The above-described exposure interval may be effected in the field with the electronic imaging camera 12 connected to the hard copy printer 14 in the manner as previously described. In this case, processed, digitally formatted, and compressed electronic image information signals are directed to a printer interface 108 for transmission by way of the electrical contacts 78 and 70 to the hard copy printer 14. Alternatively, the above-described exposure interval could be implemented in the field by the electronic imaging camera 12 without connection to the hard copy printer 14 in which case the storage device 80 would be inserted within the recessed groove 72 of the camera housing 16 and the processed, digitally formatted, and compressed electronic image information signals directed by way of the interface 108 for storage in the storage device 80.

In the case where the electronic imaging camera 12 and hard copy printer 14 are interconnected then it will be understood that the storage device 80 is inserted into the recessed groove 73 in the above-described manner for connection to the hard copy printer 14. Thus, the processed, digitally formatted, and compressed electronic image information signals provided from the electronic imaging camera 12 by way of the interface 108 may be directed by way of another interface 112 in the printer housing 44 for storage in the storage device 80. Alternatively, and at the camera user's discretion by way of appropriately actuated switches on the control panel 64 there is provided an appropriate signal from a control circuit 111 to direct the electronic image information signals received from the electronic camera 12 to a circuit 114 for uncompressing the previously compressed electronic image information signals.

The uncompressed electronic image information signals are thereafter directed to an image enhancement circuit 116 whereby the electronic image information signals may be enhanced in a well-known manner as more fully described in U.S. Pat. No. 4,783,840, entitled "Method for Enhancing Image Data By Noise Reduction or Sharpening", by Woo-Jin Song, issued Nov. 8, 1988, U.S. Pat. No. 4,779,142, entitled "System and Method For Electronically Recording and Playing Back Video Images With Improved Chrominance Characteristics Using Alternate Even and Odd Chrominance Signal Line Matrix Encoding", by William T. Freeman et al., issued Oct. 18, 1988, or U.S. Pat. No. 4,774,565, entitled "Method and Apparatus For Reconstructing Missing Color Samples", by William T. Freeman, issued Sept. 27, 1988, all in common assignment herewith and now all incorporated by reference herein. The enhanced electronic image information signals may thereafter be directed by way of a liquid crystal display (LCD) control circuit 128 to the liquid crystal display 62 on the hard copy printer 14. When the electronic image information signals are stored in the storage device 80, they may be continuously recalled by way of the uncompression circuit 114, image enhancement circuit 116 and LCD control circuit 128 to continuously refresh the LCD 62 and provide a continuing still image of the scene previously sensed by the camera 12 and stored in the storage device 80.

Electronic image information signals may also be simultaneously directed from the image enhancement circuit 116 to a light emitting diode (LED) driving circuit 120 which, in turn, provides the appropriate drive signals to a plurality of light emitting diode (LED) arrays 122 which, in turn, expose a photographic film unit 126 of the self-processing type. The film unit 126 is advanced past the light exposing diodes 122 by appropriate drive rollers rotatably driven by a motor (not shown) under the control of a film motion and control circuit 124. The LED drivers 120 control the energization of the LED's 122 in a manner as is fully described in U.S. Pat. No. 4,525,729, entitled "Parallel LED Exposure Control System", by Martin Agulnek et al., issued Jnne 25, 1985, in common assignment herewith, and now incorporated by reference herein. The film processing rollers ultimately advance the film unit 126 out of the film printer housing 44 by way of the exit slot 60 in a manner as is well known in the art. Thus, in this manner there can be provided an immediate hard copy of the scene sensed during the above-described exposure interval.

The camera user by actuating the appropriate switches in either the printer control panel 64 and/or the electronic camera control panel 42 while still in the field can provide the appropriate control signals by way of control circuits 111 and 110, respectively, to effect any one of a combination of the aforementioned functions. For instance, the camera user can direct the electronic information signals for each scene for storage in the storage device 80. The electronic image information signals can then be recalled for display on the LCD 62 to determine what images are to be transformed into hard copy. The camera user can have the further option of storing none of the electronic image information signals in the storage device 80 but instead directing the signals to provide immediate hard copies in the manner as now provided by conventional instant photographic cameras of the type manufactured and sold by Polaroid Corporation. Alternatively, the user may decide not to print any hard copies in the field at all but instead direct all the images for storage in the storage device 80. He can then disconnect the electronic imaging camera 12 from the printer 14 and take the printer to any convenient place, i.e., office, home, etc., where he can proceed to retrieve the previously recorded images from the storage device 80 for viewing on the LCD 62 and printing of selected images at his discretion. Once the printer 14 is disconnected from the electronic camera 12, it will rest on its major bottom wall member 46 with its LCD display 62 facing upwardly for convenient viewing.

Alternatively, the electronic imaging camera 12 may be taken into the field with its storage device 80 attached instead of the printer 14 for more convenient carrying and handling. The electronic imaging camera 12 with the storage device 80 connected in the aforementioned manner can then be utilized to record a plurality of scenes which are ultimately stored in the storage device 80. The storage device 80 may thereafter be removed from the camera housing 16 and connected to the printer housing 44 in the aforementioned manner whereupon the user can selectively view and print images previously recorded by the camera. Thus, in this manner there is provided an electronic imaging system having tremendous versatility and capability by providing immediate hard copies in the field or alternatively permitting the recording of images electronically in the field with a small compact camera and the subsequent selective viewing and printing of such recorded images in the comfort of the user's home.

Although the storage device has been described as residing in an elongated housing that can be conveniently attached to the camera housing 16 in the same manner and place by which the printer housing 44 is connected to the camera housing, it will be readily understood that the electronic information storage device may assume a variety of shapes and sizes such as a rectangular card 130 that may be inserted into corresponding slots 132, 134 in the camera and printer housings as shown in FIG. 4. In this instance, as is readily apparent, a second interface must be provided in the electronic imaging camera 12 as shown in phantom line at 106 in FIG. 3 to connect to the storage device 80 as also shown in phantom line. In the case where the camera user operates the system with the camera and printer connected, he may then have the option by way of actuating appropriate switches of the control panel 42 to direct the electronic image information signals for either storage in the storage device 130 by way of the interface 106 or to the printer 14 by way of the interface 108. Also, it should be readily understood that the storage device 130 could alternatively be an optical storage card with the camera and printer having appropriate read/write drivers associated therewith.

Other embodiments of the invention, including additions, subtractions, deletions and other modifications of the preferred disclosed embodiments of the invention will be obvious to those skilled in the art and are within the scope of the following claims.

What is claimed is:

1. A readily portable electronic imaging system comprising:

a camera housing of a size that is conveniently carried by hand;

a printer housing distinct from said camera housing and also of a size that is conveniently carried by hand;

an objective lens operatively disposed with respect to said camera housing to receive and focus incident image defining scene light;

a solid state light responsive array disposed within said camera housing for receiving incident scene light by way of said objective lens and converting such scene light into an image defining electronic information signal;

storage means releasably and operatively connectable to said camera and printer housings for storing the image defining electronic information signals;

complimentary releasable connecting means operatively associated with respect to said camera and printer housings for effecting a releasable fixed connection between said camera and printer housings, said fixed connection also operating to effect an electrical connection between said camera and printer housings;

hard copy printing means disposed within said printer housing for making a hard copy of select images from said image defining electronic information signals; and

signal control and processing means having portions disposed respectively within said camera and printer housings and responsive to user selection for effecting an exposure interval and thereafter processing said image defining electronic information signal to effect a select transformation thereof, said control means thereafter responding to user selection for directing said transformed electronic information signals to either said storage means for storage therein or said hard copy printing means for printing said hard copy wherein said portion of said signal control and processing means disposed within said printer housing is responsive to user selection when said printer housing is disconnected from said camera housing and said storage means is operatively connected to said printer housing for directing image defining electronic information signals from said storage means to said hard copy printing means in order to print hard copies of select images.

2. The system of claim 1 wherein said portion of said signal control and processing means disposed within said camera housing is responsive to user selection when said camera housing is disconnected from said printer housing and said storage means is operatively connected to said camera housing for directing image defining electronic information signals from said light responsive array to said storage means immediately subsequent to each exposure interval.

3. The system of claim 2 wherein said storage means comprises a housing having a releasable connecting

means for releasably connecting to that portion of said complimentary connecting means operatively associated with said camera housing.

4. The system of claim 3 wherein said printer housing has another releasable connecting means spaced apart from the portion of said complimentary connecting means associated with said printer housing for connecting said printer housing to said camera housing, for connecting to said releasable connecting means associated with said storage means housing.

5. The system of claim 4 wherein said releasable connecting means for effecting releasable connections between: said camera and printer housings, said camera housing and said storage means and said printer housing and said storage means comprises tongue and groove connecting members which slidably interconnect.

6. The system of claim 5 wherein said tongue and groove connecting members each comprise complimentary electrical connectors which slide over each other during the sliding movement of said tongue and groove connecting members so as to wipe clean said electrical connectors.

7. The system of claim 2 wherein said storage device comprises a solid state memory device.

8. The system of claim 2 wherein said storage copy printing means includes means for exposing a photosensitive photographic film of the self-developing type.

9. A readily portable electronic imaging system comprising:

a camera housing of a size that is conveniently carried by hand;

a printer housing distinct from said camera housing and also of a size that is conveniently carried by hand;

an objective lens operatively disposed with respect to said camera housing to receive and focus incident image defining scene light;

a solid state light responsive array disposed within said camera housing for receiving incident scene light by way of said objective lens and converting such scene light into an image defining electronic information signal;

storage means releasably and operatively connectable to said camera and printer housings for storing the image defining electronic information signals;

complimentary releasable connecting means operatively associated with respect to said camera and printer housings for effecting a releasable fixed connection between said camera and printer housings, said fixed connection also operating to effect an electrical connection between said camera and printer housings;

hard copy printing means disposed within said printer housing for making a hard copy of select images from said image defining electronic information signals; and

signal control and processing means having portions disposed respectively within said camera and printer housings and responsive to user selection for effecting an exposure interval and thereafter processing said image defining electronic information signal to effect a select transformation thereof, said control means thereafter responding to user selection for directing said transformed electronic information signals to either said storage means for storage therein or said hard copy printing means for printing said hard copy wherein said portion of said signal control and processing means disposed within said camera housing is responsive to user selection when said camera housing is disconnected from said printer housing and said storage means is operatively connected to said camera housing for directing image defining electronic information signals from said light responsive array to said storage means immediately subsequent to each exposure interval and wherein: said camera housing comprises substantially planar major bottom and top wall members interconnected by substantially planar minor side, front and back wall portions to define a substantially parallelepiped structure wherein said objective lens is disposed in said front wall portion of said camera housing, said printer housing comprises substantially planar major top and bottom wall members interconnected by substantially planar minor side wall portions to define a substantially parallelepiped structure, said complimentary releasable connecting means operatively associated with said camera and printer housings comprises portions for connecting the major bottom wall member of the camera housing to a minor side wall portion of the printer housing.

10. The camera of claim 9 wherein the minor side wall portions of the camera housing are longer than the width of the minor side wall portions of the printer housing so that the camera housing is cantilevered with respect to the printer housing when the camera and printer housings are interconnected.

11. The camera of claim 9 wherein the side wall portions of the printer housing opposite to the side wall portion that connects to the camera housing has an exit slot through which the hard copy can be advanced from the printer housing by the hard copy printing means in a direction generally parallel to the major top and bottom walls of the printer and orthogonal to the bottom wall of the camera housing when the camera and printer housings are interconnected.

12. The camera of claim 11 wherein the side wall of the printer housing having an exit slot therethrough also comprises the major surface of a pivotal door assembly that may be opened to allow loading of unexposed hard copy media.

13. The camera of claim 9 wherein the major top wall portion of the printer housing includes a display device and said signal and processing means is responsive to user selection to provide a select image defining electronic information signal to said display device to provide a visually discernible image.

14. The camera of claim 9 wherein one of the side wall portions of said printer housing is substantially orthogonal to the side wall portion that connects to the camera housing and comprises means for releasably connecting said storage means.

* * * * *

C1421 XR 4,942,477

United States Patent [19]

Nakamura

[11] **Patent Number: 4,942,477**

[45] **Date of Patent: Jul. 17, 1990**

[54] **IMAGE PICKUP PRINTING SYSTEM USING NON-NTSC SIGNALS**

[75] Inventor: **Shinya Nakamura**, Shizuoka, Japan

[73] Assignee: **Tokyo Electric Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **269,706**

[22] Filed: **Nov. 10, 1988**

[30] **Foreign Application Priority Data**

Nov. 10, 1987 [JP] Japan 62-283697

[51] **Int. Cl.**^{5} **H04N 1/40**; H04N 1/46

[52] **U.S. Cl.** **358/401**; 358/75; 358/438; 358/909

[58] **Field of Search** 358/80, 78, 75, 400, 358/401, 434, 438, 442, 444, 468, 909

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,679,074	7/1987	Sugiura et al.	358/80
4,827,347	5/1989	Bell	358/909

FOREIGN PATENT DOCUMENTS

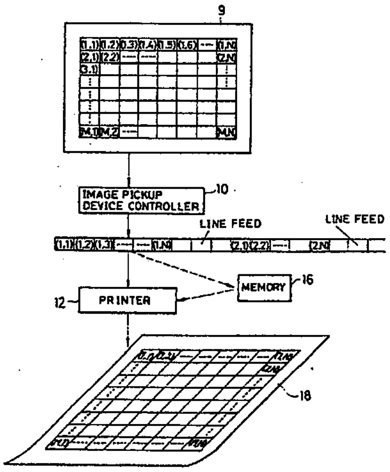
60-20685	2/1985	Japan .
61-122882	8/1986	Japan .
61-189785	8/1986	Japan .

Primary Examiner—James J. Groody
Assistant Examiner—Randall S. Svihla
Attorney, Agent, or Firm—Oblon, Spivak, McClelland, Maier & Neustadt

[57] **ABSTRACT**

The invention provides an image pickup printing system which comprises an optical device for optically controlling an optical image of an object, an image pickup device disposed at the position of a focus of the optical device for converting an optical image into electric signals for a large number of divided dot-like regions on a plane, an image pickup device controller for controlling a manner in which electric signals produced by the image pickup device are to be taken out, so as to avoid NTSC signals and a printer device for printing out electric signals produced by the image pickup device. With the image pickup printing system, a hard copy can be printed by directly using signals obtained by the image pickup device.

2 Claims, 3 Drawing Sheets



J

FIG. 1

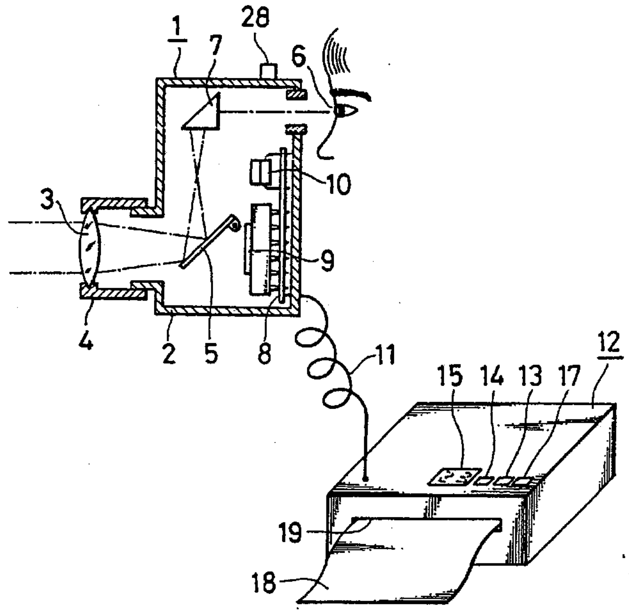


FIG. 2

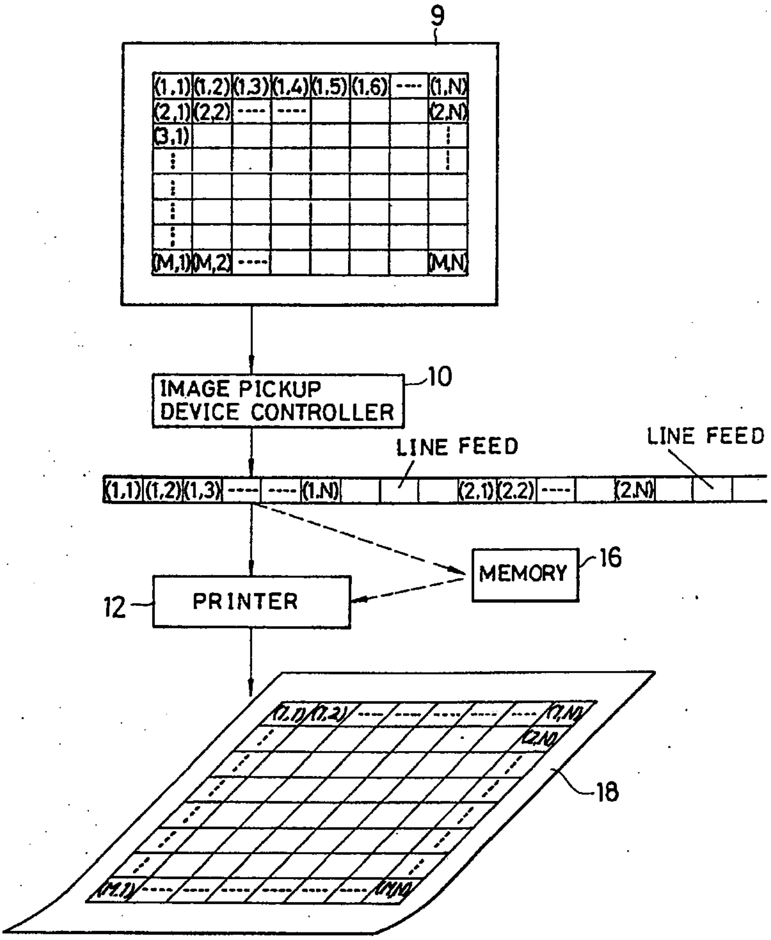

9
(1,1)
(1,2)
(1,3)
(1,4)
(1,5)
(1,6)
(1,N)
(2,1)
(2,2)
(2,N)
(3,1)
(M,1)
(M,2)
(M,N)
IMAGE PICKUP DEVICE CONTROLLER
10
LINE FEED
LINE FEED
(2,1)
(2,2)
(2,N)
MEMORY
16
PRINTER
12
18

FIG. 3 PRIOR ART

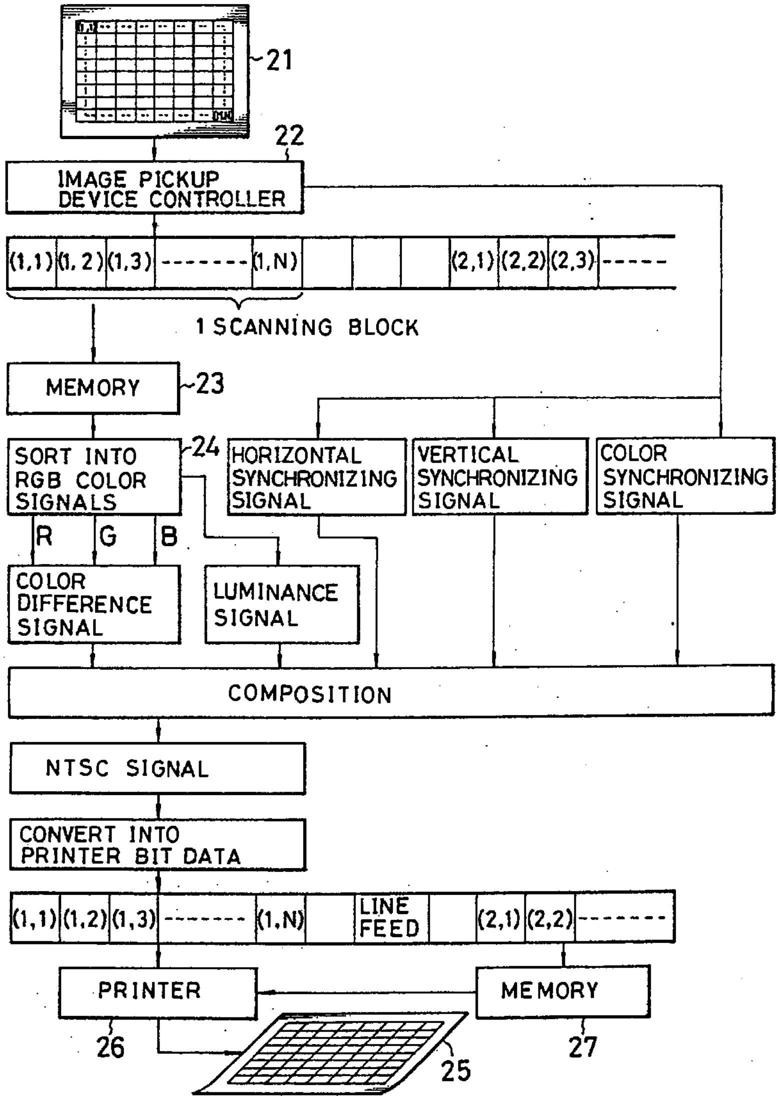


IMAGE PICKUP PRINTING SYSTEM USING NON-NTSC SIGNALS

FIELD OF THE INVENTION AND RELATED ART STATEMENT

This invention relates to an image pickup printing system which involves a combination of a technique of a camera for taking a picture of an optical image of an object for photographing, a technique of an image sensor for converting an optical image into electric signals and a technique of a printer for printing out a picture image in response to electric signals.

Conventionally, means for converting an optical image of an object for photographing into electric signals and storing the electric signals therein are known and disclosed, for example, in Japanese Patent Laid-Open No. 60-20685 and Japanese Patent Laid-Open No. 61-189785. In the means thus disclosed, an image pickup device is a video camera and converted electric signals are video signals. Meanwhile, means disclosed in Japanese Utility Model Laid-Open No. 61-122882 converts an optical image into television signals similarly as in the preceding means.

In the devices described above, picture image signals of an electronic camera are stored as NTSC signals. Accordingly, there is a problem that, when it is intended to obtain a hard copy in accordance with such picture image signals, the NTSC signals must be converted into image signals for a printer. Accordingly, processing of picture image signals is complicated, and also the cost thereof is high.

Meanwhile, for the object of storage of picture image signals, a record medium such as a floppy disk must be used separately, and when the device is to be moved, also the record medium must be moved, which is inconvenient.

Subsequently, an example of conventional electronic camera system will be described with reference to FIG. 3. The electronic camera system includes a CCD (charge coupled device) 21 serving as an image pickup device, and an image pickup device controller 22 for controlling a manner in which signals produced by means of the CCD 21 are to be sent out.

The image pickup device controller 22 extracts electric signals, for example, for the first line from (1, 1) to (1, N) in series from electric signals produced by means of the CCD 21, then inserts a line feed signal, and then extracts signals for the second line from (2, 1) to (2, N) in series. In this manner, the signals finally to (M, N) are sent out in series. The electric signals converted in this manner are inputted to and stored in a memory 23.

The signals in the memory 23 are then sorted into RGB (red, green and blue) color signals, and color difference signals of R, G and B and luminance signals of Y are produced. Such color difference signals and luminance signals of Y are combined by a combining circuit with horizontal synchronizing signals, vertical synchronizing signals and color synchronizing signals produced by the image pickup device controller 22 so that they are converted into NTSC (National Television System Committee) signals.

In order to obtain a picture image as a hard copy 25 from such NTSC signals, the following procedure is normally taken. In particular, the NTSC signals are first converted into printer bit data, and signals for the first line from (1, 1) to (1, N) are extracted in series from the printer bit data and then a line feed signal is added before signals for the second line from (2, 1) to (2, N) are subsequently extracted in series. The signals of the lines of the printer bit data thus extracted with line feed signals individually added in this manner are then either printed directly on a printer 26 or stored once into a memory before they are printed.

Accordingly, such problems as described above are exhibited.

Objects and Summary of the Invention

It is a first object of the present invention to provide an image pickup printing system wherein picture image signals picked up by an image pickup device are readily converted into signals for a printer to obtain a hard copy.

It is a second object of the present invention to provide an image pickup printing system wherein a matter written on a blackboard or the like can be obtained readily as a hard copy.

In order to attain the objects, according to the present invention, there is provided an image pickup printing system, comprising an optical device for optically controlling an optical image of an object, an image pickup device disposed at the position of a focus of the optical device for converting an optical image into electric signals for a large number of divided dot-like regions on a plane, an image pickup device controller for controlling a manner in which electric signals produced by the image pickup device are to be taken out, and a printer device for printing out electric signals produced by the image pickup device.

Accordingly, a suitable optical image is produced by the optical device by suitably adjusting the angle and depth of field of an object for photographing in a similar manner as in a conventional camera, and then the optical image is divided into the plurality of dot-like regions by means of the image pickup device to produce corresponding electric signals, whereafter the electric signals are converted into signals of a signal aspect conforming to the printer device by the image pickup device controller, and then a hard copy of the signals is obtained by the printer device. Therefore, no step of displaying a picture image by means of an electronic display means such as a CRT is involved, and processing of signals proceeds such that an optical image produced by the optical device is recognized and converted into electric signals by the image pickup device and then the electric signals are directly converted into signals of a signal aspect conforming to the printer device. Accordingly, the processing is simple, and no special separate picture image storage means is required.

The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration, partly in section, of an image pickup printing system showing an embodiment of the present invention;

FIG. 2 is a flow chart illustrating a flow of signals in the image pickup printing system of FIG. 1; and

FIG. 3 is a block diagram illustrating a conventional electronic camera system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2, there is shown an image pickup printing system according to a preferred embodiment of the present invention. The image pickup printing device shown includes an optical device 1 similar to a conventional camera. The optical device 1 includes a housing 2 and an interchangeable lens 3 mounted on a front wall of the housing 2. The lens 3 is actually mounted on a lens barrel 4 mounted for turning movement on the housing 2 such that an optical image to be produced by the lens 3 may be optically controlled by turning the lens barrel 4. Further, though not specifically shown, a diaphragm device connected to an adjusting ring is also disposed on a light path of the lens 3. Also a reflecting mirror 5 for changing the direction of an optical image is disposed on the light path of the lens 3 such that it may be pivoted upwardly and downwardly around an axis at an upper end thereof. A pentagonal prism 7 for introducing an optical image to an eye 6 of the photographer is located above the reflecting mirror 5.

A second push-button switch 28 for determining a timing at which a picture image is to be taken out is provided on an upper wall of the housing 2. The push-button switch 28 corresponds to a shutter of a conventional camera.

A PC plate 8 is located in the housing 2 adjacent a rear wall of the housing 2, and a CCD serving as an image pickup device is provided on the PC plate 8 and positioned at a focus of the lens 3. An image pickup device controller 10 for controlling a manner in which signals produced by means of the CCD are to be sent out is mounted on the PC plate 8.

A printer device 12 in the form of, for example, a laser printer is connected to the optical device 1 by a signal cable 11 connected to the PC plate 8. The printer device 12 has an internal structure similar to that of a conventional laser printer, and accordingly, description of the internal structure is omitted herein. The printer device 12, however, includes a first push-button switch 13 for determining a timing at which a picture image is to be taken out and instructing the printer device 12 of a hard copy, a copy number specifying button 14 for setting a number of hard copies, a copy number indicating device 15 for indicating a specified number of hard copies, and a copy switch 17 for causing the printer device 12 to print the stored contents of a memory 16 privided in the printer device 12, all located on an upper wall of the printer device 12. The first push-button switch 13 has the same function as the second push-button switch 28 described hereinabove. Meanwhile, an outlet port 19 for discharging a printed hard copy 18 therethrough is formed in a front wall of the printer device 12.

With the image pickup printing system having such a construction as described above, normally the housing 2 is fixed by means of a tripod or the like, and an operator will adjust the optical device 1 while observing an optical image of the pentagonal prism 7. In particular, the lens 3 is focused to an object for photographing and the amount of light is adjusted. In this instance, if the lens 3 should have an inappropriate angle of field, it should be replaced by another suitable lens.

After a picture image from which a hard coy 18 is to be obtained is determined, either the second push-button switch 28 located on the optical device 1 or the first push-button switch 13 located on the upper wall of the printer device 12 for determining a timing at which a picture image is to be taken out will be depressed. Consequently, the reflecting mirror 5 is jumped up so that an optical image passing the lens 3 is focused to form an image on the CCD 9. The CCD 9 is divided into $M \times N$ small regions including M rows and N columns and converts an amount of light at each of the regions into an electric signal of a corresponding quantity of electricity. Thus, as shown in FIG. 2, signals from (1, 1) to (M, N are delivered to the image pickup device controller 10.

The image pickup device controller 10 controls a manner in which the aforementioned electric signals produced by the CCD 9 are sent out. For example, the signals for the first line from (1, 1) to (1, N) are extracted in series and then a line feed signal is added, and after then, the signals for the second line from (2, 1) to (2, N). In this manner, the signals finally to (M, N) are sent out in series. The electric signals converted in this manner are inputted to and stored in the memory 16 and at the same time inputted to a printer of the printer device 12 by which they are printed out promptly. Thus, a hard copy 18 is obtained on which a picture image similar to the object for photographing is printed.

It is to be noted that, when a similar hard copy 18 becomes necessary later, the copy switch 17 should be depressed. Consequently, a similar hard copy 18 is produced in accordance with the signals stored in the memory 16.

Meanwhile, the signal aspect of electric signals by the image pickup device controller 10 can be changed depending upon the type of the printing device 12. In particular, while it is required in the case of a laser printer that the signals from (1, 1) to (M, N) are sent out in series as described hereinabove, in the case of a dot printer such as, for example, a thermal printer or an ink jet printer wherein a plurality of printing elements are disposed in a column, signals for a plurality of rows will be sent out at the same time.

It is to be noted that while in the embodiment described above the image pickup device controller 9 is described provided in the housing 2, it may otherwise be provided in the printer device 12. Further, while the housing 2 and the printer device 12 are interconnected by means of the signal cable 11, the signal cable 11, may be omitted while transmission of signals is effected making use of infrared rays or the like.

As described hereinabove, according to the present invention, an image pickup printing system comprises an optical device for optically controlling an optical image of an object, an image pickup device disposed at the position of a focus of the optical device for converting an optical image into electric signals for a large number of divided dot-like regions on a plane, an image pickup device controller for controlling a manner in which electric signals produced by the image pickup device are to be taken out, and a printer device for printing out electric signals produced by the image pickup device. With the image pickup printing system, a suitable optical image is produced by the optical device by suitably adjusting the angle and depth of field of an object for photographing in a similar manner as in a conventional camera, and then the optical image is divided into the plurality of dot-like regions on a plane by means of the image pickup device to produce corresponding electric signals, whereafter the electric signals are converted into signals of a signal aspect conforming to the printer device by the image pickup device controller. Accordingly, the image pickup printing system has various effects. In particular, a hard copy of the signals of the signal aspect conforming to the printer device can be obtained by the printer device. Further, since no step of displaying a picture image by means of an electronic display means such as a CRT is involved, processing of signals may be effected such that an optical image produced by the optical device is recognized and converted into electric signals by the image pickup device and then the electric signals are directly converted into signals of a signal aspect conforming to the printer device. Accordingly, since there is no step of converting the signals into NTSC signals or the like, the processing is simple. Besides, a hard copy can be obtained without requiring a special separate picture image storage means, and a matter written on a blackboard or the like can be obtained readily as a hard copy.

Having now fully described the invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit and scope of the invention as set forth herein.

What is claimed is:

1. An image pickup printing system, comprising:

an optical system for focusing an image of an object;

means for converting said image to a plurality of electrical signals being disposed at the focal position of said optical system, said means for converting including a matrix of regions with each region producing one of said plurality of electrical signals;

means for controlling the transfer of said plurality of electrical signals to produce a serial signal formed of serially arranged signals corresponding to rows of said regions with the rows being separated by at least one signal indicating line feed, said serial signal having a format for directly driving a printing means;

memory means connected to said means for controlling for receiving and storing said serial signal;

printing means connected to said memory means and said means for controlling for printing said image wherein the serial signal is selectively received from said memory means and from said means for controlling.

2. An image pickup printing system according to claim 1, wherein a first switch is provided with said optical system and a second switch is provided at said printing means, said means for converting being responsive to both said first switch and said second switch to print an image.

* * * * *

5/032/911

United States Patent [19]

Takimoto

[11] **Patent Number: 5,032,911**

[45] **Date of Patent: Jul. 16, 1991**

[54] **VIDEO IMAGE PRINTER USING LIQUID CRYSTAL LIGHT VALVES AND PRIMARY AUXILIARY DIRECTION SCANNING**

[75] Inventor: **Masaaki Takimoto**, Tokyo, Japan

[73] Assignee: **Fuji Photo Film Co., Ltd.**, Kanagawa, Japan

[21] Appl. No.: **514,802**

[22] Filed: **Apr. 26, 1990**

[30] **Foreign Application Priority Data**

Apr. 28, 1989 [JP] Japan 1-110065

[51] Int. Cl.⁵ **G03F 3/10; H04N 1/23**

[52] U.S. Cl. **358/76**; 358/302

[58] Field of Search .... 358/75, 76, 302; 355/27, 38, 71; 354/85, 86; 350/331 R

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,595,259	6/1986	Perregaux	350/331 R
4,605,972	8/1986	Hatanaka	358/302
4,712,878	12/1987	Taniguchi et al.	350/331 R
4,745,433	5/1988	Fujimura et al.	350/331 R
4,839,676	6/1989	Lippert et al.	354/86
4,859,034	8/1989	Shiraishi et al.	350/331 R

Primary Examiner—Howard W. Britton

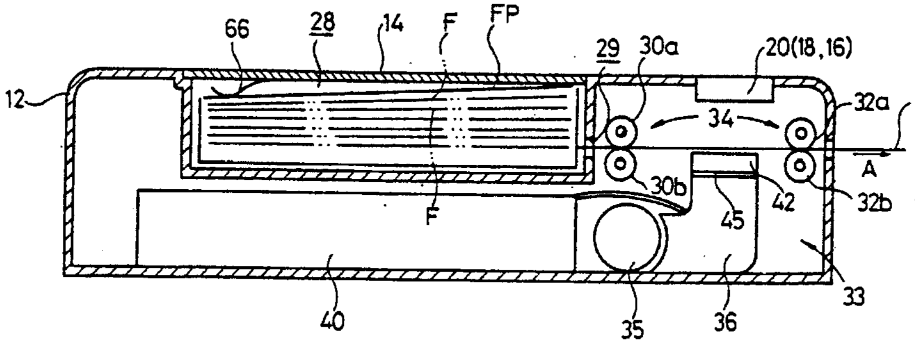
Assistant Examiner—Kim Yen Vu

Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas

[57] **ABSTRACT**

A video image printer is coupled to a video signal source such as a video camera, an electronic still camera, a video tape recorder, a television receiver, or the like, for producing a hard copy bearing a recorded image which is displayed by on a monitor display. The video image printer includes a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal, color filters mounted on one end of the liquid crystal light valve, and a light source optically coupled to the one end of the liquid crystal light valve. A photographic film is disposed on the side of an opposite end of the liquid crystal light valve, the film carrying a self-processing solution. The film is selectively exposed to an image that is formed by light from the light source through the color filter means and the liquid crystal light valve controlled by the applied video signal. The video image printer also includes a pair of squeezing rollers for spreading the processing solution over the film which has been exposed.

14 Claims, 9 Drawing Sheets



K

FIG.1

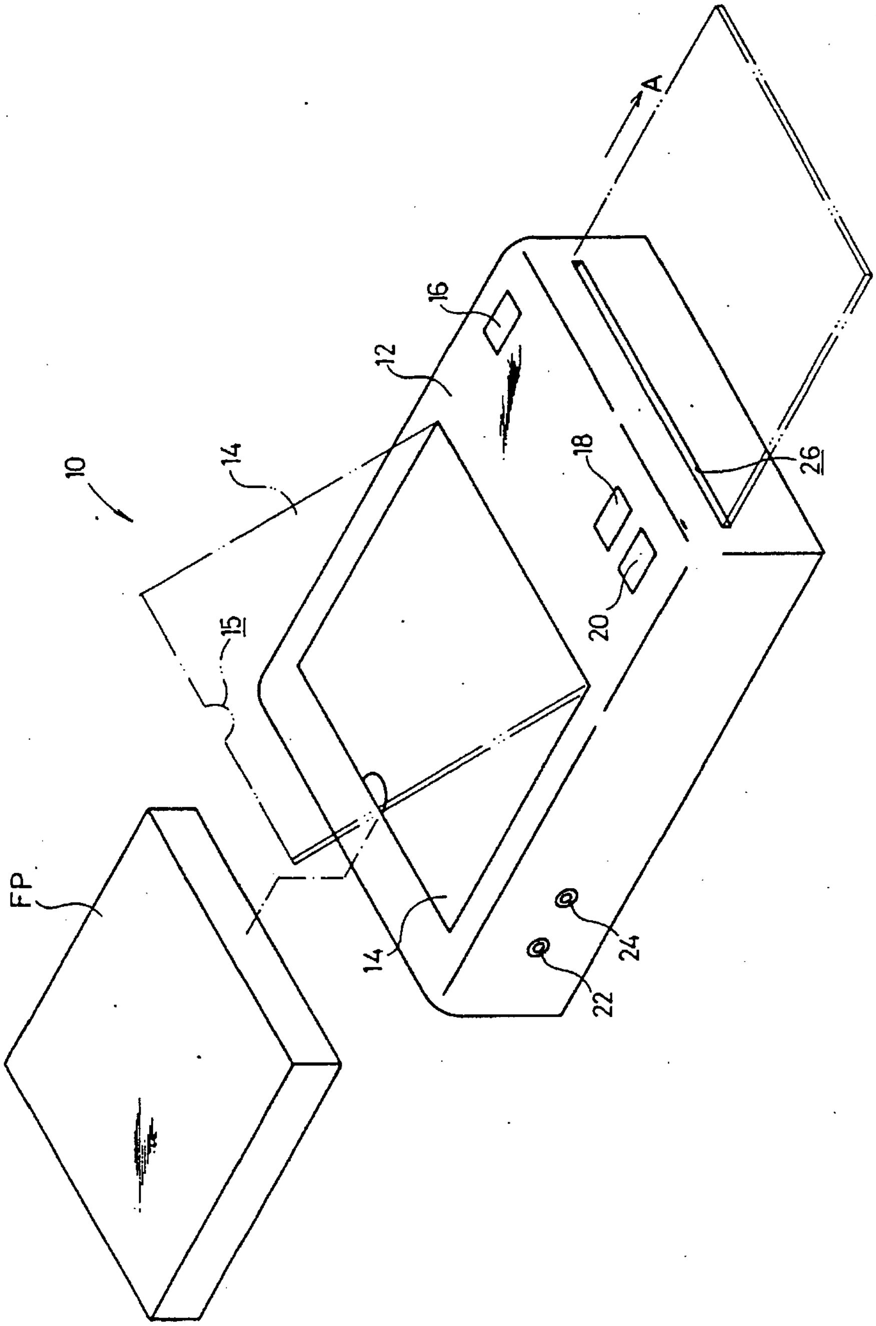


FIG.2

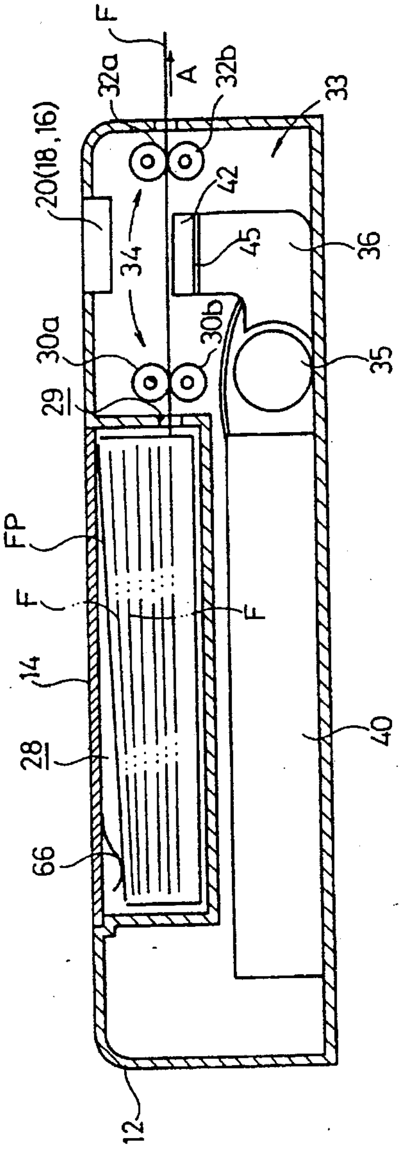


FIG. 3

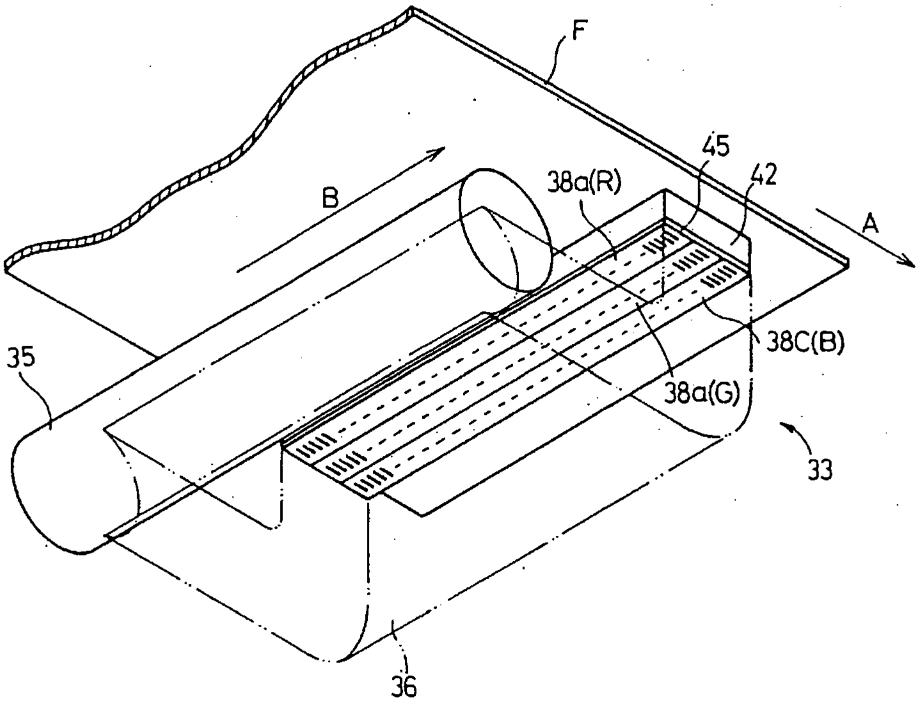


FIG. 4

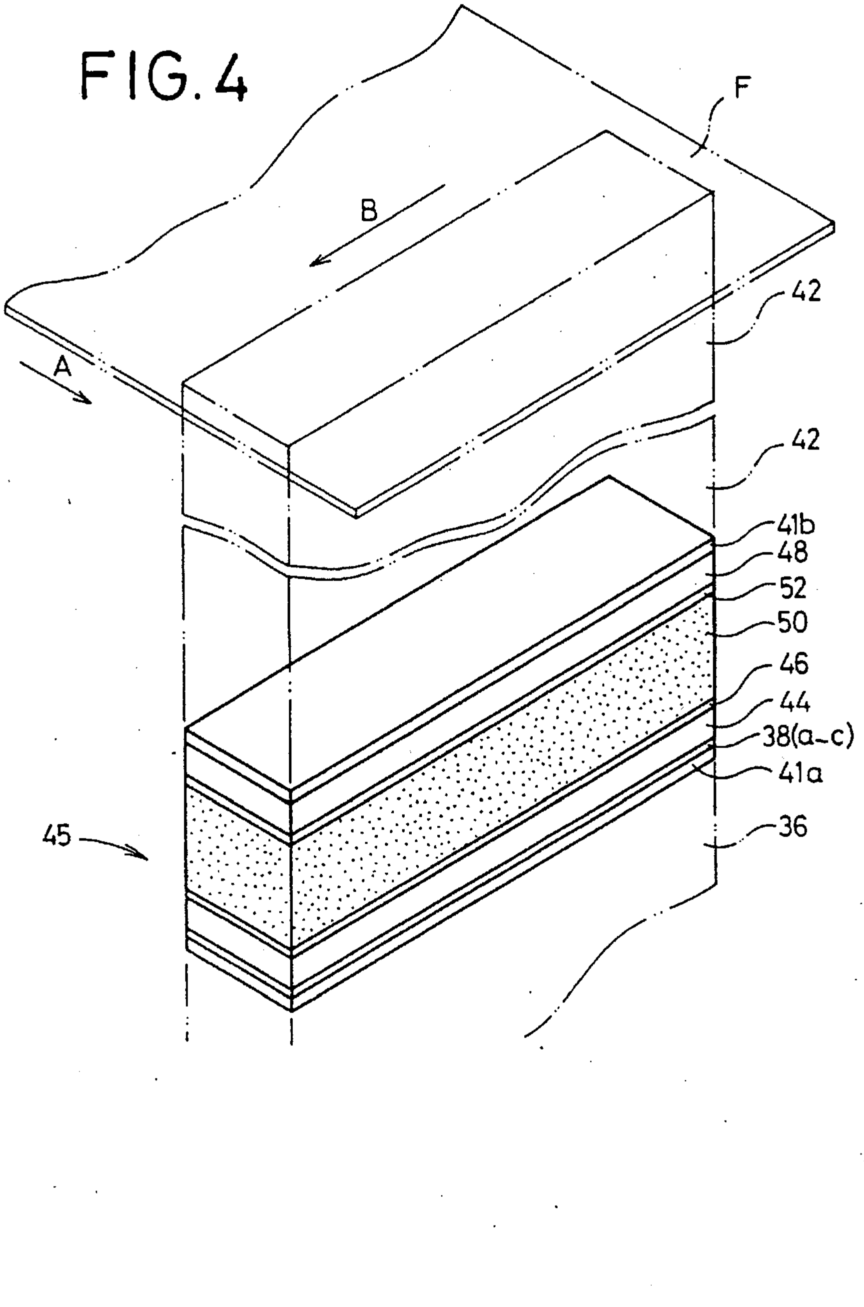


FIG.5

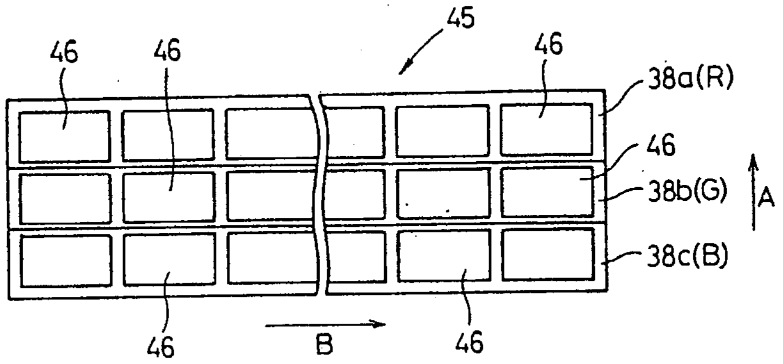

45
46
46
46
38a(R)
46
38b(G)
A
38c(B)
46
B
46

FIG.8

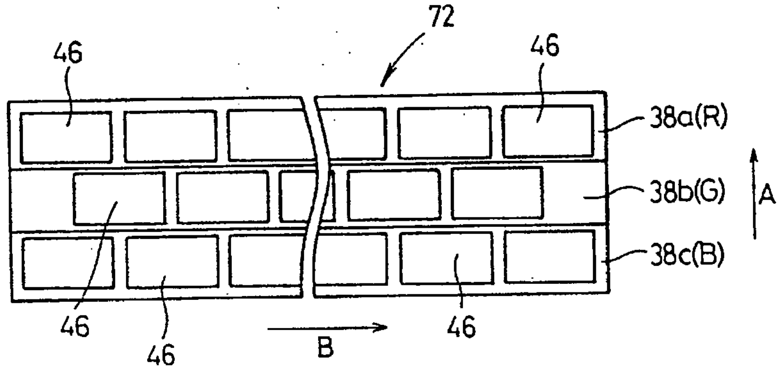

72
46
46
38a(R)
38b(G)
A
38c(B)
46
46
B
46

FIG.6

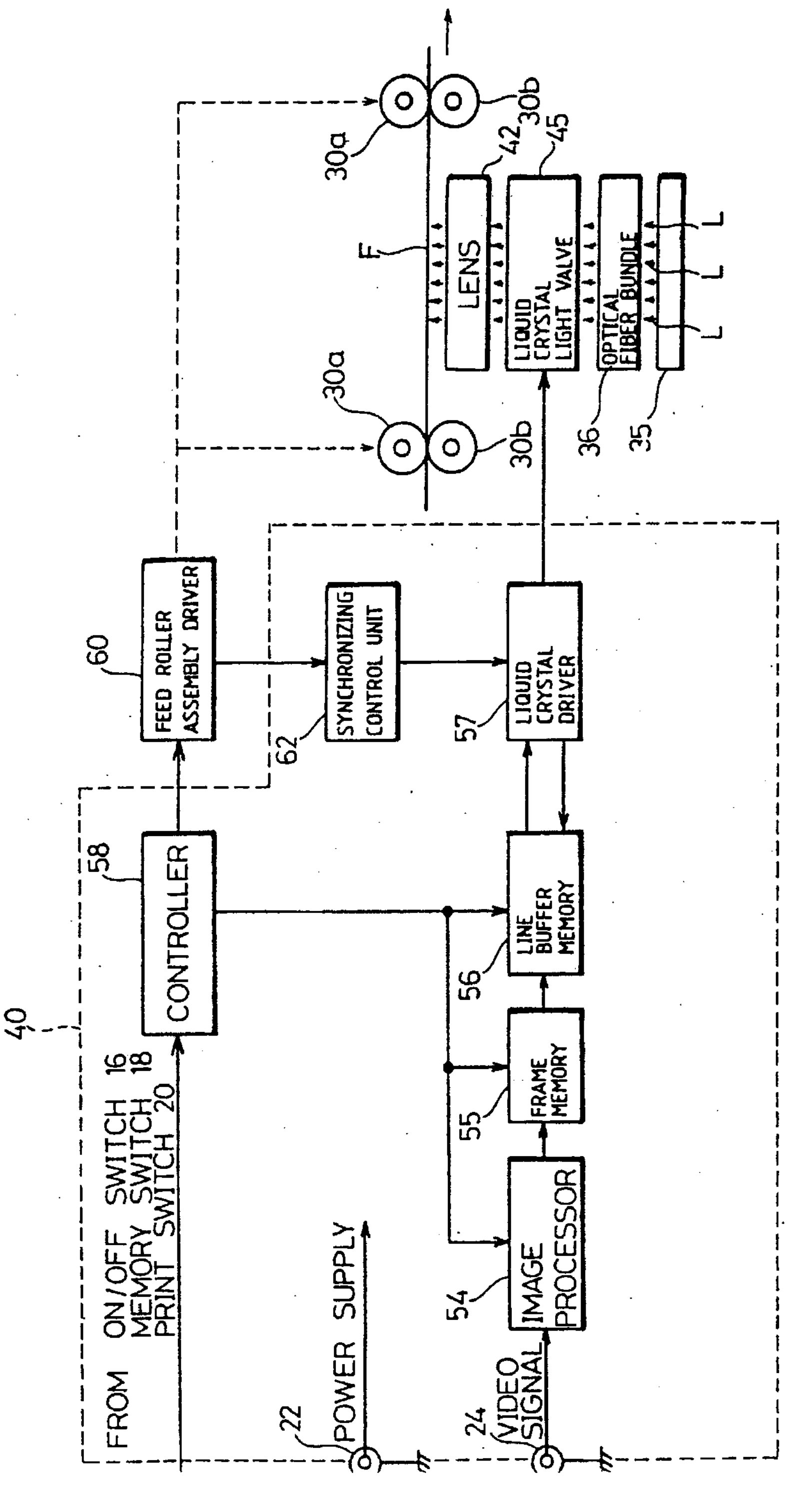

30a
30b
30a
30b
42
45
F
LENS
LIQUID CRYSTAL LIGHT VALVE
OPTICAL FIBER BUNDLE
L
L
L
36
35
60
FEED ROLLER ASSEMBLY DRIVER
62
SYNCHRONIZING CONTROL UNIT
57
LIQUID CRYSTAL DRIVER
58
CONTROLLER
40
56
LINE BUFFER MEMORY
55
FRAME MEMORY
54
IMAGE PROCESSOR
FROM ON/OFF SWITCH 16
MEMORY SWITCH 18
PRINT SWITCH 20
POWER SUPPLY
22
24
VIDEO SIGNAL

FIG.7

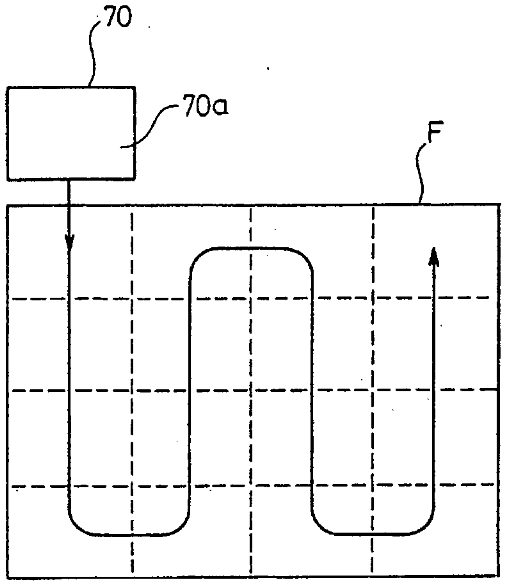


FIG.9

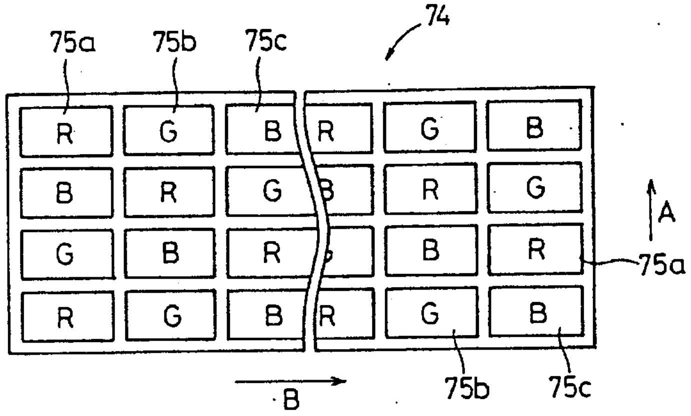

74
75a
75b
75c
R
G
B
R
G
B
B
R
G
B
R
G
G
B
R
B
R
R
G
B
R
G
B
A
75a
B
75b
75c

FIG.10

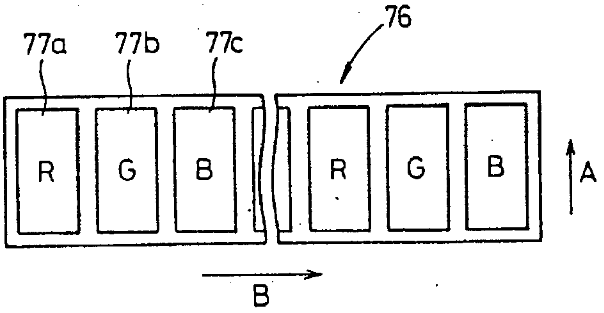
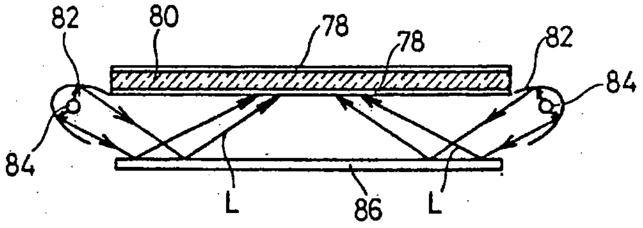

76
77a
77b
77c
R
G
B
R
G
B
A
B

FIG.11



VIDEO IMAGE PRINTER USING LIQUID CRYSTAL LIGHT VALVES AND PRIMARY AUXILIARY DIRECTION SCANNING

BACKGROUND OF THE INVENTION

The present invention relates to a video image printer for reproducing an image on a photosensitive medium based on a video signal, and more particularly to a video image printer for driving a liquid crystal light valve based on image information borne by a video signal, to allow light to be transmitted through the light valve for exposure of a photosensitive medium to reproduce an image thereon.

There has been a growing demand for video image printers which produce hard copies bearing reproduced images that have been displayed on monitor displays. Such video image printers are used in various applications. For example, a video image printer may be used in video shops or the like which provide a quick printout service. Medical organizations may find video image printouts useful as a diagnostic aid or for data storage. Video image printers may find home use for obtaining photoprints of desired displayed video images. It is desired that printouts or hard copies thus produced be of high image quality.

One known recording method employed by video image printers is a thermal recording process in which an image is printed on a heat-sensitive recording medium directly by a thermal head. However, the thermal recording process is disadvantageous in that the heat-sensitive recording medium is easily degraded and hence cannot be preserved over a long period of time, and it can record images in only two colors, i.e., black and white.

The above problems can be solved by a thermal image transfer recording process. According to this process, a recording medium is in the form of a plain sheet of paper, and a type ribbon composed of strips of magenta, cyan, and yellow is positioned adjacent to the recording medium. The colors that are carried by the type ribbon are thermally transferred to the recording medium by a thermal head. The thermal image transfer recording process is however employed in reproducing only a colored image of line art because the process is unable to reproduce continuous tone images due to difficulty in controlling the amount of coloring materials to be transferred.

Continuous tone images can be reproduced by a thermal sublimation process in which a sublimable ink is vaporized and transferred to a recording medium, in a quantity depending on the intensity of heat generated by a thermal head. The temperature of the thermal head can be varied by an electric current supplied to the thermal head, thus controlling the amount of ink to be vaporized. The process lends itself to the conversion of image densities into a multiplicity of tones. The thermal sublimation process requires that the recording medium be even and uniform on its surface. Therefore, the process usually employs a dedicated recording medium in the form of a sheet of paper coated with a polyester, and hence requires the expenditure of a high running cost.

Any of the recording methods referred to above is a thermal recording process, and needs to incorporate a heat dissipation device in recording equipment. The equipment which operates according to these methods is not small and light, and also not portable.

Another recording process known in the art is a laser beam scanning process. However, laser beam scanning recording devices are large because of the scanning of a recording medium with a laser beam. The laser beam scanning recording devices are also expensive since the light deflector for deflecting the laser beam is expensive.

Still another recording arrangement employs a piezoelectric device for atomizing and ejecting a liquid ink through nozzles. The recording system has a relatively low recording speed since it uses four nozzles for printing an image in a serial fashion. It is a big disadvantage of this recording system that these ink ejecting nozzles are often plugged. It is highly difficult to keep the nozzles in good operating conditions.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide a video image printer which drives a liquid crystal light valve based on image information borne by an input video signal, to allow light to be transmitted through the light valve for exposure of a self-processing film of a silver-salt photosensitive material, known as an instantaneous photographic film, to reproduce a high-quality colored image thereon, the video image printer being small and lightweight.

Another object of the present invention is to provide a video image printer comprising a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal, color filter means mounted on one end of the liquid crystal light valve, a light source optically coupled to the one end of the liquid crystal light valve, a film disposed on the side of an opposite end of the liquid crystal light valve and carrying a self-processing solution, the film being selectively exposable to an image that is formed by light from the light source through the color filter means and the liquid crystal light valve controlled by the applied video signal, and means for spreading the processing solution over the film which has been exposed.

Still another object of the present invention is to provide the video image printer wherein the spreading means comprises a pair of squeezing rollers for sandwiching and pressing the film therebetween.

Yet another object of the present invention is to provide the video image printer further comprising a graded-index lens array disposed between the film and the opposite end of the liquid crystal light valve.

Yet still another object of the present invention is to provide the video image printer wherein the liquid crystal light valve includes a twisted nematic liquid crystal.

A further object of the present invention is to provide the video image printer wherein the liquid crystal light valve includes a ferroelectric smectic liquid crystal with a helix axis thereof extending along the normal direction of smectic layers of the liquid crystal.

A still further object of the present invention is to provide the video image printer further including means for feeding the film in an auxiliary scanning direction while the film is being scanned in a main scanning direction perpendicular to the auxiliary scanning direction so as to be exposed to the image, wherein the color filter means comprises three linear color filters extending parallel to the main scanning direction, the liquid crystal light valve comprising a matrix of pixel electrodes arranged in arrays corresponding respectively to the color filters.

A yet still further object of the present invention is to provide the video image printer further including means for feeding the film in an auxiliary scanning direction while the film is being scanned in a main scanning direction perpendicular to the auxiliary scanning direction so as to be exposed to the image, wherein the color filter means comprises three linear color filters extending parallel to the main scanning direction, the liquid crystal light valve comprising a plurality of pixel electrodes arranged in arrays corresponding respectively to the color filters, the pixel electrodes being staggered in the auxiliary scanning direction.

Still another object of the present invention is to provide the video image printer wherein the color filter means comprises a mosaic pattern of color filters of R, G, B.

Still another object of the present invention is to provide the video image printer further including means for feeding the film in an auxiliary scanning direction while the film is being scanned in a main scanning direction perpendicular to the auxiliary scanning direction so as to be exposed to the image, wherein the color filter means comprises a plurality of color filters of R, G, B, the color filters being arranged in parallel stripes extending in the auxiliary scanning direction.

Yet another object of the present invention is to provide the video image printer wherein the light source comprises a rod-shaped light source.

Yet still another object of the present invention is to provide the video image printer wherein the light source comprises a combination of a point light source and a condenser lens.

A still further object of the present invention is to provide the video image printer wherein the light source comprises an electroluminescent panel.

A yet further object of the present invention is to provide the video image printer wherein the light source comprises a plurality of juxtaposed linear light sources and a diffusion plate for diffusing light emitted from the linear light sources.

A further object of the present invention is to provide the video image printer wherein the light source comprises a transmissive plate with diffusion layers disposed respectively on upper and lower surfaces thereof, a reflecting plate disposed in confronting relation to the transmissive plate, a pair of mirrors of parabolic cross section disposed one on each side of the transmissive plate and the reflecting plate, and a pair of linear light sources disposed respectively at the focal points of the mirrors.

The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a video image printer according to an embodiment of the present invention;

FIG. 2 is a vertical cross-sectional view of the video image printer;

FIG. 3 is an enlarged fragmentary perspective view of an exposure recording unit in the video image printer shown in FIGS. 1 and 2;

FIG. 4 is a fragmentary perspective view of a liquid crystal light valve having color filters in the video image printer;

FIG. 5 is a view showing the relationship between the color filters and pixel electrodes of the liquid crystal light valve;

FIG. 6 is a block diagram of an electric circuit incorporated in the video image printer;

FIG. 7 is a view showing the relationship between a liquid crystal light valve and a film in a video image printer according to another embodiment of the present invention;

FIGS. 8 through 10 are views showing the relationship between color filters and pixel electrodes of liquid crystal light valves in video image printers according to other embodiments of the present invention; and

FIG. 11 is a schematic side elevational view of a light source in a video image printer according to still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a video image printer **10** according to an embodiment of the present invention includes a casing **12** having a lid **14**, an on/off switch **16**, a memory switch **18**, and a print switch **20**. The lid **14**, on the upper side of the casing **12**, is pivotally coupled at one end to the casing **12** and has a semicircular recess **15** defined in the other end. The lid **14** can be opened, i.e., swung away from the casing **12** and closed, i.e., swung toward the casing **12**, by the user who grips the lid **14** through the recess **15**. The casing **12** also supports on one side panel a power supply input terminal **22** and a video signal input terminal **24**. A rectangular slot **26** is horizontally defined in a front side panel of the casing **12**. A recorded film F, which is made of a silver-salt photographic material and has self-processing solutions, is withdrawn from the casing **12** through the slot **26**.

As shown in FIG. 2, the casing **12** has a film loading box **28** for storing a film pack FP which contains a stack of self-processing films F. The film loading box **28** has a slot **29** defined in a side panel thereof in substantial horizontal alignment with the slot **26**. The casing **12** houses a feed roller assembly **34** which is disposed between the film loading box **28** and the front side panel of the casing **12**. The feed roller assembly **34** includes a pair of rim drive rollers **30***a*, **30***b* disposed in the casing **12** adjacent to the slot **29**, for gripping and drawing one, at a time, of the self-processing films F, and a pair of squeezing rollers **32***a*, **32***b* disposed near the slot **26**, for developing a recorded image on an exposed film F. An exposure recording unit **33** for exposing the film F to record an image thereon is also housed in the casing **12** and positioned in a position between the rim driver roller pair and the squeezing roller pair. As shown in FIG. 3, the exposure recording unit **33** comprises a rod-shaped light source **35** comprising a halogen lamp or the like, an optical fiber bundle **36** for guiding light from the light source **35**, three color filters **38***a* through **38***c* of red (R), green (G), and blue (B) disposed on the upper end of the optical fiber bundle **36** and extending parallel to the auxiliary scanning direction indicated by the arrow A which is perpendicular to the main scanning direction indicated by the arrow B, a liquid crystal light valve **45** disposed on the color filters **38***a* through **38***c*, and a graded-index lens array **42** disposed on the liquid crystal light valve **45**. While the film M is moving on and across the graded-index lens array **42**, the film M is exposed to light which is emitted from the light source **35** and passes through the optical fiber bundle

36, the color filters **38***a* through **38***c*, the liquid crystal light valve **45**, and the graded-index lens array **42**.

FIG. **4** shows the liquid crystal light valve **45** in detail, with the color filters **38***a* through **38***c* combined therewith. The liquid crystal light valve **45** includes polarizers **41***a*, **41***b* disposed respectively on lower and upper sides of the liquid crystal light valve **45**, the polarizers **41***a*, **41***b* having parallel polarizing directions, respectively. A first glass substrate **44** is positioned inwardly of the polarizer **41***a*, which is disposed on the upper exit end of the optical fiber bundle **36**. The color filters **38***a* through **38***c*, in the form of films colored by dyes of three colors R, G, B and deposited thereon by vacuum evaporation, are disposed on one surface of the first glass substrate **44** which faces the polarizer **41***a*. Instead of forming thin films as the color filters **38***a* through **38***c* on the first glass substrate **44** by vacuum evaporation, layers of gelatin or resin colored by dyes, or layers of resin with pigments dispersed therein may be coated on one surface of the first glass substrate **44**. Transparent electrodes, i.e., pixel electrodes **46** are arranged in linear arrays extending in the main scanning direction indicated by the arrow B (see FIG. **5**) along the color filters **38***a* through **38***c*.

A second glass substrate **48** is positioned inwardly of the polarizer **41***b*. Between the pixel electrodes **46** and the second glass substrate **48**, there is sealed a liquid crystal **50** such as a twisted nematic liquid crystal or the like. A common transparent electrode **52** is deposited between the second glass substrate **48** and the liquid crystal **50**, the common electrode **52** being deposited on one surface of the second glass substrate **48** by vacuum evaporation. The polarizer **41***b* is disposed on the opposite surface of the second glass substrate **48**. Light that has passed through the polarizer **41***b* is applied through the graded-index lens array **42** to the film F for exposure thereof.

The graded-index lens array **42** comprises an array of cylindrical lenses each having a radial graded index profile, the cylindrical lenses being vertically aligned with the pixel electrodes **46**. The graded-index lens array **42** is effective in reducing the distance between the film F and the liquid crystal light valve **45**.

The video image printer **10** of the above construction incorporates an electric circuit **40** shown in FIG. **6**. The electric circuit **40** comprises an image processor **54** for processing a video signal which is applied from the video signal input terminal **24**, a frame memory **55** for storing an output signal from the image processor **54**, a line buffer memory **56** connected to the frame memory **56**, a liquid crystal driver **57** for driving the liquid crystal light valve **45** based on one line of an image signal from the line buffer memory **56**, a controller **58** for receiving control signals from the on/off switch **16**, the memory switch **18**, and the print switch **20**, a feed roller assembly driver **60** for driving the feed roller assembly **34** under the control of the controller **58**, and a synchronizing control unit **62** for synchronously controlling the liquid crystal driver **57** based on an output signal from the feed roller assembly driver **60**.

The video image printer according to the present invention is basically constructed as described above. Operation and advantages of the video image printer will now be described below.

The video image printer **10** is connected through the video image input terminal **24** to a video signal source (not shown) such as a video camera, an electronic still camera, a video tape recorder, a television receiver, or the like. In operation, the video image printer **10** produces a hard copy in the form of a film F on which image information represented by a video signal from such a video signal source is recorded.

The user first connects the power supply input terminal **22** to an external power supply, and presses the on/off switch **16** to turn on the video image printer **10**. Then, the user inserts a finger into the recess **15** and lifts the lid **14**, and load a film pack FP containing stacked instantaneous photographic films F into the film loading box **28**. The loaded film pack FP is securely held down by a spring **66** (see FIG. **2**) on the back of the lid **14**.

If the user wants to have a hard copy of an image which is being displayed on a monitor display coupled to the video signal source, the user presses the print switch **20**. In response to a control signal from the print switch **20**, the controller **58** energizes the feed roller assembly driver **60** to drive the rim driver rollers **30***a*, **30***b* for withdrawing one film F from the film pack FP and positioning the film F in confronting relation to the graded-index lens array **42** on the upper end of the liquid crystal light valve **45**. The video signal transmitted from the monitor display is converted into image density information and color or RGB information, for each of the pixels of the liquid crystal light valve **45**, i.e., the pixel electrodes **46**, by the image processor **54**. One frame, at a time, of such image density information and RGB information is stored in the frame memory **55**. The stored image density information and RGB information are then stored, one scanning line at a time, in the line buffer memory **56**.

Positional information about the film F which is fed in the auxiliary scanning direction A is sent from the feed roller assembly driver **60** to the synchronizing control unit **62**. The liquid crystal driver **57** is of a known arrangement for successively scanning and driving the liquid crystal light valve **45** by application of a voltage to the pixel electrodes **46** successively in the main scanning direction indicated by the arrow B (FIGS. **3** and **5**) according to certain timing. More specifically, the liquid crystal driver **57** reads the stored image density information and RGB information corresponding to a selected pixel electrode **46** in response to a timing signal from the synchronizing control unit **62**, and applies a voltage to the selected pixel electrode **46** based on the image density information and RGB information thus read. In this manner, the pixels corresponding to the selected pixel electrodes **46** can be set to desired degrees of lightness. For example, when no voltage is applied to the liquid crystal **50**, light L emitted from the light source **35** passes through the optical fiber bundle **36**, the polarizer **41***a*, and any one of the color filters **38***a* through **38***c*. Since the polarizing direction of the light L is turned 90° by the liquid crystal **50**, the light L is blocked by and cannot go through the polarizer **41***b*. When a voltage higher than a predetermined threshold level is applied to the liquid crystal **50**, the orientation of the liquid crystal **50** is varied, i.e., the polarizing direction of the light L is not twisted 90° thereby, and the light L is allowed to pass through the polarizer **41***b* and the graded-index lens array **42** to the film F. Therefore, the film F is exposed to a transmitted image which is composed of pixels having respective hues and brightnesses which are controlled by the liquid crystal light valve **45**.

The film F is exposed successively line by line, and is introduced between the squeezing rollers **32***a*, **32***b* in synchronism with the exposure of the film F. The squeezing rollers **32***a*. **32***b*. serving as a means for spreading processing solutions, sandwich and press the film F therebetween, while at the same time feeding the film F in the auxiliary scanning direction A. During this time. the processing solutions which are carried by the self-processing film F are spread over and coated on the film F, thereby developing the recorded image into a visible image. In this manner, the film M carrying the image corresponding to the video signal is discharged as a hard copy from the video image printer **10**.

When the memory switch **18** is pressed, the image signal corresponding to the applied video signal is stored for one frame in the frame memory **64**.

In the illustrated embodiment, the liquid crystal **50** of the liquid crystal light valve **45** comprises a twisted nematic liquid crystal. However, the liquid crystal **50** may be a ferroelectric smectic liquid crystal in which molecules are arranged in layers, with the helix axis extending along the normal direction of the layers of the liquid crystal. The ferroelectric liquid crystal is quicker in response than the nematic liquid crystal, can control the intensity of light in an increased range through pulse number modulation because of the quick response. Therefore, a video image printer employing the ferroelectric smectic liquid crystal can produce images in a wide range of tones.

In the illustrated video image printer, the film F is fed while it is being exposed. FIG. 7 shows a video image printer according to another embodiment of the present invention. The video image printer includes a liquid crystal light valve **70** having an image forming area **70***a* the size of which is equal to the size of a liquid crystal display for use on a 1-inch viewfinder or a 2- or 3-inch television receiver. In operation, the liquid crystal light valve **70** is moved along the surface of the film F, e.g., in the direction indicated by the arrow to form an image all over the film F.

In the illustrated embodiment, as shown in FIG. 5, the path of light from the single light source is divided into three paths corresponding to three parallel color filters **38***a* through **38***c* that extend in the main scanning direction B, and the pixel electrodes **46** which are arranged in arrays aligned with the color filters **38***a* through **38***c* are also arrayed in the auxiliary scanning direction A. As shown in FIG. 8, the pixel electrodes **46** may be staggered or zigzagged the auxiliary scanning direction A, rather than being arranged in the matrix pattern. Three light sources may be employed so that they correspond respectively to the color filters **38***a* through **38***c*..

The color filters and the pixel electrodes in the liquid crystal light valve are not limited to the linear arrangement. FIG. 9 shows a liquid crystal light valve **74** including R, G, B color filters **75***a* through **75***c* which are arranged in a mosaic pattern. FIG. 10 illustrates another liquid crystal light valve **76** including pixel electrodes and color filters **77***a* through **77***c* which are in the shape of parallel stripes extending in the auxiliary scanning direction A.

The light source for emitting light may be a combination of a point light source and a condenser lens, or an electroluminescent panel, or a plurality of juxtaposed linear light sources and a diffusion plate for diffusing light emitted from the linear light sources. FIG. 11 shows a light source according to still another embodiment of the present invention. As shown in FIG. 11, two diffusion layers **78** are attached to upper and lower surfaces, respectively, of a flat transmissive plate **80**, and two elongate mirrors **82** of parabolic cross section are disposed one on each side of the flat plate **80**. Linear light sources **84** are positioned at the focal points, respectively, of the mirrors **82**, and extend along the mirrors **82**. A reflecting plate **86** is disposed below the flat transmissive plate **80** in confronting relation thereto. Light L emitted from the linear light sources **84** is reflected by the mirrors **82** and the reflecting plate **86** so as to pass through the flat transmissive plate **80**, so that the light of uniform illuminance will be applied to the liquid crystal light valve.

The R, G, B color filters are incorporated in the liquid crystal light valve in the illustrated embodiment. However, the liquid crystal light valve and the R, G, B color filters may be separate from each other, and the R, G, B color filters may be disposed between the light source and the liquid crystal light valve and extend perpendicularly to the axis of light emitted from the light source. In operation, the color filters are rotated and the film F is exposed to a colored image passing through the color filters.

With the present invention, as described above, the self-processing film coated with a silver-salt photosensitive material is exposed to light which is transmitted through the color filters and the liquid crystal light valve that is controlled according to an input video signal. Since the silver-salt photosensitive material is used on the film, images reproduced thereon are very high in quality. Use of the self-processing film shortens the time required to obtain a desired hard copy. The liquid crystal light valve is effective in producing images in a wide range of tones. The video image printer of the invention is also small in size since it does not employ any thermal head or any laser scanning optical system.

Although certain preferred embodiments have been shown and described, it should be understood that many changes and modifications may be made therein without departing from the scope of the appended claims.

What is claimed is:

1. A video image printer comprising:
   - a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal;
   - color filter means mounted on one end of said liquid crystal light valve;
   - a light source optically coupled to said one end of said liquid crystal light valve;
   - a film disposed on the side of an opposite end of said liquid crystal light valve and carrying a self-processing solution, said film being selectively exposable to an image that is formed by light from said light source through said color filter means and said liquid crystal light valve controlled by the applied video signal;
   - means for spreading the processing solution over the film which has been exposed; and,
   - means for feeding said film in an auxiliary scanning direction while said film is being scanned in a main scanning direction transverse to said auxiliary scanning direction so as to be exposed to the image.

2. A video image printer according to claim 1, wherein said spreading means comprises a pair of squeezing rollers for sandwiching and pressing the film therebetween.

3. A video image printer according to claim 1, further comprising a graded-index lens array disposed between

said film and said opposite end of the liquid crystal light valve.

4. A video image printer according to claim 1, wherein said liquid crystal light valve includes a twisted nematic liquid crystal.

5. A video image printer according to claim 1, wherein said liquid crystal light valve includes a ferroelectric smectic liquid crystal with a helix axis thereof extending along the normal direction of smectic layers of the liquid crystal.

6. A video image printer comprising:

a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal;

color filter means mounted on one end of said liquid crystal light valve;

a light source optically coupled to said one end of said liquid crystal light valve;

a film disposed on the side of an opposite end of said liquid crystal light valve and carrying a self-processing solution, said film being selectively exposable to an image that is formed by light from said light source through said color filter means and said liquid crystal light valve controlled by the applied video signal;

means for spreading the processing solution over the film which has been exposed; and,

means for feeding said film in an auxiliary scanning direction while said film is being scanned in a main scanning direction perpendicular to said auxiliary scanning direction so as to be exposed to the image, wherein said color filter means comprises three linear color filters extending parallel to said main scanning direction, said liquid crystal light valve comprising a matrix of pixel electrodes arranged in arrays corresponding respectively to said color filters.

7. A video image printer comprising:

a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal;

color filter means mounted on one end of said liquid crystal light valve;

a light source optically coupled to said one end of said liquid crystal light valve;

a film disposed on the side of an opposite end of said liquid crystal light valve and carrying a self-processing solution, said film being selectively exposable to an image that is formed by light from said light source through said color filter means and said liquid crystal light valve controlled by the applied video signal;.

means for spreading the processing solution over the film which has been exposed; and,

means for feeding said film in an auxiliary scanning direction while said film is being scanned in a main scanning direction perpendicular to said auxiliary scanning direction so as to be exposed to the image, wherein said color filter means comprises three linear color filters extending parallel to said main scanning direction, said liquid crystal light valve comprising a plurality of pixel electrodes arranged in arrays corresponding respectively to said color filters, said pixel electrodes being staggered in said auxiliary scanning direction.

8. A video image printer according to claim 1, wherein said color filter means comprises a mosaic pattern of color filters of R, G, B.

9. A video image printer comprising:

a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal;

color filter means mounted on one end of said liquid crystal light valve;

a light source optically coupled to said one end of said liquid crystal light valve;

a film disposed on the side of an opposite end of said liquid crystal light valve and carrying a self-processing solution, said film being selectively exposable to an image that is formed by light from said light source through said color filter means and said liquid crystal light valve controlled by the applied video signal;

means for spreading the processing solution over the film which has been exposed; and,

means for feeding said film in an auxiliary scanning direction while said film is being scanned in a main scanning direction perpendicular to said auxiliary scanning direction so as to be exposed to the image, wherein said color filter means comprises a plurality of color filters of R, G, B, said color filters being arranged in parallel stripes extending in said auxiliary scanning direction.

10. A video image printer according to claim 1, wherein said light source comprises a rod-shaped light source.

11. A video image printer according to claim 1, wherein said light source comprises a combination of a point light source and a condenser lens.

12. A video image printer according to claim 1, wherein said light source comprises an electroluminescent panel.

13. A video image printer according to claim 1, wherein said light source comprises a plurality of juxtaposed linear light sources and a diffusion plate for diffusing light emitted from said linear light sources.

14. A video image printer comprising:

a liquid crystal light valve with a liquid crystal orientation thereof variable depending on an applied video signal;

color filter means mounted on one end of said liquid crystal light valve;

a light source optically coupled to said one end of said liquid crystal light valve;

a film disposed on the side of an opposite end of said liquid crystal light valve and carrying a self-processing solution, said film being selectively exposable to an image that is formed by light from said light source through said color filter means and said liquid crystal light valve controlled by the applied video signal; and,

means for spreading the processing solution over the film which has been exposed;

wherein said light source comprises a transmissive plate with diffusion layers disposed respectively on upper and lower surfaces thereof, a reflecting plate disposed in confronting relation to said transmissive plate, a pair of mirrors of parabolic cross section disposed one on each side of said transmissive plate and said reflecting plate, and a pair of linear light sources disposed respectively at the focal points of said mirrors.

* * * * *

[11] tent Number: **5,047,870**

Filo [45] **Date of Patent: Sep. 10, 1991**

[54] IMAGE REPRODUCTION SYSTEM UTILIZING SINGLE OPERATION SCANNING/REPRODUCING

[75] Inventor: **Andrew Filo, Cupertino, Calif.**

[73] Assignee: **Optum Corporation, Cupertino, Calif.**

[21] Appl. No.: **169,791**

[22] Filed: **Mar. 17, 1988**

[51] **Int. Cl.^{5}** **H04N 1/04**

[52] **U.S. Cl.** **358/472; 358/296; 358/909**

[58] **Field of Search** .... 358/286, 285, 294, 296, 358/101, 213.11, 213.12, 217, 906, 909, 471, 472, 474, 476, 229, 451, 482, 209; 346/76 PH; 382/59, 101

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,662,103	5/1972	Wildmer et al.	358/474
3,707,601	12/1972	Goble	358/476
4,075,664	2/1978	Aoki et al.	358/286
4,317,137	2/1982	Tompkins	358/286
4,319,283	3/1982	Ozawa et al.	358/286
4,375,916	3/1983	Levine	355/5
4,424,524	1/1984	Daniele	358/472
4,438,459	3/1984	Levine	358/258
4,492,966	1/1985	Seki et al.	358/296
4,495,523	1/1985	Ozawa	358/293
4,523,235	6/1985	Rajchman	358/256
4,574,317	3/1986	Scheible	358/285
4,609,946	9/1986	Thaler	358/286
4,611,246	9/1986	Nihei	358/256
4,630,127	12/1986	Fuwa	358/285
4,641,357	2/1987	Satoh	382/61
4,642,699	2/1987	Ohi	358/280
4,658,304	4/1987	Tsumekawa et al.	358/906
4,660,082	4/1987	Tomohisa et al.	358/163
4,667,252	5/1987	Nakamura et al.	358/286
4,700,238	10/1987	Ingiyama	358/283
4,714,966	12/1987	Saito et al.	358/906
4,731,667	3/1988	Watanabe et al.	358/286
4,737,858	4/1988	De Baryshe	358/296
4,748,516	3/1988	Harano et al.	358/286
4,777,533	10/1988	Watanabe	358/286
4,809,080	2/1989	Kotani et al.	358/
4,839,741	6/1989	Wilson	358/474
4,872,063	10/1989	Filo	358/474
4,905,090	2/1990	Miyake	358/296
4,920,421	4/1990	Stemmle	358/296

FOREIGN PATENT DOCUMENTS

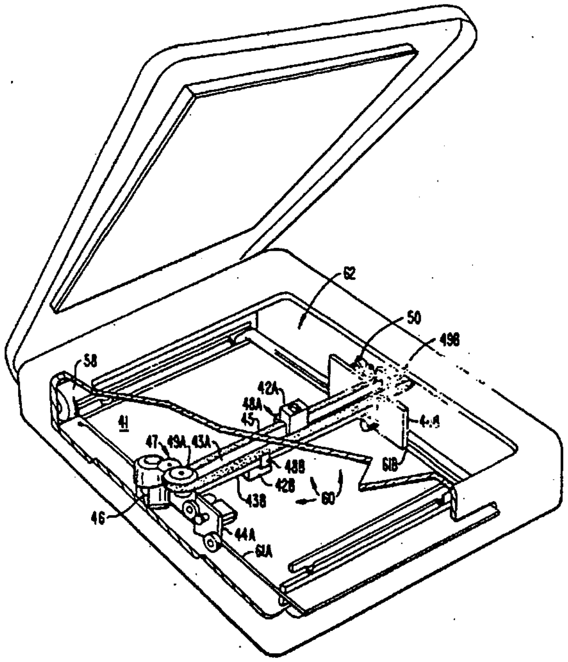
0129476	10/1981	Japan .
0005662	1/1985	Japan .

Primary Examiner—James J. Groody
Assistant Examiner—Kim Yen Vu
Attorney, Agent, or Firm—Keith Kline

[57] **ABSTRACT**

A scanning imaging system in which the viewing and reproduction functions are integrated into a single scanning head. The scanning system is economical in terms of cost and function, and is useful in many applications such as modem, photocopier and even photographic technologies.

24 Claims, 11 Drawing Sheets



L

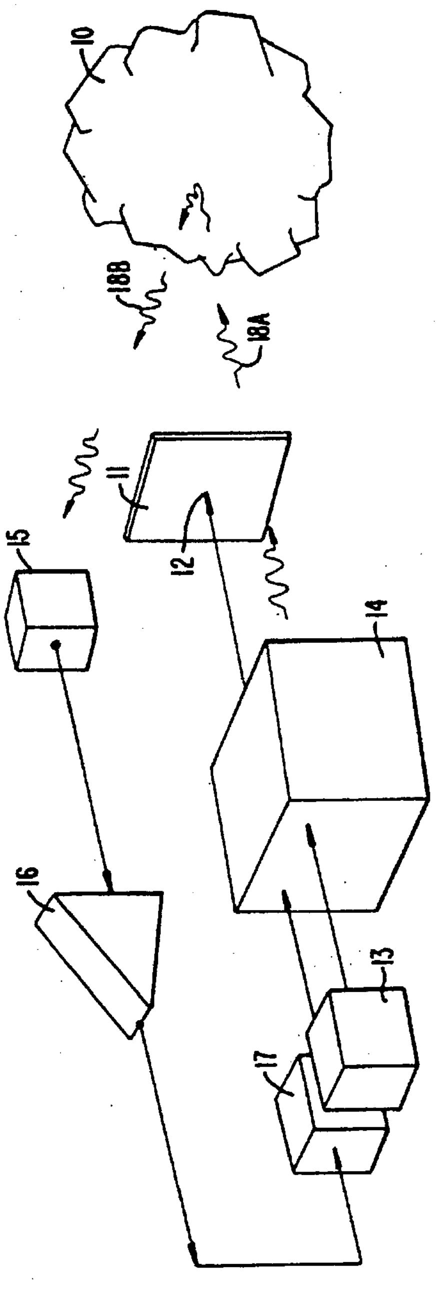


FIG._1.

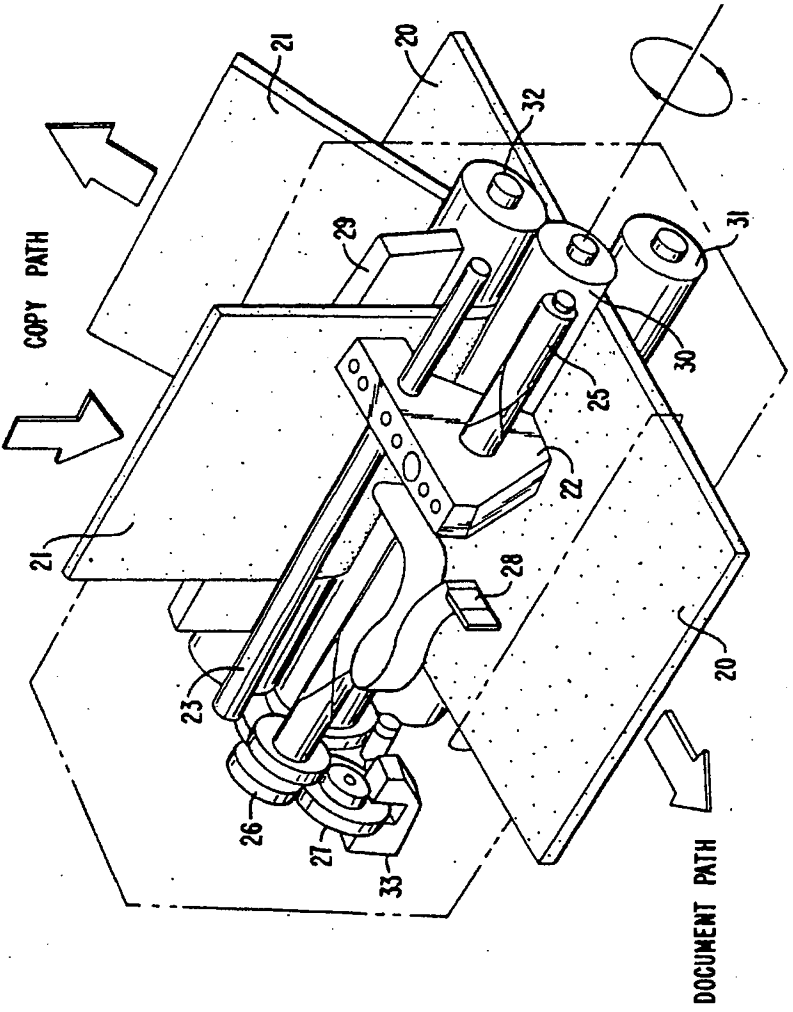

21
20
32
29
31
30
25
22
28
20
23
26
27
33
21
COPY PATH
DOCUMENT PATH

FIG._2A.

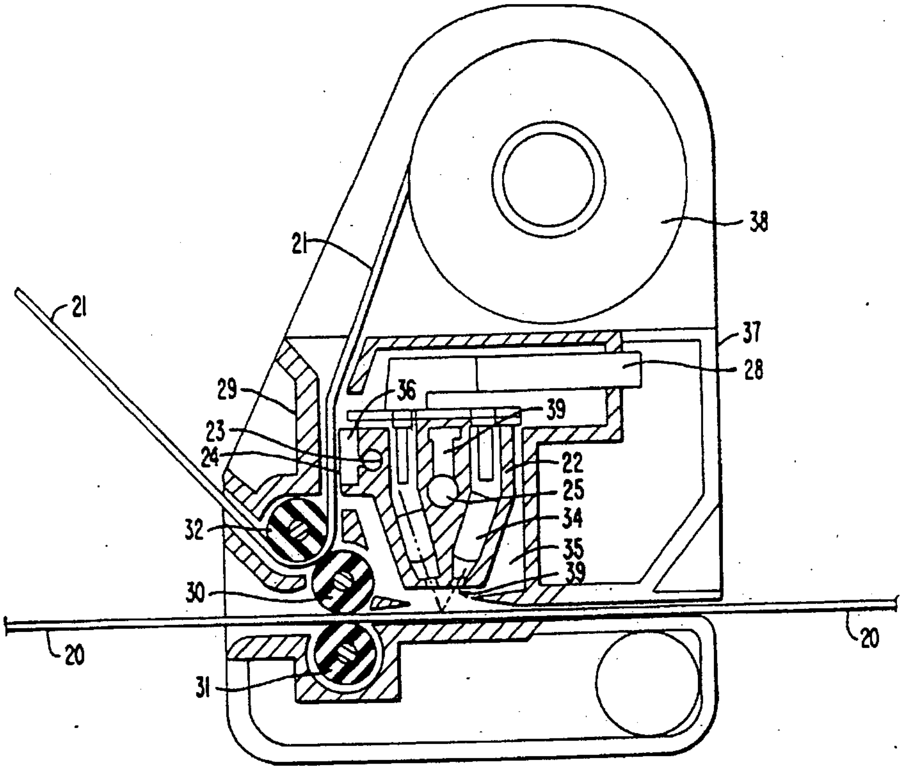


FIG._2B.

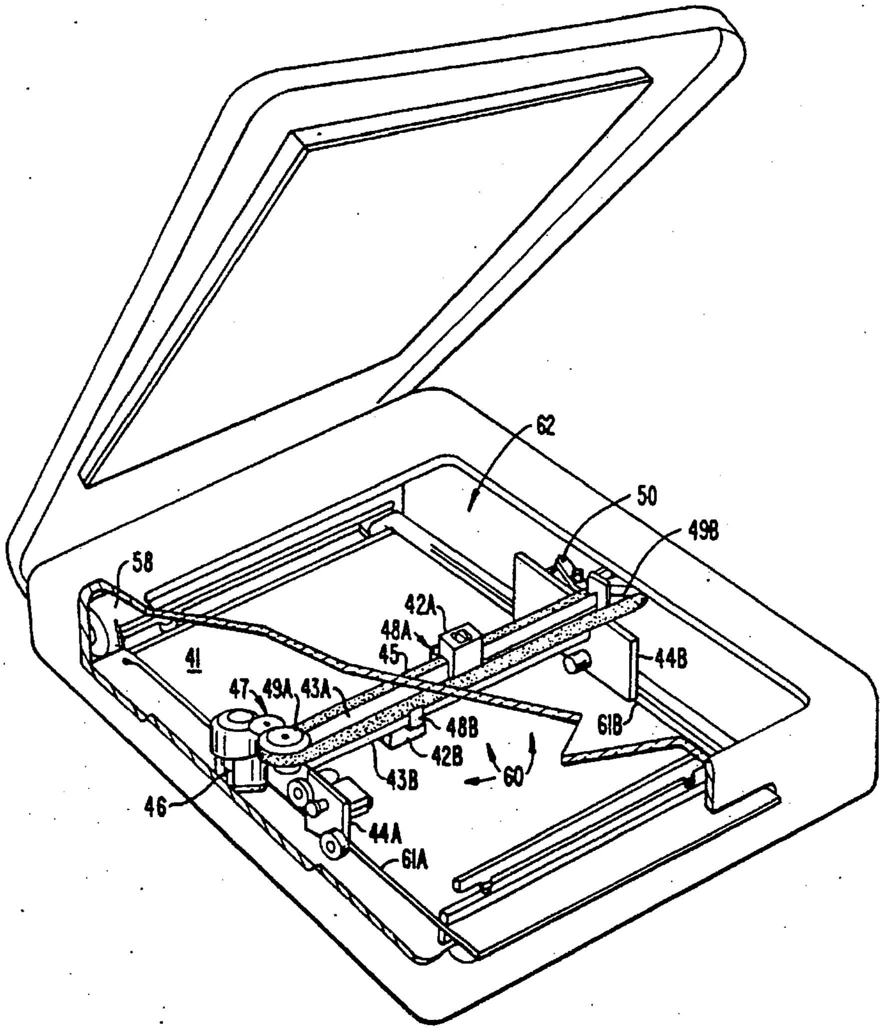

62
50
49B
58
42A
48A
45
44B
41
47
49A
43A
61B
48B
42B
60
43B
46
44A
61A

FIG._3A.

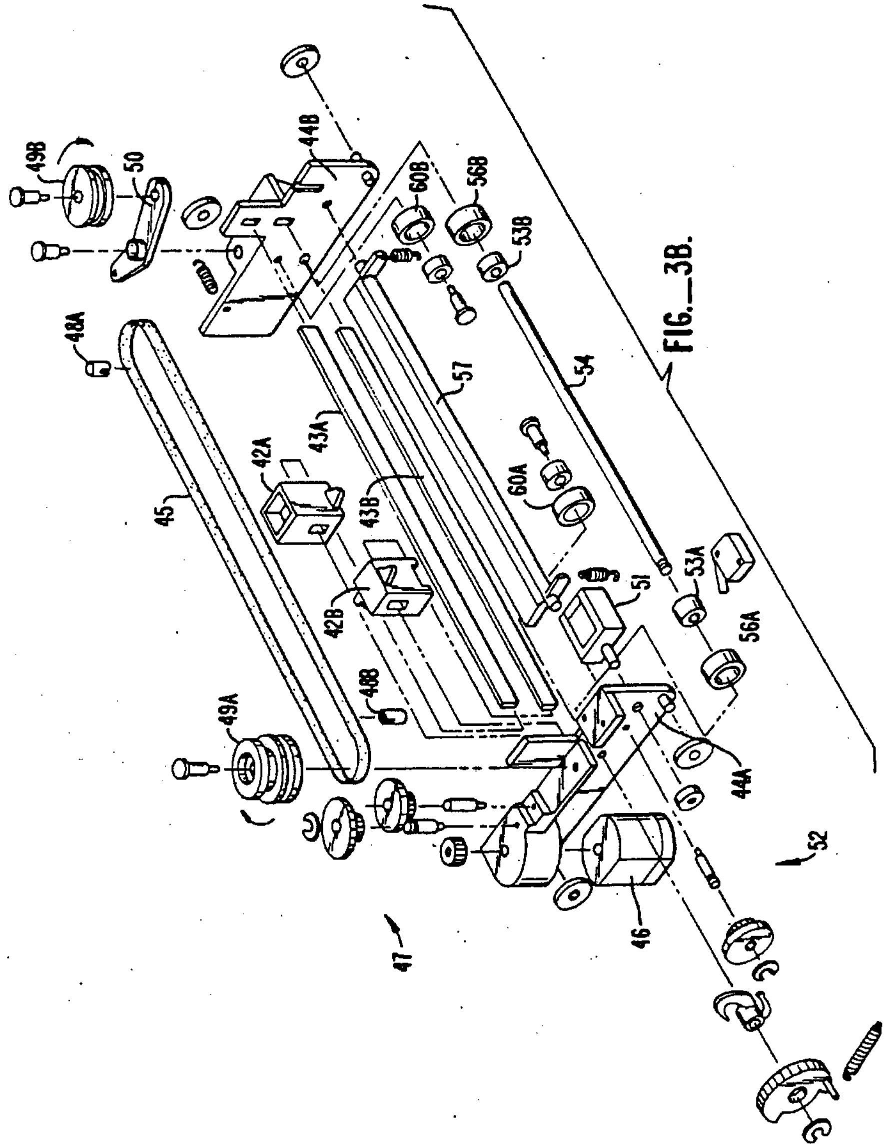

49B
50
44B
60B
56B
53B
48A
57
54
43A
42A
43B
60A
45
51
53A
42B
56A
48B
49A
44A
52
46
47

FIG.__3B.

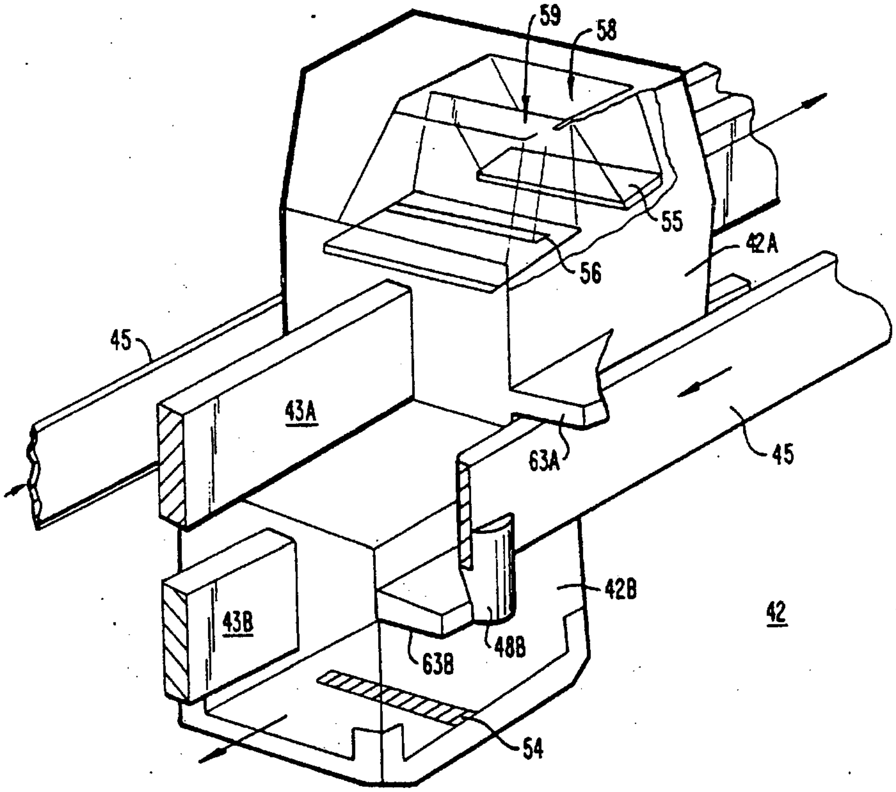


FIG._3C.

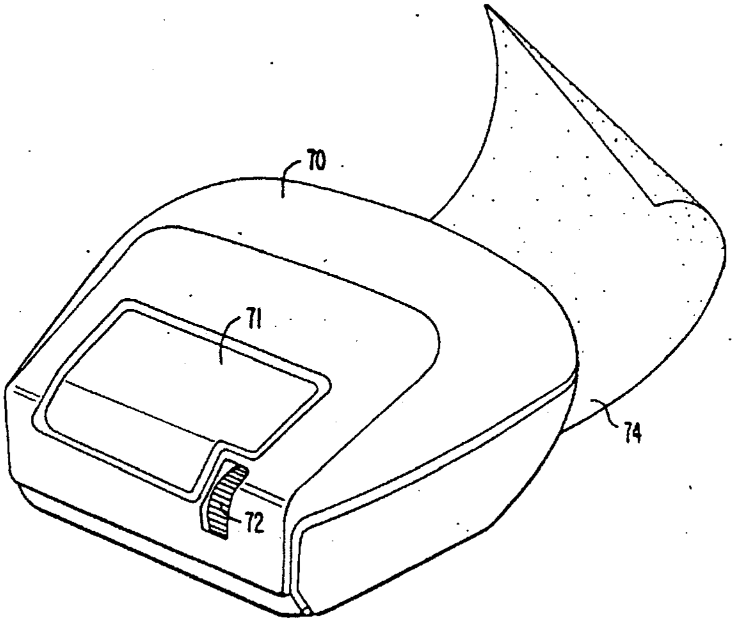


FIG._4A.

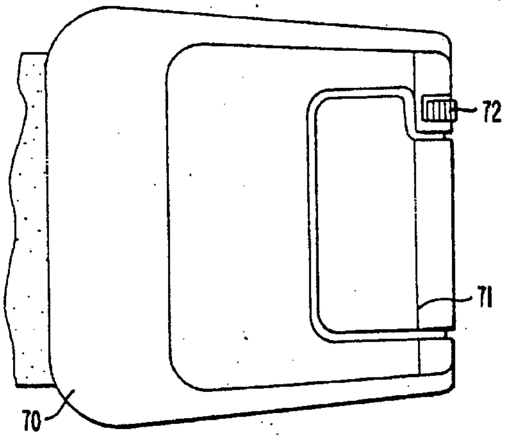


FIG._4B.

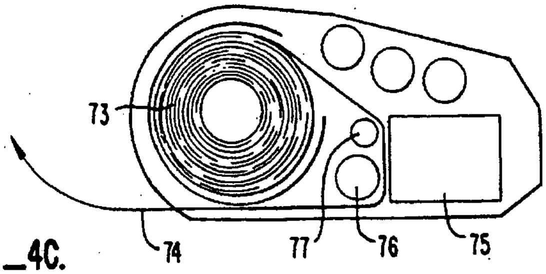


FIG._4C.

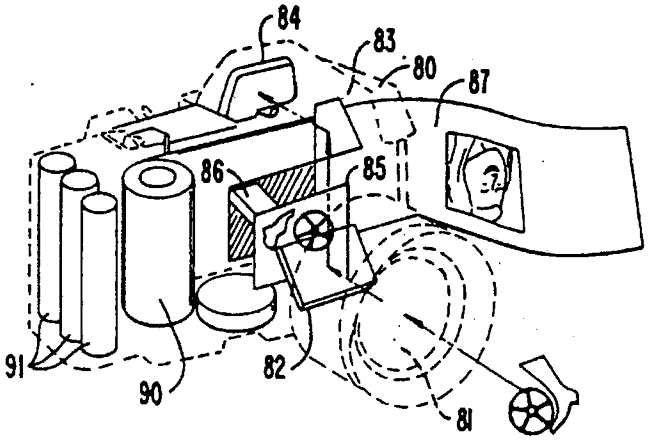


FIG._5A.

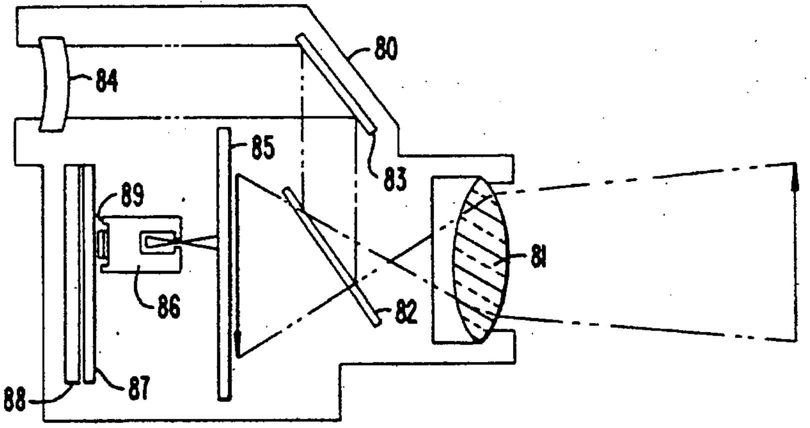


FIG._5B.

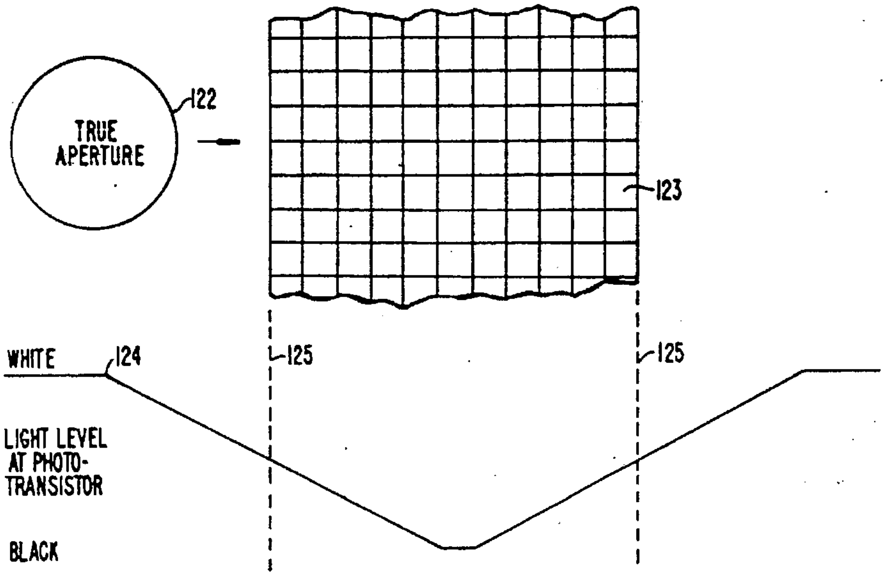

TRUE APERTURE
122
123
WHITE
124
125
125
LIGHT LEVEL AT PHOTO-TRANSISTOR
BLACK

FIG._6.

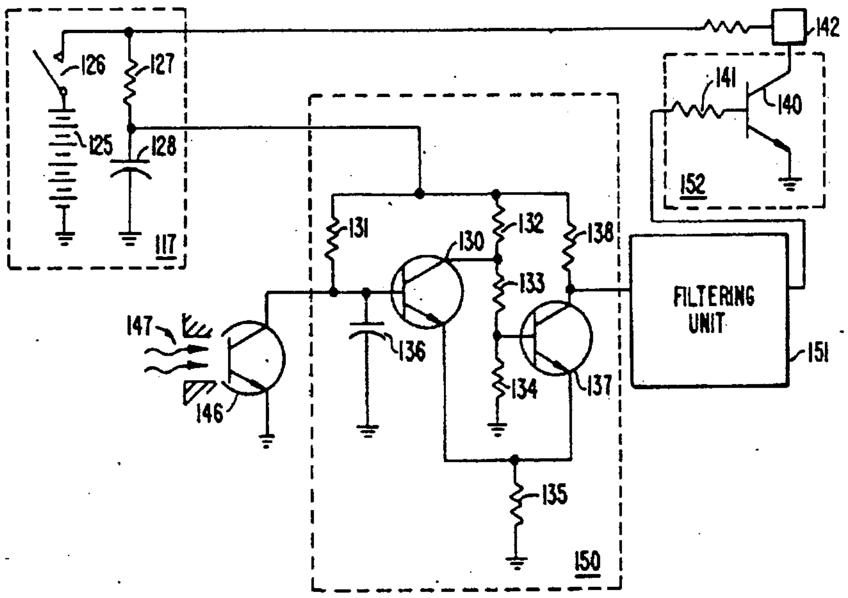

142
126
127
125
128
117
141
140
152
131
130
132
138
133
147
136
137
134
146
FILTERING UNIT
151
135
150

FIG._7.

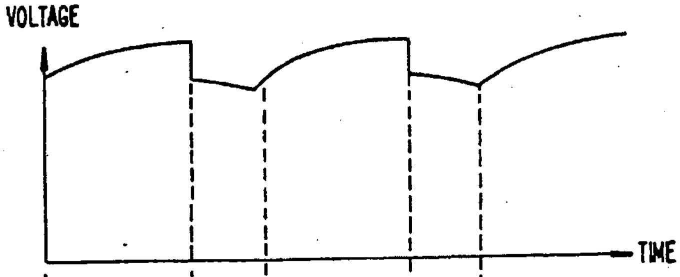


FIG. 8A
(A)
VOLTAGE SIGNAL
AT BASE OF
TRANSISTOR 130

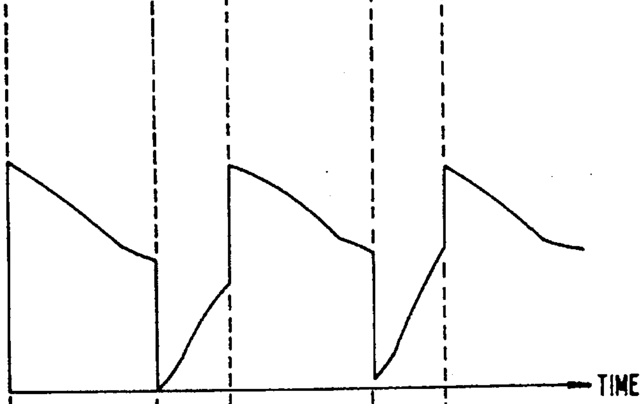


FIG. 8B
(B)
VOLTAGE SIGNAL
AT COLLECTOR OF
TRANSISTOR 130

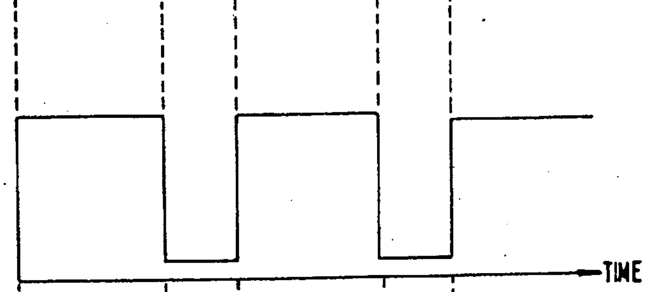


FIG. 8C
(C)
VOLTAGE SIGNAL
AT EMITTER OF
TRANSISTOR 130

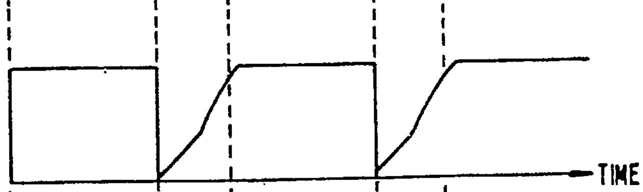


FIG. 8D
(D)
VOLTAGE SIGNAL
AT BASE OF
TRANSISTOR 137

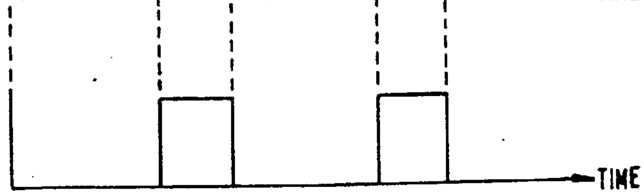


FIG. 8E
(E)
VOLTAGE SIGNAL
AT COLLECTOR OF
TRANSISTOR 137

FIG. 9A (A) VOLTAGE SIGNAL AT BASE OF TRANSISTOR 130

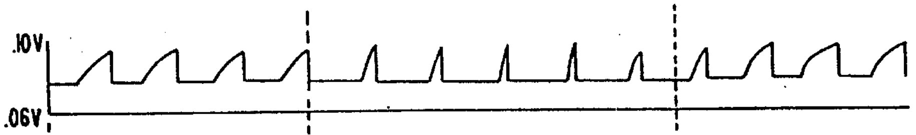


FIG. 9B (B) VOLTAGE SIGNAL AT COLLECTOR OF TRANSISTOR 130

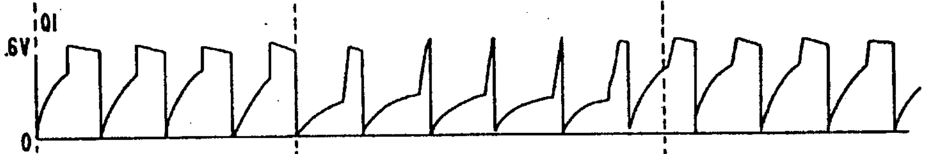


FIG. 9C (C) VOLTAGE SIGNAL AT COLLECTOR OF TRANSISTOR 137

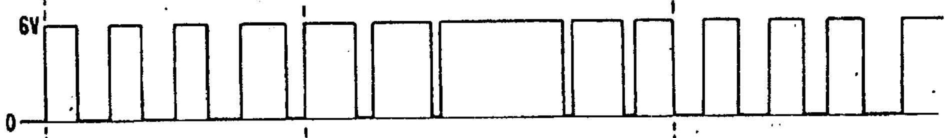


FIG. 9D (D) HEAT OUTPUT FROM PRINT HEAD

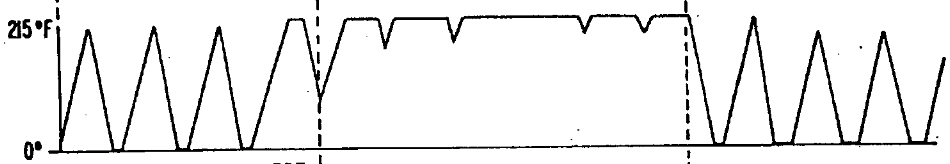
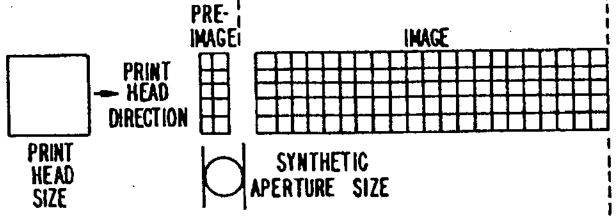


FIG. 9E (E) IMAGE ON THERMAL PAPER



COMBINED SCANNING/REPRODUCING HEAD

FIELD OF THE INVENTION

The present invention is related to systems by which objects are viewed by scanning and by which images are reproduced by scanning and, more particularly, to highly compact and integrated scanning imaging systems.

BACKGROUND OF THE INVENTION

Scanning systems have one or both functions of viewing objects and reproducing images of the objects on a medium. "Scanning" refers to the typical point-by-point method by which an object is viewed or an image is reproduced. An example of a scanning system which is used to "read" or view a restricted range of objects is the bar code reader which is often found in retail merchandising stores. With the sale of an item of merchandise, the reader is passed over a pattern of bars, the "object," attached to the item for a nearly instantaneous access of price information and an update of sales and inventory information.

An example of scanning system which is used to reproduce images is television. A television set uses a raster scan technique for creating images on the screen of a cathode ray tube.

The present invention is directed toward a scanning imaging system, i.e., a system by which an object is viewed by the system and an image is created by scanning. In general, the organization of a scanning imaging system has a radiation source element which directs radiation toward the viewed object, a detector element which receives the radiation reflected by the object and converts the radiation into electrical signals, an element for processing the electrical signals, and an imaging element for converting the processed signals into an reproduced image of the object.

Heretofore, scanning imaging systems have had different combinations of a detector element scanning the object with a source of radiation to perform the viewing function. Such combinations have included a detector element scanning with the radiation source element fixed with respect to the object or even with the radiation source element completely eliminated (where, for example, ambient light is used in place of the radiation source), or the detector element fixed and the radiation source element performing the scanning function.

In these systems the radiation source element, the detector element, and the reproduction element are treated as separate units of the system. In a few instances, the viewing elements (the source element and detector element) have been combined into one scanning unit, such as in the case of a bar code reader discussed above. However, the need for highly compact and integrated scanning imaging systems remains largely unsatisfied.

The present invention satisfies this need for a scanning imaging system which is not only compact, but also easily manufacturable and thus low in cost, high in performance with low power requirements. The present invention has the further benefit of being able to perform the viewing and reproduction functions simultaneously or separately as is required.

SUMMARY OF THE INVENTION

The present invention provides for a scanning imaging system in which the elements necessary for object viewing (the radiation source and detector) and the element for image reproduction (the reproduction element) are combined. With the combination of these elements, both reading and reproduction functions can be performed at the same time in one scanning operation. Besides the savings in operation time from image reading to reproduction, the present invention provides for savings in space and number of parts for a compact and low cost system. The system consumes less power since the scanning operation is performed once for both reading and reproduction functions.

Applications of the present invention include facsimile machines and photocopy machines which are highly compact and low-cost. For example, the present invention permits photocopy machines which are not required to employ expensive stepper motors or encoders for the scanning operation. Simple D.C. motors, mechanical springs and even manual power are sufficient.

Still another application is electronic photography. Thus the uses for the present invention are many.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed and more comprehensive understanding of the present invention may be achieved by perusing the following Detailed Description of Preferred Embodiments and the following drawings:

FIG. 1 illustrates the general organization of one embodiment of the scanning imaging system of the present invention.

FIG. 2A is a perspective view of a facsimile machine utilizing the present invention; FIG. 2B is a cross-sectional view of the facsimile machine in FIG. 2A.

FIG. 3A is a perspective view of photocopier utilizing the present invention in which original document and copy are arranged in opposition to each other; FIG. 3B is an exploded view of the scanner assembly of FIG. 3A; and FIG. 3C is a detailed view of the scanning head and subunits of FIG. 3B.

FIG. 4A is a perspective view of a pocket photocopier in the form of a mouse utilizing the present invention; FIG. 4B is a top view of the same photocopier, while FIG. 4C is a cross-sectional view.

FIG. 5A is a perspective view with broken away portions of an electronic camera using the present invention; FIG. 5B is a cross-sectional view of the camera of FIG. 5A.

FIG. 6 illustrates the problem of resolution posed by the width of an viewing aperture.

FIG. 7 is an embodiment of the synthetic aperture circuit of the present invention.

FIG. 8 shows the signal wave forms at various points of the periodic signal generation unit of FIG. 3.

FIG. 9 shows the modulation of the signal wave forms of FIG. 8 by the amount of light received through the viewing aperture.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 illustrates the various elements in a scanning imaging system according to the present invention. The system scans an object **10** and produces an image **12** of the object **10** on a medium **11**, such as paper. The system in FIG. 1 has a radiation source element **13** which is coupled with a scanning element **14** for the scanning operation. The radiation source element **13** produces radiation **18A** from the scanning element **14** to strike the object **10**. The radiation, typically light, is reflected by the object 10 and the reflected radiation 18B is received by a detector element 15 and transformed into electrical signals. The electrical signals are processed by a signal processing element 16 for a reproduction element 17, which is responsive to the signals. The reproduction element 17 is coupled to the scanning element 14 and reproduces the image 12 on the medium 11 as the object 10 is scanned.

Heretofore, the elements associated with the viewing function and the reproduction function have remained disparate in operation. The radiation source element and detector element have been attached to one scanning element to view an image of an object, while the reproduction element has been attached to another scanning element to reproduce the object's image.

As illustrated in FIG. 1, the present invention combines the viewing elements and reproduction element into one scanning head. Thus one scanning operation can perform both the reading function and the reproduction function. This combination lowers the number of parts for manufacture and reduces the amount and time of labor for assembly and as a result, reduces the cost of a scanning imaging system. Operationally, the present invention permits highly compact designs with high performance. For example, the viewing and reproduction functions of the system can be performed simultaneously.

In the specific organization shown in FIG. 1 only the radiation source 13 of the two viewing elements is associated with the scanning element 14. The detector element 15 could also be associated with the scanning element 14. As the scanning element 14 scans the object 10 by directing radiation from the source 13 to the object 10, the scanning detector element 15 receives the reflected radiation. At the same time the reproduction element 17 creates the image 12 on the medium 11.

Still another scanning imaging system may require only the detector element 15 and reproduction element 17 to be associated with the scanning element 14. A source of radiation may not be needed in such a system. For example, the radiation could be just ambient light which is reflected off the object 10. An example of such a system is shown below in the embodiment illustrated by FIG. 5A-5C.

Facsimile Machine

The facsimile machine shown in FIG. 2A and FIG. 2B illustrates the present invention and its advantages. The facsimile machine views the images on an original paper 20 (the object to be copied in the language of FIG. 1) for transmission to another facsimile machine. The image of an object transmitted from a distant facsimile is reproduced on a second sheet 21 of paper (the medium in the language of FIG. 1). The facsimile machine has a scanning head 22 (scanning element) which contains a light emitting diode 35 (radiation source element) and a phototransistor 34 (detector element) which receives the light reflected on the sheet 20. Neither the light emitting diode 35 and phototransistor 34 are shown in FIG. 2A; both elements are shown in FIG. 2B. The phototransistor 34 is connected by a cable 28 from the scanning head 22 to a signal processing circuit (not shown) which receives electrical signals from the phototransistor 34. The signal processing circuit sends the processed signals back through the scanning head cable 28 to a thermal printhead 24 also mounted on the scanning head 22.

For viewing, the original paper 20 passes between a drive roller 30 and an idler roller 31. The copy paper 21, upon which a reproduction is to be made or "printed," passes between the drive roller 30 and an idler roller 32. The motion of the original paper 20 is in the direction of the arrow denoted as the Document Path in FIG. 2A and the motion of the copy paper 21 is as denoted by the arrow marked Copy Path. Both motions occur as the drive roller 30 is driven around its long axis by a set of drive gears, which are not shown. The design of such drive gears is well known to those skilled in the art.

The scanning head 22 is mounted so as to slide along a guide rod 23 under power by the rotation of a helix rod 25. As the helix rod 25 is rotated by a set of drive gears 26, a pin 39 in the scan printhead 22 engages the grooves in the helix rod 25 so that the scan printhead 22 moves back and forth perpendicular to the motion of the document sheet 20 and the copy sheet 21.

The position of the scanning head 22 is obtained by an encoder wheel 27 which is coupled to the drive gear 26. As the drive gear rotates in one direction or another, the encoder wheel 27 likewise rotates. As the encoder 27 rotates, a set of apertures around the edge of the encoder wheel 27 passes between an encoder unit S3 which has a light emitting diode and a phototransistor on the other side. The flickering of the light from the light emitting diode through the apertures in the encoder wheel 27 permits the encoder unit to determine in what direction the drive gear is rotating and the amount of rotation, as is known in the art.

FIG. 2B, a cross-sectional view of a facsimile machine of FIG. 2A, shows some of these details in the housing 37 of the device. The copy sheet 21 comes from a roll 38 of thermal paper. The drawing also shows a cross-section of the scanning head 22, which contains the light emitting diode 35 whose reflected light is detected by the phototransistor 34, also mounted on the scanning head 22. The phototransistor 34 is responsive to the light passing through a viewing aperture 39. Both the light emitting diode 35 and the phototransistor 34 are connected to electrical sources of power through the cable 28. The phototransistor 34 is also connected to the signal processing circuit, which is discussed below in detail.

The reproduction element is a thermal printhead 24 which is mounted on a backing 36. The backing 36 acts as a thermal sink for the heat from the printhead 24 and ensures that the marks on the paper 21 remain localized for high image resolution.

Though the description of the viewing operation of the original paper 20 has been described separately from the reproduction operation on the copy paper 21, it should be readily apparent that the combination of these two operations changes the facsimile machine previously described into a photocopy machine. The paper 21 becomes a "copy" of the original paper 20. Moreover, the present invention permits the reproduction of images upon the copy paper 21 to occur simultaneously as the original paper 20 is viewed.

Furthermore, it should be noted that possible variations to the single radiation source element and photodetectors are linear arrays of such elements. In such a case, the number of print elements corresponds to the number of arrayed elements.

Photocopy Machine

FIGS. 3A-3C illustrate a photocopy machine utilizing the present invention. The device is in and form of a flat slate for a lightweight, portable and inexpensive photocopier as shown in FIG. 3A. The machine copies the images (again, the objects according to previous language) on an original sheet onto a sheet 41 below from a roll of paper 58. The original sheet is placed on a clear plate 62 forming most of the top surface housing of the photocopier. The illustration in FIG. 3A removes most of the housing of the photocopy machine to show the internal workings of the photocopy mechanism.

The photocopy machine of FIG. 3A has a scanning assembly 60 mounted on a pair of rails 61A, 61B on the sides of the photocopy machine housing. After being pulled into a starting position at one end of the housing, the scanning assembly 60 begins operation. The pulling action also pulls the sheet 41 off the roll 58 of thermal paper. Then a scanning head 42 on the assembly 60 begins a side-to-side action between the side plates 44A, 44B. The assembly 60 drives itself in a direction perpendicular to the motion of the scanning head 42 back toward its rest position toward the roll 58. Thus, the scanning head 42 views the original sheet and copies onto the oppositely positioned sheet 41.

A more detailed view of the scanning assembly 60 and head 42 is in FIG. 3B. The scanning head 42 has two subunits 42A and 42B, one of which contains elements for viewing and the other element for reproduction. The subheads 42A and 42B are coupled together by a drive belt 45, which is powered by a belt drive roller 49A mounted to the first side plate 44A. The drive roller 49A is rotated by a set of gears 47 and a drive motor 46 which is connected to the first side plate 44A. The other end of the drive belt 45 rotates on an idler roller 49B which is, in turn, mounted to an idler arm 50. The idler arm 50 is spring-loaded so that the drive belt 45 is under constant tension.

The scanner assembly 60 drives itself perpendicularly to the reciprocal motion of the subunits 42A and 42B by a pair of drive rollers 56A and 56B which are connected by drive rod 54. The sheet 41 of copy paper is pressed against the rollers 56A, 56B by a pair of pinch rollers 60A, 60B which are respectively mounted to the side plates 44A, 44B. The scanning assembly 60 is driven in the transverse direction by the rotation of the drive rollers 56A, 56B under power of a drive motor 51A through a set of drive gears 52 until the end position is reached.

The subunits 42A, 42B slide along the guide bars 43A, 43B respectively between the side plates 44A, 44B. For movement the subunit 42A has a pair of wings cams 63A, 64A (not shown), and the subunit 42B has a second pair of wing cams 63B, 64B (not shown). Each of the wings cams of a pair have an inclined surface which face in opposite directions. The wing cams 63A, 64A on the subunit 42A engage an upper drive pin 48A attached to the upper edge of the drive belt 45. The wings cams 63B, 64B on the subunit 42B engage a lower drive pin 48B which is attached to the lower edge of the belt 45.

As the belt 45 is driven, the drive pins 48A, 48B respectively engage the wing cams on the subunits 42A, 42B. As shown in FIG. 3C the lower drive pin 48B engages one (63B) of two wings cams on the subunit 42B. The belt 45 and pin 48B drives the subunit 42B along the lower guide bar 43B until the subunit 42B encounters the side wall 44A. At this point the pin 48B slides along the inclined surface of the wing cam 63B away from the subunit 42B and off the cam 63B. The pin 48B rotates around the drive roller 49A and travels back in the opposite direction to engage the wing cam 64B (not shown) on the opposite side of the subunit 42B. The subunit 42B then is driven in the opposite direction to the second side wall 44B. Then the pin 48B disengages itself from the wing cam 64B, rotates around the idler roller 49B to engage the wing cam 63B again. In this manner the subunit 42B is driven back and forth between the two side plates 44A, 44B.

The upper drive pin 48A attached to the drive belt 45 is directly opposite from the lower drive pin 48B. In the same manner as described with respect to the subunit 42B, the subunit 42A is driven back and forth between the side plates 44A, 44B. The timing of the movement of the subunit 42A, however, is reciprocal to that of the subunit 42B.

The subunit 42A contains the elements for the viewing function, i.e., a linear array 55 of light-emitting diodes as a source of radiation and a linear array 56 of phototransistors to receive the light reflected from the original paper 40. The LED array 55 illuminates the sheet 40 through a rectangular aperture 58; the array 56 of phototransistors receives the reflected light through a second rectangular aperture 59, which is contiguous to the first aperture 58.

The subunit 42B contains the reproduction element in the form of a linear array 54 of thermal printheads. The number of printheads in the array 54 corresponds to the number of phototransistors in the array 56. Each printhead is responsive to the signals from one of the phototransistors in the subunit 42A. The connection between individual printheads and phototransistors is arranged so that images produced on the copy sheet 41 are reproductions of the images on the original sheet.

Variations of a photocopier unit may be made using the present invention. For example, where the photocopier in FIG. 3A and 3B drives the original paper past the scanning head 42 by motor power, a spring may be used.

As shown in FIGS. 4A, 4C, the present invention allows for highly compact photocopiers. The small, pocket photocopier in FIGS. 4A-4B is in the form of a "mouse" commonly used with personal computers. The pocket copier has an external housing 70 having a flat button 71 for switching the copier on. An adjustable roller switch 72 controls the contrast for the reproduction of images on the copier paper 74.

FIG. 4C shows a cross-sectional side view of the pocket copier. Internally the copier contains a roll 73 of thermal paper passing by a drive roller 77 and idler roller 76. The idler roller 76 provides the necessary backing for a scanning head 75.

The pocket copier is operated by slowly pushing the copier over an original document. As the copier is pushed forward (the direction faced by the flat button switch 71), the strip of thermal copy paper 74 is unrolled from the roll 73 past the scanning head 75. The scanning head 75 moves back and forth scanning the images on the original document below and copying the perceived images on the part of the original document covered by the pocket copier onto the copy paper 74. Power for the scanning head 75 is provided by a friction roller, which engages the document below and rotates as the copier is pushed forward.

An alternative to the moving scanning head 75 is a scanning head having a linear array of light-emitting diodes, phototransistors and thermal print elements arranged perpendicular to the motion of the pocket copier. Such a pocket copier has the advantage of a smaller number of moving parts.

Electronic Camera

The scanning imaging system of the present invention is not limited only to facsimile machines and photocopiers. FIG. 5 illustrates a camera for instant electronic photography. The camera, as shown in a perspective view of FIG. 5A, has a housing 80. The camera also has a lens 81 which focuses the image by a beam splitter mirror 82 upon a view finder 84 through a mirror 83. The beam splitter mirror 82 also permits the image to be focused upon a projection screen 85. The purpose of focusing the image on the screen 85 is to provide an image that can be easily scanned. All these elements are common to present day single lens reflex cameras.

The present invention provides additionally for a scanning head 86 which scans the focused image on the projection screen 85 and reproduces the image by a thermal printhead 89 upon a sheet of thermal paper 87. The thermal paper 87 passes between a backer 88 and the thermal printhead 89. It should be noted that since the printhead converts the focused image on the projection screen 85 to electrical signals before sending them on to the thermal printhead 89, the set of electrical signals corresponding to the focused image can be optionally stored in an electronic memory for later reproduction. Hence, the present invention permits instant electronic photography by which images can be reproduced immediately or stored for later reproduction.

FIG. 5B shows a cross-sectional view of the electronic camera of FIG. 5A to illustrate the relationship between the scanning head 86, the thermal paper 87, and the backer 88.

Signal Processing Circuit

For a signal processing element the present invention provides for a signal processing circuit which acts as a synthetic aperture circuit for increasing the resolution of an aperture receiving radiation from an object for the more accurate reproduction of an image of the object.

A problem with all scanning systems is that the aperture which receives the radiation from the object is necessarily of a finite size. Ideally, the size of the aperture should be infinitely small so that the image of the object is scanned point-by-point. Without an infinitely small aperture, the image of the scanned object is distorted. This degrades the resolution of the scanning system.

Prior efforts to improve the resolution of apertures in scanning systems have used optical components, such as lenses, optical fibers, mirrors, and prisms, to create a focused image of the object received by the scanning system. However, these components require particular attention to their shapes and the relative positioning of the components between themselves and the photodetector. All these concerns add to the cost of the scanning system.

The present invention provides for an efficient and economical way of increasing the scanning resolution of the scanning aperture without the use of optical components.

FIG. 6 illustrates this problem of aperture resolution. Since any photodetector is necessarily responsive to radiation over a certain amount of area, all scanning systems have limitations of resolution caused by the scanning aperture size, or more precisely, the width of the aperture in the scanning direction.

FIG. 6 shows a viewing aperture scanning from left to right with respect to an image 123. A line 124 indicates the amount of light being received by a photodetector, such as a phototransistor, through the aperture 122. The intensity of the light begins to drop as soon as the forward or right edge of the aperture 122 encounters the left edge of a dark object 123. As the aperture 122 continues its scan, more and more of the dark object appears before the aperture 122 and the light intensity continues to fall. When the aperture 122 is completely blanketed by the object 123 the light level reaches its minimum. However, as soon as the forward edge of the aperture 122 reaches the right hand edge of the dark object 123, the light intensity begins to rise again. The net result is that a dark image having definite edges on a white background is perceived as an image with varying shades of grey having an apparent width in the scan direction of two times the diameter of the aperture 122 plus the true width of the object 123 in the scan direction. Thus image resolution is low.

The use of a comparator to discriminate the light intensity signals into white or black at a predetermined level does not solve all the problems of restoring resolution. For example, the comparator having a discrimination level halfway between the "white" and "black" levels represented in FIG. 6 prevents features having widths up to the diameter of the aperture from being reproduced. Furthermore, techniques which can be used to detect features smaller than the aperture diameter lead to further difficulties. The discriminator can be set at level very close to the "white" level, for example. However, this leads to distortions of the reproduced image. Additional techniques which may be used to compensate for the size and direction of the features of objects to be reproduced add complexity to the scanning system.

A synthetic circuit as detailed below increases image resolution at low cost and is particularly adapted for the scanning of objects at a fixed distance from the scanning aperture, such as found in the facsimile and photocopy machines described above. For the particular embodiment discussed below, the present invention increases the resolution of the viewing aperture such that the true diameter of the aperture appears to be reduced to that of an aperture nearly one-third smaller. The size of the viewing aperture 39 in FIG. 2B and the viewing aperture 59 in FIG. 3 is effectively reduced. Resolution of the images reproduced is greatly increased.

FIG. 7 shows an embodiment of the synthetic aperture circuit of the present invention. The synthetic aperture circuit is placed in the signal processing unit 16 of a scanning imaging system, such as illustrated in FIG. 1. The circuit has basically three parts, a periodic signal generation unit 150, a filtering unit 151 and a driver unit 152, which are connected to a power supply unit 117.

The periodic signal generation unit 150 is coupled to a phototransistor 146 which receives the radiation (light) through a scanning aperture 147, which is symbolically shown. The phototransistor 146 is exemplary of the phototransistor 34 in FIG. 2B and each phototransistor in the linear array 56 in FIG. 3C. The unit 150 generates a periodic signal which has a duty cycle which is responsive to the phototransistor 146 and the amount of light the phototransistor is receiving.

The unit 150 is coupled to the filtering unit 151 which generates an output signal responsive to the duty cycle of the periodic signal. The filtering unit discriminates between "black" and "white" when the duty cycle is at a certain predetermined amount, 50%, for example. As explained below, in some embodiments a filtering unit

151 in itself is not used. However, the filtering function is still performed by other circuit elements.

The filtering unit 151 is coupled to the driver unit 152. The unit 152 conditions the output signal from the filter unit 151 to drive a reproduction element 142, such as a thermal printhead discussed with respect to the facsimile and photocopy machines above, or even an acoustic unit for modem communication over telephone lines.

The particular details of the periodic signal generating unit 150 are as follows. A first transistor 130 has its base electrode connected to the collector electrode of the phototransistor 146. The base electrode of the transistor 130 is also connected through a resistor 131 to the power supply 117 and connected to ground through a capacitor 136. The emitter electrode of the transistor 130 is connected to ground through a resistor 135, while the collector electrode of the transistor 130 is connected to the power supply 117 through a resistor 132.

The unit 150 also has a second transistor 137 which has its base electrode connected to the collector electrode of the transistor 130 through a resistor 133 and connected to ground through another resistor 134. The emitter electrode of the transistor 137 is connected in parallel to the emitter electrode of the transistor 130 to ground through the resistor 135. The collector electrode of the transistor 137 is connected through a resistor 138 to the power supply 117.

A periodic signal is generated by the switching of the first transistor 130 "off" and "on" (in the sense of operating the transistor in the linear region where it can be saturated, or respectively biased to an off condition) through the charge and discharge of the capacitor 136. The second transistor 137 operates to amplify the output signal of the transistor 130 in a complementary fashion, i.e., when transistor 130 is high, the output of the second transistor 137 is low and when the transistor 130 is low, the output of the transistor 137 is high.

The operation of the unit 150 is illustrated in FIGS. 8A–8E which details the waveforms of the voltage signals at various nodes of the circuit 150 having particular values for the circuit elements. The transistors 130, 137 are discrete transistors, part no. 2N2222, with the resistor 131 having an adjustable value of 500 to 1000 Kohms, the resistor 132 having a value of 4.7 Kohms, the resistor 133 1 Kohms, the resistor 134 6.7 Kohms, the resistor 135 47 ohms, and the resistor 138 1 Kohms. The capacitor 136 has a capacitance of 10 pFs. It should be noted that the resistance 131 is adjustable to provide an adjustable contrast for the images to be reproduced.

Assuming that the transistor 130 is off, the capacitor 136 and the base electrode of the transistor 130 begins to charge by the current through the resistor 131 and the leakage current through the resistor 132 and reverse biased collector-base junction of the transistor 130. The voltage at the base electrode becomes higher and higher as the capacitor 136 charges until the transistor 130 turns on. At this point the voltage at the base electrode drops and the discharge of the capacitor begins. Since the transistor 130 is now on, the current through the resistor 132 is such that the voltage on the base electrode of the second transistor 137 is lowered to turn that transistor off. With the transistor 137 off, the amount of current through the resistor 135 is decreased which permits further discharge of the capacitor 136. Finally, the discharge of the capacitor 136 is such that the voltage on the base electrode of the transistor 130 is so low so that the transistor 130 turns off and the charging of the capacitor 136 begins once more. The charge and discharge cycle of the base electrode of the transistor 130 is shown in FIG. 8A.

The output signal at the collector electrode of the transistor 130 is shown in FIG. 8B. When the transistor 130 is biased nominally off, the voltage at the collector electrode (the voltage between resistors 132 and 133) drops as the charge at the base electrode of the transistor 130 builds. This voltage drop is due to the fact that the transistor 130 is not truly off, but actually operating in the linear region. Thus, more and more current is drawn through the resistor 132 as the charge on the capacitor 136 builds until the transistor 130 is saturated on. At this point, the voltage of the collector electrode drops near ground.

After the initial surge through the transistor 130, less current enters the base of the transistor 130 and the amount of current drawn through the resistor 132 and the collector electrode falls, thereby causing the voltage at the collector electrode to rise. The rise continues until the transistor 130 is "biased off" in its linear region. The charge on the capacitor 136 once again builds for another cycle.

FIG. 8D illustrates the state of the transistor 137. When the transistor 130 is fully off, the transistor 137 is on and the voltage at the base electrode of the transistor 137 is a constant, due to the base-emitter voltage drop and the small resistance of the resistor 135. When the transistor 130 is on and the transistor 137 is off, the base electrode of the transistor 137 tracks the voltage of the collector electrode of the transistor 130 because the transistor 137 is off.

The resulting output signal of the transistor 137 is shown in FIG. 8E. Note that the signal now is more or less a square wave with the signal high when the transistor 130 is on and the transistor 137 is off. The original signal at the base of the transistor 130 of a few tenths of a few hundredths of a volt has been amplified to a voltage swing of about 6 volts and shaped into a square wave format.

Images are picked up by the modulation by the phototransistor 146 of the signal at the base electrode of the transistor 130. The amount of incident radiation received by the phototransistor 146 turns the transistor 146 off and on to thereby affect the rate of charging of the capacitor 136. When a large amount of incident radiation is received by the phototransistor 146, for example, the scanning of a white area, more time is required for the capacitor 136 to charge. This is due to the fact that the phototransistor 146 diverts some of the current through the resistor 131 and the resistor 132 (through the reversed biased base-collector junction of the transistor 130).

This modulation of the charging cycle of the capacitor 136 (as the scanning aperture 147 makes the white-to-black-to-white transitions of FIG. 6) is shown in FIG. 5A. What results is a modulation of the length of time the output signal from the collector of the transistor 137 is high. That is, the duty cycle of the periodic signal generated is modified by the amount of light received by the phototransistor 146. It should be noted, though, that the period of the cycle is not necessarily constant. It has been found to change by approximately 20%. This modulation of the duty cycle of the output of the unit 150 is used to resolve the image which is received through the scanning operation of the phototransistor 146.

The modulated signal from the periodic signal generation unit 150 is fed into the filtering unit 151. The filtering unit 151 operates as a low-pass filter, a type of circuit well known to those skilled in the electronic circuit field. The unit 151 transmits a signal to the driver unit 152 indicative of a "black" reading when the duty cycle of the modulated signal of the unit 150 exceeds a certain level. At this point the driver unit 152 switches to turn on the reproduction element 142.

The filtering operation of the modulated periodic signal from the unit 150 can be performed by specialized circuits, such as a circuit for pulse width modulation to generate either audio and electrical signals for modem signals according to CCITT T1 or T2 standards. A linear array of phototransistors 146 with corresponding periodic signal generation units 150 can be used for the higher performance CCITT T3 applications.

The filtering unit 151 may even be eliminated in certain applications, such as in lower performance photocopy machines. FIG. 9D illustrates the heat of a thermal printhead which is used as the reproduction element 142. The printhead receives the signal from the driver transistor 140 of the driver unit 152, which in turn receives the modulated signals directly from the periodic signal generation unit 150 without the intervention of the filtering unit 151. As indicated by the sawtooth wave forms, the printhead has a definite response time, i.e., a time for the print head to heat up to a maximum temperature and then fall. By a matching of the RC time constant and frequency of the unit 150 and the response time of the print head, the print head itself, the output device, acts as a filtering circuit which is responsive to the particular duty cycle from the output signal on the circuit 150. As indicated in FIGS. 9C and 9D, the thermal head remains on to a greater or lesser degree when the duty cycle of the output signal exceeds a certain amount. The image is reconstructed upon heat-sensitive paper matched to the thermal head. In this way, the output device and the filtering circuit are combined into one. Filtering is performed thermally, rather than electronically.

Matching or adjustment of the particular thermal printhead (with its particular thermal mass) to the sensitivity of the thermal paper and the scanning speed of the printhead also improves the reproduced image. By a proper matching it is possible to create image features on the thermal paper which are narrower than the width of the printhead. FIG. 9E illustrates a possible effect in the present imaging system. A "pre-image" appears before the image proper due to the heating cycle of the printhead as it reaches the image. By a matching the pre-image can be minimized. The pre-image is smaller than the size of the printhead and is indicative of the resolution of the matched printhead.

The net result for the embodiment above is that an imaging aperture of 0.021 inches operates as an aperture of only 0.0085 inches in diameter. The apparent or synthetic aperture has resolution three diameters finer than its true size. This technique has the further advantage that the imaging aperture is not required to contact the viewed object, such as the case of bar code readers. In the case of facsimile machines and photocopiers, the present invention allows the aperture to be displaced 0.125 inches or greater from the original document surface thereby avoiding many problems if contact were required.

Thus, by matching the requirements of a particular scanning system with the actual limitations of the phototransistor and its output device, the present invention can effectively reduce the aperture of a scanning head in the scanning direction for a very high degree of resolution.

The resolution of the circuit is dependent upon the period of oscillation of the transistor 130. This period is dependent upon the charge and discharge cycle of the capacitance element 136, which is determined by the RC time constant for the periodic signal generation unit 50, where C is the capacitance of the capacitance element 136 and R is the total resistance of the current path charging the element 136. The RC time constant for a particular application is determined by multiplying the desired resolution, the dots per inch, by the scan rate, the speed at which the scan head moves across the area to be scanned. This product yields a maximum image frequency. The maximum image frequency is multiplied by an arbitrary factor, say 3, to provide an adequate resolution. This yields the required RC time constant. It should be noted that this is a theoretical calculation and that in practice the response time of the phototransistor 146 must be accounted for. Furthermore, the response time of the device reproducing the scanned object must also be considered as discussed above. If the response time of the phototransistor or the image reproduction device is too long, then it cannot provide the desired resolution of the image which is reproduced.

The frequency of the periodic signal can be increased by making the capacitance element 136 smaller. The reduction in capacitance reduces the RC time constant and makes the frequency of the oscillation of the transistor 130 higher. However, a practical limitation of about 1 pF for capacitance element 136 exists for the particular discrete element embodiment of the periodic signal generation unit 150 discussed previously. For smaller capacitances and higher frequencies, an integrated circuit form of the periodic generation unit 150 avoids many of the problems of higher frequency, such as parasitic capacitances and uncertain response times of the transistors. In an integrated circuit parasitic capacitances may be accounted for and used as a capacitance element.

At higher frequences the wave forms of the signals of the previously discussed embodiment of the unit 150 are essentially the same as those in FIG. 9 with some variation in the period and amplitude of the signals. The particular shapes of the signals are also slightly different. Most of these changes can be attributed to the peculiarities of the response of the transistors 130, 137. The linear bias and switching regions shift with frequency. Also, the magnitude of the signals produced diminish with greater speed (slew rate). However, the circuit remains operational if these variations are accounted for.

It should also be evident that while the synthetic aperture circuit has been described with respect to a single phototransistor (and single print head), the circuit can be applied to linear arrays of phototransistors (and print heads), such the portable photocopy device of FIGS. 3A, 3B and 3C.

Therefore, while the present invention has been described with respect to particular embodiments, the present invention should be considered limited only by the meets and bounds of the appended claims.

What is claimed is:

1. A system for reproducing on a medium an image of an illuminated object, said system comprising:

means for detecting reflected illumination from said object by scanning in a first plane, said means generating signals responsive to the detected illumination,

means for processing signals from said detecting means, wherein said signal processing means includes means for increasing the resolution of said detecting means, and

means associated with said detecting means and responsive to said processing means, for reproducing images in a second, non-coplanar, plane fixed with respect to said first plane on said medium,

whereby said reproducing means creates said image on said medium by the scanning of said detecting means, and whereby,

said reproducing means creates said image as said detecting means scans said object thus requiring no storage of the signal generated by said detecting means.

2. The system as in claim 1 wherein said resolution increasing means comprises a circuit responsive to signals from said detecting means, said circuit having

means coupled to said detecting means for generating a periodic signal, the duty cycle of said periodic signal responsive to said detecting means; and

means coupled to said generating means for generating an output signal responsive to said duty cycle.

3. The system as in claim 2 wherein said detecting means comprises a phototransistor.

4. The system as in claim 2 wherein said output generating means is responsive only to said periodic signals with duty cycle greater than a predetermined amount.

5. The system as in claim 4 wherein said output generating means comprises a low pass filter circuit.

6. The circuit as in claim 4 wherein said output generating means is an output device for forming said image of said object.

7. The circuit as in claim 6 wherein said output generating means comprises a thermal printhead.

8. The circuit as in claim 2 wherein said periodic generating means comprises a first transistor having a collector electrode coupled to a first reference voltage source and an emitter electrode coupled to a second reference voltage source, and base electrode coupled to a first resistive means and capacitive means, whereby said first transistor switches off and on periodically with the charging and discharging of said capacitive means.

9. The circuit as in claim 8 wherein said capacitive means comprises parasitic capacitance at said first transistor base electrode.

10. The circuit as in claim 9 wherein said first resistive means and said capacitive means are connected serially between said first and second reference voltage sources and said transistor base electrode connected between said resistive and capacitive means.

11. The circuit as in claim 10 wherein said first resistive means is connected to said first reference voltage source and said capacitive means is connected to said second reference voltage source.

12. The circuit as in claim 8 further comprising a second transistor having a collector electrode coupled to said first reference voltage source, an emitter electrode coupled to said second reference voltage source and a base electrode coupled to said collector electrode of said first transistor so that said second transistor operates to amplify the signal at said first transistor collector electrode.

13. The circuit as in claim 12 further comprising an output terminal connected to said collector electrode of said second transistor for connection to said output generating means.

14. The circuit as in claim 12 wherein said first transistor collector electrode is connected to said first reference voltage source through a second resistive means, said first transistor collector electrode also connected to said second transistor base electrode through a third resistive means, and said second transistor base electrode base electrode further connected to said second reference voltage source through a fourth resistive means.

15. The circuit as in claim 12 wherein said emitter electrodes of said first and second transistors are connected to said second reference voltage source through a fifth resistance means.

16. A system for reproducing a document onto paper, said system comprising:

means for scanning said document in one plane, said scanning means having means for illuminating said document and means for detecting images on said document by the illumination reflected from said document, said detecting means generating signals responsive to said images;

means for processing signals from said detecting means wherein said signal processing means includes means for increasing the resolution of said detecting means, and

means associated with said scanning means and responsive to said processing means, for reproducing said images on said paper, said paper oriented in a predetermined manner with respect to said document,

whereby said reproducing means creates said images on said paper by the operation of said scanning means, and whereby,

said reproducing means creates said image on said paper as said scanning means scans said document, thus requiring no storage of the signal generated by the processing means.

17. The system as in claim 16 wherein said resolution increasing means comprises a circuit having

means coupled to said detecting means for generating a periodic signal, the duty cycle of said periodic signal responsive to said detecting means; and

means coupled to said generating means for generating an output signal responsive to said duty cycle.

18. The system as in claim 17 wherein said detecting means comprises a phototransistor.

19. The system as in claim 17 wherein said output generating means is responsive only to said periodic signals with duty cycle greater than a predetermined amount.

20. The system as in claim 19 wherein said output generating means comprises a low pass filter circuit.

21. A system for reproducing on a medium an image of an illuminated object, said system comprising:

means for detecting reflected illumination from said object by scanning in a first plane, said means generating signals responsive to the detected illumination,

means for processing signals from said detecting means, and

means associated with said detecting means and responsive to said processing means, for reproducing images in a second, non-coplanar, plane fixed with respect said first plane on said medium.

whereby said reproducing means creates said image on said medium by the scanning of said detecting means, and whereby,

said reproducing means creates said image as said detecting means scans said object thus requiring no storage of the signal generated by said detecting means

wherein said first plane and said second plane are parallel, and

wherein said medium comprises paper, said illuminated object comprises a document and said system is a photocopier, and

wherein said detecting means is mounted on a first scanning head, which first scanning head is slidably mounted on a first guide bar, and said reproducing means is mounted on a second scanning head, which second scanning head is slidably mounted on a second guide bar, and

wherein said first and second scanning heads are reciprocally driven during operation, and

wherein said first and second scanning heads are driven by a single belt.

22. A system for reproducing on a medium an image of an illuminated object, said system comprising:

means for detecting reflected illumination from said object by scanning in a first plane, said means generating signals responsive to the detected illumination,

means for processing signals from said detecting means, and

means associated with said detecting means and responsive to said processing means, for reproducing images in a second, non-coplanar, plane fixed with respect to said first plane on said medium,

whereby said reproducing means creates said image on said medium by the scanning of said detecting means, and whereby,

said reproducing means creates said image as said detecting means scans said object thus requiring no storage of the signal generated by said detecting means, and

further comprising a lens focusing said reflected illumination upon a screen coincident with said first plane.

23. The system as in claim 22 wherein said screen is between said detecting means and said lens.

24. The system as in claim 23 wherein said system comprises a camera.

* * * * *

Rank(R)	Database	Mode
R 1 OF 1	PATENTS-US	Page

Utility

REAL-TIME CONVERSION OF STILL-VIDEO TO HALF-TONE FOR HARD COPY OUTPUT (SUCH AS ON A FACSIMILE MACHINE)

PATENT NO.: 5 ,193,012
ISSUED: March 09, 1993 (19930309)
INVENTOR(s): Schmidt, Jonathan E., San Antonio, TX (Texas), US (United States of America)
ASSIGNEE(s): Snap-Fax Corporation, (A U.S. Company or Corporation), Dallas, TX (Texas), US (United States of America) [Assignee Code(s):
APPL. NO.: 7-693,444
FILED: April 29, 1991 (19910429)
U.S. CLASS: 358-456 cross ref: 347-254; 358-909.1
INTL CLASS: [5] B41J 3-02
FIELD OF SEARCH: 358-298; 358-456; 358-444; 358-80; 358-79; 358-78; 358-77; 358-76; 358-75; 358-909; 346-154; 346-155; 346-76PH; 346-76L; 346-76R

References Cited

U.S. PATENT DOCUMENTS

4,158,2036/1979Johnson, Jr. et al.346-76PH
4,443,1214/1984Arai346-76PH
4,492,4821/1985Eguchi et al.346-76PH
4,521,7906/1985Allard346-155
4,556,89112/1985Matsushita et al.346-76PH
4,858,0208/1989Homma358-909
4,937,6766/1990Finelli et al.358-909
4,942,4777/1990Nakamura358-909

PRIMARY EXAMINER: Brinich, Stephen
ATTORNEY, AGENT, OR FIRM: Baker & Botts
CLAIMS: 27
EXEMPLARY CLAIM: 21
DRAWING PAGES: 3
DRAWING FIGURES: 9
ART UNIT: 262
FULL TEXT: 790 lines

ABSTRACT

A real-time still-video to facsimile conversion system (FIG. 3) converts a still-video image frame into a half-tone facsimile reproduction without having to store an entire intermediated grey-scale image frame. Conversion of a still-video image to a half-tone facsimile output is accomplished by repeatedly transmitting the still-video image frame from a still-video

M

source to a still-video input circuit (10), with a virtual facsimile page synchronization module (20) providing synchronization to a virtual facsimile page. In successive image frames, a video pixel grabber (34) grabs successive columns of image pixels, and provides them to a half-tone pixel converter (32) for conversion to facsimile lines--for the exemplary embodiment a 3X3 half-tone pixel format is used, so that the 525 raster lines of an image pixel column are transformed into three facsimile lines using a total of 1575 dots per line (out of the standard 1728 dot facsimile line). After conversion of each column of image pixels, the corresponding facsimile lines are buffered in a facsimile multi-line buffer (36) for conventional facsimile transmission by a half-tone facsimile output module (40) to a facsimile machine for facsimile reproduction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the geometry of the still-video to facsimile transformation, including the 90 degree rotation of the image.

FIGS. 2a-2f illustrate six of the possible ten half-tone facsimile pixels available using the exemplary 3X3 dot cluster arrangement.

FIG. 3 is a functional block diagram of the exemplary real-time still-video to facsimile conversion system.

FIG. 4 is a flow diagram illustrating the operation of the real-time still-video to facsimile conversion system.

TECHNICAL FIELD OF THE INVENTION

The invention relates generally to still-video technology, and more particularly relates to a system and method for real-time conversion of still-video image data into output data for hard copy image reproduction. In even greater particularity, the invention enables still-video images captured on video storage media to be converted in real-time to half-tone data without conversion to an intermediate (gray scale or half-tone) image for communication to facsimile equipment for hard copy output.

BACKGROUND OF THE INVENTION

Still-video equipment produces still-video snapshots of moving or stationary images. In contrast to conventional photographic equipment, the video image or "picture" is captured as digital data on magnetic storage media such as a floppy disk.

The specific problem to which the invention is applicable is the reproduction of still-video images captured on magnetic media in hard copy form.

Still-video systems can transmit still-video (or freeze-frame) images, in color or black and white, over telecommunications facilities, and then print hard copy reproductions of those images. Specific examples include: (a) wire photography; (b) still-video peripheral equipment; and (c) specialty products.

Wire photography, and its extension radio photography, have long been used by the news media. The most common form involves an input device that converts photographs into encoded signals for communication over telecommunications facilities or radio. At the receiving end, reproducing equipment reconverts the encoded image signals by exposing photographic film or other sensitized paper. The term facsimile is often used with these products.

Still-video equipment has recently become available from such vendors such as Canon and Sony, and is again primarily used by the television and print media, although applications are expanding rapidly in such areas as insurance investigation and real estate. A still-video camera (or camcorder) captures a full-color still-video image that can be reproduced using a special video printer that converts the still-video image data into hard copy form. For applications requiring communication of the still-video image, transmit/receive units are available that transmit/receive video signals--the signal begins and ends as a video image, and proprietary transmission techniques are typically used for communication.

An example of a specialty product is the PhotoPhone from Image Data Corporation. This product has a video camera, display and storage facility in a terminal package. One terminal can send a real-time or stored still-video image to another for display or storage, or printing on special video printers. The signal begins and ends as a video image, and may use standard or proprietary transmission techniques.

Another example of a specialty product is the special peripheral equipment available for personal computers (PCs) that enable the input/output, storage and processing of still-video images in digitized formats. For instance, the Canon PV-540 is a floppy disk drive that uses conventional still-video disks, digitizing a still-video image using a conventional format, and communicating with the PC through a standard computer I/O port.

Most PC communication utilities for still-video images are based on one of a number of conventional data record formats. Once an image is stored in one of these formats as a single file under the PC operating system, it can be mailed by E-mail or communicated by any of the common communications programs to another PC. The still-video image file can be transferred to photographic film, or printed on conventional laser printers.

Laser printers and some other image output equipment often use a half-tone format that produces a half-tone photographic image. More recently, standard facsimile equipment has been enhanced for transmitting half-tone images. In addition, for personal computers, facsimile interface products are available for digitally capturing a complete still-video picture from a video source, and, through a software transformation, creating a half-tone image suitable for transmission to a facsimile machine.

These half-tone images are created by arranging the conventional facsimile dot-pattern output into half-tone pixels--dot matrix areas, or dot clusters, that contain a predetermined number dots. A half-tone picture is composed of half-tone pixels, each of which can be varied from white to black by appropriately selecting the number of dots that are included within a pixel.

Producing optimum image quality in half-tone is considered an "art" in the publishing business. Many parameters are manipulated, including shades of grey, dots per inch, the shape of the dots, the arrangement of the dot dither (a smoothing technique), screen angle (the angular relationship of the dots to each other), and transfer functions (changing the density at various gray levels to compensate for ink retention). Half-tone resolution in newspapers have "rulings" of from 55 to 150 lines per inch, while magazine parameters commonly fall between 120 to 150 lines per inch.

In currently available equipment for producing half-tone reproductions of still-video images, an entire still-video image is stored as an intermediate digitized grey-scale image frame prior to being converted to half-tone data for producing a hard copy output. Such an intermediated storage stage is disadvantageous in a number of respects.

Cost factors can become significant if additional components, such as memory chips and supporting logic, are required (thereby also increasing power consumption). In particular, the requirement for digital memory to store an intermediate still-video half-tone frame significantly increases the size of the resulting electronics including, if portability is desired, battery storage. Also, intermediate digital storage requires an intermediate grey-scale digitization that introduces irregularity into subsequent image transformations, with resulting loss of resolution and image quality degradation.

In particular, in the case of facsimile printing that also involves a digital format in the form of the printing dots, the image patterns from the intermediate grey-scale image data can result in beat-frequencies or super patterns when merged with the facsimile dot formats. These extra patterns can cause significant image quality degradation without substantial electronic filtering. Such filtering requires extra components and can, itself, degrade resolution or image quality.

Accordingly, a need exists for still-video conversion equipment that can convert still-video image data in real-time for hard copy output without the need for creating or storing an intermediate still-video image frame.

SUMMARY OF THE INVENTION

The invention is a real-time still-video to half-tone conversion system and method for directly converting a still-video image into a half-tone hard copy without requiring the creation or storage of an intermediate image frame. In an exemplary application, the invention is used to convert still-video images captured on video floppy disks into half-tone image data for hard copy output using conventional facsimile equipment.

In one aspect of the invention, the real-time still-video conversion technique is initiated by repetitive transmissions of a still-video image frame from the still-video source. Each still-video image frame is synchronized to a virtual hard copy page defined by a matrix of pixels, with each virtual hard copy pixel being associated with a corresponding image pixel of the still-video frame, with each image pixel being characterized by an amplitude value.

In successive identical still-video image frames, selected successive blocks of image pixels are converted into corresponding blocks of half-tone pixels, each with a selected half-tone dot pattern. Each converted block of half-tone pixels is then transmitted to the hard copy output device to produce half-tone hard copy output.

This half-tone conversion process is repeated until the still-video frame is completely converted into a half-tone hard copy.

In another aspect of the invention, a real-time still-video conversion system includes: a video input circuit, a virtual page synchronization generator, a half-tone pixel generator, and a transmitter circuit.

The video input circuit receives the repeated transmissions of a selected still-video image frame from the still-video source. The virtual page synchronization generator synchronizes each of these identical still-video image frames to a virtual hard copy page defined by a matrix of hard copy pixels, i.e., each image pixel (characterized by an amplitude value) is associated with a corresponding hard copy pixel.

In successive still-video image frames, the half-tone pixel generator converts selected successive blocks of image pixels into corresponding half-tone pixels, each with a selected half-tone dot pattern.

After conversion, the transmitter circuit transmits each converted block of half-tone pixels is then transmitted to the hard copy output device, which produces half-tone hard copy output. In this manner, successive blocks of image pixels from successive still-video image frames are converted and then transmitted to the hard copy output device until the still-video frame is completely converted into a half-tone hard copy.

In an exemplary embodiment of the invention, the real-time still-video to facsimile conversions system is used to convert a still-video image into half-tone facsimile data for producing a half-tone hard copy on standard facsimile equipment. Video processing is performed on the received still-video image frames to optimize the operation of the system for facsimile data.

The virtual page synchronization generator defines a virtual hard copy page in which the still-video image frame is rotated 90 degrees, yielding an aspect ratio for the half-tone facsimile that corresponds to conventional video and photographic aspect ratios. For example, with this rotation, a 3:1 mapping of the standard 525 line video raster format uses 1575 (3X525) of the 1728 dots of the standard facsimile line format, so that a 3X3 half-tone facsimile pixel format is achieved by using three facsimile lines to define a single line of half-tone facsimile pixels corresponding to a column string of still-video image pixels.

Under control of the virtual page synchronization generator, a still-video image pixel grabber circuit grabs successive column strings of image pixels and digitizes the video amplitude for each image pixel. Each digitized column string of image pixels is input to the half-tone pixel generator, which converts each image pixel into a corresponding 3X3 half-tone pixel, using conventional smoothing techniques to improve image quality.

A multi-line buffer is used to hold up to six lines of facsimile data, i.e., two lines of half-tone facsimile pixels corresponding to two column strings of image pixels. These facsimile lines are sequentially read out of the multi-line buffer and transmitted to standard facsimile equipment for half-tone hard copy output of the still-video image.
The virtual page synchronization generator, the half-tone pixel generator, and the multi-line buffer are preferably implemented in software using a conventional microprocessor. The microprocessor interfaces to a conventional integrated facsimile modem, reading facsimile data out of the multi-line buffer and performing virtual facsimile page generation and protocol conversion.

The technical advantages of the invention include the following. The real-time conversion technique enables the design of still-video to facsimile equipment that is portable and low cost, while providing a good quality half-tone reproduction of a still-video image or other picture that can be captured and stored in a still-video format. With such a product, a still-video image database can be made accessible as printed output without the additional expense of video printers. Moreover, a still-video image can be propagated at facsimile speeds to conventional facsimile equipment over standard telecommunications facilities.

The real-time still-video to facsimile technique converts the still-video output from standard still-video equipment into a corresponding continuous facsimile data transmission for output as a half-tone facsimile reproduction. Conventional smoothing and other video processing can be employed to optimize the quality of the half-tone conversion. Eliminating the need for creating or storing an intermediate frame obviates the need to provide additional memory (and associated supporting logic) to store the intermediate frame, thereby reducing both size and power consumption, and facilitating portable designs. In addition, eliminating the intermediate conversion and storage operations removes an intermediate digitization, thereby reducing filtering requirements.

A more complete description of the invention, as well as further features and advantages, are provided by the Detailed Description of exemplary embodiments of the invention, read in conjunction with the accompanying Drawings. Although the Detailed Description and the Drawings are directed to specific exemplary embodiments, various modifications of these exemplary embodiments, as well as alternative embodiments, will be suggested to those skilled in the art, and it is to be understood that invention encompasses any modifications or alternative embodiments that fall within the scope of the appended claims.

DETAILED DESCRIPTION OF THE INVENTION
The detailed description of exemplary embodiments of the real-time still-video to half-tone conversion system is organized as follows:

The exemplary implementation is a real-time still-video to facsimile conversion system that converts still-video images captured by standard still-video equipment into half-tone facsimile data for transmission to standard facsimile equipment and resulting hard-copy output as a half-tone facsimile image. Such a product offers unique remote imaging solutions for a wide variety of applications, such as intelligence gathering, priority news, insurance investigations, and real estate. However, the real-time still-video to half-tone conversion technique has general applicability to converting still-video images into a half-tone format without requiring the creation or storage of a grey-scale or other intermediate image frame.

1. Still-Video

The real-time still-video to facsimile system uses currently available still-video equipment capable of capturing a still-video image (or "snap-shot") as analog still-video data onto a storage media, such as a video floppy disk. The still-video equipment is able access stored still-video data for a selected still-video image to provide a steady still-video output.

Examples of such still-video equipment that are commercially available are the Sony Mavica or Canon XAPSHOT. Basically, this still-video equipment has standardized around a miniature floppy disc approximately 21/2 inches square using one of two formats: lower-resolution field capture in which stores half the 525 lines of the full video frame in 50 pictures on the floppy, and higher-resolution frame capture which stores the full 525 lines in 25 pictures on the floppy.

Some cameras can play the video back to a video device such as a television, video recorder or computer with video input, as well as the real-time still-video to facsimile conversion system. Playback begins with the user selecting the picture, by number, which is fed to the receiving device. In addition, playback devices are available that read the floppy discs and create video, or digitally convert a still-video image which may be read by a computer through an I/O channel as a grey-scale image.

In addition to still-video equipment, the still-video source can be a single frame a camcorder, VCR, or optical disk.

2. Still-Video to Half-Tone Transformation

The real-time still-video to facsimile conversion technique converts the steady still-video output from the still-video equipment into a corresponding steady half-tone facsimile output signal. For the exemplary application of the real-time conversion technique, the half-tone facsimile output signal is communicated as a normal facsimile transmission to standard facsimile equipment for output as a half-tone facsimile reproduction of the still-video image.

The exemplary real-time still-video to facsimile conversion technique involves: (a) receiving from a still-video source continuously transmitted frames of a still-video image; (b) synchronizing each still-video image frame to a virtual half-tone facsimile page in which the still-video image is characterized as a matrix of line and column pixels and a 90 degree rotation is used to map column strings of still-video image pixels into corresponding lines of 3X3 half-tone facsimile pixels; (c) grabbing successive column strings of still-video image pixels corresponding to successive lines of half-tone facsimile pixels; and (d)) converting each column string of still-video image pixels into facsimile lines that define a corresponding line of half-tone facsimile pixels. These facsimile lines that define the half-tone facsimile pixels ar then transmitted line by line to standard facsimile equipment to produce a half-tone facsimile (hard copy) output.

2.1. Still-Video to Facsimile Rotation

FIG. 1 illustrates the transformation from a still-video image format 11 to a facsimile format 12. The exemplary still-video image comprises a standard 525 line video raster image with a 4:3 aspect ratio. The exemplary facsimile page is based on the standard facsimile format of 1728 dots per line.

For the exemplary embodiment, the still-video image is characterized as a line and column matrix of still-video image pixels: 525 raster lines and 700 column positions, corresponding to the 4:3 aspect ratio. Transformation of these still-video image pixels into corresponding facsimile half-tone pixels is accomplished with a 90 degree rotation of the image. For example, a column string 13 of still-video image pixels is rotated into a line 14 of the facsimile half-tone pixels (with each line 14 on the facsimile page being formed by three facsimile lines).

The use of a 90 degree rotation of the image more closely fits the standard 4:3 video aspect ratio, with the width being greater than the height. This transformation also conveniently maps the 525 video lines into the fixed 1728 dot facsimile format using a ratio of 3 to 1 for a total of 1575 (525X3) facsimile dots (leaving unused less than 5 percent of the facsimile page on either side). As a result, assigning three facsimile lines to each of the rotated column strings of still-video image pixels yields a single line of 3X3 half-tone facsimile pixels.

2.2. Half-Tone Facsimile Pixels

FIGS. 2a-2f illustrate the exemplary 3X3 dot cluster matrix used to provide half-tone facsimile pixels. That is, each pixel comprises a cluster of 9 facsimile dots providing a 10-level grey scale of 0 to 9.

The choice of an exemplary 10-level grey scale represents a trade-off between grey level representation and pixel resolution, a trade-off that is effected by such factors as the noise of video signals and the simple averaging associated with the dot cluster pattern of each pixel, as well as perceived image quality. In addition, the exemplary 3X3 matrix fits well with the 90 degree transformation of a still-video column with 525 video raster lines onto a 1728-dot line of a facsimile page, providing 3 dots per raster line (for a total of 1575 dots) --a transformation technique that is relatively simple to perform and involves a relatively low level of digitization noise.

The dot clusters that form the half-tone facsimile pixels can accommodate either fixed or dithered geometries. The cluster size can be increased to increase the number of levels of grey which can be represented at the expense of the number of clusters which, when reduced, lowers resolution.

3. Real-Time Conversion System

The exemplary real-time still-video to facsimile system is designed to be a configured as a self contained package with an internal battery, including external interfaces for a telephone instrument and the telephone line, as well as video input/output. The system is compatible with manufacture from low cost, low power, monolithic integrated circuits.

FIG. 3 is a schematic block diagram of the real-time still-video to facsimile conversion system. It includes modules for Still-Video Input 10, Virtual Facsimile Page Synchronization 20, Half-Tone Transformation 30, and Half-Tone Facsimile Output 40. In particular, the half-tone facsimile output module 40 implements conventional facsimile communications between the still-video to facsimile conversion system and standard Group III facsimile equipment.

3.1. Still-Video Input

The still-video input module 10 includes an analog input circuit 12 and a video processing circuit 14.

The analog input circuit 10 is accessed through the still-video input connector. Still-video images are accepted from a standard still-video source (not shown). For example, the still-video input can be an unchanging scene in a video camera, a freeze frame from a video disk or VCR, or a still-video camera.

During conversion for half-tone facsimile output, the still-video source transmits a still-video image as continuous frames, typically every 30th of a second.

The analog video input circuit provides a conventional interface to analog video signals. It provides standard input protection, gain control and signal amplification using commercially available integrated circuit components available from a number of manufacturers.

The Video processing circuit 14 customizes the response of the video amplifier in the analog video input circuit, optimizing the characteristics of the still-video signal for the exemplary application of providing a half-tone facsimile hard copy of the still-video image. Such processing includes standard gain compression and gain, as well as control over frequency response.

3.2. Virtual Page Synchronization

The virtual facsimile page synchronization module 20 includes a sync detection and timing generator 22 and a virtual facsimile page generator 24.

The synch detection and timing generator 22 provides standard video/coincidence detection and synchronization, using components that are commercially available from a number of manufacturers. Using conventional video synchronization techniques, this circuit synchronizes to the raster line and column position of a conventional still-video frame using digital line and column counters, establishing a line and column matrix of still-video image pixels (525 lines by 700 columns). In particular, the coincidence detection function provides a reliable indication of the presence of a stable video input signal, and can be used to trigger the real-time still-video to half-tone conversion process (as well as a VIDEO OK indicator lamp).

The synch detection and timing generator 22 provides frame synchronization signals to the virtual facsimile page synchronization generator 24, as well as to the video processing circuit 14 in the still-video input module 10.

The virtual facsimile page generator 24 synchronizes the still-video image frame to a virtual facsimile page. That is, the 525 by 700 line and column matrix defining the still-video image is in effect mapped into a corresponding virtual facsimile page matrix of 525 by 700 half-tone facsimile pixels, each of which is a 3X3 matrix of facsimile dots, using 1525 dots per facsimile line (525X3) and 2100 total facsimile lines (700X3). For the exemplary real-time still-video to facsimile conversion system, the virtual facsimile page generator is implemented in software using a commercially available microprocessor (such as the 85C15) which can generate multiple timing signals from a single crystal time base.

Thus, virtual page synchronization correlates the still-video image to a the standard facsimile format that would have been produced by conventional facsimile scanning.

3.3. Half-Tone Transformation

The half-tone transformation module 30 includes a half-tone pixel generator 32, a video pixel grabber 34, a facsimile multi-line buffer 36, and a facsimile line generator and protocol converter 38.

The half-tone facsimile pixel generator 32 processes column strings of still-video pixels, and generates the appropriate half-tone (grey scale) pattern of facsimile dots. Still-video to half-tone conversion processing is synchronized by the sync detection and timing generator 22.

The half-tone facsimile pixel generator 32 implements conventional half-tone processing techniques, including dot pattern selection and smoothing, to convert each still-video image pixel into an appropriate half-tone facsimile dot pattern. For example, conventional look-up table operations and weighting and smoothing algorithms can be used to transform digitized still-video pixels into half-tone.

The video pixel grabber circuit 34 is responsive to the virtual facsimile page synchronization generator 24 for grabbing selected column strings of still-video image pixels. Synchronization to the still-video image is provided by the sync detection and timing generator 22. Under the cross-synchronization control of the virtual facsimile page synchronization generator and the sync detection and timing generator, the video pixel grabber grabs selected still-video image pixels (6 bit video amplitude information) according to line and column position. Coincidence of the video sync timing and virtual facsimile page timing signals triggers standard analog to digital conversion of the selected video image pixel, thereby providing a corresponding digital video amplitude value to the half-tone pixel generator 32.

The half-tone pixel generator converts each column string of still-video image pixels into the appropriate three lines of facsimile data (a total of 525 pixels). These facsimile lines are buffered in the facsimile multi-line buffer for transmission to facsimile equipment.

The facsimile multi-line buffer 36 holds six facsimile lines corresponding to two lines of half-tone facsimile pixels (which correspond to two columns of still-video image pixels). Thus, the total buffer storage used is 1728 X6 bits (1296 bytes). Three entire facsimile lines are buffered before facsimile transmission. As one set of three facsimile lines (one line of half-tone facsimile pixels) is transmitted, the other three facsimile lines are generated by the half-tone pixel generator and buffered in the facsimile multi-line buffer in preparation for transmission. This pipelining permits continuous transmission of facsimile data, as well as back-smoothing for dithering (randomization of using any of the buffered facsimile lines that are not actually being transmitted.

Conventional half-tone processing techniques, including pattern selection and smoothing, can be used to optimize the real-time still-video to facsimile conversion system for facsimile hard copy output. Regarding pattern selection, the simplest approach is to use table look-up with fixed dot patterns, although more sophisticated non-linear transformations involving analysis of video signal quality and adjacent pixels could be used. Regarding smoothing, an analysis of adjacent pixels can be used to provide dot pattern adjustments to improve image quality, including back-smoothing using one or more facsimile lines from previously buffered half-tone facsimile pixels.

The facsimile line generator and protocol converter reads the facsimile data out of the facsimile multi-line buffer 32, and transmits it to the half-tone hard copy output module 40 for transmission to a facsimile machine for hard copy output. The facsimile line generator and protocol controller operates conventionally in sequentially retrieving facsimile lines from the facsimile multi-line buffer 36, and providing the proper protocol interface for the integrated facsimile modem. It synchronizes the retrieval of facsimile lines and the transmission of the associated facsimile data through the integrated facsimile modem 44 (the protocol defined by the CCITT Group 3 Facsimile specification is followed).

For the exemplary real-time still-video to facsimile conversion system, those functions performed by the half-tone transformation module 30, other than those performed by the video pixel grabber circuit 34, are implemented conventionally in software using a commercially available microprocessor (such as the 85C15). Thus, the microprocessor is programmed to perform the functions of half-tone pixel generation 32, facsimile multi-line buffering 36, and a facsimile line generation and protocol conversion 38, along with the function of virtual facsimile page generation 24.

The video pixel grabber circuit 34 is implemented in a conventional manner using commercially available components. For example, the circuit can be assembled using digital counters, an 8-bit MUX, and a 6-bit analog-to-digital converter (such as an RCA 3100). The MUX operates as a sample-and-hold front end for the A/D converter. The A/D converter can operate at about 65 microseconds because it is converting only one video pixel per raster scan line--each still-video frame the video pixel grabber circuit 34 is only required to grab a single column of still-video pixels to form a column string of digitized still-video pixels.

3.4. Half-Tone Facsimile Output

The half-tone facsimile output module 40 includes an integrated facsimile modem 44, and a certified telephone interface 46. In addition, lamp display 48 and indicator lamps 49 provide optional maintenance control (including communications activity and video detection).

The integrated facsimile modem 44 is a conventional low power, integrated facsimile modem chip. The circuit is controlled by the facsimile line generator and protocol converter 38, and implements conventional facsimile communications according to Group 3 facsimile protocol negotiations and control.

The certified telephone interface 46 is a conventional telephone interface component that follows the guidelines and requirements of FCC ruling Part 68 (a different implementation would be required in different countries). It includes the isolation, protection, and interface connection as defined. The phone line interface connector is the RJ-11 connector, one for the telephone line and one for the telephone set used to initiate calls to a facsimile machine or other hard copy output device.

3.5. Still-Video to Facsimile Operation

FIG. 4 illustrates the operation of the real-time still-video to facsimile conversion system. The conversion of a still-video image frame into a facsimile half-tone hard copy begins with the repetitive transmission of the still-video image frame to the real-time still-video to facsimile conversion system.

Referring to FIGS. 1 and 4, the still-video image frames are received (51) at the analog video input circuit 12. A received still-video image frame is input to the video processing circuit 14, and to the sync detection and timing generator 22. The sync detection and timing generator synchronizes to the still-video image frame: row (raster line) numbers from 1 to 525, and column position numbers from 1 to 700 (assuming a 4/3 aspect ratio).

The microprocessor waits (52) for the sync detection and timing generator to detect a coincident sync condition, indicating valid video. When coincidence is detected, the microprocessor resets (54) the virtual facsimile page generator 24 to Line 1, Pixel-Position 1, designated L1,P1, the initial facsimile pixel position of the first line of the virtual facsimile page. This initial dot position corresponds to the initial still-video image pixel at column 1, row 1 (or raster line 1), designated C1,R1.

At the same time, the microprocessor invokes the facsimile modem 44, which attempts to establish (53) a facsimile communications link to a selected facsimile machine. The microprocessor awaits the establishment of a facsimile connection, and when that is detected, begins the half-tone conversion and facsimile line transmission operations.

The virtual facsimile page generator 24 provides the line/pixel-position count to the video pixel grabber (34), which also receives the column/row count for the still-video image frame from the sync detection and timing generator 22. The video pixel grabber grabs (56) the still-video image pixel based on cross-synchronization between the two counts.

The video pixel grabber performs (57) an A-to-D conversion of analog still-video pixel to obtain corresponding digital still-video pixel (six-bit amplitude value). This still-video image pixel data is provided (58) to the half-tone facsimile pixel generator for conversion to half-tone.

The half-tone facsimile pixel generator converts the still-video image pixel data to a 3X3 half-tone facsimile pixel using a table look-up operation. In addition, half-tone processing can be performed to appropriately adjust the selected half-tone facsimile pixel value for improved image quality.

This 3X3 half-tone facsimile pixel is then loaded (59) into the facsimile multi-line buffer 36--for the L1,P1 pixel, the first three facsimile dot positions on each of the first three facsimile lines in the buffer.

If the facsimile pixel position count in the virtual facsimile page generator is not the last facsimile pixel-position on current line of the virtual facsimile page (61), then the microprocessor increments (62) the virtual facsimile page generator position to the next facsimile pixel position of the virtual facsimile page, L1,P+1 which corresponds to the next still-video image pixel C1,R+1 (i.e., column 1, next row or raster line).

If the facsimile pixel position count has reached 525, corresponding to the 525 raster lines of each still-video image column, then the microprocessor resets (64) the virtual facsimile page generator to the second facsimile line, first pixel position L2,P1 which corresponds to the first row (raster line) of the second still-video image column. In addition, a facsimile pixel position count of 525 indicates that an entire line of facsimile pixels has been converted into three corresponding lines of facsimile dots, which are in the multi-line buffer.

When three complete facsimile lines are in the facsimile multi-line buffer, the microprocessor invokes (65) the facsimile line generator and protocol converter 38 to transmit those facsimile lines through the facsimile modem 44 to the facsimile machine for half-tone hard copy output. The hard copy output from the facsimile machine appears in a landscape format as a half-tone reproduction of the transmitted still-video image frame.

4. Exemplary Applications

Exemplary applications for the real-time still-video to facsimile conversion system of the invention include the following.
The system can be used to capture, store, print and communicate the contents of conference-room display boards, such as marker boards. In the case of marker boards, current products, which involve expensive, proprietary and complex mechanics, could be replaced by the still-video conversion system of the invention, enabling the contents of any still-video image of a board to be printed on a local or remote facsimile machine.

The system can be used to provide immediate image transmission to remote offices (anywhere in the world at facsimile speeds), and provides an inexpensive means of an image storage and retrieval (for images of personnel, products, events or other photographic subjects) when used with standard still-video equipment. The image data base is immediately accessible as printed output without the additional expense of video printers.

The system can be built into commercial facsimile products to add both local and remote (to other facsimile machines) still-video hard copy.

Adding the system to existing facsimile products can take advantage of existing electronics in those products, such as the facsimile modem, to provide a low cost capability upgrade.

What is claimed is:

1. A method of real-time still-video conversion for converting a still-video image frame captured by a still-video source into a half-tone reproduction produced by a hard copy output device without requiring the creation or storage of an intermediate image frame, comprising the steps:
for each still-video image frame, receiving repeated transmissions of the still-video image frame from the 10 still-video source until conversion is complete;
for each transmission of the still-video image frame, synchronizing the frame to a virtual hard copy page the defines a matrix of virtual hard copy pixels, with each virtual hard copy pixel being associated with a corresponding image pixel of the still-video frame which is characterized by an amplitude value;
in successive still-video image frames, converting successive blocks of image pixels into corresponding blocks of half-tone pixels, with each half-tone pixel having an appropriate half-tone dot pattern; and then transmitting each converted half-tone pixel in a block to the hard copy output device for producing a half-tone hard copy output;
repeating this conversion process until the still-video image frame is completely converted into a half-tone hard copy.

2. The method of real-time still-video conversion of claim 1, further comprising, after the step of receiving still-video image transmissions, the step:
video processing the received still-video image frame to optimize the conversion process for the hard copy output device.

3. The method of real-time still-video conversion of claim 1, wherein the step of converting image pixels into half-tone pixels includes half-tone processing the image pixels to optimize the conversion process for the hard copy output device.

4. The method of real-time still-video conversion of claim 3, wherein half-tone processing includes adjusting the half-tone dot pattern for adjacent half-tone pixels to provide smoothing for the hard copy output.
5. The method of real-time still-video conversion of claim 1, wherein a virtual hard copy page is formed by a predetermined number of hard copy lines each with a predetermined number of half-tone dot positions, such that each virtual hard copy pixel is defined by a predetermined number of adjacent half-tone dot positions on a predetermined number of adjacent lines, thereby forming a half-tone dot-matrix.

6. The method of real-time still-video conversion of claim 5, wherein the still-video image is divided into rows and columns of image pixels, and wherein the step of converting image pixels into half-tone pixels comprises the steps of:
in successive still video image frames, grabbing successive columns of

image pixels;
using a 90 degree transformation rotation, converting each column of image pixels into a corresponding number of lines of half-tone dots to form a line of half-tone pixels, with each half-tone pixel being formed by a half-tone dot-matrix with an appropriate half-tone dot pattern.

7. The method of real-time still-video conversion of claim 6, wherein the still-video image frame is formed by 525 raster lines, wherein the hard copy output device is a facsimile machine using a dot format of at least 1575 dot positions per line, and wherein the half-tone dot-matrix is a 3X3 matrix such that each column of still-video image pixels is transformed into three hard copy lines with each still-video image pixel being assigned a corresponding half-tone pixel with three adjacent half-tone dot positions on each of the three hard copy lines.

8. The method of real-time still-video conversion of claim 1, further comprising, after the step of converting image pixels into half-tone pixels, the step of:
buffering an entire block of converted half-tone pixels prior to transmission of any of the pixels to the hard copy device.

9. The method of real-time still-video conversion of claim 8, wherein a virtual hard copy page is formed by a predetermined number of hard copy lines each with a predetermined number of half-tone dot positions, such that each virtual hard copy pixel is defined by a predetermined number of adjacent half-tone dot positions on a predetermined number of adjacent lines, thereby forming a half-tone dot-matrix, and wherein the block of converted half-tone pixels comprises an entire line of half-tone pixels formed by a corresponding number of hard copy lines.

10. The method of real-time still-video conversion of claim 9, wherein at least two lines of half-tone pixels are buffered, and wherein the step of converting image pixels into half-tone pixels includes half-tone processing the image pixels by adjusting the half-tone dot pattern for adjacent half-tone pixels on the same line and on adjacent lines to provide smoothing for the hard copy output.

11. A real-time still-video conversion system for converting a still-video image frame captured by a still-video source into a half-tone hard copy of the still-video image frame produced by a hard copy output device without requiring the creation or storage of an intermediate image frame, comprising:
a video input circuit for receiving repeated transmissions of a still-video image frame from the still-video source until conversion of that frame is complete;
a virtual page synchronizer for synchronizing each transmission of the still-video image frame to a virtual hard copy page that defines a matrix of virtual hard copy pixels, with each virtual hard copy pixel being associated with a corresponding image pixel of the still-video frame which is characterized by an amplitude value;
a half-tone transformer for converting successive blocks of image pixels from successive still-video image frames into corresponding blocks of

half-tone pixels, with each half-tone pixel having an appropriate half-tone dot pattern; and
a transmitter circuit for transmitting each converted half-tone pixel in a block to the hard copy output device for producing a half-tone hard copy output;
such that successive blocks of image pixels from successive still-video image frames are converted by said half-tone pixel generator and transmitted to the hard copy output device until the still-video frame is completely converted into a half-tone hard copy.

12. The real-time still-video conversion system of claim 11, further comprising:
an input video processor for processing the received still-video image frame to optimize the conversion process for the hard copy output device.

13. The real-time still-video conversion system of claim 11, wherein the half-tone transformer performs half-tone processing of the image pixels to optimize the conversion process for the hard copy output device.

14. The real-time still-video conversion system of claim 13, wherein half-tone processing includes adjusting the half-tone dot pattern for adjacent half-tone pixels to provide smoothing for the hard copy output.

15. The real-time still-video conversion system of claim 11, wherein a virtual hard copy page is formed by a predetermined number of hard copy lines each with a predetermined number of half-tone dot positions, such that each virtual hard copy pixel is defined by a predetermined number of adjacent half-tone dot positions on a predetermined number of adjacent lines, thereby forming a half-tone dot-matrix.

16. The real-time still-video conversion system of claim 15, wherein the still-video image is divided into rows and columns of image pixels, and wherein the half-tone transformer comprises:
an image pixel grabber for grabbing, in successive still video image frames, successive columns of image pixels;
a half-tone pixel generator for converting, using a 90 degree transformation rotation, each column of image pixels into a corresponding number of lines of half-tone dots to form a line of half-tone pixels, with each half-tone pixel being formed by a half-tone dot-matrix with an appropriate half-tone dot pattern.

17. The real-time still-video conversion system of claim 16, wherein the still-video image frame is formed by 525 raster lines, wherein the hard copy output device is a facsimile machine using a dot format of at least 1575 dot positions per line, and wherein the half-tone dot-matrix is a 3X3 matrix such that each column of still-video image pixels is transformed into three hard copy lines with each still-video image pixel being assigned a corresponding half-tone pixel with three adjacent half-tone dot positions on each of the three hard copy lines.

18. The real-time still-video conversion system of claim 11, further comprising a buffer for buffering an entire block of converted half-tone

pixels prior to transmission of any of the pixels to the hard copy device.

19. The real-time still-video conversion system of claim 18, wherein a virtual hard copy page is formed by a predetermined number of hard copy lines each with a predetermined number of half-tone dot positions, such that each virtual hard copy pixel is defined by a predetermined number of adjacent half-tone dot positions on a predetermined number of adjacent lines, thereby forming a half-tone dot-matrix, and wherein the block of converted half-tone pixels comprises an entire line of half-tone pixels formed by a corresponding number of hard copy lines.

20. The real-time still-video conversion system of claim 19, wherein at least two lines of half-tone pixels are buffered, and wherein the half-tone pixel generator processes the image pixels by adjusting the half-tone dot pattern for adjacent half-tone pixels on the same line and on adjacent lines to provide smoothing for the hard copy output.

21. A method of real-time still-video conversion for converting a still-video image frame captured by a still-video source into a half-tone facsimile reproduction produced by a conventional facsimile machine without requiring the creation or storage of an intermediate image frame, comprising the steps:
for each still-video image frame, receiving repeated transmissions of the still-video image frame from the still-video source until conversion is complete;
for each transmission of the still-video image frame, synchronizing the frame to a virtual facsimile page that defines a matrix of virtual facsimile pixels, with each virtual facsimile pixel being associated with a corresponding image pixel of the still-video frame which is characterized by an amplitude value;
the virtual facsimile page being formed by a predetermined number of virtual facsimile lines each with a predetermined number of half-tone dot positions, such that each virtual facsimile pixel is defined by a predetermined number of adjacent half-tone dot positions on a predetermined number of adjacent virtual facsimile lines, thereby forming a half-tone dot-matrix;
in successive still-video image frames, converting successive blocks of image pixels into a corresponding line of half-tone pixels, each line of half-tone pixels being formed by corresponding virtual facsimile lines, and each half-tone pixel having an appropriate half-tone dot pattern;
buffering the virtual facsimile lines associated with at least one line of half-tone pixels; and then
transmitting the buffered virtual facsimile lines to the facsimile machine for producing a half-tone facsimile output;
repeating this conversion process until the still-video image frame is completely converted into a half-tone facsimile reproduction.

22. The method of real-time still-video conversion of claim 21, further comprising, after the step of receiving still-video image transmissions, the step:
video processing the received still-video image frame to optimize the conversion process for facsimile reproduction.

23. The method of real-time still-video conversion of claim 21, wherein the step of converting image pixels into half-tone pixels includes half-tone processing the image pixels to optimize the conversion process for facsimile reproduction.

24. The method of real-time still-video conversion of claim 23, wherein half-tone processing includes adjusting the half-tone dot pattern for adjacent half-tone pixels to provide smoothing for the facsimile reproduction.

25. The method of real-time still-video conversion of claim 21, wherein the still-video image is divided into rows and columns of image pixels, and wherein the step of converting image pixels into half-tone pixels comprises the steps of:
in successive still video image frames, grabbing successive columns of image pixels;
using a 90 degree transformation rotation, converting each column of image pixels into a corresponding number of facsimile lines of half-tone dots to form a line of half-tone pixels, with each half-tone pixel being formed by a half-tone dot-matrix with an appropriate half-tone dot pattern.

26. The method of real-time still-video conversion of claim 25, wherein the still-video image frame is formed by 525 raster lines, wherein the facsimile machine uses a dot format of at least 1575 dot positions per line, and wherein the half-tone dot-matrix is a 3X3 matrix such that each column of still-video image pixels is transformed into three facsimile lines with each still-video image pixel being assigned a corresponding half-tone pixel with three adjacent half-tone dot positions on each of the three facsimile lines.

27. The method of real-time still-video conversion of claim 26, wherein at least two lines of half-tone pixels are buffered, and wherein the step of converting image pixels into half-tone pixels includes half-tone processing the image pixels by adjusting the half-tone dot pattern for adjacent half-tone pixels on the same line and on adjacent lines to provide smoothing for the facsimile output.

	Type	Hits	Search Text	DBs	Time Stamp	Comments	Error Definitio	Errors
666	BRS	0	analog same camera same cellular same (fax or facsimile)	USPAT	2000/08/14 14:49			0
667	BRS	118	((FAX OR FACSIMILE) AND CELLULAR AND CAMERA AND ANALOG)	USPAT	2000/08/14 16:03			0
668	BRS	10	"5235432".UREF.	USPAT	2000/08/14 16:07			0
669	BRS	6	"5546194".UREF.	USPAT	2000/08/14 16:11			0
670	BRS	395	(DITHER$4 NEAR3 (HALFTONE OR (HALF ADJ TONE)))	USPAT	2000/08/14 16:14			0
671	BRS	1	(("5235432".PN.) AND CELLULAR)	USPAT	2000/08/14 16:15			0
672	BRS	1	(("5235432".PN.) AND ColoR)	USPAT	2000/08/14 16:28			0
673	BRS	0	(("5546194".PN.) AND CellulaR)	USPAT	2000/08/14 16:29			0

United States Patent [19]

Creedon et al.

[11] **Patent Number: 5,235,432**

[45] **Date of Patent: Aug. 10, 1993**

[54] VIDEO-TO-FACSIMILE SIGNAL CONVERTER

[76] Inventors: **Brendan G. Creedon**, 805 Pomona Ave., Albany, Calif. 94706; **Lou Katz**, 3317 Brunell Dr., Oakland, Calif. 94602

[21] Appl. No.: **796,634**

[22] Filed: **Nov. 22, 1991**

[51] **Int. Cl.^{5}** **H04N 1/04**

[52] **U.S. Cl.** **358/479**; 358/433; 358/442; 358/445; 358/455; 358/456; 358/457; 358/468

[58] **Field of Search** 358/400, 401, 405, 406, 358/426, 201.1, 261.2, 261.3, 261.4, 429, 430, 431, 432, 433, 434, 435, 436, 442, 443, 445, 455, 456, 457, 458, 465, 468, 471, 476, 479, 141, 142, 160; 382/54, 55

[56] **References Cited**

U.S. PATENT DOCUMENTS

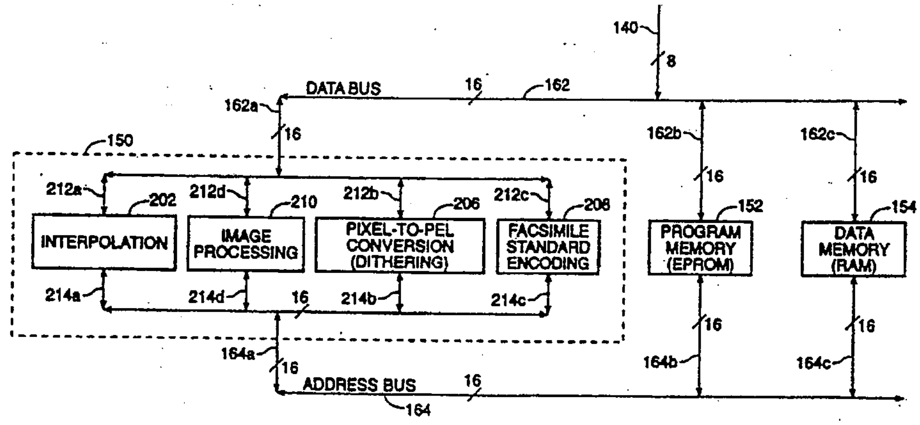
4,514,767 4/1985 Kubota et al. 382/54
4,720,849 1/1988 Tayama 358/401
4,802,008 1/1989 Walling 358/406
4,979,028 12/1990 Minematsu et al. 358/261.4
5,067,019 11/1991 Juday et al. 358/160

Primary Examiner—Edward L. Coles, Sr.
Assistant Examiner—Jerome Grant, II

[57] **ABSTRACT**

A video-to-facsimile signal converter includes means for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of the continuous tone video image. An analog-to-digital converter receives and converts an analog video signal to digital video data which is captured by a video data two-field buffer. A digital signal processor, in conjunction with a memory look-up table, processes the captured video data by: interpolating the video data from the video resolution up to a higher facsimile resolution; selectively enhancing the image by sharpening image edges; precompensating the interpolated video data by altering its contrast transfer function; and dithering the interpolated and precompensated video data to produce video pel data blocks which correspond to the original video pixel data blocks and have similar composite gray-scale values. A facsimile encoder then encodes the interpolated, precompensated and dithered video data in accordance with the CCITT Group 3 facsimile standard. A MODEM and data access arrangement couple the facsimile-encoded signal onto a telephone line for transmission to and reception by a facsimile receiver for simulating the original continuous tone video image.

26 Claims, 9 Drawing Sheets



N

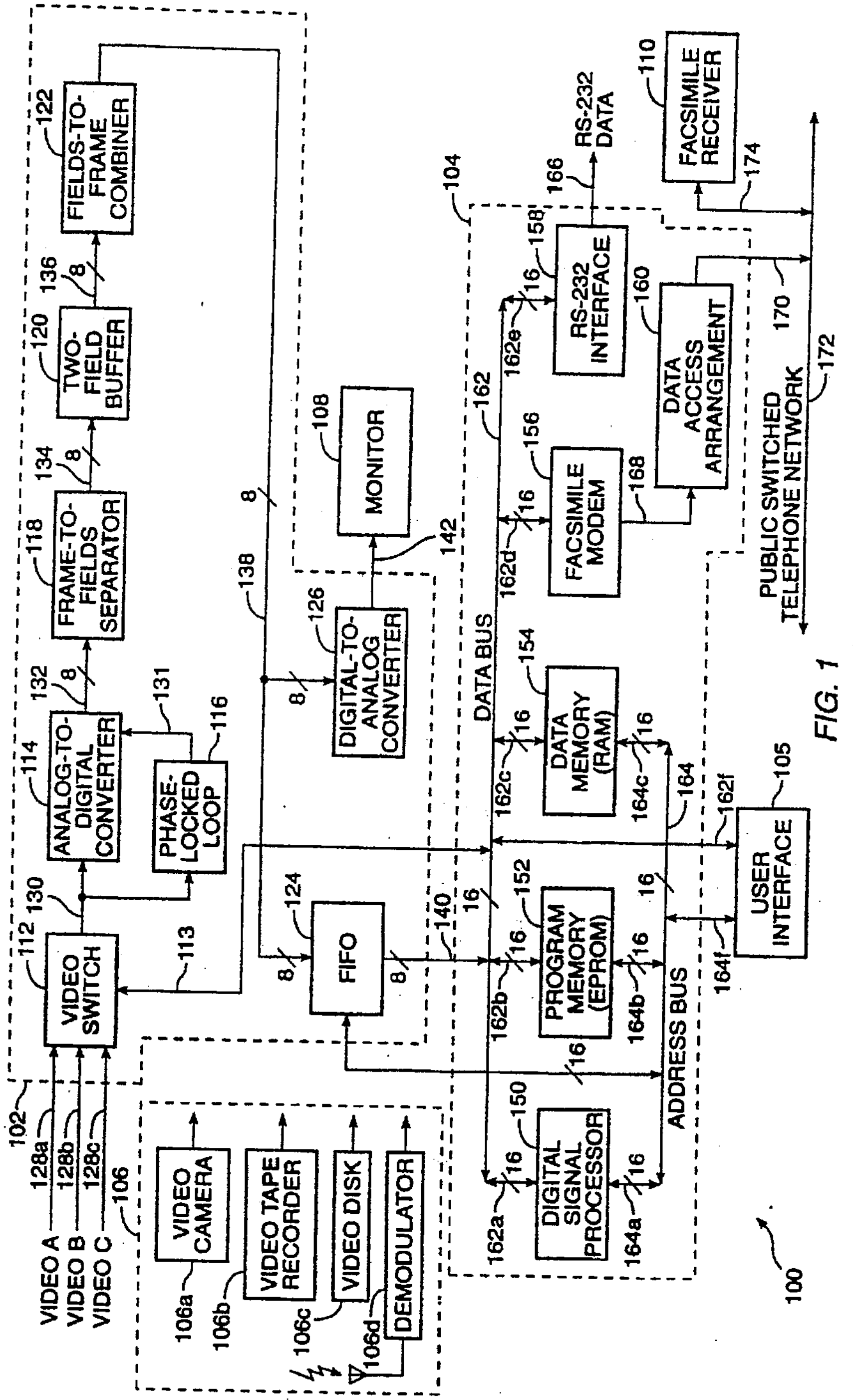

VIDEO A
VIDEO B
VIDEO C
128a
128b
128c
102
106
VIDEO SWITCH
112
130
113
ANALOG-TO-DIGITAL CONVERTER
114
PHASE-LOCKED LOOP
116
131
132
8
FRAME-TO-FIELDS SEPARATOR
118
134
TWO-FIELD BUFFER
120
136
FIELDS-TO-FRAME COMBINER
122
138
DIGITAL-TO-ANALOG CONVERTER
126
142
MONITOR
108
FIFO
124
140
16
VIDEO CAMERA
106a
VIDEO TAPE RECORDER
106b
VIDEO DISK
106c
DEMODULATOR
106d
DIGITAL SIGNAL PROCESSOR
150
162a
164a
PROGRAM MEMORY (EPROM)
152
162b
164b
DATA MEMORY (RAM)
154
162c
164c
FACSIMILE MODEM
156
162d
168
RS-232 INTERFACE
158
162e
166
RS-232 DATA
DATA ACCESS ARRANGEMENT
160
170
DATA BUS
162
ADDRESS BUS
164
USER INTERFACE
105
162f
164f
104
FACSIMILE RECEIVER
110
174
PUBLIC SWITCHED TELEPHONE NETWORK
172
100

FIG. 1

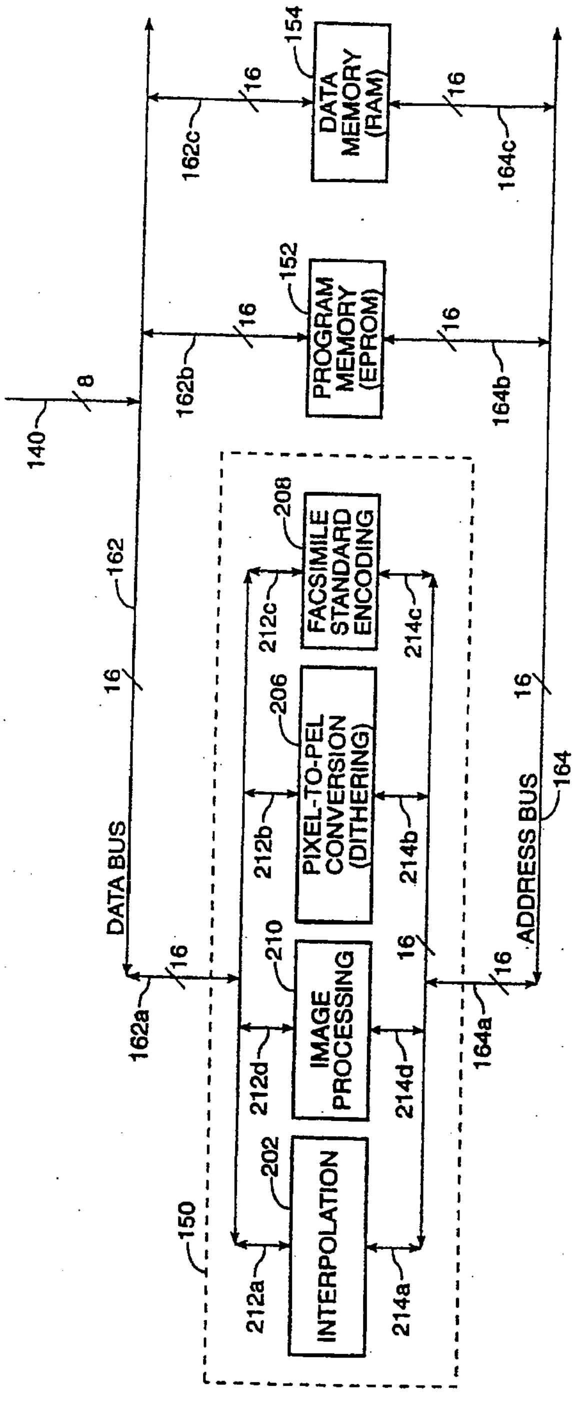

DATA BUS
ADDRESS BUS
DATA MEMORY (RAM)
PROGRAM MEMORY (EPROM)
FACSIMILE STANDARD ENCODING
PIXEL-TO-PEL CONVERSION (DITHERING)
IMAGE PROCESSING
INTERPOLATION
140
8
162
162a
162b
162c
164
164a
164b
164c
16
150
152
154
202
206
208
210
212a
212b
212c
212d
214a
214b
214c
214d

FIG. 2a

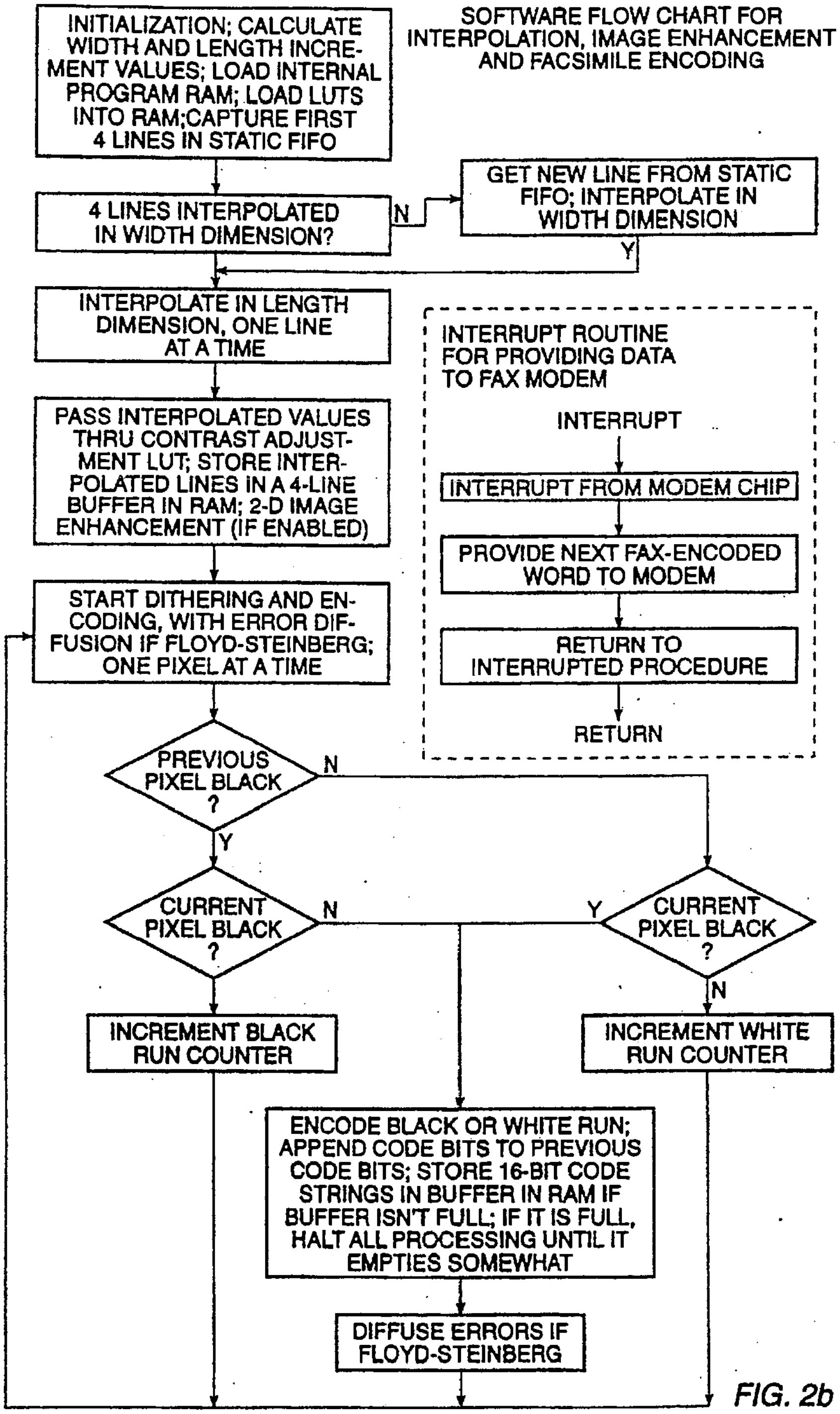

SOFTWARE FLOW CHART FOR INTERPOLATION, IMAGE ENHANCEMENT AND FACSIMILE ENCODING
INITIALIZATION; CALCULATE WIDTH AND LENGTH INCREMENT VALUES; LOAD INTERNAL PROGRAM RAM; LOAD LUTS INTO RAM;CAPTURE FIRST 4 LINES IN STATIC FIFO
4 LINES INTERPOLATED IN WIDTH DIMENSION?
N
GET NEW LINE FROM STATIC FIFO; INTERPOLATE IN WIDTH DIMENSION
Y
INTERPOLATE IN LENGTH DIMENSION, ONE LINE AT A TIME
PASS INTERPOLATED VALUES THRU CONTRAST ADJUSTMENT LUT; STORE INTERPOLATED LINES IN A 4-LINE BUFFER IN RAM; 2-D IMAGE ENHANCEMENT (IF ENABLED)
START DITHERING AND ENCODING, WITH ERROR DIFFUSION IF FLOYD-STEINBERG; ONE PIXEL AT A TIME
INTERRUPT ROUTINE FOR PROVIDING DATA TO FAX MODEM
INTERRUPT
INTERRUPT FROM MODEM CHIP
PROVIDE NEXT FAX-ENCODED WORD TO MODEM
RETURN TO INTERRUPTED PROCEDURE
RETURN
PREVIOUS PIXEL BLACK ?
N
Y
CURRENT PIXEL BLACK ?
N
Y
CURRENT PIXEL BLACK ?
N
INCREMENT BLACK RUN COUNTER
INCREMENT WHITE RUN COUNTER
ENCODE BLACK OR WHITE RUN; APPEND CODE BITS TO PREVIOUS CODE BITS; STORE 16-BIT CODE STRINGS IN BUFFER IN RAM IF BUFFER ISN'T FULL; IF IT IS FULL, HALT ALL PROCESSING UNTIL IT EMPTIES SOMEWHAT
DIFFUSE ERRORS IF FLOYD-STEINBERG

FIG. 2b

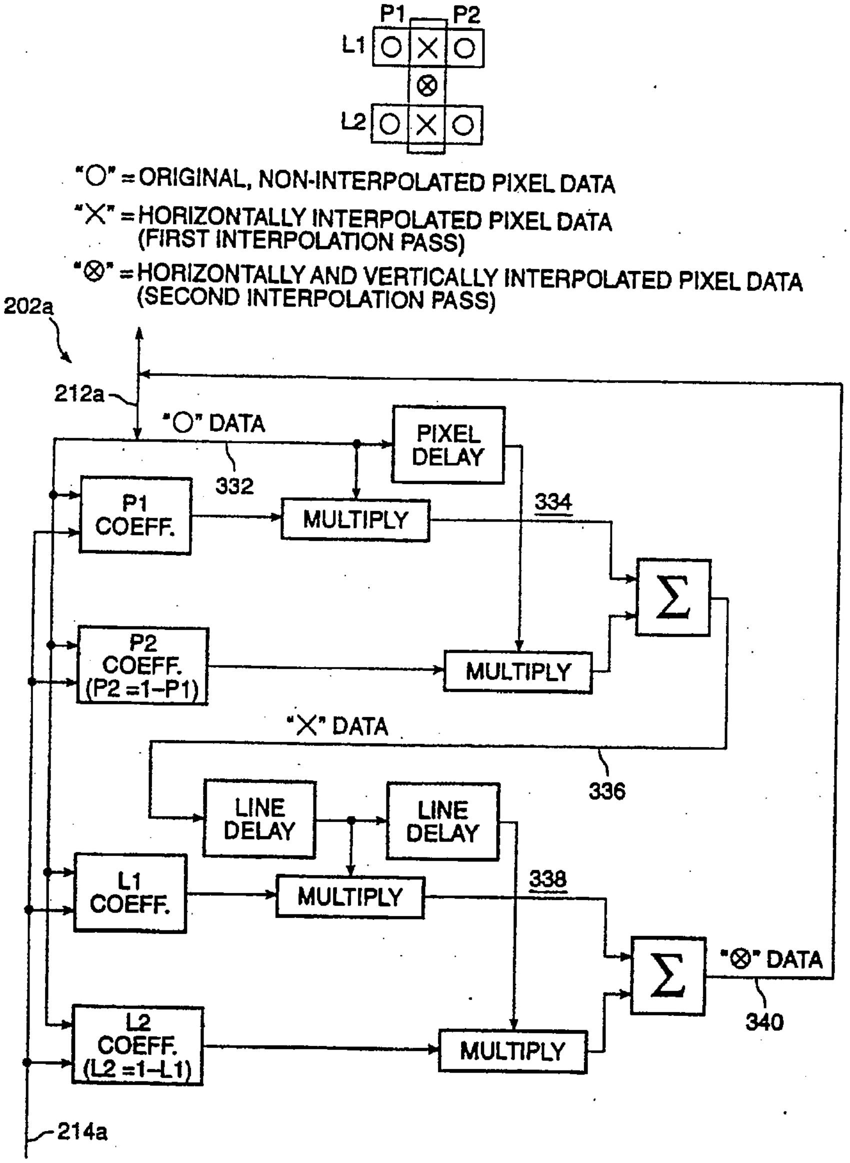
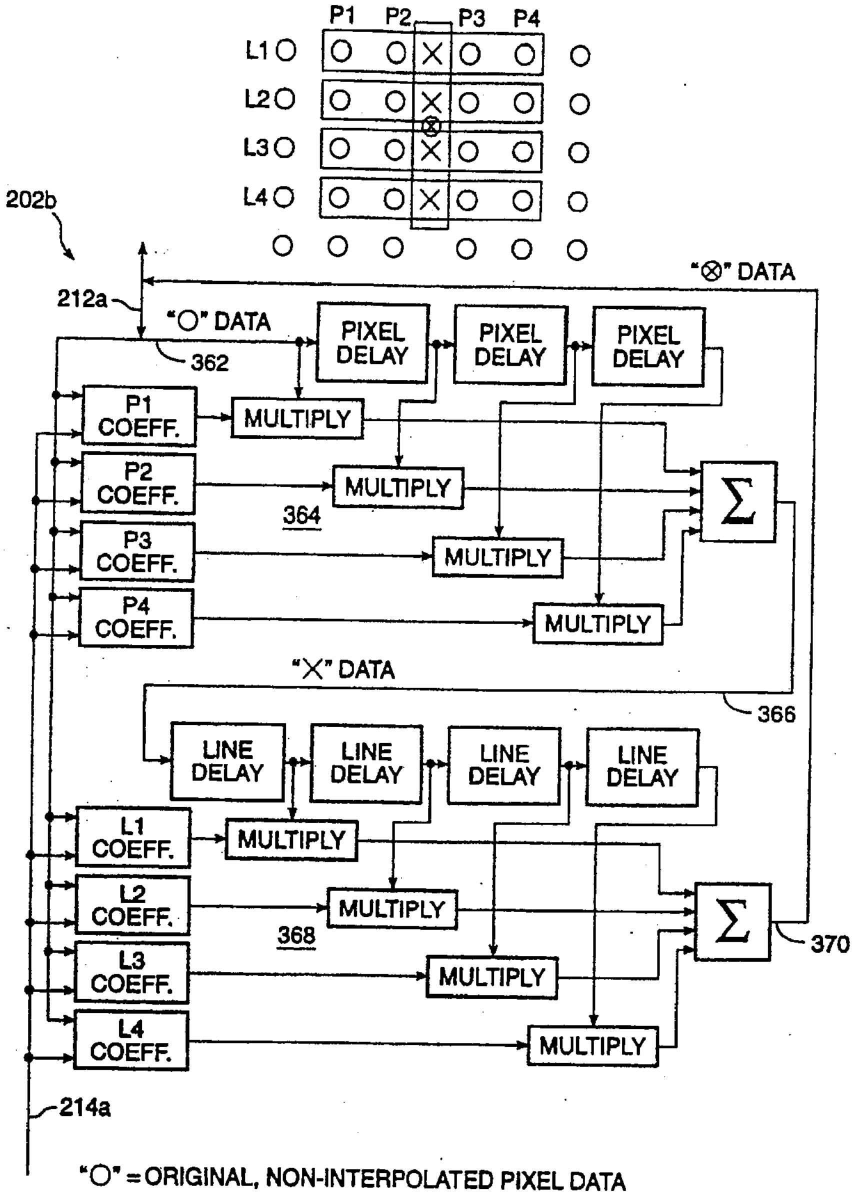

P1
P2
L1
L2
"O" = ORIGINAL, NON-INTERPOLATED PIXEL DATA
"X" = HORIZONTALLY INTERPOLATED PIXEL DATA (FIRST INTERPOLATION PASS)
"⊗" = HORIZONTALLY AND VERTICALLY INTERPOLATED PIXEL DATA (SECOND INTERPOLATION PASS)
202a
212a
"O" DATA
332
PIXEL DELAY
P1 COEFF.
MULTIPLY
334
Σ
P2 COEFF. (P2 =1−P1)
MULTIPLY
"X" DATA
336
LINE DELAY
LINE DELAY
L1 COEFF.
MULTIPLY
338
Σ
"⊗" DATA
340
L2 COEFF. (L2 =1−L1)
MULTIPLY
214a

FIG. 3a



"O" = ORIGINAL, NON-INTERPOLATED PIXEL DATA

"X" = HORIZONTALLY INTERPOLATED PIXEL DATA (FIRST INTERPOLATION PASS)

"⊗" = HORIZONTALLY AND VERTICALLY INTERPOLATED PIXEL DATA (SECOND INTERPOLATION PASS)

FIG. 3b

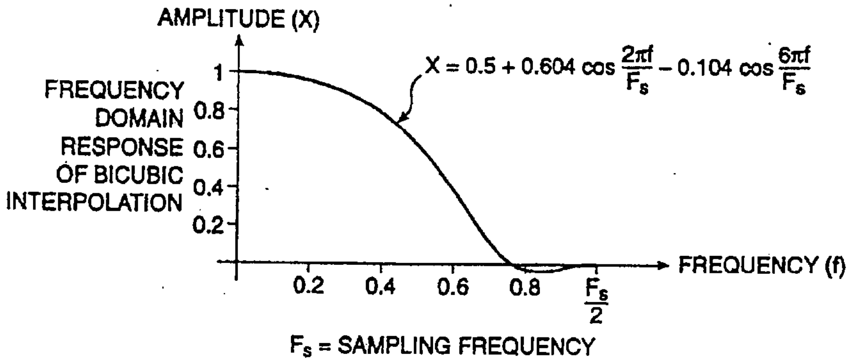
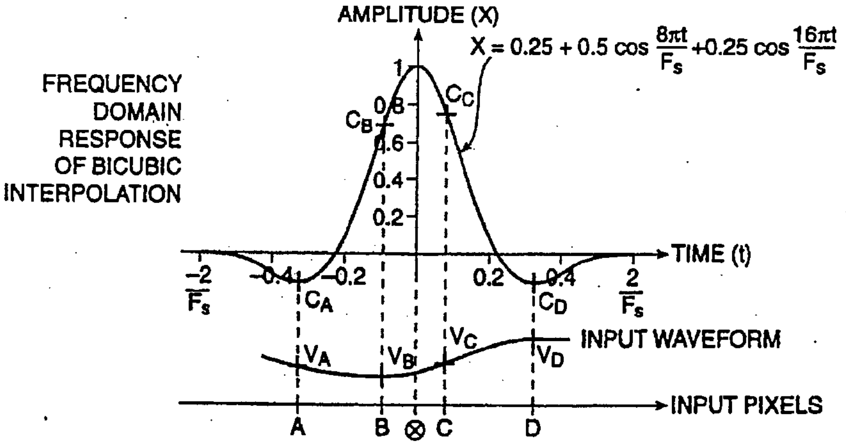


FIG. 3c



$\otimes = C_A V_A + C_B V_B + C_C V_C + C_D V_D$

F_s = SAMPLING FREQUENCY

C_m = INTERPOLATION COEFFICIENTS

V_m = INPUT PIXEL DATA (SAMPLES OF INPUT WAVEFORM TAKEN AT F_s)

FIG. 3d

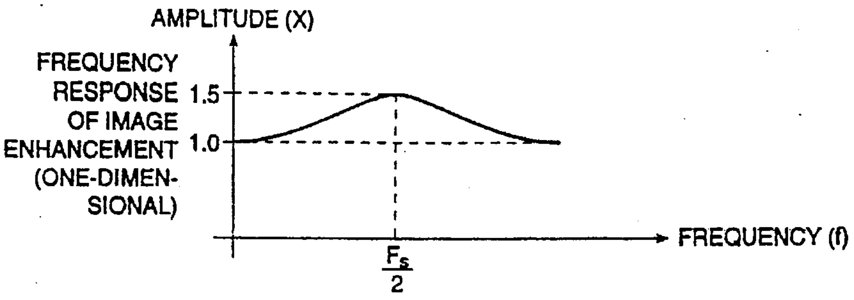
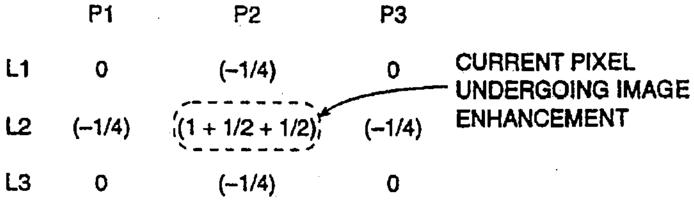


FIG. 4a



	P1	P2	P3
L1	0	(−1/4)	0
L2	(−1/4)	(1 + 1/2 + 1/2)	(−1/4)
L3	0	(−1/4)	0

FIG. 4b

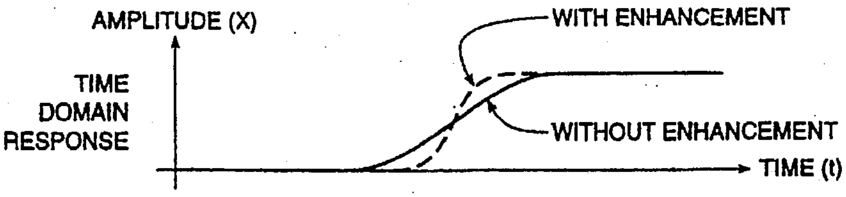


FIG. 4c

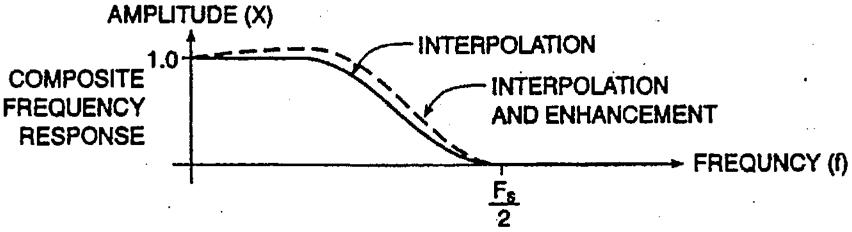


FIG. 4d

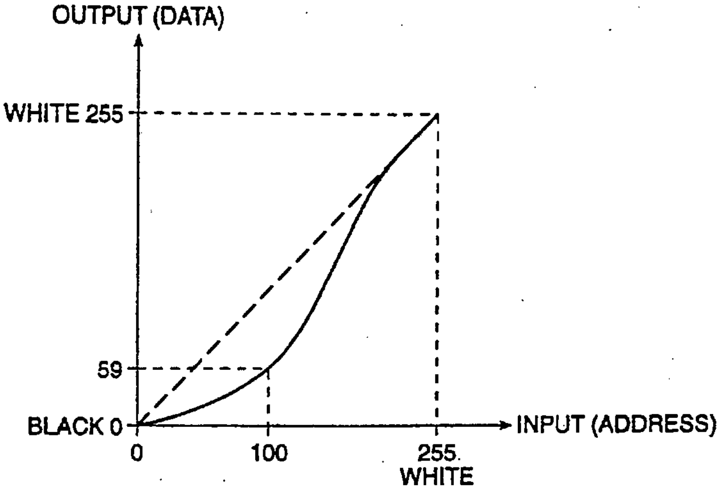

OUTPUT (DATA)
WHITE 255
59
BLACK 0
0
100
255
WHITE
INPUT (ADDRESS)

FIG. 5a

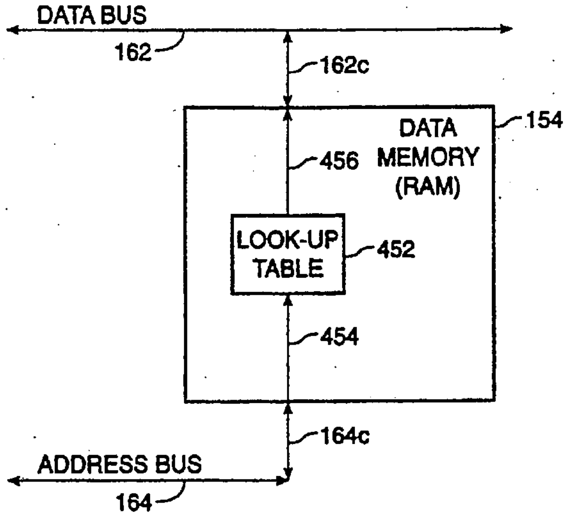

DATA BUS
162
162c
154
DATA MEMORY (RAM)
456
LOOK-UP TABLE
452
454
164c
ADDRESS BUS
164

FIG. 5b

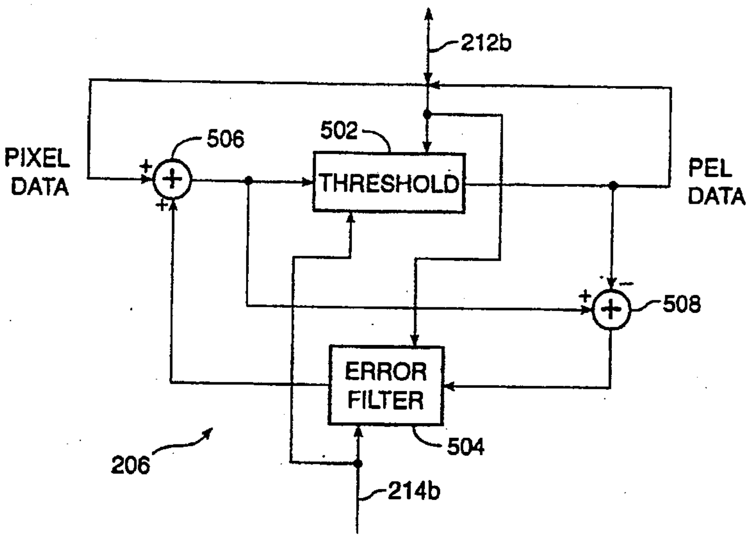

212b
PIXEL DATA
+
+
506
502
THRESHOLD
PEL DATA
+
−
508
ERROR FILTER
504
206
214b

FIG. 6

VIDEO-TO-FACSIMILE SIGNAL CONVERTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to video signal processors, and in particular, video signal processors for receiving and converting a video signal having multiple bits per pixel and representing a continuous tone video image to a facsimile signal having a single bit per pixel for transmission to and reception by a facsimile machine for producing a hard copy representation of the continuous tone video image.

2. Description of the Related Art

As the sophistication and capabilities of video system components such as video cameras and tape recorders have increased and their costs have decreased, uses for such components to capture and retain visual images in the form of video signals have increased in both number and form. Two uses in particular have become substantially more widespread. One use involves the capture and retention of visual images for use at a later time. Video signal recorders, such as video tape recorders, video cassette recorders or video disks, have served quite well for such uses. Another use involves the capture and transmission of video images for use at a distant, e.g. remote, location. This type of use has generally required some means of signal transmission to convey the video signal representing the visual image to the remote location. Such means of signal transmission typically include the use of some form of hard-wired video signal transmission medium, such as co-axial cable, or a radio frequency ("RF") transceiver. The former if often unwieldy or impractical, particularly over long distances, while the latter is often expensive and subject to restricted and heavily regulated RF spectrum allocations.

Other means for conveying video signals which has been used with some success are telephone networks. By converting the subject video signal to a digital video signal consisting of video pixel data and coupling it onto a telephone line via a modulator-demodulator ("MODEM"), the video information can be transmitted, albeit slowly, to many possible locations. At the receiving end, the video pixel data can be retrieved with another MODEM and processed as needed for viewing on a video monitor or storage on video tape. Alternatively, the video pixel data, if transmitted in accordance with an appropriate data standard, can be received by a facsimile machine and "reproduced" in the form of a hard copy printout.

However, such "reproduction" by a facsimile machine is not accurate. A video signal representing a continuous tone video image, when digitized, contains video pixel data (e.g. eight bits) representing the gray-scale values, or contrast range, of the continuous tone video image. However, a facsimile machine is capable of reproducing pel data (i.e. single bit) only, which may be thought of as a single bit per pixel. Accordingly, some form of "thresholding" is often performed to convert the video pixel data to video pel data for use by the facsimile machine. However, this generally results in a reproduced video image having a flat or grainy appearance. One technique which has been used with varying success to avoid this flat image appearance is "dithering." In "dithering," for each selected group of original pixels a group of corresponding pels is produced, which as a group, has a composite gray-scale value similar to that of the original group of pixels.

Accordingly, it would be desirable to have a video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal suitable for transmission to and reception by a commercial facsimile machine for more accurately "reproducing" the continuous tone video image by way of a hard copy printout.

SUMMARY OF THE INVENTION

A video-to-facsimile signal converter in accordance with the present invention receives and converts a video signal representing a continuous tone video image to a facsimile signal suitable for transmission to and reception by a facsimile receiver for simulating the continuous tone video image. The present invention includes means for selective data interpolation, image processing, signal contrast alteration, pixel-to-pel data signal conversion and encoding, as well as means for providing appropriate control signals for each of these operations.

The data interpolator, in accordance with a conversion control signal, receives and interpolates a pixel data signal representing the continuous tone video image by converting the size of the video image to a size appropriate for a facsimile printout. The image processor means selectively processes the pixel data signal to provide the desired image (e.g. sharpened, negative, contour-mapped) for printing out on a facsimile machine. The signal contrast alternation means, in accordance with a conversion control signal, receives and selectively alters the interpolated pixel data signal to selectively alter its contrast transfer function. The pixel-to-pel data signal converter, in accordance with a conversion control signal, receives and converts the interpolated and selectively altered pixel data signal to a pel data signal. The pel data signal has a composite gray-scale value when viewed over a block of pels which closely approximates the composite gray-scale value over the corresponding block of pixels. The encoder, in accordance with a conversion control signal, encodes the pel data signal according to a selected facsimile encoding standard to produce a facsimile standard signal. A preferred embodiment of the present invention uses a digital signal processor as the means for selective data interpolation, image processing, signal constrast alteration, pixel-to-pel data signal conversion and encoding, with a memory as the means for providing appropriate control signals for each of these operations.

These and other features and advantages of the present invention will be understood upon consideration of the following detailed description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a video system using a video-to-facsimile signal converter in accordance with the present invention.

FIG. 2A is a functional block diagram of a video-to-facsimile signal converter in accordance with the present invention.

FIG. 2B is a flowchart representing the video-to-facsimile signal conversion performed by the video-to-facsimile signal converter of FIG. 2A.

FIG. 3A is a functional block diagram of an exemplary bilinear interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3B is a functional block diagram of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3C illustrates the frequency domain response of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3D illustrates the time domain response of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4A illustrates the frequency response of an exemplary image enhancement operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4B illustrates the two-dimensional filter coefficients for an exemplary image enhancement operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4C illustrates the relative time domain responses for the video-to-facsimile signal converter of FIG. 2A with and without an image enhancement operation.

FIG. 4D illustrates the composite frequency responses for the video-to-facsimile signal converter of FIG. 2A with an interpolation operation only, and with both interpolation and image enhancement operations.

FIG. 5A illustrates an exemplary contrast alteration curve representing the transfer function of the contrast alteration operation of the video-to-facsimile signal converter of FIG. 2A.

FIG. 5B is a functional block diagram of an exemplary contrast alteration means for the video-to-facsimile signal converter of FIG. 2A.

FIG. 6 is a functional block diagram of the operation of an error diffusion algorithm used for a pixel-to-pel data conversion operation for the video-to-facsimile signal converter of FIG. 2A.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a video system 100 using a video-to-facsimile signal converter in accordance with the present invention includes a video signal processing section 102, a video signal conversion section 104 and a user interface 105. As discussed further below, normal operation of the video system 100 will include use of a video source 106. a video monitor 108 and a facsimile receiver 110.

The video processor section 102 includes a: video switch 112; analog-to-digital converter ("ADC") 114; phase-locked loop ("PLL") 116; frame-to-fields separator 118; two-field buffer 120; fields-to-frame combiner 122; first-in, first-out memory ("FIFO") 124; and digital-to-analog converter ("DAC") 126. The video switch 112 receives a plurality of video input signals 128a, 128b, 128c, which can be video signals in accordance with a number of formats (e.g. NTSC or PAL in color or monochrome), and a switch control signal 113. Any of these video input signals 128a, 128b, 128c can come from virtually any type of video source 106. The video source 106 can be of many different types, such as a video camera 106a, video tape recorder 106b, video disk player 106c or a demodulator 106d which receives some form of over-the-air video broadcast signal. The switch control signal 113, received from the video signal conversion section 104 (discussed further below), determines which video input signal 128a, 128b, 128c is selected.

The selected video signal 130 from the video switch 112 is received by the ADC 114 and PLL 116. The PLL 116, based upon its input video signal 130, generates a synchronization signal 131 for the ADC 114. The ADC

114 samples (at a sampling frequency F_S of approximately 9.7 MHz) and converts its input video signal 130 to a 8-bit wide digitized monochrome video signal 132. Each 8-bit word within this signal 132 represents a pixel, and therefore provides a 256-value gray-scale.

The digitized video signal 132 is received by the frame-to-fields separator 118. The frame-to-fields separator 118 allows the two fields which make up a video frame to be treated separately. Video data 134 representing both fields can be stored in the two-field buffer 120, and can provide a deinterlaced frame image. Alternatively, video data 134 representing one field (either odd or even) can be selected and used as the representation of the original video image. The buffered two-field video data 136 is received by the fields-to-frame combiner 122 for selective recombination. This allows for the display of either a correct, i.e. interlaced, two-field frame or a frame made up of two copies of one field (odd or even).

The video frame data 138 is received by the FIFO 124 and DAC 126. The FIFO 124 receives and stores several selected lines (as desired) from this video frame data 138 and provides corresponding, selectively delayed output video data 140 on a first-in, first-out basis. The DAC 126 converts the digital video frame data 138 to an analog video signal 142 for reception and display on a video monitor 108. This allows the user of the system 100 to view the video information which is being processed by the video processing section 102 and converted by the video converting section 104.

Although in the preferred embodiment described herein the digitized 132 and subsequently processed video signals 134, 136, 138 represent monochrome video information, it should be understood that the ADC 114 can alternatively be designed to sample and convert an analog color input video signal 130 to a digital color signal. For example, this digital color signal can include three 8-bit wide digitized video signals (in serial or parallel) which represent red, green and blue video information. Each group of three 8-bit words within such a color signal would represent the red, green and blue color components of a pixel. The color components could be those of any system used to represent color, such as RGB, YUV (PAL) or CYMK.

The video converter section 104 includes a: digital signal processor ("DSP") 150; program memory (e.g. EPROM) 152; data memory (e.g. RAM) 154; facsimile MODEM 156; RS-232 interface 158; and a data access arrangement ("DAA") 160. A data bus 162 is included for receiving the data 140 from the FIFO 124 (in the video processing section 102, as discussed above) and for transferring data among the DSP 150, program memory 152, data memory 154, facsimile MODEM 156 and RS-232 interface 158. An address bus 164 is included to allow the DSP 150 to address the FIFO 124, program memory 152 and data memory 154, as desired.

The data 140 from the FIFO 124, transferred via the data bus 162, is received by the DSP 150 for processing. As discussed further below, the DSP 150 processes this data in accordance with instructions received from the program memory 152 and data received from the data memory 154 via the data bus 162 and address bus 164. Once processed, the data is transferred via the data bus 162 to the facsimile MODEM 156 or RS-232 interface 158.

The RS-232 interface 158 encodes data received by it and provides an RS-232 data signal 166 for external use. The facsimile MODEM 156 converts (e.g. modulates) data received by it for transmission over a telephone line. The facsimile MODEM 156 provides this converted signal 168 to the data access arrangement 160, which in turn provides an appropriately coupled facsimile signal 170 for transmission over a telephone network 172. As discussed further below, a facsimile receiver 110, when appropriately addressed, receives a signal 174 from the telephone network 172 containing the video information to be simulated in the form of hard copy printout.

Interfaces other than the data access arrangement 160 which can be used include an acoustic coupler (not shown) for use with a public telephone or cellular telephone, and a cellular telephone MODEM (not shown) for communicating directly via the cellular telephone network frequencies.

The user interface 105 can be composed as desired of various devices. In a preferred embodiment, a numeric keypad and liquid crystal display ("LCD") are used, respectively, for inputting data or instructions and displaying data or status information. Alternatively, other devices can be used as desired, such as an alphanumeric keypad and a CRT video display screen.

Referring to FIG. 2A, the DSP 150 provides means for interpolation 202, image processing 210, pixel-to-pel conversion 206 and facsimile standard encoding 208 of the video data 140 received from the FIFO 124. Internal data bus interfaces 212*a*, 212*b*, 212*c*, 212*d* and address bus interfaces 214*a*, 214*b*, 214*c*, 214*d* provide access to and from the external data bus interface 162*a* and address bus interface 164*a*, respectively. This access allows the DSP 150 to receive instructions from the program memory 152 and data from the data memory 154, as well as address the memories 152, 154. As discussed further below, in a preferred embodiment, the interpolator 202, image processor 210, pixel-to-pel converter 206 and facsimile standard encoder 208 represent operations of software modules which are executed by the DSP 150 (discussed further below).

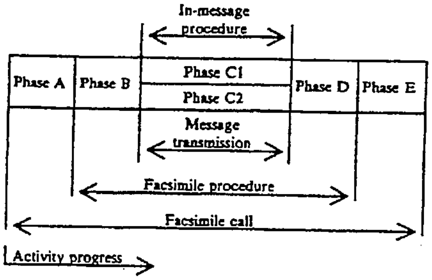
The interpolator 202 receives the video data 140 via the data bus 162 and data bus interfaces 162*a*, 212*a* and interpolates it in accordance with instructions received from the program memory 152 via the data bus 162 and data bus interfaces 162*b*, 162*a*, 212*a* (discussed further below). The image processor 210 selectively receives the interpolated data via the data bus interfaces 212*a*, 212*d* and processes it in accordance with instructions received from the program memory 152 via the data bus 162 and data bus interfaces 162*b*, 162*a*, 212*d* (discussed further below). The interpolated and image-processed data is transferred, via the data bus 162 and data bus interfaces 212*d*, 162*a*, 162*c*, to the data memory 154 for alteration of its contrast range, i.e. dot gain correction (discussed further below).

In accordance with instructions and data received from the program memory 152 and data memory 154 via the data bus 162 and address bus 164, respectively, the interpolated, image-processed and contrast-altered data is then retrieved from the data memory 154 via the data bus 162 and data bus interfaces 162*c*, 162*a*, 212*b*, and processed by the pixel-to-pel converter 206 for conversion to pel data (discussed further below). The pel data, i.e. dithered data, is transferred to the data memory 154 for temporary storage prior to its encoding by the facsimile standard encoder 208.

In accordance with instructions and data received from the program memory 152 and data memory 154 via the data bus 162 and address bus 164, respectively, the pel data is then retrieved from the data memory 154 via the data bus 162 and data bus interfaces 162*c*, 162*a*, 212*c*, and encoded according to a facsimile standard. The facsimile standard-encoded pel data is then sent to the data bus 162 for transfer to the facsimile MODEM 156 or RS-232 interface 158.

In a preferred embodiment of the present invention, the facsimile standard encoding 208 is done in accordance with CCITT Group 3 (Recommendations T.4 and T.30). The time sequence of the facsimile standard-encoded pel data is as shown below in Chart 1.

CHART 1



During phase B of the above-identified time sequence, the initiation of and handshaking for the facsimile message can be performed in accordance with the capabilities of the sending and receiving equipment as outlined in Recommendation T.30, part of which is shown below in Table 1.

TABLE 1

CCITT Group 3 Facsimile Standard

Bit No.	From Receiver DIS/DTC	From Transmitter DCS
1	Transmitter - T.2 operation	
2	Receiver - T.2 operation	Receiver - T.2 operation
3	T.2 IOC = 176	T.2 IOC = 176
4	Transmitter - T.3 operation	
5	Receiver - T.3 operation	Receiver - T.3 operation
6	Reserved for future T.3 operation features	
7	Reserved for future T.3 operation features	
8	Reserved for future T.3 operation features	
9	Transmitter - T.4 operation	
10	Receiver - T.4 operation	Receiver - T.4 operation
11, 12	Data signalling rate	Data signalling rate
(0,0)	V.27 ter fallback mode	2400 bit/s V.27 ter
(0,1)	V.27 ter	4800 bit/s V.27 ter
(1,0)	V.29	9600 bit/s V.29
(1,1)	V.27 ter and V.29	7200 bit/s V.29
13	Reserved for new modulation system	
14	Reserved for new modulation system	
15	Vertical resolution = 7.7 line/mm	Vertical resolution = 7.7 line/mm (200 dpi)
16	Two dimensional coding capability	Two dimensional coding
17, 18	Recording width capabilities	Recording width
(0,0)	1728 picture elements along scan line length of 215 mm ± 1%	1728 picture elements along scan line length of 215 mm ± 1%
(0,1)	1728 picture elements along scan line length of 215 mm ±	2432 picture elements along

TABLE 1-continued

CCITT Group 3 Facsimile Standard

Bit No.	From Receiver DIS/DTC	From Transmitter DCS
	1%	
	2048 picture elements along scan line length of 255 mm ± 1%	scan line length of 303 mm ± 1%
	2432 picture elements along scan line length of 303 mm ± 1%	
(1,0)	1728 picture elements along scan line length of 215 mm ± 1% and 2048 picture elements along scan line length of 255 mm ± 1%	2048 picture elements along scan line 255 mm ± 1%
(1,1)	Invalid	Invalid
19, 20	Maximum recording length capability	Maximum recording length
(0,0)	A4 (297 mm)	A4 (297 mm)
(0,1)	Unlimited	Unlimited
(1,0)	A4 (297 mm) and B4 (364 mm)	B4 (364 mm)
(1,1)	Invalid	Invalid
21, 22 23	Minimum scan line time capability at the receiver	Minimum scan line time
(0,0,0)	20 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	20 ms
(0,0,1)	40 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	40 ms
(0,1,0)	10 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	10 ms
(1,0,0)	5 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	5 ms
(0,1,1)	10 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,1,0)	20 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,0,1)	40 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,1,1)	0 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	0 ms
24	Extend field	Extend field
25	2400 bit/s handshaking	2400 bit/s handshaking
26	Uncompressed mode	Uncompressed mode
27	Error correction mode	Error correction mode
28	Set to "0"	Frame size 0 = 256 octets 1 = 64 octets
29	Error limiting mode	Error limiting mode
30	Reserved for G4 capability on PSTN	Reserved for G4 capability on PSTN
31	Unassigned	
32	Extend field	Extend field
33	Validity of bits 17, 18	Recording width
(0)	Bits 17, 18 are valid	Recording width indicated by bits 17, 18
(1)	Bits 17, 18 are invalid	Recording width indicated by this field bit information
34	Recording width capability 1216 picture elements along scan line length of 151 mm ± 1%	Middle 1216 elements of 1728 picture elements
35	Recording width capability 864 picture elements along scan line length of 107 mm ± 1%	Middle 864 elements of 1728 picture elements
36	Recording width capability 1728 picture elements along scan line length of 151 mm ± 1%	Invalid
37	Recording width capability 1728 picture elements along scan line length of 107 mm ± 1%	Invalid
38	Reserved for future recording width capability	
39	Reserved for future recording width capability	

TABLE 1-continued

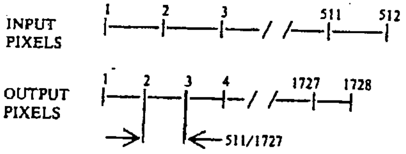
CCITT Group 3 Facsimile Standard

Bit No.	From Receiver DIS/DTC	From Transmitter DCS
40	Extend field	Extend field

Referring to FIG. 2B, a simplified software flowchart depicting these operations in accordance with the foregoing discussion is illustrated. This flowchart represents the sequence of operations performed by the DSP 150 in accordance with instructions stored within the program memory **152** (discussed further below).

The interpolation operation discussed above inserts new pixel data in between existing pixel data by interpolating adjacent pixel data, typically in a bilinear (two-dimensional linear) or bicubic (two-dimensional cubic) fashion. The two-dimensional interpolation (bilinear or bicubic) is performed in two one-dimensional passes, i.e. first horizontally (inter-pixel) and then vertically (inter-line). For example, in the case where 512 pixels on each line are to be expanded to 1728 pixels, the original 512 pixels are first interpolated horizontally to produce 1728 pixels with a concommittant reduction in the individual pixel spacing (i.e. to 5111727), as depicted below in Chart 2.

CHART 2



For bilinear interpolation of each interpolated pixel N, where N∊{0,1,2, . . . ,1727}, adjacent input pixels P and P+1 are used, where P=INT[N(511)/1727)], and INT(X/Y)=integer value of the quotient X/Y. Thus, in the case of the 1000th pixel, i.e. N=1000, pixel **295** (INT[1000(511)/1727)]=295) and pixel **296** (INT[1000(511)/1727)]+1=296) are used. Since the quotient [1000(511)/1727)]=295.89, the interpolation can be done within the DSP 150 via the simple computation:

$$N=(\text{PIXEL }\#295)(1-0.89)+(\text{PIXEL }\#296)(0.89)$$

Alternatively, a look-up table within the data memory **154** can be used, wherein a finite number of interpolation coefficients can be stored for use as needed. An exemplary table of bilinear interpolation coefficients for the present invention are listed below in Table 2. In the foregoing example for N=1000, entry #7 from Table 2 would be used, i.e. coefficients 0.109375 and 0.890625, selected as follows:

$$\begin{aligned} (P+1)-[N(511)/1727)] &= 296-[1000(511)/1727)] \\ &= 296-295.89 \\ &= 0.11 \end{aligned}$$

$$\begin{aligned} 0.11(\#\text{ of coefficient entries}) &= 0.11(64) \\ &= 7.11 \end{aligned}$$

Nearest integer to 7.11 = 7

where:

$$N=(\text{PIXEL }\#295)(0.109375)+(\text{PIXEL }\#296)(0.890625)$$

TABLE 2

BILINEAR INTERPOLATION COEFFICIENTS

Entry	L_A	L_B	Entry	L_A	L_B
0	0.0	1.0	32	0.5	0.5
1	0.015625	0.984375		0.515625	0.484375
2	0.03125	0.96875		0.53125	0.46875
3	0.046875	0.953125	35	0.546875	0.453125
4	0.0625	0.9375		0.5625	0.4375
5	0.078125	0.921875		0.578125	0.421875
6	0.09375	0.90625		0.59375	0.40625
7	0.109375	0.890625		0.609375	0.390625
8	0.125	0.875	40	0.625	0.375
9	0.140625	0.859375		0.640625	0.359375
10	0.15625	0.84375		0.65625	0.34375
	0.171875	0.828125		0.671875	0.328125
	0.1875	0.8125		0.6875	0.3125
	0.203125	0.796875	45	0.703125	0.296875
	0.21875	0.78125		0.71875	0.28125
15	0.234375	0.765625		0.734375	0.265625
	0.25	0.75		0.75	0.25
	0.265625	0.734375		0.765625	0.234375
	0.28125	0.71875	50	0.78125	0.21875
	0.296875	0.703125		0.796875	0.203125
20	0.3125	0.6875		0.8125	0.01875
	0.328125	0.671875		0.828125	0.171875
	0.34375	0.65625		0.84375	0.15625
	0.359375	0.640625	55	0.859375	0.140625
	0.375	0.625		0.875	0.125
25	0.390625	0.609375		0.890625	0.109375
	0.40625	0.59375		0.90625	0.09375
	0.421875	0.578125		0.921875	0.078125
	0.4375	0.5625	60	0.9375	0.0625
	0.453125	0.546875		0.953125	0.046875
30	0.46875	0.53125		0.96875	0.03125
31	0.484375	0.515625	63	0.984375	0.015625

Referring to FIG. 3A, the operation of an exemplary bilinear interpolator *202a* is depicted. Incoming, non-interpolated pixel data 332, received via the data bus interface *212a*, is horizontally interpolated by a horizontal linear interpolator 334. The horizontally interpolated pixel data 336 is received and vertically interpolated by a vertical linear interpolator 338. The horizontally and vertically interpolated pixel data 340 is then available for transfer to the data memory 154 for temporary storage, as discussed above. The pixel coefficients P1, P2, L1, L2 (discussed above) are selectively provided in accordance with instructions and addressing received via the data bus interface *212a* and address interface *214a* from the program memory 152 and data memory 154.

Referring to FIG. 3B, the operation of an exemplary bicubic interpolator *202b* is depicted. Incoming, non-interpolated pixel data 362, received via the data bus interface *212a*, is horizontally interpolated by a horizontal cubic interpolator 364. The horizontally interpolated pixel data 366 is received and vertically interpolated by a vertical cubic interpolator 368. The horizontally and vertically interpolated pixel data 370 is then available for transfer to the data memory 154 for temporary storage, as discussed above. The pixel coefficients P1, P2, P3, P4, L1, L2, L3, L4 (discussed further below) are selectively provided in accordance with instructions and addressing received via the data bus interface *212a* and address interface *214a* from the program memory 152 and data memory 154.

It should be understood that the time delays represented by the "pixel delay" blocks in FIGS. 3A and 3B are not required as discrete elements or operations if the original, non-interpolated pixel data is retrieved from the data memory 154 at the appropriate times. Further, the time delays represented by the "line delay" blocks are not required as discrete elements or operations if the horizontally interpolated pixel data is temporarily stored in and retrieved from the data memory 154 at the appropriate times.

Using the example discussed above for bilinear horizontal interpolation of 511 pixels to 1728 pixels, bicubic horizontal interpolation of interpolated pixel N uses adjacent input pixels P−1, P, P+1 and P+2, where P=INT[N(511)/1727)], and INT(X/Y)=integer value of the quotient X/Y. Thus, in the case of the 1000th pixel, i.e. N=1000, pixel 294 (INT[1000(511)/1727)]−1=294), pixel 295 (INT[1000(511)/1727)]=295), pixel 296 (INT[1000(511)/1727)]+1=296) and pixel 297 (INT[1000(511)/1727)]+2=297) are used.

The bicubic interpolation coefficients are stored in the data memory 154 for access and use by the DSP 150 as needed. An exemplary table of bicubic interpolation coefficients for the present invention are listed below in Table 3. In accordance with the discussion above for the example of N=1000, entry #7 from Table 3 would be used, i.e. the four coefficients −0.0072528, 0.100095, 0.978025 and −0.070867 (selected as shown above).

TABLE 3

BICUBIC INTERPOLATION COEFFICIENTS

Entry	C_A	C_B	C_C	C_D
0	0.0	0.0	1.0	0.0
1	−0.000150545	0.0125718	0.999548	−0.0119695
2	−0.000601546	0.0257377	0.998194	−0.0233
3	−0.0013511	0.0394882	0.995939	−0.0340764
4	−0.00239604	0.0538123	0.992789	−0.0442049
5	−0.00373195	0.0686975	0.988748	−0.0537132
6	−0.00535317	0.0841302	0.983823	−0.0626003
7	−0.0072528	0.100095	0.978025	−0.070867
8	−0.00942276	0.116575	0.971363	−0.078515
9	−0.0118537	0.133553	0.963848	−0.0855479
10	−0.0145353	0.15101	0.955496	−0.0919704
	−0.0174559	0.168924	0.94632	−0.0977885
	−0.0206028	0.187275	0.936338	−0.10301
	−0.0239622	0.206039	0.925566	−0.107643
	−0.0275194	0.225192	0.914025	−0.111698
15	−0.0312586	0.24471	0.901734	−0.115185
	−0.0351631	0.264565	0.888716	−0.118118
	−0.0392151	0.284731	0.874995	−0.12051
	−0.0433963	0.305179	0.860593	−0.122376
	−0.0476873	0.325881	0.845537	−0.12373
20	−0.0520681	0.346806	0.829853	−0.124591
	−0.0565178	0.367923	0.813569	−0.124975
	−0.0610151	0.389202	0.796713	−0.124901
	−0.065538	0.41061	0.779316	−0.124388
	−0.0700639	0.432114	0.761406	−0.123456
25	−0.0745699	0.453682	0.743015	−0.122127
	−0.0790326	0.475278	0.724175	−0.120421
	−0.0834282	0.496871	0.704918	−0.118361
	−0.0877326	0.518424	0.685278	−0.115969
	−0.0919218	0.539904	0.665287	−0.113269
30	−0.0959713	0.561275	0.64498	−0.110284
	−0.0998566	0.582503	0.62439	−0.107037
	−0.103553	0.603553	0.603553	−0.103553
	−0.107037	0.62439	0.582503	−0.0998566
	−0.110284	0.64498	0.561275	−0.0959713
35	−0.113269	0.665287	0.539904	−0.0919218
	−0.115969	0.685278	0.518424	−0.0877326
	−0.118361	0.704918	0.496871	−0.0834282
	−0.120421	0.724175	0.475278	−0.0790326
39	−0.122127	0.743015	0.453682	−0.0745699
40	−0.123456	0.761406	0.432114	−0.0700639
41	−0.124388	0.779316	0.41061	−0.065538
	−0.124901	0.796713	0.389202	−0.0610151
	−0.124975	0.813569	0.367923	−0.0565178
	−0.124591	0.829853	0.346806	−0.0520681
45	−0.12373	0.845537	0.325881	−0.0476873

TABLE 3-continued

	BICUBIC INTERPOLATION COEFFICIENTS			
Entry	C_A	C_B	C_C	C_D
	−0.122376	0.860593	0.305179	−0.0433963
	−0.12051	0.874995	0.284731	−0.0392151
	−0.118118	0.888716	0.264565	−0.0351631
	−0.115185	0.901734	0.24471	−0.0312586
50	−0.111698	0.914025	0.225192	−0.0275194
	−0.107643	0.925566	0.206039	−0.0239622
	−0.10301	0.936338	0.187275	−0.0206028
	−0.0977885	0.94632	0.168924	−0.0174559
	−0.0919704	0.955496	0.15101	−0.0145353
55	−0.0855479	0.963848	0.133553	−0.0118537
	−0.078515	0.971363	0.116575	−0.00942276
	−0.070867	0.978025	0.100095	−0.0072528
	−0.0626003	0.983823	0.0841302	−0.00535317
	−0.0537132	0.988748	0.0686975	−0.00373195
60	−0.0442049	0.992789	0.0538123	−0.00239604
	−0.0340764	0.995939	0.0394882	−0.0013511
	−0.02333	0.998194	0.0257377	−0.000601546
63	−0.0119695	0.999548	0.0125718	−0.000150545

Referring to FIG. 3C, the filtering effect of the bicubic interpolation in the frequency domain is shown. The amplitude versus frequency function is similar to that of a low-pass filter. During bicubic interpolation, the product of this function and the function representing the frequency response of the incoming pixel data provides the output, i.e. interpolated, pixel data.

Referring to FIG. 3D, the filtering effect of the bicubic interpolation in the time domain is shown. Also shown are the graphical relationships between the input pixels and the corresponding interpolation coefficients' values. Here in FIG. 3D, input pixels A, B, C, and D would correspond to pixels **294**, **295**, **296** and **297**, respectively, as discussed in the example above. During bicubic interpolation, the convolution of this function and the incoming pixel data provides the output, i.e. interpolated, pixel data ($C_AV_A+C_BV_B+C_CV_C+C_DV_D$).

The image processing **210** performed can be of several various types, such as video data inversion, contour mapping or contrast manipulation. Video data inversion would provide for a "negative" image. Contour mapping would involve the application of multiple thresholds to the video data for providing an image with more of a stepped gray-scale, or for allowing the detection of changes in a scene being monitored using simple comparison techniques. One form of contrast manipulation can involve the changing of the video data contrast transfer function to expose image details otherwise hidden in shadows or a dark scene.

In a preferred embodiment of the present invention, the image processing **210** performed is image enhancement, which is done in two dimensions. As seen in FIG. 4A, the one-dimensional frequency response of the image enhancement is amplification of data signal amplitudes at the frequencies closely adjacent to half of the sampling frequency ($F_S/2$) of the ADC **114**. As seen in FIG. 4B, a two-dimensional filter is used where, in both the horizontal and vertical filtering, the current input pixel data undergoing enhancement is multiplied by a coefficient of 2.0 and the immediately adjacent horizontal and vertical pixels' data are each multiplied by a coefficient of −0.25. The sum of these products provides the image-enhanced pixel data.

Referring to FIG. 4C, the effect of the image enhancement can be seen in the time domain. The edges of an image are sharpened in the sense that data amplitude transitions are rendered more steep, i.e. faster. The effect in the frequency domain, as shown in FIG. 4D, is to increase the frequency at which the response begins to roll of, i.e. increase the effective low-pass filter bandwidth as compared to that of interpolation only (discussed above).

Referring to FIG. 5A, an exemplary output versus input transfer function is illustrated graphically for the contrast alteration, or dot gain correction, process performed by the DSP **150**, program memory **152** and data memory **154**, as discussed above (FIG. 2A). As seen in FIG. 5A, the transfer function, normally a linear output versus input relationship, is selectively altered to cause input pixel information having medium gray-scale values to be darkened. This type of altered transfer function can be computed or derived semi-empirically to give the best results with a gray-scale ramp input as the test image. Further, this type of altered transfer function represents the inverse of the typical nonlinear characteristics of a typical facsimile printing mechanism, thereby providing a form of precompensation for the video image data to be printed thereby.

Referring to FIG. 5B, a preferred implementation of the aforementioned contrast alteration process includes a look-up table **452** which is constructed within a portion of the data memory **154**. The interpolated pixel data **454** is received via the address bus **164** and address bus interface **164c** and serves as the input address(es) for the look-up table **452**. The accessed data **456** has values which are in accordance with the desired transfer function, as discussed above (FIG. 5A). This data **456** is conveyed via the data bus interface **162c** to the data bus **162** for transfer to the DSP **150** and conversion by the pixel-to-pel converter **206** as discussed above (FIG. 2A).

It should be understood that, since the look-up table **452** uses only a portion of the data memory **154** and that portion need not necessarily begin at address location "zero," the input addresses, i.e. the interpolated pixel data **454**, can include an address offset. The address offset would increment the address values appropriately to access that portion of the data memory **154** constituting the look-up table **452**. The address offset can be generated and added to the interpolated pixel data **454** by the DSP **150**, with the result placed onto the address bus **164**.

As initially discussed above, the pixel-to-pel converter **206** receives and converts pixel data to pel data. This process, often referred to as "dithering," can be performed in accordance with a number of techniques. Three techniques, as discussed below and represented in Matrices **1-3** below, involve using a: 45° Classical Screen (Matrix **1**); Line Screen (Matrix **2**); or Spiral-Dot Screen (Matrix **3**). A more detailed discussion regarding these techniques can be found in R. Ulichney, "Digital Halftoning," pp. 77-126, MIT Press 1987 (incorporated herein by reference).

Referring to Matrix 1 below, the 45° Classical Screen mimics the 50-100 lines per inch screen traditionally used in printing a continuous tone image in newspapers or magazines. The triangularly-shaped numerical arrays are replicated over the entire image, thereby giving a superimposed screen which alternates from light to dark, 50-100 times per inch. The number within the numerical arrays are threshold values to which the 8-bit pixel's gray-scale value are compared one at a time to resolve **19** (Matrix **1**(a)) or **33** (Matrix **1**(b)) gray levels.

The incoming pixel data is compared with the corresponding threshold value within the superimposed threshold numerical array, and if the pixel value is less than the threshold value, a black dot is printed. Conversely, if the pixel value is greater than the threshold value, no black dot is printed. In this way, each pixel (8-bit) is converted to a pel (1-bit) which the receiving facsimile machine **110** (FIG. 1) can print out either as a black dot, or as the absence of a black dot. The resulting image, now seen through the superimposed Classical Screen, consists of pels, i.e. 1-bit pixels.

MATRIX 1:
Threshold Arrays for 45° Classical Screens

(a) M = 3 (19 levels of gray with 8-bit pixel values over range of 0–255)

			134			
		27	175	243		
	54	40	187	202	216	
134	162	148	121	94	108	134
	243	229	81	13	27	
		216	67	54		
			134			

(b) M = 4 (33 levels of gray with 8-bit pixel values over range of 0–255)

				147				
			78	217	225			
		16	85	209	248	240		
	54	62	116	186	202	194	140	
147	163	155	132	109	93	101	124	147
	225	233	178	39	31	23	78	
		240	171	47	8	16		
			140	70	54			
				147				

Referring below to Matrix 2, the Line Screen operates similarly to the Classical Screen, except that the superimposed screen is at 0°, rather than 45°. This will produce a final image which is more coarse, but will reduce the transmission time since the facsimile standard encoding (discussed further below) operates along lines. The Line Screen tends to concentrate dots along lines, whereas the Classical Screen concentrates them in a 45° orientation.

MATRIX 2:
Threshold Array for Line Screen

(37 levels of gray with 8-bit pixel values over range of 0–255)

	249	235	221	214	228	242	249	
	166	152	138	131	145	159	166	
	83	69	55	48	62	76	83	
. . .	42	28	14	7	21	35	42	. . .
	125	111	97	90	104	118	125	
	208	194	180	173	187	201	208	
	249	235	221	214	228	242	249	

Referring below to Matrix 3, the Spiral-Dot Screen operates in accordance with the foregoing discussion, with the superimposed screen oriented at 45°. This screen tends to create circular regions of varying intensity, similar to a picture oriented in a typical newspaper.

MATRIX 3:
Threshold Array for Spiral-Dot Screen

(26 levels of gray with 8-bit pixel values over range of 0–255)

	207	217	226	236	246	207	
	197	69	79	89	98	197	
. . .	187	59	10	20	108	187	. . .
	177	49	39	30	118	177	
	167	158	148	138	128	167	
	207	217	226	236	246	207	

The foregoing screen approaches in accordance with Matrices 1–3 compare each unmodified pixel within the image with a threshold value which varies depending upon the current pixel's position within the video image. Referring below to Matrix 4, a preferred embodiment of the present invention uses a technique in which error diffusion is performed in accordance with the Floyd-Steinberg error propagation theory. Floyd-Steinberg error diffusion differs from the foregoing screen approaches in that while each pixel is compared to a fixed threshold, the pixel value being compared consists of its original value plus an error value propagated from surrounding pixels. When the current pixel value is greater than the threshold, the error value is equal to 255 subtracted from the current pixel value. If the current pixel value is less than the threshold, the error value is zero.

MATRIX 4: Error Filter Values

$$\left(\frac{1}{16}X\right)\quad\begin{array}{ccc} & \cdot & 7 \\ 3 & 5 & 1 \end{array}$$

Floyd and Steinberg (1975)
(rectangular grid)
("·" represents the current pixel)

Referring to FIG. 6, the pixel-to-pel converter **206** performs pixel-to-pel conversion in accordance with the Floyd-Steinberg theory, which can be visualized as shown. The pixel data (interpolated, contrast-altered and selectively image-enhanced), received from the data memory **154** (FIG. 2A) via the data bus interface **212*b***, is converted to pel data using a threshold **502**, error filter **504**, input adder **506** and output adder **508**. As seen above in Matrix 4, to propagate the pixel error in accordance with the Floyd-Steinberg theory, 7/16ths of the error value is added to the next pixel on the same line, 3/16ths of the error value is added to the pixel on the line below and one pixel position to the left, 5/16ths of the error value is added to the pixel directly below, and 1/16th of the error value is added to the pixel below and to the right, as shown. The effect of the Floyd-Steinberg error diffusion is to approximate a gray-scale value, or tone, within a region by producing the approximate number of black dots which correspond to the gray-scale value of the original image, with the dots spread as randomly as possible so that no particular structure is visible.

As initially discussed above, the facsimile standard encoding of the pel data is in accordance with the CCITT Group 3 (Recommendation T.4) facsimile standard. In a preferred embodiment of the present invention, the facsimile standard encoder 208 (FIG. 2A) also performs one-dimensional modified Huffman encoding upon the pel data. One-dimensional modified Huffman encoding is advantageous in that small numbers of binary digits can be used to represent long runs of black or white pels.

Each line of data is composed of a series of variable length code words, each of which represents a run length of either all white or all black picture elements. The white and black runs alternate, and a total of 1728 picture elements represent one typical horizontal scan line of 215 mm length. To maintain synchronization, all data lines begin with a white run length code word. However, if the actual scan line begins with a black run, a white run length of zero will be sent. The black or white run lengths, up to a maximum of one scan line (1728 picture elements or "pels") are defined by the code words in Tables 4 and 5 below.

The code words are of two types: (1) Terminating Codes; and (2) Make-Up Codes. Each run length is represented by either a Terminating Code word, or a Make-Up Code word followed by a Terminating Code word. Run lengths in the range of 0–63 pels are encoded with their appropriate Terminating Code word from Table 4. As shown in Table 4, there are different code words for black and white run lengths.

TABLE 4

Terminating Codes			
White run length	Code Word	Black run length	Code Word
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100

TABLE 4-continued

Terminating Codes			
White run length	Code Word	Black run length	Code Word
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

Run lengths in the range of 64–1728 pels are encoded first by the Make-Up Code word from Table 5 representing the run length which is equal to or shorter than that required, followed by the Terminating Code word from Table 4 representing the difference between the required run length and the run length represented by that Make-Up Code.

TABLE 5

Make-Up Codes			
White run length	Code Word	Black run length	Code Word
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	0000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101
EOL	000000000001	EOL	00000000001

Run lengths greater than 1728 pels are encoded first by the Make-Up Code word from Table 6 representing the run length which is equal to or shorter than that required, followed by the Terminating Code word from

Table 4 representing the difference between the required run length and the run length represented by that Make-Up Code.

TABLE 6

Make-Up Codes
Note: For machines which accommodate larger paper widths while maintaining the standard horizontal resolution the following Make-Up Code set is provided:

Run length (black and white)	Make-Up Codes
1792	00000001000
1856	00000001100
1920	00000001101
1984	000000010010
2048	000000010011
2112	000000010100
2176	000000010101
2240	000000010110
2304	000000010111
2368	000000011100
2432	000000011101
2496	000000011110
2560	000000011111

As discussed above, the program memory 152 (FIG. 1) provides the instructions for the DSP 150 to carry out its data processing functions (FIGS. 2A and 2B). An exemplary listing of the software for providing those instructions in accordance with the foregoing discussion and figures is included below in Appendix A preceding the claims.

Various other modifications and alterations in the structure and method of operation of this invention will be apparent to those skilled in the art without departing from the scope and spirit of this invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments.

APPENDIX A

```
ASSEMBLY CODE FOR CORE PROCESSING FOR VIDEO TO FAX CONVERSION.
(Using the ADSP2105 DSP chip).

Operation;

External hardware captures 4 lines (4x512) or 4 columns (4x480) of pixels,
depending on whether rotation is disabled, or enabled.  The data is
stored in a static 2kx8 FIFO.  If rotation is enabled, the data needs
to be deinterleaved from its 4-byte vertical grouping; this is done
as data is transferred from the SFIFO to SRAM.

The 4 lines of data are interpolated from 480 to 1728 (or 1576);
whenever a new line is required, it is read from the SFIFO into the
circular 4x480 (or 4x512) buffer addressed by i7.  For simplicity,
4 new lines are grabbed after each transfer into SRAM.  (Note; sometimes,
several lines are read from the SFIFO, as at the start of a frame or
when decimation is required for A6 size).

The 4 interpolated lines are held in the circular buffer addressed by i5.
These are accessed to create the final interpolated fax width and length
resolution lines, which are stored in a 2x1728 (or 1576) circular buffer
addressed by i1. This buffer is only required for Floyd-Steinberg error
diffusion.

Optional image enhancement (under user control can then be performed).
This consists of a 2-D filter with a high-frequency boost to
enhance edges.

The pixels are then contrast-adjusted, using a look-up table, to
compensate for nonlinearities in the fax machine at the receiving
end.

Each interpolated fax resolution pixel is dithered, either by line or
classical screen (simple comparison) or with Floyd-Steinberg error
diffusion, at which point the white/black runlength is incremented./
If the color toggles at the current pixel, the runlength up to the
current pixel is encoded using Huffman 1-D encoding.  If the
number of new code bits plus the code bits left over from the last
encoding operation is 16 or more, the 16 most-significant are moved
to the huffman-encoded output buffer, where they can be picked up
whenever there is a modem interrupt.


Index registers;
i0      width interpolation coeffs, 128 entries, stored in ext RAM or
        length interpolation coeffs, 128 entries, stored in ext RAM
i1      2 interpolated lines, for error diffusion (2x1728 or 2x1576),
        always operate on the old half, and propagate onto the new half
i2      Floyd-Steinberg or screen coeffs, 4 or more, stored internally
```

```
i3      dot gain correction, 256 entries, stored in ext RAM
i4      bit count for Huffman encoding, also ext RAM huffman code table
        (364 words, 128 each for white and black, 54 each for white and
        black makeup)
i5      current fax output line (i.e fax resolutions), 4x1728 or 4x1576
i6      huffman encoded output buffer, several kwords
i7      current video input line (i.e video resolutions), 4x480 or 4x512

Modify values for index registers;
m0      0
m1      1
m2      -1
m3      128/3 = 32 (required for interpolation coeffs)
m4      1728 (or whatever line to line offset is)
m5      -1728
m6      480 (or 512 depending on rotation on or off)
m7      -480 (or -512)

Length values for index registers;
l0      1k (? length of buffer for fax output)
l1      4x480 or 4x512, for video input data
l2      4x1728 or 4x1576, for intermediate fax width resolution lines
l3      2x1728 or 2x1576, for Floyd-Steinberg error diffusion buffer

cntr    1728 or 1576 (the number of pixels to be interpolated to).  cntr
        decrements, and is used to index lines or columns of pixels, so that
        the first pixel is at an address offset into SRAM of 1728, rather
        than at 0.  cntr is used both during transfer from static FIFO to
        SRAM, and during interpolation.

{
*************************************************************
                          INTERPOLATION

Bicubic interpolation, with the data stored externally in
SRAM, the width interpolation coefficients stored internally
in program RAM, and the length interpolation coefficients
transferred from external RAM or EPROM to internal program RAM
at the start of each new fax output line (this means both
coefficient and data loading during each MAC instruction, since
the PMD and the DMD busses are used).

Data and coefficients are in 1.15 format, of which only the 8
msb are significant (the lower 8 are zeroed at power on and are
generally ignored).

2-pass, with interpolation in the width direction, then in the
length direction, is more efficient (requires fewer instructions)
than 1-pass, which is a 4x4 kernel at each output pixel.  However,
it does require storage of 4 fax-width lines.

Calling parameters;
        cntr            current fax width pixel number
        phase_w         fax width phase increment
Return parameters;

*************************************************************
Fax width interpolation;
This loop may be required more than once if decimating, or at
the start of a field.  It converts the input line (at 480 or 512)
to fax_w (1728 or 1576), using cubic interpolation.  The
interpolated lines are stored in the circular buffer addressed
by i5, which is 4 lines (4x1728 or 1576) long.  Take data from
buffer i7, and store it in buffer i5.
*************************************************************
}

        cntr=dm(fax_w);         fax_w=1728 or 1576
        i5=dm(interp_prev);     i5=previous pointer to buffer
                                (i.e. will add new line after last
                                new line)
        ay0=dm(input_prev);     ay=prev pointer to input i7 buffer

        do width until ce;      loop for fax width
```

```
        mx0=cntr;              cntr=current output pixel number
        my0=phase_w;           phase_w=phase increment, from RAM
        mr=mx0*my0;            current output pix location
        ar=mr1+ay0-1;          mr1=integer part = nearest input pixel
                               on the left-hand side of current output posn
        i7=ar;                 i7 points to the first interp pixel
        ay0=w_interp_st+31;    ax=address of 31th entry in coeff table
                               (the right-most posn of the first coeff to be
                               used)
        sr0=mr0 lshift by -11; shift fract part of output pix location from
                               16 bits to 5 bits (value is 0 to 31, which
                               equals 128/4)
        ar=ay0-sr0;            ar=address of interp coeff for first pixel
                               (i.e. 0 to 31th entry in coeff table)
        i0=ar;                 i0 points to first interp coeff (in internal
                               program RAM)

        mr=0,mx0=dm(i7,m1),my0=pm(i0,m1); mx=first pixel, my=first coeff
        cntr=3;
        do w_int until ce;     loop 4 times
w_int:  mr=mr+mx0*my0,mx0=dm(i7,m1),my0=pm(i0,m1);   multiply-accumulate i:
                                                     width direction
        if mv sat mr;          saturate if necessary


width:  dm(i5,m1)=mr1;         store interpolated value in i5

        dm(interp_prev)=i5;    store pointer to i5 for next time around
        dm(input_prev)=i7;     store pointer to i7 for next time around

}
************************************************************
Fax length interpolation
This loop is required once per fax line out.  It converts from 4 lines
(stored in buffer i5) of width fax_w, to one line (stored in buffer i1)
of width fax_w.  The loop is fax_w long (i.e. do entire line of fax
resolution width at the one time).  Before storing interpolated back
into i1 buffer, use the dot gain lookup table (i3) to give the
correct gray-scale image.
************************************************************
}
        cntr=dm(fax_w);        fax_w=1728 or 1576
        i1=dm(interp_prev);    i1=previous pointer to buffer
        i5=dm(i5_start_adr);   i5=beg of 4x1728 intermediate buffer
        ay0=dm(len_coef_start_adr); ay0=start of length coeffs

        mx0=cntr;              cntr=current output pixel number
        my0=phase_l;           phase_l=phase increment, from RAM
        mr=mx0*my0;            current output pix location
        af=ay0+31;             ar=address of 31th entry in coeff table
                               (the right-most posn of the first coeff to be
                               used)
        sr0=mr0 lshift by -11; shift fract part of output pix location from
                               16 bits to 5 bits (value is 0 to 31, which
                               equals 128/4)
        ar=af-sr0;             ar=address of interp coeff for first pixel
                               (i.e. 0 to 31th entry in coeff table)
        i0=ar;                 i0 points to first interp coeff (in internal
                               program RAM)

        ar=dm(i0,m3);          move the 4 length coeffs into int prog RAM
        pm(l_coeff0)=ar;
        ar=dm(i0,m3);
        pm(l_coeff1)=ar;
        ar=dm(i0,m3);
        pm(l_coeff2)=ar;
        ar=dm(i0,m0);
        pm(l_coeff3)=ar;

        do width until ce;     loop for fax width
        mr=0,mx0=dm(i5,m4),my0=pm(c0); mx=first pixel, my=first coeff
        mr=mr+mx0*my0,mx0=dm(i5,m4),my0=pm(c1); multiply-accumulate in
        mr=mr+mx0*my0,mx0=dm(i5,m4),my0=pm(c2); width direction
        mr=mr+mx0*my0,mx0=dm(i5,m5),my0=pm(c3);
```

```
was_w:  ax0=dm(i1,m0);                  ax0=current pixel from RAM
        ar0=ax0-ay0;                    ar0>0 if white, <0 if black
                                        (status is latched until below)
        if ge jump still_w;             still white
        ax0=0;                          offset for white codes = 0
        dm(prev)=m2;                    change prev to -1
        jump encode;                    toggling from white to black

still_w: ar0=ax0-255*256;               create error value
        if av sat ar;                   saturate if necessary;
        av=0;                           clear overflow bit
        dm(i1,m0)=ar0;                  store in RAM
        modify (i4,m1);                 increment white count
        jump diffuse;

{
**************************************************************
                              ENCODING

1-D huffman encoding, with table stored in RAM as 185 2-word entries,
with 1st word = bit count for code word, 2nd word = code.  Calculate the
address into the huffman table as if it were 1-word entries, then
adjust for 2-word entries before adding the table starting address.

Calling parameters;
        ax0                     offset for white/black codes (0 or 182)
        i4                      bit count
        prev                    already toggled, so 0 if black, -1
                                if white
        huff_bits_left          code word is left-justified in sr1, with
                                this number of bit posns free to the rhs
        prev_code               bits left over from previous code, left-
                                justified
Return parameters;
        fax buffer              new 16-bit encoded value added (if
                                appropriate)

**************************************************************
}
encode: si=i4;                          check to see if need makeup codes
                                        (i4=run length > 63)
        sr0=lshift si by +6;            logical shift by 6 = divide by 64
        ay0=si;                         ay=run length
        af=pass 0;                      af=0
        ar=sr0+0;                       need sign status
        if gt af=64;                    if sr0>0, need offset to makeup codes
        ax1=63;                         mask for run length
        ar=ax1 AND ay0;                 mask run length < 64
        af=ar+af;                       ar=run length + makeup
        ar=ax0+af;                      ar=run length + makeup + b/w offset
        sr0=lshift ar by -1;            sr0=2xar, because table = 2-word entr
        ay0=dm(huff_start);             ay=huffman code table start address
        ar=sr0+ay0;                     offset into huffman code table
        i4=ar;                          store huffman pointer in index reg

        sr1=dm(prev_code);              sr1=code bits left from prev codeword
        si=dm(i4,m1);                   si=Huffman code word from RAM
        sr=sr or lshift si, ay0=dm(huff_bits_left);     left shift si and
                                                        or with present sr
        ax0=dm(i4,m0);                  read in code word length from RAM
        ar=ay0-ax0;                     new code word length in sr
        if neg jump huff_out;           if pos, still have bits posns spare

        dm(huff_bits_left)=ar0;         # of bit posns free for next code
        dm(prev_code)=sr1;              sr1=code bits to save until next word
        jump diffuse;
 huff_out: ax0=i6;                      check that not overwriting buffer; a
                                        pointer for writing buffer
        ay0=fax_buf_out;                ay=pointer for reading buffer
        ar=ax0-ay0;
        if eq jump fax_buf_error;       if equal, about to overwrite buffer;
                                        jump to error-handling routing
                                        (wait until buffer empties)

        dm(i6,m1)=sr1;                  write sr1 to fax output buffer
        ar0=16+ar0;                     ar0 is -ve, result is spare bit posn
```

```
        dm(huff_bits_left)=ar0;           # of bit posns free for next code
        dm(prev_code)=sr0;                sr0=code bits to save until next word
        jump diffuse;                     jump to error diffusion


{
**************************************************************
                           ERROR DIFFUSION

Floyd Steinberg error diffusion;
                          o      7
                  3       5      1
Calling parameters;
        i1=current pixel (value or value-255)
        i2=start of error coeffs
Return parameters;
        i2=start of error coeffs
**************************************************************
}

diffuse:mx0=dm(i5,m1);                    mx=current error
        my0=dm(i2,m1);                    my=error mult (7/16)
        mr=dm(i5,m0);                     mr=next pixel, m0=0
        mr=mr+mx0*my0, my0=dm(i2,m1);     mr=next pixel+error, my=error mult(3/1
        if mv sat mr;                     saturate if necessary
        dm(i5,m4)=mr;                     store next pixel in RAM (or use
                                              ax0=mr)
        mr=dm(i5,m0);                     mr=pixel from next line
        mr=mr+mx0*my0, my0=dm(i2,m1);     mr=pixel+error, my=error mult(5/16)
        if mv sat mr;                     saturate if necessary
        dm(i5,m1)=mr;                     store in RAM

        mr=dm(i5,m0);                     mr=pixel from next line
        mr=mr+mx0*my0, my0=dm(i2,m1);     mr=pixel+error, my=error mult(1/16)
        if mv sat mr;                     saturate if necessary
        dm(i5,m1)=mr;                     store in RAM

        mr=dm(i5,m0);                     mr=pixel from next line
        mr=mr+mx0*my0;                    mr=pixel+error;
        if mv sat mr;                     saturate if necessary
        dm(i5,m5)=mr;                     store in RAM, i5=current pix next time
loop1:  i3=first_fs_compt;                set i3 back to point to the first comp

        fs_prev=i1;                       store current pointer to RAM for use
                                          next time
```

What is claimed is:

1. A video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal converter comprising:

- data interpolator means for receiving an interpolation instruction signal and in accordance therewith receiving and interpolating a pixel data signal representing a continuous tone video image, wherein said received pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on a contrast transfer function for said continuous tone video image;
- data alteration means for receiving and selectively altering said interpolated plurality of image pixel data within said interpolated pixel data signal to selectively alter said contrast transfer function gray-scale value;
- pixel-to-pel data converter means for receiving a conversion instruction signal and in accordance therewith receiving and converting said interpolated and selectively altered pixel data signal to a pel data signal, wherein said pel data signal includes at least one pel data block having a composite pel data block gray-scale value, and wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar;
- encoder means for receiving an encoding instruction signal and in accordance therewith receiving and encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal; and
- instruction source means for providing said interpolation, conversion and encoding instruction signals.

2. A video-to-facsimile signal converter as recited in claim 1, wherein said data interpolator means comprises a digital signal processor coupled to said instruction source means for receiving said interpolation instruction signal and in accordance therewith receiving and interpolating said pixel data signal.

3. A video-to-facsimile signal converter as recited in claim 1, wherein said data alteration means comprises a memory look-up table for receiving said interpolated plurality of image pixel data within said interpolated pixel data signal as input addresses therefor and for

outputting said interpolated and altered pixel data signal as output data therefrom.

4. A video-to-facsimile signal converter as recited in claim 1, wherein said pixel-to-pel data converter means comprises a digital signal processor coupled to said instruction source means and said data alteration means for receiving said conversion instruction signal and in accordance therewith receiving and converting said interpolated and altered pixel data signal to said pel data signal.

5. A video-to-facsimile signal converter as recited in claim 1, wherein said encoder means comprises a digital signal processor coupled to said instruction source means for receiving said encoding instruction signal and in accordance therewith receiving and encoding said pel data signal in accordance with CCITT Group 3 to produce said facsimile standard signal.

6. A video-to-facsimile signal converter as recited in claim 1, further comprising video signal receiver means for receiving a video signal representing said continuous tone video image and providing said pixel data signal.

7. A video-to-facsimile signal converter as recited in claim 6, further comprising video signal source means for providing said video signal representing said continuous tone video image.

8. A video-to-facsimile signal converter as recited in claim 6, wherein said video signal receiver means comprises an analog-to-digital converter and a video data buffer coupled to said data interpolator means for receiving, digitizing and buffering an analog video signal representing said continuous tone video image, and for providing said pixel data signal.

9. A video-to-facsimile signal converter as recited in claim 1, further comprising signal converter means for receiving and converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

10. A video-to-facsimile signal converter as recited in claim 9, wherein said signal converter means comprises a facsimile MODEM coupled to said encoder means for receiving and modulating said facsimile standard signal to provide said facsimile transmission signal for transmission to and reception by a facsimile receiver.

11. A video-to-facsimile signal converter as recited in claim 9, further comprising telephone network interface means for receiving and coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

12. A video-to-facsimile signal converter as recited in claim 11, wherein said telephone network interface means comprises a data access arrangement coupled to said signal converter means for receiving and coupling said facsimile transmission signal onto a telephone line.

13. A video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal converter comprising:

digital signal processor means for receiving a pixel data signal representing a continuous tone video image, wherein said received pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on an original contrast transfer function for said continuous tone video image, and for receiving a plurality of conversion instruction signals and in accordance therewith:

interpolating said plurality of image pixel data,

outputting said interpolated plurality of image pixel data,

receiving a plurality of selectively altered image pixel data which corresponds to said interpolated plurality of image pixel data and has a selectively altered contrast transfer function gray-scale value which is selectively dissimilar to said original contrast transfer function gray-scale value,

dithering said plurality of selectively altered image pixel data to produce a pel data signal including at least one pel data block having a composite pel data block gray-scale value, wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar, and

encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal;

look-up table means for receiving said outputted, interpolated plurality of image pixel data and for providing said plurality of selectively altered image pixel data; and

memory means for providing said plurality of conversion instruction signals.

14. A video-to-facsimile signal converter as recited in claim 13, further comprising video signal receiver means for receiving a video signal representing said continuous tone video image and providing said pixel data signal.

15. A video-to-facsimile signal converter as recited in claim 14, further comprising video signal source means for providing said video signal representing said continuous tone video image.

16. A video-to-facsimile signal converter as recited in claim 14, wherein said video signal receiver means comprise an analog-to-digital converter and a video data buffer coupled to said digital signal processor means for receiving, digitizing and buffering an analog video signal representing said continuous tone video image, and for providing said pixel data signal.

17. A video-to-facsimile signal converter as recited in claim 13, further comprising signal converter means for receiving and converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

18. A video-to-facsimile signal converter as recited in claim 17, further comprising telephone network interface means for receiving and coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

19. A video-to-facsimile signal converter as recited in claim 18, wherein said telephone network interface means comprises a data access arrangement coupled to said signal converter means for receiving and coupling said facsimile transmission signal onto a telephone line.

20. A video-to-facsimile signal converter as recited in claim 17, wherein said signal converter means comprises a facsimile MODEM coupled to said digital signal processor means for receiving and modulating said facsimile standard signal to provide said facsimile transmission signal for transmission to and reception by a facsimile receiver.

21. A video-to-facsimile signal conversion method for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for

transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal conversion method comprising the steps of receiving a plurality of conversion instruction signals and in accordance therewith:

receiving a pixel data signal representing a continuous tone video image, wherein said pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on a contrast transfer function for said continuous tone video image;

interpolating said pixel data signal;

selectively altering said interpolated plurality of image pixel data within said interpolated pixel data signal to selectively alter said contrast transfer function gray-scale value;

converting said interpolated and selectively altered pixel data signal to a pel data signal, wherein said pel data signal includes at least one pel data block having a composite pel data block gray-scale value, and wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar; and

encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal.

22. A video-to-facsimile signal conversion method as recited in claim 21, further comprising the steps of:

receiving an analog video signal representing said continuous tone video image; and

digitizing and buffering said analog video signal to provide said pixel data signal.

23. A video-to-facsimile signal conversion method as recited in claim 21, wherein said step of converting said interpolated and altered pixel data signal to said pel data signal comprises dithering said pixel data signal.

24. A video-to-facsimile signal conversion method as recited in claim 21, further comprising the step of converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

25. A video-to-facsimile signal conversion method as recited in claim 24, further comprising the step of coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

26. A video-to-facsimile signal conversion method as recited in claim 24, wherein said step of converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver comprises modulating said facsimile standard signal to provide said facsimile transmission signal.

* * * * *

PN 7467986

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

December 03, 2013

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: *09/006,073*
FILING DATE: *January 12, 1998*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

M. BASSFORD
Certifying Officer

PART (2) OF (2) PARTS

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

d

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
09/006,073	01/12/98	MONROE D	58959.12

LM31/1207

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

EXAMINER	
POKRZYWA, J	
ART UNIT	PAPER NUMBER
2722	6

DATE MAILED: 12/07/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

PTO-90C (Rev. 2/95)

1- File Copy

Office Action Summary	Application No. 09/006,073	Applicant(s) Monroe, David A.
	Examiner Joseph Pokrzywa	Group Art Unit 2722

☐ Responsive to communication(s) filed on ______________.

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire 3 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) *1-266* is/are pending in the application.

Of the above, claim(s) *29-180, 182-189, and 191-266* is/are withdrawn from consideration.

☐ Claim(s) ______________ is/are allowed.

☒ Claim(s) *1-28, 181, and 190* is/are rejected.

☐ Claim(s) ______________ is/are objected to.

☐ Claims ______________ are subject to restriction or election requirement.

Application Papers

☒ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☒ The drawing(s) filed on *Jan 12, 1998* is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ______________ is ☐approved ☐disapproved.

☒ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ______________.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ______________.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). 5

☐ Interview Summary, PTO-413

☒ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

— SEE OFFICE ACTION ON THE FOLLOWING PAGES —

U. S. Patent and Trademark Office
PTO-326 (Rev. 9-95) **Office Action Summary** Part of Paper No. 6

DETAILED ACTION

Election/Restriction

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

    I. **Claims 1 through 28, 181, and 190** are drawn to a system of capturing an image and transmitting it to a remote receiving station, wherein the system includes a subprocessor for generating a Group-III facsimile compatible signal, classified in class 358, subclass 400.

    II. **Claims 29 through 69, 144 through 167, and 263 through 266** are drawn to a system of capturing an image and transmitting it to a remote receiving station, wherein the system includes an image capture device, a processor, and a transmitter, wherein the components can be modular, the components can be housed in one unit, or the system can be a portable, handheld system, classified in class 348, subclass 373.

    III. **Claims 70 through 111** are drawn to a system of capturing an image and transmitting it to a remote receiving station through a wireless transmission, classified in 348, subclass 723.

    IV. **Claims 112 through 143** are drawn to image processing system which includes a trigger device for activating the system to initiate image capture, classified in class 348, subclass 152.

V. **Claims 168 through 180, 182 through 189** are drawn to a system of capturing an image and transmitting it to a remote receiving station, wherein the system includes an image capture device, a processor, a transmitter, and an audio capture device, classified in class 348, subclass 462.

VI. **Claims 191 through 229** are drawn to a system of capturing an image and transmitting it to a remote receiving station in any of a plurality of selected protocols, classified in class 379 subclass 100.12.

VII. **Claims 230 through 247** are drawn to a system of capturing an image and transmitting it to a remote receiving station, wherein the system includes an image capture device, a processor, a transmitter, and a self-contained power source, classified in class 348, subclass 372.

VIII. **Claims 248 through 252** are drawn to a method for capturing an analog signal and converting it to a digital signal for transmission over a telephone system, classified in class 358, subclass 472.

IX. **Claims 253 through 262** are drawn to a method for sampling visual images in a zone for a record of an incident, classified in class 348, subclass 143.

2. The inventions are distinct, each from the other because of the following reasons: Inventions I, II, III, IV, V, VI, VII, VIII, and IX are related as subcombinations disclosed as usable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately usable.

In the instant case, invention I has separate utility such as a standard Group III facsimile device which reads a document and transmits the document to a destination in a Group-III format, while invention II has separate utility such as a video camera with modular attachments, while invention III has separate utility such as a television broadcast wherein a camera in a remote area captures an image and sends the image through a radio frequency, while invention IV has separate utility such as an intrusion detection device, with a motion detector, while invention V has separate utility such as a video telephone or a camera with a microphone, while invention VI has separate utility such as transmitting an image of a document through multiple networks using different protocols, while invention VII has separate utility such as a camera with a battery pack, while invention VIII has separate utility such as capturing an analog signal through a camera, converting the signal, and transmitting the signal over a telephone line, while invention IX has separate utility such as providing a surveillance system wherein visual images are sampled for a record of an incident. See MPEP § 806.05(d).

3. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

4. During a telephone conversation with Stephen F. Schlather on Monday, November 29, 1999 a provisional election was made without traverse to prosecute the invention of Group I, claims 1 through 28, 181, and 190. Affirmation of this election must be made by applicant in replying to this Office action. Claims 29 through 180, 182 through 189, and 191 through 266 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

Information Disclosure Statement

5. The references listed in the Information Disclosure Statement submitted on 11/2/95 have been considered by the examiner (see attached PTO-1449).

Drawings

6. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character "81" has been used to designate both the hardwired personal computer in Fig. 4 and the data multiplexer circuit in Fig. 5, and reference character "83" has been used to designate both the communications interface module in Fig. 4 and the sync signal in Fig. 5. Correction is required.

7. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description:

reference numeral "29", on page 10, line 11.

Correction is required.

8. The drawings are objected to because of the problems addressed in the attached PTO-948, and because of:

in Fig. 4, PC modem protocol box "66" should read "68" as read on page 12, lines 27 and 28.

Correction is required.

Specification

9. The disclosure is objected to because of the following informalities:

on page 11, line 13, PCMCIA card 50" should read PCMCIA card 72";

on page 18, line 20, "Fig. 8." should be removed;

on page 21, line 24, "ne imagery formats" should read "new imagery formats";

Appropriate correction is required.

Claim Objections

10. Applicant is advised that should **claim 12** be found allowable, **claim 181** will be rejected under 35 U.S.C. 101 as being a substantial duplicate thereof. When two claims in an application are duplicates or else are so close in content that they both cover the same thing, despite a slight difference in wording, it is proper after allowing one claim to reject the other as being a substantial duplicate of the allowed claim. See MPEP § 706.03(k).

11. Applicant is advised that should **claim 26** be found allowable, **claim 190** will be rejected under 35 U.S.C. 101 as being a substantial duplicate thereof. When two claims in an application are duplicates or else are so close in content that they both cover the same thing, despite a slight difference in wording, it is proper after allowing one claim to reject the other as being a substantial duplicate of the allowed claim. See MPEP § 706.03(k).

12. **Claims 25 and 27** are objected to because of the following informalities:

in ***claim 25***, line 2, "control apparatus any" should read "control apparatus <u>controlling</u> any";

in ***claim 27***, line 2, "plurality images" should read "plurality <u>of</u> images".

Appropriate correction is required.

Claim Rejections - 35 USC § 112

13. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

14. **Claims 1 through 28, 181, and 190** are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

15. ***Claim 1*** recites the limitation "the digital signal" in line 8. There is insufficient antecedent basis for this limitation in the claim.

16. ***Claim 3*** recites the limitation "said memory" in line 1. There is insufficient antecedent basis for this limitation in the claim.

17. ***Claim 13*** recites the limitation "the camera" in line 2. There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections - 35 USC § 102

18. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.
>
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

19. **Claims 1, 2, 4, 12, 13, 16, 18, 20, 21, and 181** are rejected under 35 U.S.C. 102(b) as being anticipated by Ross (U.S. Patent Number 5,546,194).

Regarding ***claim 1***, Ross discloses a self-contained image processing system (see Fig. 1) for capturing a visual image and transmitting it to a remote receiving station, with the system comprising an image capture device (video camera 10, column 3, lines 4 through 5), a processor (control system 22 in Fig. 1, or CPU 44 in Fig. 2) for generating a data signal representing the image (column 3, lines 20 through 29, and column 3, line 63 through column 4, line 20), a communications device (Group III fax transmitter 20 in Fig. 1, and fax modem 50 in Fig. 2) adapted for transmitting the data signal to the remote receiving station (column 2, lines 15 through 29, wherein the remote receiving station is inherently included in the system), and a subprocessor (Group III formatter 18) for generating a Group-III facsimile compatible signal representing the data signal (column 3, lines 30 through 52).

Regarding ***claim 2***, Ross discloses the system discussed above in claim 1, and further teaches of a memory for receiving and storing the data signal (RAM 38, column 3, line 65 through column 4, line 11), and wherein the communications device is adapted for recalling the stored data signal from memory (column 4, lines 21 through 36).

Regarding ***claim 4***, Ross discloses the system discussed above in claim 1, and further teaches of the image capture device is an analog camera (video camera 10) for generating an analog image signal (column 3, lines 4 through 9), and there is further included an analog to digital converter for converting the analog image signal to a digital signal (A/D converter 34, column 4, lines 3 through 6).

Regarding ***claim 12***, Ross discloses the system discussed above in claim 1, and further teaches of the image capture device is an analog video camera for generating a video signal (column 3, lines 4 through 9). Further Ross teaches that the processor comprises a sync detector (sync separator 24, column 3, lines 53 through 62) and a video address generator (address multiplexer 43, column 4, lines 6 through 11) for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame (column 3, lines 20 through 62), a random access memory (RAM 38) for receiving and storing the converted, synchronized signal frame-by-frame (column 4, lines 3 through 22), a processor routine for converting the signals stored in the memory to a protocol adapted for transmission (column 4, lines 22 through 36) to a remote, compatible protocol receiving station (inherently included), and a communications device (FAX modem 50) for transmitting the signal in the proper protocol to the compatible receiving station (column 5, lines 7 through 16).

Regarding ***claim 13***, Ross discloses the system discussed above in claim 1, and further teaches of the system is of modular construction (seen in Fig. 2), and the image capture device (video camera 10), the processor (CPU 44), and the communications device (fax modem 50) are each independent, functional units (column 3, lines 5 through 8, and lines 53 through 56; column 4, lines 10 through 18; and column 4, lines 18 through 20) which may be coupled to one another for defining the assembled system (seen in Fig. 2).

Regarding ***claim 16***, Ross discloses the system discussed above in claim 2, and further teaches of the image data signal is stored in a raw video format (column 3, lines 20 through 22).

Regarding ***claim 18***, Ross discloses the system discussed above in claim 2, and further teaches of the image data signal is stored in a half-tone format (column 3, lines 30 through 40).

Regarding ***claim 20***, Ross discloses the system discussed above in claim 1, and further teaches of the remote receiving station is a gray-scale facsimile machine (column 3, lines 30 through 41, with the receiving station inherently receives the gray-scale image, thus being a gray-scale facsimile machine) and the image data signal is generated in a gray-scale format and protocol (column 3, lines 30 through 41).

Regarding ***claim 21***, Ross discloses the system discussed above in claim 1, and further teaches of the remote receiving station is a color facsimile machine (column 3, lines 20 through 41, with the receiving station inherently receives the color image, thus being a color facsimile machine) and the image data signal is generated in a full color format and protocol (column 3, lines 20 through 41).

Regarding ***claim 181***, Ross discloses the system discussed above in claim 1, and further teaches of the image capture device is an analog video camera for generating a video signal (column 3, lines 4 through 9). Further Ross teaches that the processor comprises a sync detector (sync separator 24, column 3, lines 53 through 62) and a video address generator (address multiplexer 43, column 4, lines 6 through 11) for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame (column 3, lines 20 through 62), a random access memory (RAM 38) for receiving and storing the converted, synchronized signal frame-by-frame (column 4, lines 3 through 22), a processor routine for converting the signals stored in the memory to a protocol adapted for transmission (column 4, lines 22 through 36) to a remote, compatible protocol receiving station (inherently included), and a communications device (FAX modem 50) for transmitting the signal in the proper protocol to the compatible receiving station (column 5, lines 7 through 16).

20. **Claims 1, 2, 6-11, 15, 17, 19, 21-23, and 27** are rejected under 35 U.S.C. 102(b) as being anticipated by Hassan *et al.* (U.S. Patent Number 5,550,646).

Regarding ***claim 1***, Hassan discloses a self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (column 1, lines 47 through 52), with the system comprising an image capture device (device 110 in Fig. 1), a processor (microcontroller 205) for generating a data signal representing the image (column 3, lines 21 through 46), a communications device adapted for transmitting the data signal to the remote receiving station (fax modem 240, column 4, line 65 through column 5, line 9), and a subprocessor for generating a Group-III facsimile compatible signal representing the data signal (column 4, line 65 through column 5, line 9).

Regarding ***claim 2***, Hassan discloses the system discussed above in claim 1, and further teaches of a memory for receiving and storing the data signal (RAM 207, column 3, lines 47 through 50), and wherein the communications device is adapted for recalling the stored data signal from memory (column 5, lines 35 through 44, and column 5, lines 52 through 56).

Regarding ***claim 6***, Hassan discloses the system discussed above in claim 1, and further teaches of a integrated wireless telephone associated with the communications device (column 5, lines 7 through 9).

Regarding ***claim 7***, Hassan discloses the system discussed above in claim 1, and further teaches of a housing for housing all of the elements of the system in an integrated body (device 110, seen in Fig. 1).

Regarding ***claim 8***, Hassan discloses the system discussed above in claim 1, and further teaches of the image capture device is a digital camera (column 3, lines 30 through 50).

Regarding ***claim 9***, Hassan discloses the system discussed above in claim 2, and further teaches of including a view screen for viewing the captured and stored image (LCD display 215, column 4, lines 19 through 31).

Regarding ***claim 10***, Hassan discloses the system discussed above in claim 1, and further teaches of a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy (column 1, lines 52 through 63, column 2, line 64 through column 3, line 4, and column 6, lines 22 through 42).

Regarding ***claim 11***, Hassan discloses the system discussed above in claim 1, and further teaches of the processor is adapted for generating a signal in any of a plurality of selected protocols (column 6, line 62 through column 7, line 2, column 3, lines 5 through 20, and column 4, line 65 through column 65, line 9) and wherein the communications device is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station (column 2, lines 39 through 66).

Regarding ***claim 15***, Hassan discloses the system discussed above in claim 1, and further teaches of a data processor (keypad control circuit 213) for creating a text data signal associated with the image data signal (column 4, lines 1 through 18).

Regarding ***claim 17***, Hassan discloses the system discussed above in claim 2, and further teaches of the image data signal is stored in a compressed format (column 4, lines 43 through 48, and column 6, lines 43 through 50).

Regarding ***claim 19***, Hassan discloses the system discussed above in claim 1, and further teaches of the remote receiving station is a standard bi-level facsimile machine (remote receiving facsimile 140, column 2, lines 1 through 16, and lines 39 through 58) and the image data signal is generated in a standard bi-level facsimile machine format and protocol (column 4, line 65 through column 5, line 22).

Regarding ***claim 21***, Hassan discloses the system discussed above in claim 1, and further teaches of the remote receiving station is a color facsimile machine (column 7, line 1) and the image data signal is generated in a full color format and protocol (column 6, line 62 through column 7, line 2).

Regarding ***claim 22***, Hassan discloses the system discussed above in claim 1, and further teaches of the remote receiving station is a digital device and the image data is digital (column 4, line 65 through column 5, line 9).

Regarding ***claim 23***, Hassan discloses the system discussed above in claim 1, and further teaches of a self-contained power source for powering the system (column 5, lines 23 through 25).

Regarding ***claim 27***, Hassan discloses the system discussed above in claim 1, and further teaches of the image capture device may be controlled to capture a plurality of images in controlled order (column 6, lines 43 through 62).

21. **Claims 1, 14, 24-26, and 190** are rejected under 35 U.S.C. 102(e) as being anticipated by Shibata *et al.* (U.S. Patent Number 5,689,300).

Regarding ***claim 1***, Shibata discloses a self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (column 2, line 22 through column 3, line 3), with the system comprising an image capture device (camera 1, column 6, lines 33 through 38), a processor for generating a data signal representing the image (control unit 26, column 5, line 64 through column 6, line 12, and column 6, lines 39 through 46), a communications device adapted for transmitting the data signal to the remote receiving station (G3-FAX modular jack 107 and G3-FAX interface 16, column 7, lines 10 through 25, and column 10, line 45 through column 11, line 21), and a subprocessor (multiplexor/demultiplexor 20) for generating a Group-III facsimile compatible signal representing the data signal (column 6, lines 13 through 24).

Regarding ***claim 14***, Shibata discloses the system discussed above in claim 1, and further teaches of an audio signal capture device (hands-free microphone 14, handset 15, or external microphone 108) adapted for capturing an audio signal in correlation with the captured video signal (column 6, lines 47 through 65).

Regarding ***claim 24***, Shibata discloses the system discussed above in claim 1, and further teaches of a control apparatus (control keyboard 2002, seen in Figs. 20A and 22) for remotely controlling operating functions of the image capture device (column 19, line 26 through column 12).

Regarding ***claim 25***, Shibata discloses the system discussed above in claim 24, and further teaches of the image capture device is a camera with a shuttered lens (column 15, lines 3 through 7, and camera 1, which outputs still pictures, column 8, lines 3 through 13) and where the control apparatus controlling any combination of lens direction, iris, focus, and shutter speed (column 11, lines 50 through 63, and column 19, lines 1 through 50).

Regarding ***claim 26***, Shibata discloses the system discussed above in claim 1, and further teaches of an input device (control keyboard 2002, seen in Figs. 20A and 22) for controlling the processor configuration from a remote location (column 19, line 26 through column 12).

Regarding ***claim 190***, Shibata discloses the system discussed above in claim 1, and further teaches of an input device (control keyboard 2002, seen in Figs. 20A and 22) for controlling the processor configuration from a remote location (column 19, line 26 through column 12).

Claim Rejections - 35 USC § 103

22. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

23. **Claims 3 and 5** are rejected under 35 U.S.C. 103(a) as being unpatentable over Ross (U.S. Patent Number 5,546,194).

Regarding ***claim 3***, Ross discloses the system discussed above in claim 1, wherein the system is adapted for selectively charging and discharging a random access medium (RAM 38, column 4, lines 3 through 36). However, Ross fails to teach if the random access medium is removable. Typically in the art, video cassettes and floppy disks are used are used for recording images, which are both inherently removable random access mediums. Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include a removable random access medium in Ross's system. Ross's system could easily be modified to include a removable random access medium since it is well known in the art to have a removable RAM.

Regarding ***claim 5***, Ross discloses the system discussed above in claim 3, and further teaches of the subprocessor comprising a gray scale bit map column 3, lines 36 and 37), a half tone converter (column 3, lines 36 through 41), and a binary bit map (column 3, lines 42 through 46).

24. **Claim 28** is rejected under 35 U.S.C. 103(a) as being unpatentable over Shibata *et al.* (U.S. Patent Number 5,689,300) in view of Hassan *et al.* (U.S. Patent Number 5,550,646).

Regarding ***claim 28***, Shibata discloses the system discussed above in claim 26, but fails to teach if the image capture device may be controlled to capture a plurality of images in a controlled order. Hassan discloses a system which teaches that an image capture device may be controlled to capture a plurality of images in controlled order (column 6, lines 43 through 62). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's teaching's in Shibata's system. Shibata's system could be modified to include Hassan's, as the systems have cumulative features.

Citation of Pertinent Prior Art

25. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure:

Freeman (U.S. Patent Number 5,684,716) discloses a remote video transmission system which transmits an audio/visual signal through telephone lines, through cellular lines or through radio frequencies;

Parulski *et al.* (U.S. Patent Number 5,666,159) discloses an electronic camera system which can selectively transmit image data to selected receivers;

Bush *et al.* (U.S. Patent Number 5,539,452) discloses a system of transmitting audio and video information over a standard telephone line;

Galen *et al.* (U.S. Patent Number 5,515,176) discloses a system of transmitting image data to a remote receiver using Group III protocol.

Conclusion

26. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Joe Pokrzywa whose telephone number is (703) 305-0146. The examiner can normally be reached on Monday through Friday from 8:00 a.m. to 4:30 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward Coles, can be reached on (703) 305-4712. The fax phone number for this Group is (703) 308-6606.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 305-3800/4700.

EDWARD L. COLES
SUPERVISORY PATENT EXAMINER
GROUP 2700

Joseph R. Pokrzywa

November 29, 1999

FORM PTO 948 (REV. 11-97) U.S. DEPARTMENT OF COMMERCE-Patent and Trademark Office Application No. 09/006073

NOTICE OF DRAFTPERSON'S PATENT DRAWING REVIEW

The drawing filed (insert date) 1/12/98 are:

A. ______ not objected to by the Draftperson under 37 CFR 1.84 or 1.152.

B. [✓] objected to by the Draftperson under 37 CFR 1.84 or 1.152 as indicated below. The Examiner will require submission of new, corrected drawings when necessary. Corrected drawings must be submitted according to the instructions on the back of this notice.

1. DRAWINGS. 37 CFR 1.84(a): Acceptable categories of drawings: Black ink. Color.
   - ______ Color drawing are not acceptable until petition is granted. Fig.(s) ______
   - ______ Pencil and non black ink is not permitted. Fig(s) ______
2. PHOTOGRAPHS. 37 CFR 1.84(b)
   - ______ Photographs are not acceptable until petition is granted, ______ 3 full-tone sets are required. Fig(s) ______
   - ______ Photographs not properly mounted (must brystol board or photographic double-weight paper). Fig(s) ______
   - ______ Poor quailty (half-tone). Fig(s) ______
3. TYPE OF PAPER. 37 CFR 1.84(e)
   - ______ Paper not flexible, strong, white and durable. Fig.(s) ______
   - ______ Erasures, alterations, overwritings, interlineations, folds, copy machine marks not acceptable. (too thin)
   - ______ Mylar, vellum paper is not acceptable (too thin). Fig(s) ______
4. SIZE OF PAPER. 37 CFR 1.84(F): Acceptable sizes:
   - [✓] 21.0 cm by 29.7 cm (DIN size A4)
   - [✓] 21.6 cm by 27.9 cm (8 1/2 x 11 inches)
   - ______ All drawings sheets not the same size. Sheet(s) ______
5. MARGINS. 37 CFR 18.4(g): Acceptable margins:
   - Top 2.5 cm Left 2.5 cm Right 1.5 cm Bottom 1.0 cm SIZE: A4 Size
   - Top 2.5 cm Left 2.5 cm Right 1.5 cm Bottom 1.0 cm SIZE: 8 1/2 x 11
   - ______ Margins not acceptable. Fig(s) ______
   - ______ Top (T) ______ Left (L)
   - ______ Right (R) ______ Bottom (B)
6. VIEWS. CFR 1.84(h)
   REMINDER: Specification may require revision to correspond to drawing changes.
   - ______ Views connected by projection lines or lead lines. Fig.(s) ______

   Partial views. 37 CFR 1.84(h)(2)
   - ______ Brackets needed to show figure as one entity. Fig.(s) ______
   - ______ Views not labeled separately or properly. Fig.(s) ______
   - ______ Enlarged view not labeled separately or properly. Fig.(s) ______
7. SECTIONAL VIEWS. 37 CFR 1.84(h)(3)
   - ______ Hatching not indicated for sectional portions of an object. Fig.(s) ______
   - ______ Sectional designation should be noted with Arabic or Roman numbers. Fig.(s) ______
8. ARRANGEMENT OF VIEWS. 37 CFR 1.84(i)
   - ______ Words do not appear on a horizontal, left-to-right fashion when page is either upright or turned, so that the top becomes the right side, except for graphs. Fig.(s) ______
   - ______ Views not on the same plane on drawing sheet. Fig.(s) ______
9. SCALE. 37 CFR 1.84(k)
   - ______ Scale not large enough to show mechansim without crowding when drawing is reduced in size to two-thirds in reproduction. Fig.(s) ______
10. CHARACTER OF LINES, NUMBERS, & LETTERS. 37 CFR 1.84(l)
    - [✓] Lines, numbers & letters not uniformly thick and well defined, clean, durable, and black (poor line quality). Fig.(s) 8A-8L
11. SHADING. 37 CFR 1.84(m)
    - ______ Solid black areas pale. Fig.(s) ______
    - ______ Solid black shading not permitted. Fig.(s) ______
    - ______ Shade lines, pale, rough and blurred. Fig.(s)
12. NUMBERS, LETTERS, & REFERENCE CHARACTERS: 37 CFR 1.48(p)
    - [✓] Numbers and reference characters not plain and legible. Fig.(s) 7A, 7B, 8A-8L
    - [✓] Figure legends are poor. Fig.(s) 8A-8L
    - ______ Numbers and reference characters not oriented in the same direction as the view. 37 CFR 1.84(p)(3) Fig.(s) ______
    - ______ English alphabet not used. 37 CFR 1.84(p)(3) Fig.(s) ______
    - [✓] Numbers, letters and reference characters must be at least .32 cm (1/8 inch) in height. 37 CFR 1.84(p)(3) Fig.(s) 8A-8L
13. LEAD LINES. 37 CFR 1.84(q)
    - ______ Lead lines cross each other. Fig.(s) ______
    - ______ Lead lines missing. Fig.(s) ______
14. NUMBERING OF SHEETS OF DRAWINGS. 37 CFR 1.48(t)
    - ______ Sheets not numbered consecutively, and in Ababic numerals beginning with number 1. Fig.(s) ______
15. NUMBERING OF VIEWS. 37 CFR 1.84(u)
    - ______ Views not numbered consecutively, and in Abrabic numerals, beginning with number 1. Fig.(s) ______
16. CORRECTIONS. 37 CFR 1.84(w)
    - ______ Corrections not made from PTO-948 dated ______
17. DESIGN DRAWINGS. 37 CFR 1.152
    - ______ Surface shading shown not appropriate. Fig.(s) ______
    - ______ Solid black shading not used for color contrast. Fig.(s) ______

COMMENTS

- DWG. SHEETS IMPROPER SIZE

(Fig 8A-8L)

REVIEWER T. Rogers DATE 11/30/99 TELEPHONE NO. 703 308 8335

ATTACHMENT TO PAPER NO. ______

PTO COPY

REMINDER

Drawing changes may also require changes in the specification, e.g., if Fig. I is changed to Fig. IA, Fig. IB, Fig. IC, etc., the specification, at the Brief Description of the Drawings, must likewise be changed. Please make such changes by 37 CFR 1.312 Amendment at the time of submitting drawing changes.

INFORMATION ON HOW TO EFFECT DRAWING CHANGES

1. Correction of Informalities--37 CFR 1.85

File new drawings with the changes incorporated therein. The application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application, should be placed on the back of each sheet of drawings in accordance with 37 CFR 1.84(c). Applicant may delay filing of the new drawings until receipt of the Notice of Allowability (PTOL-37). Extensions of time may be obtained under the provisions of 37 CFR 1.136. The drawing should be filed as a separate paper with a transmittal letter addressed to the Drawing Review Branch.

2. Timing of Corrections

Applicant is required to submit **acceptable** corrected drawings within the three-month shortened statutory period set in the Notice of Allowability (PTOL-37). If a correction is determined to be unacceptable by the Office, applicant must arrange to have acceptable correction resubmitted within the original three-month period to avoid the necessity of obtaining as extension of time and paying the extension fee. Therefore, applicant should file corrected drawings as soon as possible.

Failure to take corrective action within set (or extended) period will result in **ABANDONMENT** of the Application.

3. Corrections other than Informalities Noted by the Drawing Review Branch on the Form PTO 948

All changes to the drawings, other than informalities noted by the Drawing Review Branch, **MUST** be approved by the examiner before the application will be allowed. No changes will be permitted to be made, other than correction of informalities, unless the examiner has approved the proposed changes.

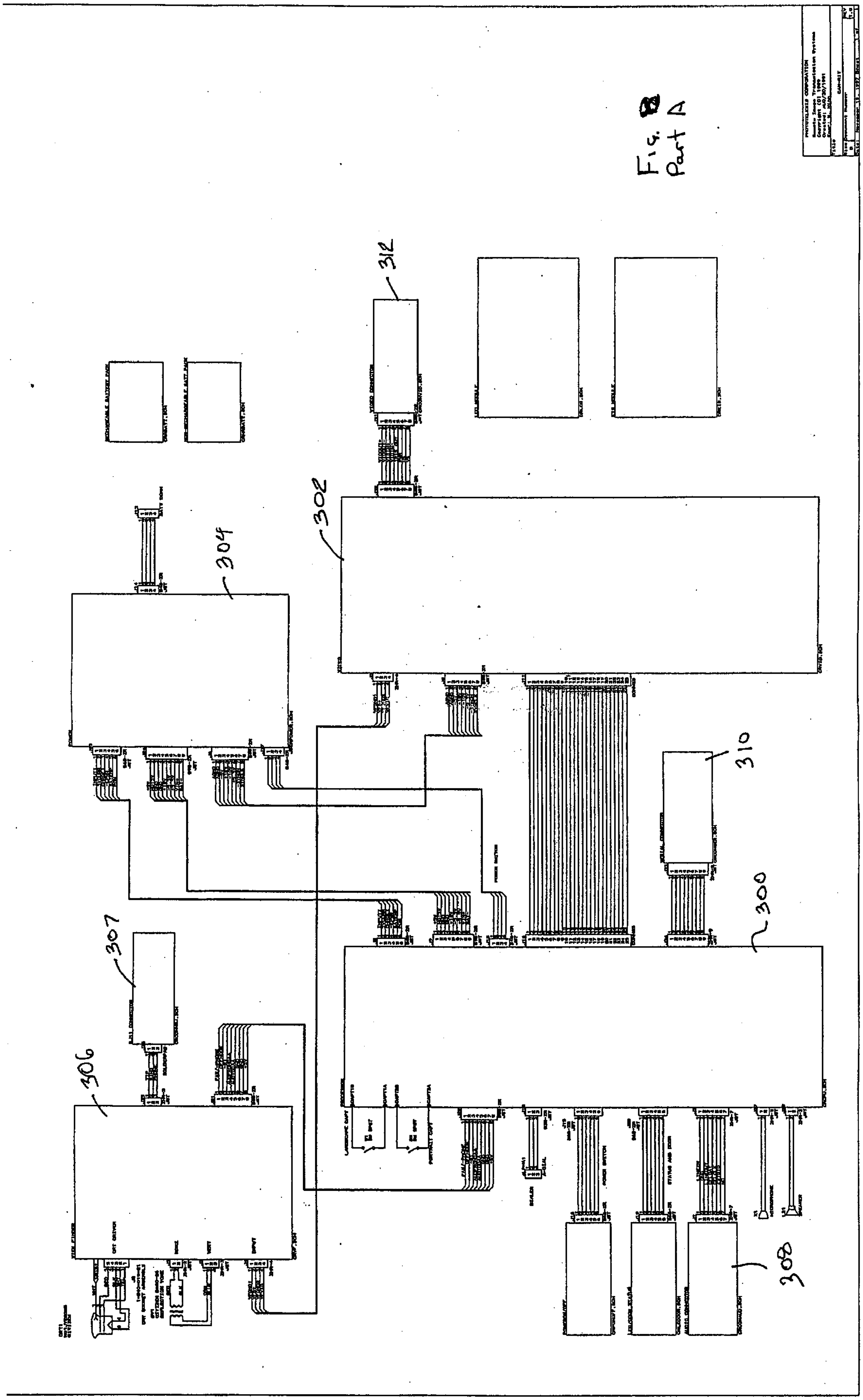


Fig. [illegible]
Part A

Fig 8 Part B

Title
GAMUT AUDIO LOGIC
Size
Document Number
REV

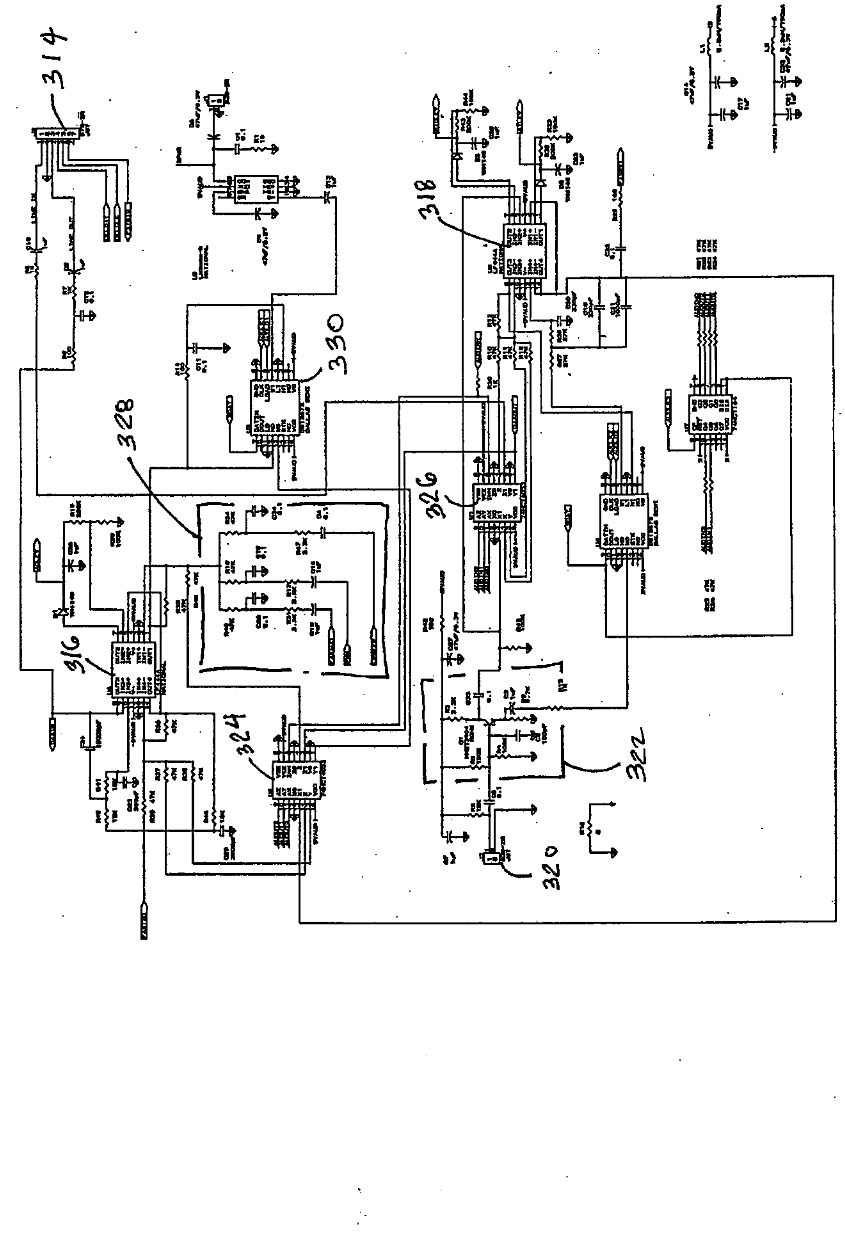
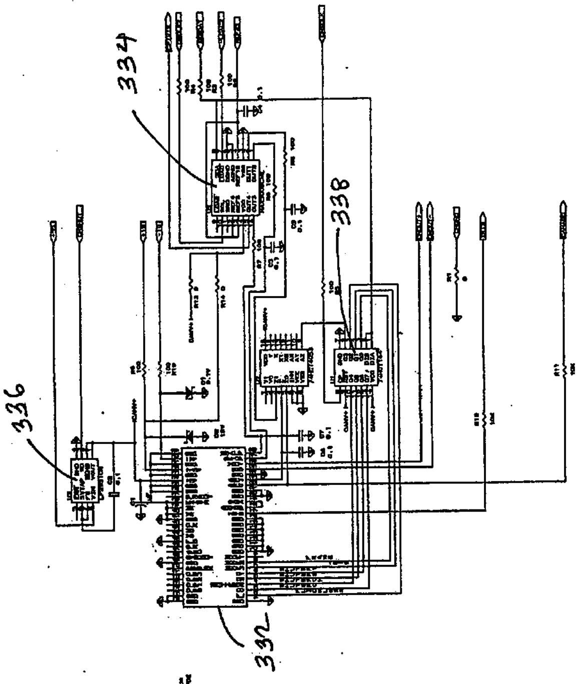


Fig. 8 Part c



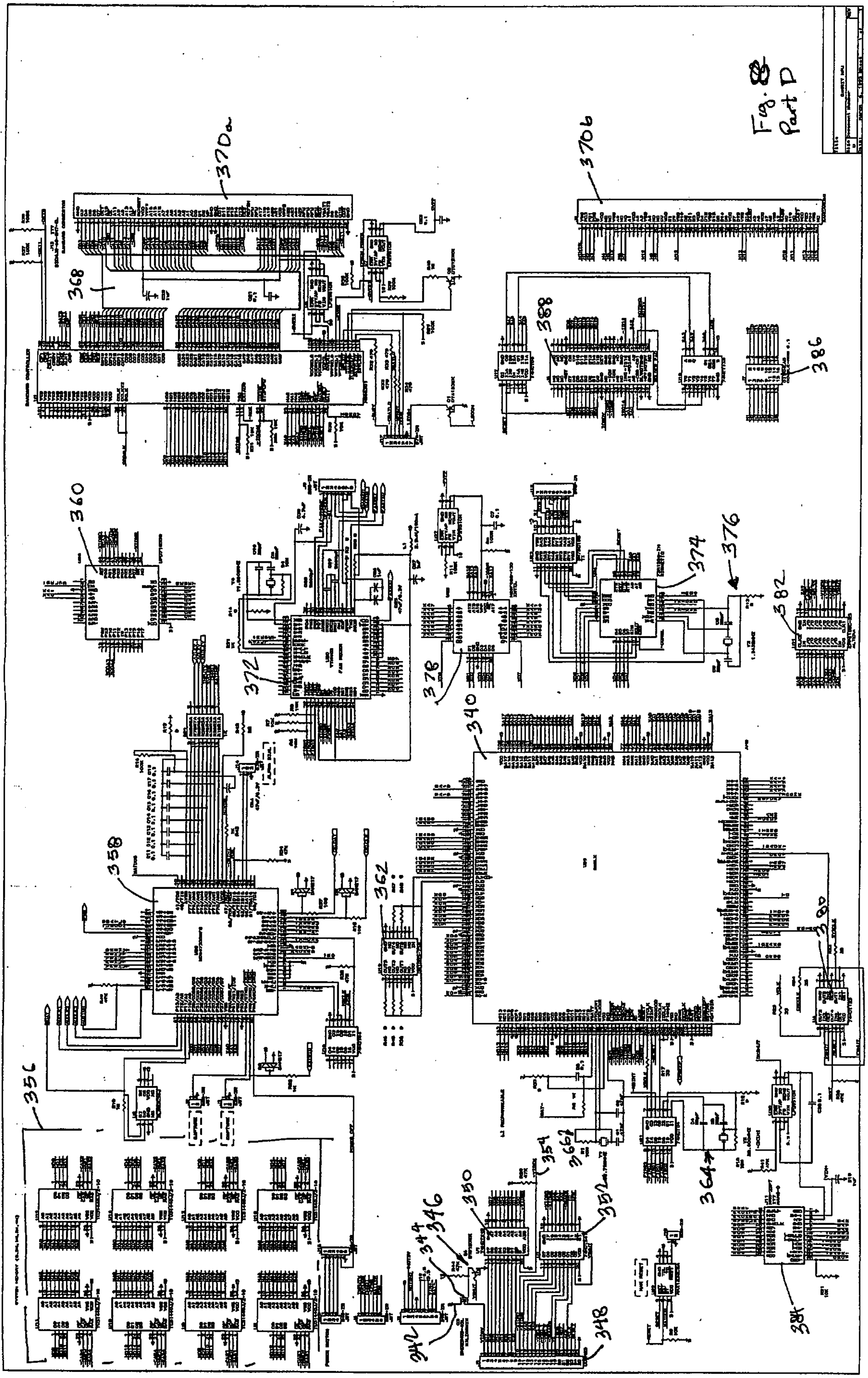


Fig. 8 Part D
370a
370b
368
388
386
360
374
376
382
372
378
340
358
362
380
356
354
366
364
352
350
346
344
342
348
384

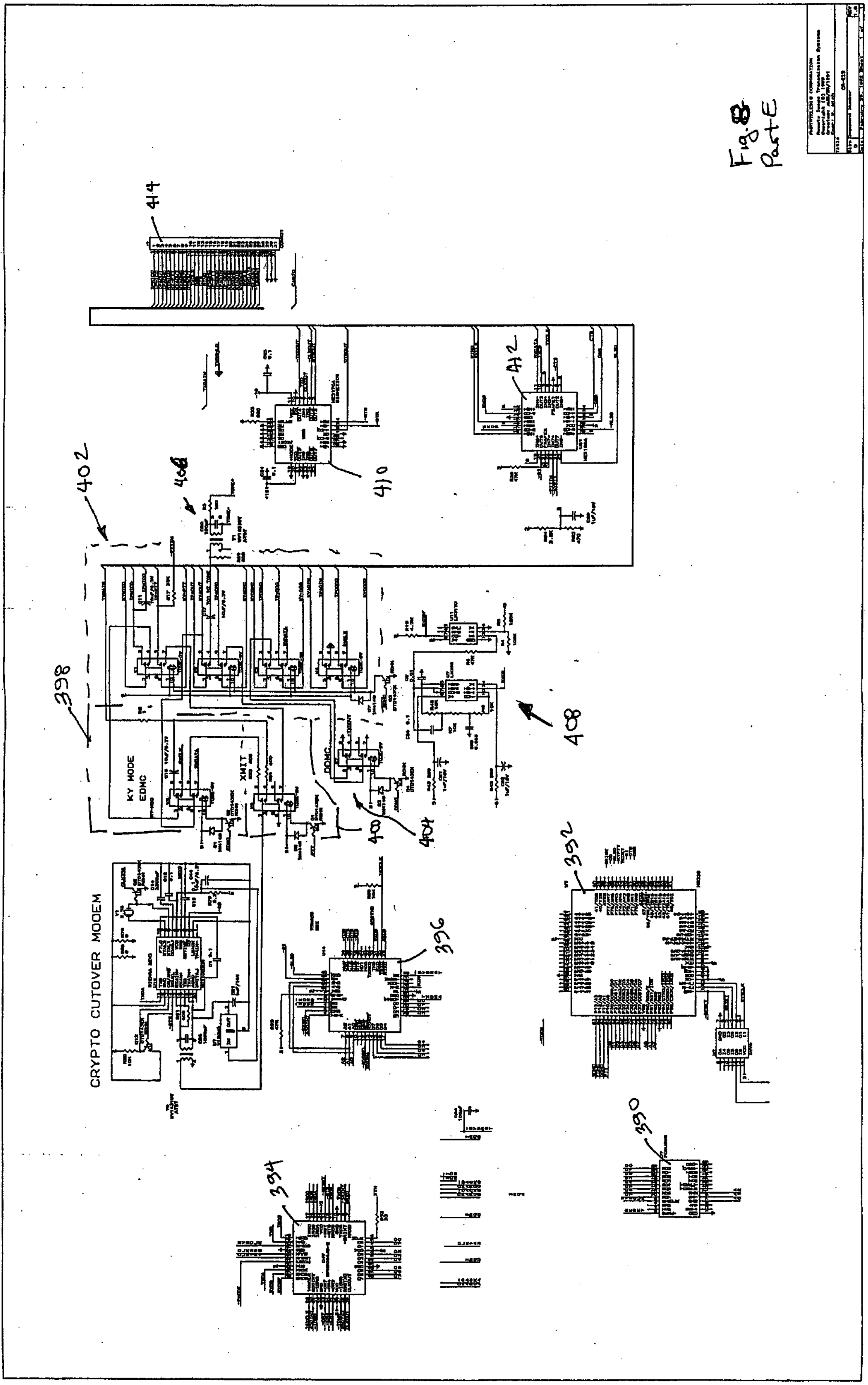

414
402
406
412
410
398
KY MODE
EDMC
XMIT
DDMC
408
400
404
CRYPTO CUTOVER MODEM
392
396
390
394

Fig. 8 Part E

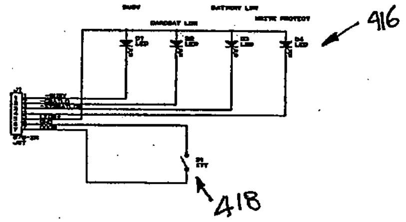


Fig. 8
Part F

PHOTOTELESIS CORPORATION
Remote Image Transmission Systems
Copyright (C) 1990
Created: AUG/20/1991
Engr: R. [illegible]

Title
GAMBIT STATUS AND DOOR STATUS

Size B
Document Number
REV 1.0

Date: February 21, 1992 Sheet 1 of 1

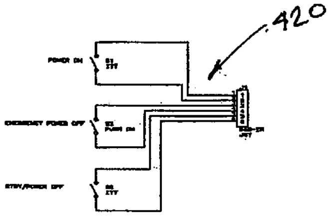


Fig. 8
Part G

PHOTOTELESIS CORPORATION
Remote Image Transmission Systems
Copyright (C) 1989
Created: AUG/30/1991

Title
GAMBIT POWER ON/OFF PCB

Size	Document Number	REV
A		1.0

Date: February 23, 1993 Sheet 1 of 1

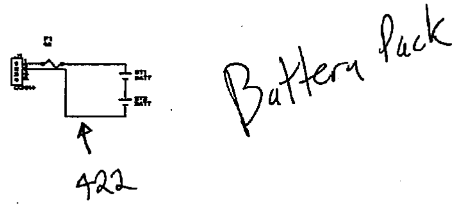


Fig. 8
Part H

PHOTOTELESIS

Title
CAM KIT NON RECHARGEABLE BATTERY

Size D
Document Number
REV

Date: February 13, 1998 Sheet 1 of 1

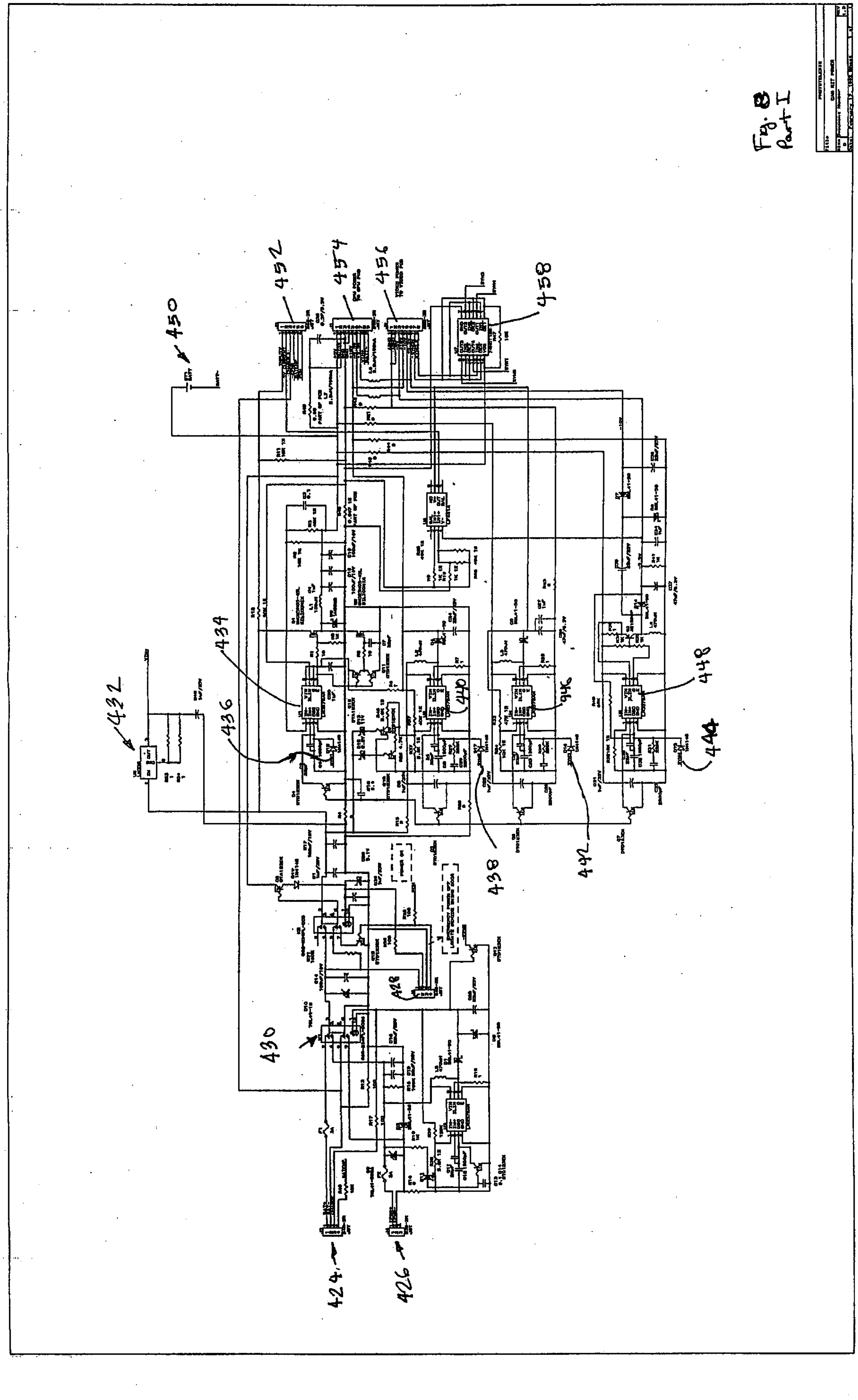

450
452
454
456
458
432
434
436
440
446
448
444
438
442
430
428
424
426

Fig. 8 Part I

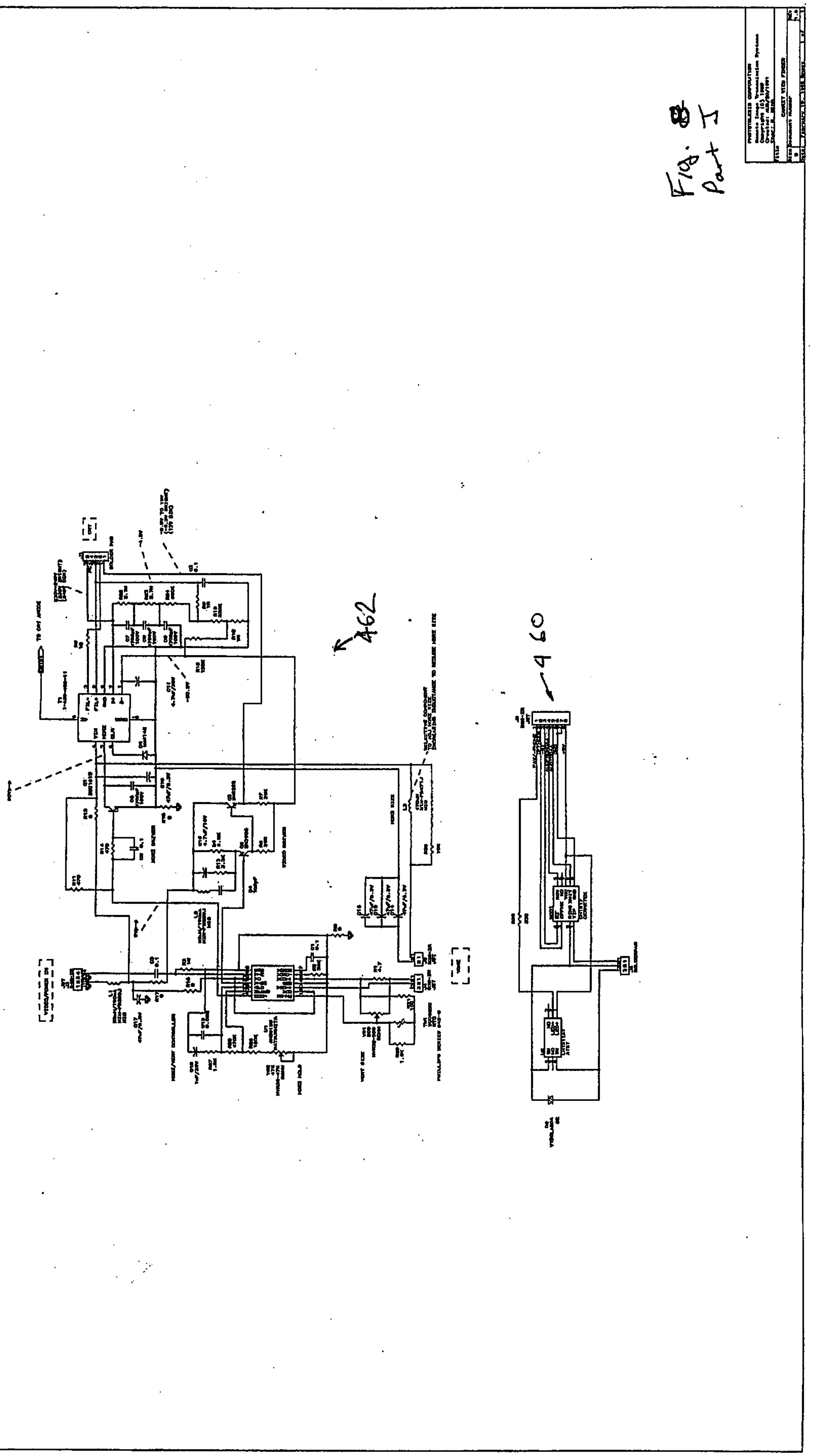


Fig. 8
Part I
462
460
PHOTOTELESIS CORPORATION
Remote Image Transmission Systems
Copyright (C) 1998
CAMERA VIEW FINDER

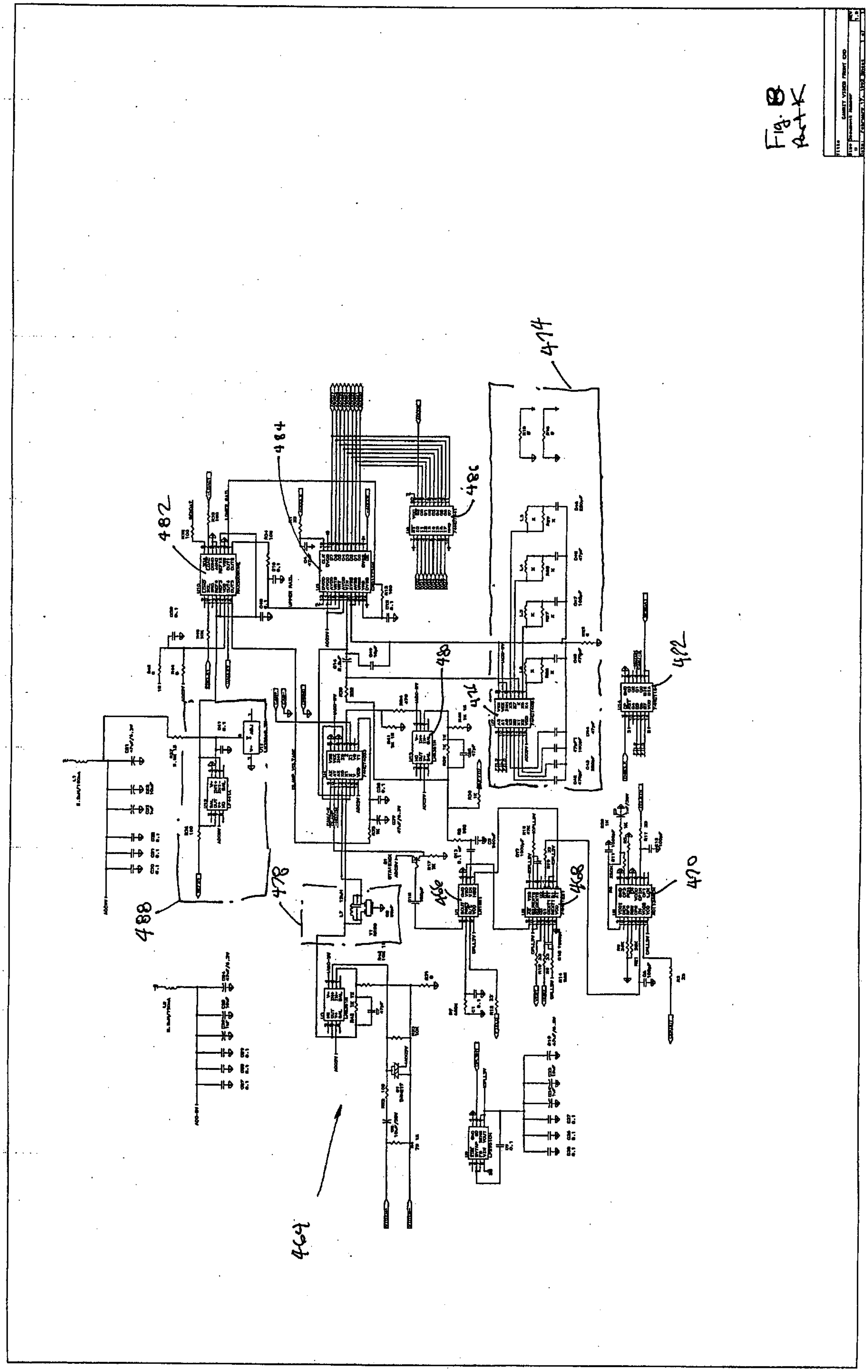

482
484
486
474
480
472
492
488
478
466
468
470
464
Title
VIDEO FRONT END
Size
Document Number
Date:
REV

Fig. 8
Part K

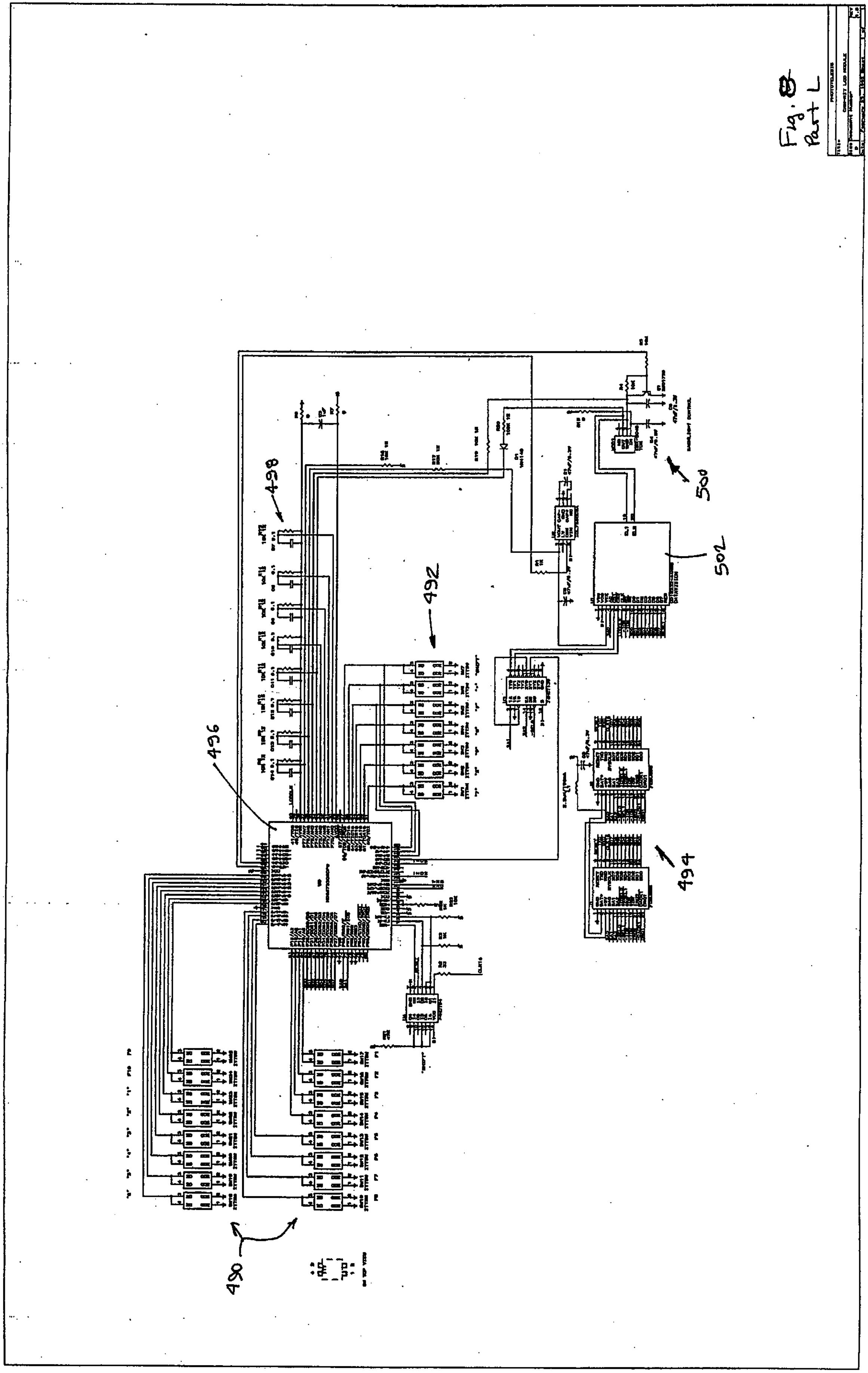


Fig. 8 Part L

Notice of References Cited

Application No. 09/006,073	Applicant(s) Monroe, David A.	
Examiner Joseph Pokrzywa	Group Art Unit 2722	Page 1 of 1

U.S. PATENT DOCUMENTS

		DOCUMENT NO.	DATE	NAME	CLASS	SUBCLASS
	A	5,546,194	8/13/96	Ross	358	445
	B	5,550,646	8/27/96	Hassan et al.	358	442
	C	5,689,300	11/18/97	Shibata et al.	348	15
	D	5,684,716	11/4/97	Freeman	348	14
	E	5,666,159	9/9/97	Parulski et al.	348	211
	F	5,539,452	7/23/96	Bush et al.	348	17
	G	5,515,176	5/7/96	Galen et al.	358	403
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUBCLASS
	N						
	O						
	P						
	Q						
	R						
	S						
	T						

NON-PATENT DOCUMENTS

		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	DATE
	U		
	V		
	W		
	X		

U. S. Patent and Trademark Office
PTO-892 (Rev. 9-95)

Notice of References Cited

Part of Paper No. 6

US005546194A

United States Patent [19]

Ross

[11] **Patent Number: 5,546,194**

[45] **Date of Patent: Aug. 13, 1996**

[54] **METHOD AND APPARATUS FOR CONVERTING A VIDEO IMAGE FORMAT TO A GROUP III FAX FORMAT**

[75] Inventor: **Jay B. Ross**, Pennington, N.J.

[73] Assignee: **Videofaxx, Inc.**, Lambertville, N.J.

[21] Appl. No.: **216,666**

[22] Filed: **Mar. 23, 1994**

[51] **Int. Cl.⁶** **H04N 1/40**; H04N 1/00; H04N 1/32; H04N 1/04

[52] **U.S. Cl.** **358/445**; 358/456; 358/400; 358/448; 358/479; 358/442; 382/298; 348/441

[58] **Field of Search** .... 358/457, 407, 358/438, 444, 456, 909, 261.1, 445, 400, 448, 468, 427, 479, 442; 382/56, 54, 298, 299; 346/76 PH; 379/88, 100; 348/441, 448, 459, 573, 458

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,315,285	2/1982	Sommer et al.	358/280
4,399,470	8/1983	Hibbard	358/284
4,593,325	6/1986	Kannapell et al.	385/282
4,977,605	12/1990	Fardeau et al.	382/51
5,093,871	3/1992	Klein et al.	382/51
5,193,012	3/1993	Schmidt	358/456
5,235,432	8/1993	Creedon et al.	358/445
5,359,694	10/1994	Concordel	358/445

OTHER PUBLICATIONS

Lewis, Rhys, B.Sc., Ph.D., "Practical Digital Image Processing," IBM, UK Scientific Centre, Winchester, Hants, Ellis Horwood, Limited, 1990.

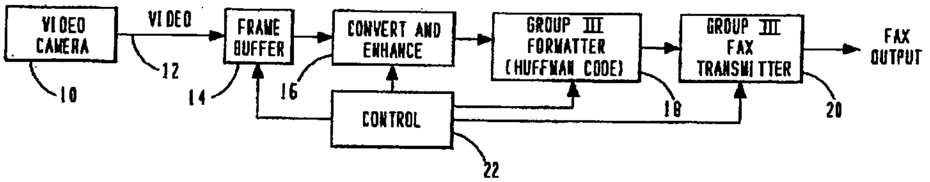
Csenger, Michael, "Brooktrout Ships Fax Server for Private Nets," *Communications Week*, Nov. 8, 1993, p. 25.

Primary Examiner—Edward L. Coles, Sr.
Assistant Examiner—Kimberly A. Williams
Attorney, Agent, or Firm—Gregory M. Howison

[57] **ABSTRACT**

A video-to-FAX conversion system includes a video camera (10) for generating video signals which are then captured by a frame grabber and stored in a frame buffer (14). The data in the frame buffer is comprised of digitized values from the video signal which are stored in pixels with a first aspect ratio. A conversion device (16) is operable to map information in the frame buffer to the binary output space of a Group III FAX protocol and perform contrast enhancement thereon. The contrast enhancement includes the steps of first generating a histogram of all of the pixel values in the frame buffer (14) after expansion thereof into the output space of the Group III FAX. The histogram values are then utilized to generate an adjusted value for each of the gray scale values available for the pixels in the frame buffer 14. Each pixel in the frame buffer (14) is then expanded and the contrast enhancement applied thereto to adjust the values therein. The pixels are then processed through a dithering operation to diffuse error across the output space and then a determination is made as to whether it is a black pixel or a white pixel. This operation is done on-the-fly such that an expanded frame buffer is not required, as only a predetermined number of horizontal scan lines are required for both the contrast enhancement and image dithering operation prior to sending them to a Group III formatter (18) and, subsequently, to a Group III FAX transmitter (20) for the output of the Group III FAX.

18 Claims, 6 Drawing Sheets



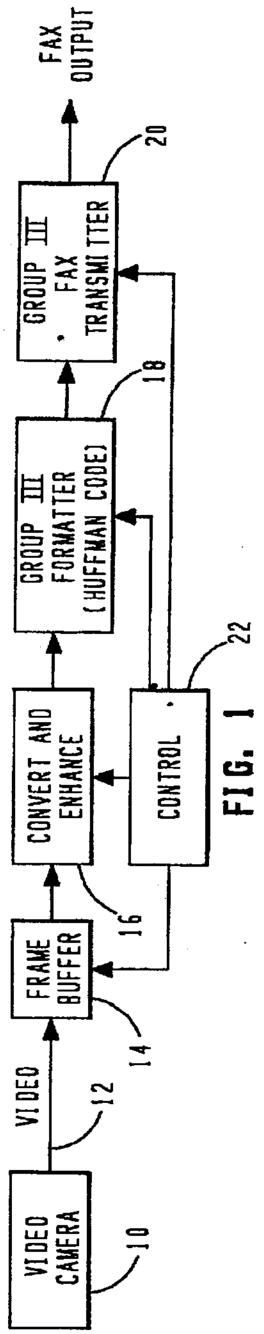

VIDEO CAMERA
10
VIDEO
12
FRAME BUFFER
14
CONVERT AND ENHANCE
16
GROUP III FORMATTER (HUFFMAN CODE)
18
GROUP III FAX TRANSMITTER
20
FAX OUTPUT
CONTROL
22

FIG. 1

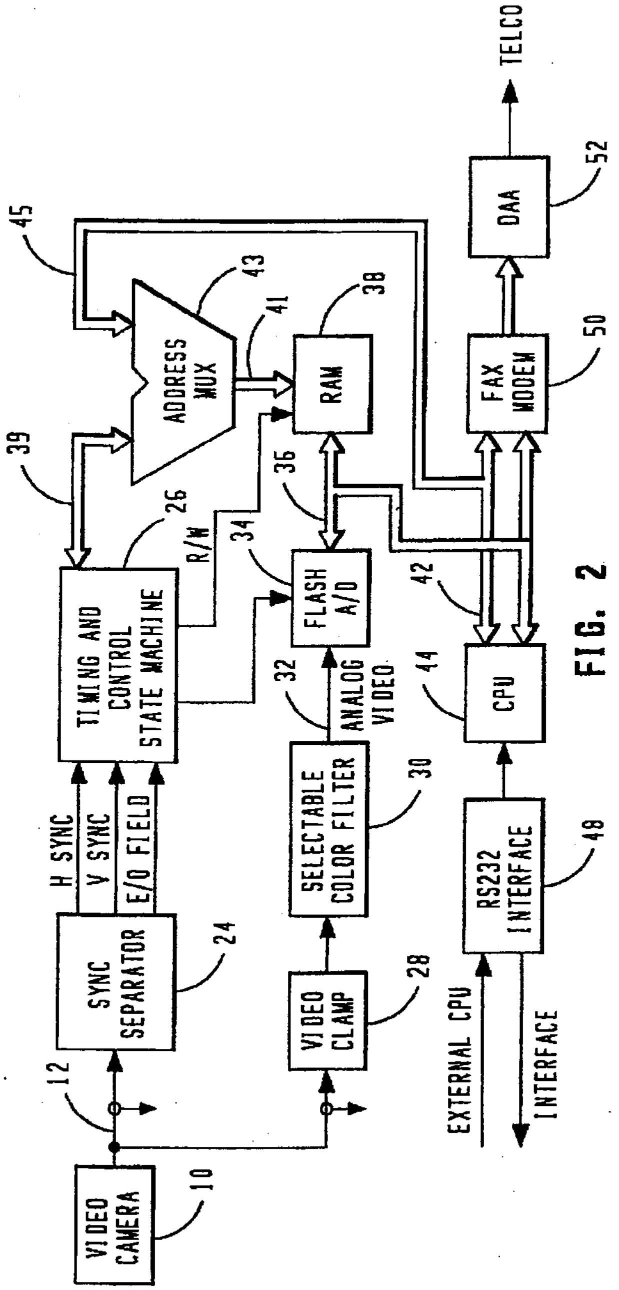

VIDEO CAMERA
10
12
SYNC SEPARATOR
24
H SYNC
V SYNC
E/O FIELD
TIMING AND CONTROL STATE MACHINE
26
R/W
39
ADDRESS MUX
43
45
41
RAM
38
36
34
FLASH A/D
32
ANALOG VIDEO
SELECTABLE COLOR FILTER
30
VIDEO CLAMP
28
42
CPU
44
RS232 INTERFACE
48
EXTERNAL CPU INTERFACE
FAX MODEM
50
DAA
52
TELCO

FIG. 2

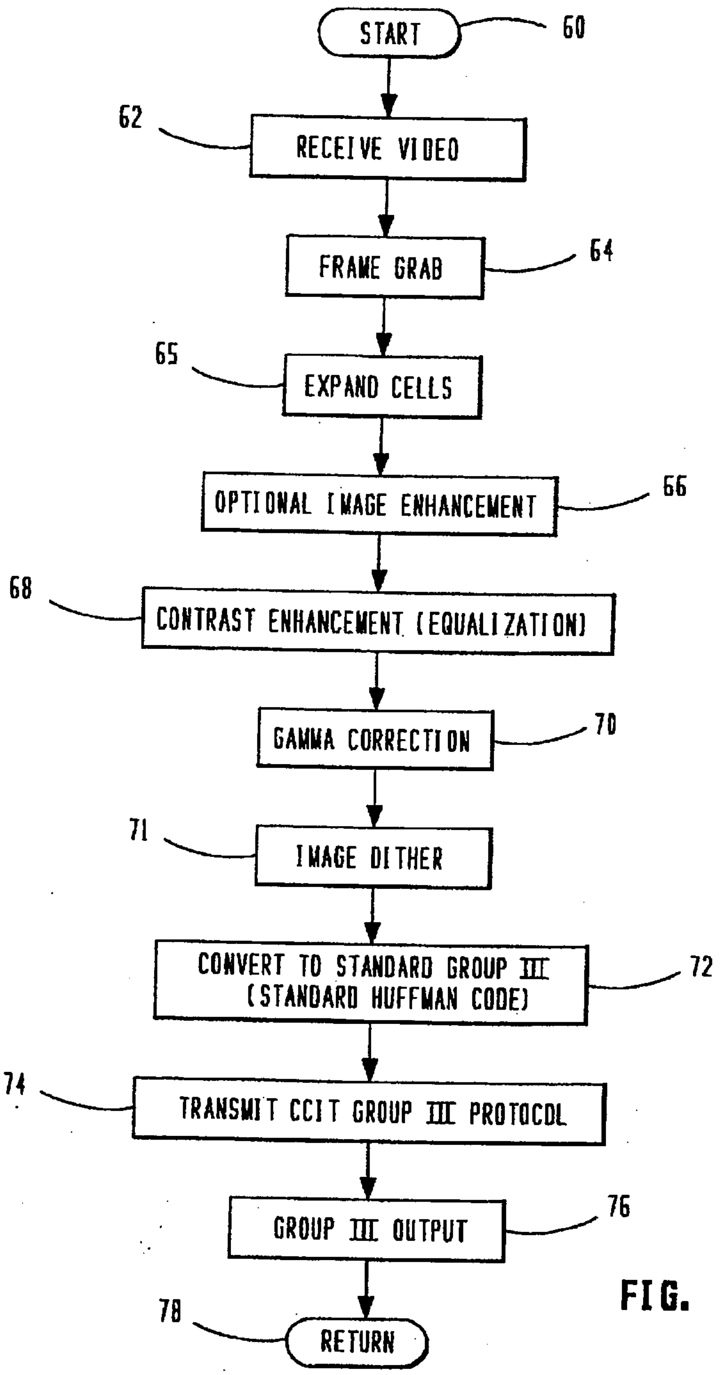

START
60
62
RECEIVE VIDEO
FRAME GRAB
64
65
EXPAND CELLS
OPTIONAL IMAGE ENHANCEMENT
66
68
CONTRAST ENHANCEMENT (EQUALIZATION)
GAMMA CORRECTION
70
71
IMAGE DITHER
CONVERT TO STANDARD GROUP III (STANDARD HUFFMAN CODE)
72
74
TRANSMIT CCIT GROUP III PROTOCOL
GROUP III OUTPUT
76
78
RETURN

FIG. 3

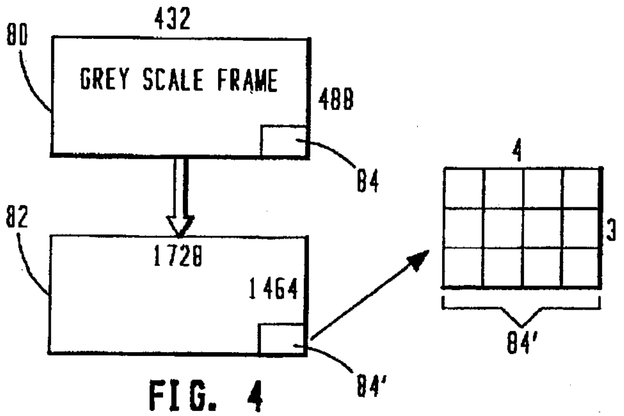


FIG. 4

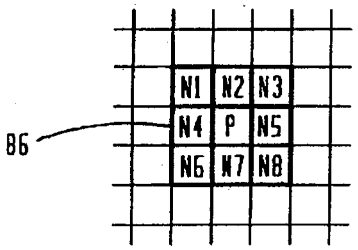


FIG. 5

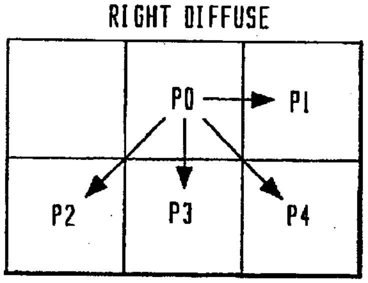


FIG. 7a

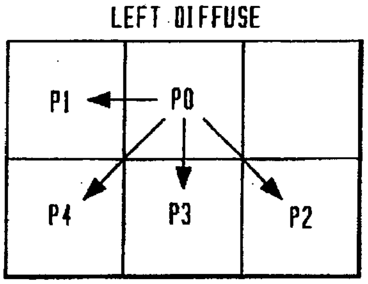


FIG. 7b

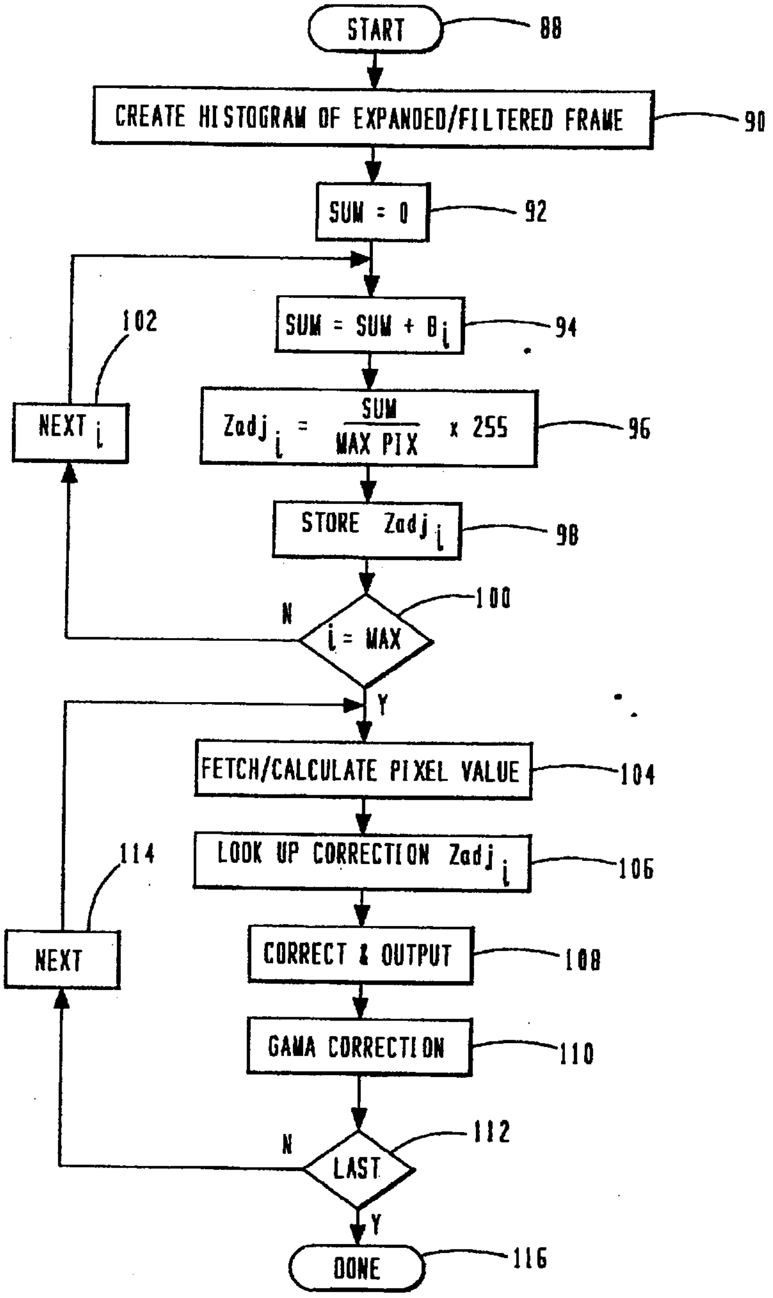

START
88
CREATE HISTOGRAM OF EXPANDED/FILTERED FRAME
90
SUM = 0
92
SUM = SUM + B i
94
102
NEXT i
Zadj i = SUM / MAX PIX x 255
96
STORE Zadj i
98
N
i = MAX
100
Y
FETCH/CALCULATE PIXEL VALUE
104
LOOK UP CORRECTION Zadj i
106
114
NEXT
CORRECT & OUTPUT
108
GAMA CORRECTION
110
N
LAST
112
Y
DONE
116

FIG. 6

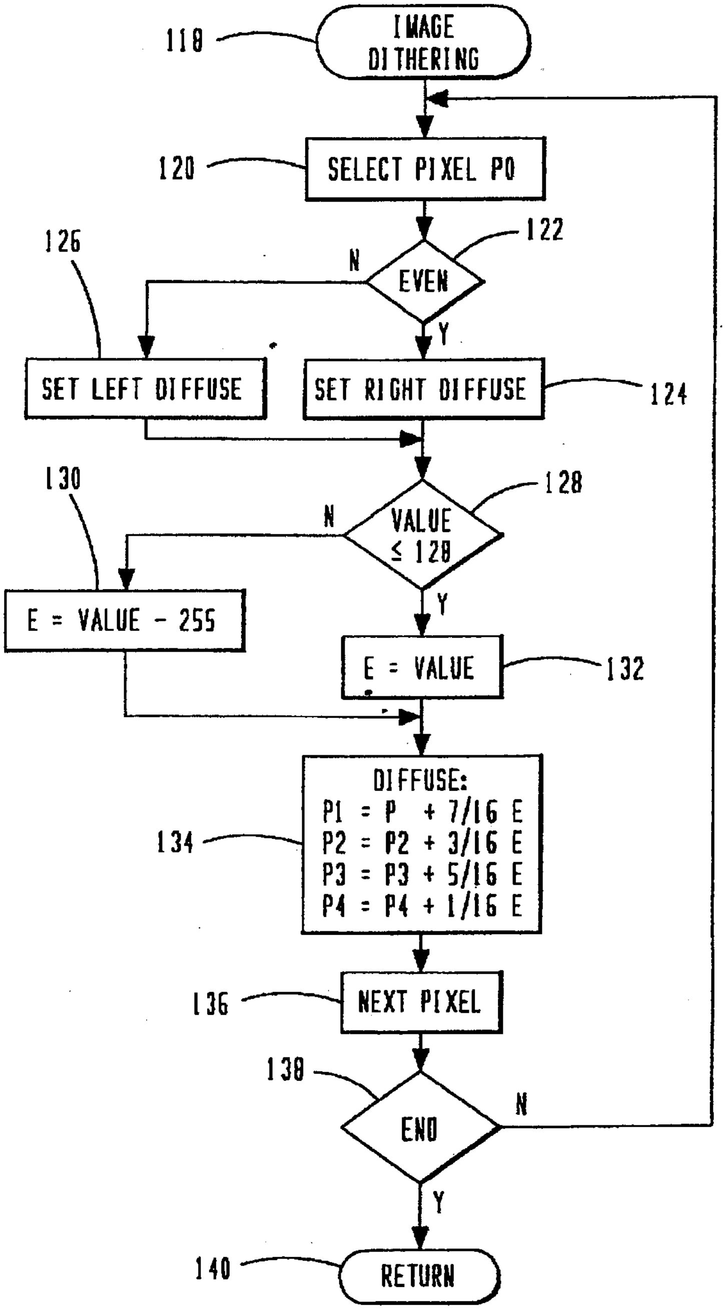

118
IMAGE DITHERING
120
SELECT PIXEL P0
122
EVEN
N
Y
126
SET LEFT DIFFUSE
SET RIGHT DIFFUSE
124
130
128
VALUE ≤ 128
N
Y
E = VALUE - 255
E = VALUE
132
DIFFUSE:
P1 = P + 7/16 E
P2 = P2 + 3/16 E
P3 = P3 + 5/16 E
P4 = P4 + 1/16 E
134
136
NEXT PIXEL
138
END
N
Y
140
RETURN

FIG. 7

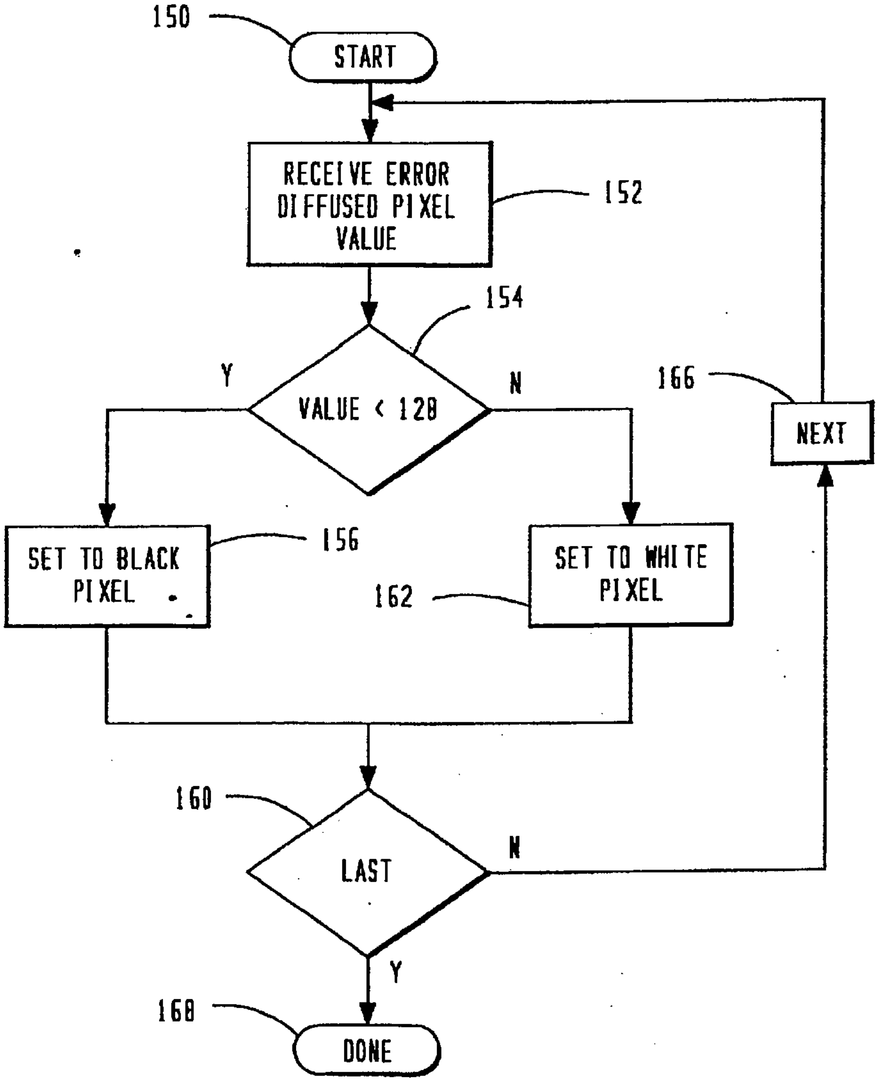

150
START
RECEIVE ERROR DIFFUSED PIXEL VALUE
152
154
VALUE < 128
Y
N
166
NEXT
SET TO BLACK PIXEL
156
SET TO WHITE PIXEL
162
160
LAST
N
Y
168
DONE

FIG. 8

METHOD AND APPARATUS FOR CONVERTING A VIDEO IMAGE FORMAT TO A GROUP III FAX FORMAT

TECHNICAL FIELD OF THE INVENTION

The present invention pertains in general to facsimile apparatus, and more particularly, to an apparatus for receiving video image format and converting it to a Group III FAX format and then transmitting it as a Group III FAX.

BACKGROUND OF THE INVENTION

In present day technology, images are received and stored in various formats. On the reception end, the image can be input either through a scanner or through a frame grabber that is operable to receive a video input from a video camera, for example, and then digitize the image for storage thereof. Each of these input devices provides a predetermined format for the stored image. For example, the scanner has a predefined scanning head that determines the maximum resolution of the image. A relatively high resolution scanner may allow for 300 dots per inch (DPI) or more along the horizontal axis, each dot representing either a dark pixel (picture element) or a white pixel. This image is then stored as an image file with one of a predetermined number of image file formats. With respect to the frame grabber, this typically samples the incoming video on a given horizontal scan line, there being a predetermined number of horizontal scan lines per frame, and then dividing up the analog input value into "samples" or pixels that each have a digitized value of eight bits, representing the analog value. The image is then stored as a digitized frame in a frame buffer.

When an image is to be output, it is necessary to ensure that the stored image can be "mapped" to the output space of the output device. For example, if a scanner scanned at a resolution of 300 DPI and this were to be output on a laser printer at a resolution of, for example, 300 DPI, this would be a relatively easy task. However, if the resolution of the stored image were not equal to that of the output device, some adjustment would be required to map the full image to the full output space. One place this presents a problem is with respect to a received facsimile image, which typically has a resolution of 200 DPI. This would therefore require that each pixel be expanded to represent 1½ pixels on the output. However, if the output device were a facsimile image, this would require a 300 DPI stored image to be translated to a 200 DPI FAX image. Typically, the image is merely reduced by a factor of two such that it is 150 DPI and then transmitted such that it only occupies ¾ of a horizontal line in order to alleviate the need for translating pixels.

In order to convert a scanned image from either a scanner or a video source into pixels, it is necessary to perform various image enhancements. Since the input values from either a scanner or a video source are analog values, it is necessary to convert them to "gray-scales" in order to represent them with pixels that are either black or white. For example, a gray area would be represented by alternating black and white pixels. If the tone were decreased to a much grayer level approaching white, the number of white pixels would dominate the number of black pixels. This, of course, would be the reverse for a relatively dark gray area, wherein the black pixels would dominate over the white pixels. Since the eye cannot decipher individual pixels, it "averages the pixels". One area that has not been addressed for present technology is the receipt of a video image and subsequent retransmission of that image by facsimile. The difficulty that arises with this type of transmission is the incompatibility between the two formats. As described above, a facsimile typically operates at 200 DPI in a binary output space, wherein a typical video image is captured in an analog input space by a frame grabber and digitized with a resolution of 432 pixels across and 488 pixels along the vertical. The problem exists wherein it is necessary to map each pixel in the video image into black or white pixels in a facsimile transmission, and this mapping function controlled such that it covers the entire image or entire output space.

SUMMARY OF THE INVENTION

The present invention disclosed and claimed herein comprises a video-to-Group III FAX converter. The converter includes a video input for receiving a video image and digitizing it to provide sequential frames of input information. A first conversion device is provided for convening the frames in the video image to an array of digitized analog pixels in a frame buffer. These are arranged in a first image space that is not compatible with the output image space of the Group III FAX protocol. A mapping device is then operable to map the image space of the frame buffer to a binary image space associated with the Group III FAX format. This binary image space is comprised of binary image pixels. A FAX transmission device then transmits the binary image pixels in the binary image space via a Group III FAX protocol over a FAX transmission media.

In another aspect of the present invention, a contrast enhancement device is provided for adjusting the analog values in the frame buffer for optimal contrast in the binary image space. The mapping device is first operable to expand each of the pixels in the frame buffer to an associated portion of the binary image space. These expanded pixels are then processed with the contrast enhancement device to adjust the analog values therein. An image dithering operation is then performed on these expanded and enhanced pixel values to diffuse error across the binary image space, before conversion to the binary pixels. Thereafter, each of the pixel values is compared to a threshold and, if below the threshold, converted to a black pixel and, if above the threshold, converted to a white pixel.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

FIG. 1 illustrates a block diagram of the overall system;

FIG. 2 illustrates a block diagram of the frame grabber;

FIG. 3 illustrates a flowchart for the overall operation system;

FIG. 4 illustrates a block diagram for the cell expansion;

FIG. 5 illustrates a diagrammatic view of the optional enhancement technique;

FIG. 6 illustrates a flowchart for the contrast enhancement feature;

FIG. 7 illustrates a flowchart for the image dithering technique;

FIGS. 7*a* and 7*b* illustrate diagrammatic views for the contrast enhancement operation; and

FIG. 8 illustrates a flowchart depicting the setting of the binary pixel value.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, there is illustrated a block diagram of the overall system. A video source comprising a video camera 10 generates on an output 12 a video signal. This is a conventional video camera, and the video format is a well-known standard. The video format provides an analog output that is output in a serial manner. The output is comprised of a plurality of horizontal scan lines arranged in a "frame" to provide an image, the images bounded along the horizontal line by the beginning and end of the line, which defines a horizontal sync pulse. The vertical boundaries at the top and the bottom are defined by vertical sync pulses. Therefore, at the beginning of a horizontal sync pulse, a horizontal scan line is initiated and, at the end of the horizontal scan line, another horizontal sync pulse occurs and another horizontal scan line is begun. At the last horizontal scan line, a vertical sync pulse occurs. Again, this is a conventional video format.

The video 12 is received, digitized and stored in a frame buffer 14. The frame buffer 14 allows the sampled video to be stored in the form of pixels. Each sample comprises a digitized analog value which is termed a "sample". This sample is stored as an 8-bit word for conventional black and white. If color is involved, there could be an 8-bit word for each color or four 8-bit words. However, the preferred embodiment is involved only with black and white, although it should be understood that color could be utilized.

The frame buffer 14 is utilized to store the original data for the frame that was received from the video camera 10. This information in its stored state is not compatible with a Group III facsimile output. Therefore, the information in the frame buffer is accessed and input to a conversion device 16 that is operable to convert the information in the frame buffer 14 into a compatible format for a Group III FAX. Further, the information is enhanced and filtered, since conversion from a digitized analog value (gray scale) to a half-tone binary pixel output results in some loss of image. This is achieved with various enhancement devices as will be described hereinbelow.

After conversion and enhancement, the binary bit-mapped information is then input to a Group III formatter 18, which is operable to utilize a Huffman code for formatting the binary pixel information into a compatible format for a Group III transmitter. This is a conventional formatting operation, which provides headers, end of page indications, etc., for the purpose of transmitting a Group III FAX. This is then transmitted to a Group III FAX transmitter 20 to provide an output. The operation of the frame buffer 14, the conversion device 16, the Group III formatter 18 and the Group III transmitter 20 is controlled by a control system 22.

Referring now to FIG. 2, there is illustrated a more detailed block diagram of the overall system. The video camera 10 has the output thereof input through the line 12 to a sync separator 24. The sync separator 24 is a conventional integrated circuit that is operable to extract from the video signal the horizontal sync (HSync), the vertical sync (VSync) and the even and odd fields. These are input to a timing and control state machine 26. Again, the extraction of the horizontal sync and vertical sync timing signals from the video signal are conventional.

The output of video camera 10 on the line 12 is also input to a video clamp circuit 28, which video clamp circuit is operable to maintain a DC bias on the input video. The output of the video clamp circuit is output to a selectable color filter 30 to provide the selective filtering thereto at a frequency of 3.5 MHz, conventionally referred to as a trap filter. This results in a filtered analog video output signal on line 32. This is processed through a flash analog-to-digital (A/D) converter 34 to provide on a data bus 36 digital data for storage in a RAM 38. The A/D converter 34 and the RAM 38 are controlled by the state machine 26. Additionally, the RAM 38 is controlled through an address/control bus 41, which is output from an address multiplexer 43. The multiplexer 43 has two inputs, one from the state machine 26 through an address bus 39, and one from a CPU 44 through an address bus 45. The data bus 36 is also input to the central processing unit (CPU) 44, CPU 44 providing general control functions thereto. The CPU 44 is operable to interface from an external location to the system through an RS 232 interface circuit 48. Additionally, the CPU 44 is operable to interface through the data bus 36 and the address bus 45 with a FAX modem 50, this then output through a DAA device 52 to the telephone company. The FAX modem 50 is a conventional peripheral device which can either be a chip set or it can be an external board.

In operation, the video information on line 12 is captured as a frame and stored in the RAM 38. The RAM 38 is comprised of more than one device, but is represented as a single block in FIG. 2. The information in the frame buffer, which comprises part of the RAM 38, is processed to enhance and map the information into the output space of a typical Group III facsimile protocol. However, as will be described hereinbelow, the enhanced image is not stored in the RAM 38. Rather, the overall image in the frame buffer is processed to determine how each line should be processed; thereafter each horizontal line of information in the frame buffer internal to the RAM 38 is processed on a line-by-line basis in a serial manner and output to the FAX modem 50 in an "on the fly" operation. However, if sufficient memory were provided, the entire output image could be prestored and then output at a later time.

Referring now to FIG. 3, there is illustrated a flowchart depicting the overall operation of the system. The flowchart is initiated at a block 60 and then proceeds to a function block 62 to receive the video signal. The program then flows to a function block 64 to perform the frame grab operation. As described above, this is an operation whereby the input video signal is digitized and stored in a frame buffer. The program then flows to a function block 65 to expand the number of pixels to a format that will map the number of pixels in a typical frame to the number of pixels in a Group III facsimile. Since they are not the same, it is necessary to increase the number of pixels that represent a single scan line and then map the number of pixels representing the scan line in the frame buffer to that representing the line in a conventional Group III facsimile protocol.

After expansion, the program flows to a function block 66 to perform an optional image enhancement which accents edges, as will be described hereinbelow. The program then flows to a function block 68 to perform a contrast enhancement or equalization. It should be noted that at this point the data is still represented by a gray scale value which is a digitized value stored as an 8-bit word. This, in and of itself, is not compatible with a binary pixel representation that exists with a Group III facsimile protocol. The contrast enhancement is an important aspect of the present invention in that it is "automatic" and the user does not need to adjust it. It merely recognizes in a relatively dark image that intensities can be equalized over the entire surface of the image to remove some of the dark areas and lighten them up. With respect to a relatively light image, the contrast enhancement actually darkens it to highlight some of the finer details. This will be described hereinbelow. The program then flows to a function block 70 to perform a gamma correction (nonlinear intensity correction) and then to a function block 71 to perform an image dither operation. This image dither operation will convert the digitized 8-bit values to binary values of either a dark or a light pixel.

After the image has been fully mapped into a binary pixel map having an aspect ratio compatible with the Group III FAX protocol, the program flows to a function block 72 in order to convert the output to a standard Group III format via a standard Huffman code. This basically adds headers, etc. that are necessary to operate under Group III protocol. The program then flows to a function block 74 to transmit the image at a CCIT Group III protocol FAX and then to a function block 76 representing the Group III FAX output. The program flows to return block 78 to send the next image.

Referring now to FIG. 4, there is illustrated a diagrammatic view of the cell expansion routine. A first frame 80 represents the information stored in the frame buffer. As described hereinabove, this information is extracted in the frame grabber operation, digitized and stored in the RAM 38 as a frame of information and maintained therein for processing of the frame until the full image is sent out as a Group III FAX. The information in the frame 80 is arranged as gray scale pixels in a 432×488 format and then each pixel in the frame 80 expanded into a 4×3 space, as represented by a virtual frame 82. The frame 82 is virtual by the fact that it is never completely formed and stored in the RAM 38; rather, it is formed on the fly, as will be described in more detail hereinbelow.

By expanding each pixel in the frame 80 to a 4×3 field, the virtual frame 82 will now have 1728 pixels along the horizontal and 1464 pixels along each vertical column. For descriptive purposes, a single pixel 84 in the frame 80 is mapped as a field 84', the field 84' comprised of four pixels along each horizontal row and three pixels along each column. However, without enhancement, the value of each of the pixels in the frame 84' has the same value as the single pixel 84.

Referring now to FIG. 5, there is illustrated a diagrammatic view of the optional image enhancement procedure. After the cells have been expanded, a moving neighborhood window 86 is moved across the virtual frame 82, the moving input window 86 comprising a 3×3 pixel window having nine pixels contained therein. The center pixel is referred to by "P" with the remaining neighboring pixels around the border thereof referred to by "N1", "N2", "N3", "N4", "N5", "N6", "N7" and "N8". The window 86 moves from left to right along a single row of pixels and then begins at the next row of pixels moving from left to right. The center pixel value "P'" is calculated via a spatial filtering technique referred to as an "unsharp filter" algorithm. This algorithm essentially takes the value of the center pixel "P" and multiples it by a factor of three and then subtracts therefrom twice the average of all of the pixels in the moving window by the following equation:

$$P' = 3 \times P - 2\left\{ \frac{(\Sigma N) + P}{9} \right\} \tag{1}$$

This provides a little "crispness" to the image prior to performing the following steps. Again, this is a general spatial filtering technique.

Referring now to FIG. 6, there is illustrated a flowchart depicting the contrast enhancement operation. The program is initiated at a start block 88 and then proceeds to a function block 90 to indicate that a histogram is to be formed of the expanded/filtered frame. As described above, the expanded virtual frame 82 is a "virtual" frame in that it is never completely formed and stored in memory, to minimize memory requirements. Therefore, only a predetermined number of horizontal scan lines in the virtual frame 82 are maintained, this corresponding to approximately three horizontal scan lines of the original frame 80. However, in order to create a histogram, it is necessary to first process through all of the pixels in the virtual frame 82. This will therefore require an entire pass through the algorithm with all of the information in the frame for forming the expanded frame and the optional enhancement described above with respect to FIG. 5.

In the first scan through, the program will flow to a function block 92 to set a Sum value equal to zero. The program will then flow to a function block 94 to increase the Sum value by a Bin count value within the histogram. Since there are 256 possible gray scale values for a given pixel, it is necessary to cycle through the virtual frame 82 and determine how many pixels fall in any given gray scale range. If the image were a very dark image, a large number of pixels would fall to the lower end of the histogram; however, if the image were a white image, a large number of pixels would fall in the Bin values at the upper end of the histogram.

For the first pass through, the value of I is set equal to zero such that the value of SUM is increased by the value of B_0. The program then flows to a function block 96 to calculate the pixel adjust value $Zadj_i$ as follows:

$$Zadj_i = \frac{SUM}{MAXPIX} \times 255 \tag{2}$$

The value of MAXPIX is, in the preferred embodiment, equal to 2,529, 729 pixels. After the adjusted pixel value for the i^{th} value is calculated, the program flows to a function block 98 to store the adjusted pixel value and then flows to a decision block 100 to determine if the value of i is equal to MAX, i.e., 255. If not, the program flows along the "N" path to a function block 102 to increase the value of i and then back to the input of function block 94 to again increment the value SUM by the next value of B. This continues until i is equal to 255, at which time the program will flow from decision block 100 along the "Y" path thereof to a function block 104.

Function block 104 is operable to perform the actual contrast enhancement. The function block 104 indicates the operation wherein the pixel value for a given pixel is retrieved, it being a bit word, and then the value calculated The program flows to a function block 106 to lookup the correction $Zadj_i$ from the lookup table, this being calculated in function block 96 in the first pass through the virtual frame 82. The pixel value is then adjusted by this value and output, as indicated by a function block 108. The program then flows to a function block 110 to provide gamma correction to the output contrast enhanced pixel and then to a decision block 112. The gamma correction is a well-known technique which is provided by a lookup table. Therefore, each pixel positioned in the virtual frame 82 has associated therewith a gamma correction factor, which is applied in the function block 110. The decision block 112 determines whether the last pixel in the virtual frame 82 has been corrected and output. If not, the program flows along an "N" path back through a function block 114 to select the next pixel and then back to the input of the function block 104. When the last pixel has been corrected, the program flows along a "Y" path to a Done block 116.

Referring now to FIG. 7, there is illustrated a flowchart depicting the image dithering operation, which is initiated at a block 118. As described above, image dithering is required to convert from the 8-bit value output in the contrast enhancement procedure described above with respect to the flowchart of FIG. 6, and convert it to a binary pixel of either a black dot or a white dot. The technique utilized in the present invention is one of diffusing error across the virtual frame 82. It should be noted that the dithering process is operated on-the-fly. The program flows from the block 118 to a function block 120 to select the pixel and then to a decision block 122 to determine if the pixel is selected from an even row or an odd row. As will be described hereinbelow, the error diffusion for an even row diffuses to the right as the row is traversed and then the next row, the output row, is traversed from right to left and, therefore, the error is diffused to the left. If it is an even row, the program flows to a function block 124 along the "Y" path to set the system for a "Right Diffuse" operation. If it is an odd line, the program flows along the "N" path from decision block 122 to a function block 126 to set the system for a "left diffuse" operation. The output of both function block 124 and 126 flow to a decision block 128.

The decision block 128 determines whether the value of the pixel is less than 128, one-half the total value of 256. Essentially, a decision is made that anything above a value of 128 is a white pixel and anything equal to or below a value of 128 is a black pixel. If the value is greater than 128, the program flows along an "N" path to a function block 130 to set the error value "E" to be equal to the value of the pixel minus the value 255. However, if the value is equal to or less than 128, the program will flow from decision block 128 along the "Y" path thereof to a function block 132 to set the error equal to the actual pixel value. The program will then flow to a function block 134 from both function blocks 130 and 132.

In function block 134, the diffuse operation is performed. The diffuse operation is described with reference to diagrammatic views of FIGS. 7*a* and 7*b*. In FIG. 7*a*, there is illustrated a diagrammatic view of the "fight diffuse" operation and, in FIG. 7*b*, there is illustrated a diagrammatic view of the "left diffuse" operation. In the diffusion operation to the right, the error in each pixel is diffused to the right, which is referred to as "east", over one and down one, which is referred to as the "southeast" direction, directly down, which is referred to as the "south" direction and one to the left and down, which is referred to as the "southwest" direction. The pixel that is diffused is referred to as the P0 pixel. The east pixel is referred to as P1, the southwest pixel is referred to as P2, the south pixel is referred to as P3 and the southeast pixel is referred to as P4. In the left diffuse operation, the pixel P0 is diffused to the "west" as pixel P1, to the southwest as pixel P4, to the south as pixel P3 and to the southeast as pixel P2. The value of pixels P1, P2, P3 and P4 for both the Right Diffuse and Left Diffuse operation are set forth in the following table:

TABLE 1

P1	P1 + 7/16E
P2	P2 + 3/16E
P3	P3 + 5/16E
P4	P4 + 1/16E

It can be seen that each of the pixel values is increased by a percentage of the value of "E". Of course, the function block 130 sets this as a negative value such that the error correction is in the negative direction. For example, if the value of P0 were equal to 30 out of a maximum value of 255, this would flow through the function block 132 and the value of E would be equal to "230". the large amount of the error would flow to pixel P1 with the next highest level flowing to pixel P3. The smallest amount would flow to pixel P4. However, if the pixel value were equal to 200, the value of "E" would be −55. Therefore, each of the pixel values P1–P4 would be decreased in value.

After diffusing the error, the program would flow to a function block 136 to select the next pixel, and then to a decision block 138 to determine if this was the last pixel. If not, the program would flow along a "N" path back to the input of a function block 120 and diffuse the error across the next pixel group of pixels. Whenever the edge of a line occurs, the values P1 and P4 would be set to "0". When the end of the virtual frame 82 occurs, the programs flows from decision block 138 to a return block 140.

Referring now to FIG. 8, there is illustrated a flowchart depicting the setting of the binary pixel value. The program is initiated at a start block 150 and then proceeds to a function block 152 wherein the error diffused pixel value calculated in the flowchart of FIG. 7 is retrieved and then the program flows to a decision block 154 to determine if the value of the error diffused pixel is less than 28. If so, this indicates a black pixel, which is set in a function block 156, and then the program proceeds to a decision block 160. If the value is greater than 128, the program flows along an "N" path to set the value of the pixel to a white pixel, as indicated by a function block 162. The program then flows to a decision block wherein the determination is made as to whether this was the last pixel. If not, the program flows along the "N" path to a function block 166 to select the next pixel and then to the input of function block 152 to receive the next error diffused pixel value. When the last pixel has been processed in the virtual frame 82, the program flows along the "Y" path from decision block 160 to a done block 168.

It can be seen that the contrast enhancement operation requires an entire pass through all values stored in the frame buffer 80 for the original video image that was digitized and stored there. The cell expansion is done as necessary to calculate the various adjusted values for each of the 256 gray scale levels. Once this is done, a lookup table is formed and then a contrast enhancement performed, again only on the selected pixels as they are retrieved for output. Once the histogram values are calculated, it is then only necessary to retrieve pixel values from the frame buffer 80, expand them, apply the contrast enhancement adjustment value thereon and then perform the image dithering operations thereon. After the image dithering operation is performed, i.e., the error diffusion operation, the pixel values are selected as being either a black pixel or a white pixel, based upon the error diffused value as it compares to the threshold of 128. This, therefore, does not require the entire virtual frame 82 to be stored in memory. Since the facsimile output generates a single line at a time, this can be done at the same time that the facsimile is being generated and output in the serial fashion associated with a facsimile transaction.

Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A video-to-Group III FAX converter, comprising:

an video input for receiving a video input signal having sequential lines of video information;

a first conversion device for converting said lines of video information to an array of analog pixels in a frame buffer, each of said analog pixels having a digital value that represents an analog sampled value within an associated one of said lines of video information;

a mapping device for mapping said array of said analog pixels in said frame buffer to a binary image space associated with a Group III FAX format as binary image pixels, said binary image space comprising a larger number of binary image pixels than said analog pixels stored in said frame buffer, and wherein said mapping device is operable to expand each of said analog pixels stored in said frame buffer to provide an expanded array of analog pixels having an aspect ratio corresponding to the aspect ratio of said binary image pixels, said mapping device mapping said analog pixels in said frame buffer to said expanded array of analog pixels by mapping said analog pixels to virtual pixels in a virtual frame buffer as intermediate values and having an associated virtual image space substantially similar to the image space of said expanded array of analog pixels such that less than the total number of said virtual pixels corresponding to said binary image pixels are generated and stored at a given time in said virtual frame buffer, said mapping device having a spatial filter for filtering said intermediate mapped pixels in said virtual frame buffer to provide filtered virtual pixels which form said expanded array of analog pixels, said mapping device operable to map said expanded array of analog pixels to said binary image space; and

a FAX transmission device for transmitting said binary image pixels in said binary image space via a Group III FAX protocol over a FAX transmission medium.

2. The converter of claim 1 and further comprising a contrast enhancement device for adjusting the digital values in said frame buffer for optimal contrast in said binary image space.

3. The converter of claim 1, wherein only the ones of said analog pixels in said frame buffer associated with a predetermined number of the sequential lines of video information are mapped into said virtual frame buffer at said given time.

4. The converter of claim 1, wherein said virtual frame buffer is comprised of an intermediate virtual frame buffer having intermediate virtual pixels each corresponding to said virtual pixels and an output virtual frame buffer having output virtual pixels each corresponding to said virtual pixels, and said mapping device comprises:

an intermediate mapping device for mapping the values of said analog pixels stored in said in said frame buffer to corresponding ones of said intermediate virtual pixels in said intermediate virtual frame buffer in the aspect ratio of said binary image space;

a binary image mapping device for mapping said intermediate virtual pixels in said intermediate virtual frame buffer to said output virtual pixels in said output virtual frame buffer; and

a contrast enhancement device for adjusting the values of said intermediate virtual pixels in said intermediate virtual frame buffer prior to mapping into said output virtual frame buffer for optimal contrast in said binary image space.

5. The converter of claim 4, wherein said contrast enhancement device comprises:

a histogram device for generating a histogram of the contents of said intermediate virtual frame buffer for all of said virtual pixels associated therewith; and

an adjustment device for calculating an adjusting factor for each pixel in said intermediate virtual frame buffer in said histogram as a function said generated histogram, and adjusting the value of each of said virtual pixels in said intermediate frame buffer by said associated adjustment factor prior to mapping thereof to said output virtual frame buffer.

6. The converter of claim 5, and further comprising a gamma correction device having a plurality of gamma correction factors stored in a lookup table and operable to correct the values of each of said intermediate virtual pixels in said immediate virtual frame buffer by said associated gamma correction factors stored in said lookup table prior to mapping said intermediate virtual pixels into said output virtual frame buffer by said output mapping device.

7. The converter of claim 5, wherein said binary mapping device comprises means for converting the value of each of said output virtual pixels to a two-state value prior to mapping thereof into said binary image space, one state representing a dark area in said binary image space and one state representing a white image in said binary image space.

8. The converter of claim 7, and further comprising:

an image dithering device for comparing the value of each of said intermediate virtual pixels in said intermediate virtual frame buffer after adjusting the value thereof by said contrast enhancement device to a predetermined threshold and calculating an error relative to said predetermined threshold, said image dithering device operable to diffuse said calculated error across neighboring pixels to said each pixel prior to mapping to said output virtual frame buffer; and

a binary decision device for comparing said error diffused values of said output virtual pixels from said output virtual frame buffer after contrast enhancement thereof such that one binary state is generated when said error diffused values exceed said threshold, and the other of said binary image states is generated when said error diffused values is less than said predetermined threshold.

9. The converter of claim 4, wherein said mapping device is operable to map only the ones of said pixels stored in said frame buffer required to generate a single line in said binary image space.

10. A method for converting a video formatted signal into a Group III FAX formatted signal for transmission as a Group III FAX, comprising the steps of:

receiving a video input signal having sequential fines of video information;

converting with a first conversion device the lines of video information to an array of analog pixels in a frame buffer, each of the analog pixels having a digital value that represents an analog sampled value within an associated one of the lines of video information,

mapping the array of analog pixels in the frame buffer to a binary image space associated with a Group III FAX format as binary image pixels, the binary image space comprises a larger number of binary image pixels than the analog pixels stored in the frame buffer, and wherein the step of mapping is operable to expand each of the analog pixels stored in the frame buffer to provide an expanded array of analog pixels having an aspect ratio corresponding to the aspect ratio of the binary image the step of mapping the analog pixels in the frame buffer to the expanded array of analog pixels mapping the analog pixels to virtual pixels in a virtual frame buffer as intermediate values and having an associated virtual image space substantially similar to the image space of the expanded array of analog pixels such that less than the total number of the virtual pixels corresponding to the binary image pixels are generated and stored at a given time in the virtual frame buffer, the step of mapping filtering the intermediate mapped pixels in said virtual frame buffer with a spatial filter to provide filtered virtual pixels which form the expanded array of analog pixels, the step of mapping operable to map the expanded array of analog pixels to the binary image space; and

transmitting the binary image pixels in the binary image space via a Group III FAX protocol over a FAX transmission medium.

11. The method of claim 10, and further comprising the step of adjusting the digital values in the frame buffer for optimal contrast in the binary image space.

12. The method of claim 10, wherein only the ones of the analog pixels in the frame buffer associated with a predetermined number of the sequential lines of video information are mapped into the virtual frame buffer via the step of mapping at the given time.

13. The method of claim 10, and further comprising providing an intermediate virtual frame buffer having intermediate virtual pixels, each corresponding to the virtual pixels and providing an output virtual frame buffer having output virtual frame pixels, each corresponding to the virtual pixels, and wherein the step of mapping comprises:

mapping in an intermediate mapping step the values of the analog pixels stored in the frame buffer to corresponding ones of the intermediate virtual pixels in the intermediate virtual frame buffer in the aspect ratio of the binary image space;

mapping in a binary image mapping step the intermediate virtual pixels in the intermediate virtual frame buffer to the output virtual pixels in the output virtual frame buffer; and

ajusting the values of the intermediate virtual pixels in the intermediate virtual frame buffer prior to mapping into the output virtual frame buffer for optimal contrast in the binary image phase.

14. The method of claim 13, wherein the step of adjusting the values of intermediate virtual pixels comprises the state of:

generating a histogram of the contents of the intermediate virtual frame buffer from all the virtual pixels associated therewith; and

calculating an adjusting factor for each pixel in the intermediate virtual frame buffer in the histogram as a function of the generated histogram, and adjusting the value of the virtual pixels in the intermediate frame buffer by the associated adjusting factor prior to mapping thereof to the output virtual frame buffer.

15. The method of claim 14, and further comprising the step of storing a plurality of gamma correction values in a lookup table and correcting the values of each of the intermediate virtual pixels in the intermediate virtual frame buffer by the associated gamma correction factors stored in the lookup table prior to the step of mapping the intermediate virtual pixels into the output virtual frame buffer.

16. The method of claim 14, wherein the step of mapping comprises the step of converting the value of each of the output virtual pixels to a two-state value prior to mapping thereof into the binary image space, one state representing a dark area in the binary image space and one state representing a white image in the binary image space.

17. The method of claim 16, and further comprising the steps of:

comparing in an image dithering device the value of each of the intermediate virtual pixels in the intermediate virtual frame buffer after the step of adjusting the value thereof to a predetermined threshold;

calculating an error relative to the predetermined threshold;

diffusing the calculated error across neighboring pixels to each pixel prior to mapping to the output virtual frame buffer; and

comparing the error diffused values of the output virtual pixels from the output virtual frame buffer after the step of adjusting the values thereof by the adjusting factor such that one binary state is generated when the error diffused values exceed the threshold and the other of the binary image states is generated when the error diffused view is less than the predetermined threshold.

18. The method of claim 13, wherein the step of mapping is operable to map only the ones of the pixels stored in the frame buffer required to generate a single line in the binary image space.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,546,194
DATED : August 13, 1996
INVENTOR(S) : Ross

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2, line 19, delete "convening", and insert therefor --converting--;

Column 6, line 39, delete "SLIM", and insert therefor --SUM--;

Column 7, line 37, delete ""fight diffuse""; and insert therefor --"right diffuse"--;

Column 8, line 21, delete "28", and insert therefor --128--;

Signed and Sealed this
Eighth Day of July, 1997

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

[redacted]

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,546,194

DATED : August 13, 1996

INVENTOR(S) : Ross

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2, line 19, delete “convening”, and insert therefor --converting--;

Column 6, line 39, delete “SLIM”, and insert therefor --SUM--;

Column 7, line 37, delete ““fight diffuse””; and insert therefor --“right diffuse”--;

Column 8, line 21, delete “28”, and insert therefor --128--;

Signed and Sealed this

Eighth Day of July, 1997

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

US005550646A

United States Patent [19]

Hassan et al.

[11] **Patent Number: 5,550,646**

[45] **Date of Patent: Aug. 27, 1996**

[54] **IMAGE COMMUNICATION SYSTEM AND METHOD**

[75] Inventors: **Ahmad M. Hassan**, Madison; **Russel R. Johnston**, Bedminster; **John C. Krejci**, Sparta, all of N.J.

[73] Assignee: **Lucent Technologies Inc.**, Murray Hill, N.J.

[21] Appl. No.: **120,254**

[22] Filed: **Sep. 13, 1993**

[51] **Int. Cl.**^{6} **H04N 1/32**

[52] **U.S. Cl.** 358/442; 358/400; 379/100; 348/18

[58] **Field of Search** 358/400, 440, 358/468, 442, 909.1, 456, 457; 379/96–98, 100; 348/14, 17, 18; 370/94.1, 94.2, 95.1; H04N 1/00, 1/32

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,953,668	4/1976	Judice	348/910
4,587,633	5/1986	Wang et al.	379/96
4,614,977	9/1986	Kawasaki et al.	358/260
4,646,160	2/1987	Iizuka et al.	358/402
4,811,239	3/1989	Tsao et al.	364/519
4,827,085	5/1989	Yaniv et al.	178/18
5,020,096	5/1991	Sakakibara et al.	379/96
5,036,390	7/1991	Masunaga	348/14
5,086,455	2/1992	Satomi et al.	379/100
5,136,628	8/1992	Araki et al.	348/18
5,182,635	1/1993	Nakashima et al.	348/17
5,237,429	8/1993	Zuiss et al.	379/100
5,263,025	11/1993	Torri et al. .	

OTHER PUBLICATIONS

Table of Contents—Electronic Imaging 88—International Electronic Imaging Exposition & Conference, Oct. 1988.

H. Farhangi et al. "A Microprocessor-Based Still Frame Capturing System" Displays, Oct. 1982, pp. 212–217.

A. Mathur et al. "Image Management Software for Decompressions, Scaling and Display of Digitized Images", Electronic Imaging 88—International Electronic Imaging Exposition & Conference, Oct. 1988. pp. 1208–1213.

M. Rabbani et al. "An Optimized Image Data Compression Technique Utilized in the Kodak SV9600 Still Video Transceiver", Proceedings of the SPIE—The International Society for Optical Engineering, vol. 1071, 1989, pp. 246–256.

L. P. Glidewell "Filmless Camera Technology Boosts Image Transmission", Defense Electronics, Jun. 1989, pp. 105–112.

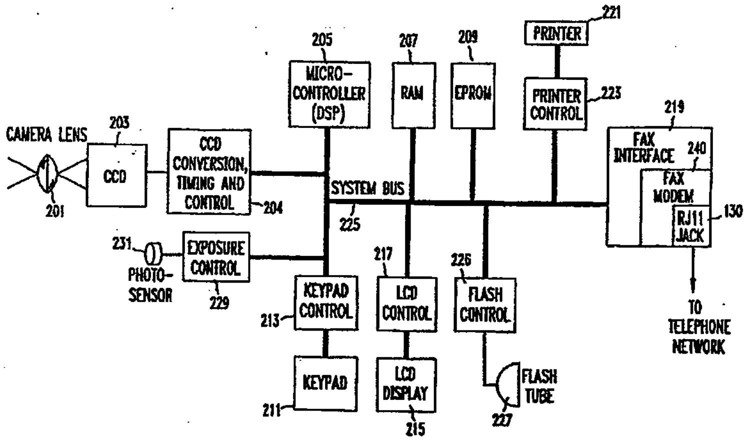
Primary Examiner—Kim Yen Vu

Attorney, Agent, or Firm—Barry H. Freedman; Mark K. Young

[57] **ABSTRACT**

An image communication system and method includes an image capture device which utilizes CCD technology to "take a picture", i.e., to capture an image, and then to generate a digital representation of that image which may be applied to a fax modem and then transmitted to a remote facsimile machine via a telephone communication link. The digital image is processed, such as by dithering, to enhance its presentability, so that shades of gray present in a conventional black and white photograph are converted to a pattern of black and white dots which retains the character of the original image in spite of subsequent facsimile transmission. The image capture device may include a printer and a memory for storing multiple images as well as the destination numbers of facsimile machines which are intended to receive copies of the images.

7 Claims, 4 Drawing Sheets



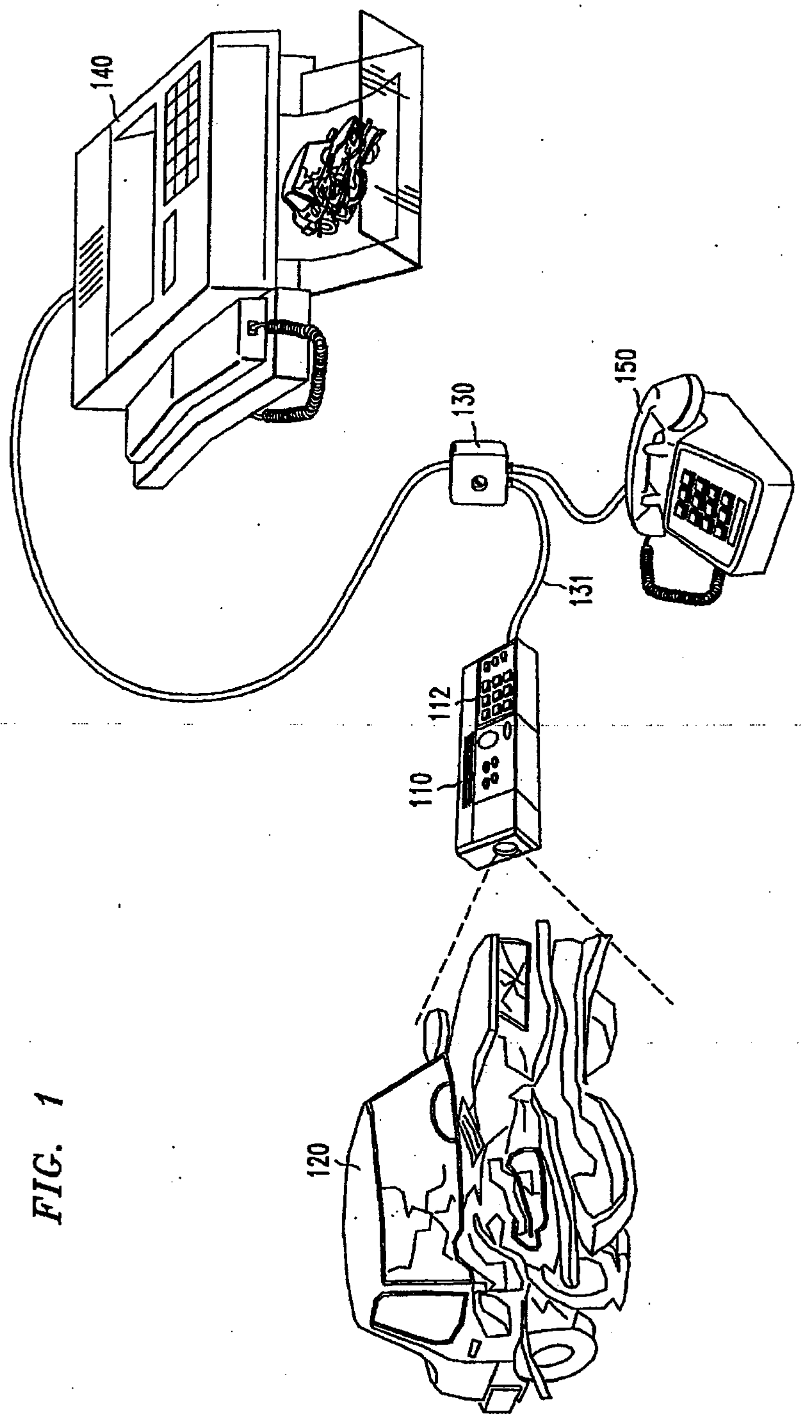


FIG. 1

FIG. 2

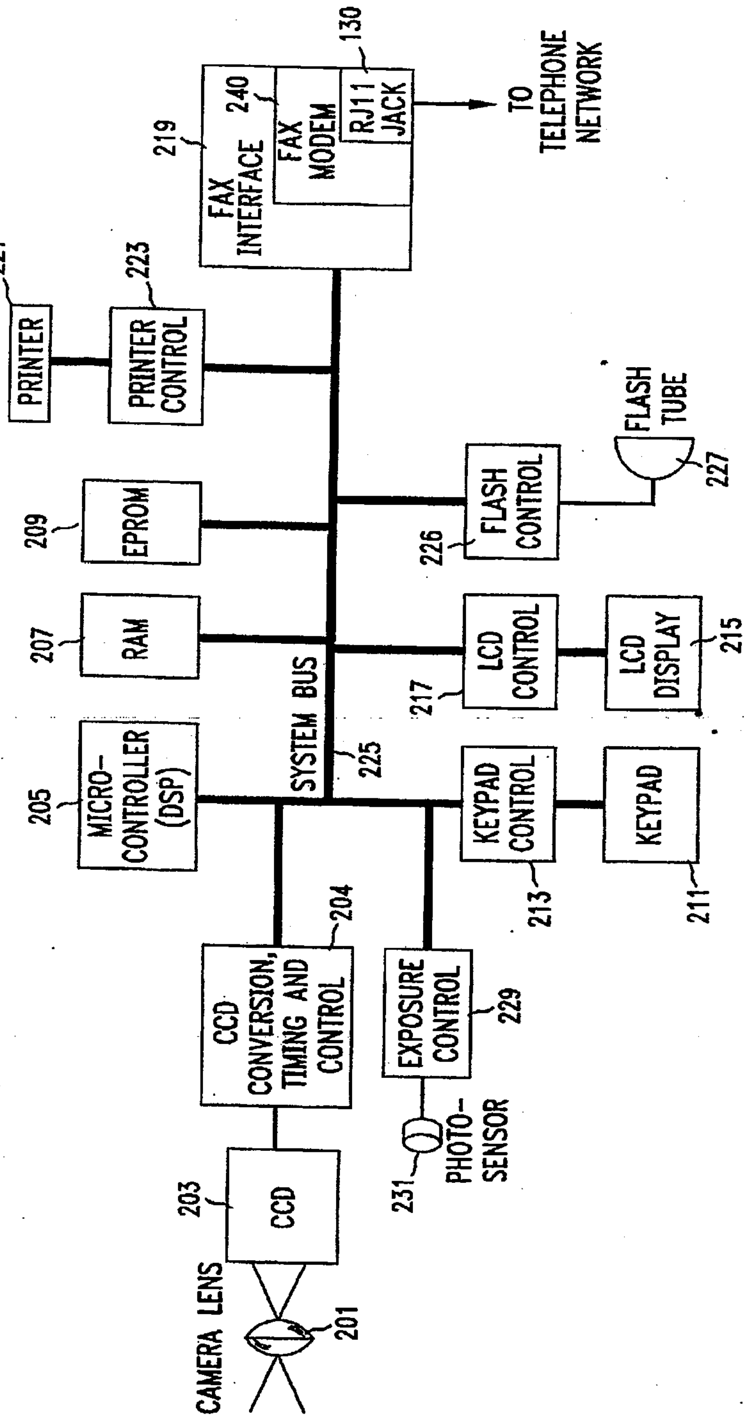

CAMERA LENS
201
203
CCD
CCD CONVERSION, TIMING AND CONTROL
204
EXPOSURE CONTROL
229
231
PHOTO-SENSOR
205
MICRO-CONTROLLER (DSP)
SYSTEM BUS
225
KEYPAD CONTROL
213
KEYPAD
211
207
RAM
LCD CONTROL
217
LCD DISPLAY
215
209
EPROM
FLASH CONTROL
226
FLASH TUBE
227
PRINTER
221
PRINTER CONTROL
223
FAX INTERFACE
219
FAX MODEM
240
RJ11 JACK
130
TO TELEPHONE NETWORK

FIG. 3

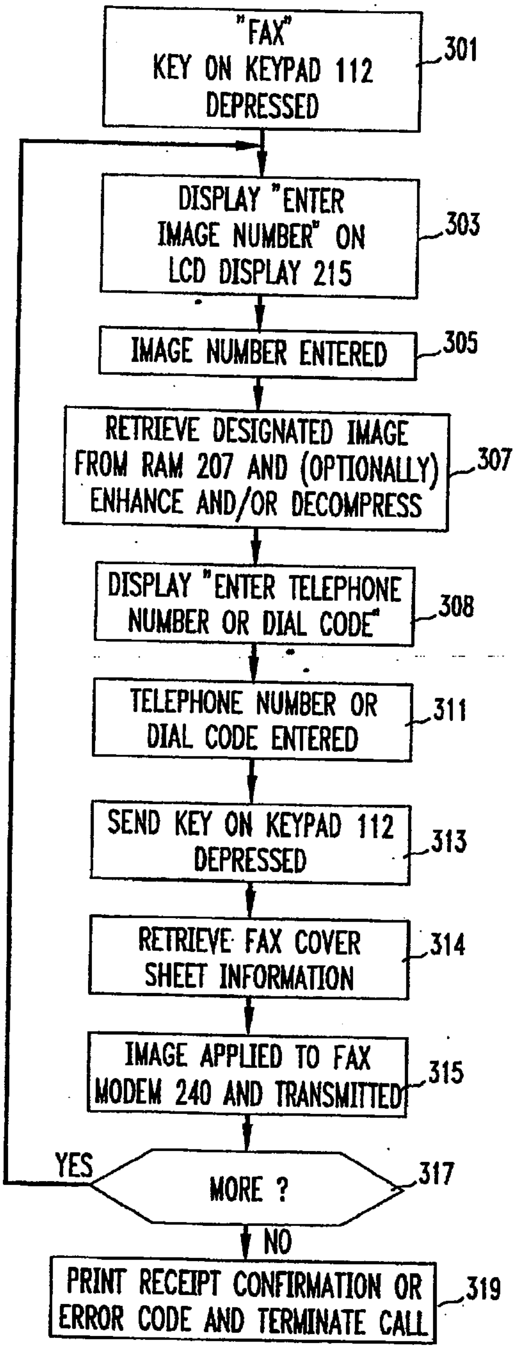

"FAX" KEY ON KEYPAD 112 DEPRESSED
301
DISPLAY "ENTER IMAGE NUMBER" ON LCD DISPLAY 215
303
IMAGE NUMBER ENTERED
305
RETRIEVE DESIGNATED IMAGE FROM RAM 207 AND (OPTIONALLY) ENHANCE AND/OR DECOMPRESS
307
DISPLAY "ENTER TELEPHONE NUMBER OR DIAL CODE"
308
TELEPHONE NUMBER OR DIAL CODE ENTERED
311
SEND KEY ON KEYPAD 112 DEPRESSED
313
RETRIEVE FAX COVER SHEET INFORMATION
314
IMAGE APPLIED TO FAX MODEM 240 AND TRANSMITTED
315
YES
MORE ?
317
NO
PRINT RECEIPT CONFIRMATION OR ERROR CODE AND TERMINATE CALL
319

FIG. 4

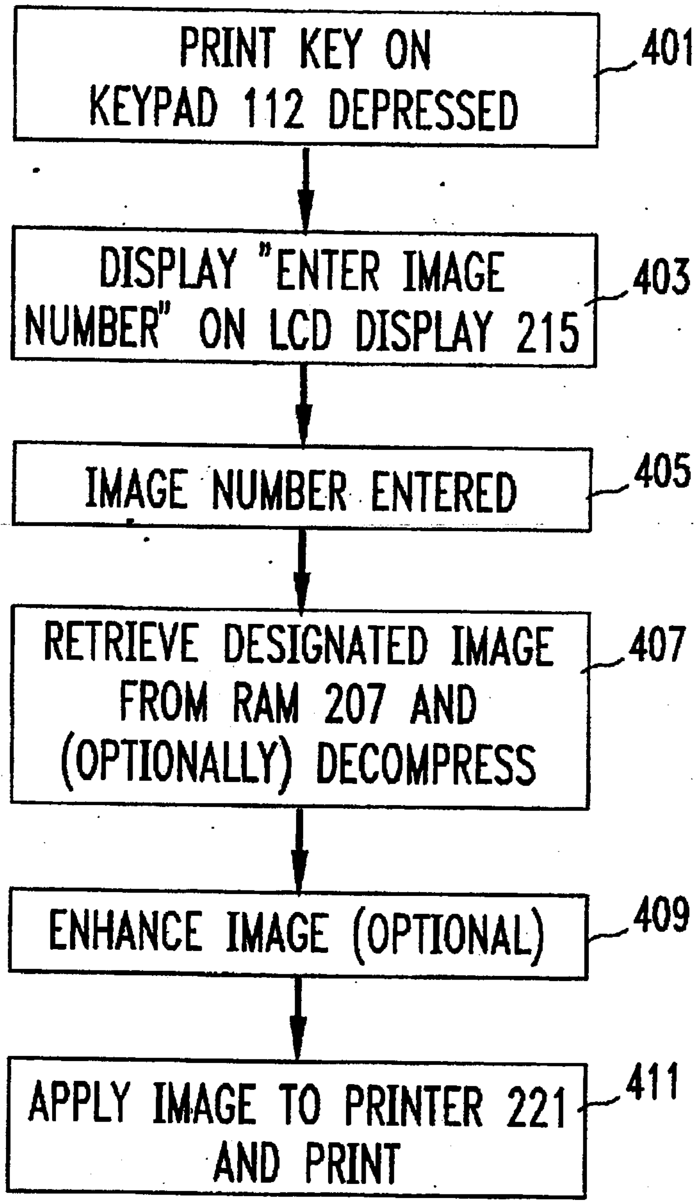

PRINT KEY ON KEYPAD 112 DEPRESSED
401
DISPLAY "ENTER IMAGE NUMBER" ON LCD DISPLAY 215
403
IMAGE NUMBER ENTERED
405
RETRIEVE DESIGNATED IMAGE FROM RAM 207 AND (OPTIONALLY) DECOMPRESS
407
ENHANCE IMAGE (OPTIONAL)
409
APPLY IMAGE TO PRINTER 221 AND PRINT
411

IMAGE COMMUNICATION SYSTEM AND METHOD

FIELD OF THE INVENTION

This invention relates generally to communication of images, and, in particular to transmission of image information to a facsimile receiver.

BACKGROUND OF THE INVENTION

Visual communications systems and techniques, in which images are captured and transmitted via the telecommunications network, have recently become increasingly significant. For example, AT&T has recently introduced its VideoPhone 2000, which attaches to ordinary telephone lines. A real time moving image of the persons using the system is transmitted, along with the verbal conversation. However, the VideoPhone and similar systems are not portable, and must be used either in a fixed location, or in any event near a location in which a connection to the telephone network is available. Also, such systems are relatively expensive.

Another entry in this market, also available from AT&T, is the Picasso still image phone, which is used in conjunction with a conventional video camera and a television receiver. At the transmitting end, a still image from the video camera is captured in the Picasso phone, and then transmitted to the remote Picasso phone, where it is stored and then displayed on a television receiver. This arrangement too is neither portable nor inexpensive.

Yet other image capture and display products are called digital cameras or instant electronic cameras, such as are described in U.S. Pat. No. 4,074,324 issued to J. S. Barrett on Feb. 14, 1978. Commercially available digital cameras include the Model 3 available from DYCAM and the Fotoman Plus available from Logitech. With a digital camera, an image is scanned by an internal charge coupled device (CCD), digitized and stored inside the camera. A personal computer is then needed to view, manipulate and store the image. These digital cameras are designed as computer peripherals, specifically, as input devices for computer based applications. No provision is made in digital cameras for remote display of the images.

SUMMARY OF THE INVENTION

In accordance with our invention, an image communication system and method includes an image capture device which utilizes CCD technology to "take a picture", i.e., to capture an image, and then to generate a digital representation of that image that can be transmitted via a telephone communication link to a remote facsimile machine. The digital image is advantageously processed to enhance its presentability, and stored. The enhancement of the digital image essentially converts the shades of gray present in a conventional black and white photograph to a pattern of black and white dots (sometimes called picture elements or pels) which retains the character of the original image in spite of subsubsequent facsimile transmission and possible photocoping that may thereafter occur. This assures that the image can be displayed on an output device, such as a facsimile machine that is capable of producing only an essentially black and white bit mapped image. The image capture device may include a miniature printer, but is nevertheless compact and lightweight, so that the device can be easily transported to a location at which a connection to the telephone network is available.

In one embodiment, the image capture device is arranged so that it may be connected directly to a standard telephone line, for example, by using a conventional RJ11 jack and plug. Alternatively, the image capture device may be connected to or include a built in cellular telephone. In either event, the user may establish the communications connection to a remote facsimile machine by entering the destination number(s) of one or more facsimile machines which are intended to receive copies of the image into a keypad, or retreiving the destination number from a memory in the image capture device. The stored image is then applied to a fax modem disposed within the image capture device, which converts the stored information to an appropriate format, and then dials the number of the remote facsimile machine to establish the required communications connection(s) for transmission of the facsimile image.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will be more fully appreciated by consideration of the following detailed description, which should be read in light of the accompanying drawing in which:

FIG. 1 is a schematic diagram illustrating an image capture device arranged in accordance with the present invention, and its use in a system to enable communication of a captured image to a remote facsimile machine;

FIG. 2 is a block diagram of image capture device 110 of FIG. 1;

FIG. 3 is a flow diagram illustrating the steps performed by the system of FIG. 1 when a captured image is to be transmitted to a remote facsimile machine; and

FIG. 4 is a flow diagram illustrating the steps performed by the system of FIG. 1 when a captured image is to be printed locally.

DETAILED DESCRIPTION

Referring first to FIG. 1, there is shown a schematic diagram illustrating an image capture device arranged in accordance with the present invention, and its use in a system to enable communication of a captured image to a remote facsimile machine. The image capture device is designated generally as 110, and in appearance resembles a small, portable, hand held camera. Image capture device 110 is arranged, as described in more detail below, to "take a picture", such as a picture of damaged automobile 120, and to store a digital representation (image) of the picture in an internal memory. The image remains in the memory until the image capture device can be connected or gain access to a telecommunications network, such as by being connected to an ordinary telephone jack 130 by a telephone line 131, or being connected to a cellular telephone arranged to establish an over the air communications link. A communications connection can then be established between image capture device 110 and a remote facsimile machine 140, such as by keying the number of facsimile machine 140 on a keypad 112 built into image capture device 110. Alternatively, as shown in FIG. 1, dialing may be accomplished using telephone 150 which is connected to the same jack 130 and bridged on the telephone line. When the connection is made, a "send" button on the image capture device is activated, causing the stored digital representation to be applied to a fax modem in the device. The image, in this case, of the damaged automobile, is thus transmitted to and displayed on the remote facsimile machine. Advantageously, the image capture device also includes a printing capability, such as may be provided by a miniature thermal printer, so that a hard copy of a stored image may be generated and reviewed. This is helpful in previewing the image that is to be transmitted to a remote facsimile machine.

Dialing can be accomplished in an alternative arrangement, such as by first storing a sequence of digits representing the dialed number in a memory within the image capture device, and by thereafter reading out and applying the digits to a dialing circuit at the time the connection is established.

The advantages of the present invention are that the image capture device is small, portable and inexpensive. It can be connected to the telephone network anywhere an ordinary telephone jack is available, or, if provided with a cellular telephone capability or connection, anywhere cellular service is available, and a picture stored in the camera can be transmitted to any conventional facsimile machine in near real time. The invention thus would be of great value to architects, landscapers, designers, artists, engineers, insurance adjusters, auto repairmen, teachers, doctors, advertising agencies, marketing departments, etc.

Referring now to FIG. 2, there is shown a block diagram of image capture device **110** of FIG. 1. A picture is taken by the device by focusing light collected by a lens assembly **201** on a charge coupled device (CCD) **203**, which has an associated control element **204** that operates in response to commands issued by a microcontroller **205** and communicated to CCD **203** via a system bus **225**. Microcontroller **205** may be implemented in a digital signal processor (DSP) chip, such as the 3210 chip available from AT&T, which preferably includes an internal clock function. The combination of lens assembly **201**, CCD **203** and control element **204** are well known to those skilled in the art, and can be found in digital cameras such as those made by Dycam. Well known functionality in such arrangements includes automatic focusing of the image provided by lens assembly **201**. As an alternative to automatic focusing, and to save cost, lens assembly **201** may be arranged with a large focal depth. Automatic aperture/exposure control may be provided using photo sensor **231**, which is arranged to measure the lighting conditions relative to the image being captured, and provide a signal to exposure control circuit **229** which is connected to system bus **225**. In cases where the ambient lighting conditions are inadequate, a signal may be sent to flash control circuit **226** to actuate a built-in flash tube **227**. In addition, automatic color balance and other camera features may be provided.

The image output from CCD **203** is processed in microcontroller **205** to enhance presentability, illustratively by dithering, and then stored, in compressed digital form, in a random access memory (RAM) **207**. Compression may be achieved using any well known compression/archiving algorithm, which is later reversed by corresponding decompression when the image is later printed or transmitted to a remote facsimile machine. The purpose of the dithering (or other enhancement) is to enable the picture to be displayed on a facsimile machine that is essentially limited to displaying black and white bit mapped pictures, rather than grey scale images. This can be explained as follows: The image captured by CCD **203** is generally about 640 by about 480 pixels, each having 16 possible grey levels. This image may be dithered to around 1500 by 1000 black and white pixels, such that each original pixel is represented by a two by two block of pixels, which may have sixteen different black and white patterns. If the dithered image is transmitted to a fax machine which reproduces 200 pixels (dots) per inch, an image of approximately 7.5 inches by 5 inches can be produced, when displayed sideways on a page.

Keypad **211** is provided in image capture device so that a user can input commands and other information into the device, and the commands can be passed to microcontroller **205** via a keypad control circuit **213** and system bus **225**. Advantageously, keypad **211** and keypad control circuit **213** are arranged to implement a command set that includes various commands that initiate the taking of a picture (i.e., shutter control), storing a picture in memory, printing a picture, deleting a picture from memory, and initiation of transmission of one or more pictures to a remote facsimile machine. The information that can be input via keypad **211** includes the telephone numbers of one or more facsimile machines with which the device can communicate, and other operating instructions and parameters associated with facsimiles, such as a designation of the point of origination, the resolution of the display, and so on. The keypad can be fabricated from a well known rubber mat disposed on PCB switches.

LCD display **215**, and its associated LCD control circuit **217**, are included in the image capture device to provide the user with a visual indication of the operating modes and status of the device. Specific alphanumerics shown on LCD display **215** are determined by signals generated by microcontroller **205**. Typical information that may be displayed include the image number of the image being captured, which corresponds to the "film counter" function of a conventional camera, the current time and date, the number of images already stored (and the date and time they were stored), the image number of the image being recalled from RAM **207** and transmitted to a remote facsimile machine, and so on.

RAM **207**, which is used for storing images captured by the image capture device, should have a capacity of approximately 4 MBytes, so that approximately 20 images can be stored. 4 MBytes will be sufficient, since each image requires approximately 640×480 / 2=153600 bytes. Advantageously, the image capture device is arranged so that the date and time an image is captured in taken from an internal clock in microcontroller **205** and stored together with the image itself. This enables convenient image retrieval, for example, based upon the sequence in which images were captured.

An EPROM **209** is used to store programs used in microcontroller **205**, that control the overall operation of the image capture device, and specific functions performed. Specifically, EPROM **209** may store dithering and/or compression algorithms used to process and/or compress the digital image prior to storage in RAM **207**. Also, EPROM **209** controls the "prompts" that may be displayed on LCD display **215** when various functions are activated. For example, when an image is captured, the user of the system may be prompted to enter a supplemental ID number or other text information by displaying a legend on LCD display **215** that reads "enter ID on keypad". This supplemental ID or relevant notes would be entered by a user via alphanumeric keypad **211**, and stored with the digital image in RAM **207**. The supplemental ID or notes could later be recalled and displayed on LCD display **215**, so that a user could be reminded of important facts (such as client name, file number, etc.) associated with a particular digital image. In a similar fashion, a camera identification number may be entered to identify the camera when a fax is sent or image printed. EPROM **209** may be implemented using commercially available CMOS devices.

A facsimile interface **219** is provided in the image capture device in order to prepare an enhanced digital image for transmission to a remote facsimile machine. Facsimile interface 219 includes a fax modem 240 and associated control electronics, which may be arranged to send the bit map image using standard FAX protocol, Group 3, with normal FAX transmission hand shaking. The output of fax modem 240 is applied to the telephone network via a physical connection through jack 130, which, as stated previously, may be a conventional RJ11jack. Alternatively, the output of fax modem 240 may be applied as an input to the transmitter section of a cellular telephone.

Local printing is accomplished in the image capture device by a printer 221 which, as stated previously, may be a miniature thermal printer, a dot matrix printer, or another type of printing device. Printer 221 may also print and output messages indicating the status of facsimile transmissions, such as confirmation that a message was successfully received, or error messages. The microcontroller 205 may provide suitable conversion between the digital image format used when images are applied to system bus 225 after being retrieved from RAM 207, the format of text messages, and the format used in printer 221. The associated printer control circuit 223 provides line feed and other basic mechanism control functionalities over printer 221.

Power for the elements of image capture device 110 is provided from a battery, preferably rechargeable, which is not shown in FIG. 2.

Referring now to FIG. 3, there is shown a flow diagram illustrating the steps performed by the system of FIG. 1 when a captured image is to be transmitted to a remote facsimile machine. The process is initiated in step 301, when a user depresses a "FAX" key, being a designated command represented by one of the keys (or a combination of keys) on keypad 211. The fax transmission command is recognized in microcontroller 205, and the fax transmission "program" is retrieved from EPROM 209. In step 303, information is supplied to LCD control circuit 217, generating a display on LCD display 215 requesting the user to "ENTER IMAGE NUMBER", i.e., the identification of a particular image stored in RAM 207. When a particular stored image is identified by one or more entries on keypad 211 in step 305, the designated image is retrieved from RAM 207 and converted by microcontroller 205, in step 307, illustratively from compressed storage format to group III fax format, as described above. At this time, the image may be processed to enhance its presentability, such as by dithering, if dithering was not performed previously when the image was captured and stored.

Next, in step 309, the user is prompted for the telephone number of the remote facsimile machine, by display of a suitable legend on LCD display 215. The telephone number may be manually entered in step 311, by use of keypad 211. Alternatively, a particular prestored telephone number may be indicated by entry of an associated dial code in step 311. In the latter event, microcontroller 205 would be arranged to retrieve the associated number from RAM 207 in response to receipt of the code. Once the number is entered, a "SEND" key on keypad 211 is actuated in step 313, causing a facsimile cover sheet to be retrieved in step 314 and both the cover sheet and the stored image to be applied to fax modem 240 in facsimile interface 219, in step 315. Modem 240 converts the image to standard facsimile format, and applies the output signal, including conventional modem control signals, to the communications channel, such as telephone line 131 via jack 130, which serves as the physical interface.

Note here that the fax cover sheet retrieved in step 314 can be automatically generated in accordance with our invention by storing certain information for the cover sheet in RAM 207. The stored information is then augmented by the current date and time obtained from the clock in microcontroller 205, as well as the stored date and time (indicating when the image was captured) and supplemental ID number associated with the digital image being transmitted, if previously provided by the user. A camera identification number, which is provided by the user and stored in RAM 207, may also be included in the cover sheet.

After transmission of a stored image is complete, the user is prompted in step 317 to determine if other images are to be transmitted. If a positive response is entered via keypad 112, the process of FIG. 3 is repeated, beginning with step 303. If a negative response is entered, of if no response in entered within a predetermined time period, the process is completed in step 319, wherein information indicating confirmation of receipt of the facsimile is received in fax modem 240 from the remote fax machine, or if an error condition is reported, that information is received. Such information may be stored temporarily in RAM 207, and then printed on printer 221 in step 319.

FIG. 4 is a flow diagram illustrating the steps performed by the system of FIG. 1 when a captured image is to be printed locally. The beginning portion of the process, which is similar to the beginning portion of the process of FIG. 3, is initiated in step 401, when a user depresses a "PRINT" key, being a designated command represented by one of the keys (or a combination of keys) on keypad 112. The print command is recognized in microcontroller 205, and the print "program" is retrieved from EPROM 209. In step 403, information is supplied to LCD control circuit 217, generating a display on LCD display 215 requesting the user to "ENTER IMAGE NUMBER", i.e., the identification of a particular image stored in RAM 207. When a particular stored image is identified by one or more entries on keypad 211 in step 405, the designated image is retrieved from RAM 207 and converted by microcontroller 205, in step 407, from compressed storage format to appropriate printer format, illustratively bit mapped graphics. At this time, the image may be processed in step 409 to enhance its presentability. Finally, in step 411, the image is applied to printer control circuit 223 and printer 221 for local printing.

Various changes and modifications may be made in the invention by those of ordinary skill in the art. Thus, it is intended that the invention be limited only by the appended claims. For example, the use of compression in the storage of an image in RAM 207 and the later decompression before printing or transmission to a remote facsimile machine, is entirely optional, and compression can be dispensed with in order to save either processing time or cost. In addition, dithering (or other image processing) can be performed at the time that the image is retrieved for printing or transmission, rather than at the time that the image is stored in RAM 207. This alternate arrangement would be used when time delay in retrieval is not an important factor, since, in this arrangement, images could be captured and stored in RAM 207 more quickly. As a yet further alternative, the image capture device can include additional "temporary" memory, to facilitate the capture of several images in a short time period. Each captured image is stored in the temporary memory in real time, and, at a later time, dithered (and optionally compressed) and stored in RAM 207. Note also that while black and white facsimiles have been described above, the present invention could easily be extended to color facsimile processing. In such implementations, the conversion of a color image captured by the image capture device to a representation of the image that could be transmitted to a color facsimile would be arranged to comply with established standards and protocols.

We claim:

1. An image communication system comprising

a portable image capture device including means arranged to generate digital representations of images;

means for processing said digital representations so that shades of gray present in said images are converted to patterns of black and white dots;

memory means for storing destination numbers of facsimile machines which are intended to receive copies of said images;

a Group III compatible fax modem; and means for supplying one of said stored destination numbers and one of said processed digital representations to said fax modem, so that said image may be transmitted to a remote Group III compatible facsimile machine.

2. The invention defined in claim 1 wherein said image communication system further includes a printer arranged to print a copy of said processed digital representations.

3. The invention defined in claim 1 wherein said memory means is arranged to store multiple images.

4. The invention of claim 1 wherein said portable image capture device includes a CCD camera.

5. An image communication method comprising the steps of

generating a digital representation of an image in a portable image capture device;

processing said digital representation so that shades of gray present in said image are converted to a pattern of black and white dots;

storing said digital representation as well as destination numbers of Group III compatible facsimile machines which are intended to receive copies of said images in a memory in said portable device; and

supplying one of said stored destination numbers and one of said processed digital representations to a Group III compatible fax modem in said portable device, so that said image may be transmitted from said portable device to one or more remotely located ones of said facsimile machines.

6. The method defined in claim 5 wherein said method further includes the step of storing multiple images in said memory.

7. The invention of claim 5 wherein said portable image capture device includes a CCD camera.

* * * * *

United States Patent [19]

Shibata et al.

[11] **Patent Number: 5,689,300**

[45] **Date of Patent: Nov. 18, 1997**

[54] **PICTURE CODEC AND TELECONFERENCE TERMINAL EQUIPMENT**

[75] Inventors: **Yoji Shibata**, Yokosuka; **Masaaki Takizawa**, Tokyo; **Hitoshi Matsushima**, Tachikawa; **Hiroshi Yoshikawa**, Fujisawa; **Atsuo Yoshida**, Kokubunji; **Toru Ebihara**, Higashimurayama; **Jun Furuya**, Kokubunji; **Yukinobu Maruyama**, Tokyo; **Takehiko Yamada**, Chigasaki, all of Japan

[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

[21] Appl. No.: **509,591**

[22] Filed: **Jul. 31, 1995**

Related U.S. Application Data

[63] Continuation of Ser. No. 913,402, Jul. 15, 1992, and a continuation-in-part of Ser. No. 384,955, Feb. 7, 1995, which is a continuation of Ser. No. 838,348, Feb. 20, 1992, Pat. No. 5,396,269.

[30] **Foreign Application Priority Data**

Jul. 15, 1991	[JP]	Japan	3-174049
Jan. 24, 1992	[JP]	Japan	4-011196

[51] **Int. Cl.**^{6} **H04M 11/00**

[52] **U.S. Cl.** **348/15; 379/96; 379/100; 348/373; 358/400**

[58] **Field of Search** 379/93, 94, 90, 379/96–100, 201, 202, 110; 358/400, 479, 487; 361/679–683; 364/180, 189, 709.01, 709.12; 248/917–923; D18/36; D16/232, 208; 348/14–16, 373–376; 355/230, 231, 21, 39–41, 61, 64, 75

[56] **References Cited**

U.S. PATENT DOCUMENTS

D. 308,222	5/1990	Sano et al.	D18/36
D. 323,819	2/1992	Iimura	D16/232
D. 327,672	7/1992	Iimura	D16/232
D. 342,272	12/1993	Saito et al.	D16/208
3,970,792	7/1976	Benham et al.	379/53
4,054,908	10/1977	Poirier et al.	348/15
4,238,773	12/1980	Tsuboka et al.	

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

0379354	1/1990	European Pat. Off. .
A222989	1/1990	Japan .
A239790	2/1990	Japan .
2260871	1/1991	Japan .
2260882	1/1991	Japan .
3-93377	4/1991	Japan .
4156194	9/1992	Japan .

OTHER PUBLICATIONS

G.S. Bhusri, "Considerations for ISDN Planning and Implementation", IEEE Communications Magazine, Jan. 1984, vol. 22, No. 1, pp. 18–32.

Advertisement pages of the October 1986 issues of *The British Journal of Photography*.

L. van Loon, "An Experimental video telephone network", Philips Telecommunications Review, vol. 32, No. 1, pp. 11–24 Apr. 1974.

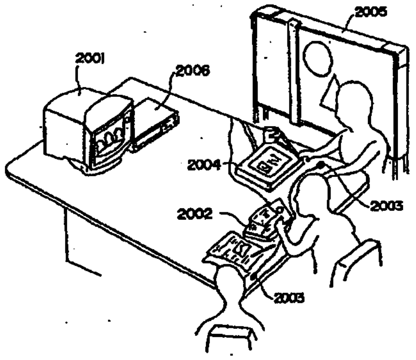
Primary Examiner—Wing F. Chan

Attorney, Agent, or Firm—Antonelli, Terry, Stout & Kraus, LLP

[57] **ABSTRACT**

In a teleconference terminal equipment; a picture codec for simultaneously displaying a still picture and video on a single screen, comprising an analog-to-digital converter which converts a picture signal into digital picture data, a picture-in-picture processor which is supplied with the digital picture data as self-picture data of the terminal equipment, a video decoder or a still picture decoder which decodes input picture data and delivers the decoded data to the P-in-P processor, and a digital-to-analog converter which is supplied with picture data for forming a P-in-P frame, having been produced from the self-picture data and the decoded data by the P-in-P processor, and which converts the supplied picture data into an analog signal and delivers the analog signal as an output.

5 Claims, 36 Drawing Sheets



U.S. PATENT DOCUMENTS

4,244,649	1/1981	Rees et al.	355/61
4,415,136	11/1983	Knoll	248/921
4,562,988	1/1986	Bumgardner	248/921
4,589,713	5/1986	Pfuhl et al.	248/921
4,645,872	2/1987	Pressman et al.	379/54
4,650,929	3/1987	Boerger et al.	379/54
4,741,025	4/1988	Maruyama et al.	379/202
4,831,455	5/1989	Ishikawa et al.	358/229
4,834,329	5/1989	Delapp	248/923
4,887,158	12/1989	Guichard et al.	348/17
4,916,550	4/1990	Miyake et al.	358/229
4,924,311	5/1990	Ohki et al.	379/53
4,953,159	8/1990	Hayden et al.	379/53
4,961,211	10/1990	Tsugane et al.	379/54
4,965,819	10/1990	Kannes	379/53
5,111,498	5/1992	Guichard et al.	348/20
5,130,817	7/1992	Iwaki	379/100
5,206,721	4/1993	Ashida et al.	379/54
5,247,330	9/1993	Ohyama et al.	348/373
5,396,269	3/1995	Gotoh et al.	348/14

FIG. 1

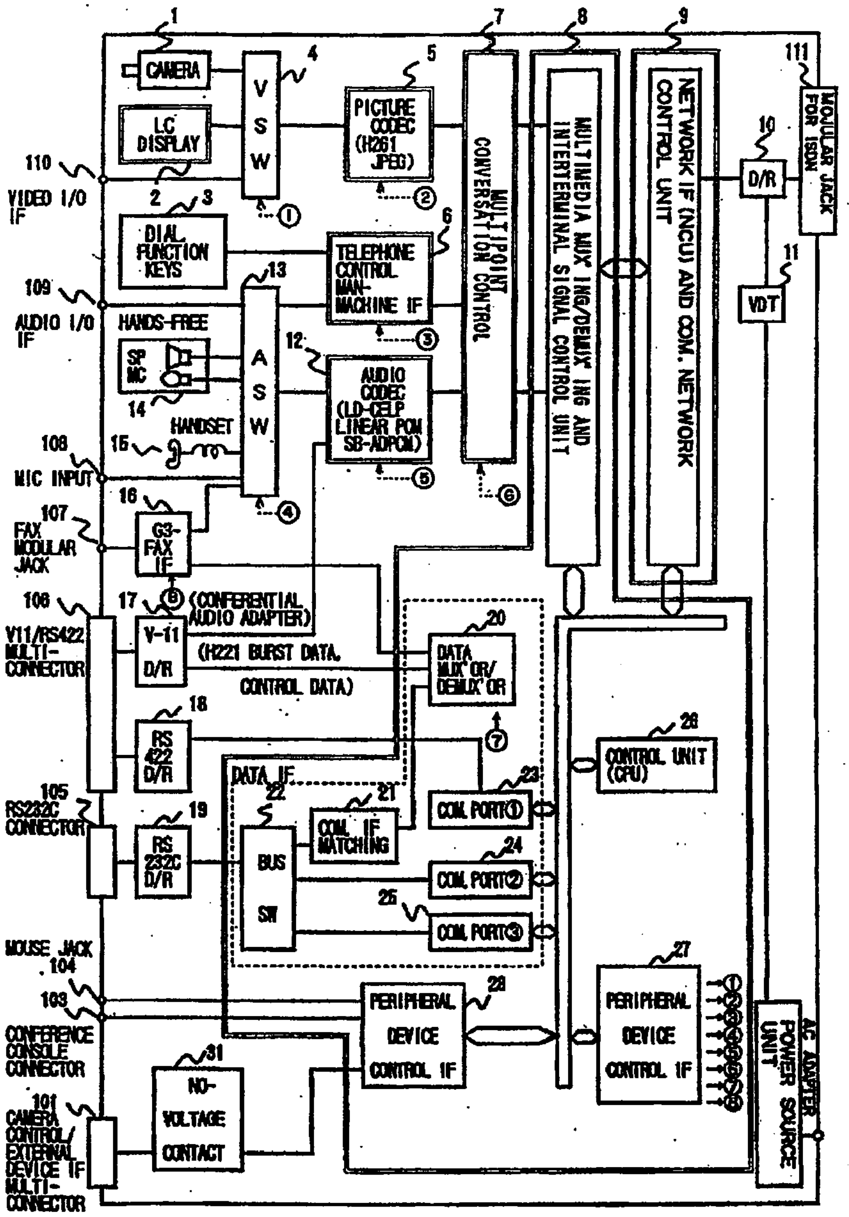
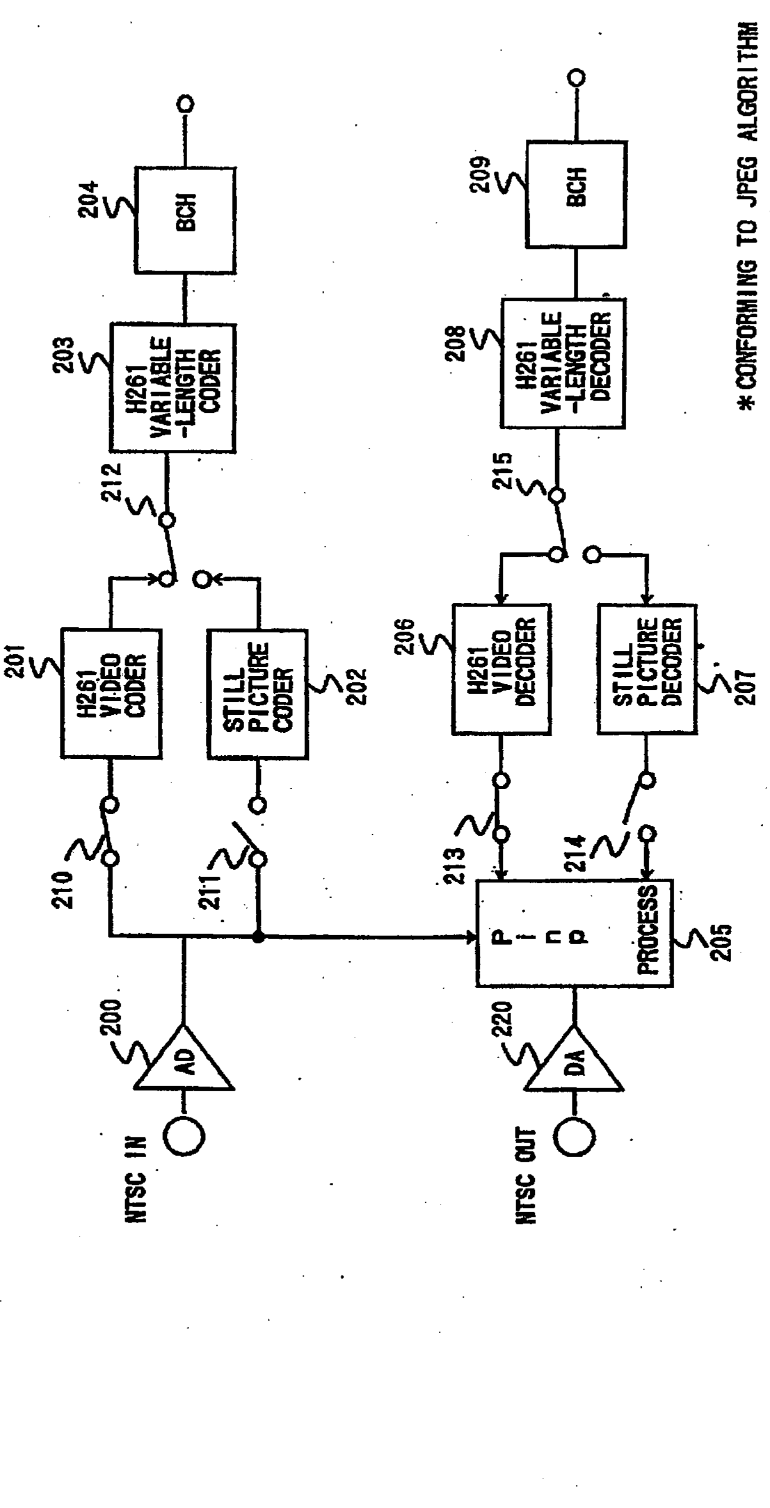

1
CAMERA
4
V
S
W
5
PICTURE CODEC (H261 JPEG)
7
MULTIPOINT CONVERSATION CONTROL
8
MULTIMEDIA MUX ING/DEMUX ING AND INTERTERMINAL SIGNAL CONTROL UNIT
9
NETWORK IF (NCU) AND COM. NETWORK CONTROL UNIT
111
MODULAR JACK FOR ISDN
10
D/R
11
VDT
LC DISPLAY
110
VIDEO I/O IF
2
3
①
②
DIAL FUNCTION KEYS
6
TELEPHONE CONTROL MAN-MACHINE IF
③
109
AUDIO I/O IF
13
HANDS-FREE
SP
MC
14
A
S
W
12
AUDIO CODEC (LD-CELP LINEAR PCM SB-ADPCM)
HANDSET
15
108
MIC INPUT
④
⑤
⑥
16
107
FAX MODULAR JACK
G3-FAX IF
⑧ (CONFERENTIAL AUDIO ADAPTER)
17
106
V11/RS422 MULTI-CONNECTOR
V-11 D/R
(H221 BURST DATA, CONTROL DATA)
20
DATA MUX'OR/ DEMUX'OR
⑦
18
RS 422 D/R
26
CONTROL UNIT (CPU)
DATA IF
22
21
23
COM. PORT①
105
RS232C CONNECTOR
19
RS 232C D/R
BUS SW
COM. IF MATCHING
24
COM. PORT②
25
COM. PORT③
MOUSE JACK
104
103
CONFERENCE CONSOLE CONNECTOR
29
PERIPHERAL DEVICE CONTROL IF
27
PERIPHERAL DEVICE CONTROL IF
①②③④⑤⑥⑦⑧
AC ADAPTER
POWER SOURCE UNIT
31
NO-VOLTAGE CONTACT
101
CAMERA CONTROL/ EXTERNAL DEVICE IF MULTI-CONNECTOR

FIG. 2



* CONFORMING TO JPEG ALGORITHM

FIG. 3

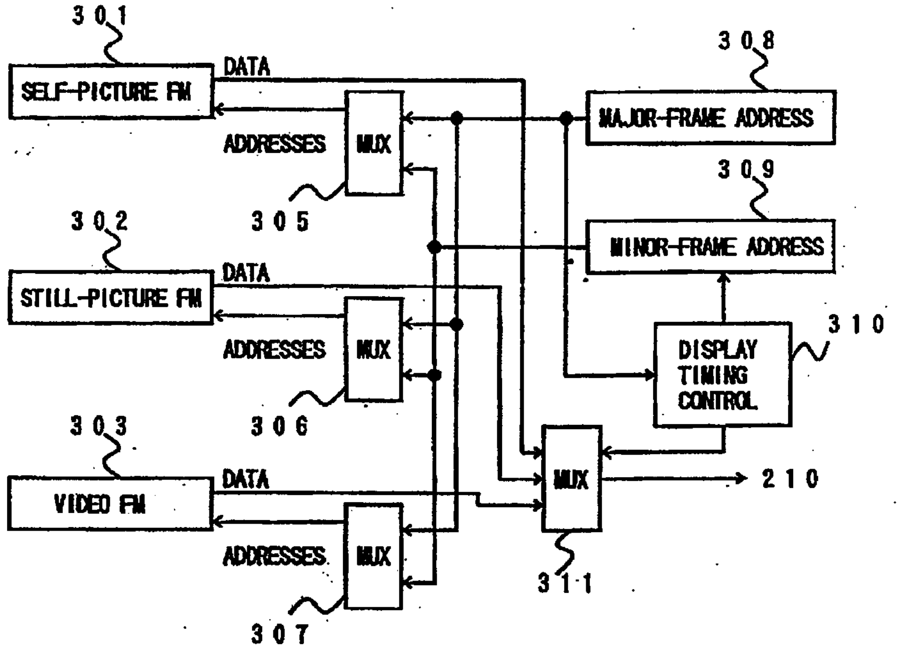

301
SELF-PICTURE FM
DATA
ADDRESSES
MUX
305
302
STILL-PICTURE FM
DATA
ADDRESSES
MUX
306
303
VIDEO FM
DATA
ADDRESSES
MUX
307
308
MAJOR-FRAME ADDRESS
309
MINOR-FRAME ADDRESS
310
DISPLAY TIMING CONTROL
MUX
311
210

FIG. 4(a)

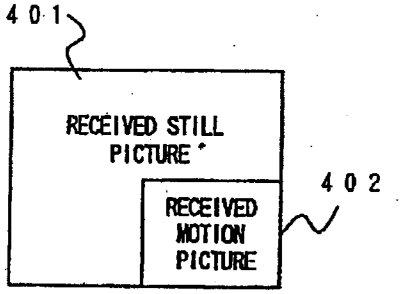


FIG. 4(b)

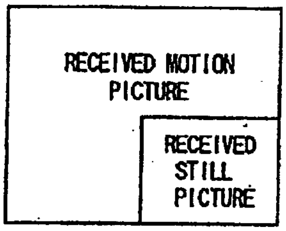


FIG. 4(c)

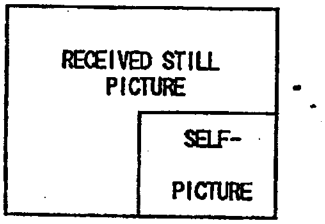


FIG. 4(d)

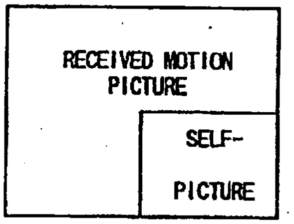


FIG. 4(e)

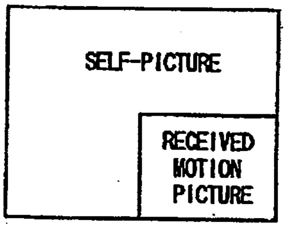


FIG. 4(f)

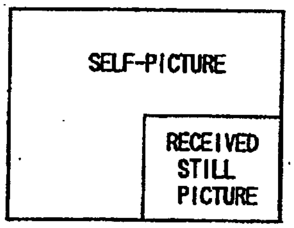


FIG. 5

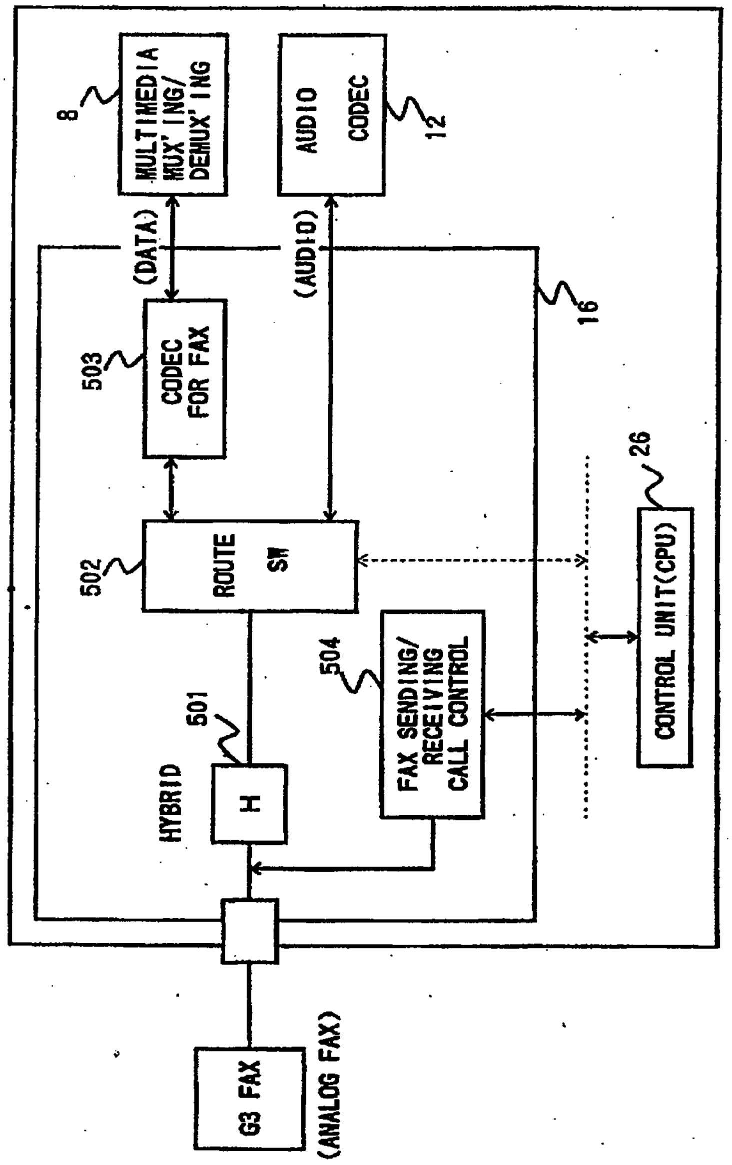

MULTIMEDIA MUX'ING/ DEMUX'ING
8
AUDIO CODEC
12
(DATA)
(AUDIO)
16
CODEC FOR FAX
503
ROUTE SW
502
26
CONTROL UNIT(CPU)
FAX SENDING/ RECEIVING CALL CONTROL
504
HYBRID
H
501
G3 FAX
(ANALOG FAX)

FIG. 6

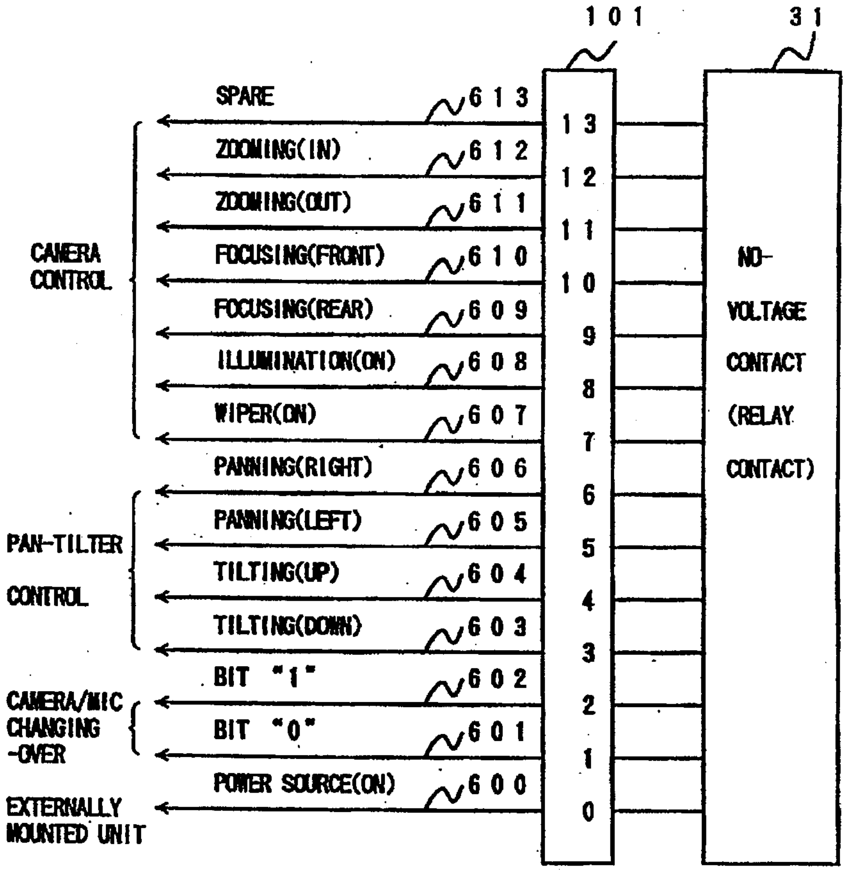

101
31
SPARE 613
ZOOMING(IN) 612
ZOOMING(OUT) 611
FOCUSING(FRONT) 610
FOCUSING(REAR) 609
ILLUMINATION(ON) 608
WIPER(ON) 607
PANNING(RIGHT) 606
PANNING(LEFT) 605
TILTING(UP) 604
TILTING(DOWN) 603
BIT "1" 602
BIT "0" 601
POWER SOURCE(ON) 600
CAMERA CONTROL
PAN-TILTER CONTROL
CAMERA/MIC CHANGING -OVER
EXTERNALLY MOUNTED UNIT
13
12
11
10
9
8
7
6
5
4
3
2
1
0
NO-VOLTAGE CONTACT (RELAY CONTACT)

FIG. 7

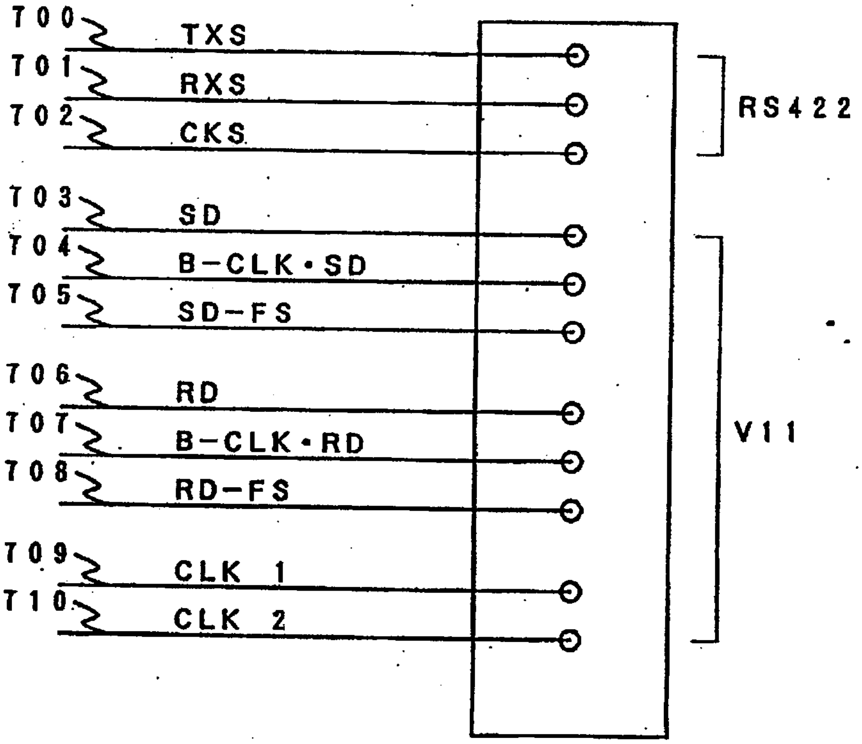

700
TXS
701
RXS
702
CKS
RS422
703
SD
704
B-CLK•SD
705
SD-FS
706
RD
707
B-CLK•RD
708
RD-FS
709
CLK 1
710
CLK 2
V11

FIG.8A

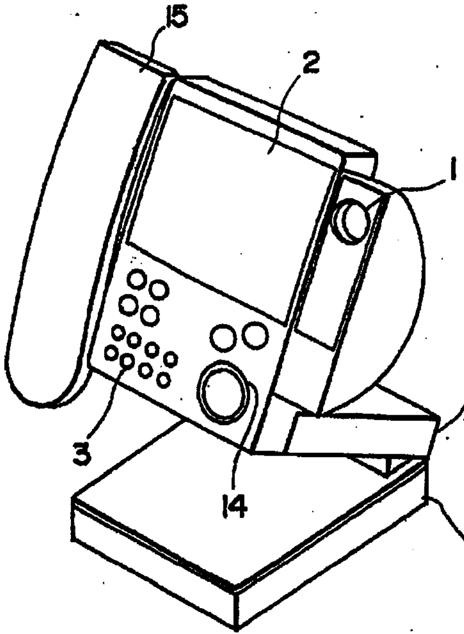

15
2
1
3
14

FIG.8B

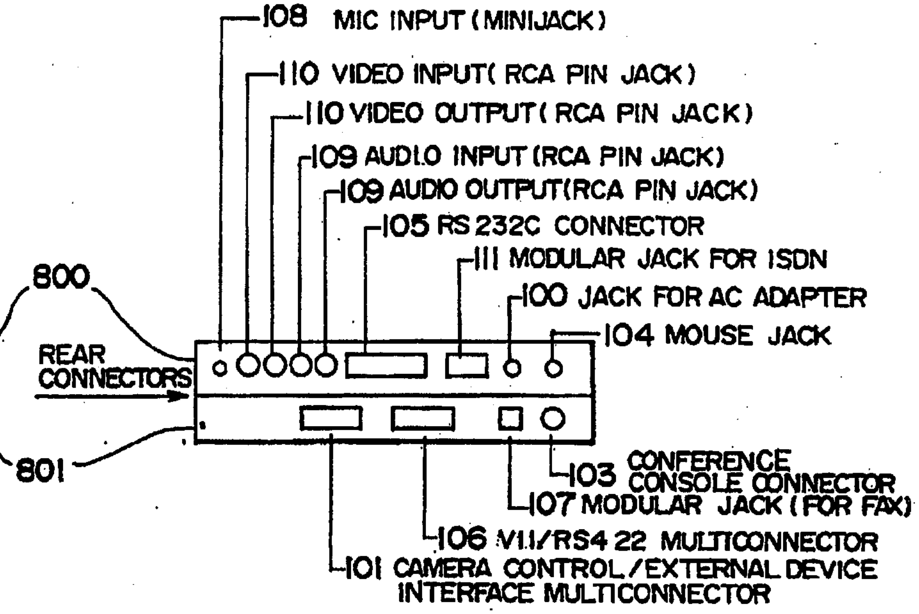

108 MIC INPUT (MINIJACK)
110 VIDEO INPUT(RCA PIN JACK)
110 VIDEO OUTPUT(RCA PIN JACK)
109 AUDI.O INPUT (RCA PIN JACK)
109 AUDIO OUTPUT(RCA PIN JACK)
105 RS 232C CONNECTOR
111 MODULAR JACK FOR ISDN
100 JACK FOR AC ADAPTER
104 MOUSE JACK
800
REAR CONNECTORS
801
103 CONFERENCE CONSOLE CONNECTOR
107 MODULAR JACK (FOR FAX)
106 V11/RS4 22 MULTICONNECTOR
101 CAMERA CONTROL/EXTERNAL DEVICE INTERFACE MULTICONNECTOR

FIG. 9

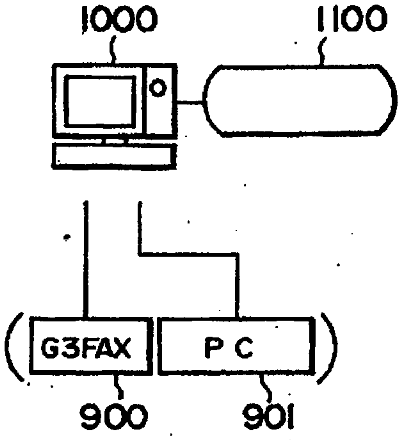

1000
1100
G3FAX
P C
900
901

FIG. 10

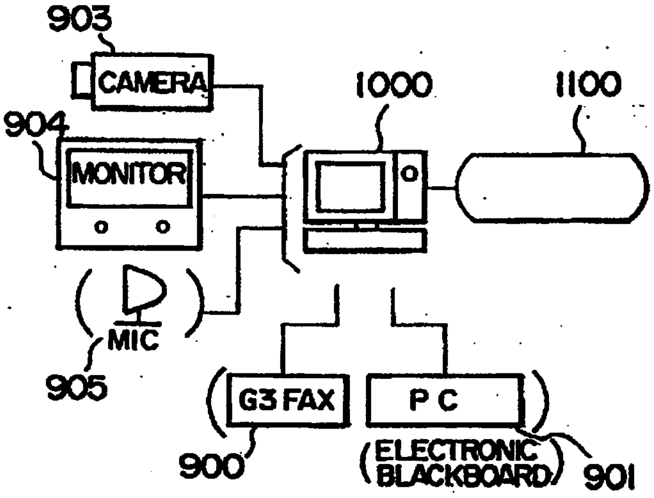
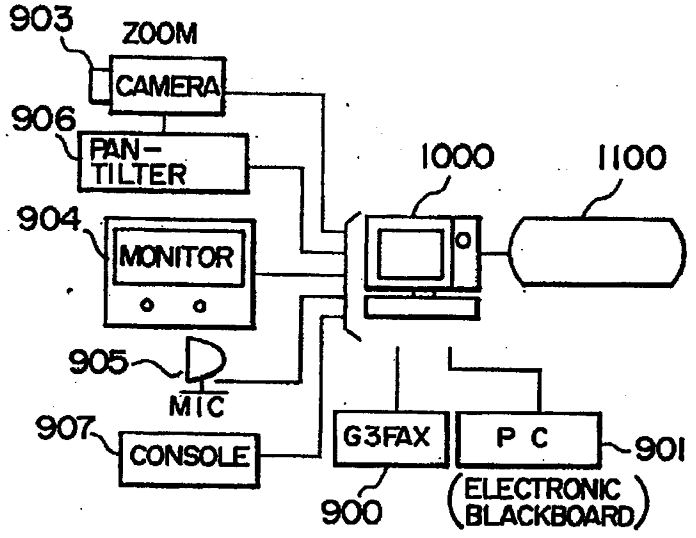
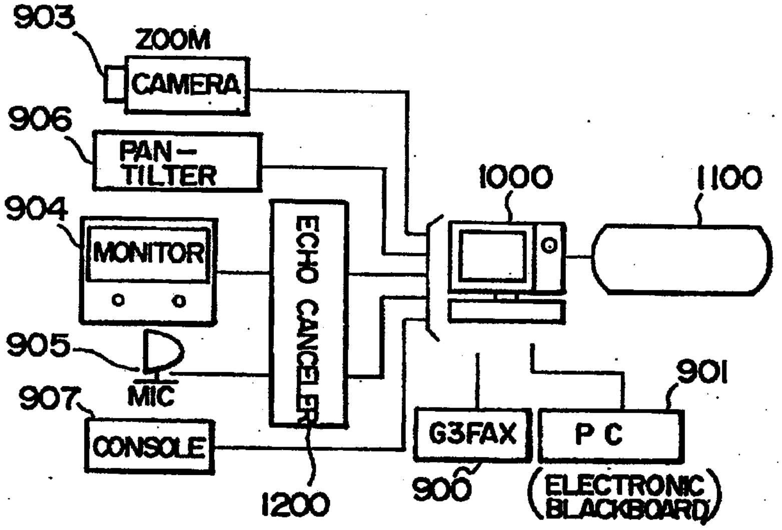

903
CAMERA
904
MONITOR
1000
1100
MIC
905
G3 FAX
P C
(ELECTRONIC BLACKBOARD)
900
901

FIG. 11



903
ZOOM
CAMERA
906
PAN-TILTER
904
MONITOR
905
MIC
907
CONSOLE
1000
1100
G3FAX
900
P C
(ELECTRONIC BLACKBOARD)
901

FIG. 12



903
ZOOM
CAMERA
906
PAN-TILTER
904
MONITOR
905
MIC
907
CONSOLE
ECHO CANCELER
1200
1000
1100
G3FAX
900
P C
(ELECTRONIC BLACKBOARD)
901

FIG. 13

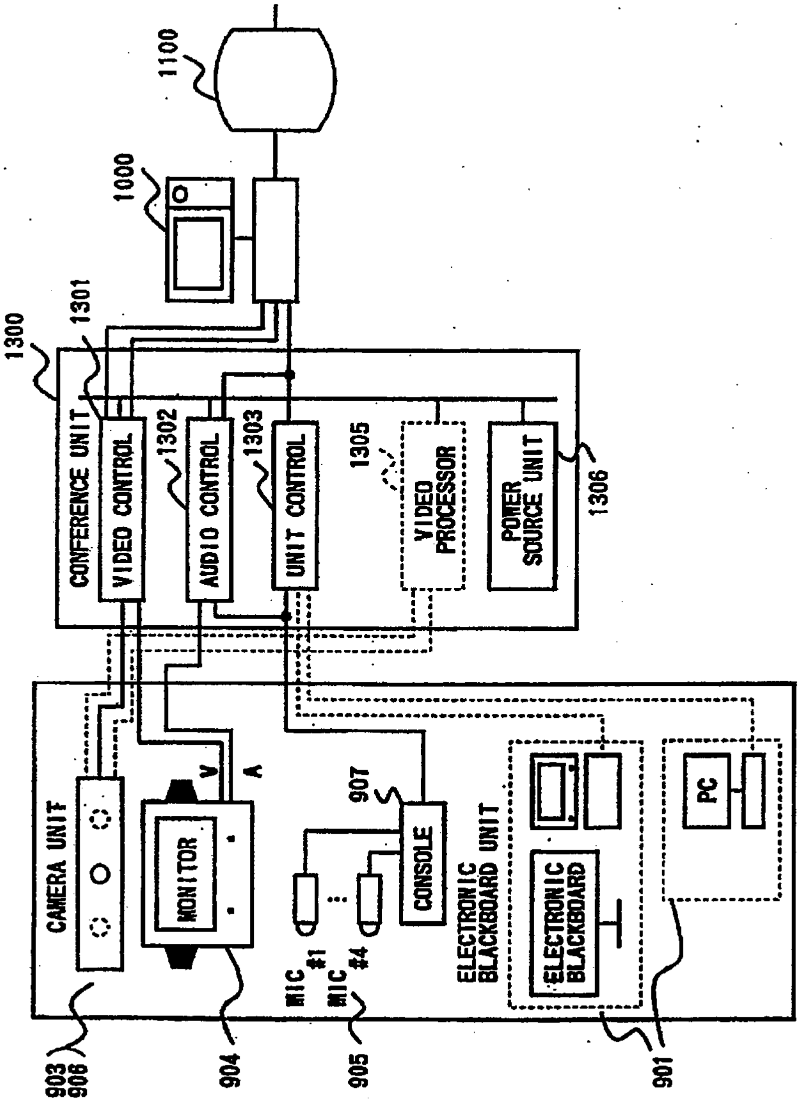

1100
1000
1300
1301
CONFERENCE UNIT
VIDEO CONTROL
1302
AUDIO CONTROL
1303
UNIT CONTROL
1305
VIDEO PROCESSOR
POWER SOURCE UNIT
1306
CAMERA UNIT
MONITOR
V
A
907
CONSOLE
MIC #1
MIC #4
ELECTRONIC BLACKBOARD UNIT
ELECTRONIC BLACKBOARD
PC
903
908
904
905
901

FIG. 14

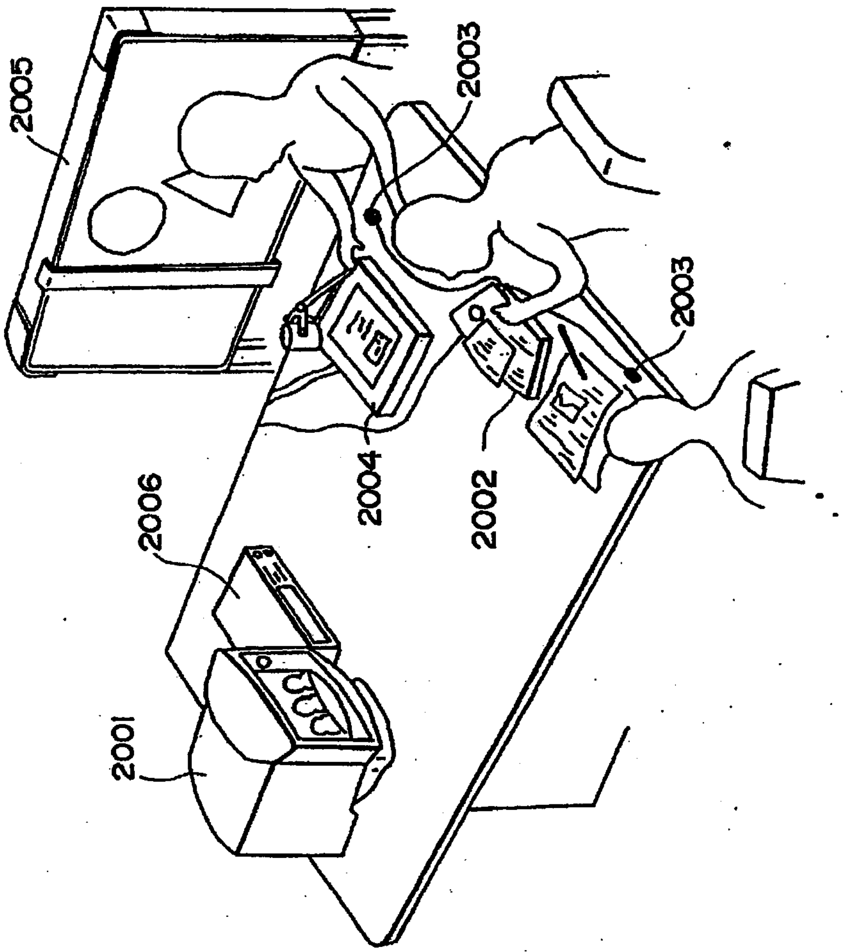
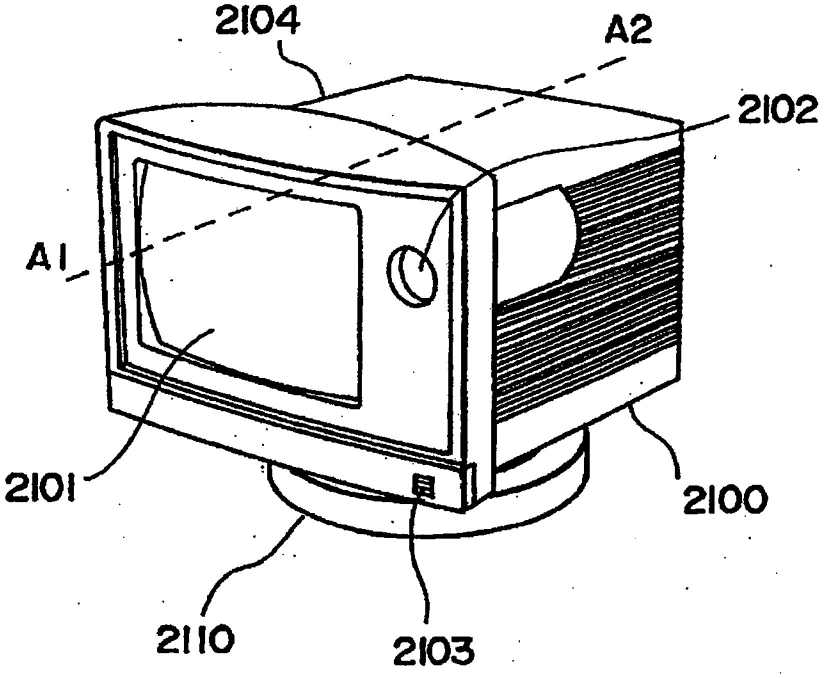


FIG. 15



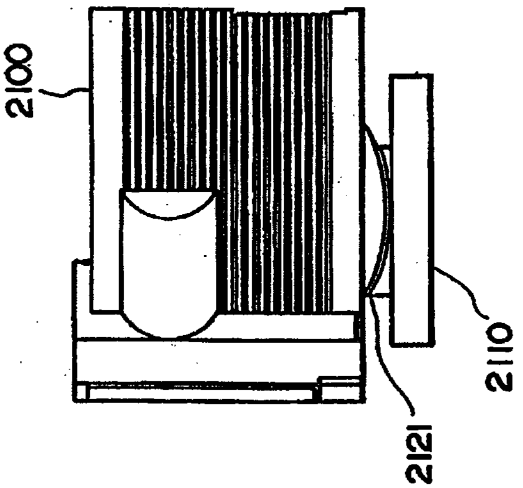


FIG. 16A

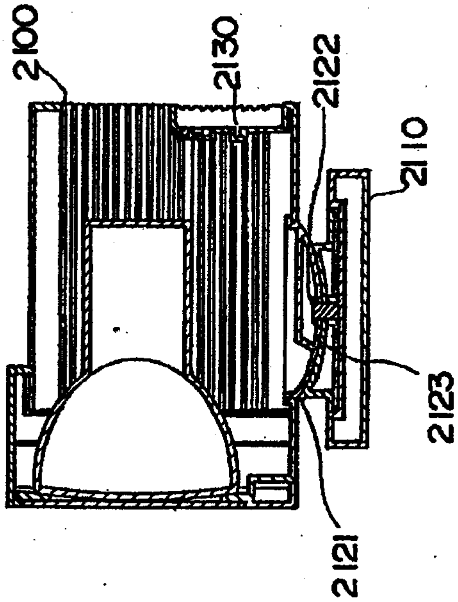


FIG. 16B

FIG. 17A

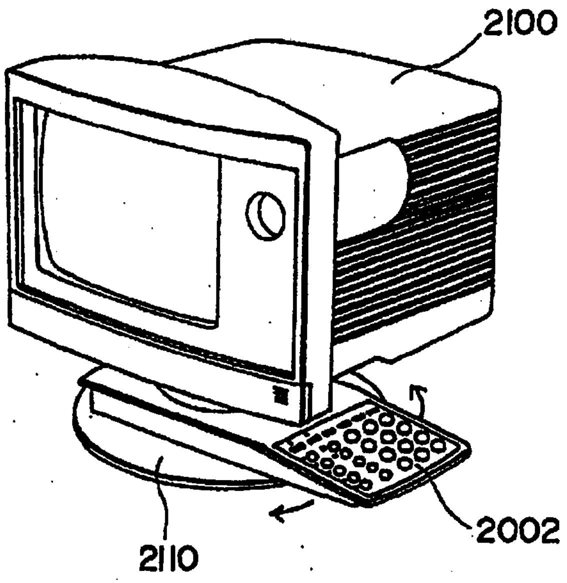


FIG. 17B

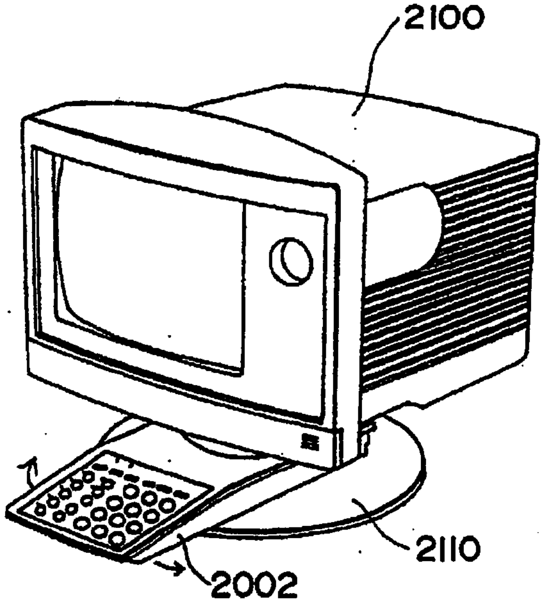


FIG. 18B

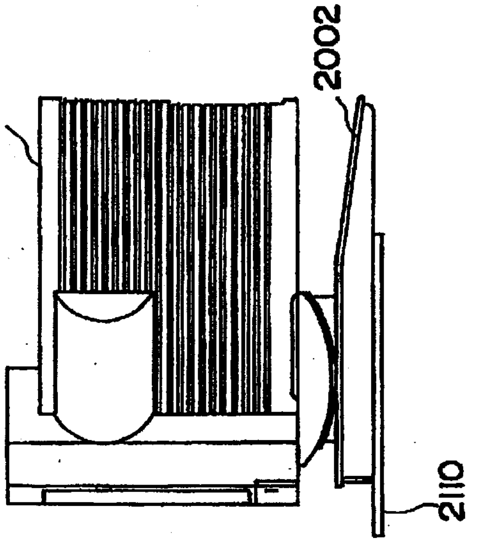


FIG. 18A

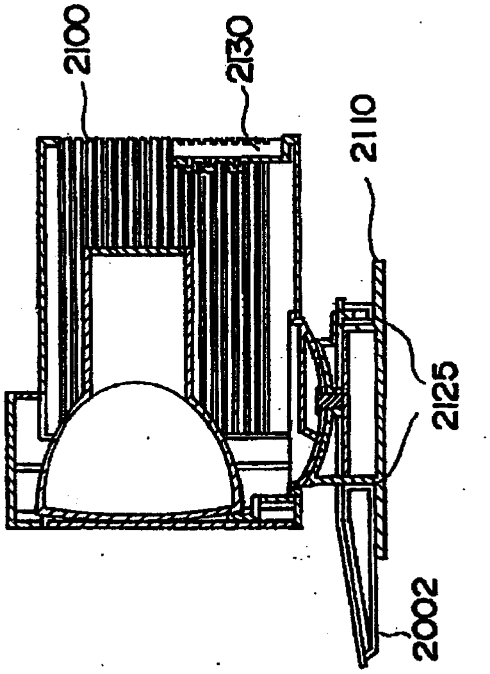


FIG. 19

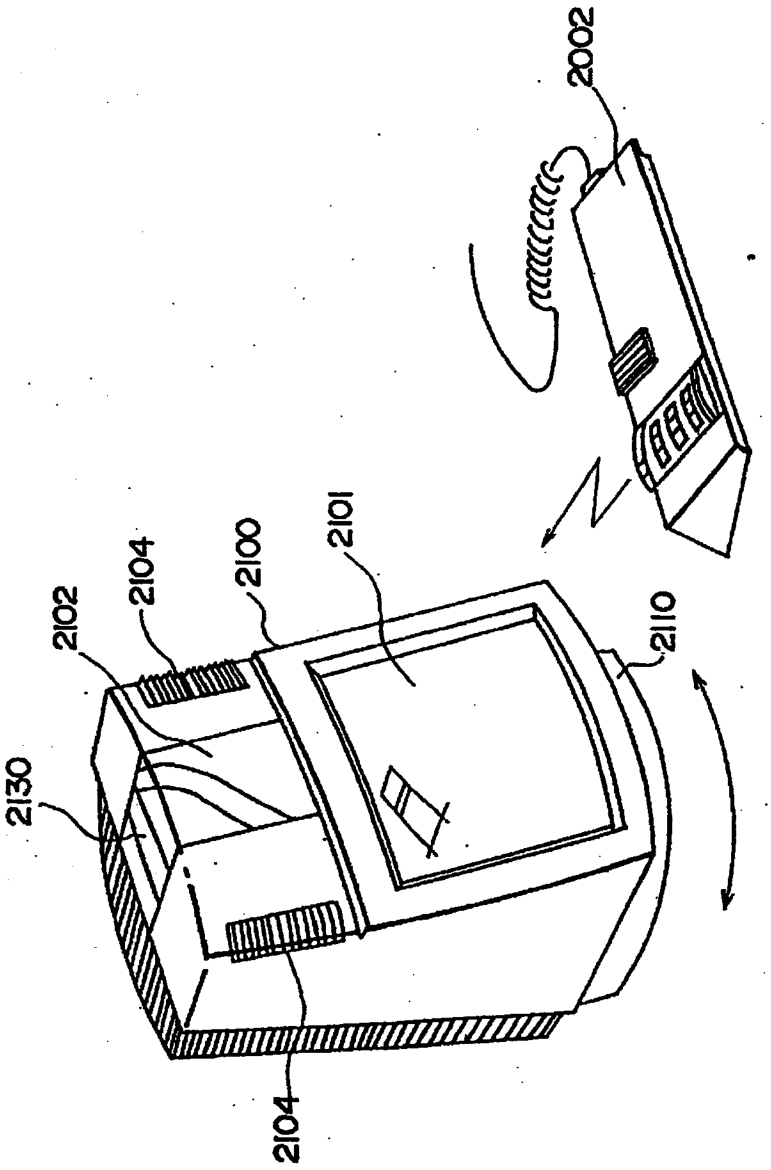


FIG. 20A

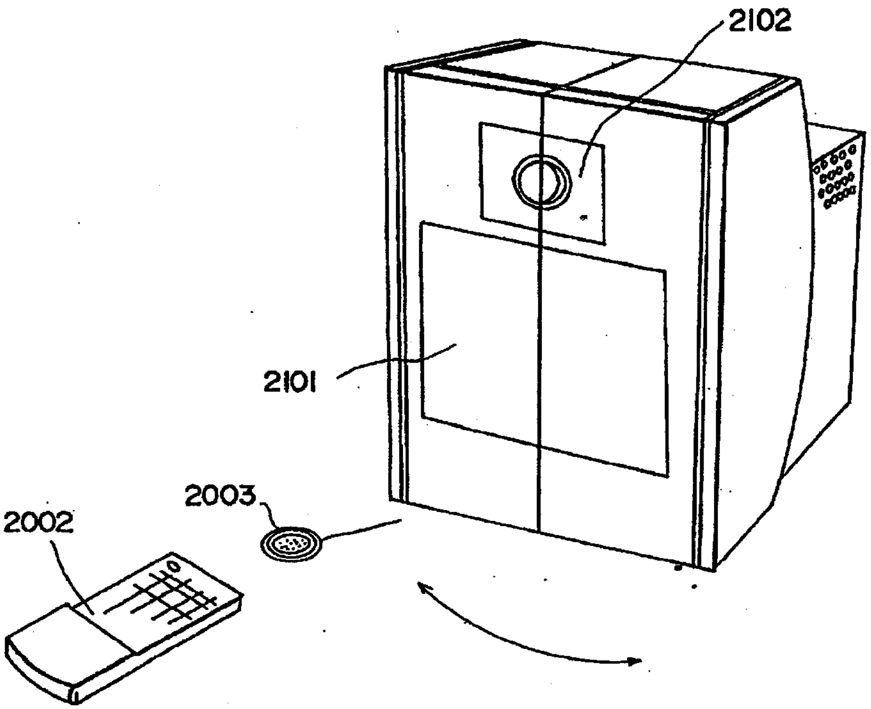


FIG. 20B

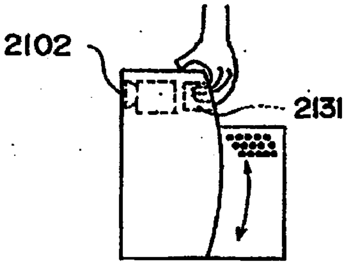


FIG. 21

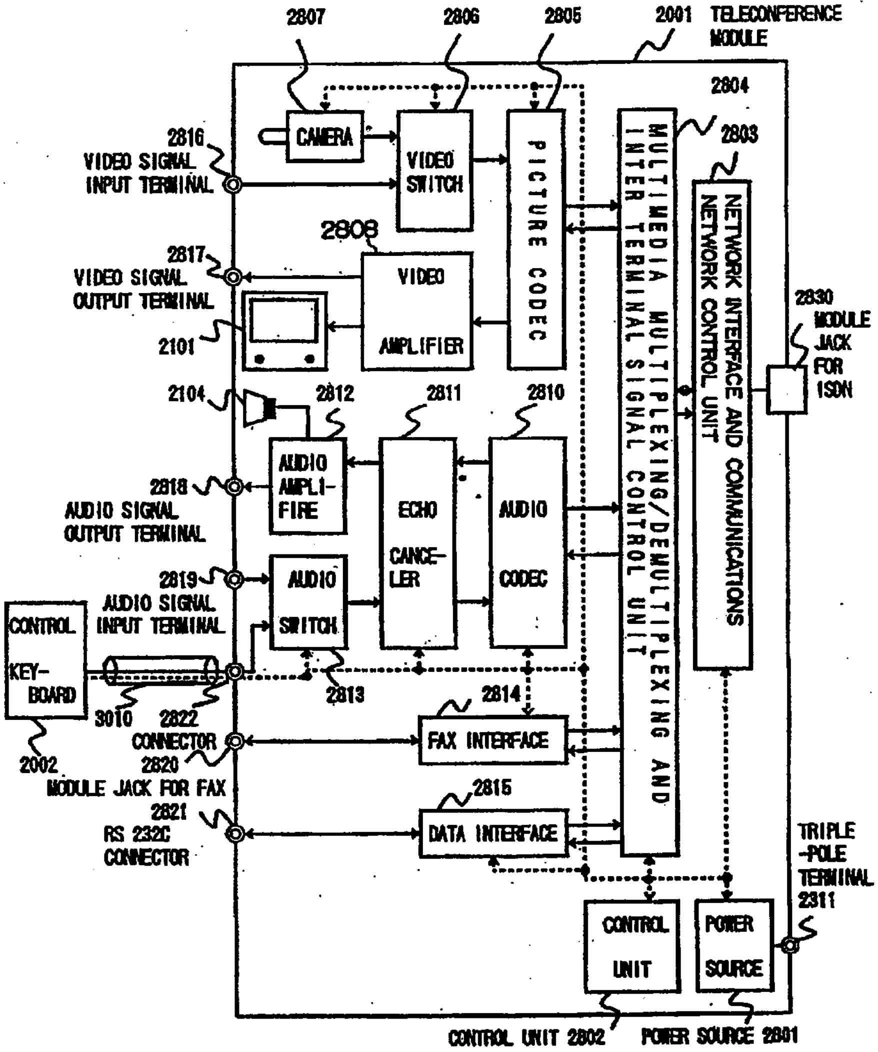

2807
2806
2805
2001 TELECONFERENCE MODULE
2804
2803
CAMERA
VIDEO SWITCH
PICTURE CODEC
MULTIMEDIA MULTIPLEXING/DEMULTIPLEXING AND INTER TERMINAL SIGNAL CONTROL UNIT
NETWORK INTERFACE AND COMMUNICATIONS NETWORK CONTROL UNIT
2816 VIDEO SIGNAL INPUT TERMINAL
2808
2817 VIDEO SIGNAL OUTPUT TERMINAL
VIDEO AMPLIFIER
2101
2830 MODULE JACK FOR ISDN
2104
2812
2811
2810
AUDIO AMPLI-FIRE
ECHO CANCE-LER
AUDIO CODEC
2818 AUDIO SIGNAL OUTPUT TERMINAL
2819 AUDIO SIGNAL INPUT TERMINAL
AUDIO SWITCH
CONTROL KEY-BOARD
3010
2822 CONNECTOR
2813
2814
FAX INTERFACE
2002
2820 MODULE JACK FOR FAX
2821 RS 232C CONNECTOR
2815
DATA INTERFACE
TRIPLE-POLE TERMINAL 2311
CONTROL UNIT
POWER SOURCE
CONTROL UNIT 2802
POWER SOURCE 2801

FIG. 22

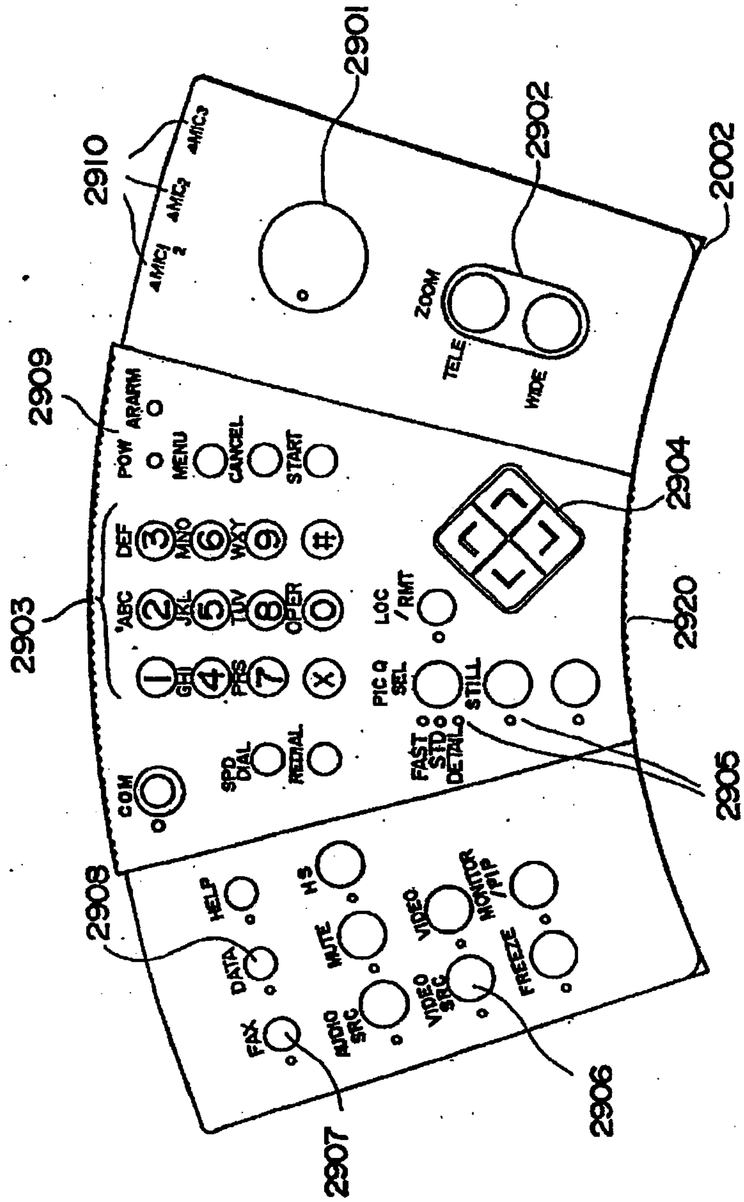

2901
2902
2002
2910
AMIC1 2
AMIC2
AMIC3
ZOOM
TELE
WIDE
2909
ARARM
POW
MENU
CANCEL
START
2904
DEF 3
MNO 6
WXY 9
#
ABC 2
JKL 5
TUV 8
OPER 0
1
GHI 4
PRS 7
X
LOC /RMT
PIC Q SEL
STILL
FAST STD DETAIL
2905
2920
2903
COM
SPD DIAL
REDIAL
2908
HELP
HS
DATA
MUTE
VIDEO
MONITOR /PIP
FAX
AUDIO SRC
VIDEO SRC
FREEZE
2906
2907

FIG. 23A

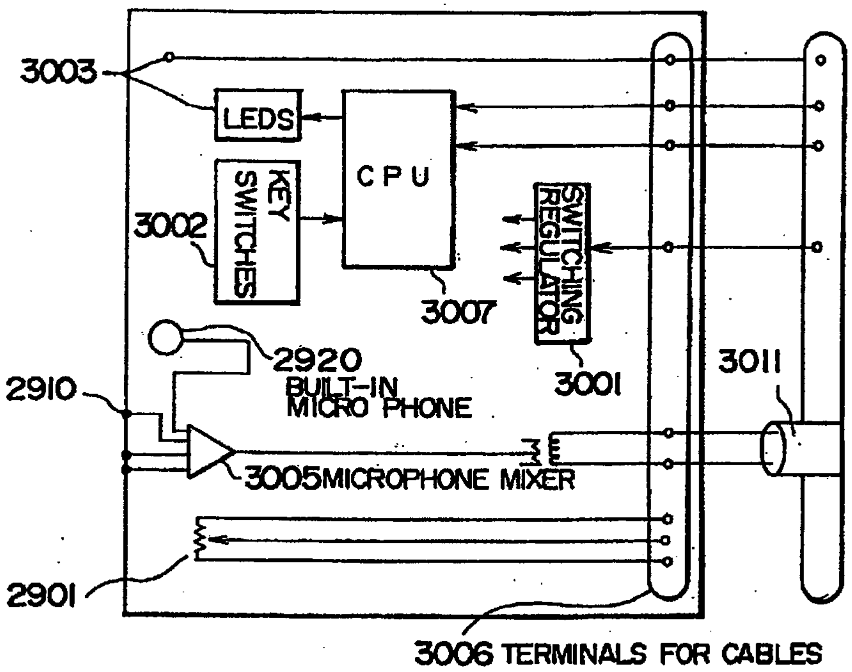


FIG. 23B

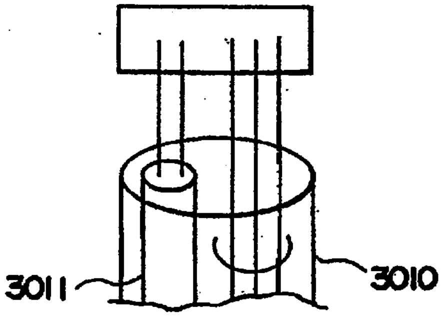


FIG. 24

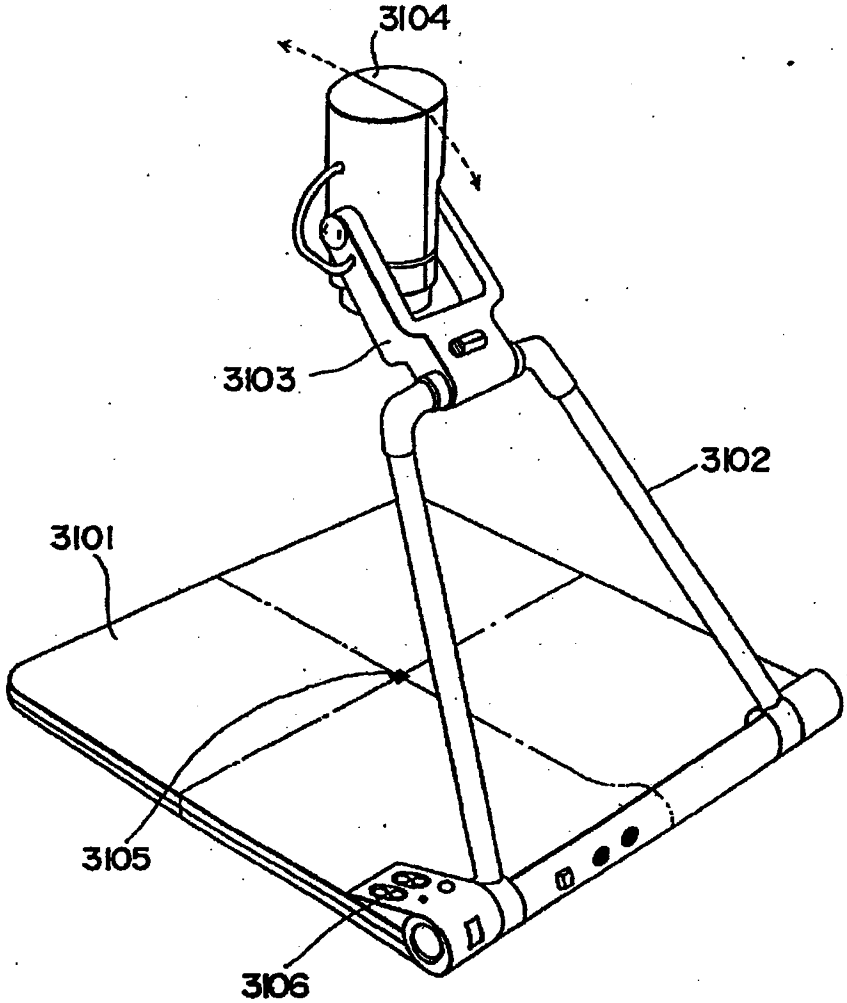


FIG. 25A

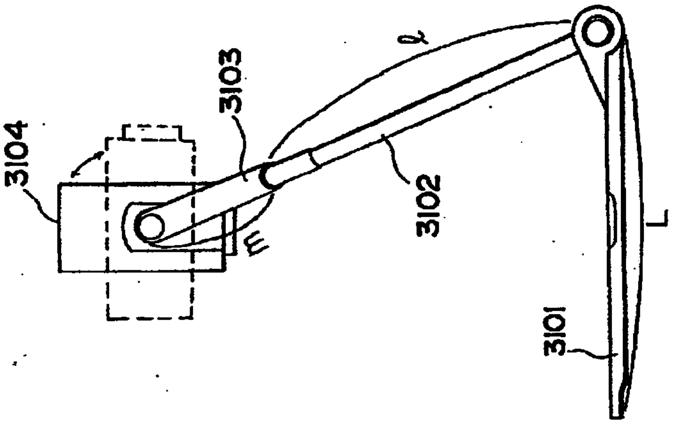


FIG. 25B

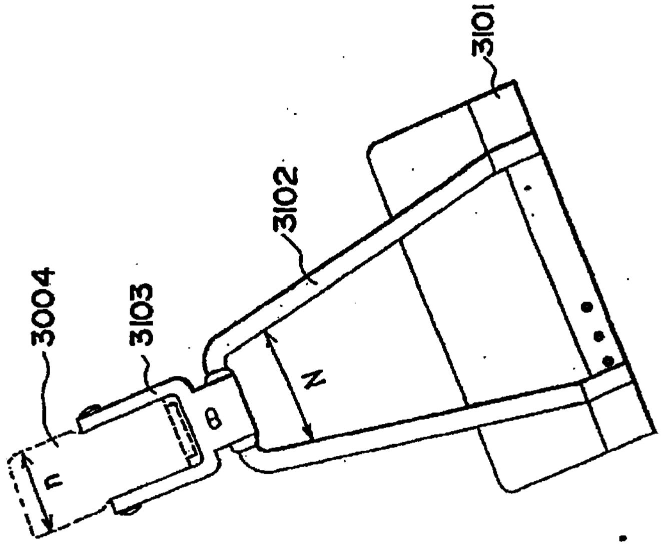


FIG. 26A

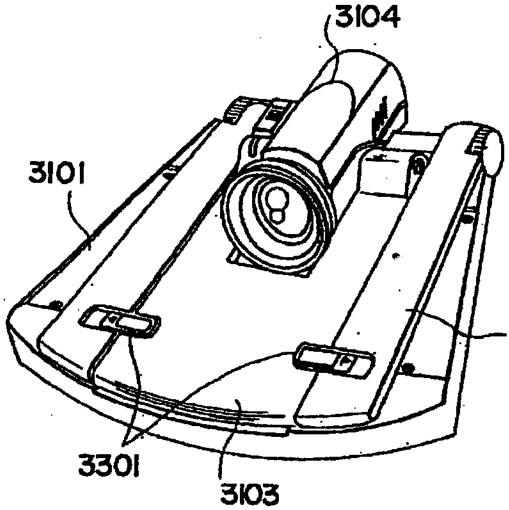


FIG. 26B

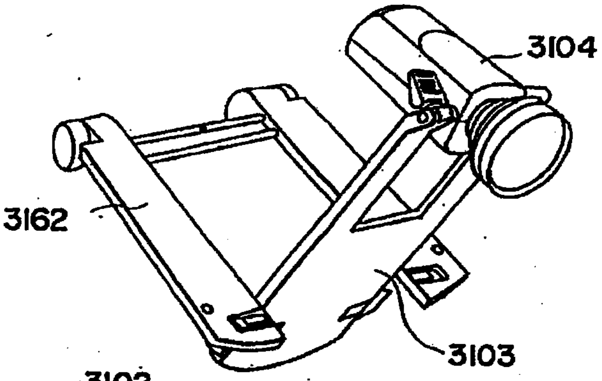


FIG. 26C

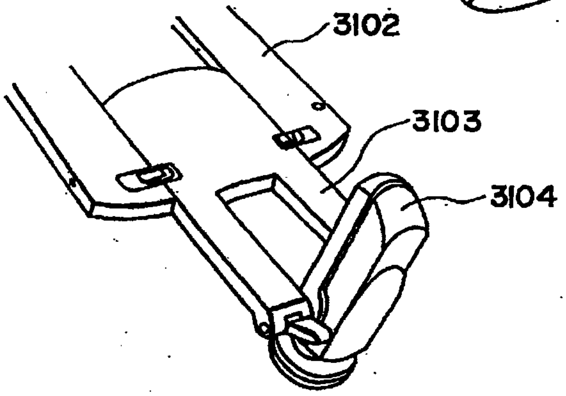


FIG. 27

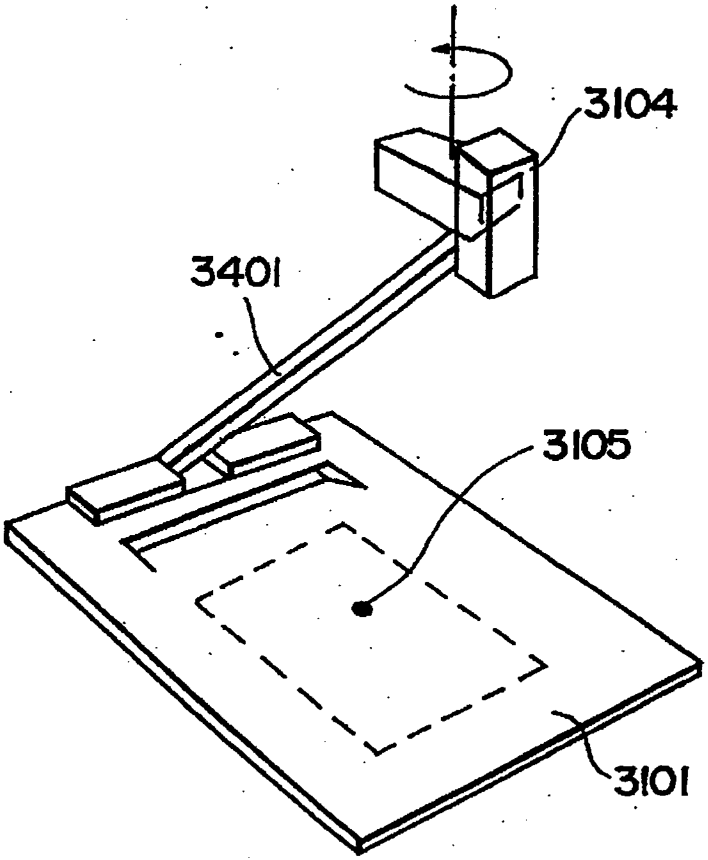


FIG. 28

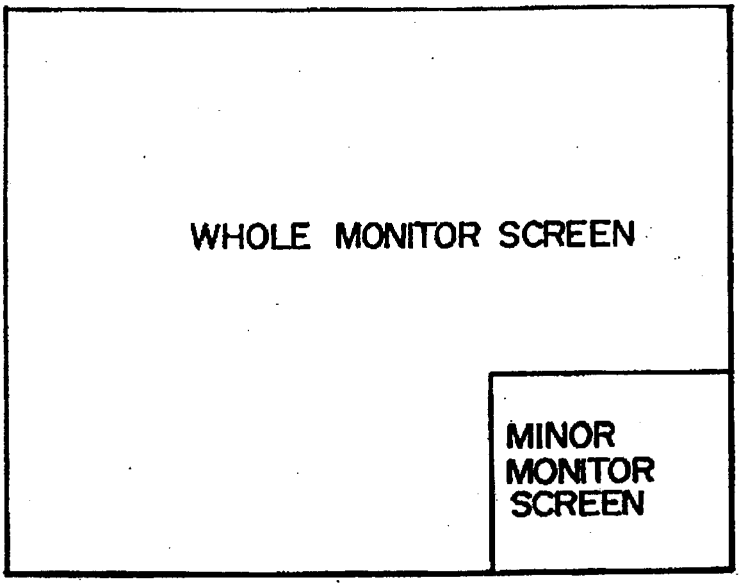


FIG. 29a

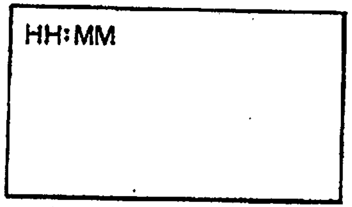


FIG. 29b

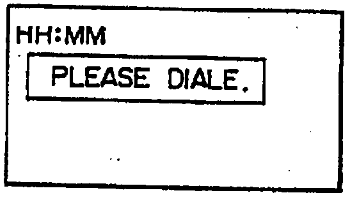


FIG. 29c

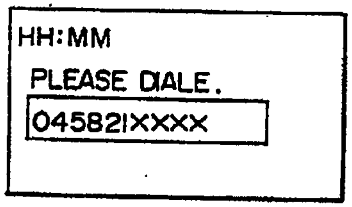


FIG. 29d

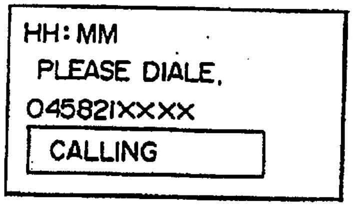


FIG. 29e

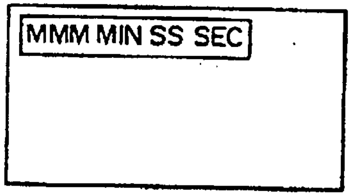


FIG. 29f

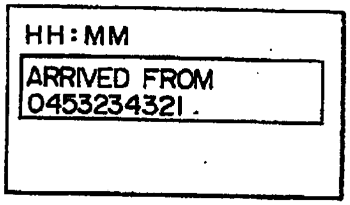


FIG. 30a

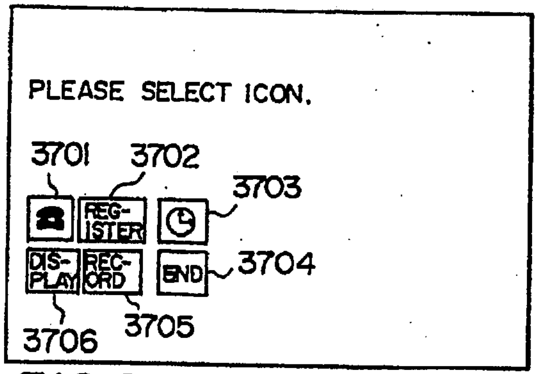


FIG. 30b

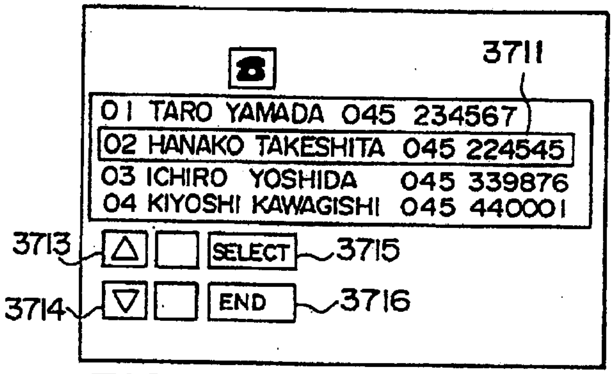


FIG. 30c

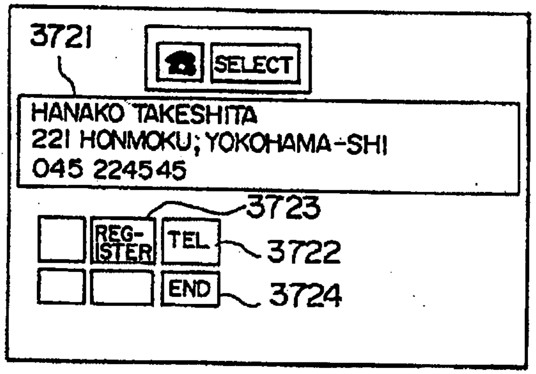


FIG. 30d

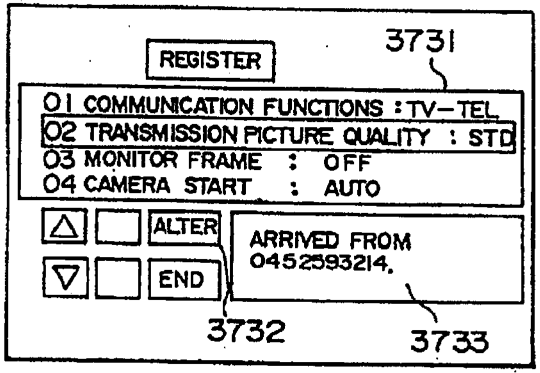


FIG.31A

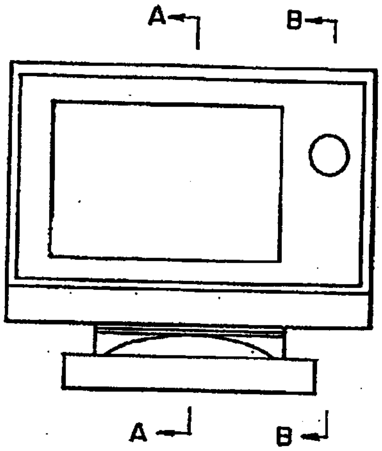


FIG.31B

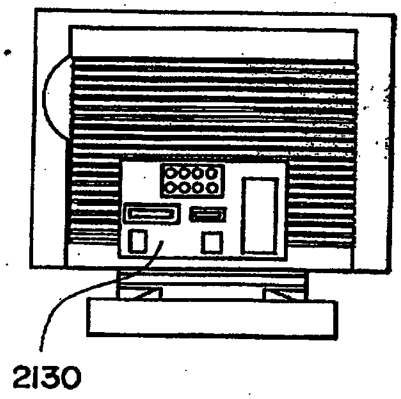


FIG.31C

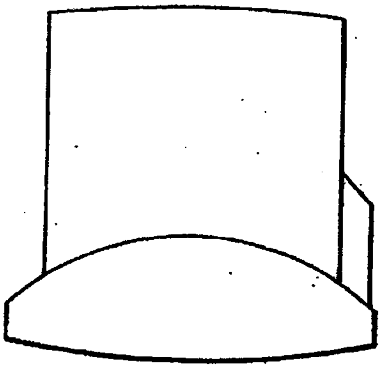


FIG.31D

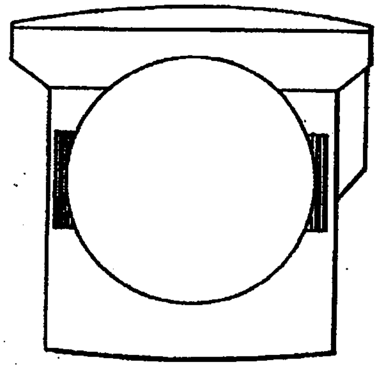


FIG. 32A

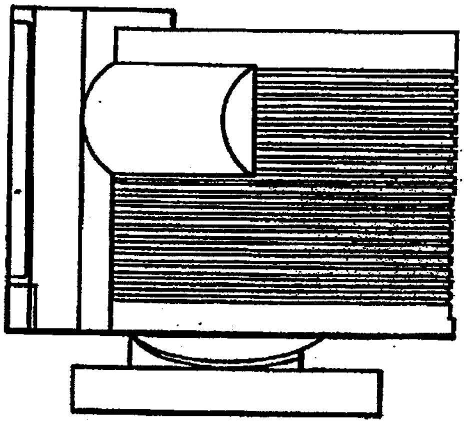


FIG. 32B

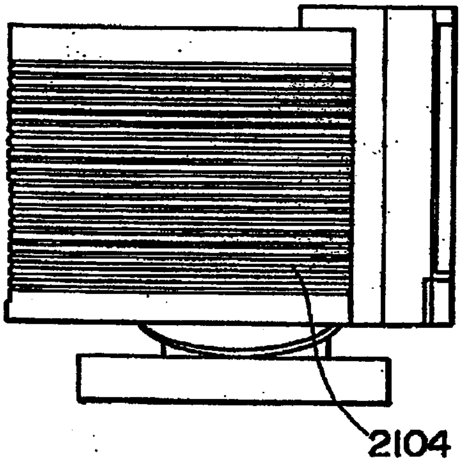


FIG. 33

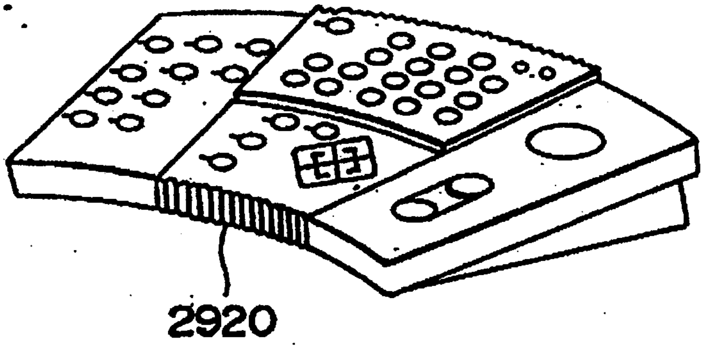


FIG. 34A

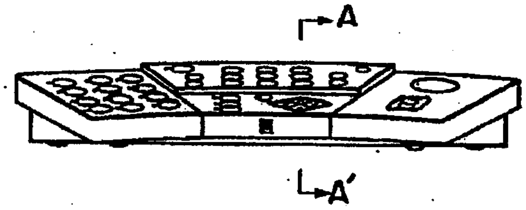


FIG. 34B

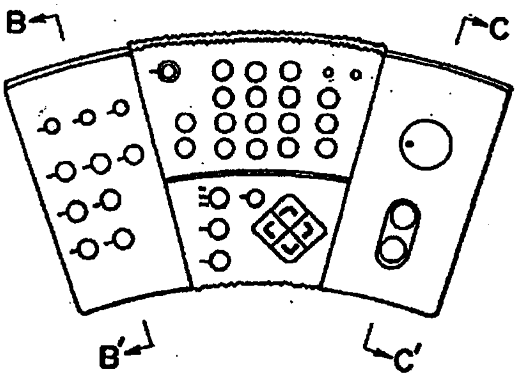


FIG. 34C

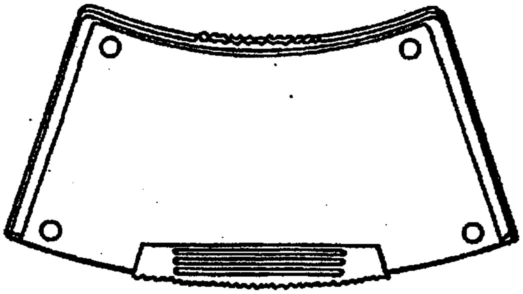


FIG.35A

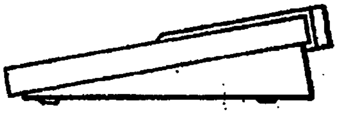


FIG.35B

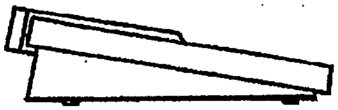


FIG.35C

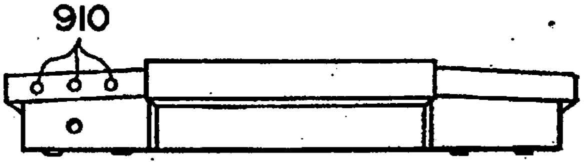


FIG.35D

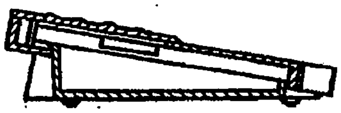


FIG.35E

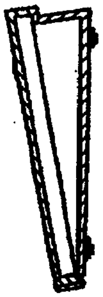


FIG.35F

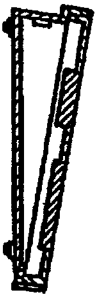


FIG. 36A

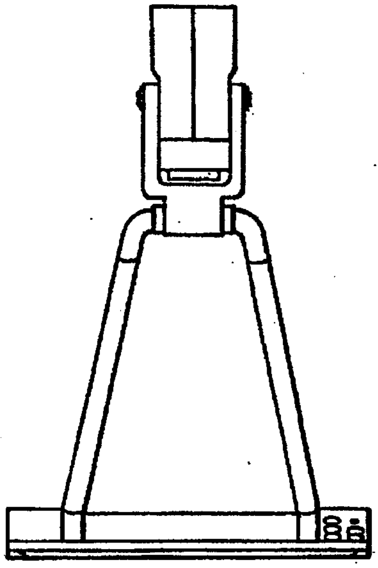


FIG. 36B

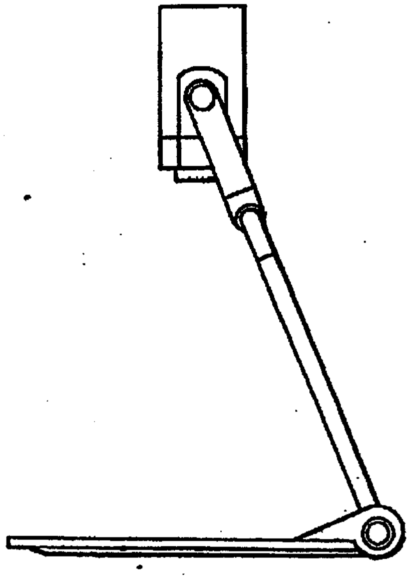


FIG. 36C

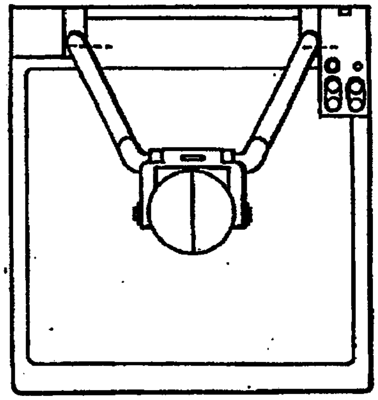


FIG. 36D

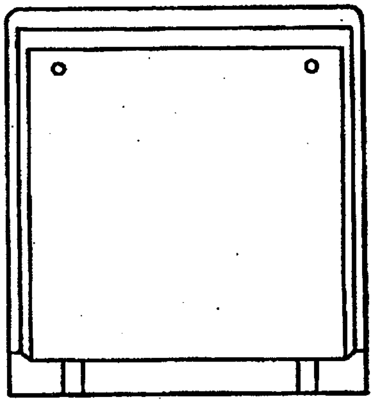


FIG. 37A

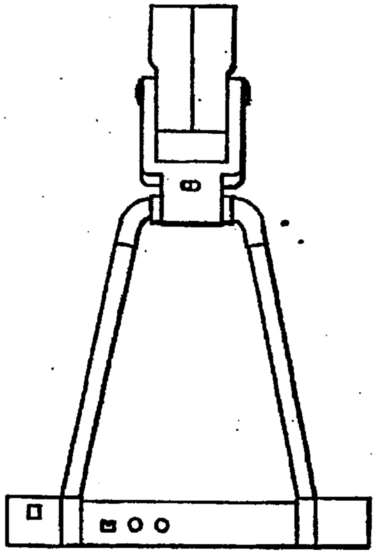


FIG. 37B

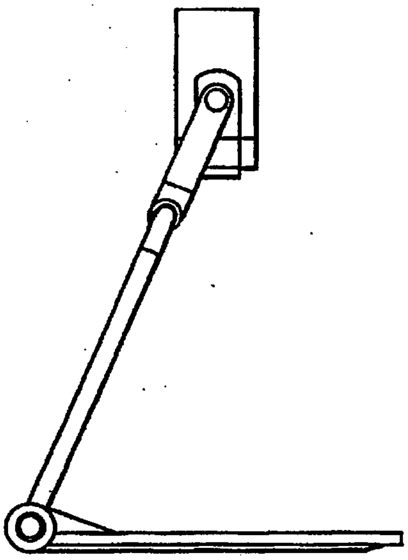


FIG. 38A

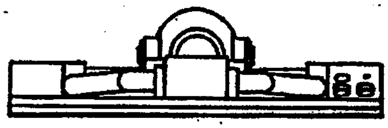
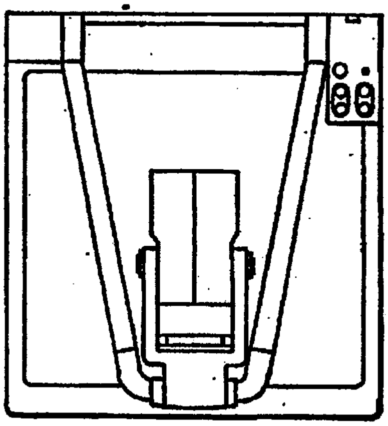


FIG. 38B

FIG. 38C



PICTURE CODEC AND TELECONFERENCE TERMINAL EQUIPMENT

This is a continuation of application Ser. No. 07/913,402, filed Jul. 15, 1992 and a continuation-in-part of application Ser. No. 08/384,955, filed Feb. 7, 1995; which is a continuation of application Ser. No. 07/838,348, filed Feb. 20, 1992, now U.S. Pat. No. 5,396,269.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a teleconference system which makes it possible to hold an audio and video meeting between distant places connected by a communications network.

2. Description of the Prior Art

A prior-art equipment for a teleconference system is constructed by combining independent devices such as a display unit, a codec, a camera, a microphone and a console. In some cases, a document camera, an electronic blackboard and a small-sized computer are further combined in accordance with functions required for conferences.

Moreover, since such a prior-art teleconference equipment constructed by combining the independent devices is large in scale, a teleconference room for exclusive use is usually required for the teleconference. On the other hand, there is also an equipment for a teleconference system wherein fundamental devices are housed in a single rack so as to be movable, thereby dispensing with the need for a conference room for exclusive use.

In the teleconference system thus constructed, ordinarily still pictures and video can be exchanged between the terminals of the system.

Techniques relevant to the teleconference equipments are disclosed in the official gazettes of Japanese Patent Applications Laid-open No. 39790/1990 and No. 22989/1990.

In addition, Japanese Patent Applications concerning teleconference systems filed by the assignee of the present application are Patent Applications Laid-open Nos. 120889/1992 and 166884/1991, and Patent Applications Nos. 406984/1990, 25987/1991, 25991/1991, 174025/1991, 174046/1991, 174031/1991, 34009/1991 and 27086/1991.

Meanwhile, in the prior-art equipment for the teleconference system, the codec includes an A/D (analog-to-digital) converter and a D/A (digital-to-analog) converter for each of a still picture and video, and the still picture display and video display of a display unit are changed-over by switching a still picture signal and a motion picture signal which are delivered from the two D/A converters.

Alternatively, the simultaneous display of the still pictures and video is realized by delivering the still picture and motion picture signals to two separate display units, respectively.

With the method wherein the still picture display and the video display are changed-over, the conversation of the pertinent communicating terminal with the opposite terminal is not conveyed smoothly on account of a complicated switching operation, etc.

On the other hand, with the method wherein the still picture signal and the motion picture signal are respectively displayed on the separate display units, these two display units are necessitated to render the terminal equipment large in size. Besides, while the user of the equipment is watching the still picture, his/her eyes shift widely and are inevitably averted from the opposite communicating person.

It is therefore an object of the present invention to provide a teleconference equipment in which a still picture and video can be simultaneously displayed on a single display screen.

In the prior-art teleconference system, the teleconference room for exclusive use needs to be prepared as stated before, so that the introduction of the teleconference system involves a heavy financial burden. Moreover, when holding the teleconference, conferees must move to the teleconference room which is inconvenient.

In this regard, even the portable teleconference equipment needs to be moved by several people on account of the size and weight thereof and cannot be used with ease.

Because of such circumstances, there has been a great demand in recent years for the ability to hold a teleconference more conveniently and more readily.

SUMMARY OF THE INVENTION

It is therefore another object of the present invention to provide a desktop type teleconference equipment which is small in size and which is easily portable.

In order to accomplish the objects, according to the present invention, there is provided a picture codec to which an analog picture signal, coded still picture data for playback and coded motion picture data for playback are input, and from which coded picture data obtained by coding the input analog picture signal and an analog picture signal obtained by decoding either of the input coded still picture data for playback and coded motion picture data for playback are output, the picture code comprises an analog-to-digital converter which converts the input analog picture signal into digital picture data, a still picture coder which codes the digital picture data produced by the analog-to-digital converter, so as to deliver coded still picture data, a video coder which codes the digital picture data produced by the analog-to-digital converter, so as to deliver coded motion picture data, a selector which selects either of the coded motion picture data delivered from the video coder and the coded still picture data delivered from the still picture coder, and which delivers the selected picture data as the output coded picture data, a still picture decoder which decodes the input coded still picture data for playback, into decoded still picture data, a video decoder which decodes the input coded motion picture data for playback, into decoded motion picture data, a picture-in-picture processor which generates picture-in-picture frame data on the basis of the decoded still picture data delivered from the still picture decoder, the decoded motion picture data delivered from the video decoder and the digital picture data delivered from the analog-to-digital converter, the picture-in-picture frame data forming a picture-in-picture frame which concerns at least two of the decoded still picture data, the decoded motion picture data and the digital picture data and a digital-to-analog converter which converts the picture-in-picture frame data generated by the picture-in-picture processor, into the output analog picture signal, and which delivers the output analog picture signal.

Further, there is provided a teleconference terminal equipment which comprises the picture codec as defined in the above paragraph, a communication control unit which transmits either of the coded still picture data and the coded motion picture data delivered from the picture codec, through a digital communication channel, and which receives either of the coded still picture data for playback and the coded motion picture data for playback through the digital communication channel and then delivers the received picture data to the picture codec, a camera which delivers the analog picture signal to the picture codec and a display unit which displays a picture indicated by the output analog picture signal of the picture codec.

Owing to the construction of the picture codec, a still picture and video can be simultaneously displayed on a single screen.

Moreover, the teleconference terminal equipment is small in size and is easily portable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing the general arrangement of a teleconference terminal equipment according to the first embodiment of the present invention;

FIG. 2 is a block diagram showing the construction of a picture codec which is included in the teleconference terminal equipment of the first embodiment;

FIG. 3 is a block diagram showing the construction of a PinP (Picture in Picture) processor which is included in the teleconference terminal equipment of the first embodiment;

FIGS. 4(*a*)–4(*f*) are explanatory diagrams showing the aspects of a PinP process which is performed in the teleconference terminal equipment of the first embodiment;

FIG. 5 is a block diagram showing the construction of a G3-FAX (group 3 type facsimile) interface which is included in the teleconference terminal equipment of the first embodiment;

FIG. 6 is an explanatory diagram showing the construction of a camera control/external device multiconnector which is included in the teleconference terminal equipment of the first embodiment;

FIG. 7 is an explanatory diagram showing the construction of a V11/RS422 multiconnector which is included in the teleconference terminal equipment of the first embodiment;

FIGS. 8(*a*) and 8(*b*) are a perspective view and a rear view, respectively, showing the external appearance of the teleconference terminal equipment of the first embodiment;

FIG. 9 is a block diagram showing an example of the construction of a teleconference system according to the first embodiment of the present invention;

FIG. 10 is a block diagram showing another example of the construction of the teleconference system of the first embodiment;

FIG. 11 is a block diagram showing still another example of the construction of the teleconference system of the first embodiment;

FIG. 12 is a block diagram showing yet another example of the construction of the teleconference system of the first embodiment;

FIG. 13 is a block diagram showing a further example of the construction of the teleconference system of the first embodiment;

FIG. 14 is an explanatory view showing the construction and service situation of a teleconference system according to the second embodiment of the present invention;

FIG. 15 is an exterior view showing the construction of the first teleconference terminal equipment according to the second embodiment of the present invention;

FIGS. 16A and 16B are a side view and a sectional view, respectively, of the first teleconference terminal equipment of the second embodiment;

FIGS. 17A and 17B are exterior views showing the construction of the second teleconference terminal equipment according to the second embodiment of the present invention;

FIGS. 18A and 18B are a sectional view and a side view, respectively, of the second teleconference terminal equipment of the second embodiment;

FIG. 19 is an exterior view showing the construction of the third teleconference terminal equipment according to the second embodiment of the present invention;

FIGS. 20A and 20B are an exterior view and an explanatory view, respectively, showing the construction of the fourth teleconference terminal equipment according to the second embodiment of the present invention;

FIG. 21 is a block diagram showing the internal construction of the teleconference terminal equipment of the second embodiment;

FIG. 22 is an explanatory view showing the external construction of a control keyboard according to the second embodiment of the present invention;

FIGS. 23A and 23B are a block diagram and a schematic diagram, respectively, showing the internal construction of the control keyboard of the second embodiment;

FIG. 24 is an exterior view showing the construction of the first document photographing stand according to the second embodiment of the present invention;

FIGS. 25A and 25B are a side view and a rear view, respectively, of the first document photographing stand of the second embodiment;

FIGS. 26A, 26B and 26C are exterior views showing the construction of the second document photographing stand according to the second embodiment of the present invention;

FIG. 27 is an exterior view showing the construction of the third document photographing stand according to the second embodiment of the present invention;

FIG. 28 is an explanatory view showing the situation of a minor frame display in the teleconference terminal equipment of the second embodiment;

FIGS. 29(*a*)–29(*f*) are is an explanatory diagrams showing messages which are displayed on a monitor screen in the teleconference terminal equipment of the second embodiment;

FIGS. 30(*a*)–30(*d*) are explanatory diagrams showing graphic user interfaces which are offered by the teleconference terminal equipment of the second embodiment;

FIGS. 31A, 31B, 31C and 31D are a front view, a rear view, a plan view and a bottom view, respectively, of the first teleconference terminal equipment of the second embodiment;

FIGS. 32A and 32B are a right side view and a left side view, respectively, of the first teleconference terminal equipment of the second embodiment;

FIG. 33 is a perspective view of the control keyboard of the second embodiment;

FIGS. 34A, 34B and 34C are a front view, a plan view and a bottom view, respectively, of the control keyboard of the second embodiment;

FIGS. 35A, 35B, 35C, 35D, 35E and 35F are, respectively, a fight side view, a left side view, a rear view, a schematic sectional view taken along line A–A' in FIG. 34A, a schematic sectional view taken along line B–B' in FIG. 34B and a schematic sectional view taken along line C–C in FIG. 34B;

FIGS. 36A, 36B, 36C and 36D are a front view, a fight side view, a plan view and a bottom view, respectively, of the document photographing stand of the second embodiment;

FIGS. 37A and 37B are a rear view and a left side view, respectively, of the document photographing stand of the second embodiment; and

FIGS. 38A, 38B and 38C are a front view, a right side view and a plan view, showing the folded state of the document photographing stand of the second embodiment.

PREFERRED EMBODIMENTS OF THE INVENTION

Now, the first embodiment of a teleconference terminal equipment according to the present invention will be described.

FIG. 1 illustrates the functional block arrangement of the teleconference terminal equipment in this embodiment.

As shown in the figure, the teleconference terminal equipment of this embodiment comprises a camera 1, an LCD (liquid-crystal display) 2, dial function keys 3, a VSW (video switch) 4, a picture codec 5, a telephone control man-machine interface 6, a multipoint conversation control 7, a multimedia multiplexing/demultiplexing and interterminal signal control unit 8, a network interface and communications network control unit 9, a D/R (driver) 10, a VDT (voltage detector) 11, an audio codec 12, an ASW (audio switch) 13, a hands-free set 14, a handset 15, a G3-FAX interface 16, a V11 D/R 17, an RS422 D/R 18, an RS232C D/R 19, a data multiplexor/demultiplexor 20, a communication interface matching section 21, a bus SW (switch) 22, communication ports 23–25, a control unit 26, peripheral device control interfaces 27–28, and a no-voltage contact 31.

In addition, as external input/output terminals, the teleconference terminal equipment comprises a video I/O interface 110, an audio I/O interface 109, a microphone input 108, a G3-FAX modular jack 107, a V11/RS422 multiconnector 106, an RS232C connector 105, a mouse jack 104, a conference console connector 103, and a camera control and external device multiconnector 101.

The network interface and communications network control unit 9 is connected to a digital communications network through the D/R 10, and it performs the communication controls and communication processing between the teleconference terminal equipment and the network, such as establishing a communication channel with the opposite communicating terminal equipment. The multimedia multiplexing/demultiplexing and interterminal signal control unit 8 performs various controls between the pertinent terminal equipment and the opposite terminal equipment. Besides, this control unit 8 demultiplexes video data, audio data, data to be multiplexed/demultiplexed, control data, etc. from within a received communication frame into the individual data types, and it multiplexes such types of data into a transmission communication frame. The video data mentioned above is interface data on the network side of the picture codec 5, while the audio data is interface data on the network side of the audio codec 12. The data to be multiplexed/demultiplexed is interface data with respect to the data multiplexor/demultiplexor 20. The control data is transferred between the control unit 8 and the control unit 6.

The data multiplexor/demultiplexor 20 further demultiplexes the data demultiplexed from within the received communication frame by the multimedia multiplexing/demultiplexing and interterminal signal control unit 8, into individual data types in accordance with protocols stipulated with the opposite communicating terminal equipment beforehand.

Specifically, in a case where a frame stipulated in Consultative Committee on International Telephone and Telegraph (CCITT) Recommendation H. 221 is taken as the communication frame, the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 transfers FAS or BAS data within the frame to and from the control unit 26, audio data to and from the audio codec 12, video data in, e.g., a frame stipulated in CCITT Recommendation H. 261 published January 1990 to and from the picture codec 5, and data to-be-multiplexed/demultiplexed to and from the data multiplexor/demultiplexor 20. Besides, in a case where MLP data is contained in the frame stipulated in Recommendation H. 221, it is transferred between the control unit 8 and either the control unit 26 or the data multiplexor/demultiplexor 20 under the control of the control unit 26.

Herein, the data multiplexor/demultiplexor 20 demultiplexes the data to-be-demultiplexed into G3-FAX data, computer data, various control data, etc. in accordance with the protocols stipulated with the opposite communicating terminal equipment beforehand, and it delivers the demultiplexed data items to the G3-FAX modular jack 107, V11/RS422 multiconnector 106 and RS232C connector 105. Contrariwise, the data multiplexor/demultiplexor 20 multiplexes the data to-be-multiplexed delivered from the G3-FAX modular jack 107, V11/RS422 multiconnector 106 and RS232C connector 105 and delivers the multiplexed data items to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8.

In the case of holding a multipoint teleconference, the multipoint conversation control 7 performs controls required for the start and proceeding of the multipoint teleconference. In contrast, in the case of holding no multipoint teleconference, the control 7 merely relays data. The VDT 11 is a means for detecting the feed voltage of the pertinent terminal equipment.

The camera 1 picks up a picture, which is presented as a display output by the LCD 2. The VSW 4 is a video switch which changes-over the connection of the picture codec 5 with the camera 1, LCD 2 and video I/O interface 110. The video input/output of an external video I/O device can be connected with the video I/O interface 110.

The picture codec 5 codes a picture signal supplied through the VSW 4, and delivers the coded signal to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 through the multipoint conversation control 7. In addition, the picture codec 5 decodes the video data demultiplexed from the received communication frame by the control unit 8 and delivers an output through the VSW 4.

The hands-free set 14 is a microphone and a loudspeaker for freeing hands. The G3-FAX interface 16 is a modular jack to which a group 3 type facsimile can be connected. The audio input/output of an external audio I/O device can be connected to the audio I/O interface 109. An external microphone can be connected to the microphone input 108.

The ASW 13 is an audio switch which changes-over the connection of the audio codec 12 with the hands-free set 14, handset 15, G3-FAX interface 16, audio I/O interface 109 and microphone input 108.

The audio codec 12 codes a speech signal supplied through the ASW 13, and delivers the coded signal to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 through the multipoint conversation control 7. In addition, the audio codec 12 decodes the audio data demultiplexed from the received communication frame by the control unit 8 and delivers an output through the ASW 13. Incidentally, the audio codec 12 is connected to the V11/RS422 multiconnector 106 through the V11 D/R 17.

The dial function keys 3 are keys for accepting the instructions of a user. The telephone control man-machine interface 6 controls the ASW 13 in accordance with a key input from the dial function keys 3, so as to connect the audio codec 12 with the hands-free set 14, handset 15, G3-FAX interface 16 or microphone input 108. Besides, the instruction based on the key input is transferred to the multipoint conversation control 7 through the telephone control man-machine interface 6. In response to this instruction, the multipoint conversation control 7 controls the multipoint teleconference.

The G3-FAX interface 16 delivers a signal to-be-transmitted supplied from the G3 FAX (group 3 type facsimile) being an analog FAX connected to the G3-FAX connector 107, to the audio codec 12 through the ASW 13 in the case of treating the FAX data as audio data, while it digitizes the signal to-be-transmitted into a code and delivers the code to the data multiplexor/demultiplexor 20 in the case of treating the FAX data as data to-be-multiplexed. Contrariwise, when supplied with received data toward the G3 FAX by the audio codec 12, the G3-FAX interface 16 supplies the G3-FAX modular jack 107 with the received data as it is, and when supplied with received data toward the G3 FAX by the data multiplexor/demultiplexor 20, the G3-FAX interface 16 decodes the received data into an analog signal and delivers the analog signal to the G3-FAX modular jack 107.

The RS232C connector 105 serves as an RS232C interface, and it is a connector to which a computer, a word processor or an electronic blackboard can be connected. This RS232C connector 105 is connected to the control unit 26 or the data multiplexor/demultiplexor 20 through the bus SW 22. The communication interface matching section 21 matches the data rate of the input/output data of the data multiplexor/demultiplexor 20 with that of the input/output data of the RS232C interface 105. The communication ports 24 and 25 are ones which the control unit 26 uses in relation to the RS232C interface 105.

The V11/RS422 multiconnector 106 serves as a V11 interface and an RS422 interface, and it is a connector for connecting an external device. In this embodiment, an example in which a conference unit is connected will be described later.

The multiconnector 106 as the RS422 interface is connected to the control unit 26 through the bus SW 22. The communication port 23 is one which the control unit 26 uses in relation to the RS422 interface 106. The multiconnector 106 as the V11 interface is connected to the data multiplexor/demultiplexor 20.

In compliance with the commands of the control unit 26, the peripheral device control interfaces 27 and 28 control the various components in the teleconference terminal equipment, a mouse connected to the mouse jack 104, and a conferential console connected to the conference console connector 103. Also, they control an external device such as external camera through the camera control/external device multiconnector 101.

Incidentally, the camera control/external device multiconnector 101 transfers the command of the control unit 26 to the external device by means of the no-voltage contact 31.

The details of the picture codec 5 will be explained below

FIG. 2 illustrates the construction of the picture codec 5.

Referring to the figure, the picture codec 5 includes an A/D (analog-to-digital) converter 200, a video coder 201, a still picture coder 202, a variable-length coder 203, a BCH (Bose-Chaudhuri-Hocquenghem code unit) 204, a PinP (picture-in-picture) processor 205, a video decoder 206, a D/A (digital-to-analog) converter 220, a still picture decoder 207, a variable-length decoder 208, a BCH 209, and video switches 210, 211, 212, 213, 214 and 215.

Thus, in this embodiment, a still picture and video are treated, but the signals thereof are digitized by the single A/D converter 200. This is based on the fact that the still picture and the video are not usually transmitted at the same time on account of the limited transmission capacity of a communication channel employed in a digital communications network. That is, in order to quickly send the still picture of large data quantity to the opposite communicating terminal equipment, the transmission of the video is usually suspended during that of the still picture.

Besides, in this embodiment, a still picture and video which have been received are displayed in a multiplexed state within an identical frame through the PinP processor 205 to be detailed later, thereby making it more convenient for use. Moreover, the still pictures and video are multiplexed into the identical frame before analogizing the signals of the respective pictures, whereby the single D/A converter 220 suffices for turning the picture data of both the pictures into analog signals.

Next, the operation of the picture codec 5 will be explained.

When supplied with a picture signal through the VSW 4, the A/D converter 200 converts the picture signal into a digital signal. Incidentally, although an NTSC signal is assumed as the picture signal to-be-input in this embodiment, even a signal conforming to another standard such as PAL or RGB can be similarly processed. The digitized picture data is transferred to the PinP processor 205 as the picture data of the pertinent terminal equipment itself.

Under the control of the peripheral device control interface 27, the video switches 210 and 211 deliver the digitized picture data to either the video coder 201 or the still picture coder 202, depending upon whether the input picture signal is for a still picture or video.

The video coder 201 codes the delivered picture data in accordance with code rules based on the DCT (discrete cosine transform) stipulated in CCITT Recommendation H. 261. Also, the still picture coder 202 codes the delivered picture data in accordance with predetermined code rules. When supplied with the coded picture data through the video switch 212 from either the video coder 201 or the still picture coder 202, the variable-length coder 203 turns the supplied image data into a variable-length code in accordance with variable-length code rules stipulated in CCITT Recommendation H. 261. When supplied with the variable-length code of the image data from the variable-length coder 203, the BCH 204 adds BCH data for error correction to the supplied code into video data and transfers the video data to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 through the multipoint conversation control 7.

On the other hand, when the BCH 209 is supplied with video data or still picture data through the multipoint conversation control 7 from the multimedia multiplexing/demultiplexing and interterminal signal control unit 8, it checks BCH data for error correction and delivers the error-corrected video data or still picture data to the variable-length decoder 208. This variable-length decoder 208 decodes the delivered picture data in accordance with the variable-length code rules stipulated in CCITT Recommendation H. 261. The data decoded by the variable-length decoder 208 is transferred to either the video decoder 206 or the still picture decoder 207 through the video switch 215, depending upon whether it is the video data or the still picture data. When supplied with the video data decoded by the variable-length decoder **208**, the video decoder **206** decodes it in accordance with the code rules stipulated in CCITT Recommendation H. 261. Also, when supplied with the still picture data decoded by the variable-length decoder **208**, the still picture decoder **207** decodes it in accordance with predetermined code rules such as code rules conforming to the JPEG Joint Photographic Expert Group algorithm of the ISO International Organization of Standardization Standard published March 1991. The picture data decoded by video decoder **206** or still picture decoder **207** is transferred as received motion picture data or received still picture data to the PinP processor **205** through the corresponding video switch **213** or **214**.

If necessary, the PinP processor **205** performs a PinP process to be described later, by the use of the image data of the pertinent terminal equipment itself transferred from the A/D converter **200** and the image data decoded by the video decoder **206** or the still picture decoder **207**, and it supplies the D/A converter **220** with the resulting image data which has been subjected to the PinP process. The D/A converter **220** converts the supplied image data into an analog signal, which is delivered to the video switch **4**.

Then, the picture signal is presented as a display output on the LCD **2** or the like in accordance with the operation of the video switch **4**.

Next, the details of the PinP processor **205** will be explained.

FIG. 3 illustrates the construction of the PinP processor **205**.

Referring to the figure, the PinP processor **205** includes a self-picture frame memory **301**, a still-picture frame memory **302**, a video frame memory **303**, MUX'es (multiplexors) **305**, **306** and **307**, a major-frame address generator **308**, a minor-frame address generator **309**, a display frame timing controller **310**, and a MUX **311**.

Next, the PinP process which is performed by the PinP processor **205** will be explained with reference to FIG. 4.

The "PinP process" is a process for producing a picture-in-picture frame from a plurality of pictures. That is, it is a process for multiplexing and outputting two picture data in order that different output pictures may be displayed in a major frame area and a minor frame area as illustrated in FIG. 4.

In this embodiment, the two picture data are selected from among the three picture data of the self-picture data transferred from the A/D converter **200**, the received still picture data transferred from the still picture decoder **207** and the received motion picture data transferred from the video decoder **206**, and they are multiplexed and output so as to be displayed in the major and minor frame areas. In the case where, in this manner, the PinP process is carried out by selecting two from the three picture data of the self-picture data, received still picture data and received motion picture data, six types of picture-in-picture frames can be produced as shown at symbols (a)-(f) in FIG. 4.

The PinP process of the PinP processor **205** proceeds as stated below.

The self-picture frame memory **301** stores the transferred self-picture data therein. The still-picture frame memory **302** stores the received still picture data therein. The video frame memory **303** stores the received motion picture data therein. The contents of the individual frame memories are sequentially updated.

The major-frame address generator **308** generates addresses for fetching the data of a picture to be displayed in the major frame area, in display sequence from the frame memory in which the picture data are stored. While the major-frame address generator **308** is generating the data addresses of the above picture corresponding to the major frame area, the minor-frame address generator **309** generates in parallel with the address generation of the generator **308**, addresses for fetching the data of a picture to be displayed in the minor frame area, in display sequence from the frame memory in which the picture data are stored. On this occasion, the address generation timings of the minor-frame address generator **309** are controlled by the display timing controller **310**. Besides, the picture to be displayed in the minor frame area must be reduced in size as shown in FIG. 4. Therefore, the minor-frame address generator **309** generates skipped addresses in accordance with a reduction rate so as to thin out pixels and then fetch the picture data from the frame memory.

Herein, the addresses generated by the major-frame address generator **308** are afforded through the corresponding MUX **305**, **306** or **307** to the frame memory **301**, **302** or **303** in which the picture data to be displayed in the major frame area are stored. Likewise, the addresses generated by the minor-frame address generator **309** are afforded through the corresponding MUX **305**, **306** or **307** to the frame memory **301**, **302** or **303** in which the picture data to be displayed in the minor frame area are stored.

While the minor-frame address generator **309** is generating the aforementioned addresses corresponding to the minor frame area, the MUX **311** selects and delivers the picture data fetched from the frame memory in which the picture data to be displayed in the minor frame area are stored. At any other time, the MUX **311** selects and delivers the picture data fetched from the frame memory in which the picture data to be displayed in the major frame area are stored. A change-over timing for these operation modes of the MUX **311** is controlled by the display timing controller **310**.

Incidentally, the frame memories of the PinP processor **205** may well be shared for frame memories which the video coder **201**, still picture coder **202**, video decoder **206** and still picture decoder **207** use for the coding and the decoding.

Next, the details of the G3-FAX interface **16** will be explained.

FIG. 5 illustrates the construction of the G3-FAX interface **16**.

Referring to the figure, the interface **16** includes a hybrid **501**, a route SW (switch) **502**, a codec **503** for the facsimile, and a FAX sending/receiving call control **504**.

When the FAX sending/receiving call control **504** is informed of the reception of G3-FAX data through the peripheral device control interface **27** by the control unit **26**, it applies a ringer signal to the G3-FAX modular jack **107**. In addition, the FAX sending/receiving call control **504** detects the off-hook or on-hook condition of the G3 FAX connected with the G3-FAX modular jack **107** and reports the detected condition to the control unit **26** through the peripheral device control interface **27**. Besides, if necessary, the control **504** reports the content of dialing in the G3 FAX connected with the G3-FAX modular jack **107**, to the control unit **26** through the peripheral device control interface **27**.

The hybrid **501** matches the half-duplex interface of the G3-FAX modular jack **107** with the full-duplex interface of the route SW side. In a case where the route SW **502** has been informed to the effect of treating the G3-FAX data as data to-be-multiplexed, through the peripheral device control interface **27** by the control unit **26**, it connects the hybrid

501 to the audio codec 12. In consequence, the audio codec 12 codes the data sent by the connected G3 FAX and transfers the coded data as audio data to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 through the multipoint conversation control 7.

On the other hand, in a case where the route SW 502 has been informed to the effect of treating the G3-FAX data as audio data, through the peripheral device control interface 27 by the control unit 26, it connects the hybrid 501 to the codec 503 for the FAX. The FAX codec 503 codes the sent data of the connected G3 FAX in accordance with the μ/A rules, the ADPCM or the like, and transfers the coded data as data to-be-multiplexed to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8 through the data multiplexor/demultiplexor 20.

In this manner, according to this embodiment, the ordinary G3 FAX can be connected to the teleconference terminal equipment and then used without altering the interface thereof. Furthermore, the G3-FAX data is coded using the FAX codec 503 and then treated as the data to-be-multiplexed, whereby a telephone conversation is possible with the audio codec 12 even during communications with the G3 FAX.

Next, the camera control/external device multiconnector 101 will be explained.

The teleconference terminal equipment according to this embodiment can have an external camera, an external monitor, an external microphone/external loudspeaker, etc. connected thereto by the video I/O interface 110, the audio I/O interface 109, the microphone input 108, etc.

The camera control/external device multiconnector 101 is a connector for controlling the external camera as well as illumination therefor, and the external microphone among the aforementioned external I/O devices. The control employing this multiconnector 101 is realized in such a way that the control unit 26 controls the no-voltage contact such as the relay contact 31 in compliance with an instruction from the dial function keys 3, an instruction from the console connected to the conference console connector 103, or control data received from the opposite communicating terminal equipment and transferred through the multimedia multiplexing/demultiplexing and interterminal signal control unit 8. Incidentally, in the case stated before where the frame stipulated in CCITT Recommendation H. 221 is presumed as the communication frame, the control unit 26 receives the control data in the form of the FAS, BAS or MLP data from the opposite communicating terminal equipment and controls the no-voltage contact 31 in accordance with the received control data.

FIG. 6 illustrates the construction of the camera control/external device multiconnector 101. As shown in the figure, the multiconnector 101 contains the signals of spare 613; zooming 612, 611; focusing 610, 609; illumination 608; wiper 607; panning 606, 605; tilting 604, 603; camera/microphone changing-over 602, 601; and power source 600.

Using these signals, the control unit 26 can control the zooming and focusing of the external camera, and the illumination, a wiper, and panning and tilting for the external camera, through the camera control/external device multiconnector 101. Also, it can control the change-over between the camera and the microphone, and the turn-ON/OFF of the power source of any desired external device through the multiconnector 101.

Next, the V11/RS422 multiconnector 106 will be explained.

The V11/RS422 multiconnector 106 is a connector which includes a V11interface and an RS422 interface.

In this embodiment, it is assumed that the conference unit to be described later is connected to the V11/RS422 multiconnector 106.

The RS422 interface within the V11/RS422 multiconnector 106 is connected with the control unit 26 through the communication port 23. The control unit 26 transfers control data to and from the conference unit by the use of the RS422 interface.

The V11interface within the V11/RS422 multiconnector 106 is connected to the data multiplexor/demultiplexor 20 and the audio codec 12. On the basis of the control of the control unit 26, the data multiplexor/demultiplexor 20 demultiplexes control data and data to-be-demultiplexed supplied from the multimedia multiplexing/demultiplexing and interterminal signal control unit 8, and it delivers the resulting data to the V11 interface. Contrariwise, the data multiplexor/demultiplexor 20 multiplexes control data and data to-be-multiplexed delivered from the V11interface, with FAX data etc. delivered from the G3-FAX interface 16, and it supplies the resulting data to the multimedia multiplexing/demultiplexing and interterminal signal control unit 8. Incidentally, in the case of employing the aforementioned H. 221 frame as the communication frame, MPL data can be used as the control data.

Herein, the data which is delivered from the data multiplexor/demultiplexor 20 to the V11interface is in the form of the actual burst data demultiplexed and extracted from the communication frame. Likewise, the data which is delivered from the V11interface to the data multiplexor/demultiplexor 20 is burst data having the same transfer rate as that of data contained in the communication frame.

As stated above, in this embodiment, the data area and control data area of the communication frame can be opened to the exterior as they are. Accordingly, the V 11 interface can freely utilize the predetermined data area or control data area contained in the communication frame.

Here, FIG. 7 illustrates the construction of the V11/RS422 multiconnector 106.

Referring to the figure, parts 700–702 constitute the RS422 interface, and parts 703–710 the V11interface.

The RS422 interface includes the lines of transmission data 700, reception data 701 and a transfer clock 702. The V11 interface includes the lines of sending data 703, a sending burst clock 704 synchronized with sending burst data, a sending frame sink 705, receiving data 706, a receiving burst clock 707 synchronized with receiving burst data, a receiving frame sink 708, and two types of basic clocks 709, 710.

Next, the external appearance of the teleconference terminal equipment according to this embodiment are illustrated in FIGS. 8(*a*) and 8(*b*).

FIG. 8(*a*) is a perspective view of the terminal equipment seen obliquely from the front thereof, while FIG. 8(*b*) is a rear view of the essential portions thereof showing the arrangement of connectors.

Now, the constructions of teleconference systems each of which employs the teleconference terminal equipment according to this embodiment will be described with reference to FIG. 9 thru FIG. 13. In these figures, numeral 1000 indicates the teleconference terminal equipment.

FIG. 9 shows the teleconference system which is suitable for the personal telephonic communications between one person and another, FIG. 10 shows the teleconference system which is suitable for a teleconference among a small number of people, FIG. 11 shows the teleconference system of simplified type which is used for a teleconference, FIG. 12 shows the teleconference system which is suitable for a regular teleconference, and FIG. 13 shows the teleconference system which is suitable for a larger teleconference.

As seen from the figures, according to the teleconference systems in this embodiment, a G3 FAX 900, a computer 901 such as a personal computer or word processor, a camera 903, a monitor 904, a microphone 905, a camera pan-tilter 906, a conference console 907, etc. can be connected by the video I/O interface 110, audio I/O interface 109, microphone input 108, G3-FAX modular jack 107, V11/RS422 multiconnector 106, RS232C connector 105, mouse jack 104, conference console connector 103, and camera control/external device multiconnector 101. Thus, the teleconference systems can be flexibly constructed in accordance with intended uses.

In particular, according to the teleconference system in this embodiment, the external interface based on the digital data of the audio codec 12 is included in the V11/R422 multiconnector 106 as stated before. As shown in FIG. 12, therefore, a digital echo canceler 1200 of high performance can be disposed outside if it is need.

As shown in FIG. 13, a G3 FAX 900, data processing devices 901 such as a personal computer or word processor and an electronic blackboard, a camera 903, a monitor 904, microphones 905, a camera pan-tilter 906,. a conference console 907, etc. may well be connected through a conference unit 1300 so as to realize higher degrees of conference functions.

As shown in FIG. 13, the conference unit 1300 includes a video controller 1301, an audio controller 1302, a unit controller 1303, a video processor 1305 and a power source unit 1306. The video controller 1301 is connected to the video I/O interface 110 of the teleconference system. The audio controller 1302, unit controller 1303 and video processor 1305 are connected with the V11/RS422 multiconnector 106 of the teleconference system through the unshown data interface unit thereof.

The unit controller 1303 controls any of the constituents of the conference unit 1300 in compliance with an instruction from the conference console 907, an instruction from the control unit 26 of the teleconference system as delivered through the RS422 interface, or control data received through the V11 interface from the opposite communicating terminal equipment. In addition, the unit controller 1303 transfers data received through the V11interface from the opposite communicating terminal, equipment, between this V11interface and the data processing devices 901 such as the personal computer or word processor and the electronic blackboard.

The video controller 1301 and the still picture processor control the change-over between the camera and the monitor, for example, which are connected to the video I/O interface 110 of the teleconference system. The audio controller 1302 controls the change-over between the microphone and the loudspeaker, for example, which are connected to the audio codec 12 of the teleconference system through the V11 interface. In addition, the audio controller 1302 performs an echo canceling process as may be needed. The video processor 1305 performs the control of the camera pan-tilter 906.

In this manner, according to the teleconference system of this embodiment, the pertinent terminal equipment can communicate with the conference unit connected to the opposite communicating terminal equipment through the mutual direct controls which are performed by the use of the data area and the control data area opened to the external devices as stated before.

As thus far described, according to the first embodiment, it is possible to provide the teleconference system in which the still picture and the video can be simultaneously displayed on the single screen.

Now, the second embodiment of a teleconference terminal equipment according to the present invention will be described.

First, FIG. 14 illustrates the construction of a teleconference system which employs the teleconference terminal equipment according to this embodiment.

Referring to the figure, the embodiment includes the teleconference terminal equipment 2001 connected to a digital communications network, a control keyboard 2002, microphones 2003, a document photographing stand 2004, an electronic blackboard 2005 and a video tape recorder 2006.

The illustrated teleconference system is fundamentally configured of the teleconference terminal equipment 2001, the control keyboard 2002 connected to the teleconference terminal equipment 2001, and the microphones. 2003 connected to the teleconference terminal equipment 2001 through the control keyboard 2002. If necessary, the system is additionally furnished with the document photographing stand 2004, electronic blackboard 2005 and video tape recorder 2006 by connecting them to the teleconference terminal equipment 2001. Besides, as will be described later, a facsimile machine and a small-sized computer can be connected to the teleconference terminal equipment 2001 as required.

As shown in the figure, the teleconference system of this embodiment features the desktop type teleconference terminal equipment 2001. Owing to the desktop type construction, when the teleconference terminal equipment 2001 is carried in with the control keyboard 2002 and the microphones 2003, a teleconference can be held in an ordinary conference room or by the use of a mere conference desk.

The teleconference terminal equipment 2001 will now be explained.

FIG. 15 illustrates the external appearance of the teleconference terminal equipment 2001 according to this embodiment. Referring to the figure, numeral 2100 indicates the body of the terminal equipment 2001, numeral 2101 amonitor employing a cathode-ray tube 11 inches in size, numeral 2102 a camera window, numeral 2103 a ringer speaker, and numeral 2110 a base. Although not seen in the figure, a speaker window (for a loudspeaker 2104) is provided on the left side of the body 2100, and various terminals are provided on the rear surface thereof. A built-in camera is disposed behind the camera window 2102.

Next, FIG. 16A is a side view of the teleconference terminal equipment 2001, while FIG. 16B is a sectional view thereof taken along line A1-A2 in FIG. 15. Here, mechanisms inside the body 2100 are omitted from the illustrations.

As shown in FIGS. 16A and 16B, the body 2100 and the base 2110 are connected by a tilt and swivel mechanism 2121, so that the body 2100 is turnable relative to the base 2110 through predetermined angles in the vertical and horizontal directions. That is, the body 2100 is turnable about an arbor 2122 through the predetermined angle in the horizontal direction, and it is turnable along a slot 2123 through the predetermined angle in the vertical direction.

Incidentally, numeral 2130 denotes a terminal area where the various input/output terminals are disposed.

In this embodiment, the camera includes a wide-angle lens of 57°. By employing the wide-angle lens for the camera in this manner, a plurality of users can be simultaneously photographed even when they are a short distance away. Accordingly, a plurality of conferees at a conference desk on each communicating side, for example, can hold a teleconference merely by putting the teleconference terminal equipment 2001 on one end of the conference desk. Incidentally, in this embodiment, it is assumed as standard that several conferees will utilize the teleconference terminal equipment 2001 having the 11-inch monitor 2101, at a position which is about 1.5 meters remote from this teleconference terminal equipment. Thus, the wide-angle lens is set at 57° so that a horizontal width of 1.5 meters can be photographed at the aforementioned position. The wide-angle lens, however, may well be set at any suitable angle, depending upon the size of the screen of the monitor and the service conditions of the teleconference terminal equipment. In general, an angle of about 60° will be desirable.

Meanwhile, the control keyboard 2002 should preferably be provided separately from the teleconference terminal equipment 2001 to enable the smooth progress of the conference. Alternatively, however, a control keyboard may well be provided unitarily with a teleconference terminal equipment.

By way of example, FIGS. 17A and 17B illustrate the external appearance of the teleconference terminal equipment which is unitarily provided with the control keyboard 2002.

As shown in the figures, in this example, the control keyboard 2002 is mounted on the base 2110 between the body 2100 and this base. Besides, as shown in FIG. 18A, this control keyboard 2002 is mounted on the base 2110 by a turning mechanism 2125. Accordingly, it can be housed under the body 2100 as shown in FIG. 18B while the terminal equipment is not used. Moreover, with such a turnable control keyboard, each of the conferees is easily able to operate the control keyboard during the use of the terminal equipment.

Although the camera is arranged by the side of the cathode-ray tube in each of the foregoing teleconference terminal equipments of the second embodiment, it may well be arranged above the cathode-ray tube.

By way of example, FIG. 19 illustrates the external appearance of a teleconference terminal equipment in which the camera is arranged above the cathode-ray tube 2101.

Referring to the figure, numeral 2102 indicates a camera window, behind which the camera is installed. Numeral 2130 indicates a drawer type handle which is attached in order to facilitate carrying the teleconference terminal equipment. In this example, loudspeakers 2104 are arranged in the front of the teleconference terminal equipment. Also in this example, the body 2100 and the base 2110 are connected by a turning mechanism, whereby the teleconference terminal equipment can be freely positioned in the horizontal direction. Incidentally, the teleconference terminal equipment of this example can be operated through a wireless remote control from the control keyboard 2002.

Next, FIGS. 20A and 20B illustrate another example of the teleconference terminal equipment in which the camera is arranged above the cathode-ray tube 2101.

As clearly shown in FIG. 20B, the depthwise dimension of the camera arranged behind the camera window 2102 is short compared with that of the cathode-ray tube 2101. This fact is utilized here in the example, and the part of the teleconference terminal equipment behind the camera window 2102 is shortened to form a carrying handle 2131.

Now, the internal construction of the teleconference terminal equipment 2001 will be explained.

FIG. 21 shows the internal construction of this teleconference terminal equipment. As shown in the figure, the internal construction of the teleconference terminal equipment according to the second embodiment is substantially the same as that of the teleconference terminal equipment according to the first embodiment described with reference to FIG. 1 before.

Referring to the figure, numeral 2830 indicates a terminal which is to be connected to the digital communications network. In this embodiment, the digital communications network is assumed to be the ISDN (integrated service digital network), and the terminal 2830 to be a modular jack having eight pins. Besides, the teleconference terminal equipment 2001 includes the camera 2807, the monitor 2101, the loudspeaker 2104, a video switch 2806, a video amplifier 2808, a picture codec 2805, a multimedia multiplexing/demultiplexing and interterminal signal control unit 2804, a network interface and communications network control unit 2803, an audio codec 2810, an echo canceler 2811, an audio switch 2813, an audio amplifier 2812, a FAX interface 2814, a data interface 2815, a control unit 2802 and a power source 2801.

Included as the external I/O terminals are video I/O interfaces 2816 and 2817, audio I/O interfaces 2818 and 2819, a modular jack 2820 for a G3 FAX (group 3 facsimile), an RS232C connector 2821, and a connector 2822 for the control keyboard 2002. These connectors and the above terminal 2830 are arranged on the rear surface of the teleconference terminal equipment 2001 (refer to FIG. 15).

Herein, the network interface and communications network control unit 2803 is connected to the ISDN through the connector 2830, and it performs the communication controls and communication processing between the pertinent teleconference terminal equipment and the network, such as establishing a communication channel with the opposite communicating terminal equipment. The multimedia multiplexing/demultiplexing and interterminal signal control unit 2804 performs various controls between the pertinent terminal equipment and the opposite terminal equipment. Besides, this control unit 2804 demultiplexes video data, audio data, data to be multiplexed/demultiplexed, control data, etc. from within a received communication frame into the individual data types, and it multiplexes such types of data into a transmission communication frame. The video data mentioned above is interface data on the network side of the picture codec 2805, while the audio data is interface data on the network side of the audio codec 2810. The data to be multiplexed/demultiplexed is interface data with respect to the data interface 2815 and the FAX interface 2814. The control data is transferred between the control unit 2804 and the control unit 2802.

The multimedia multiplexing/demultiplexing and interterminal signal control unit 2804 further demultiplexes the data demultiplexed from within the received communication frame, into G3-FAX data, computer data, various control data, etc. in accordance with protocols stipulated with the opposite transmission terminal equipment beforehand, and it delivers these data to the G3-FAX modular jack 2820 and RS232C connector 2821 through the FAX interface 2814 and data interface 2815, respectively.

Conversely, the control unit 2804 accepts data to be transmitted in a multiplexed state, from the G3-FAX modular jack 2820 and RS232C connector 2821.

The camera 2807 picks up an image, and the monitor 2101 presents the display output of a picture corresponding to the image. The video switch 2806 supplies the picture codec 2805 with an input from the video signal input terminal 2816, instead of an input from the camera 2807. Thus, the document photographing stand 2004 as well as an external camera and the picture codec 2805 can be connected to the video input interface 2816.

The picture codec 2805 codes an input picture signal, and delivers the resulting coded signal to the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804. In addition, it decodes video data demultiplexed from within a received communication frame by the control unit 2804 and then delivers the resulting decoded data to the monitor 2101 and the video output interface 2817. Accordingly, the video tape recorder 2006 can be connected to the video output interface 2817 so as to record the contents of the teleconference. Also, an external monitor can be connected.

The audio input and output terminals 2818 and 2819 can have the audio input and outputs of external audio devices connected thereto. The audio switch 2813 is one by which any of an input from the G3 FAX connected to the FAX interface 2814, an input from a device connected to the audio input interface 2819, and an input from the microphones 2003 coupled with the control keyboard 2002 connected to the connector 2822 is transferred to the audio codec 2810 through the echo canceler 2811.

The audio codec 2810 codes an input speech signal, and delivers the resulting coded signal to the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804. In addition, it decodes audio data demultiplexed from within a received communication frame by the control unit 2804 and then delivers the resulting decoded data to the loudspeaker 2104 and the audio output interface 2818 through the echo canceler 2811 as well as the audio amplifier 2812. The audio output interface 2818 has, for example, the audio input terminal of the video tape recorder 2006 connected thereto. The echo canceler 2811 performs an echo canceling process between the speech signal decoded from the audio data and the speech signal delivered from the audio switch 2813, thereby preventing the occurrence of howling during communications. Incidentally, the howling may well be prevented by replacing the echo canceler 2811 with an echo suppressor which suppresses a selected one of the output from the audio amplifier 2812 or the input to the audio switch 2813.

The FAX interface 2814 delivers a signal to-be-transmitted supplied from the G3 FAX being an analog FAX connected to the G3-FAX modular jack 2820, to the audio codec 2810 in the case of treating the FAX data as audio data, while it digitizes the signal to-be-transmitted into a code and delivers the code to the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804 in the case of treating the FAX data as data to-be-multiplexed. Contrariwise, when supplied with received data for the G3 FAX by the audio codec 2810, the FAX interface 2814 supplies the G3-FAX modular jack 2820 with the received data directly, and when supplied with received G3 FAX data by the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804, the FAX interface 2814 decodes the received data into an analog signal and delivers the analog signal to the G3-FAX modular jack 2820.

The RS232C connector 2821 serves as an RS232C interface, and it is a connector to which a computer, a word processor or an electronic blackboard can be connected. This RS232C connector 2821 is connected to the control unit 2802 or the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804 through the data interface 2815.

The control unit 2802 performs serial data communications with the control keyboard 2002. Besides, it performs various controls for the constituents of the teleconference terminal equipment 2001, for example, the display control of a menu picture to be described later, on the basis of data transferred from the multimedia multiplexing/demultiplexing and interterminal signal control unit 2804 and data transferred from the control keyboard 2002.

Meanwhile, the picture codec 2805 codes and decodes pictures in conformity with algorithms stipulated in CCITT Standard, H. 261. Herein, it can be reduced in size by applying recent highly-packaged circuit technology. A picture codec is implemented with two circuit boards each having a size nearly equal to the A5-format in, for example, a commercially-available video telephone set HV-100 (trade name) manufactured by Hitachi, Ltd. In the future, such picture codecs will be increasingly reduced in size.

Accordingly, the teleconference terminal equipment of this embodiment can be satisfactorily realized with the dimensions mentioned before in relation to FIG. 15 and FIGS. 16A and 16B, for the 11-inch cathode-ray tube. Moreover, these dimensions afford a size which is suited to installation of the terminal equipment on a desk or to carrying.

Next, the control keyboard 2002 will be explained.

FIG. 22 shows the external appearance of the control keyboard 2002. As shown in the figure, the control keyboard 2002 is in the shape of a sector. Various keys are arranged on the upper surface of this control keyboard, while terminals 2910 for connecting microphones and also terminals for cables for connections with the teleconference terminal equipment 2001 are disposed on the rear surface. Besides, a built-in microphone 2920 is arranged in the front of this control keyboard.

The keys disposed on the upper surface of the control keyboard 2002, and functions which are designated by these keys will be listed in Tables 1 and 2 below:

TABLE 1

Names	Outlines of Functions
START	Transmit func: dialing. Preset func: Input acknowledging dial.
REDIAL	Retransmitting to last called address.
SPD DIAL	Speedy dialing to registered No. by designating the No.
MUTE	Turning off transmission speech, and transmitting mute.
CANCEL	Deleting last input letter. (Also, ending help.)
COM	Alternating HOOK states.
MENU	Registering, setting and acknowledging TEL directory, operation modes, etc.
VIDEO	Non-com. period: Changing-over Auto/Manual picture sending. Com. period: Requesting for manual picture sending.
MON/PIP	Monitor-displaying transmission picture (coded picture) on Whole screen/Minor screen.
FREEZE	Freezing input of transmission picture.
AUDIO SRC	Changing-over transmission speech between handset input and external speech input.
VIDEO SRC	Changing-over transmission picture between accessory camera input and external video input.
HELP	Displaying help information on function keys, etc.

TABLE 1-continued

Names	Outlines of Functions
FAX	Connecting FAX and TEL circuit for transmission/reception.
DATA	Turning ON/OFF RS232C port for data com. between both terminal. equipments.
TELE ↑	Zooming out built-in camera. (Hard)
WIDE ↓	Zooming in built-in camera. (Hard)
VOL ↑	Increasing sound volume of loudspeaker. (Hard)
VOL ↓	Decreasing sound volume of loudspeaker. (Hard)

TABLE 2

Names	Outlines of Functions
CURSOR ↑	Spare, tilt ↑.
CURSOR ↓	Spare, tilt ↓.
CURSOR →	Spare, pan →.
CURSOR ←	Spare, pan ←.
PIC Q SEL	Changing-over quality of transmission picture in 3 stages (STD/FAST/DETAIL).
HS	Changing-over loudspeaker and handset.
LOC/RMT	Changing-over LOCAL/REMOTE for panning, tilting, zooming or focusing control.

Typical keys will be explained. In FIG. 22, numeral 2901 indicates a volume control for controlling the sound volume of the loudspeaker 2104 built in the teleconference terminal equipment 2001. Numeral 2902 indicates keys for controlling the zooming functions of the camera 2807. Denoted by numeral 2903 are numerical-keys and function keys which serve to control the communication functions of the teleconference terminal equipment 2001, and which are equivalent to those of an ISDN terminal equipment. In this embodiment, however, the numerical-keys are shared with alphabet keys. Keys 2904 serve to control a pan-tilter which is sometimes installed for the camera 2807 of the teleconference terminal equipment 2001. Besides, keys 2905 serve to change-over the picture qualities of pictures to-be-transmitted, a key 2906 serves to change-over the input of the built-in camera 2807 of the teleconference terminal equipment 2001 and the input of the external camera set on, for example, the document photographing stand 2004 as a transmission picture, and keys 2907 and 2908 serve to change-over transmission data from video or audio data to input data from the facsimile machine and small-sized computer connected to the teleconference terminal equipment 2001, respectively. Further, indicators, such as an LED 2909 for indicating the connection of the power supply, are provided on the upper surface of the control keyboard 2002.

FIGS. 23A and 23B show the internal construction of the control keyboard 2002.

As shown in FIG. 23A, the control keyboard 2002 includes a switching regulator 3001 by which a supply voltage fed from the teleconference terminal equipment 2001 is distributed to the individual parts of this control keyboard, key switches 3002 which constitute the various keys stated before, and LED's 3003. In addition, it includes a CPU 3007 which controls the key switches 3002 and the LED's 3003 while performing the serial data communications with the teleconference terminal equipment 2001 by the use of data clock pulses supplied from this teleconference terminal equipment. Also included are the built-in microphone 2920, the microphone jacks 2910 for connecting the external microphones 2003, a microphone mixer 3005 for mixing an input from the built-in microphone 2920 and inputs from the external microphones 2003, and the volume control 2901 for adjusting the sound volume of the loudspeaker of the teleconference terminal equipment 2001. Shown at numeral 3006 are terminals for cables 3010 which lead to the teleconference terminal equipment 2001.

As seen from the figures, the connections between this control keyboard 2002 and the teleconference terminal equipment 2001 are collectively effected by the single composite cable 3010. Besides, an output from the microphone mixer 3005 is sent to the teleconference terminal equipment 2001 through a transformer of 600 ohms by the use of a shielded cable 3011 which is disposed within the composite cable 3010 as shown in FIG. 23B.

Next, the document photographing stand 2004 will be explained.

FIG. 24 shows the external appearance of the document photographing stand 2004.

Roughly speaking, the document photographing stand 2004 is constructed of a work surface 3101, a lower link 3102, an upper link 3103 and the camera 3104. Besides, an LED 3105 is embedded in the central part of the platen 3101 to-be-photographed, and camera controlling keys 3106 are disposed at one corner of the work surface 3101. The camera controlling keys 3106 include zooming control keys (wide angle/telescopic), an autofocusing function enabling key and a manual focusing controlling key for the camera 3104.

The lower link 3102 is pivotally mounted on the work surface 3101, the upper link 3103 is pivotally mounted on the lower link 3102, and the camera 3104 is pivotally mounted on the upper link 3103. Thus, the camera 3104 can photograph, not only a document set on the work surface 3101, but also spaces before and behind the work surface 3101. Accordingly, when the blackboard 2005 is arranged behind the work surface 3101 as shown in FIG. 14 referred to before, characters, patterns etc. written and drawn on this blackboard can be photographed and transmitted except during the photographing of the document.

The LED 3105 embedded in the central part of the work surface 3101 serves to facilitate the positioning of the document to-be-photographed. More specifically, when an illuminator is provided in this manner, the central point of photographing can be readily established using the transmitted light even for paper or the like which is placed on the work surface 3101 for photographing. Herein, LED's may well be disposed at the four corners of a photographing region on the work surface 3101 for a document of standard size (for example, A4-format or B5-format). Owing to the transmitted light beams of such LED's, the desired region of a document larger than the standard size can be established and photographed more easily than with a conventional work surface on which the four corners are marked.

In the drawings, FIGS. 25A and 25B are a side view and a rear view, respectively, of the document photographing stand 2004.

As shown in FIG. 25A, the length l of the lower link 3102 is set so as not to exceed the length L of the work surface 3101, and the length m of the upper link 3103 is set so as to be shorter than the length l of the lower link 3102. Besides, as shown in FIG. 25B, the width N between both the arms of the lower link 3102 is set greater than the width n between both the arms of the upper link 3103. Accordingly, as seen from a front view, a side view and a plan view depicted in FIGS. 38A, 38B and 38C, respectively, the lower link 3102 can be folded onto the work surface 3101, and the upper link 3103 can be folded inside the lower link 3102. Thus, the document photographing stand 2004 can be carried or stored in a compact state.

Alternatively, the document photographing stand 2004 may well be constructed as illustrated in FIGS. 26A, 26B and 26C.

FIG. 26A shows the state in which the stand 2004 is carried or stored. FIGS. 26B and 26C show the situation in which an upper link 3103 is turned relative to a lower link 3102. Numeral 3301 indicates stoppers to restrict the turning.

Further, the document photographing stand 2004 may well be constructed in a simpler form as illustrated in FIG. 27.

The example shown in FIG. 27 is configured of a work surface 3101, a camera 3104 and a single link 3401. The link 3401 can be lengthened and shortened by a slide mechanism, and the camera 3104 is connected to the link 3401 so as to be freely turnable relative to this link.

Finally, the man-machine interface of the teleconference system will be explained. During a teleconference, the received picture of the opposite communicating side is usually displayed on the screen of the monitor 2101. When the monitor/PIP key of the control keyboard 2002 stated before is depressed, the teleconference terminal equipment 2001 presents a minor frame at the right corner of the monitor 2101 and displays the self-picture thereof photographed by its own camera 2807, as illustrated in FIG. 28. Further, when the monitor/PIP key is depressed in this state, the teleconference terminal equipment 2001 displays the self-picture on the whole monitor screen, and when the key is depressed again, the teleconference terminal equipment 2001 brings the screen back into the usual state and displays the picture of the opposite communicating side on the whole monitor screen. Such a picture-in-picture display process has been described in connection with the first embodiment, and shall not be detailed here.

In addition, the teleconference terminal equipment 2001 guides operations and reports current statuses by the use of the display of the monitor 2101.

FIG. 29 illustrates the situations of the operation guidance and status report utilizing the monitor 2101.

Letter a in FIG. 29 denotes the display of the monitor 2101 upon connection of the power supply. The current time is indicated at the left upper corner part of the display screen of the monitor 2101.

When the start key of the control keyboard 2002 is depressed in this state, the monitor display is changed as shown at b in FIG. 29, and a message promoting for a dial input is indicated. Subsequently, when the numerals of the telephone No. of the opposite communicating side for the teleconference are input with the numerical-keys of the control keyboard 2002, they are successively indicated as shown at c in FIG. 29. Next, when the start key is depressed again by the operator of the control keyboard 2002 upon acknowledging the indicated telephone No., the teleconference terminal equipment 2001 establishes a channel with the ISDN to transmit the input No., and it presents a display to indicate that it is calling the opposite terminal as shown at d in FIG. 29. Then, when communications with the opposite terminal have begun, only the elapsed time since the beginning of communication is indicated as shown at e in FIG. 29.

On the other hand, in a case where a signal or ringing arrives at the teleconference terminal equipment 2001 during a non-communicating period, a display to the effect that the signal has arrived is presented together with the telephone No. of the transmitting source as shown at f in FIG. 29.

Moreover, the teleconference terminal equipment 2001 according to this embodiment offers other various functions in a menu form.

FIG. 30 illustrates menus which are displayed on the monitor 2101.

When the menu key among the control keys is depressed when the power supply is connected or during the communications, that is, in the display state shown at a or e in FIG. 29, the main menu shown at a in FIG. 30 is displayed.

In the menu a in FIG. 30, patterns are icons which are provided in correspondence with the offered functions. The icon 3701 serves to start a telephone directory function, the icon 3702 serves to start the function of setting any of the various statuses of the teleconference terminal equipment 2001 such as the communication mode and display mode thereof, the icon 3703 serves to start the function of adjusting the time of a timepiece built into the teleconference terminal equipment 2001, the icon 3705 serves to start the function of handling information items (opposite communicating sides, telephone Nos, fees, etc.) on past communications, and the icon 3706 serves to select whether or not the time displays shown in FIG. 29 are presented. Besides, the icon 3704 serves to end the menu. The respective icons are displayed in an arrangement corresponding to the arrangement of the numerals 1-6 of the numerical-keys of the control keyboard 2002, and the depression of the key at the corresponding position starts the function which is offered by the pertinent icon.

By way of example, when the telephone directory function is started by depressing the numerical-key "1", a menu as shown at b in FIG. 30 is displayed. More specifically, the same pattern as the icon having started this function is indicated at the uppermost part, and the names and telephone Nos. of the opposite communicating persons already registered are indicated in an area 3711. The user scrolls the indication within the area 3711 by designating an icon 3713 or 3714 through the depression of the numerical-key at the corresponding position and then appoints the opposite communicating person whose information is to be handled, by designating a select icon 3715 through the depression of the numerical-key at the corresponding position. An icon 3716 is used for returning to the menu picture a in FIG. 30.

Here, when the select icon 3715 is designated, a menu shown at c in FIG. 30 is displayed. The patterns of the icon which has started the corresponding function and the icon which was indicated at the uppermost part of the parent menu of this menu are indicated at the uppermost part, and all information items registered for the selected communicating person are indicated in an area 3721. A TEL icon 3722 serves to designate a transmission to the opposite communicating person indicated in the area 3721. When the numerical-key corresponding to this icon is depressed, the teleconference terminal equipment 2001 calls the selected communicating person in accordance with the registered information and ends the menu processing steps, to shift to the display shown at d in FIG. 29. An icon 3724 in the menu c in FIG. 30 serves to alter the registered information by way of example. More specifically, when the numerical-key corresponding to this icon is depressed, the function of, for example, altering the registered information is indicated, and a new menu corresponding to the function is displayed. In the new menu, necessary input functions are similarly assigned to the keys of the control keyboard 2002 so as to accept the user's inputs of information. Herein, by way of example, alternatives to an input character are sequentially changed-over in accordance with a predetermined input key. Moreover, the conversion of inputs into Chinese characters can be realized by extending the function of a predetermined input key.

Meanwhile, in a case where the register icon 3702 has been designated in the main menu a in FIG. 30, a menu shown at d in FIG. 30 is displayed. In this menu d in FIG. 30, the current statuses of the teleconference terminal equipment 2001 are indicated in an area 3731. The user designates any indicated item and also designates an alter icon 3732 in accordance with steps similar to those of the operation of the menu b in FIG. 30, whereby the status of the designated item can be changed to another alternative registered beforehand.

In this regard, in a case where the teleconference terminal equipment 2001 has been called amidst such a hierarchic menu process, a display to the effect that a signal or ringing has arrived is presented in an area 3733.

For reference, FIG. 31A thru FIG. 38C in the accompanying drawings illustrate the six views, etc. concerning the teleconference terminal equipment 2001 depicted in FIG. 15, the control keyboard 2002 depicted in FIG. 22 and the document photographing stand 2004 depicted in FIG. 24.

FIGS. 31A, 31B, 31C and 31D are a front view, a rear view, a plan view and a bottom view, respectively, of the teleconference terminal equipment 2001. The terminals 2816–2822 and 2830 are disposed in the area 2130 shown in FIG. 31B. FIGS. 32A and 32B are a right side view and a left side view, respectively, of the teleconference terminal equipment 2001. Numeral 2104 in FIG. 32B indicates the position of the built-in loudspeaker.

FIG. 33 is a perspective view of the control keyboard 2002. Numeral 2920 in this figure indicates the position of the built-in microphone. In addition, FIGS. 34A, 34B and 34C are a front view, a plan view and a bottom view, respectively, of the control keyboard 2002. Besides, FIGS. 35A, 35B, 35C, 35D, 35E and 35F are a right side view of the control keyboard 2002, a left side view thereof, a rear view thereof, a schematic sectional view thereof taken along line A–A' in FIG. 34A, a schematic sectional view thereof taken along line B–B' in FIG. 34B, and a schematic sectional view thereof taken along line C–C' in FIG. 34B, respectively. In FIG. 35C, numeral 2910 represents the terminals for connecting the external microphones.

Next, FIGS. 36A, 36B, 36C and 36D are a front view, a right side view, a plan view and a bottom view, respectively, of the document photographing stand 2004. In addition, FIGS. 37A and 37B are a rear view and a left side view, respectively, of the stand 2004.

As referred to before, FIGS. 38A, 38B and 38C are the front view, the side view and the plan view, respectively, of the document photographing stand 2004 in the stored condition. As shown in these figures, the stand 2004 has its constituents folded up into a compact form.

As described above, according to the second embodiment, it is possible to provide the desktop type teleconference terminal equipment which is small in size and which is easily portable.

What is claimed is:

1. A document photographing stand, comprising:

a work surface for placing a document thereon;

a lower link which is pivotally mounted on said work surface;

an upper link which is pivotally mounted on said lower link;

a camera which is pivotally mounted on said upper link; and

a marker for emitting a spot light;

wherein said lower link and said upper link are respectively turnable relative to said work surface and to said lower link up to a position at which said camera is supported above said work surface;

said camera, at said position at which said camera is supported above said work surface, photographs a reflection from a front surface of said document placed on said work surface; and

said marker, being inlaid on said work surface in one of a central position and a corner position of an area to be photographed by said camera, displays a spot mark on said front surface of said document placed on said work surface by the spot light which has been emitted from said marker and has passed through said document form a back surface of said document to said front surface of said document.

2. An equipment for a teleconference in which a few persons utilize the equipment, and for exchanging pictures and video of persons in real time throügh a digital communication channel, comprising:

communication control means for transmitting and receiving multiplexed video data, user data, facsimile data and audio data through said digital communication channel;

multiplex/demultiplex means for multiplexing and demultiplexing the video data, user data, facsimile data and the audio data to be transmitted by said communication control means and having been received by the same, respectively;

a picture codec which decodes a picture signal from said video data demultiplexed by said multiplex/demultiplex means and then delivers said picture signal as an output, and which codes an input picture signal to-be-coded into said video data and then transfers said vide data to said multiplex/demultiplex means;

a camera which includes a lens having an approximately 60° field of view, and which supplies said picture codec with a picture signal of picked-up-picture as the picture signal to-be-coded;

an external video input terminal which receives a video signal from outside of the equipment and which supplies said picture codec with the video signal as the picture signal to-be-coded;

a display unit which displays a picture represented by the picture signal decoded by said picture codec;

an external video output terminal which outputs the picture signal decoded by said picture codec to outside of the equipment;

an audio codec which decodes a speech signal form said audio data demultiplexed by said multiplex/demultiplex means and then delivers said speech signal as an output, and which codes an input speech signal to-be-coded into said audio data and then transfers said audio data to said multiplex/demultiplex means;

a loud speaker which emits speech based on said speech signal decoded by said audio codec;

an external audio output terminal which outputs said speech signal decided by said audio codec to outside of the equipment;

an external data input/output terminal which receives user data from outside of the equipment and which transfers the received user data to the multiplex/demultiplex means, said external data input/output terminal outputting user data demultiplexed by said multiplex/demultiplex means to outside of the equipment;

an external facsimile signal input/output terminal which receives facsimile signal form outside of the equipment and which transfers the facsimile data represented by the received facsimile signal to the multiplex/demultiplex means, said external facsimile signal input/output terminal outputting facsimile signal represented by the facsimile data demultiplexed by said multiplex/demultiplex means to outside of the equipment; and

a housing in which said communication control means, said multiplex/demultiplex means, said picture codec, said camera, said display unit, said audio codec, said loudspeaker, said external video input terminal, said external audio output terminal, said external video output terminal, said external data input/output terminal and said external facsimile signal input/output terminal are housed, and which has a size permitting said equipment to be placed on a table and removed by a person.

3. Equipment for teleconference as defined in claim 2, wherein

said camera includes an automatic focus means for letting the camera be on focused on the few persons who utilize said equipment.

4. Equipment for teleconference as defined in claim 2, wherein

when said equipment is placed at an end of a table, said camera picks up the picture of the few persons who are sitting on the opposite end of the table and are about 1.5 meters from the equipment.

5. Equipment for teleconference as defined in claim 2 wherein

said display unit has an 11 inch screen for displaying the picture.

* * * * *

US005684716A

United States Patent [19]

Freeman

[11] **Patent Number: 5,684,716**

[45] **Date of Patent: Nov. 4, 1997**

[54] **REMOTE VIDEO TRANSMISSION SYSTEM**

[76] Inventor: **Mitchael C. Freeman**, 14318 E. 11th St., Tulsa, Okla. 74108

[21] Appl. No.: **505,454**

[22] Filed: **Jul. 21, 1995**

Related U.S. Application Data

[63] Continuation of Ser. No. 198,130, Feb. 16, 1994, Pat. No. 5,579,239.

[51] **Int. Cl.**^{6} **H04L 5/00**

[52] **U.S. Cl.** .... **364/514 C**; 455/3.1; 455/33.1; 348/14; 379/90; 386/46; 386/109

[58] **Field of Search** .... 364/514 A, 514 C; 455/3.1, 33.1; 348/14, 15; 358/311, 335; 379/90; 386/46, 109

[56] **References Cited**

U.S. PATENT DOCUMENTS

H1175	4/1993	Giorgio	370/18
2,095,360	1/1937	Green	178/5.6
2,203,758	6/1940	Walker	178/5.6
2,302,852	11/1942	Goddard	250/6
2,576,115	11/1951	Hill	178/44
2,881,427	4/1959	Huber	343/200
4,311,877	1/1982	Kahn	179/15.55 R
4,637,035	1/1987	Betts	375/8
4,663,660	5/1987	Fedele et al.	358/136
4,734,920	3/1988	Betts	375/8
4,825,286	4/1989	Graves	358/143
4,862,456	8/1989	Giorgio	370/118
4,864,567	9/1989	Giorgio	370/118
4,963,995	10/1990	Lang	358/335
4,969,040	11/1990	Gharavi	358/136
5,016,100	5/1991	Citta et al.	358/133
5,058,133	10/1991	Duncanson et al.	375/38
5,065,396	11/1991	Castellano et al.	370/84
5,127,021	6/1992	Schreiber	375/1
5,148,272	9/1992	Acampora et al.	358/133
5,253,275	10/1993	Yurt et al.	375/122
5,272,529	12/1993	Frederiksen	358/133
5,293,378	3/1994	Shimizu	370/94.1
5,355,167	10/1994	Juri	348/405
5,355,450	10/1994	Garmon et al.	395/162
5,361,278	11/1994	Vaupel et al.	375/122
5,365,272	11/1994	Siracusa	348/426
5,390,239	2/1995	Morris et al.	379/93
5,426,513	6/1995	Scorse et al.	358/433
5,426,645	6/1995	Haskin	370/118
5,440,336	8/1995	Buhro et al.	348/13
5,452,289	9/1995	Sharma et al.	370/32.1
5,471,470	11/1995	Sharma et al.	370/81
5,482,043	1/1996	Zulauf	128/660.04
5,495,284	2/1996	Katz	348/15
5,508,942	4/1996	Agarwal	364/514 R
5,579,239	11/1996	Freeman et al.	364/514 C
5,585,850	12/1996	Schwaller	348/388

OTHER PUBLICATIONS

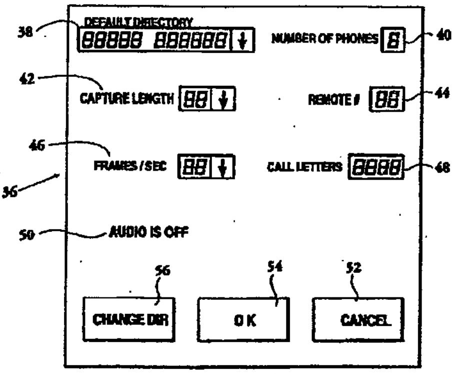
Microcom® Bridge/Router™ Introducing the WANmiser™ Advantage, Sep. 1993.

Primary Examiner—Emanuel T. Voeltz
Assistant Examiner—Patrick Assouad
Attorney, Agent, or Firm—Scott R. Zingerman; Frank J. Catalano

[57] **ABSTRACT**

A remote video transmission system for digitizing and compressing an audio/visual signal, transmitting that signal over low band width lines, such as land telephone lines, cellular telephone lines, or radio frequencies, decompressing the digitized data and converting it to an audio/visual signal for broadcast. Components of this system include: A remote unit, a host unit, and a playback unit. The remote unit is capable of digitizing and compressing the audio/visual signal as well as transmitting the compressed, digitized data. Data may be divided and sent to multiple ports for output. Data may also be edited prior to transmission. The host unit is automated to receive data transmitted from the remote unit and reassemble the data if it has been divided. The playback unit stores and automatically catalogs transmitted data files. The player unit also decompresses the digitized data files and converts them to an audio/visual signal which may then be broadcast. The audio/visual signal can either be NTSC, PAL, or Y/C video.

34 Claims, 2 Drawing Sheets



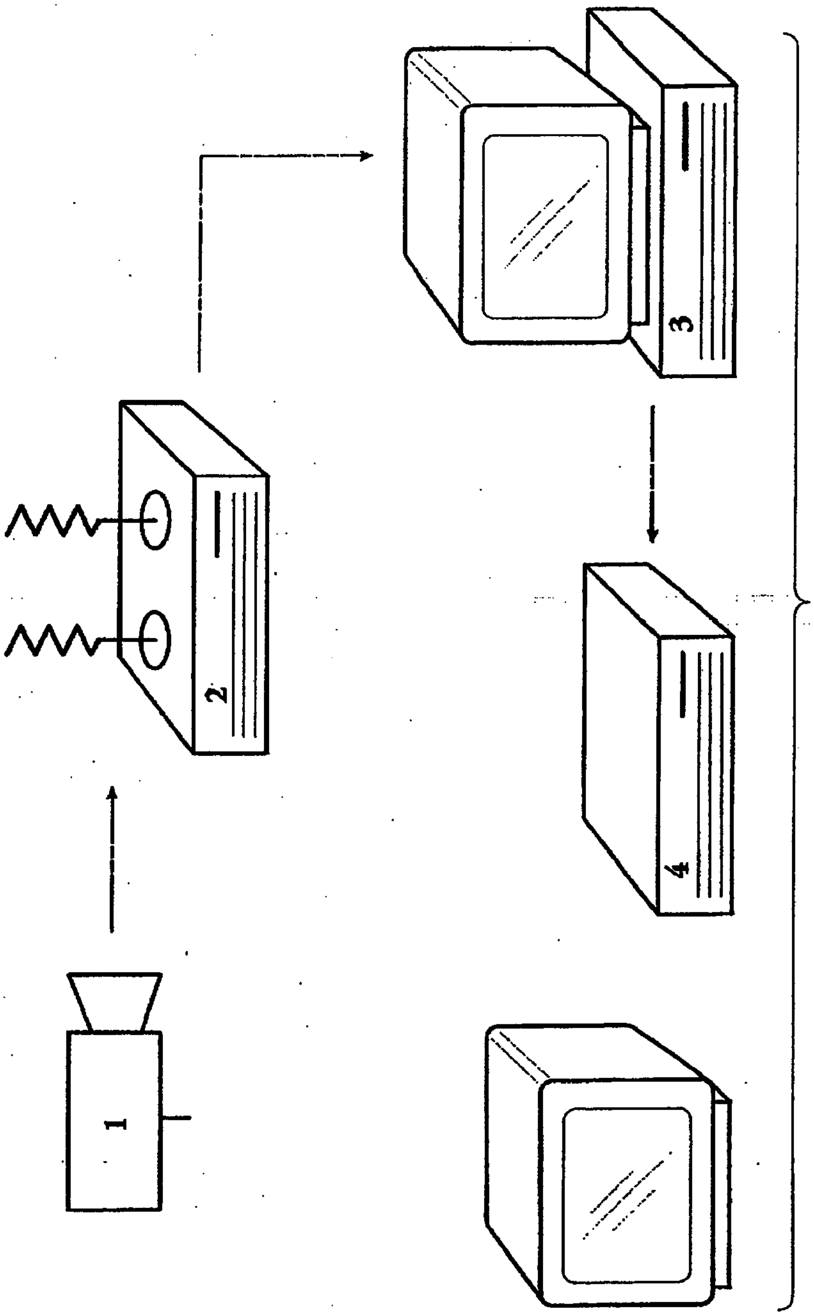


Fig. 1

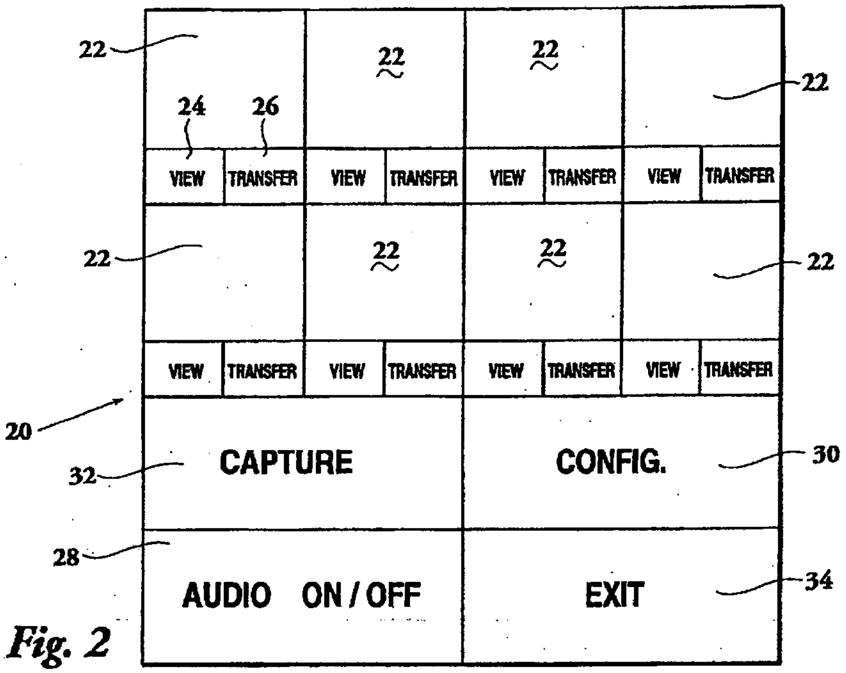

22
22
22
22
24
26
VIEW
TRANSFER
VIEW
TRANSFER
VIEW
TRANSFER
VIEW
TRANSFER
22
22
22
22
VIEW
TRANSFER
VIEW
TRANSFER
VIEW
TRANSFER
VIEW
TRANSFER
20
32
CAPTURE
CONFIG.
30
28
AUDIO ON / OFF
EXIT
34

Fig. 2

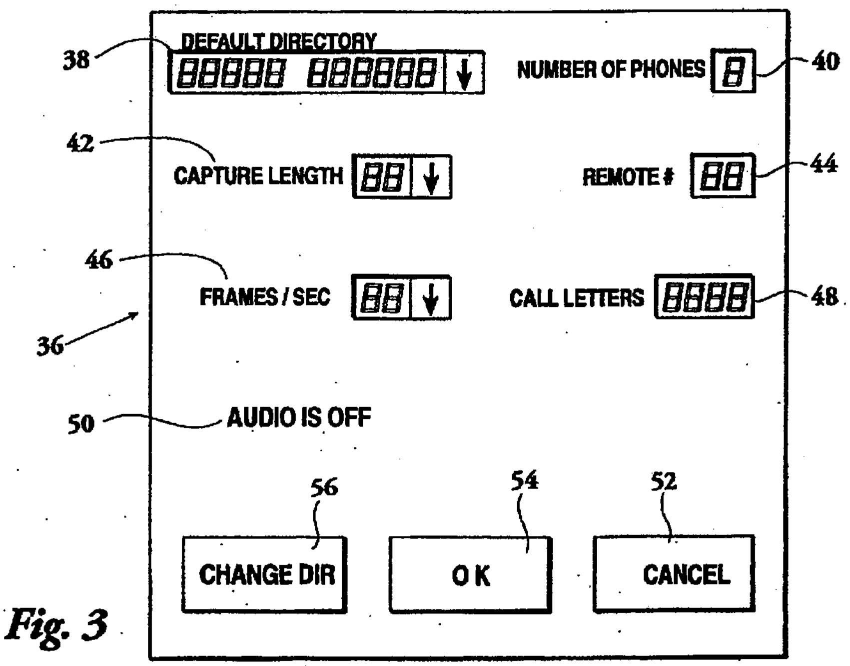

38
DEFAULT DIRECTORY
88888 888888 ↓
NUMBER OF PHONES 8
40
42
CAPTURE LENGTH 88 ↓
REMOTE # 88
44
46
FRAMES / SEC 88 ↓
CALL LETTERS 8888
48
36
50
AUDIO IS OFF
56
54
52
CHANGE DIR
O K
CANCEL

Fig. 3

REMOTE VIDEO TRANSMISSION SYSTEM

This is a continuation of application Ser. No. 08/198,130, filed on Feb. 16, 1994 now U.S. Pat. No. 5,579,239.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to capturing a video signal at one location and transmitting that signal to another location over telephone lines, cellular, radio and other telemetric frequencies.

Advances in the information highway promotes the United States as a world leader in the computer, video and broadcast industries. This invention adds to that information highway.

Transmission of a real time video signal from a remote location to a base location is conventionally done by one of two methods: Microwave or satellite. Equipment associated with these methods is extremely expensive and has significant limitations. The large amount of equipment necessary for satellite technology for remote transmission requires that the equipment be installed in trucks having an integral satellite dish. The signal is received from the video camera, beamed to the satellite, and then beamed to the base location for broadcast. The enormous amount of equipment and the sophisticated technology required makes satellite transmission extremely expensive and impractical for many applications. Satellite transmission does, however, send real time broadcast quality signals. The costs associated with satellite transmission are justifiable for large events such as sporting events where transmission could be made from a single location over a sustained period of time. It is not practical, however, for coverage such as news coverage where short segments from many different locations are necessary. An example would be in covering a natural disaster. Speed in obtaining and broadcasting video footage is a competitive requirement in news gathering situations.

The required set up time and inaccessibility of the satellite truck are significant additional limitations to satellite type transmission.

Microwave transmission technology overcomes some of the limitations of satellite technology but has several additional limitations of its own. Microwave transmission systems are less expensive and require less equipment. With a microwave system, a video signal is obtained and transmitted from the remote location at microwave frequencies from a vehicle mounted transmitting antenna to a base antenna for broadcast.

Difficulties have been encountered using this technology in aligning the antenna on the vehicle with the base antenna. Obstructions between the transmitting antenna and the base antenna may also prevent passage of the signal. Setup limitations also inhibit the use of microwave transmission systems in obtaining short segments of video at one location, transmission of that signal, moving to another location, transmission, movement, etc. Transmission is also limited to accessibility of the vehicle to the location of the subject matter.

The limitations of satellite and microwave technology have forced video broadcasters to devise alternative means of transmission, which may include: Setting up a remote microwave or satellite transmission post and transporting segments on video tape to it from multiple remote locations. More often, broadcasters capture video segments on tape and then manually transport those tapes back to the station as quickly as possible for broadcast.

With the establishment and advancements in cellular technology, television broadcasters have begun sending teams into remote locations for reports transmitted via cellular telephone. Cellular technology provides the ability to access a location and immediately report information back to the station. This use of cellular telephones transmits voice messages only and excludes video transmission altogether. Cellular technology has also been used to transmit data such as facsimile and computer file transmissions from one location to another. Cellular telephones have been quick to transmit data received from a facsimile machine or computer having a modem to a second fax machine or computer. Cellular combined with computer technology has never been used, however, to transmit a broadcast quality video signal.

A need, therefore, exists in the art for a highly portable, cost-effective method and apparatus for capturing and transmission of broadcast quality video from a remote location to a base location. A need also exists for a capture and transmission apparatus over cellular, land lines, or radio or other frequencies. Additionally, with the current FCC limitations regarding cellular transmissions from airborne craft an additional need is evidenced for video over the radio or other telemetric frequencies.

SUMMARY OF THE INVENTION

It is the purpose of the present invention to provide a method and means for capturing full-color, full-motion audio/video signals, digitizing and compressing the signals into a digitized data file, and transmitting the signals over telephone lines, cellular, radio and other telemetric frequencies.

A second object includes splitting the digitized, compressed, audio/video signal prior to transmission in order to reduce transmission time.

A further object is to provide an apparatus that will transmit audio/video files for immediate broadcast over radio frequencies, cellular telephone frequencies, or land telephone lines.

An apparatus to accomplish this purpose includes a remote unit, a host unit, and a player or a basic embodiment includes a remote and a combined host/player unit. This apparatus provides the capability of digitizing and compressing a signal which is then transmitted over low band width lines.

The remote unit includes means for digitizing and compressing a video signal, storage of the digitized and compressed data file, and transmission of this data file over telephone lines, cellular, radio and other telemetric frequency. The remote unit may also split the data file prior to transmission for multiple simultaneous transmissions in order to reduce transmission time. The host unit is automated to receive the transmitted data file, recombine it if it has been split, and store the recombined data file to the playback unit. The playback unit stores and automatically catalogs transmitted data files. The playback unit also decompresses the digitized data file and converts it to an audio/visual signal for broadcast.

In one preferred embodiment, an audio/visual signal is input into the remote unit from a video camera at a remote location. The remote unit is a combination portable personal computer having one or more computer interfaces and a corresponding number of cellular telephones. Computer software loaded on a hard disk drive in the remote unit instructs it to capture the input signal to a video capture card within the remote unit. The video capture card takes the audio/visual signal, digitizes it into a computer data file, and compresses that data file. Once digitized and compressed, the data file is captured in the computer's memory by a capture module on the video capture card. A software sequence then instructs the computer central processing unit to store the captured data file on the computer's hard disk drive. After the video file has been captured, it may be edited as desired prior to transmission to the host unit.

Once stored, a computer program sequence removes the digitized data from the hard drive, breaks the data file, and sends it to one or more computer interfaces which transmit the data file, using a corresponding number of cellular telephones, to the host unit. The data file is split and organized so as to reduce the amount of time of transmission of the data file.

A software sequence installed on the remote unit automatically catalogs data files stored in the system hard drive. These files are cataloged visually on a computer monitor for easy visual recognition. A single frame of video from each stored data file is displayed on the monitor in a catalog array to allow the operator the ability to quickly identify the file and select a file for retrieval or transmission to the host unit as required.

In an alternate embodiment, a basic one, the signal is not divided before it is transmitted. In this alternate embodiment, only a single interface and a single cellular phone are necessary.

The host unit is a desktop personal computer with installed communications software and one or more computer interfaces connected to a corresponding number of telephone lines. The interfaces are set to receive transmitted data files from the remote unit.

If the data files have been split for transmission, a software program recombines the split file back to its original single data file. A computer monitor is connected to the host unit for viewing of the stored data files at the host unit. A software program also copies this recombined data file to a network hard disk drive of the playback unit. The host unit and the playback unit are interfaced to allow transfer of data files. The computer to computer interface between the host unit and the playback unit is a computer network in the preferred embodiment, however, any known port to port connection could be substituted.

The playback unit is the interface between captured video and the master control which outputs the signal. Once the recombined data file has been stored on the networked hard disk drive of the playback unit, the data file may then either remain stored for later use or retrieved for broadcast.

Stored data files may be edited at the host location as desired.

For broadcast, a video card located in the playback unit retrieves the stored data file, decompresses the file, and converts the digitized data to VGA. The video card in the playback unit is similar to the video card in the remote unit with the exception that the card in the playback unit does not have a capture module.

Once the data file has been decompressed and converted to digital, a converter card converts the VGA signal to the desired signal for broadcast (NTSC, PAL, Y/C video, etc.) Hardware playback of the signal or output of the signal is to a monitor or VCR for storage on conventional video tape or immediate broadcast.

Other features and advantages of the invention will become apparent in view of the drawings and following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts the components and the Sequence of the process of the present invention.

FIG. 2 is the control screen of the remote unit.

FIG. 3 is the configuration screen of the remote unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The drawings represent the present invention wherein FIG. 1 depicts the remote unit 2, wherein the input signal is captured, compressed, digitized, and transmitted to a host unit 3 which receives the transmitted video signal and stores it to playback unit 4 where it can be output to a monitor or edited for playback or broadcast. In the preferred embodiment, the data file is split by the remote unit 2 prior to transmission to the host unit 3. The host unit 3 recombines the split data file and stores it to playback unit 4 via a computer network.

In the preferred embodiment, remote unit 2 is a portable personal computer having a 486DX-2/66 motherboard, 10-inch plasma display, 210 MB notebook hard disk drive, MS DOS Ver. 6.2 operating system, Microsoft® Windows™ Ver. 3.1, Microsoft® Video for Windows, Procom Plus® for Windows, trackball bus mouse, high speed serial ports, 1 MB Windows accelerator video card, video capture card with capture module, audio capture card, SVGA to NTSC converter, SVGA video adapter. The remote unit also has up to four computer interfaces such as modems, each connected to a cellular telephone.

A signal is input into remote unit 2 from any device having the capacity to output a video signal 1, such as a video camera, video cassette recorder/player, laser disc player, etc. The video signal received by the remote unit can be of any generally known format, such as NTSC, PAL, and Y/C video (or S video). The remote unit 2 is designed to be portable so that it can be transported and used in areas which are inaccessible or unsuited for a conventional desktop personal computer. It is understood, however, that remote unit 2 could be a desktop computer or have variations in its internal configuration.

The video signal input into the remote unit is received by a video card having a capture module therein. Such a card is available commercially from Intel/IBM. A computer software program such as "VIDEO FOR WINDOWS" available from MicroSoft® operates with the video card and capture module to capture, digitize, and compress the video signal into a data file. Other software packages are commercially available for use in operating environments other than windows and may be substituted for "VIDEO FOR WINDOWS."

A software sequence, discussed below, instructs "VIDEO FOR WINDOWS" what parameters to capture the file under. A permanent capture file is stored on the hard disk of the remote unit and is called up into the remote unit's RAM where an input video signal is captured. This permanent capture file has a 10 Mb default, however, in the event a larger file is created, the capture file will expand to the requisite size.

The capture card in the remote unit uses BIT-MAP technology to capture and display motion of the video file. BIT-MAP technology is suitable in order to maximize transmission speed.

As it is being captured in the capture file, the input signal is being digitized and compressed. The digitized and compressed data file is then named and captured in the computer's random access memory (RAM) for transmission to the host unit. The "VIDEO FOR WINDOWS" software package allows for editing of a data file once captured. In this way, editing can be accomplished at the remote location prior to transmission of the file. The digitized, compressed, and captured file is displayed visually on the monitor.

As stated above, the video file is captured according to system parameters selected on the remote unit for each data file. The capture software sequence A includes the following steps:

CAPTURE SOFTWARE SEQUENCE A

1. A video palette file is copied to "MICROSOFT® WINDOWS™" clipboard. This video palette file is a created data file stored on the hard disk of the remote. This video palette file is created with "VIDEO FOR WINDOWS" by loading a video clip and extracting the color palette from that clip.
2. The second step is that the control screen is painted on the monitor of the remote without pictures. FIG. 2 depicts this control screen 20 with boxes, collectively 22, shown without pictures therein.
3. Bit map files are obtained and displayed into boxes 22 of screen 20. A different bit map file will be displayed in each box 22 on screen 20. Bit map files are created by "VIDEO FOR WINDOWS" by retrieving the first frame of video from the captured video file, supplying the color from the stored palette file, and displaying this image in one of the boxes 22. These video files are displayed (or catalogued) on control screen 20 to allow quick identification and selection of a file for retrieval or transmission. The remote unit is capable of storing and displaying up to eight (8) bit map files. When the ninth file is captured, the software will automatically overwrite the oldest captured data file and display this new file on control screen 20.
4. The software sequence then reads the configuration files created as a result of user selection of capture and storage parameters. These parameters are input form a set of selection buttons found on control screen 20 of FIG. 2.
5. The user selects whether the video signal will be captured either with or without audio. "SELECTION" button 28 on control screen 20 of FIG. 2 requests the choice of capture and storage of audio. The selection buttons on screen 20 are activated using any conventional means such as the computer keyboard, mouse, or similar pointing device. An audio capture card installed in the remote unit captures the audio of an input signal. Capture with audio makes the data file longer since the audio signal must also be digitized, compressed, and stored in the remote unit's hard disk. It is evident that the longer the data file, the longer the time required for transmission of the entire data file from the remote unit to the host unit. It is often desirable to transmit video files only without audio in situations where a broadcast station wants to provide video footage of a situation quickly. It is desirable for broadcast stations to provide such video coverage as quickly as possible after a newsworthy event has taken place, such as an accident or natural disaster. In these situations, it is desirable to broadcast the video footage of the incident in a remote location. Audio coverage can be made by a reporter on location in another fashion, such as over a cellular telephone.
6. The software sequence reads the configuration files created as a result of user selection of capture and storage parameters. These parameters are input from a "SELECTION" button 30 marked "CONFIGURE" found on screen 20 of FIG. 2. Selection of the "CONFIGURE" selection button 30 calls up a configuration file from the remote hard disk: The configuration file opens a "Window" bringing up a screen showing the capture configuration options. FIG. 3 depicts the configuration screen 36 which appears as a result of selecting the configuration "SELECTION" button 30 of FIG. 2. It is not necessary to input a set of configuration parameters each time a video signal is captured since the system stores the previous set of configuration parameters which were selected for the previous capture sequence.

The configuration parameters are discussed below.

7. Once the configuration parameters are selected, the video card in the remote unit captures the input video signal to its memory. Capture includes digitizing the input video signal to form a binary data file and then compressing that file. The file is compressed in order to conserve memory space and reduce transmission time. The remote unit then stores the digitized and compressed video signal as a data file with a cap extension on the hard disk. The capture sequence is initiated by activation of the "CAPTURE" selection button 32.
8. "EXIT" selection button 34 allows the user to exit the capture software sequence to a DOS prompt. The capture software sequence may be exited prior to powering off the remote unit after a video sequence is captured, transmitted, viewed, or edited.
9. After the video sequence is captured, it may be viewed, edited, or transferred to the host unit. Each bit map file box 22 has a "VIEW" selection button 24 and a "TRANSFER" selection button 26. Upon selection of "VIEW" button 24, a captured video data file may be retrieved from the remote hard disk and the video sequence run. The video sequence is displayed in its respective bit map file box 22.

   "VIDEO FOR WINDOWS" provides the system the capability for editing a captured data file on the remote unit before it is transmitted to a host unit. As the file is being viewed, sequences may be deleted or edited together as desired.

Selection of "TRANSFER" button 26 initiates the transfer software sequence B and file splitting software sequence C, discussed below. The captured, digitized and compressed data file is then automatically transmitted to the host unit.

FIG. 3 depicts the configuration screen. Selection of the "CONFIGURE" button 30 of the capture screen 20, FIG. 2, calls up a stored configuration file. This configuration file displays the configuration screen 36 of FIG. 3.

Referring to FIG. 3, the default directory request 38 allows for a choice of host name. Default directory listing 38 is a listing of all the host locations to which a data file may be transmitted. Choosing a host name in default directory 38 accesses the transmission parameters for that host name entered and stored in a transfer file, discussed below.

Phone parameter 40 allows for selection of the number of cellular telephones to be used to transmit the captured data file from the remote unit to the host unit. The greater the number of cellular telephones used to transmit, the lesser the transmission time. It is often desirable to transmit a video file as quickly as possible, especially in broadcast news situations where the goal is to broadcast video clips of developing news features as soon as possible. Although there is no theoretical limit to the number of cellular telephones which may be installed in the remote unit upon combination of additional processors, it has been found that between two and four are sufficient for most applications.

Capture length parameter 42 allows for selection of the length of the video sequence to be captured. Generally, video sequences will be between five (5) and one hundred twenty (120) seconds in length.

The video card is capable of capturing an input video signal at a selected number of frames per second. Frames per second parameter 46 allows for this selection on configuration screen 36. The number of frames per second in which the video card will capture a video sequence generally ranges between one (1) and thirty (30) frames/second. As the number of frames per second in which the file is captured increases, the resultant captured file will approach full motion when it is viewed upon playback. It follows that the greater number of frames captured per second, the larger the data file will be upon capture, which will require a longer transmission time. It is the option of the user to select the desired number of frames per second, understanding that video quality may be sacrificed for transmission speed. In situations where the video subject is stationary, or moving slowly, this sacrifice in video quality may not be present.

In situations where multiple remote units transmit back to a single host unit, it is desirable to identify the remote unit from which transmission is commenced. This naming convention is advantageous to ensure the stored file on the host unit will not be overwritten by an identically named video file of different content. Remote # parameter 44 allows for selection of a remote unit number between 00 and 99. Upon capture, a data file is created and named with an identification of the remote unit number.

The call letter selection parameter 48 allows for input of the call letters of the host broadcast station to which the captured file will be transmitted. Any four (4) characters may be entered as the station call letters. When the capture file is created, it will be named with the input call letters in addition to the remote number as discussed above. The captured file will have a file extension cap. Input of the call letters is desirable when a remote unit transmits to several host units located at different broadcast stations having different call letters.

Audio capture parameter 50 identified whether capture of audio has been selected on capture software sequence A, FIG. 2. Audio capture parameter 50 will either display "AUDIO IS ON" or "AUDIO IS OFF," depending upon the previous selection.

Selection buttons 52, 54, and 56 of capture configuration screen 36 are selection buttons commonly found using the "MICROSOFT® WINDOWS™" environment. "CANCEL" selection button 52 instructs the remote unit to disregard any changes made on the configuration screen 36 and abort back to the control screen 20, FIG. 2. When "CANCEL" button 52 is selected, the remote unit will default back to the previously stored parameters.

If changes are made to the capture configuration screen 36, those changes can be stored as a configuration file on the disk drive. Selection button 54, marked "OK" instructs the remote unit to write over the previously saved configuration file. This new set of parameters will then become the default parameters until further changes are made using configuration screen 36.

The "CHANGE DIR" selection button 56 allows changes to be made to the dialing directories in the transfer software sequence B discussed below. Selection of the "CHANGE DIR" button 56 calls up the stored dialing directory file which allows changes to be made to the dialing directory used with the transfer software sequence C.

Upon selection, a program file is retrieved from the transfer software sequence B stored on the hard disk drive. This program file paints a dialog directory screen on the monitor of the remote unit to allow changes to be made to the dialing directory. If no changes are necessary, the transfer software sequence will use the previously stored information. The dialing directory screen is similar to dialing directory screens used with communications software packages commercially available with the exception that this dialing directory includes dialing information for each transmission line in the remote unit. In the preferred embodiment, there are four modems and four cellular telephones installed. Hence, there will be dialing directory information for each cellular telephone.

The dialing directory information stored in transfer software sequence B, and displayed in the dialing directory screen, lists the first and last name and telephone number of the receiving host unit. When the correct dialing directory information is input, it may be saved into the transfer file and the dialing directory screen exited.

Once the dialing directory information is stored and the dialing directory screen exited, capture screen 20 of FIG. 2 is again displayed on the monitor. The remote unit is now ready to transmit the newly captured video sequence to the host unit. Transmission of a data file is accomplished by selecting the "TRANSFER" button 26 in the bit map file box 22 containing the first frame of video of the file to be transmitted. Selection of "TRANSFER" button 26 initiates the transfer software sequence B and the file splitting software sequence C.

Transfer software sequence B enables the remote unit to communicate with the host unit to transmit a stored data file using the system hardware. Transfer software sequence B contains all of the instructions necessary to initialize the communications ports on the remote, obtain a cellular connection with each cellular telephone to the host unit, obtain the stored data file, initiate file splitting sequence C, and transmit the split data file. The remote unit uses the run time module of a communications software package, such as Procom Plus® for WINDOWS™ which is loaded onto the remote. Communications software packages such as Procom Plus® for WINDOWS™ are available commercially.

Upon selection of the transfer button 26 of FIG. 2, the configuration file is read containing the configuration parameters selected above. This includes the dialing directory information. Transfer software sequence B is then called for each communications port to which the data file will be transmitted. Each modem interfaces through a different communications port. In the preferred embodiment, transfer software sequence B will be called four times.

TRANSFER SOFTWARE SEQUENCE B

1. The first program called for a communications port (COM1) controls the transfer process. COM1 also controls the monitor display notifying the operator of the throughput, size of the file, and the percentage complete.
2. Each of the other communications ports communicates with COM1 in the Windows™ environment, using dynamic data exchange (DDE). DDE is known in the industry and allows multiple applications to share information.
3. COM1 calls file splitting software sequence C, discussed below, and initiates the splitting of the data file. The data file is split into 10K pieces, or files. Each 10K file is created with a DOS archive bit set affixed to the

file. As each 10K file of the data file is created, it is stored having a sequential file name extension from 001–999.

4. The modems interfacing each communication port execute the dialing directory file discussed above and obtain a connection with the telephone line on the host unit. The program automatically sends the cellular strings from each communications port to initialize the modems on the host unit. All other settings such as baud rate, protocol, and miscellaneous AT commands, are preset in the remote and host unit. The transmission system operates using a Z modem-based protocol.
5. Each communications port executes a dialing directory (DIR) command to locate a file containing an archived bit set. Once a file is located, it is retrieved, the archived bit set removed, and the 10K file transmitted from that line. It is not necessary for the stored files to be transmitted in sequential order since the host unit will recombine the file using the numbering system discussed above. If an error occurs during transmission, the program puts the archived bit set back on the file so that the 10K file can be transmitted from another line. Once transmission of a 10K file is complete, the file is saved on the hard disc, and another having an archived bit set is received and transmitted.
6. The 10K file files containing archived bit sets are retrieved, transmitted, and stored until all have been sent. When a communications port finds no more files having archived bit sets, it hangs up automatically.
7. If a cellular line loses communications with the host unit or if interference prohibits accurate transmission of a file, the line will drop out, and the remaining files will be transmitted from the remaining ports.
8. All of the transmitted, restored, 10K files are recombined into a complete data file.

Files may be transmitted using telephone lines, cellular, radio and other telemetric frequencies. In the preferred embodiment, cellular telephones are integrated with the remote unit to allow transmission of files from areas which are inaccessible to standard telephone lines. It may be desirable, in certain specialized applications, to transmit from a single remote location or locations where standard telephone lines are accessible. The remote unit may still be portable as long as a telephone jack is available for transmission. In that event, the cellular telephones are omitted from the remote, and the modems connected to standard telephone jacks, using standard telephone connectors and wiring.

In areas which are inaccessible to standard telephone lines and outside cellular telephone "cell," files can be transmitted using radio frequencies. In order to accomplish this, the cellular telephones in the remote are replaced with radio transmitters. Corresponding radio receivers are then installed in the host unit to receive the signal transmitted from the remote. Each transmitter operates using a different frequency so as to keep each signal segregated.

Transmission of the data file is accomplished automatically by the remote unit once transfer button 26 of FIG. 2 is selected. This allows the operator freedom to pursue other video clips for subsequent transfer and submission during the transmission process. In this manner, the invention provides rapid access and broadcasts the video segments from locations generally inaccessible and cost prohibitive much faster than conventional methods.

In situations where news teams are sent out in a vehicle to obtain video segments, an inverter could be installed in the vehicle to convert DC from its battery to AC to be used by the remote unit. In addition, five DB gain antennas could be mounted on the vehicle to improve transmission quality of the cellular signal. An antenna would be mounted on the vehicle for each cellular telephone in the remote unit. A video signal could then be captured at one remote location, transfer button 26 selected, and the remote unit transported in the vehicle to a different location while it is transmitting the file.

In order to decrease transmission time of the data file, it may be split into 10K files and transmitted over multiple land telephone lines, cellular telephones, or radio frequencies.

FILE SPLITTING SOFTWARE C

1. After transfer button 26 of FIG. 2 is selected, COM1 opens the main data file and begins splitting that file into 10K files.
2. A DOS archive bit set is fixed to each 10K file. This archive bit set allows the transfer software sequence B to determine whether a file on the directory is a file to be transmitted. It also enables it to determine whether a file has already been transmitted. As each file is retrieved, the DOS archive bit set is removed prior to transmission. Transmission is complete when there are no files left on the directory containing a DOS archive bit set. Each cellular line on the remote will hang up automatically.
3. After all of the 10K file files have been transmitted and each phone line has hung up, COM1 begins piecing the 10K files back together. This is accomplished by sequential read-write operation. A master data file is opened, and then the files are counted between 001–999 (or until all files are used) and pieced together in their sequential order. Twenty K (20K) pieces are read, the file is created, and then written until the entire data file has been combined.

The host unit 3 of FIG. 1 is automated to receive a data file transmitted from remote unit 2. Host unit 3 is a personal computer having a 486DX-2/66 motherboard, 210 Mb hard disk drive, monitor, high speed serial ports, 1 MB Windows accelerator video card, MS DOS Ver. 6.2 operating system, trackball bus mouse, Microsoft® Windows™ Ver. 3.1, Novell® Netware Lite™, 16 Bit Ethernet card, and a 1.44 MB floppy drive. Host unit 3 also has up to four (4) modems connected to up to four (4) separate telephone lines to receive a signal transmitted from each cellular telephone of the remote. It is not necessary to install cellular telephones in host unit 3 unless it will be transported from location to location. In the general application, however, host unit 3 will be installed at a single location and wired to one to four telephone lines.

The number of modems in host unit 3 corresponds to the number of modems used in the remote unit 2. If radio transmitters are used in remote unit 2 instead of telephones, radio receivers would be installed in host unit 3 so that there is a corresponding radio receiver for each radio transmitter. Each radio receiver in host unit 3 is set to the same frequency as the radio transmitter in remote unit 2 from which it will receive transmitted data files.

The four modems in host unit 3 receive the data file transmitted by the four cellular telephones in remote unit 2 in 10K files. Host unit 3 recombines the split data file and copies it to a network hard disk drive for access by playback unit 4. The hard disk drive on host unit 3 stores only software necessary to run the functions of host unit 3. Data files received from remote unit 2 are stored on hard disk drive of playback unit 4. Host unit 3 and playback unit 4 are networked together. A pier-to-pier network, such as "Novell Lite™" by Novell® is particularly suitable for this purpose.

When host unit 3 is turned on, it automatically runs host boot software sequence D.

HOST BOOT SOFTWARE SEQUENCE D

1. Host unit 3 looks for the server device on the network. Playback unit 4 is addressed as the network server.
2. Host unit 3 logs onto the network as host.
3. Drive letter E: is mapped as "play here." Drive E: is a RAM drive in which data files are stored for immediate playback and viewed on an NTSC monitor or output to the master control.
4. Drive letter F: is mapped as "save here." This is the subdirectory on the hard disk drive of playback unit 4 to which host unit 3 stores data files received from remote unit 2.
5. Host unit 3 loads Windows™ or another suitable operating environment.
6. File reception software sequence E is initiated. File reception software sequence E allows host unit 3 to wait for and receive incoming data files automatically.

One host unit can support as many as thirty (30) remote units. The host unit can only receive a transmitted data file from one remote unit at any given time, however.

File reception software sequence E is essentially the same as transfer software sequence B. File reception software sequence E automates each telephone line end modem of host unit 3 to obtain communication with each cellular telephone of remote unit 2 and receive the transmitted data file in 10K files and recombine the data file for storage on the hard disk drive of playback unit

FILE RECEPTION SOFTWARE SEQUENCE E

1. The first program called by host boot software sequence D for a communications port "COM1" controls the file reception process on host unit 3. "COM1" also controls the monitor display notifying the operator of the throughput, size of the file, and percentage complete.
2. Each of the other communications ports communicates with "COM1" in the WINDOWS™ environment, using dynamic data exchange (DDE). DDE is known in the industry and allows multiple applications to share information.
3. The modem's interfacing with each communications port are all ready to receive the cellular string transmitted by each cellular telephone in remote unit 2. Upon receipt of the cellular strings, the modem is ready to receive transmitted data. All other settings such as baud rate, protocol, and miscellaneous AT commands are preset in the host unit in order to automate the file receiving process.
4. As each COM port on remote unit 2 completes transfer of the data file in 10K files, the line will immediately drop out until all four lines have hung up.
5. Host unit 3 then recombines the 10K files into a complete data file using a sequential read/write operation. A master data file is opened in the E: subdirectory on the hard disk drive of the playback unit. The 10K files are then assembled according to their file extension created by remote unit 2 when the data file was split. The 10K files are assembled sequentially between 001 and 999. Twenty kilobyte (20K) pieces are read and then written until the entire data file has been recombined and stored on the network hard drive of playback unit 4.
6. Host unit 3 then executes line 1 of this file reception software sequence E and COM1 awaits connection with remote unit 2 to receive another transmitted data file.

Playback unit 4 of FIG. 1 is the interface between captured video and the station master control which outputs the signal. In the preferred embodiment, playback unit 4 is a personal computer with a 486DX-2/66 motherboard, 210 Mb hard disk drive, 1.44 MB floppy drive, high speed serial ports, 1 MB Windows accelerator video card, MS DOS Ver. 6.2 operating system, Microsoft® Windows™, Microsoft® Video for Windows, Novell® Netware Lite™, trackball bus mouse, video decompression card, audio decompression card, VGA video to NTSC scan converter, and 16 bit ethernet card. Playback unit 4 is automated so that upon boot, it logs into the network, accesses its multi-tasking environment such as Windows™, and is ready to retrieve and play stored data files.

PLAYBACK BOOT SOFTWARE SEQUENCE F

1. Playback unit 4 initializes network, with playback unit 4 being the server.
2. Playback unit 4 logs into the network as player.
3. Drive letter E: is mapped as "Play Here." Drive E: is a RAM drive in which data files are stored for immediate playback, viewed on an NTSC monitor, or output to the station's master control.
4. Driver letter F: is mapped as "Save Here." This is the subdirectory on the hard disk drive of playback unit 4 wherein which host unit 3 stores data files received from remote unit 2.
5. Playback unit 4 executes WINDOWS ™ or similar suitable multi-tasking environment such as OS/2 from IBM, UNIX, or Novell®.
6. WINDOWS™ automated to bring up the file manager.

Once the recombined data file has been stored on a network hard disk drive of playback unit 4, the data file may either remain stored for later use, edited, or retrieved for output to the master control. It may be advantageous to have numerous host units networked with a single playback unit so that numerous data files can be received from numerous remote units simultaneously. Alternatively, in a basic embodiment, host unit 3 and playback unit 4 could be integrated into a single host/playback unit.

Playback unit 4 has a video card installed in an expansion slot. This video card is similar as the video card installed in remote unit 2 with the exception that the capture module is not necessary. When a data file is retrieved by playback unit 4 for output to the master control, the video card decompresses the file and converts the digitized data to VGA.

If a data file received by host unit 3 is for immediate playback, it is "stored" in the E: drive. The E: drive is a drive for temporary storage of the data file for immediate playback or output to the master control.

If the data file received by host unit 3 is for later playback or output, it is saved in the F: drive for later retrieval. The F: drive is a subdirectory of the hard disk drive of playback unit 4 for storage of data files.

Once decompressed and converted to VGA, a scan converter card installed in playback unit 4 converts the VGA signal to the desired broadcast signal. Although "NTSC" is the most common broadcast signal, the signal could also be converted to "PAL," "Y/C video," or other broadcast signal as required. This "NTSC" signal output from the scan converter card can be viewed on an "NTSC" monitor for immediate playback for broadcast, or stored on video tape or other conventional means for later use.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction without departing from the spirit and scope of this disclosure. It is understood that the invention is not limited to the embodiment set forth herein for purposes of exemplification, but is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed is:

1. A method for transmitting a data file from a remote location to a host location, comprising:

splitting the data file into at least two components at the remote location in real time;

sequentially tagging each of said components;

transmitting said components over at least one telephone line, cellular, radio and other telemetric frequency;

receiving said transmitted components at the host location;

sequentially recombining said data file.

2. The method of claim 1 wherein said data file is split into components of equal size.

3. The method of claim 1 wherein said data file is split into 10K components.

4. The method of claim 1 wherein sequentially tagging said components further comprises the step of storing said components sequentially by alpha numeric.

5. The method of claim 4 wherein said pieces are sequentially recombined at the host location according to their sequential ordering.

6. The method of claim 1 wherein a bit flag is set to coordinate program flow.

7. A method of transmitting a data file from a remote unit with a plurality of communications ports to a host unit with a plurality of communications ports, comprising:

splitting the data file into a plurality of components, the number of said components being greater than the number of communications ports in said remote unit;

sequentially tagging each of said components;

executing the transmission of said components through the available communication ports of the remote unit to the available communication ports of the host unit via a transmission medium electronically linking each available communications port in said remote unit to a corresponding available communications port of said host unit;

recombining said data file.

8. The method of claim 7 wherein said data file is split into components of equal size.

9. The method of claim 7 wherein sequentially tagging said components further comprises the step of storing said components sequentially by alpha numerics.

10. The method of claim 9 wherein said pieces are sequentially recombined at the host location according to their sequential ordering.

11. The method of claim 7, further comprising:

storing said components of said data file prior to transmission;

setting a marker for each of said components as the data is stored;

selecting said pieces based on their marker settings and transmitting said components;

removing said marker prior to transmission.

12. The method of claim 11, including means for resetting said bit flag in the event said host unit fails to receive said transmitted component.

13. The method of claim 12 including inactivating any of said communication ports of said host unit in the event it loses connection with said host unit.

14. The method of claim 13 including transmitting the remaining components of said data file using the remaining communications ports of said remote unit in the event one is inactivated.

15. A method of claim 11 wherein the marker set on each component is a bit flag.

16. A method of transmission of a composite signal from a first location to a second location, comprising the steps of:

capturing said composite signal at the first location;

compressing said composite signal in real time;

transmitting said compressed composite signal oven a cellular frequency from said first location;

receiving said compressed composite signal at said second location.

17. The method according to claim 16 including the additional step of storing said composite signal at said first location prior to transmission.

18. The method according to claim 16 including the additional step of splitting the compressed composite signal into at least two components prior to transmission.

19. The method according to claim 18 further including the step of sequentially tagging each of said components prior to transmission.

20. The method according to claim 19 further including the step of storing said sequentially tagged components at said first location.

21. The method of claim 20 wherein said components are tagged by alpha numeric designations.

22. The method according to claim 19 wherein sequentially tagging each of said components includes placing a marker on each of said components.

23. The method according to claim 22 wherein said marker is a bit flag placed on each said component.

24. The method according to claim 18 wherein said compressed composite signal is split into components of approximately equal size.

25. The method of claim 18 wherein said compressed composite signal is split into 10K components.

26. The method of claim 25 wherein one of said components is smaller than 10K.

27. The method of claim 18 wherein said compressed composite signal is recombined at said second location.

28. The method of claim 19 wherein said tagged components are recombined in sequential order at said second location.

29. The method of claim 1 wherein said data file is compressed before it is split.

30. The method of claim 7 wherein said data file is compressed before it is split.

31. The method of claim 1 further including downloading said data file from the host unit to at least one playback unit.

32. The method of claim 7 further including downloading said data file from the host unit to at least one playback unit.

33. The method of claim 16 further including downloading said data file from the second location to a third location.

34. The method of claim 7 wherein said transmission medium is a telephone line, cellular, or other telemetric frequency.

* * * * *

US005666159A

United States Patent [19]

Parulski et al.

[11] **Patent Number: 5,666,159**

[45] **Date of Patent: Sep. 9, 1997**

[54] **ELECTRONIC CAMERA SYSTEM WITH PROGRAMMABLE TRANSMISSION CAPABILITY**

[75] Inventors: **Kenneth A. Parulski**, Rochester; **James R. Schueckler**, Leroy, both of N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.

[21] Appl. No.: 426,993

[22] Filed: **Apr. 24, 1995**

[51] **Int. Cl.^{6}** **H04N 5/232**

[52] **U.S. Cl.** **348/211; 348/723; 358/906; 386/117**

[58] **Field of Search** **348/222, 723, 348/722, 705, 724, 211, 212; 358/906, 335, 310; 386/38, 107, 117; H04N 5/222, 5/225, 5/232, 5/28**

[56] **References Cited**

U.S. PATENT DOCUMENTS

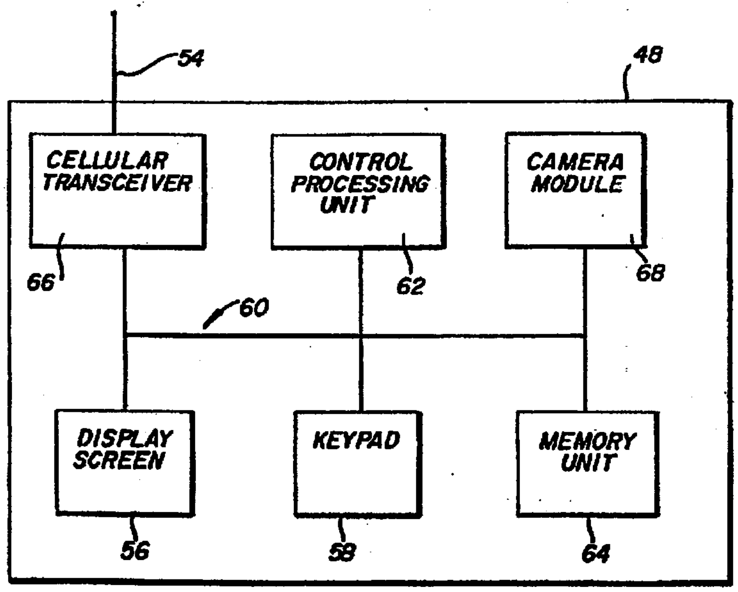
3,984,625	10/1976	Camras	178/5.6
4,097,893	6/1978	Camras	358/83
4,420,773	12/1983	Toyoda et al.	358/335
4,825,457	4/1989	Lebowitz	379/40
4,951,147	8/1990	Aknar et al.	358/209
5,128,755	7/1992	Fancher	358/108
5,170,262	12/1992	Kinoshita et al.	358/335
5,258,859	11/1993	Wada et al.	358/487
5,264,935	11/1993	Nakajima	358/181
5,272,525	12/1993	Borchardt et al.	358/83
5,442,512	8/1995	Bradbury	361/683

Primary Examiner—Michael H. Lee
Assistant Examiner—Nathan J. Flynn
Attorney, Agent, or Firm—David M. Woods

[57] **ABSTRACT**

An electronic camera system includes a programmable transmission capability for selectively transmitting electronic image data to a plurality of remote base units. In one embodiment, a camera module is detachably coupled to a portable computer including a display screen and a data entry device. The electronic image data generated by the camera module is supplied to the portable computer for display on the display screen. The data entry device is used by an operator to select which of the plurality of base units are to receive the digital image data. The digital image data is supplied by the portable computer to a radio-frequency transmitter module for transmission to the selected base units. The radio-frequency transmitter module is formed either integral with the portable computer or, like the camera module, is detachably coupled to the portable computer. In a further embodiment, a combined telephone/camera unit is provided that includes a camera module for generating electronic image data representative of a scene to be imaged, a memory unit for storing the electronic image data generated by the camera module, a display screen for displaying the electronic image data stored in the memory unit, a mechanism for selecting which of the plurality of base units is to receive the digital image data, and a cellular transceiver for transmitting the digital image data to the base units selected by the selection mechanism.

10 Claims, 7 Drawing Sheets



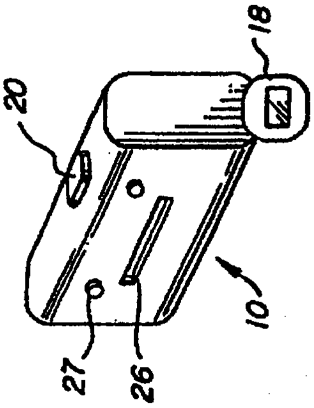


FIG. 2

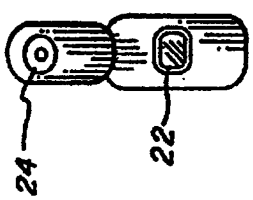


FIG. 3

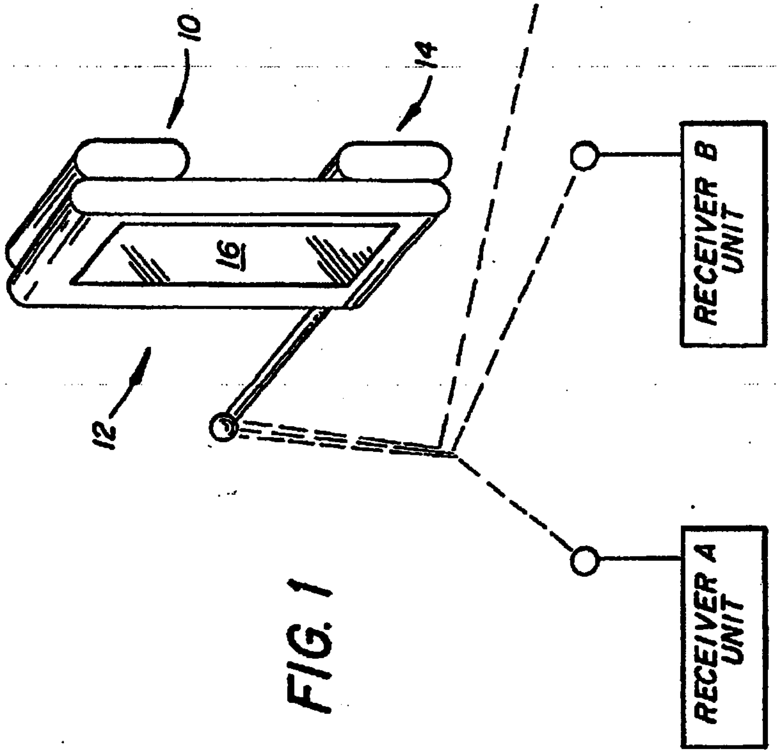


FIG. 1

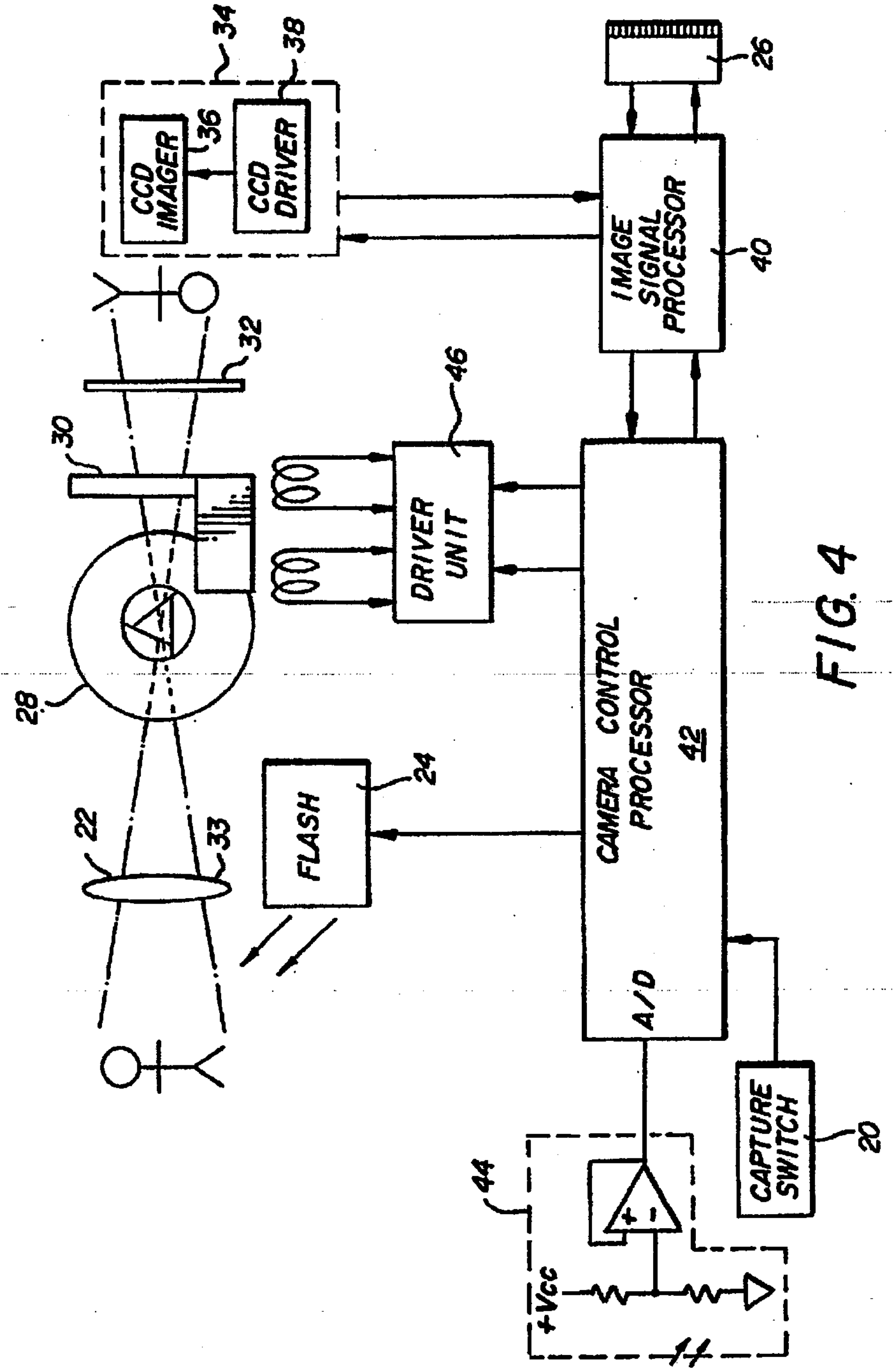
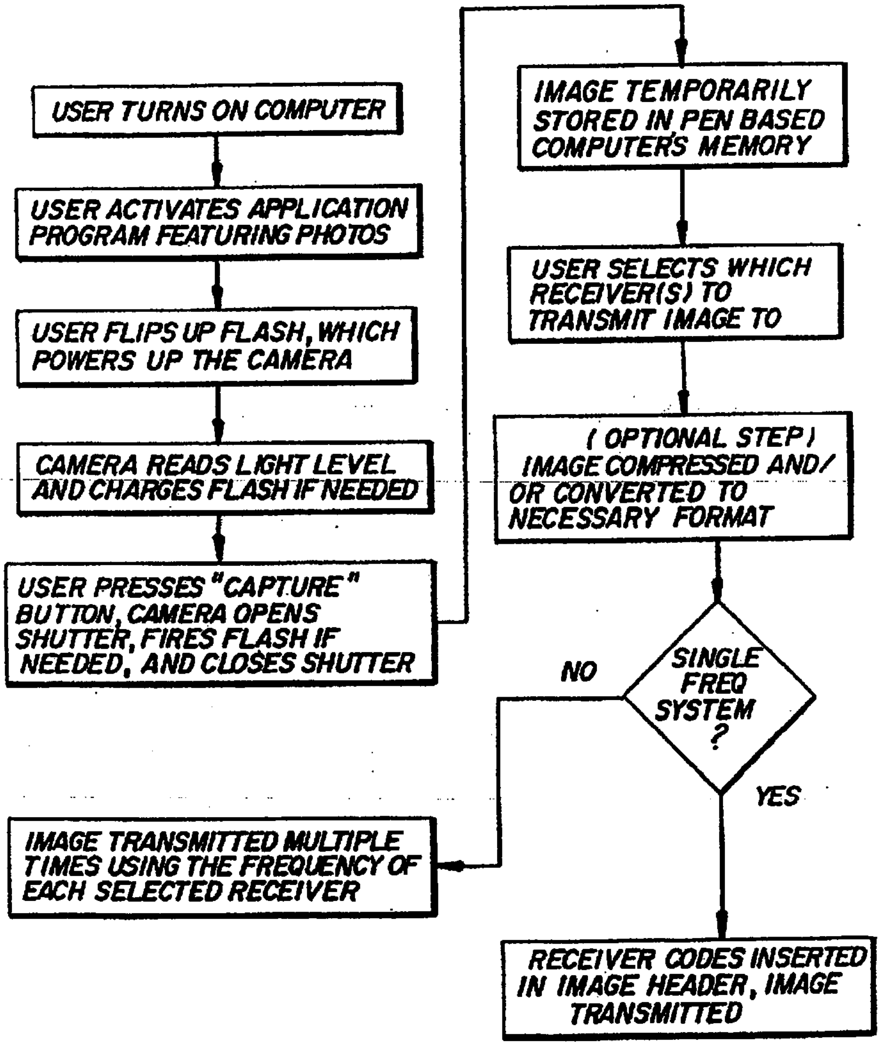

34
38
CCD IMAGER
36
CCD DRIVER
26
IMAGE SIGNAL PROCESSOR
40
32
30
46
DRIVER UNIT
28
CAMERA CONTROL PROCESSOR
42
A/D
FLASH
24
22
33
44
+Vcc
CAPTURE SWITCH
20

FIG. 4

FIG. 5


USER TURNS ON COMPUTER
USER ACTIVATES APPLICATION PROGRAM FEATURING PHOTOS
USER FLIPS UP FLASH, WHICH POWERS UP THE CAMERA
CAMERA READS LIGHT LEVEL AND CHARGES FLASH IF NEEDED
USER PRESSES "CAPTURE" BUTTON, CAMERA OPENS SHUTTER, FIRES FLASH IF NEEDED, AND CLOSES SHUTTER
IMAGE TEMPORARILY STORED IN PEN BASED COMPUTER'S MEMORY
USER SELECTS WHICH RECEIVER(S) TO TRANSMIT IMAGE TO
(OPTIONAL STEP) IMAGE COMPRESSED AND/OR CONVERTED TO NECESSARY FORMAT
SINGLE FREQ SYSTEM ?
NO
YES
IMAGE TRANSMITTED MULTIPLE TIMES USING THE FREQUENCY OF EACH SELECTED RECEIVER
RECEIVER CODES INSERTED IN IMAGE HEADER, IMAGE TRANSMITTED

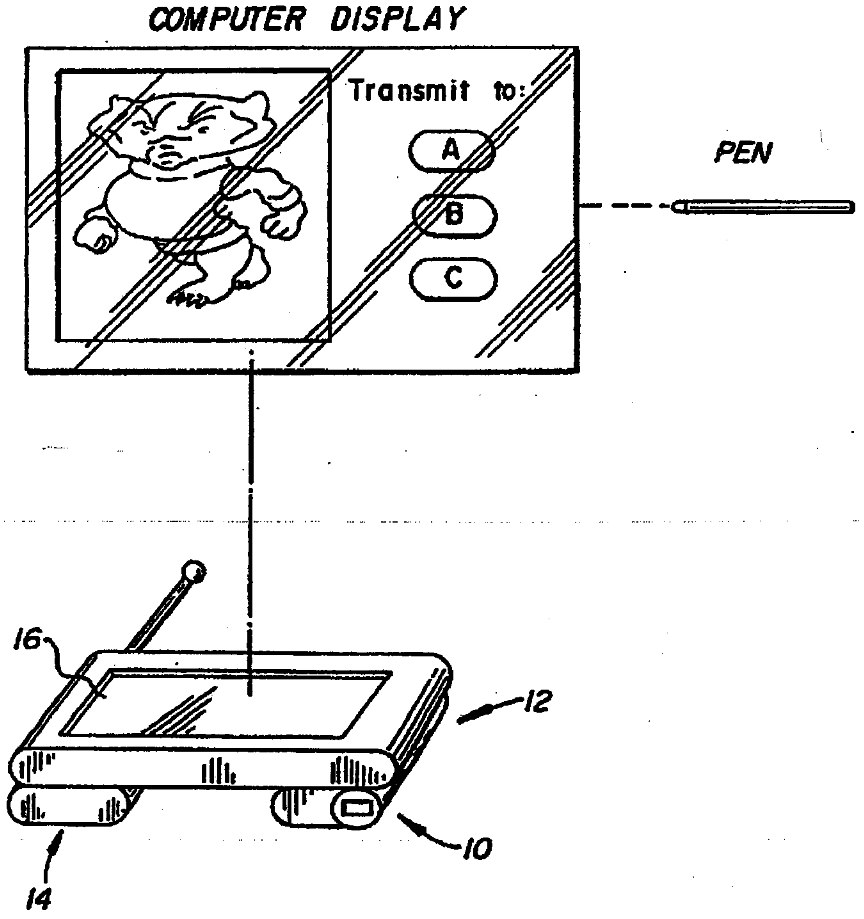


FIG. 6

FIG. 7

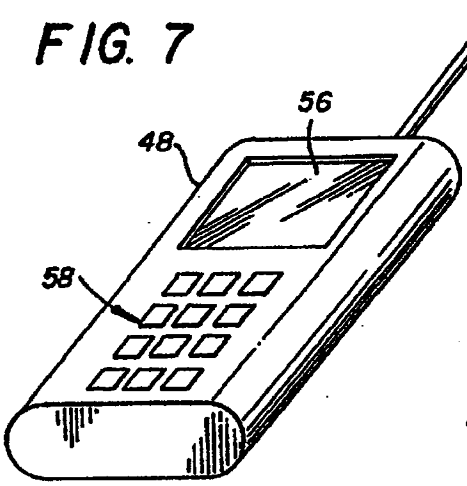
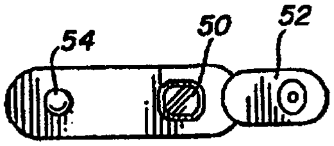


FIG. 8



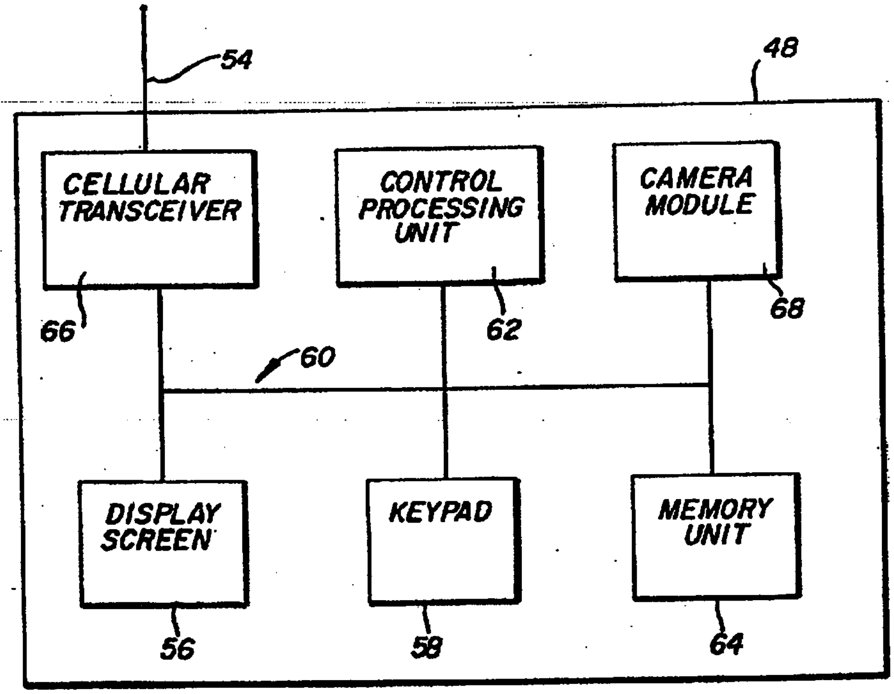


FIG. 9

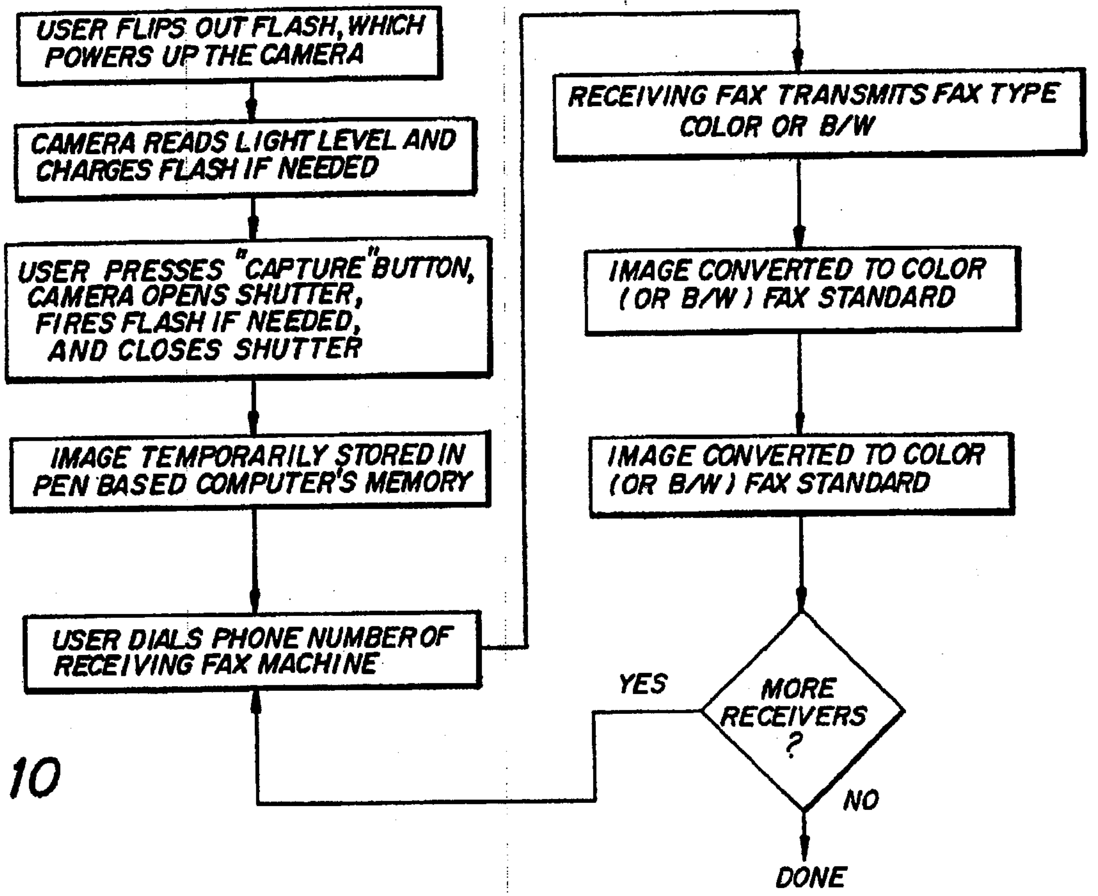

USER FLIPS OUT FLASH, WHICH POWERS UP THE CAMERA
CAMERA READS LIGHT LEVEL AND CHARGES FLASH IF NEEDED
USER PRESSES "CAPTURE" BUTTON, CAMERA OPENS SHUTTER, FIRES FLASH IF NEEDED, AND CLOSES SHUTTER
IMAGE TEMPORARILY STORED IN PEN BASED COMPUTER'S MEMORY
USER DIALS PHONE NUMBER OF RECEIVING FAX MACHINE
RECEIVING FAX TRANSMITS FAX TYPE COLOR OR B/W
IMAGE CONVERTED TO COLOR (OR B/W) FAX STANDARD
IMAGE CONVERTED TO COLOR (OR B/W) FAX STANDARD
MORE RECEIVERS ?
YES
NO
DONE

FIG. 10

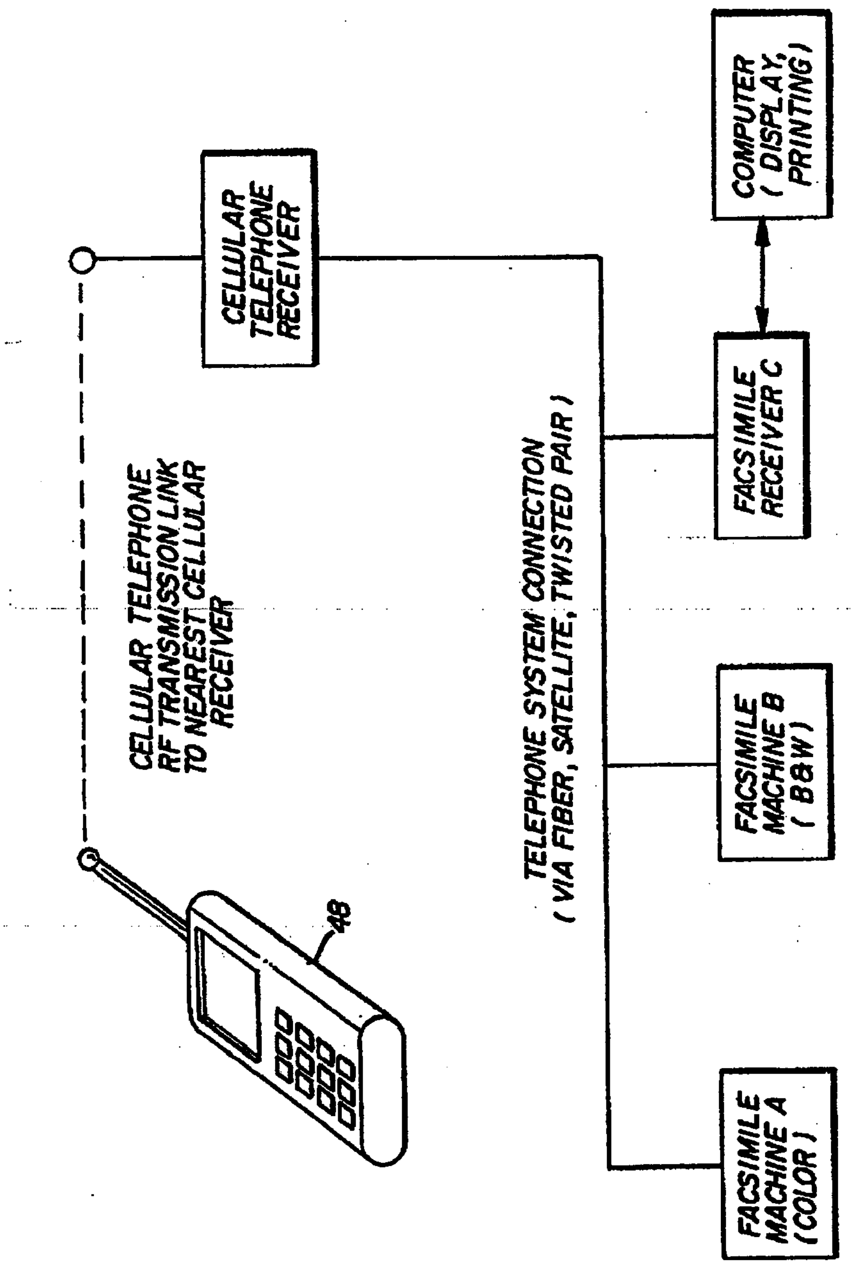

CELLULAR TELEPHONE RECEIVER
CELLULAR TELEPHONE RF TRANSMISSION LINK TO NEAREST CELLULAR RECEIVER
48
TELEPHONE SYSTEM CONNECTION (VIA FIBER, SATELLITE, TWISTED PAIR)
COMPUTER (DISPLAY, PRINTING)
FACSIMILE RECEIVER C
FACSIMILE MACHINE B (B&W)
FACSIMILE MACHINE A (COLOR)

FIG. 11

ELECTRONIC CAMERA SYSTEM WITH PROGRAMMABLE TRANSMISSION CAPABILITY

FIELD OF THE INVENTION

The invention is directed to an electronic camera system. More specifically, the invention is directed to an electronic camera system that includes a transmission mechanism for sending image data to selected receiver units.

BACKGROUND

Motion video cameras and electronic still cameras have been utilized for several years in applications involving image data transmission. Electronic image data generated from a video camera, for example, can be transmitted by a conventional broadcast television station and received by any television in the broadcast area tuned to the appropriate channel. It is not possible, however, for the transmitter to select which receivers will obtain the image data, as selection is controlled at the receiver. Image data from electronic still cameras has been transmitted via conventional telephone lines to selected receivers through the use of a computer equipped with a modem. The image data must first be downloaded from the electronic still camera to the computer, which then transmits the image data to a second modem equipped computer via the telephone line where it can be viewed or printed. Unfortunately, the requirement for a telephone line to transmit image data does not allow images to be quickly and easily transmitted from remote field locations to receiver units. While systems have been proposed that utilize radio frequency transmission to transmit image data from an electronic camera to an individual base unit, none of these systems have the capability of selectively transmitting image data to a plurality of receiver units.

In view of the above, it is an object of the invention to provide an electronic camera system that includes a programmable transmission capability for selectively transmitting electronic image data to a plurality of remote receive units.

SUMMARY OF THE INVENTION

The invention provides an electronic camera system that includes a programmable transmission capability for selectively transmitting electronic image data to a plurality of remote receiver units. In one preferred embodiment of the invention, a camera module is detachably coupled to a portable computer including a display screen and a data entry device. The camera module includes an electronic image sensor for generating digital image data representative of a scene to be imaged. The electronic image data generated by the camera module is supplied to the portable computer for display on the display screen. The data entry device is used by an operator to select which of the plurality of base units are to receive the digital image data. The digital image data is supplied by the portable computer to a radio-frequency transmitter module for transmission to the selected receiver units. The radio-frequency transmitter module is formed either integral with the portable computer or, like the camera module, is detachably coupled to the portable computer. In a further preferred embodiment, a combined telephone/camera unit is provided that includes a camera module for generating electronic image data representative of a scene to be imaged, a memory unit for storing the electronic image data generated by the camera module, a display screen for displaying the electronic image data stored in the memory unit, a mechanism for selecting which of the plurality of receiver units is to receive the digital image data, and a cellular transceiver for transmitting the digital image data to the receiver units selected by the selection mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in greater detail with reference to certain preferred embodiments thereof and the accompanying drawings, wherein:

FIG. 1 is a diagram of a camera system in accordance with a first embodiment of the invention;

FIG. 2 is a perspective side view of a camera module utilized in the camera system illustrated in FIG. 1;

FIG. 3 is a front view of the camera module illustrated in FIG. 2;

FIG. 4 is a schematic block diagram of the components of the camera module illustrated in FIG. 2;

FIG. 5 is a flow diagram illustrating the operation of the camera system illustrated in FIG. 1;

FIG. 6 illustrates the display of a captured image and a receiver unit menu selection on a display screen of the camera system illustrated in FIG. 1;

FIG. 7 is a perspective front view of a combined telephone/camera unit in accordance with a second embodiment of the invention;

FIG. 8 is a top view of the combined telephone/camera unit illustrated in FIG. 7;

FIG. 9 is a schematic block diagram of the combined telephone/camera unit illustrated in FIG. 8;

FIG. 10 is a flow diagram illustrating the operation of the combined unit illustrated in FIG. 7; and

FIG. 11 is a diagram illustrating the transmission of image data to a base unit utilizing the combined unit illustrated in FIG. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A diagram of a camera system in accordance with a first embodiment of the invention is illustrated in FIG. 1. The camera system includes a "clip-on" electronic camera module 10 coupled to a pen-based computer 12 that includes a radio frequency (RF) transmitter module 14 including an antenna. The camera module 10 can be of a form described in copending and commonly assigned U.S. patent application Ser. No. 07/988,517 entitled "Electronic Camera with Memory Card interface to a Computer", which describes a removable camera module that fits into and interfaces with a standard PCMCIA card interface slot of a pen-based computer, or of a type described in copending and commonly assigned U.S. patent application Ser. No. 07/988,560 entitled "Electronic Camera Incorporating a Computer-Compatible Bus Interface", which describes a removable camera module that interfaces directly to a standard personal computer compatible bus. The camera module 10 takes still images that can be displayed on an interactive display screen 16 of the pen-based computer 12. The RF transmitter module 14 can either be a clip-on unit, like the camera module 10, or constructed integrally with the pen-based computer 12. The interactive display screen 16 acts as an input device to the pen-based computer 12, where a stylus or "pen" is used to select various icons or "buttons" displayed on the display screen 16 to enter data or commands into the pen-based computer 12. Still images captured by the camera module 10 are transmitted from the pen-based computer 12 to one or more receiver units, labeled A, B and C in FIG. 1, via the RF transmitter module 14. The still images can be displayed, printed, manipulated or stored at the receiver units A–C.

The camera module 10 is shown in greater detail in FIGS. 2 and 3 as preferably including a slide-out optical veiwfinder 18, a capture switch 20 for initiating an image capture operation, a lens 22, a flip-out flash unit 24 that protects the lens 22 when the camera module 10 is not in use, and a computer bus connector 26 that connects the camera module 10 to either the internal bus of the pen-based computer 12 or to an interface port (such as a PCMCIA slot) of the pen-based computer 12. Mounting clips 27 are provided to aid in securing the camera module 10 to the pen-based computer 12. As shown in FIG. 4, which illustrates a schematic block diagram of the internal components of the camera module 10, scene light passes through the lens 22, an adjustable aperture 28, a shutter mechanism 30 and a filter 32 to an electronic imaging unit 34. The electronic imaging unit 34 includes a charge coupled device (CCD) electronic imaging sensor 36, for example an Eastman Kodak KAF-400, driven by a CCD driver unit 38. The electronic imaging unit 34 is coupled to an image signal processor 40 that processes an analog image signal generated by the electronic imaging sensor 36 into digital image data, and supplies the digital image data to the computer bus connector 26. Specifically, the analog image signal is supplied to a gain stage, a correlated double sampling (CDS) circuit and then an analog-to-digital (A/D) converter which are not specifically illustrated in the diagram. The digitized output signal from the A/D converter is processed via an EPROM lookup table which performs gamma correction and white balancing. The overall operation of the camera module 10 is controlled by a camera control processor 42 that includes either a general purpose microprocessor or discrete circuit elements, which receives inputs from a light measuring unit 44 and the capture switch 20, and controls the operation of the flash 24, the signal processor 40, and a driver unit 46 that controls the operation of the aperture 28 and shutter 30.

The operation of the camera system is illustrated in greater detail in the flow diagram illustrated in FIG. 5. The user turns on the pen-based computer 12 using a power switch (not shown) to activate a camera application program stored in a memory unit of the pen-based computer 12, and then flips up the flash unit 24 which causes power to be supplied to the camera module 10 by activating a power switch (not shown). The user frames the subject using the optical viewfinder 18 and presses the capture switch 20 to initiate a sequence where the scene light level is read by the camera control processor 42 using the light measuring unit 44, the aperture 28 is adjusted, and the shutter 30 is opened to expose the electronic image sensor 36 to scene light. The camera control processor 42 also controls the firing of the flash unit 24 if the light measurement taken by the light measuring unit 44 indicates insufficient scene illumination. The image captured by the electronic image sensor 36 is processed by the image signal processor 40 and supplied to the pen-based computer 12 via the connector 26, where it is stored in the memory unit of the pen-based computer 12.

As illustrated in FIG. 6, the stored image is displayed on the display screen 16 of the pen-based computer 12 along with a transmission selection menu. The user has the option of transmitting the image to one or more of the receiver units A–C. The user selects the receiver units that are to receive the image by utilizing a pen or stylus to touch the appropriate icon displayed on the display screen 16. If appropriate, the image can be compressed, using for example JPEG compression, and converted to an appropriate format by the pen-based computer 12 prior to transmission to the receiver units A–C. After selection, the image is transmitted to the selected receiver units via the RF transmitter module 14.

The RF transmission link between the RF transmitter module 14 and the receiver units A–C may be a single frequency system including a cellular system, that uses the same frequency for all receivers, or a multiple frequency system, that uses different frequencies for each of the different receiver units A–C. In the latter case, the image is transmitted multiple times, once using the appropriate frequency band for each selected receiver unit. For single frequency systems, a header code is transmitted prior to transmitting the image. The header includes an ID for each receiver that is to receive the image. In a simple case, a three bit digital code is transmitted, where the first bit is 1 if receiver unit A should receive the image and 0 if it should not, the second bit is 1 if receiver unit B should receive the image and 0 if is should not, and the third bit is 1 if receiver unit C should receive the image and 0 if not. Alternatively, each receiver unit A–C could be assigned a specific address, and the header would contain the address of each receiver that should receive the image.

A second embodiment of the invention is illustrated, in FIGS. 7 and 8. In this embodiment, a cellular telephone is provided with the components of an electronic image camera to form a combined telephone/camera unit 48. The top of the combined unit 48 includes a lens 50, a flip-up flash unit 52, and an antenna 54. The front face of the combined unit 48 is provided with a liquid crystal display screen 56 and a telephone keypad 58, both of which are coupled to an internal bus 60 along with a control processing unit 62, memory unit 64, and cellular transceiver 66 as shown in FIG. 9. The internal bus 60 is also connected to a camera module 68, which includes the same basic components as illustrated in FIG. 4, with the exception that the output from the image signal processor is supplied directly to the internal bus 60 instead of a connector.

In operation, as illustrated in greater detail by the flow diagram illustrated in FIG. 10, the user takes a picture by flipping up the flash unit 52 and pressing an image capture switch (not shown). Alternatively, a key (for example the # key) on the keypad 58 can be utilized as the image capture switch in an image capture mode of operation. The digitize picture data generated by the camera module 68 is stored in the memory unit 64 and displayed on the display screen 56. To transmit the image, the user dials the telephone number of a desired fax machine that is to receive the image using the keypad 58. The number is transmitted to the fax machine via the cellular transceiver 66. The fax machine responds back to the combined unit 48 with the type of fax mode it is capable of receiving, for example group IV fax, color fax, etc. The stored image is then converted to the appropriate fax standard by the control processing unit 62, and is transmitted to the receiving fax machine using the normal cellular telephone system that includes an RF link from the cellular transceiver 66 to a cellular base unit, which connects to the normal wire, fiber, and satellite telephone system as shown in FIG. 11. Once the image transmission is complete, the image can be transmitted to other fax machines by entering the desired numbers using the keypad 58. The memory unit 64 can include prestored phone numbers, to reduce the number of keystrokes needed to dial frequently used numbers, and can include memory for multiple images, so that multiple images can be transmitted to the same receiving fax machine, one after the other. In addition, the combined unit 48 may be pre-programmed so that the complete image capture and telephone dialing sequence is performed each time the image capture switch is activated.

The invention has been described with reference to certain preferred embodiments thereof. It will be understood, however, that modifications and variations are possible within the scope of the appended claims. For example, although the first illustrated embodiment utilizes a pen-based computer, other types of portable computers with non-interactive displays can be utilized. In such a case, commands and data would be entered via a keyboard, mouse or other data entry devices.

INDUSTRIAL UTILITY

The invention provides an electronic camera system that includes a programmable transmission capability for selectively transmitting electronic image data to a plurality of remote base units. The camera system is particularly suited to applications, such as news gathering operations, in which it is desirable to capture images in remote field locations and transmit the images to a base station for subsequent review, distribution or publication.

Reference Numerals

10 Camera Module
12 Pen-based Computer
14 RF Transmitter Module
16 Display Screen
18 Optical Viewfinder
20 Capture Switch
22 Lens
24 Flash Unit
26 Computer Bus Connector
27 Mounting Clips
28 Aperture
30 Shutter Mechanism
32 Filter
34 Electronic Imaging Unit
36 Electronic Imaging Sensor
38 CCD Driver Unit
40 Image Signal Processor
42 Camera Control Processor
44 Light Measuring Unit
46 Driver Unit
48 Telephone/Camera Unit
50 Lens
52 Flash Unit
54 Antenna
56 Display Screen
58 Keypad
60 Internal Bus
62 Control Processing Unit
64 Memory Unit
66 Cellular Transceiver
68 Camera Module

What is claimed is:

1. An electronic camera system for selectively transmitting digital image data to a plurality of base receiver units, said electronic camera system comprising:

imaging means for imaging a scene and generating digital image data representative of the imaged scene;

storage means for storing the digital image data;

display means for displaying the digital image data generated by the imaging means;

selection means for selecting at least one of the plurality of base receiver units to receive the digital image data;

radio-frequency receiver means for receiving a mode signal from the base receiver unit selected by the selection means indicating the type of transmission that can be received by the selected base receiver unit;

means responsive to the mode signal for converting the digital image data to standardized digital image data corresponding to the type of transmission that can be received by the selected base receiver unit; and

radio-frequency transmission means for transmitting the standardized digital image data to the base receiver unit selected by the selection means to receive the digital image data.

2. An electronic camera system as claimed in claim 1, wherein the radio-frequency transmission means includes a cellular transceiver.

3. An electronic camera as claimed in claim 1 wherein said imaging means is contained in a module that is separate from said display means and said selection means.

4. An electronic camera as claimed in claim 1 wherein said radio-frequency receiver means and said radio-frequency transmission means are contained in a module that is separate from said display means and said selection means.

5. An electronic camera as claimed in claim 2 wherein said cellular transceiver connects to a standard telephone system connection.

6. An electronic camera as claimed in claim 5 wherein said telephone system connection connects to said plurality of base receiver units.

7. An electronic camera as claimed in claim 6 wherein said at least one of said plurality of base receiver units includes a facsimile machine.

8. An electronic camera as claimed in 5 wherein said camera system further includes a memory unit that stores a plurality of phone numbers.

9. An electronic camera as claimed in claim 8 wherein said selection means selects one base receiver unit, and wherein said selection means selects one of said prestored phone numbers in said memory unit and automatically dials said one selected prestored phone number.

10. An electronic camera as claimed in claim 1 wherein said radio-frequency transmission means transmits standardized digital image data for a plurality of imaged scenes to said selected one of the plurality of base receiver units.

* * * * *

US005539452A

United States Patent [19]

Bush et al.

[11] **Patent Number: 5,539,452**

[45] **Date of Patent: *Jul. 23, 1996**

[54] **VIDEO TELEPHONE SYSTEM**

[75] Inventors: **Daniel R. Bush**, Franktown; **Ashok Patel**, Castle Rock; **Charlie W. Zetterower**, Parker, all of Colo.

[73] Assignee: **Alkanox Corporation**, Evergreen, Colo.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,164,980.

[21] Appl. No.: **301,893**

[22] Filed: **Sep. 6, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 628,607, Dec. 17, 1990, Pat. No. 5,347,305, which is a continuation-in-part of Ser. No. 482,649, Feb. 21, 1990, Pat. No. 5,164,980.

[51] **Int. Cl.**^{6} **H04N 7/14**

[52] **U.S. Cl.** **348/17**; 348/14

[58] **Field of Search** 348/14, 17, 15, 348/16, 18; 379/96

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,873,771	3/1975	Kleinerman et al.	179/2
4,099,202	7/1978	Cavanaugh	348/14
4,237,484	12/1980	Brown et al.	358/142
4,485,400	11/1984	Lemelson et al.	348/14
4,544,950	10/1985	Tu	358/143
4,593,318	6/1986	Eng et al.	358/142
4,715,059	12/1987	Cooper-Hart et al.	348/14
4,774,574	9/1988	Daly et al.	358/153
4,849,811	7/1989	Kleinerman	358/133
4,955,048	9/1990	Iwamura et al.	348/14
4,962,521	10/1990	Kamatsu et al.	379/53
4,985,911	1/1991	Emmons et al.	348/14
4,991,009	2/1991	Suzuki et al.	379/53
5,130,792	7/1992	Tindell	348/14
5,164,980	11/1992	Bush et al.	348/14

FOREIGN PATENT DOCUMENTS

3640680	6/1988	Germany .
61-159883	7/1986	Japan .
1-175452	7/1989	Japan .
2173675	10/1986	United Kingdom .

OTHER PUBLICATIONS

J. Anderson, et al. of Widcom, Inc., Campbell, California, *Electronics*, "Codec squeezes color teleconferencing through digital telephone lines," Jan. 26, 1984, pp. 113–115.

Rose et al., " Design and Performance of an Analysis-by--Synthesis Class of Predictive Speech Coders," Sep. 1990 IEEE Transactions of Acoustics, Speech & Processing, vol. 38, No. 9, pp. 1489–1503.

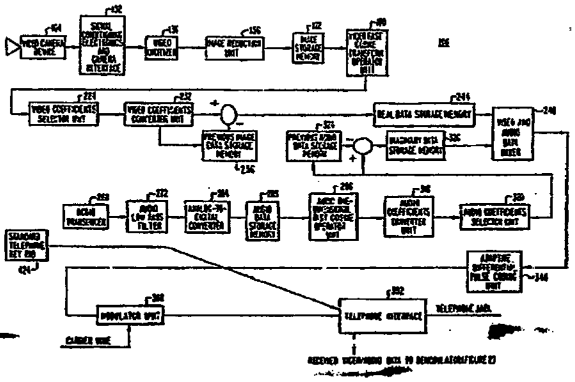
(List continued on next page.)

Primary Examiner—Curtis Kuntz
Assistant Examiner—Stella L. Woo
Attorney, Agent, or Firm—Sheridan Ross & McIntosh

[57] **ABSTRACT**

Apparatus and method are provided for the simultaneous transmission of video information and audio information in substantially real time over an ordinary voice grade telephone line having limited bandwidth in the range of about 300–3400 Hz. Because of the limited bandwidth of the ordinary telephone line, the video and audio information are compressed before transmission thereof. Each of the video information and audio information is separately compressed, mixed together and then further compressed. After the further compression, a composite signal, which includes the mixture of video and audio information, is asynchronously transmitted over the same bandwidth of the ordinary telephone line. Upon reception, the compressed information is expanded and separate video information and audio information are reproduced for viewing and hearing by the receiving party. To reduce the size of the apparatus, application specific integrated circuits (ASICs) are employed. A state machine controller apparatus is integrated with the ASIC technology to control the transfer and storing of video information and audio information and also to control the operation of the various compression and expansion stages associated with the transmitting and receiving channels.

39 Claims, 12 Drawing Sheets



OTHER PUBLICATIONS

Chen et al., "Real-Time Implementation and Performance of a 16 Kb/s Low-Delay CELP Speech Coder," S4a.4 of 1990 IEEE, pp. 181-184.
Chen, "High Quality 16 Kb/s Speech Coding with a One--Way Delay Less than Two ms," S9.1 of 1990 IEEE, pp. 453-456.
Menez et al., "A 2 ms-Delay Adaptive Code Excited Linear Predictive Coder," S9.2 of 1990 IEEE, pp. 457-460.
Gerson et al., "Vector Sum Excited Linear Prediction (VSELP) Speech Coding at 8 kbps," S9.3 of 1990 IEEE, pp. 461-464.
"Codec Squeezes Color Teleconferencing Through Digital Phone Lines," J. Anderson et al. of Widcom, Campbell, CA Jan. 26, 1984 *Electronics* pp. 113-115.
"Design and Performance of an Analysis-By-Synthesis Class of Predictive Speech Coders," Rose et al. Sep. 1990. *IEEE Transactions of Acoustics, Speech & Processing*: vol. 38, No. 9, pp. 1489-1503.

"Real-Time Implementation and Performance of a 16 Kb/s Low Delay CELP Speech Coder," Chen et al., S4a.4 of 1990 IEEE, pp. 181-184.

"High-Quality 16 Kb/s Speech Coding with a One-Way Delay Less than Two ms," Chen, S9.1 of 1990 IEEE. pp. 453-456.

"A 2 ms-Delay Adaptive Code Excited Linear Predictive Coder," Menez et al., S9.2 of 1990 IEEE, pp. 457-460.

"Vector Sum Excited Linear Prediction (VSELP) Speech Coding at 8 kbps," Gerson et al., S9.3 of 1990 IEEE, pp. 461-464.

C. H. Herbst, "Fernschbilder in Schmalen Kanälen" Funkschan, vol. 58, No. 10, pp. 104-106, May 1986.

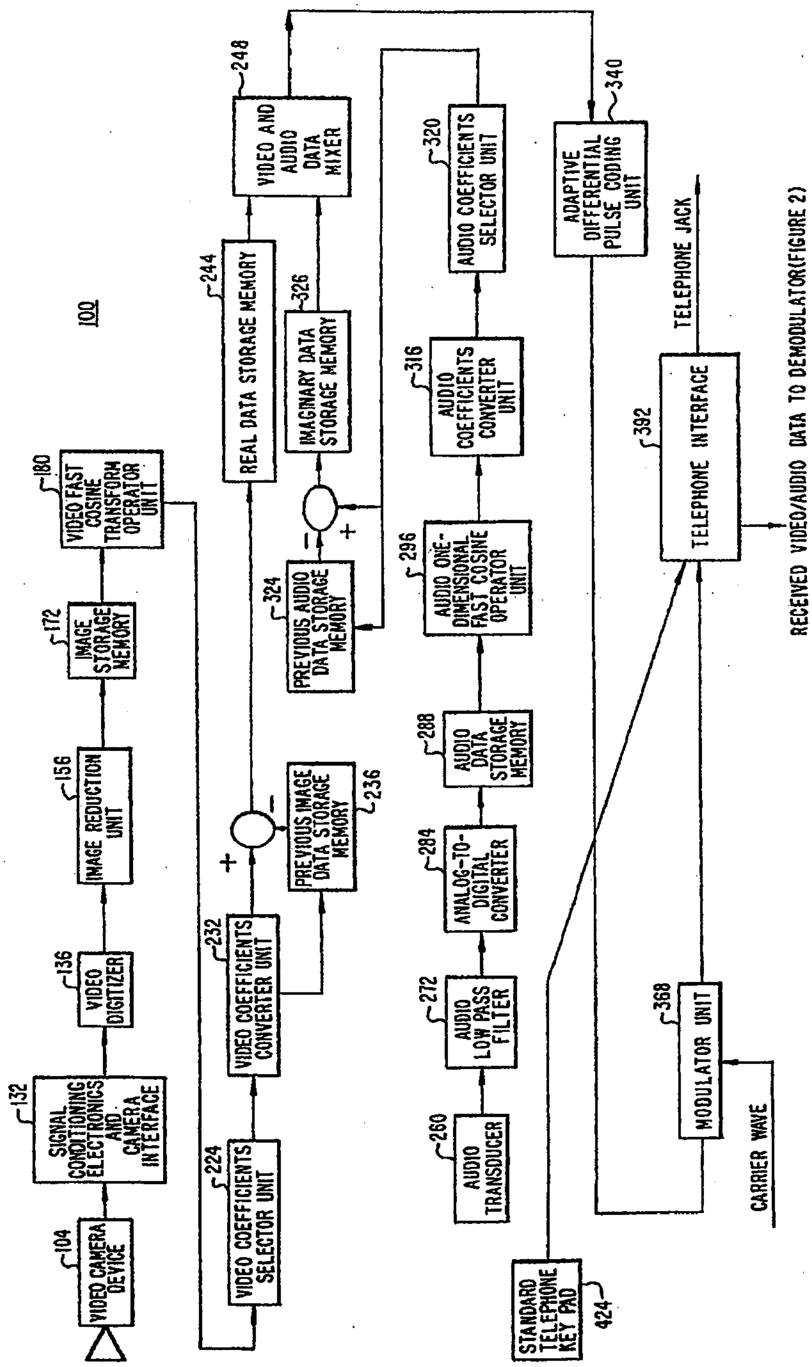

100
104
VIDEO CAMERA DEVICE
132
SIGNAL CONDITIONING ELECTRONICS AND CAMERA INTERFACE
136
VIDEO DIGITIZER
156
IMAGE REDUCTION UNIT
172
IMAGE STORAGE MEMORY
180
VIDEO FAST COSINE TRANSFORM OPERATOR UNIT
224
VIDEO COEFFICIENTS SELECTOR UNIT
232
VIDEO COEFFICIENTS CONVERTER UNIT
+
-
236
PREVIOUS IMAGE DATA STORAGE MEMORY
244
REAL DATA STORAGE MEMORY
248
VIDEO AND AUDIO DATA MIXER
324
PREVIOUS AUDIO DATA STORAGE MEMORY
-
+
326
IMAGINARY DATA STORAGE MEMORY
260
AUDIO TRANSDUCER
272
AUDIO LOW PASS FILTER
284
ANALOG-TO-DIGITAL CONVERTER
288
AUDIO DATA STORAGE MEMORY
296
AUDIO ONE-DIMENSIONAL FAST COSINE OPERATOR UNIT
316
AUDIO COEFFICIENTS CONVERTER UNIT
320
AUDIO COEFFICIENTS SELECTOR UNIT
340
ADAPTIVE DIFFERENTIAL PULSE CODING UNIT
424
STANDARD TELEPHONE KEY PAD
368
MODULATOR UNIT
CARRIER WAVE
392
TELEPHONE INTERFACE
TELEPHONE JACK
RECEIVED VIDEO/AUDIO DATA TO DEMODULATOR(FIGURE 2)

FIG.1

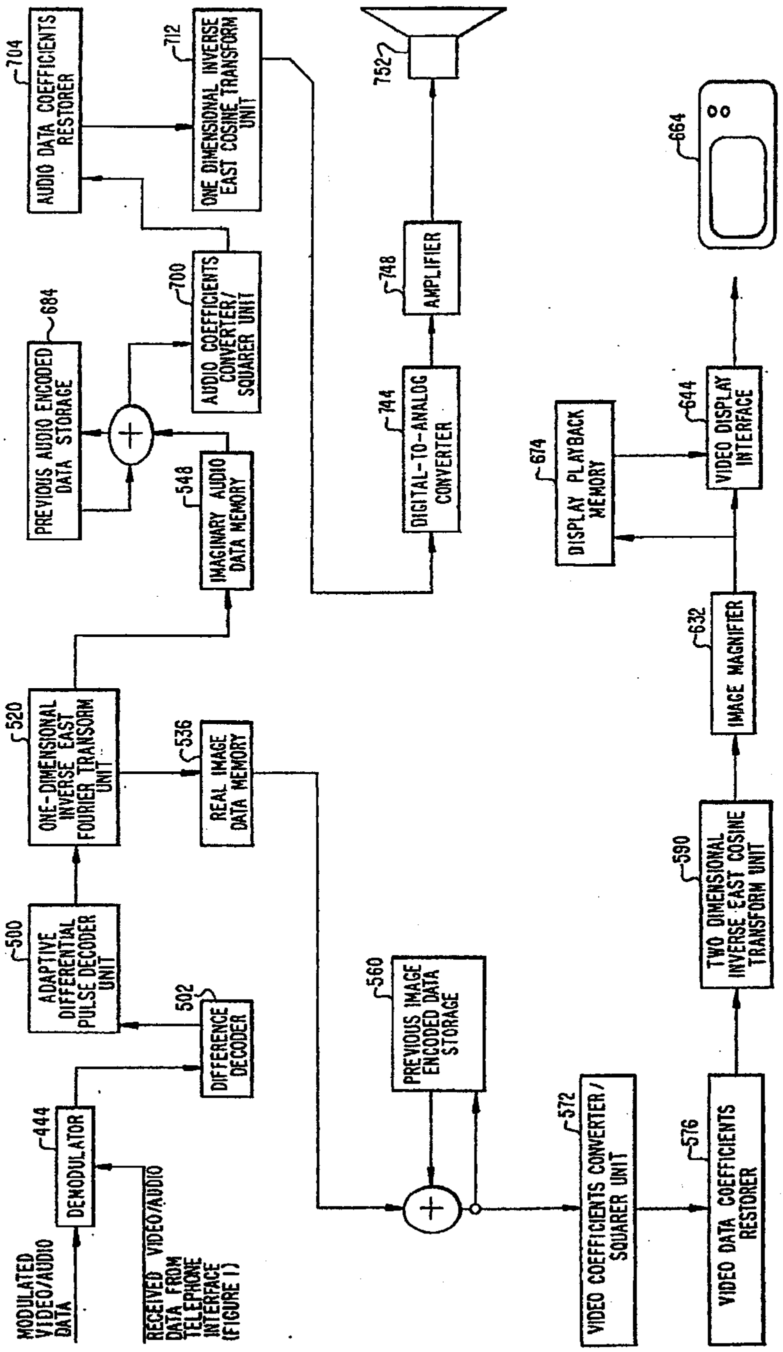

MODULATED VIDEO/AUDIO DATA
RECEIVED VIDEO/AUDIO DATA FROM TELEPHONE INTERFACE (FIGURE 1)
444
DEMODULATOR
502
DIFFERENCE DECODER
500
ADAPTIVE DIFFERENTIAL PULSE DECODER UNIT
520
ONE-DIMENSIONAL INVERSE EAST FOURIER TRANSOM UNIT
536
REAL IMAGE DATA MEMORY
548
IMAGINARY AUDIO DATA MEMORY
684
PREVIOUS AUDIO ENCODED DATA STORAGE
700
AUDIO COEFFICIENTS CONVERTER/ SQUARER UNIT
704
AUDIO DATA COEFFICIENTS RESTORER
712
ONE DIMENSIONAL INVERSE EAST COSINE TRANSFORM UNIT
744
DIGITAL-TO-ANALOG CONVERTER
748
AMPLIFIER
752
560
PREVIOUS IMAGE ENCODED DATA STORAGE
572
VIDEO COEFFICIENTS CONVERTER/ SQUARER UNIT
576
VIDEO DATA COEFFICIENTS RESTORER
590
TWO DIMENSIONAL INVERSE EAST COSINE TRANSFORM UNIT
632
IMAGE MAGNIFIER
674
DISPLAY PLAYBACK MEMORY
644
VIDEO DISPLAY INTERFACE
664

FIG.2

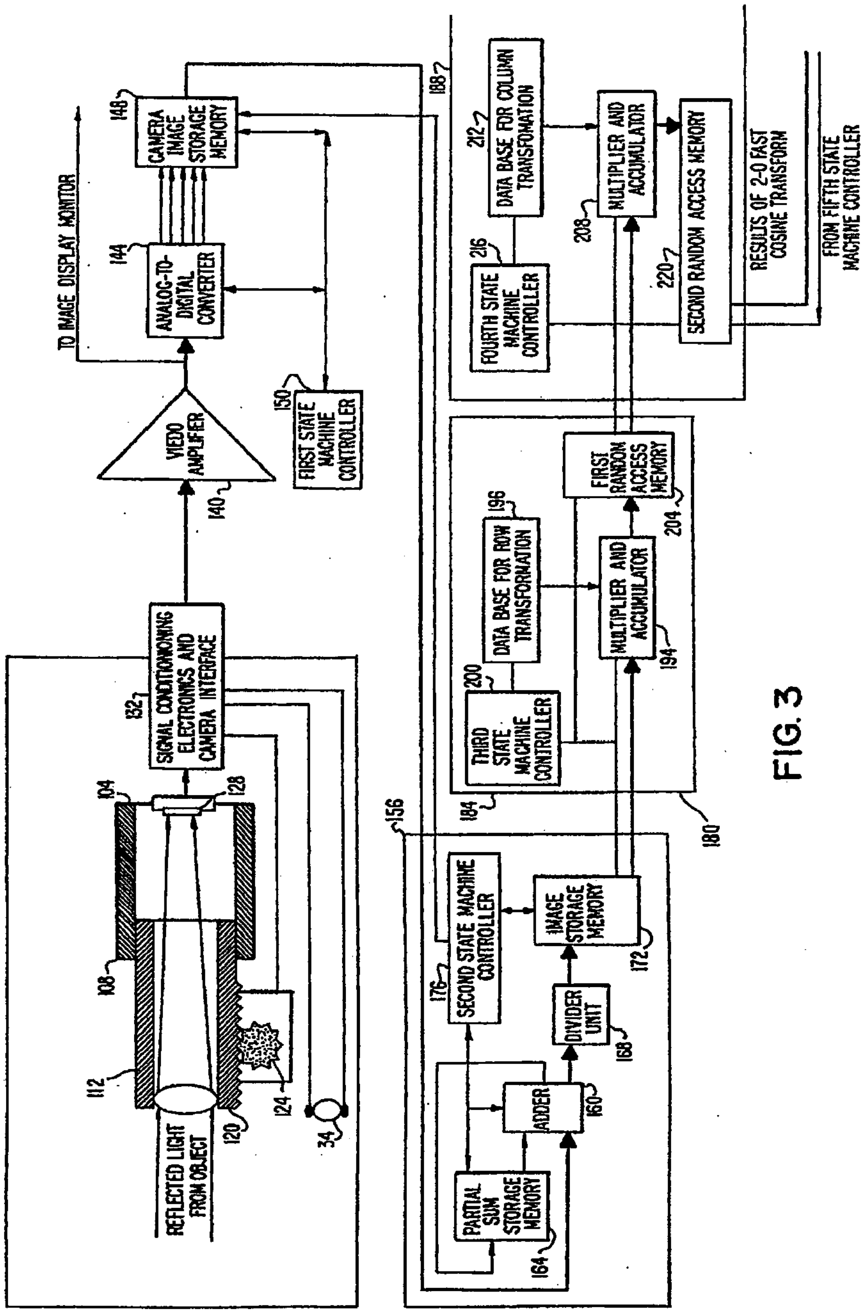

REFLECTED LIGHT FROM OBJECT
112
108
104
128
120
124
34
132
SIGNAL CONDITIONING ELECTRONICS AND CAMERA INTERFACE
140
VIEDO AMPLIFIER
TO IMAGE DISPLAY MONITOR
144
ANALOG-TO-DIGITAL CONVERTER
146
CAMERA IMAGE STORAGE MEMORY
150
FIRST STATE MACHINE CONTROLLER
188
156
164
PARTIAL SUM STORAGE MEMORY
ADDER
160
DIVIDER UNIT
168
176
SECOND STATE MACHINE CONTROLLER
IMAGE STORAGE MEMORY
172
184
180
200
THIRD STATE MACHINE CONTROLLER
196
DATA BASE FOR ROW TRANSFORMATION
MULTIPLIER AND ACCUMULATOR
194
FIRST RANDOM ACCESS MEMORY
204
216
FOURTH STATE MACHINE CONTROLLER
212
DATA BASE FOR COLUMN TRANSFORMATION
208
MULTIPLIER AND ACCUMULATOR
220
SECOND RANDOM ACCESS MEMORY
RESULTS OF 2-D FAST COSINE TRANSFORM
FROM FIFTH STATE MACHINE CONTROLLER

FIG. 3

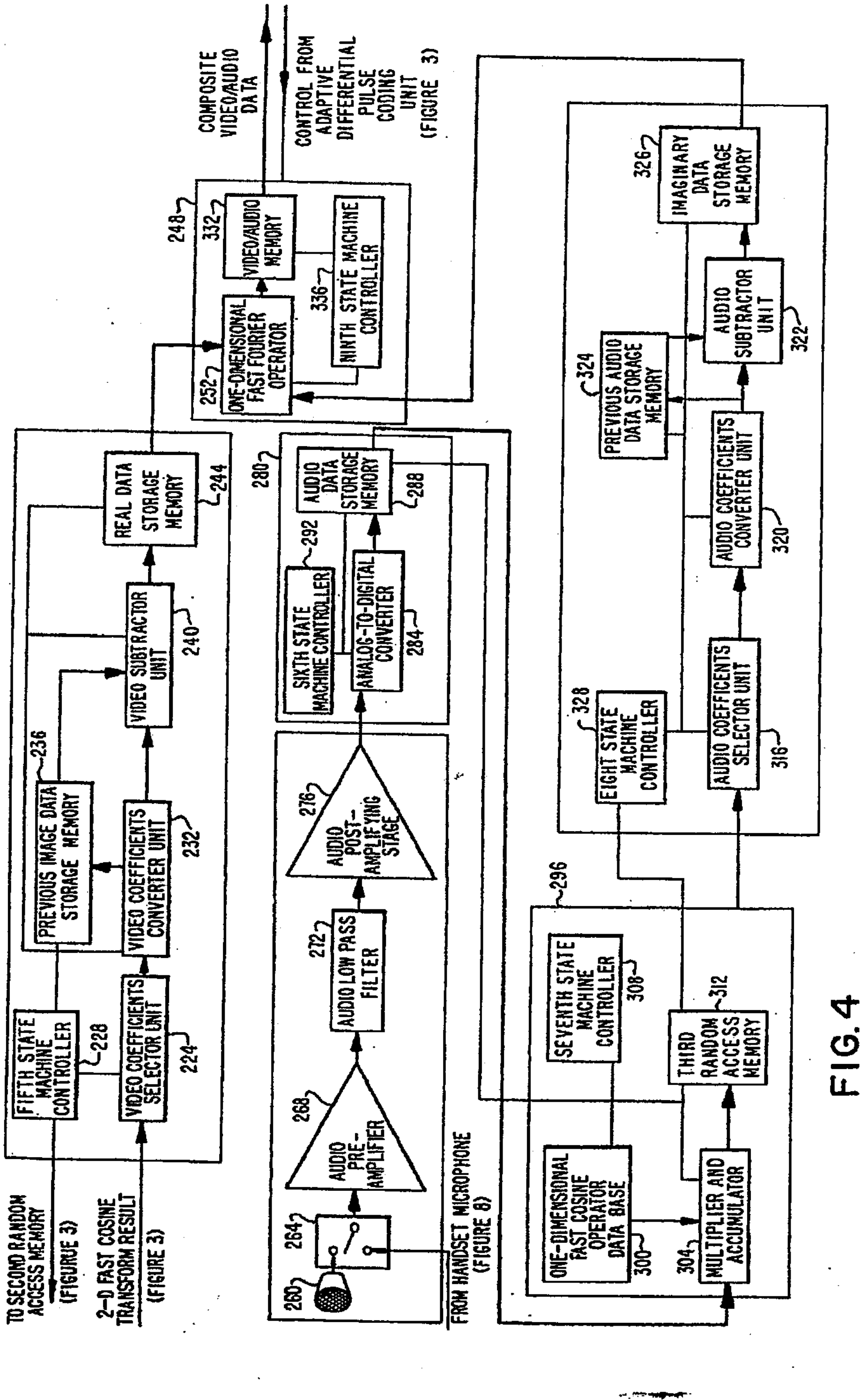

TO SECOND RANDOM ACCESS MEMORY (FIGURE 3)
2-D FAST COSINE TRANSFORM RESULT (FIGURE 3)
FIFTH STATE MACHINE CONTROLLER
228
VIDEO COEFFICIENTS SELECTOR UNIT
224
PREVIOUS IMAGE DATA STORAGE MEMORY
236
VIDEO COEFFICIENTS CONVERTER UNIT
232
VIDEO SUBTRACTOR UNIT
240
REAL DATA STORAGE MEMORY
244
ONE-DIMENSIONAL FAST FOURIER OPERATOR
252
VIDEO/AUDIO MEMORY
332
248
NINTH STATE MACHINE CONTROLLER
336
COMPOSITE VIDEO/AUDIO DATA
CONTROL FROM ADAPTIVE DIFFERENTIAL PULSE CODING UNIT (FIGURE 3)
260
264
FROM HANDSET MICROPHONE (FIGURE 8)
AUDIO PRE-AMPLIFIER
268
AUDIO LOW PASS FILTER
272
AUDIO POST-AMPLIFYING STAGE
276
SIKTH STATE MACHINE CONTROLLER
292
ANALOG-TO-DIGITAL CONVERTER
284
AUDIO DATA STORAGE MEMORY
288
280
ONE-DIMENSIONAL FAST COSINE OPERATOR DATA BASE
300
MULTIPLIER AND ACCUMULATOR
304
SEVENTH STATE MACHINE CONTROLLER
308
THIRD RANDOM ACCESS MEMORY
312
296
EIGHT STATE MACHINE CONTROLLER
328
AUDIO COEFFICENTS SELECTOR UNIT
316
AUDIO COEFFICIENTS CONVERTER UNIT
320
PREVIOUS AUDIO DATA STORAGE MEMORY
324
AUDIO SUBTRACTOR UNIT
322
IMAGINARY DATA STORAGE MEMORY
326

FIG. 4

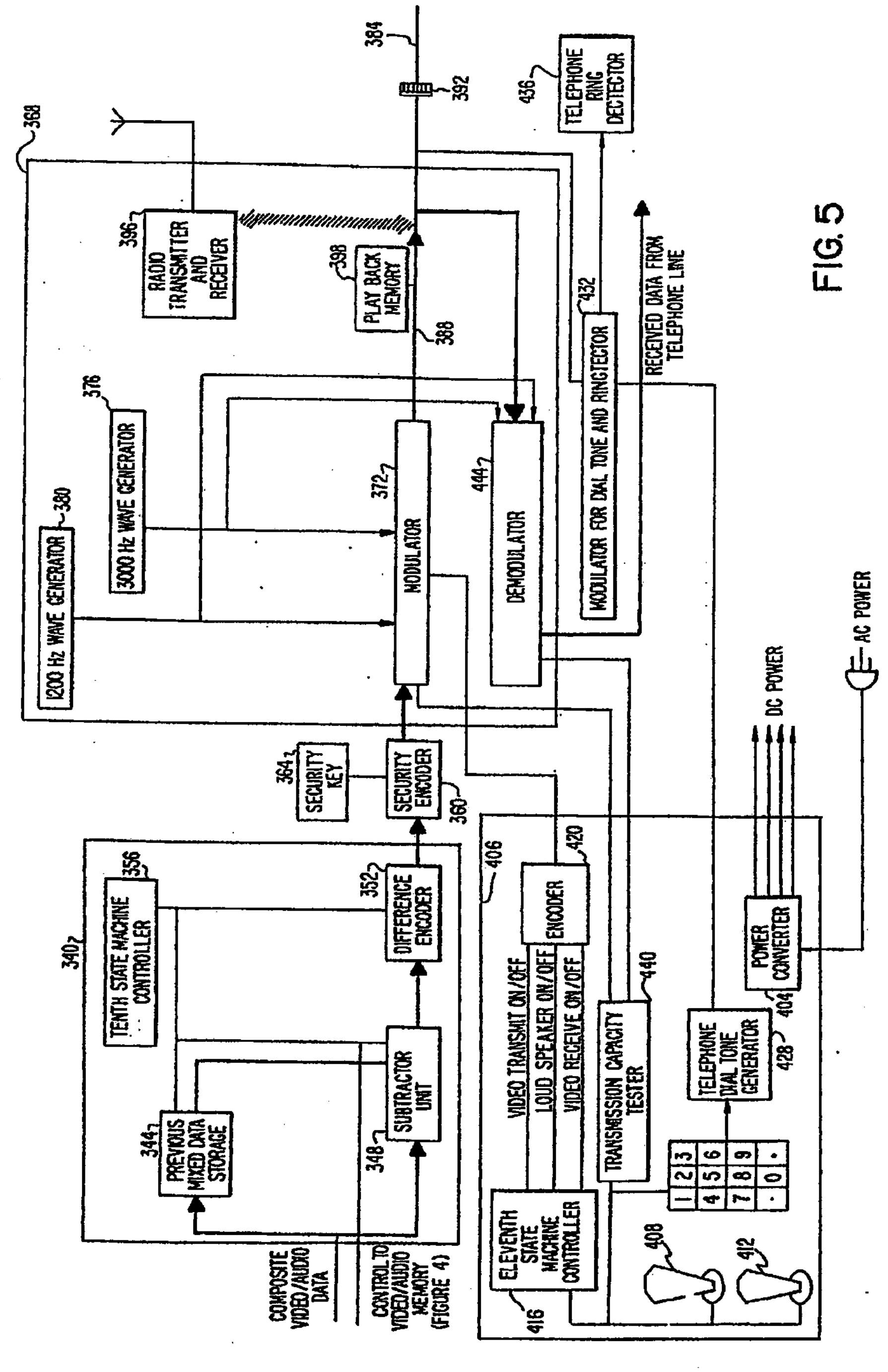

368
1200 Hz WAVE GENERATOR
380
3000 Hz WAVE GENERATOR
376
MODULATOR
372
DEMODULATOR
444
MODULATOR FOR DIAL TONE AND RINGTECTOR
432
RADIO TRANSMITTER AND RECEIVER
396
PLAY BACK MEMORY
398
388
384
392
TELEPHONE RING DECTECTOR
436
RECEIVED DATA FROM TELEPHONE LINE
SECURITY KEY
364
SECURITY ENCODER
360
340
TENTH STATE MACHINE CONTROLLER
356
DIFFERENCE ENCODER
352
SUBTRACTOR UNIT
348
PREVIOUS MIXED DATA STORAGE
344
COMPOSITE VIDEO/AUDIO DATA
CONTROL TO VIDEO/AUDIO MEMORY (FIGURE 4)
406
ENCODER
420
VIDEO TRANSMIT ON/OFF
LOUD SPEAKER ON/OFF
VIDEO RECEIVE ON/OFF
TRANSMISSION CAPACITY TESTER
440
ELEVENTH STATE MACHINE CONTROLLER
416
408
412
1 2 3
4 5 6
7 8 9
* 0 \#
TELEPHONE DIAL TONE GENERATOR
428
POWER CONVERTER
404
DC POWER
AC POWER

FIG. 5

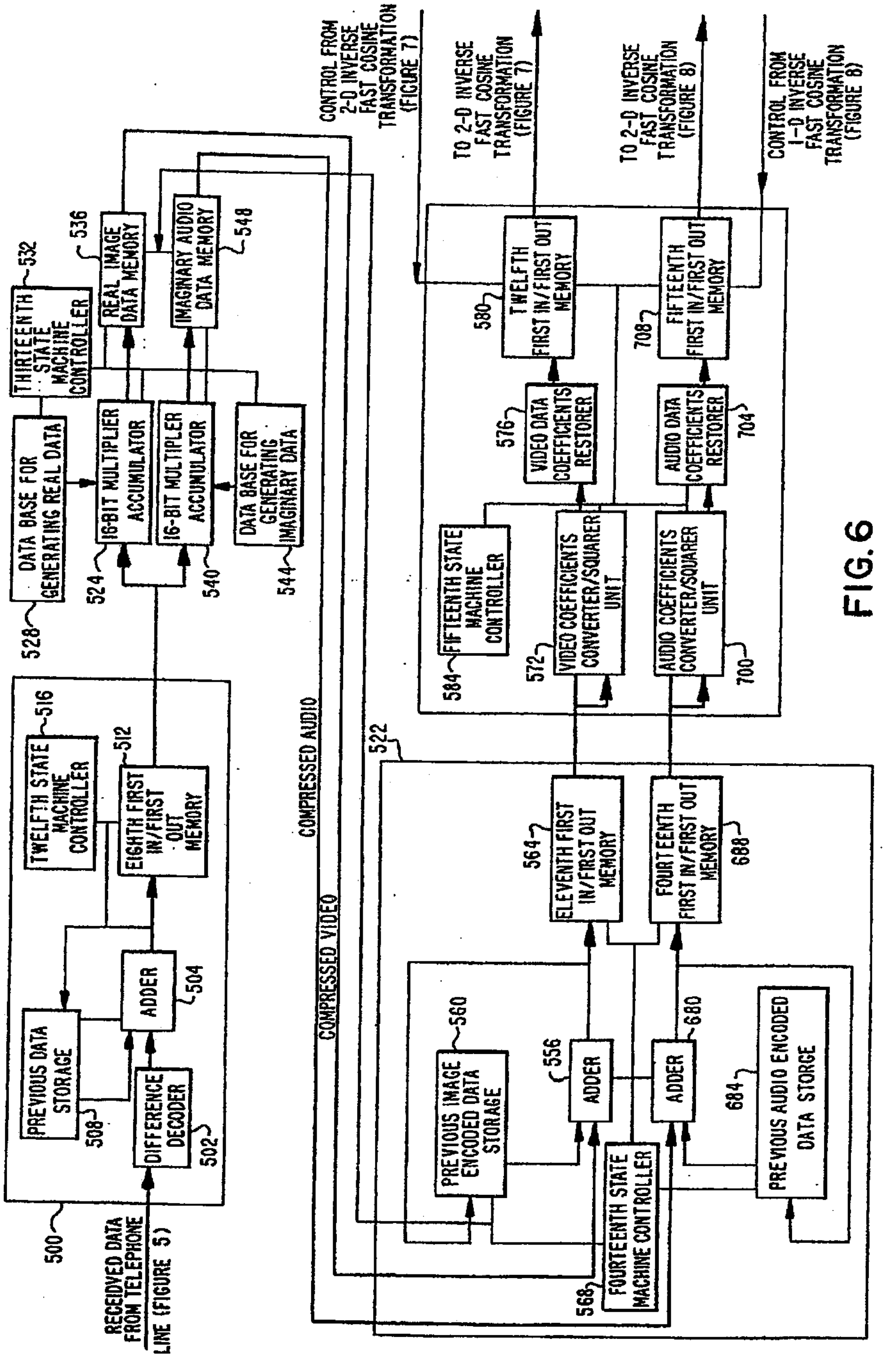

RECEIDVED DATA FROM TELEPHONE LINE (FIGURE 5)
500
DIFFERENCE DECODER
502
PREVIOUS DATA STORAGE
508
ADDER
504
TWELFTH STATE MACHINE CONTROLLER
516
EIGHTH FIRST IN/FIRST OUT MEMORY
512
DATA BASE FOR GENERATING REAL DATA
528
16-BIT MULTIPLIER ACCUMULATOR
524
16-BIT MULTIPLIER ACCUMULATOR
540
DATA BASE FOR GENERATING IMAGINARY DATA
544
THIRTEENTH STATE MACHINE CONTROLLER
532
REAL IMAGE DATA MEMORY
536
IMAGINARY AUDIO DATA MEMORY
548
COMPRESSED AUDIO
COMPRESSED VIDEO
522
PREVIOUS IMAGE ENCODED DATA STORAGE
560
ADDER
556
ADDER
680
FOURTEENTH STATE MACHINE CONTROLLER
568
PREVIOUS AUDIO ENCODED DATA STORGE
684
ELEVENTH FIRST IN/FIRST OUT MEMORY
564
FOURTEENTH FIRST IN/FIRST OUT MEMORY
688
FIFTEENTH STATE MACHINE CONTROLLER
584
VIDEO COEFFICIENTS CONVERTER/SQUARER UNIT
572
AUDIO COEFFICIENTS CONVERTER/SQUARER UNIT
700
VIDEO DATA COEFFICIENTS RESTORER
576
AUDIO DATA COEFFICIENTS RESTORER
704
TWELFTH FIRST IN/FIRST OUT MEMORY
580
FIFTEENTH FIRST IN/FIRST OUT MEMORY
708
CONTROL FROM 2-D INVERSE FAST COSINE TRANSFORMATION (FIGURE 7)
TO 2-D INVERSE FAST COSINE TRANSFORMATION (FIGURE 7)
TO 2-D INVERSE FAST COSINE TRANSFORMATION (FIGURE 8)
CONTROL FROM 1-D INVERSE FAST COSINE TRANSFORMATION (FIGURE 8)

FIG.6

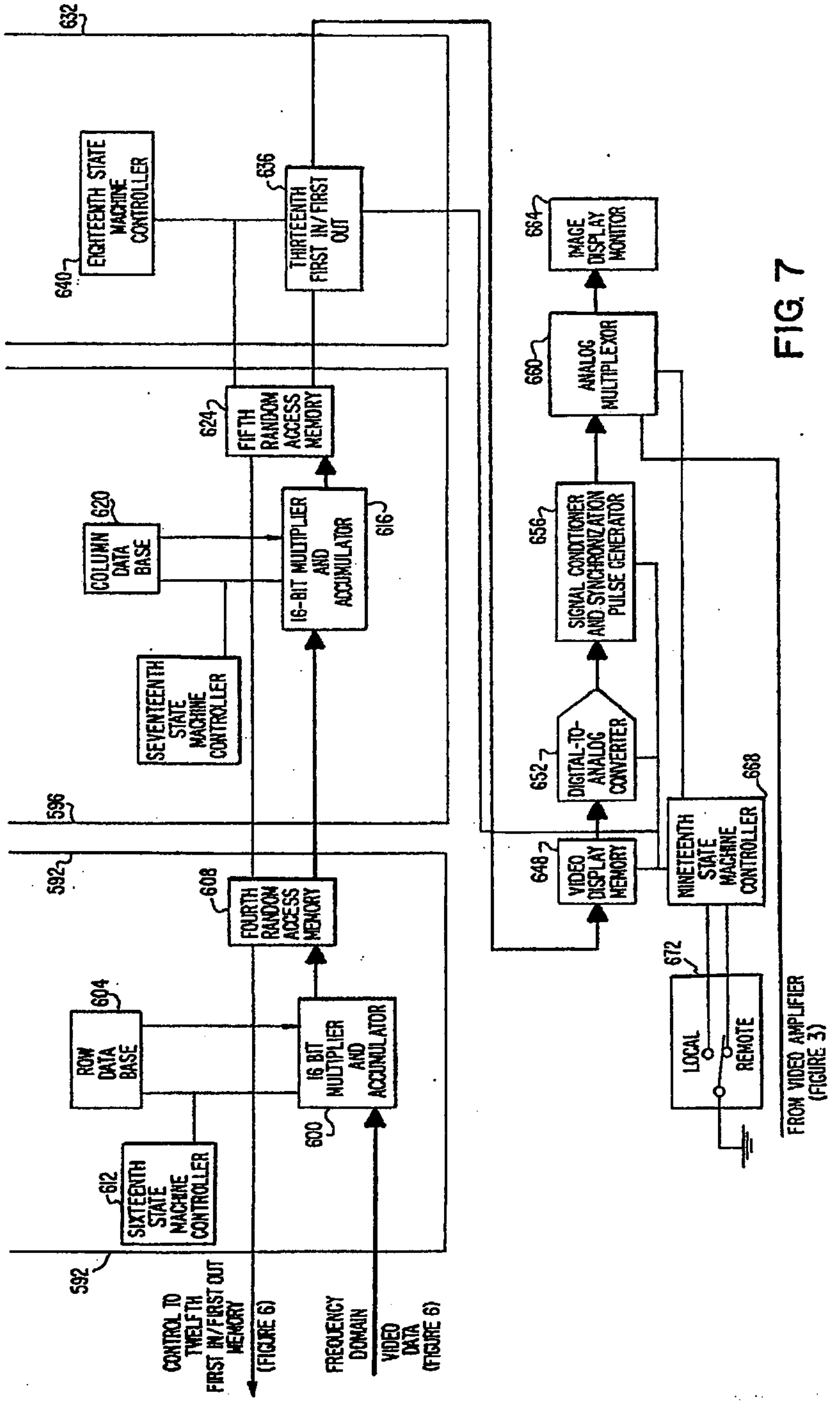

632
640
EIGHTEENTH STATE MACHINE CONTROLLER
636
THIRTEENTH FIRST IN/FIRST OUT
664
IMAGE DISPLAY MONITOR
660
ANALOG MULTIPLEXOR
624
FIFTH RANDOM ACCESS MEMORY
620
COLUMN DATA BASE
616
16-BIT MULTIPLIER AND ACCUMULATOR
656
SIGNAL CONDITIONER AND SYNCHRONIZATION PULSE GENERATOR
SEVENTEENTH STATE MACHINE CONTROLLER
652
DIGITAL-TO-ANALOG CONVERTER
668
596
592
648
VIDEO DISPLAY MEMORY
NINETEENTH STATE MACHINE CONTROLLER
608
FOURTH RANDOM ACCESS MEMORY
672
604
ROW DATA BASE
16 BIT MULTIPLIER AND ACCUMULATOR
600
LOCAL
REMOTE
FROM VIDEO AMPLIFIER (FIGURE 3)
612
SIXTEENTH STATE MACHINE CONTROLLER
592
CONTROL TO TWELFTH FIRST IN/FIRST OUT MEMORY (FIGURE 6)
FREQUENCY DOMAIN VIDEO DATA (FIGURE 6)

FIG 7

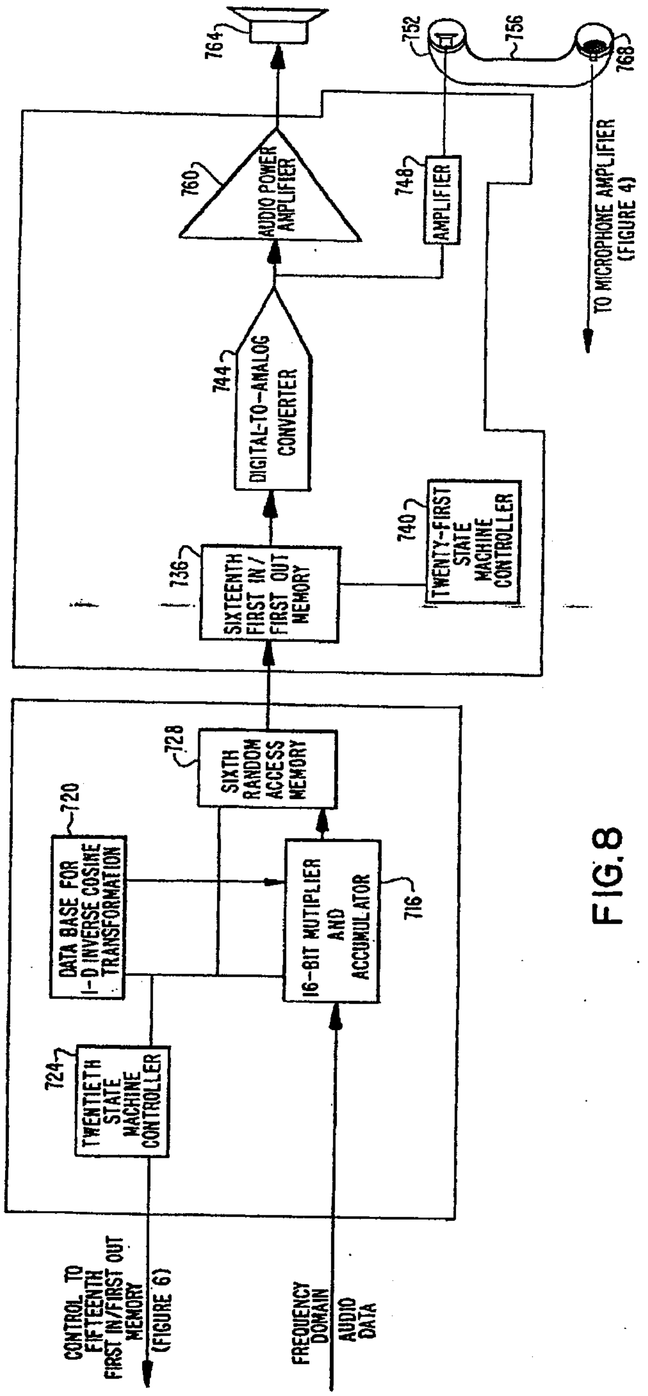

764
752
756
768
760
AUDIO POWER AMPLIFIER
748
AMPLIFIER
TO MICROPHONE AMPLIFIER (FIGURE 4)
744
DIGITAL-TO-ANALOG CONVERTER
736
SIXTEENTH FIRST IN/ FIRST OUT MEMORY
740
TWENTY-FIRST STATE MACHINE CONTROLLER
728
SIXTH RANDOM ACCESS MEMORY
720
DATA BASE FOR 1-D INVERSE COSINE TRANSFORMATION
16-BIT MUTIPLIER AND ACCUMULATOR
716
724
TWENTIETH STATE MACHINE CONTROLLER
CONTROL TO FIFTEENTH FIRST IN/FIRST OUT MEMORY (FIGURE 6)
FREQUENCY DOMAIN AUDIO DATA

FIG.8

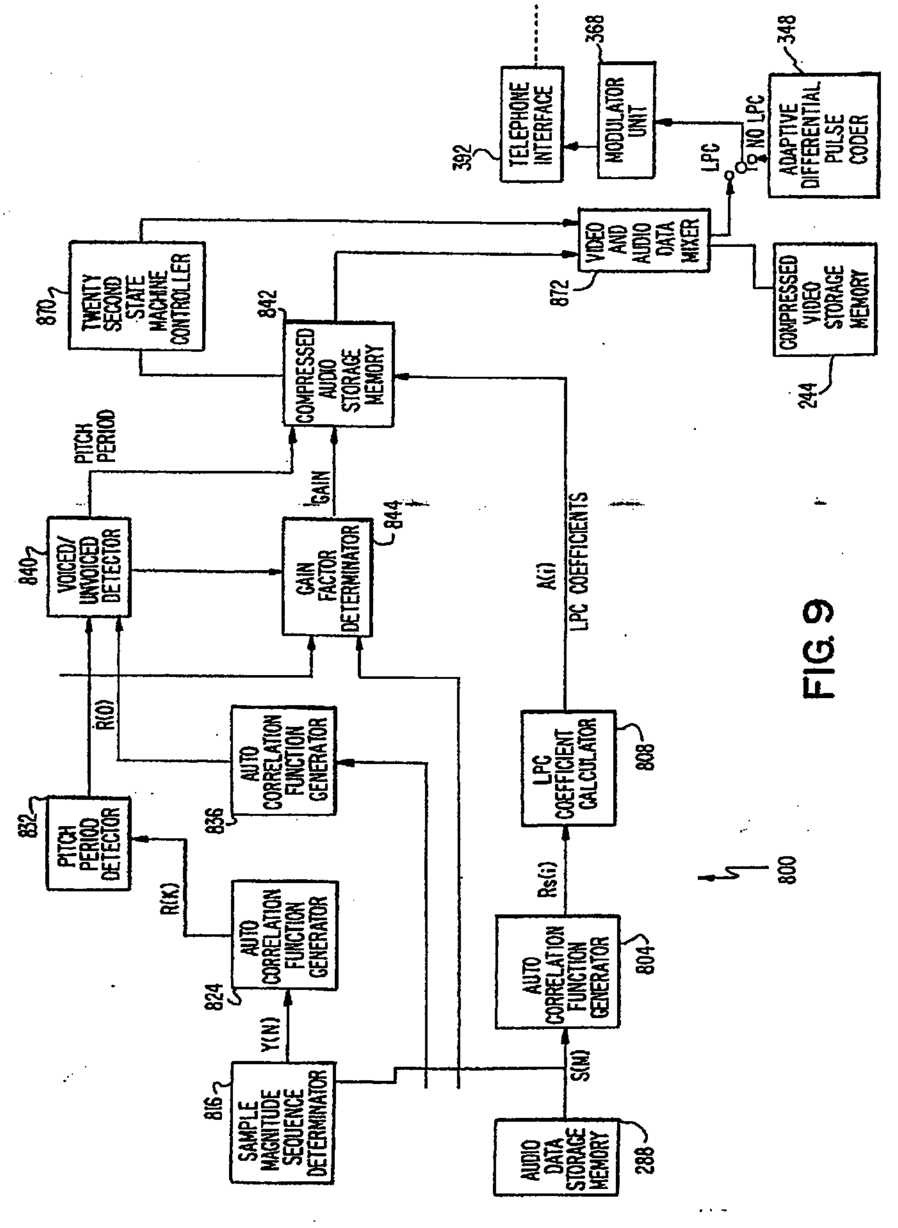

TELEPHONE INTERFACE
392
MODULATOR UNIT
368
ADAPTIVE DIFFERENTIAL PULSE CODER
348
LPC
NO LPC
VIDEO AND AUDIO DATA MIXER
872
COMPRESSED VIDEO STORAGE MEMORY
244
TWENTY SECOND STATE MACHINE CONTROLLER
870
COMPRESSED AUDIO STORAGE MEMORY
842
PITCH PERIOD
GAIN
VOICED/ UNVOICED DETECTOR
840
GAIN FACTOR DETERMINATOR
844
A(i)
LPC COEFFICIENTS
R(0)
AUTO CORRELATION FUNCTION GENERATOR
836
LPC COEFFICIENT CALCULATOR
808
PITCH PERIOD DETECTOR
832
R(K)
AUTO CORRELATION FUNCTION GENERATOR
824
Rs(i)
AUTO CORRELATION FUNCTION GENERATOR
804
800
Y(N)
SAMPLE MAGNITUDE SEQUENCE DETERMINATOR
816
S(N)
AUDIO DATA STORAGE MEMORY
288

FIG. 9

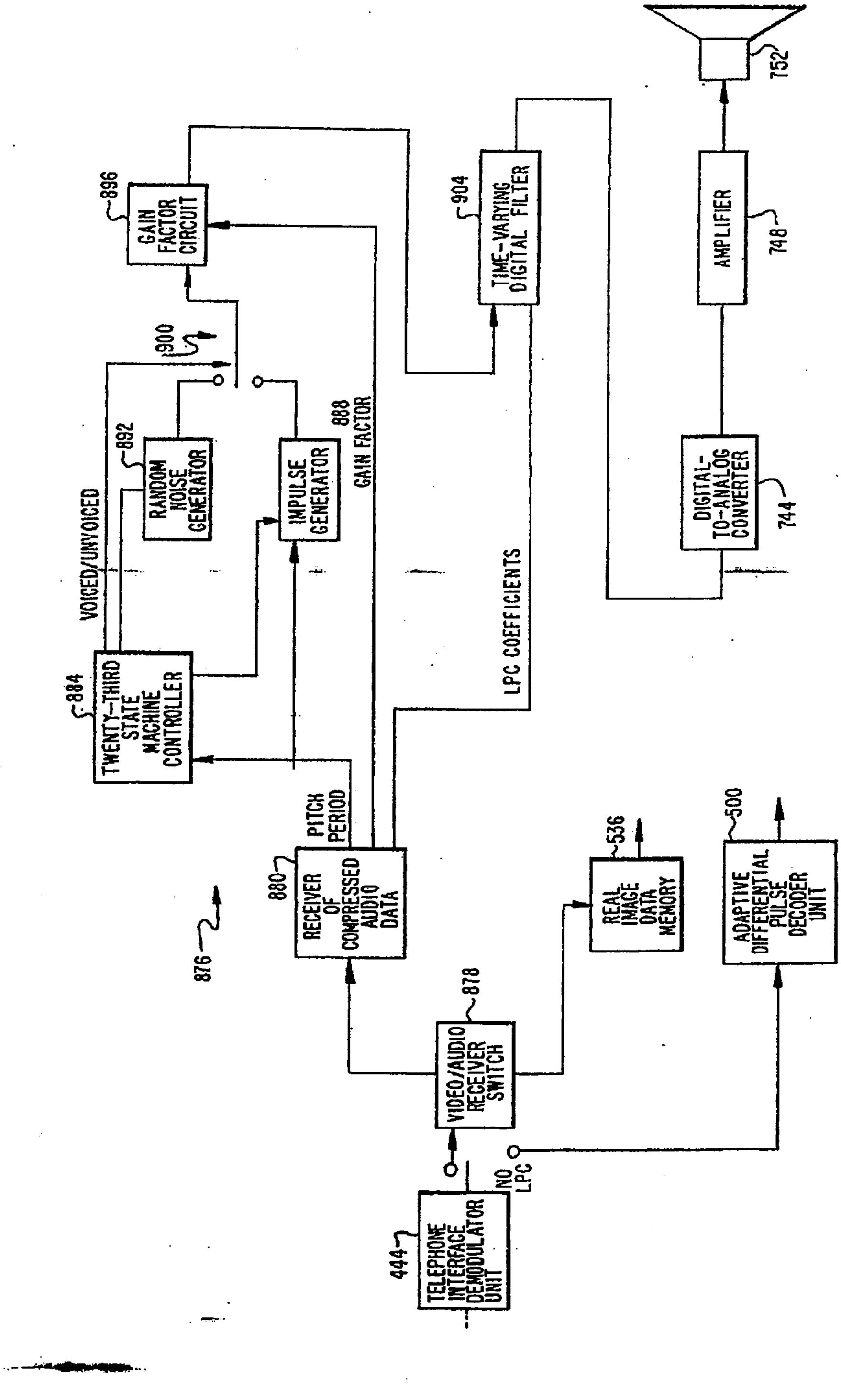

876
TELEPHONE INTERFACE DEMODULATOR UNIT
444
NO LPC
VIDEO/AUDIO RECEIVER SWITCH
878
RECEIVER OF COMPRESSED AUDIO DATA
880
REAL IMAGE DATA MEMORY
536
ADAPTIVE DIFFERENTIAL PULSE DECODER UNIT
500
PITCH PERIOD
TWENTY-THIRD STATE MACHINE CONTROLLER
884
VOICED/UNVOICED
RANDOM NOISE GENERATOR
892
IMPULSE GENERATOR
888
GAIN FACTOR
900
GAIN FACTOR CIRCUIT
896
LPC COEFFICIENTS
TIME-VARYING DIGITAL FILTER
904
DIGITAL-TO-ANALOG CONVERTER
744
AMPLIFIER
748
752

FIG. 10

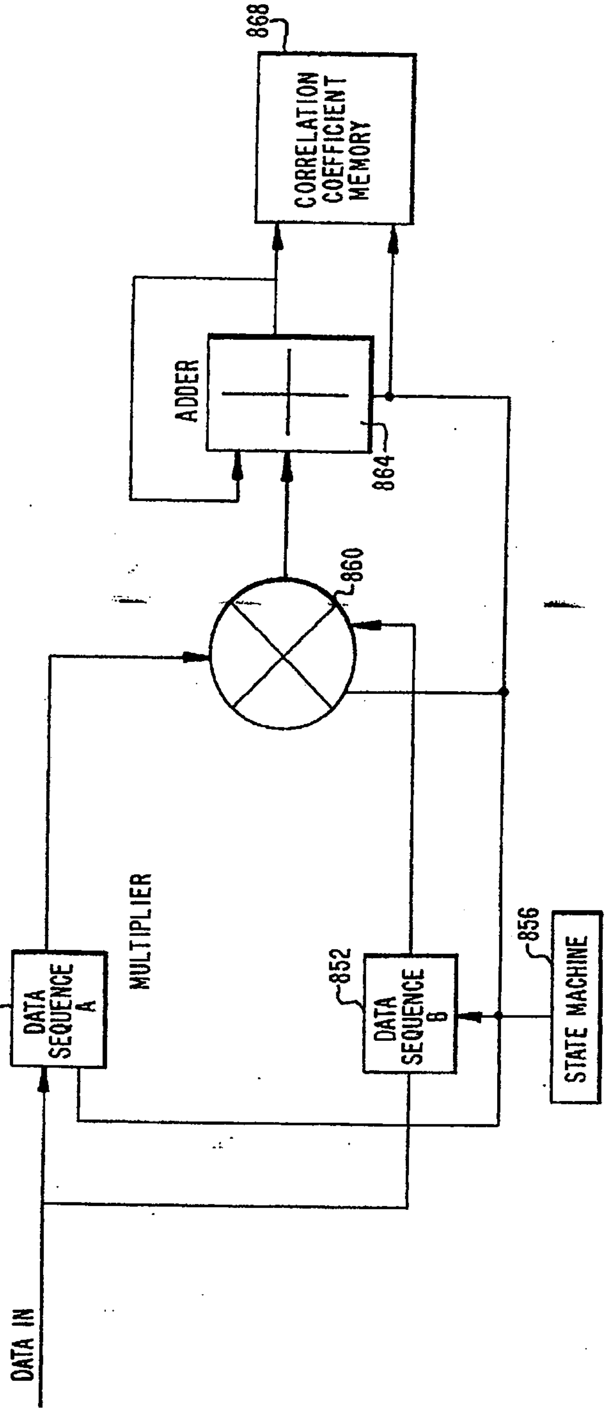

868
CORRELATION COEFFICIENT MEMORY
ADDER
864
860
MULTIPLIER
848
DATA SEQUENCE A
852
DATA SEQUENCE B
856
STATE MACHINE
DATA IN

FIG. 11

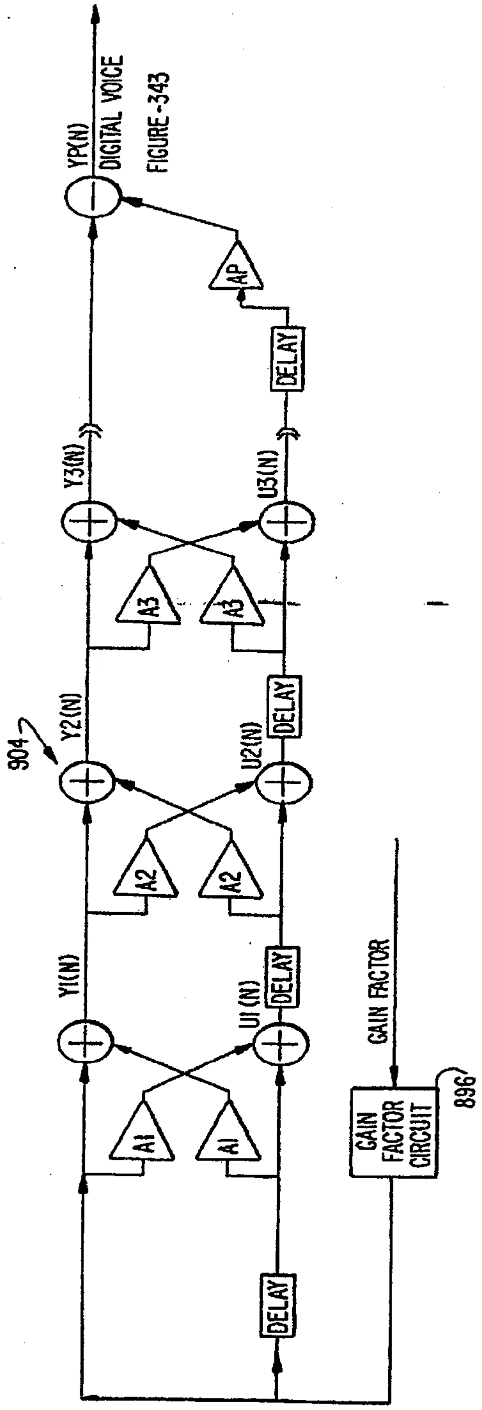

YP(N)
DIGITAL VOICE
FIGURE-343
AP
DELAY
Y3(N)
U3(N)
A3
A3
904
Y2(N)
U2(N)
DELAY
A2
A2
Y1(N)
U1 (N)
DELAY
A1
A1
GAIN FACTOR
GAIN FACTOR CIRCUIT
896
DELAY

FIG. 12

VIDEO TELEPHONE SYSTEM

RELATED APPLICATION

This application is a continuation of application Ser. No. 07/628,607, filed Dec. 17, 1990, now U.S. Pat. No. 5,347,305, which is a continuation-in-part of commonly-assigned application Ser. No. 07/482,649, filed Feb. 21, 1990, now U.S. Pat. No. 5,164,980.

FIELD OF THE INVENTION

The present invention relates to video telephones and, in particular, to apparatus and method for asynchronously transmitting and receiving a composite signal, which includes video and audio information, over an ordinary telephone line.

BACKGROUND INFORMATION

Common or ordinary voice grade telephone lines have been utilized for a number of years in connection with the transmission and reception of signals, other than audio signals. Common or ordinary voice grade telephone lines are defined as telephone lines that have substantially the same predetermined or standard bandwidth, i.e. about 300–3400 Hz, and comprise the substantial majority of telephone lines in the United States, as well as in foreign countries, for providing the telephone linkage among residences, public telephones and most businesses. By way of example, common telephone lines, having limited bandwidth, have been used for providing communication between systems or units, such as computers, which are remotely located from each other. Information or data from one computer can be transmitted to and utilized by another computer. Typically, appropriate interfacing between the computers for sending the information or data over the telephone lines is provided by means of a modem.

Ordinary telephone lines have also been used to transmit video signals. The ordinary telephone line, having a bandwidth of about 300–3400 Hz or a transmission rate of about 9.6 kbaud, does not transmit in real time a typical full motion commercial television type digital black and white and/or color digitized video image. The commercial television system displays 512x512 pixel images at 30 frames per second and uses about 6 MHz bandwidth when simultaneously transmitting video and audio signals. Because of the large bandwidth required, prior art systems do not enable one to transmit full motion images over an ordinary voice grade telephone line. In connection with the transmission of video signals, it is also required to transmit audio signals. In accordance with one technique for transmitting video and audio signals, the video signal is transmitted over the ordinary telephone line using a first, predetermined bandwidth of the limited bandwidth of the ordinary telephone line and the audio signal is transmitted using a second, predetermined bandwidth of the limited bandwidth of the ordinary telephone line. With respect to this first method, U.S. Pat. No. 4,849,811 to Kleinerman, issued Jul. 18, 1989, and entitled "Simultaneous Audio and Video Transmission with Restricted Bandwidth" describes a system in which modulated digitized image signals and filtered voice signals are transmitted together over an ordinary telephone line whereby still or freeze-frame images are provided with accompanying video. The telephone line has a limited bandwidth, for example, about 300–3500 Hz. The digitized image signals are in the range of 2400 to less than about 4000 Hz. The low pass filter limits the voice signals to a range outside the digitized image signals so that the image signals and voice signals can be transmitted at the same time but over different bandwidths of the limited bandwidth of the telephone line. Because of the separate frequencies, means must be provided for synchronizing the sending and/or receiving of the video and audio signals. In conjunction with the more rapid transmission of video images, the use of known data compression techniques is mentioned in this patent. Similarly,. in U.S. Pat. No. 3,873,771 to Kleinerman, issued Mar. 25, 1975, and entitled "Simultaneous Transmission of a Video and an Audio Signal Through an Ordinary Telephone Transmission Line," a communication system is disclosed for transmitting video and audio information using different bandwidths of the limited bandwidth of an ordinary telephone line. With regard to the transmission of video information, it is accomplished using slow scan TV techniques so that an image is not transmitted in real time, but rather the transmission requires up to about 8 seconds to transmit an image with 120 scan lines per image.

In accordance with another technique for transmitting video and audio signals, two signals are multiplexed in such a way to enable one of the two signals to be sent when the other of the two signals is not being transmitted. With respect to this second method, U.S. Pat. No. 4,485,400 to Lemelson, issued Nov. 27,1984, and entitled "Video Telephone" describes a system for transmitting video information and audio information over a standard or ordinary telephone line. The system automatically multiplexes audio and video signals. When it is determined that sounds or speech are being inputted, video signal transmission is terminated to allow for uninterrupted voice signal transmission. To identify the presence of the audio signal, a tone signal is provided indicative of audio signal transmission. U.S. Pat. No. 4,715,059 to Cooper-Hart et al., issued Dec. 22, 1987, and entitled "Conversational Video Phone" also discloses the separate transmission of audio and video signals. Video image data is transmitted during normal pauses in the telephone conversation. The objective is to permit the transmission of an image frame in less than about 3 seconds. Similarly, U.S. Pat. No. 4,099,202 to Cavannaugh, issued Jul. 4, 1978, and entitled "Multiplexed Communication of Voice Signals and Slow Scan Television Signals Over a Common Communication Channel" describes a system for multiplexing an audio signal with a slow scan television signal. The slow scan television signal includes horizontal sync pulses and the sync pulses are used in determining whether or not voice transmission should be inhibited.

All of the foregoing systems are not capable of transmitting, in substantially real time, audio and moving video image data together over an ordinary voice grade telephone line. Such systems require from about 3–60 seconds to transmit a still image. This occurs because voice grade telephone lines typically have a bandwidth of only about 300–3400 Hz. Because of this bandwidth, the amount of data or information that can be transmitted in a given time is limited. To overcome this drawback, it is known to use transmission lines, other than ordinary telephone lines, for transmitting voice and video data, or some other combination of at least two different sets of data. In such systems, transmission lines having a significantly greater bandwidth than that of ordinary telephone lines, such as fiber optic lines, are utilized. With regard to fiber optic transmission lines or other transmission lines having a much greater bandwidth than the ordinary telephone line, it is known to transmit video and audio signals in substantially real time. U.S. Pat. No. 4,544,950 to Tu, issued Oct. 1, 1985, and entitled "Technique for the Transmission of Video and Audio Signals Over a Digital Transmission Signal" discloses, in one embodiment, a conversion of a standard color video signal and two audio signals to a determined magnitude of Mbit/s optical signal, which is compatible with a predetermined signal format for transmission over a pre-selected light wave line. The system includes a high speed interface multiplexer that combines video information, video mode status information and audio signals into a first signal format. Regarding this resulting signal, two audio bits or two video mode status bits are inserted for every 48 video bits. The simultaneous transmission of two different signals is also disclosed in U.S. Pat. No. 4,237,484 to Brown et al., issued Dec. 2, 1980, and entitled "Technique for Transmitting Digital Data Together with a Video Signal." In accordance with this technique, an inputted video signal is used with a predicted signal to generate an error signal. The error signal is compressed and combined with a supplementary data signal in an adder for subsequent transmission. The supplementary data signal is applied to a transform circuit before being sent to the adder.. There is no teaching in the patent of sending the signal output by the adder circuit over an ordinary telephone line. Simultaneous transmission of three television signals is disclosed in U.S. Pat. No. 4,593,318 to Eng et al., issued Jun. 3, 1986, and entitled "Technique for the Time Compression Multiplexing of Three Television Signals." In one embodiment of the system, a time compression multiplexing technique enables the transmission of three-color television signals through a satellite transponder having a 36 MHz bandwidth in which one field signal and two field differential signals are each time compressed to permit all three signals to be sent in the period of a normal field signal of a standard TV signal. Since there are three TV sources, with each producing stereo audio, six audio signals are also transmitted. The stereo audio from each source is sent along with the video by inserting digital audio in either the vertical or horizontal blanking periods associated with the video.

In addition to providing an increased bandwidth in order to transmit a plurality of signals including video and audio signals, as some of the foregoing patents indicate, data compression techniques are employed so that compressed video information can be transmitted for subsequent expansion at a receiver station, without meaningful loss of transmitted information. In a publication from the Jan. 26, 1984, issue of *Electronics* entitled "Codec Squeezes Color Teleconferencing Through Digital Phone Lines" of J. Anderson, S. C. Fralick, E. Hamilton, A. G. Tescher and R. D. Widergren of Widcom Inc., Campbell, California, pages 113–115, various compression methods are utilized for transmitting video image data over a digital telephone line at a rate of 56 kilobits/s. The system disclosed in this publication is directed to video signal transmission and not video and audio transmission. In particular, the publication addresses compression at ratios of up to 1440:1. To achieve the compression, spectral, spatial and temporal compression techniques are employed. These data compression techniques are utilized in such a way to exploit the human eye's forgiving nature so as to make the tradeoffs that cause the least objectionable losses in picture quality. In connection with the compression, comparisons are made between new pixel information and previously transmitted pixel information so that only video information that is changing need be sent. The disclosed technique also employs an encoding method that is based on the two-dimensional cosine transform. The use of a state machine is also disclosed for looking up actual codes in Huffman code tables. Although image motion can be above a determined average where more updating is required, typically, only 10% of the pixel information needs to be replenished at the rate of 10 frames/s. The compressed video information is decoded at the receiver so that a resulting 30 frames/s rate of video information can be displayed.

With respect to compression of audio data, in addition to fast cosine transform techniques, it is well known to utilize linear predictive coding (LPC) to reduce or compress audio data being sent over a transmitting medium. Briefly, the predicting of audio data using LPC s is based on an analysis of actual, sampled audio information. Using the sampled audio, mathematical techniques are employed to obtain information that models the audio data. Such information is transmitted. At the receiving end, such audio related information permits an accurate reconstruction of the actual audio. Like the fast cosine transform, LPC techniques permit the use of limited bandwidth transmitting lines, while permitting accurate reconstruction of the actual audio. LPC is discussed, for example, in an article published in Vol. 38, No. 9, Sep. 1990 of IEEE entitled Design and Performance of an Analysis-by-Synthesis Class of Predictive Speech Coders by Richard Rose and Thomas P. Barnwell III.

In sum, many systems have been proposed or devised for transmitting video information and/or audio information, but none has been provided that relatively inexpensively sends and receives, in substantially real time, both video information and audio information over an ordinary voice grade telephone line. It would be advantageous to have such a system in order to provide real time viewing at transmitting and receiving telephones. By doing so, desirable face-to-face contact would be achieved to enhance personal, as well as business, communications. Furthermore, substantially real time viewing of documents and things would result, without meaningful sacrifice of image quality and detail.

SUMMARY OF THE INVENTION

The present invention relates to a video telephone system in which video information is transmitted simultaneously with audio information in substantially real time over ordinary voice grade telephone lines. Video and audio information are transmitted simultaneously by means of a composite signal that includes a mixture of both video data and audio data. The video information and the audio information are transmitted over the telephone line using the same bandwidth or frequency range. There is no separate bandwidth for video and audio signals. Accordingly, the video and audio information is transmitted asynchronously so that expensive synchronization hardware need not be incorporated into the present system. Preferably, the present video telephone system extensively incorporates application specific integrated circuits (ASICs). The hardware for the video telephone system can therefore be provided so as to occupy minimal space. In connection with the processing of video and audio information, a number of data compression and, upon reception of the compressed data, a number of data expansion methods are employed so that the video and audio information can be transmitted over the limited bandwidth of an ordinary telephone line. In that regard, the video telephone system compresses video information for subsequent substantially real time viewing but avoids or minimizes losses of useful information due to the data compression. With respect to the processing of video and audio information, including that associated with video and audio data compression and expansion, a state machine controller apparatus is utilized. The state machine controller apparatus is provided using the ASIC technology and enables the system to control the transfer and processing of data along the transmitting and receiving channels of the system when required whereby video and audio data is processed to provide the substantially real time imaging, together with any accompanying audio or voice information. Although a single state machine controller apparatus is provided for controlling the entire video telephone system, the system will be described in terms of a number of state machine controllers associated with one or more particular functions.

More particularly, the video telephone system includes a camera device for acquiring image information within its range and for converting the images into an analog video signal. The analog video signal is digitized using an analog-to-digital converter. The digitized video signal having video information is then applied to a first or camera image storage memory. A first state machine controller controls the conversion to digital video data and monitors the camera image storage memory. The digitized video signal is next received by an image reduction unit for reducing or compressing in spatial mode the number of video data points or pixels received from the camera device. In one embodiment, the camera device outputs video information based on a 96×96 matrix of pixels. That is, there are 96 columns by 96 rows of data points, each of which is defined or comprised of 8 digital bits in the case of a monochromatic image and 15 bits where the image is in color. The image reduction unit reduces or compresses this video information by 9 times to a 32×32 matrix of pixels. ~~This~~ is accomplished by an averaging method whereby useful or necessary video information is kept for further processing and eventual transmission. As a result of the image reduction unit, the video information is compressed by a factor of 9. A second state machine controller controls the transfer of digitized video data from the camera image storage memory to the image reduction unit, as well as controlling the operation of the averaging steps for providing reduced image data.

The compressed video data is then applied to a video fast cosine transform operator unit for converting the digitized video data from the time domain to the frequency domain so that the video data can be further compressed, while avoiding video information losses that would adversely affect the quality of the image being sent. In one embodiment, the video fast cosine transform operator unit outputs 1024 16-bit video information coefficients from the inputted 1024 (32×32) 8-bit pixels. The digital data from the video fast cosine transform operator unit is applied to a video coefficients selector unit for selecting and retaining only 400 of the 1024 coefficients inputted thereto. The selection is based on the energy content of the inputted coefficients and the selected coefficients have higher magnitudes than the rejected coefficients whereby the video information is further compressed without detrimentally affecting the video information content. The output of the video coefficients selector unit is then inputted to a video coefficients converter unit for additionally compressing the video information. That is, by a preferred method of obtaining the square root of each of the 400 16-bit coefficients representing video information inputted thereto, the video coefficients converter unit outputs 400 video data words having 8 bits each so that the video information is additionally compressed by a factor of 2. The output of the video coefficients converter unit is sent to a video subtractor unit or comparison device for comparing current and previous images or video information so that only different video information is transmitted for updating previously sent video information, without meaningful loss of quality of video information. The use of the comparison device results in a further compression of video information by a factor of about 2. In connection with implementing or providing these video data compression techniques, additional state machine controllers are utilized for controlling the transfer of video information and performing the necessary processing or arithmetical steps that are required to compress the inputted video data received by the coefficients selector unit, the coefficients converter unit and the comparison device.

The output of the comparison device is applied to a video data storage device. Another state machine controller controls the reading of video data from the video data storage device and inputs it to a video/audio data mixer. In one embodiment, the inputted video data is stored or characterized as real data for use by a fast Fourier transform operator of the video/audio data mixer.

With respect to the transmission of audio information along an audio transmitting channel, the apparatus includes a transducer, such as a microphone, for receiving sounds including those generated by the speaker's voice. The microphone Converts the sounds to an analog audio signal, which is amplified, and then sent to a low pass filter for eliminating signal content having a greater frequency than the typical audio frequency range. The output of the low pass filter is then applied to a further audio amplifier for amplification of the filtered audio signal. The amplified analog audio signal is converted to digitized audio data using an analog-to-digital converter. The digitized audio data is then sent to an audio or voice data storage memory that can be accessed by, in one embodiment, an audio fast cosine transform operator unit. A first audio state machine controller controls the conversion of the analog audio signal to digitized audio data and also monitors the contents of the audio data memory. The audio fast cosine transform operator unit includes a second audio state machine controller for controlling the transfer of digitized audio data from the audio data memory so that such data can be converted from the time domain to the frequency domain. Once the audio data is in the frequency domain, it can be compressed without meaningful loss of audio information. The audio fast cosine transform operator unit also includes an audio random access memory for storing the frequency domain audio information therein. In one embodiment, the output of the audio cosine transform operator unit is defined as being 256 16-bit data points or words. The 256 points are based on a preferred matrix of 256×1 audio data points. This particular matrix is preferred because it represents audio data that is significantly compressed for proper transmission over the limited bandwidth telephone line but without meaningful loss of audio quality. These 16-bit data points are inputted to an audio coefficients selector unit, which determines or selects a predetermined number of the 16-bit data points having a higher magnitude than the other data points. In one embodiment, the audio coefficients selector unit selects and outputs only 50 16-bit data points thereby compressing the audio information by a factor of about 5 (256/50). The output of the audio coefficients selector unit is then sent to an audio coefficients converter unit, which reduces or compresses the audio information by a further factor of 2 and outputs 50 8-bit data points. Like the video coefficients converter unit, the audio coefficients converter unit preferably implements an algorithm for obtaining the square root of the inputted audio coefficients. The output of the audio coefficients converter unit communicates with an audio data storage device for receiving the compressed audio data. Another audio state machine controller controls the transfer of audio data and the operation of the audio coefficients selector unit and the audio coefficients converter unit, as well as controls the timing and transfer of audio data from the random access memory and to the audio data storage device. For proper further processing with the video information, the audio information is stored in the audio data storage device as imaginary numbers for transmission to the video/audio data mixer.

The video/audio data mixer includes the fast Fourier transform operator for receiving compressed video data, as real numbers, and compressed audio data, as imaginary numbers. As a result of the execution of a fast Fourier transform using the fast Fourier transform operator, the mixture of image and voice data is achieved. The mixed video and audio data is stored in a video/audio data mixer memory. Control of the fast Fourier transform operator and the transfer to the mixer memory is accomplished using an additional state machine controller. The mixed video and audio information is stored in the mixer memory as complex numbers, which are next applied to an adaptive differential pulse coding unit. Preferably, only the first half of the complex numbers or data points are transmitted to the adaptive differential pulse coding unit, with the first half of the numbers being defined as located above a diagonal line that extends from the bottom left hand corner to the top right hand corner of a matrix that includes the complex numbers, which were obtained as a result of the fast Fourier transform. Such numbers significantly represent the combined video and audio information, based on their energy content. This unit further compresses the information to be transmitted. Specifically, it compresses the mixed video and audio information by a factor within the range of about 2–5 times. More specifically, the adaptive differential pulse coding unit compares the current set of complex numbers or mixed video/audio information with the previous set so that only mixed data that has changed or is different from the previous data is identified for transmission. The mixed video/audio data from the adaptive differential pulse coding unit is sent to a modulator unit. The modulator unit uses the mixed video/audio digital data to pulse code modulate a carrier wave. In one embodiment, the magnitude of the carrier frequency depends upon whether the transmitting station is the originating station or the responding station. Where the mixed data is being transmitted by an originating station, the carrier frequency is 3000 Hz, while the carrier frequency is 1200 Hz when it is responding to a transmission from an originating station. The carrier frequency is preferably modulated using pulse code modulation (PCM). The pulse code modulated carrier frequency that includes the mixed video/audio data is then transmitted over the ordinary voice grade telephone line to the receiving station.

With regard to the receipt and reproduction of the transmitted video information and audio information, the received, modulated composite signal is demodulated. Methods comparable to those used in compressing the mixed video/audio data, as well as separately compressed video and audio data, are then employed to decompress or expand the received data. Likewise also, a number of state machine controllers integrated with one or more ASIC circuits, and together constituting the single state machine controller apparatus, are provided to effect the expansion operations, as well as the transfer of video and audio data including the mixed video/audio data. In particular, the audio information is obtained from the transmitted mixed video/audio data, further expanded and converted to an analog signal for applying to a conventional speaker piece or unit so that the transmitted audio can be heard by the listener. Likewise, separate video information is obtained from the mixed video/audio data that was transmitted, further expanded and converted to an analog video signal for subsequent reproduction or reconversion as a number of pixels, which comprise the transmitted image, using a conventional display or monitor, such as a CRT or liquid crystal display.

In another embodiment, instead of using the fast cosine transform to compress inputted audio data, a linear predictive coding (LPC) coder determines predictor coefficients or values that are used to accurately model or predict audio data, based on actual, sampled audio data. In this manner, actual audio data can be accurately represented by the determined information, which is transmitted over ordinary voice grade telephone lines having limited bandwidth. The LPC method approximates the inputted audio data based on the premise that a sample of speech or audio information can be approximated as a linear combination of previous "p" speech samples. The approximation relies on use of determined predictor coefficients A(i), with $1 \leqq i \leqq p$. Such predictor coefficients are utilized with actual speech signal samples S(M) to linearly predict further and other speech samples. Briefly, if values of A(i), for i=1 to p are known, then further values of the speech can be calculated or "predicted." The LPC coder computes the "p" speech predictor coefficients.

In connection with the LPC coder implementation, the raw audio data is digitized at a predetermined number of samples/second. A preselected or predetermined number (N) of consecutive samples of speech are processed by the LPC. For each determination using N samples, "p" predictor coefficients are determined. In addition to the determination of LPC coefficients, the LPC coder also includes a pitch period detector for detecting the period K of the N samples of the inputted raw audio data or speech. The pitch period K approximates the time before the audio signal repeats itself. The pitch period is also used to determine whether the presently received raw audio data is voiced speech (voice cords are used for the speech) or unvoiced speech. In the case of "unvoiced" speech, there is no pitch period since such an audio signal is random and not periodic. Additionally, the detected pitch period and speech signal samples S(M) are inputted to a gain factor circuit for determining a gain factor or factors associated with the N samples of speech and which will be used in accurately reproducing the speech at the receiver station. In that regard, when the LPC coder is utilized, for each N samples of audio data to be transmitted, a predetermined number of bits representing the determined pitch period, a number of predetermined bits representing each of the predictor coefficients and a predetermined number of bits representing the value(s) of the gain. After transmission over the common telephone lines or other transmission medium, such audio related information is inputted to a receiver of compressed audio data. This receiver separately outputs signals representative of the magnitudes of the LPC coefficients, the pitch period and the gain factors. The signals representative of such audio information are employed to synthesize real time actual audio data that accurately represents the raw speech that is inputted at the transmitting station.

The LPC method is preferred over the fast cosine transform compression technique for "compressing" audio data. The LPC coder, on a relative basis, is more accurately able to represent the raw speech being transmitted at the limited bandwidth. Hence, when the raw speech is "decompressed" at the receiving end, a relatively higher quality of speech is achieved.

In addition to the foregoing components of the video telephone system, it also preferably includes a security encoder for use in preventing understanding of the transmitted mixed video/audio data by anyone other than the person or persons for whom the transmission is intended. In connection with the transmission of video information and audio information to only a particular person or persons, those persons must be provided with the necessary security encoder information to properly decode the transmitted video and audio information. The system also preferably includes a telephone line bandwidth testing device for determining the useful bandwidth of the telephone line or lines over which the video/audio data transmission is to occur. As a result of such testing, the rate of transmission of video and audio data can be optimized. For example, it might be determined that the telephone line or lines over which the transmission is to occur has a relatively greater bandwidth in order to permit the transmission of mixed video/audio data at a relatively greater rate. In such a case, the transmission of the data can be made in a manner that best utilizes or optimizes the greater bandwidth. To enhance the quality of the video images being transmitted, the camera device has an autofocusing capability whereby the camera lens is physically adjustable using a feedback loop and a converging algorithm. That is, the lens of the camera device is checked at a first position for optimum focusing. It is then checked at a second position, depending upon whether or not the second position results in a better focus or not, the position of the camera lens is adjusted in a direction or manner that is intended to improve the focus. These steps are continued until the focus is optimized. The video telephone system further enables the called party to record a video message, as well as an audio message, when the called party does not respond to the telephone ring from the originating station because, for example, the called party is not there when the telephone call is made. A video storage device can be activated for storing the compressed, mixed video/audio data for later processing and expansion by the called party at his/her convenience.

In view of the foregoing summary, a number of salient features of the present invention are readily discerned. A video telephone system is provided for transmitting images or video information over ordinary voice grade telephone lines. This is accomplished in substantially real time so that the party receiving the video message perceives video images from the transmitting party at substantially the same time that they are sent so that a realistic, rather than a still or freeze frame, display is presented. The video and audio information are transmitted together in asynchronous fashion so that costly synchronizing hardware is not needed. The present invention results in the transmission over a limited bandwidth of useful quality and useful resolution picture or image. This is accomplished by transmitting only compressed video information that results in a substantially real time video transmission, while avoiding or minimizing unwanted losses due to video data compression. In that regard, the transmission rate is selected so as to provide realistic viewing by the recipient while not transmitting at an unnecessarily greater rate. For example, the present invention preferably does not transmit video images at the television rate of 30 frames/second. Rather, image updating can be provided at a rate of about 7–7.5 frames/second without sacrificing realistic picture viewing. Additionally, rapid and efficient processing of video information and audio information are provided in the present system by means of state machine controllers. Data compression and data expansion techniques are uniquely configured to achieve the substantially real time transmission and reception, including separate compression and expansion of video information and audio information, as well as compression and expansion of mixed video/audio data. This enhanced processing of data is also realized because of the utilization of a state machine controller apparatus, instead of microprocessors, whereby less time is expended in performing the necessary data transfer and data computation steps. Further, the various processing steps are rapidly executed by means of operations that occur when necessary. Lastly, the video telephone system has a compact size primarily due to the use of ASIC technology so that various hardware components, including those that constitute the state machine controller apparatus, can be formed and provided in minute spaces and, even though there are thousands of logic gates provided as part of the state machine controller apparatus, such can be constructed so as to result in extremely small spaces being occupied by the hardware of the present system.

Additional advantages of the present invention will become readily apparent from the following discussion, particularly when taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the audio and video transmitting channels of the video telephone system;

FIG. 2 is a block diagram of the video and audio receiving channels of the video telephone system;

FIG. 3 is a block diagram illustrating further details of the camera device, the video digitizer, image reduction unit and two-dimensional fast cosine transform operator unit of the video transmission channel;

FIG. 4 is a block diagram illustrating further details of the audio transmitting channel, the compression of video data by means of the coefficients selector, square root extractor and subtractor units and the video/audio data mixer;

FIG. 5 is a block diagram illustrating further details of the adaptive differential pulse coding unit and modulator unit, as well as schematically illustrating a telephone control board;

FIG. 6 illustrates further details of the video and audio receiving channels including the adaptive differential pulse decoder unit, the audio and video data separator, the video frame difference restorer, and video and audio multipliers and coefficients restorer units;

FIG. 7 is a block diagram illustrating further details of the video receiving channel two-dimensional inverse cosine transform operator unit, image magnifier unit and video display interface;

FIG. 8 is a block diagram illustrating further details of the audio receiving channel including the one-dimensional inverse cosine transform operator unit and the speaker and handset interface;

FIG. 9 is a block diagram illustrating another embodiment associated with the transmission of audio data using a linear predictive coding (LPC) coder;

FIG. 10 is a block diagram illustrating a receiving station having a linear predictive coding (LPC) decoder;

FIG. 11 is a block diagram illustrating a representative autocorrelation function generator used with the LPC coder; and

FIG. 12 is a block diagram illustrating details of the time-varying digital filter utilized at the receiving station as part of the LPC decoder.

DETAILED DESCRIPTION

In accordance with the present invention, a telephone system is provided for transmitting images, together with sounds, over ordinary voice grade digital or analog telephone lines, having a limited bandwidth, in substantially real time. As used herein, substantially real time refers to the capability of providing images to a receiving party over such telephone lines at about the same time they are occurring at the transmitting party telephone station and in contrast to video telephone systems in which freeze or still frame pictures are sent over such ordinary telephone lines. The substantially real time transmission is primarily achieved using a number of data compression, and subsequent data expansion, methods that compress, and then expand, the video information, in one embodiment, by a total factor of at least 57 times.

With reference initially to FIG. 1, the video transmission channel relating to the obtaining and processing of video information for transmission will first be described. The telephone system 100 includes a video camera device 104 for receiving light reflected from an object or objects that are being viewed by the camera device 104 and for converting such light information to video signals having video information. With reference also to FIG. 3, the camera device 104 includes a camera body 108 and a linearly movable adjusting member 112 that is adapted to move relative to the camera body 108. Fixedly held within the adjustable member 112 is a lens device 116 for receiving and focusing the reflected light. The camera device 104 includes mechanical hardware for use in causing movement of the adjustable member 112 relative to the camera body 108. The mechanical hardware includes, in one embodiment, rack 120 and pinion 124. The rack 120 is formed as part of the adjustable member 112, while the pinion 124 is caused to move or rotate so that it moves along the teeth of the rack 120 to thereby move the adjustable member 112 in a selected one of two directions of movement, either towards the camera body 108 or away therefrom. The camera device 104 also includes a light sensitive device or image sensor 128, which may be a two dimensional capacitor charged coupled device (CCD) or MOS type array, for sensing the intensity of the light reflected from the object or objects within the range of the lens device 116. The microvolt level output from the image sensor 128 is filtered and amplified to a one volt peak level by signal conditioning electronics and camera interface 132. The camera device 104 also includes a photosensor 134 for receiving or sensing light. The photosensor 134 is used to adjust the biasing of the image sensor 128 so that the image sensor 128 is able to automatically adjust in response to the surrounding light.

The camera device 104 is able to focus automatically. A focused image has sharper edges than unfocused images. The sharper edges are due to the presence of greater amounts of high frequency components. The signal conditioning electronics and camera interface 132 measures such high frequency components, with the lens device 116 being located at a first position. The lens device 116 is then moved to a second position using the adjustable member 112 and the high frequency components associated with the sharper edges are measured again. The difference between the two measurements is utilized to predict a next position of the lens device 116 that may result in the maximum high frequency components being obtained. In conjunction with making this determination, the video information output of the center line of the image sensor 128 is received by a one-dimensional cosine transform operator found within the signal conditioning electronics and camera interface 132. The high frequency coefficients obtained by this cosine transform operation are measured. Based on the results of the measurement, the lens device 116 is electromechanically moved

using the adjustable member 112. The new video information output of the center line of the image sensor 128 is transformed using the fast cosine transform. The high frequency coefficients obtained as a result of this transform are measured. The lens device 116 is again moved forward or backward until it reaches a position that results in the highest magnitude of high frequency coefficients. At this point, the camera device 104 is properly adjusted.

The analog video signal having video information outputted from the camera device 104 is supplied to a video digitizer 136, which includes a video amplifier 140 for amplifying the 0–1 volt peak level output to a 0–5 volt peak-to-peak level. The amplified video signal is then applied to an analog-to-digital converter 144 for converting the analog video signal to a digitized video signal. Digitized video information represented by the digitized video signal is stored in a first or camera image storage memory 148. The first memory 148 is, preferably, a first in/first out (FIFO) type memory. The use of the FIFO memory allows data or information to be written into the memory by one controller while another controller is reading from the same memory. In conjunction with the reading and writing operations, the video digitizer 136 includes a first state machine controller 150, which communicates with the analog-to-digital converter 144 and the first memory 148. The first state machine controller 150 controls the sampling or operation of the analog-to-digital converter 144 and monitors the status of the first memory 148. That is, the first state machine controller 150 checks or monitors the contents of the first memory 148 to make sure that memory space is available and controls where the digitized video information should be stored therein. The first state machine controller 150, like the other state machine controllers to be described herein, are optimally custom designed to execute only one predetermined major task. Such state machines can perform the required operations or instructions in significantly less time than conventional microprocessors. For example, the execution speed of the state machine controller can be up to 50 times faster than that of a typical general purpose microprocessor. Microprocessors are designed to execute one instruction at a time using more than one clock cycle, while the state machine controller can acquire two numbers from two different locations, add them, and store the result at a third location in only one clock cycle.

In one embodiment, the first state machine controller 150 controls the analog-to-digital converter 144 such that the inputted analog video signal is sampled at a sampling rate from 9000–262,000 samples per image frame, depending on image size. The analog-to-digital converter 144 digitizes the inputted analog signal to an 8-bit resolution in the case of a monochrome image and, in the case of color images, a total of 15 bits per word, with there being to a 5 bits for each of the red, green and blue colors. In the preferred embodiment, the amplified analog video signal outputted by the video amplifier 140 is also provided to an analog multiplexer and an image display unit of video information receiving hardware (see FIG. 8).

The video telephone system 100 also includes an image reduction unit 156 for compressing video image data stored in the first memory 148. In particular, the image reduction unit 156 implements a spatial mode of data compression to reduce the image size of the video data from a first matrix size having a number of pixels to a second, smaller matrix size having a second, reduced number of pixels. In one embodiment, the image reduction unit 156 compresses a frame having 96×96 pixels to one of 32×32 pixels. The image reduction unit 156 includes an adder 160 for receiving video information from the first memory and adding the same to an input from a partial sum storage memory **164**. In one embodiment, individual video information from the first memory **148** is received for nine different pixels. The nine pixels of video information are obtained from three consecutive lines or rows of pixels of a particular frame and, for each of such rows, the three pixels are located next to each other, starting with the beginning of the row or line. In connection with reducing the image data, memory locations in the partial sum storage memory **164** are cleared. The first pixel of the top line or row for a particular frame is acquired from the first memory **148**. This first pixel is added to the cleared output from the partial sum storage memory **164** using the adder **160**. The result is stored in the partial sum storage memory **164**. The second pixel of that same top line, which is the pixel adjacent to the first pixel, is then acquired from the first memory **148** and added to the partial sum stored in the memory **164**. The third pixel of the same top line is then obtained from the first memory **148** and added to the result of the addition, which was previously stored in a first location of the memory **164**. Then the next three pixels of the same top line are added in the same way and the resulting sum is stored in a second location of the memory **164**. This process is continued for all of the pixels of the top line, with the sums being stored in N/3 different locations in the memory **164**, where N is the total number of pixels per line. Subsequently, the sum of the first three pixels of the next line are added to the partial sum stored in the first location of the partial sum storage memory **164**. Similarly, the sum of the next adjacent three pixels of the same second line is added to that partial sum stored in the second location of the memory **164**. This process is repeated until the sum of three pixels in all three pixel segments of the second line are added to the partial sum of the corresponding segment of the first line. These steps are repeated for the third line of the frame. However, when the third pixel of each three pixel segment is added to the partial sum, the resulting sum is applied to a divider unit **168** for dividing the resulting sum by 9. The result of this division is written in a second or 32×32 image storage memory **172**, which is also preferably a first in/first out memory. At the same time that this division result is being written into the second memory **172**, the first location in the memory **164** is being cleared. As a result, the second memory **172** contains a magnitude or value that is the average of the first 3×3 pixel block and the next location in the second memory **172** contains the average of the next 3×3 pixel block. As can be understood, further and adjacent memory locations of the second memory **172** contain averages of other and the remaining 3×3 pixel blocks.

The image reduction unit **156** also includes a second state machine controller **176**, which communicates with the adder **160**, partial sum storage memory **164**, divider unit **168** and the second memory **172**, as well as the first memory **148**. The second state machine controller **176** controls the timing and data transfer from the first memory **148**, controls the adding of video data using the adder **160**, stores and retrieves partial sum video data using the memory **164**, activates the divider unit **168**, controls timing and data transfer from the first memory **148** for conducing the averaging process, as well as monitoring and controlling the contents of the second memory **172**. As can be appreciated, the use of the first and second state machine controllers **150**, **176**, as well as the first in/first out memories **148**, **172**, permits video data to be written into the first memory **148** at the same time video data is being read out therefrom for image compression. Consequently, the steps of video digitizing can occur at the same time image compression is occurring on other video data using the image reduction unit **156**.

The video telephone system **100** also includes an apparatus for converting the compressed video information, inputted by the image reduction unit **156**, from the time domain to the frequency domain. In the preferred embodiment, this conversion of image data is accomplished using a video fast cosine transform operator unit **180**. The fast cosine transform operator unit **180** includes a row transform operator unit **184** and a column transform operator unit **188**. The row transform operator unit **184** includes a 16-bit multiplier and accumulator **192** and a data base for row transformation **196**. The operation and timing of these units is controlled by a third state machine controller **200**. The row transformation, as part of the fast cosine transform, is accomplished using well-known techniques. That is, the transformation acquires video data from the second memory **172** to be multiplied with a basis vector matrix [B]. The basis vector matrix has the property that $[B]*[B]^T=[1]$, where [B] is a square matrix and $[B]^T$ is its transpose. The values of the elements of the [B] matrix are stored in the data base **196**. With regard to the values of such elements, if [B]matrix has a N×N size and b(i,j) is its element in the i-th row and the j-th column, the value of the element b(1,j) of [B] matrix is computed using the following formula: b(1,j)=1/sqrt (N) for i=1 and j=1 to N; or b(i,j)=sqrt 2/N)*cos(pi*(i−1)*2*(j−1)+1)/2*N)) when i is greater than 1. The matrix [1] is an identity matrix in which all elements thereof are zeros except elements on the diagonal from the top left corner to the bottom right corner, each of which has a value of one. During the row transformation using the row transform operator unit **184**, the [B] matrix is multiplied by a [V]matrix to obtain a [R] matrix, i.e. [R]=[B]*[V]. The matrix [V] includes the video data outputted from the second memory **172**. The elements of the [R] matrix are stored in a first random access memory **204**, as they are obtained by the computation performed in the 16-bit multiplier and accumulator **192**. The third state machine controller **200** controls the transfer of the compressed video data from the second memory **172** to the 16-bit multiplier and accumulator **192**, as well as controlling the transfer of the [B] matrix elements from the data base **196** to the multiplier and accumulator **192**, together with controlling the operation of the multiplier and accumulator **192**. Similar to the cooperation between the first and second state machine controllers **152**, **176**, the third state machine controller **200** is able to control the row-wise transformation by accessing the second memory **172** at the same time the second state machine controller **176** is controlling the inputting of average video data thereto.

With respect to the column transform operator unit **188**, it includes elements comparable to the row transform operator unit **184** including a 16-bit multiplier and accumulator **208** for receiving the results of the row-wise transformation stored in the first random access memory **204**. The multiplier data base for column transformation **212** is provided in communication with the 16-bit multiplier and accumulator **208**. The element values of the matrix $[B]^T$ which are required to perform the column-wise transformation, are stored in the multiplier data base **212** for transfer to the 16-bit multiplier and accumulator **208**, under the control of a fourth state machine controller **216**. The element values of the [R] matrix are applied to the 16-bit multiplier and accumulator **208** to effect the column-wise transformation and obtain a resulting [C] matrix using the formula $[C]=[R]*[B]^T$. The elements of the [C] matrix are the coefficients obtained as a result of the two-dimensional fast cosine transformation. The elements of the [C] matrix are stored in the second random access memory **220**. Similar to the third state machine controller **200**, the fourth state machine controller **216** controls data transfer from the first random access memory **204**, transfer of column data base data to the 16-bit multiplier and accumulator **208** from the data base **212**, and the transfer of a resulting computed [C] matrix to the second random access memory **220**. As a result of the fast cosine transformation unit, in the embodiment in which a 32×32 pixel matrix constitutes the image frame and a monochrome image is being provided, with each pixel being represented by 8 bits, the output from the fast cosine transform operator unit **180**, for each frame, includes 1024 16-bit video data words or points. It should be understood that the matrices stored in the multiplier data bases **196**, **212** could be provided so as to permit two-dimensional cosine transformation on a variety of matrix sizes such as 4×4, 8×8, 16×16, 32×32, 64×64, 128×128 and 256×256 matrices or blocks of image data.

Referring now to FIG. 4, as well as FIG. 1, the video telephone system **100** also includes a video coefficients selector unit **224**, which communicates with the second random access memory **220**. Under the control of a fifth state machine controller **228**, the results of the two-dimensional fast cosine transformation are applied to the coefficients selector unit **224**, which performs an analysis of the cosine transform coefficients and determines, for outputting therefrom, only those minimum number of coefficients whose combined energy content is more than a predetermined percentage of the total energy of such coefficients. In the embodiment in which a frame constitutes 1024 16-bit coefficients, the coefficients selector unit **24** outputs a total of 400 16-bit data words thereby further compressing the video information associated with one frame by a factor of about 2.5 (1024/400).

Further compression of the video information along the video transmitting channel is accomplished using a compression technique and hardware that reduces the number of bits that make up the video data words. In one embodiment, the number of data bits is reduced from 16 bits/word to 8-bits/word. This is preferably accomplished using a video coefficients converter or square root extractor unit **232**, which obtains the square root of each 16-bit word inputted thereto. The operation of the square root extractor unit **232** is controlled by the fifth state machine controller **228**. As a result, the video data is compressed by a factor of two using the square root extractor unit **232**. Each of the 8-bit coefficients obtained by the square root operation is stored in a third first in/first out or previous image data storage memory **236** under the control of the fifth state machine controller **228**. The coding with the square root method is preferred over merely dropping or discounting the least significant 8-bits from the 16-bit data word because, in connection with the dropping technique, the lower magnitude numbers of the coefficients are subsequently magnified 256 times when the 8-bit coefficients are restored to 16-bit coefficients at the receiving station. In such a case, the expanded image would have poorer quality.

To further compress the video information, the video telephone system **100** includes a video subtractor unit **240**, which cooperates with the output of the square root extractor **232** and an input received from the third memory **236**. That is, to reduce the transmission of redundant video information, previously transmitted video information is compared with current video information so that only the difference between two consecutive images is transmitted. In that regard, the fifth state machine controller **228** controls video data transfer from the third memory **236** to the subtractor unit **240**, as well as the outputting of the square root value from the square root extractor unit **232** so that a comparison or subtraction can be made by the subtractor **240** under the control of the fifth state machine controller **228**. The coded difference between successive frames or images outputted by the subtractor unit **240** is then applied to a fourth first in/first out or real data storage memory **244**. Control and monitoring of the transfer of the further compressed video data to the fourth memory **244** is controlled by the fifth state machine controller **228**. As can be appreciated, such control occurs concurrently with the other operations associated with compressing the video information, such as which are accomplished by the coefficients selector unit **24** and the square root extractor unit **232**. As a result of the operation of the subtractor unit **240**, the video information is compressed by an additional factor of two.

The video telephone system **100** further includes a video and audio data mixer **248** for outputting a composite signal having mixed video information and audio information. The mixer **248** includes a one-dimensional fast Fourier operator **252**, which requires complex numbers as its inputs. In the preferred embodiment, the compressed video information is fed to the fast Fourier operator **252** as real numbers and audio information is fed thereto as imaginary numbers, although the video information could constitute the imaginary numbers and the audio information could constitute the real numbers.

With respect to the generation of compressed audio information for eventual inputting to the one-dimensional fast Fourier operator **252** of the video and audio data mixer **248**, reference is made to the transmitting audio channel of FIG. 1, as well as FIG. 4, which illustrates details of the audio transmission channel. In particular, an audio transducer **260**, such as a microphone, is utilized for receiving sounds typically inputted by the speaker or caller using the video telephone system **100**. The microvolt level output of the transducer **260** is selected by a microphone selector switch **264**. The output generated by the transducer **260** is amplified by the pre-amplifier **268** to a 0–2 volt peak-to-peak level. The amplified analog audio signal is received by an audio low pass filter **272**, which allows only low frequency voice or audio signals to pass through. Such audio signals have less than a frequency of about 3000 Hz. All other frequencies are rejected or filtered out. The output of the low pass filter **272** is then applied to an audio post-amplifying stage **276** for further amplification to obtain a 0–5 volt level analog voice signal. Two-stage amplification of the audio signal is used to reduce offset and saturation error effects on the audio signal.

The audio transmitting channel of the video telephone system **100** also includes an audio digitizer **280** for generating digitized values of inputted analog audio information. The audio digitizer **280** includes an analog- to-digital converter **284**, which receives the analog audio signal from the post-amplifier **276**. The digitized audio output from the analog-to-digital converter **284** is sent to an audio data storage or fifth first in/first out memory **288** to be written therein for subsequent access and reading for the purpose of compressing such audio information. Control of the analog audio signal conversion, as well as monitoring and control of the fifth memory **288** is achieved using a sixth state machine controller **292**. In one embodiment, the 0–5 volt level analog audio signal is digitized at 8000 samples/second. The sixth state machine controller **292** generates sampling clock signals to sample the analog signal and to initiate the analog-to-digital conversion and also causes the writing of the converted digital data into the fifth memory **288**.

In connection with the compression of the digitized audio information, it is first transformed from the time domain to the frequency domain using an audio one-dimensional fast cosine operator unit **296** having a fast cosine operator data base **300**. Also included as part of the fast cosine operator unit **296** is a 16-bit multiplier and accumulator **304**, which receives 8-bit audio data words or points from the fifth memory **288**. A seventh state machine controller **308** controls the transfer of data from the fifth memory **288** to the 16-bit multiplier and accumulator **304** and also controls the sending of the data from the data base **300** to the 16-bit multiplier **304**. The operation of the 16-bit multiplier **304** is also controlled by the seventh state machine controller **308**. The results of the one dimensional cosine transformation are stored in a third random access memory **312**. In connection with the transformation, it is conducted in the same manner as the row-wise transformation previously described with regard to the row transformation unit **184**, except audio information is being transformed, instead of video information. The [B] matrix associated with the audio transformation has the same matrix elements or data as the [B] matrix for the video cosine transformation. The transformed audio data matrix [E] is determined by the multiplication of the inputted audio data, defined using matrix [A], with the [B] matrix, i.e., [E]=[B]*[A]. A column-wise transformation of audio information is not necessary to achieve a suitable time to frequency transformation using the inputted audio information. In one embodiment, 256 8-bit data words or points of voice data are converted from time domain to frequency domain data. The 256 audio data words correlate with a matrix of 256×1, which constitutes a one-dimensional matrix that is preferred for providing a balance between desired audio data compression and maintaining high quality audio information in the embodiment where the audio analog signal is sampled at 8000 samples/sec.

Similar to the compression of video data, the output from the one-dimensional fast cosine operator unit **296** is subsequently processed for compressing the same before transmission. That is, the output from the third random access memory **312** is applied to an audio coefficients selector unit **316** for determining which coefficients of the inputted 256 16-bit data words have the greater magnitudes of energy for outputting them to an audio coefficients converter or square root extractor unit **320**. In the embodiment described, the 256 16-bit words are reduced to 50 16-bit words having the greater energy for input to an audio coefficients converter/encoding or square root extractor unit **320**. The audio coefficients selector unit **316** therefore compresses the audio information by a factor of about 5 (256/50). The audio square root extractor unit **320** further compresses the audio information in a manner comparable to the video square root extractor unit **232** so that the inputted audio information is further compressed by another factor of two. The output of the audio square root extractor unit **320** is applied to an audio subtractor unit **322** and a previous audio data storage or sixth first in/first out memory **324**. Like the video channel, the audio subtractor unit **322** basically compares current and just previously sent audio information by taking the difference between the previous audio information stored in the sixth memory **324** and the current audio information outputted by the audio square root extractor unit **320**. The result of this difference is fed to an imaginary data storage or seventh first in/first out memory **326**. The audio subtractor unit **322** acts to further compress the inputted audio information by a factor of two.

An eighth state machine controller **328** is used to control the timing and transfer of frequency domain audio information for the desired compression and eventual storage in the seventh memory **326**. In particular, the eighth state machine controller **328** controls the timing and transfer of audio data from the third random access memory **312** to the audio coefficients selector unit **316**. It also controls the operation of the coefficients selector unit **316** and that of the audio square root extractor unit **320**. The eighth state machine controller **328** further controls the subtraction operation including the timing and transfer of audio data to and from the sixth memory **324** so that the comparison determination can be properly made between successive audio information data points. Additionally, the controller **328** controls the writing of audio information into the proper locations in the seventh memory **326**, as well as monitoring the contents thereof.

The digitized compressed audio information stored in the seventh memory **326** is next fed to the video/audio data mixer **248**. In the preferred embodiment, such audio information is sent as imaginary numbers to the fast Fourier operator **252**. The fast Fourier operator **252** performs a fast Fourier operation using the inputted video data as real numbers and the inputted audio data as imaginary numbers. The output of the fast Fourier operator **252** is a set of complex numbers, which are stored in a video/audio first in/first out memory **332**. The fast Fourier transformation is a well-known mathematical technique for obtaining complex numbers in digital format using inputted real and imaginary numbers. The video/data mixer **248** also includes a ninth state machine controller **336**, which controls the transfer and timing of the real and imaginary video and audio data to the fast Fourier operator **252**, as well as controlling the steps performed by the fast Fourier operator **252**. Transfer of the outputted complex numbers to the video/audio memory **332**, as well as monitoring its contents, is achieved using the ninth state machine controller **336**.

The mixed video/audio data stored in the memory locations of the video/audio memory **332** is further compressed using an adaptive differential pulse coding unit **340**. As seen in FIG. **5**, the coding unit **340** includes a previous mixed data storage **344** for storing mixed data from the previously received mixed video/audio data, which includes the previous image frame and audio information accompanying such video information. The coding unit **340** also includes a subtractor unit **348** for receiving the mixed video/audio information from the video/audio memory **332**. The data stored in the previous data storage **344** is compared with or subtracted from the current mixed data using the subtractor unit **348**. This operation results in outputting only mixed video/audio data that is different from the mixed data, which was previously sent. Such a comparison substantially reduces the amount of redundant mixed data that is to be transmitted over the ordinary telephone lines and therefore reduces the amount and rate of mixed data that needs to be sent to accurately represent the mixed video information and audio information. As a practical matter, during most of the time when the speaking party is talking on the telephone, most of the image data that is being transmitted is not changing. Consequently, the difference between previous and current mixed data sets will approach zero, except for the difference due to audio or motion relaxed information. To take advantage of such slight differences between current and previous information for transmission purposes, the pulse coding unit **340** also includes a difference encoder **352**, which receives the output from the subtractor unit **348**. In one embodiment, the difference encoder **352** encodes the inputted mixed data to a fewer number of bits using run length coding methods. In accordance with this method, a count is made as to how many consecutive data words have the same value. Upon determining how many have the same value, the data can be encoded to compress the same before transmission. By way of example, if it is determined that there has been essentially no change over the previous transmission for a determined amount of time, this might be represented as five consecutive 8-bit data words or points, which comprises a total of 40 bits. This information could be encoded such that the first byte of an 8-bit word is 0 and the second byte of the same 8-bit word is coded as 5 to indicate 5 bytes of consecutive zeros. By this example, the number of bits that are required to be sent to provide the video and audio information is 16 bits 2 bytes), instead of 40 bits. The difference encoder 352 also adds a synchronization code to the coded block data so that the receiving station can identify the starting and ending of the real mixed data stream. The difference encoder 352 also adds one data word to the data stream to indicate the total number of data words sent in a current frame or block of mixed data.

A tenth state machine controller 356 is in electrical communication with the previous data storage 344, the subtractor unit 348 and the difference encoder 352 for controlling their operations and the inputting of mixed video/audio data thereto. The tenth state machine controller 356 also controls the transfer of the mixed video/audio data from the mixed video/audio memory 332 and functions simultaneously with the other state machine controllers including the ninth state machine controller 336 for achieving the desired simultaneous operations associated with the processing, including compression, and transmission of video information and audio information.

As seen in FIG. 5, in the preferred embodiment, the video telephone system 100 also includes a security encoder 360 for receiving the encoded mixed video/audio information outputted by the difference encoder 352. A security key 364 communicates with the security encoder 360, with the security key 364 being preferably a 16-bit data register which stores a user-selected security code. The security code is inputted to the security encoder 360 to encode the mixed data received by the security encoder 360. The desired or expected called party would be apprised of the security code so that the called party can use it in decoding the transmitted video information and audio information. Normally, the security code may be changed on a regular basis, such as on a daily basis, so that it is more difficult to decipher the transmitted video and audio data, if an unauthorized person were to tap or otherwise access the telephone lines along which the mixed data is sent.

Before transmission of the mixed data stream, a carrier frequency is provided that is modulated by the inputted mixed data from the security encoder 360. This is accomplished using a modulator unit 368, which includes a modulator 372 for receiving the encoded mixed video/audio data. The modulator 372 modulates a carrier wave having a predetermined frequency using the inputted mixed data. In one embodiment, the modulator 368 includes a 3000 Hz wave generator 376, which inputs a carrier wave to the modulator 372 having a 3000 Hz frequency. A 1200 Hz wave generator 380 is also provided for inputting a carrier signal having a 1200 Hz frequency to the modulator 372. One of these two carrier waves is utilized as the carrier frequency for transmitting the mixed data. In one embodiment, the 3000 Hz wave carrier is used when the mixed data is generated by the person who originated the telephone call and the 1200 Hz wave is modulated by the mixed data when such mixed data was generated by the person responding to the originating call. With the use of two different carrier frequencies, the source of the mixed data can be readily determined. The output of the modulator 372 is fed to the ordinary voice grade telephone line 384 using conventional cable 388 and a telephone interface or standard RJ-11 type connector 392. In the case in which the modulated wave is to be transmitted over a radio link, the modulated wave is fed to a radio transmitter and receiver unit 396. It should also be appreciated that the modulated wave could also be sent to a printer, magnetic media, volatile memory, non-volatile memory, and any other playback memory 398 for storage and subsequent retrieving for playback purposes. It should be further understood that a playback memory could be located to store compressed video/audio data when such is received after transmission over the telephone lines.

With regard to installation and initializing use of the video telephone system 100, as illustrated in FIG. 5, a power cable 400 is connected to a standard electrical outlet, which cable 400 supplies power to a power converter 404. The power converter 404 is part of a control panel or board 406 and is used to convert the AC input power to predetermined DC voltage levels, e.g., ±5 VDC and ±12 VDC. The DC voltages are used to power the parts and components of the video telephone system 100 that require such electric power. A video switch 408 is provided to either enable or disable the transmission of video information or images to a calling or receiving station. The control panel 406 also includes a speaker switch 412, which is used to turn off the loud speaker for privacy when a handset is used for telephone conversations. The output from each of these two switches 408, 412 is applied to an eleventh state machine controller 416 for controlling the use of such inputs including providing signals indicative of the states of these two switches. In that regard, the output of the eleventh state machine controller 416 is sent to an encoder 420 for encoding such information in a format that is understood by the telephone receiving station. The output of the encoder 420 is fed to the modulator 372 so that such information can be relayed to the receiving station in the form of a modulated carrier wave and before the transmission of the mixed video/audio data. The telephone control board 406 also includes a standard telephone key pad 424 which is used to dial or input the telephone number that is to receive the video and/or audio transmission. Associated with the telephone key pad 424 is a telephone dial tone generator 428 for producing a dial tone, which is used to modulate a carrier wave using a modulator for dial tone and ring detector 432. The output of the modulator 432 is applied to the telephone cable 388 for transmitting the modulated wave having dial tone information along the ordinary telephone line 384. Additionally, a telephone ring indicator 436, which communicates with the modulator 432, is used to provide an indication that the video telephone is being accessed or ringing.

In order to insure that the ordinary voice grade telephone line or lines 384 have the capacity to receive the expected to be transmitted video information and/or audio information, the control panel 406 includes a transmission capacity tester 440. The tester 440 tests the maximum capacity of a telephone line to transmit data at any predetermined time. To accomplish such testing, the tester 440 places the video telephone system 100 into a remote loop back mode by sending a predetermined, unique code to the receiving station. The transmission capacity tester at the receiving station intercepts the incoming predetermined code and places the receiving station in loop back mode. As a result, the receiving station sends all transmitted data back to the transmitting unit until loop back mode is terminated by the transmitting station. Once the receiving station is in the loop back mode, the sending station combines a 16-bit word into one cycle of analog data and sends it to the receiving station. The receiving station sends the received data back to the sending station. The data received back at the sending station is compared with the data originally sent. If the data received is not the data that was sent, then it is determined that the telephone line is unable to send a 16-bit word or data point in one cycle. If such a determination is made, a 16-bit data word is sent in two cycles, with an 8-bit word being sent per analog cycle, to the receiving station. The receiving station once again returns the sent data back to the sending station, which is compared with the two 8-bit words that were just sent. If there is no match based on the comparison, then 4 bits per cycle are sent. Using four cycles, 16 bits of data are sent again to the receiving station. This testing can be continued with two bits per cycle and one bit per cycle. When a match between transmitted and received data is achieved, the number of bits used to achieve that match indicates the maximum data transmission capacity of the telephone line. In the foregoing examples, the transmission capacity tester 440 determines whether 48,000, 24,000, 12,000, 6,000 or 3,000 bits/second can be sent with a 3,000 Hz carrier wave. It also verifies whether 19,200, 9,600, 4,800, 2,400 or 1,200 bits/second can be sent using 1,200 Hz as a carrier wave. The bits of data or data stream used for testing the telephone line capacity includes five unique 16-bit data words that are also used as a diagnostic test pattern which can detect any stuck high, stuck low or shorted digital signal lines involved within the telephone interface electronics. The eleventh state machine controller 416 controls the operation of the transmission capacity tester 440 and is used in making the determination as to the capacity of the telephone line or lines along which the expected to be transmitted video information and/or audio information is to be provided.

With the generation of the compressed video information and compressed audio information having been described, reference is now made to FIGS. 6–8 for a discussion of the video and audio receiving channels that receive the mixed video/audio data from the ordinary telephone line or lines and process the same, including decompression or expansion, so that the images and the sounds provided by the transmitting party can be seen and heard by the receiving party. The modulated carrier wave must first be demodulated to recover the compressed mixed video/data information. Such demodulation is achieved by a demodulator 444, which is illustrated in FIG. 5 as being associated with the previously described transmitting station. As can be understood, both the call originating station and the call responding station must each have transmission and reception capabilities. Consequently, the demodulator 444 at the transmitting station includes the same components and functions in the same manner as a demodulator, which is part of the video telephone system 100 at the receiving station. The demodulator 444 removes the intelligence, i.e. mixed video/audio data, from the carrier frequency after being received from the ordinary telephone line 384. The mixed video/audio data can then be decompressed or expanded using a number of expansion methods, comparable to the methods utilized in compressing the data.

As seen in FIG. 6, the mixed video/audio data is first applied to an adaptive differential pulse decoder unit 500. The pulse decoder unit 500 essentially reverses the function or process performed by the pulse coding unit 340 and regenerates the same data that was inputted to the pulse coder 340. The pulse decoder unit 500 includes a difference decoder 502 that receives the mixed video and audio data from the ordinary telephone line 384 and decodes the mixed data so that the data is outputted therefrom in essentially the same form that it had when it was inputted to the difference encoder 352. The output of the decoder 502 is delivered to an adder 504 for adding currently received mixed data to mixed video/audio data previously stored in previous data storage 508. The previous data storage 508 stores previously received mixed data including data that was found to be redundant or the same as mixed data that is now being transmitted. The adding of the previous data to the current data by means of the adder 504 results in an output comparable to the input to the subtractor unit 348. This regenerated mixed data is written into an eighth first in/first out memory 512. The output of the adder 504 is also sent to the previous data storage 508 for use in combining with the next block of mixed data. A twelfth state machine controller 516 controls the operation of the decoder unit 502 and the adder 504, as well as the transfer of expanded, mixed data to the previous data storage 508 and the eighth memory 512. The twelfth state machine controller 516 also monitors the contents of the eighth memory 512 to determine whether storage space is available for the expanded mixed data outputted by the adder 504.

The receiving section of the video telephone system 100 also includes a one-dimensional inverse fast Fourier transform unit 520. Similar to the pulse decoder unit 500, the inverse transform unit 520 reconstructs the video information and audio information that was inputted to the video/audio data mixer 248. Accordingly, the inverse transform operator provides separate compressed video information and audio information. The unit 520 includes two separate channels, each of which receives the same input from the eighth memory 512. In conjunction with the video information channel, the mixed data stream from the eighth memory 512 is inputted to a 16-bit multiplier accumulator 524. Also inputted to the multiplier accumulator 524 is data stored in the data base for generating real data 528. Under control of the thirteenth state machine controller 532, the mixed data from the eighth memory 512 and data from the data base 528 are applied to the multiplier accumulator 524 to perform the inverse transform function, as is well known in the art. The inverse transform, performed using the multiplier accumulator 524, results in obtaining real number portions of complex numbers, which are then stored in a real image data or ninth first in/first out memory 536. The thirteenth state machine controller 532 controls the transfer of the real number portions to the ninth memory 536, as well as monitoring its contents. The compressed video information stored in the ninth memory 536 corresponds to the compressed video information inputted to the video/audio data mixer 248.

With respect to the channel for obtaining or separating the compressed audio information from the mixed data stream, the 16-bit multiplier accumulator 540 receives the inputted mixed data stream from the eighth memory 512. An inverse fast Fourier transform is performed on this inputted data using the data from the data bate to generate imaginary data 544, under the control of the thirteenth state machine controller 532. The results of this inverse transform are imaginary number portions of the complex numbers set outputted by the two multiplier accumulators 524, 540. The imaginary number portions are written into an imaginary audio data or tenth first in/first out memory 548. As with the video information separating channel, the thirteenth state machine controller 532 also controls the transfer of separated, compressed audio information to the tenth memory from the multiplier accumulator 548 and checks the contents of the tenth memory to insure that proper storage of the separated compressed audio information is made.

To further expand the received video data, now separated from the audio data, a frame to frame difference restorer **552** is provided. This restorer **552** restores video image information that had previously been removed using the subtractor unit **240** prior to transmission of the video information. To accomplish the restoration, it is necessary that previous video information be combined with current video information. More particularly, the frame difference restorer **552** includes an adder **556** for receiving the separated compressed video information in the form of 8-bit words or data points. The adder **556** combines the current video data with previously received video data that was found to be redundant and which had previously been removed by the subtractor unit **240** during compression of the video data before transmission. With regard to previous image data, a previous image encoded data storage **560** is provided, which has memory locations corresponding to each of the elements of the 32×32 matrix of video information so that the output, after video information associated with one frame has been sent to the adder **556**, is a frame of video data of 32×32 elements, each having 8 bits and which are stored in an eleventh first in/first out memory **564**. A fourteenth state machine controller **568** electrically communicates with the eighth memory **536** for controlling the transfer of separated compressed video information therefrom to the adder **556**. The fourteenth state machine controller **568** also controls the operating steps performed by the adder **556** and the transfer of video information to the previous image data storage **560**, as well as obtaining such data for inputting to the adder **556**. Similar to other state machines, the fourteenth state machine controller **568** also monitors the contents of the eleventh memory **564** and writes the 8-bit video data into the proper locations of the eleventh memory **564**.

Continuing the description of the video information receiving channel, the video telephone system **100** also includes an 8-bits to 16-bits coefficients converter or multiplier, preferably a squarer, unit **572** for squaring each of the 8-bit data points stored in the tenth memory in order to store or decode the 8-bit video data words to 16-bit words. This expansion is followed by a further expansion using a video data coefficients restorer **576**. Specifically, the restorer **576** receives the results of the multiplier **572** in the two-dimensional square format. The 400 coefficients which were selected by the coefficients selector unit **224** are decoded to their meaningful values and stored at appropriate locations in a two-dimensional, 32×32 memory array, corresponding to one frame of a video image. The remaining 624 locations of the 32×32 array (1024 locations) are zeroed out. The results of the video data coefficients restorer **576** are written into a twelfth first in/first out memory **580** which, for each frame of video, uses 32×32 memory locations. Similar to the restorer **576**, which decodes the video information previously compressed by the coefficients selector unit **224** before transmission, the multiplier unit **572** restores or reverses the operation of the square root extractor unit **232**. In conjunction with properly controlling these expansion modes or methods, a fifteenth state machine controller **584** is provided for controller the transfer of compressed video data from the eleventh memory **564** to the multiplier **572** and subsequent transfers to the restorer **576** and the twelfth memory **580**. Additionally, the fifteenth state machine controller **584** controls the operating steps associated with the multiplier unit **572** and the restorer **576**, as well as monitoring the contents of the twelfth memory **580** and writing the expanded video data into the proper locations in the twelfth memory **580**.

With reference to FIG. **7**, the video telephone system **100** video receiving channel further includes a two-dimensional inverse fast cosine transformer unit **590** for converting the video information from the frequency domain to the time domain. To implement this transformation or conversion, an inverse row transform unit **592** and an inverse column transform unit **596** of the transformer unit **590** are employed. Each of the units **592**, **596** inverse transforms or decodes the inputted video information that had been previously transformed in the video transmitting channel using the row transform unit **184** and the column transform unit **188**, respectively. The inverse row transform unit **592** includes a 16-bit multiplier and accumulator **600** for receiving sequentially, in connection with each frame of a video image, 32×32 16-bit data words. Electrically communicating with the multiplier and accumulator **600** is a row data base **604** which has stored therein data for performing the inverse transformation by rows. In particular, the data base **604** includes the matrix elements associated with the $[B]^T$ matrix. The inputted video information to the multiplier and accumulator **600** constitutes the restored 16-bit coefficients and, for each frame of video data, can be defined as a 32×32 [C]' matrix. The result of the inverse transform is a 32×32 [R'] matrix. The elements of the [R'] matrix are written into and stored in a fourth random access memory **608**. The elements of the [R'] represent regenerated or reproduced video data. A sixteenth state machine controller **612** controls the timing and transfer of the video information from the twelfth memory **580**, the operation of the inverse row wise transform and the writing of the results into the fourth random access memory **608**.

To complete the inverse transformation, the elements of the [R'] matrix are serially transferred to a 16-bit multiplier and accumulator **616**. Like the multiplier and accumulator **600**, the multiplier and accumulator **616** performs the necessary multiplications and additions for implementing the inverse column wise transformation of the inputted video data. This is accomplished in conjunction with data inputted from the column data base **620**, which is multiplied with the data from the fourth random access memory **608**. Specifically, the data from the data base **620** includes the elements of the [B] matrix. As a result of this inverse transformation, and outputted by the multiplier and accumulator **616**, is one frame of video data, i.e., a 32×32 [V'] matrix, whose elements represent time domain video information. The [V'] matrix is obtained as a result of the computation of [R']*[B]. The elements of the [V'] matrix are written into a fifth random access memory **624** and, with respect to a 32×32 frame, such video information is substantially similar to the original image that was obtained by the camera device **104** at the transmitting station, except that it must be magnified or restored to the original image size. A seventeenth state machine controller **628** controls the transfer of row wise transformed video data from the fourth random access memory **608** to the multiplier and accumulator **616**, as well as the outputting of elements of the [V'] matrix to the fifth random access memory **624**. The seventeenth state machine controller **628** further controls the operation of the multiplier and accumulator **616** including the transfer of data from the data base **620**, which is used in the performance of the inverse cosine transformation by columns.

To restore the time domain video information to the image size previously obtained using the camera device **104**, an image magnifier **632** communicates with the fifth random access memory **624**. The image magnifier **632** expands or magnifies the inputted video data so that, in the embodiment in which a frame of 32×32 elements has been generated and stored in the fifth random access memory 624, a 96×96 resulting matrix or frame of video information is achieved. The image magnifier 632 includes a thirteenth first in/first out memory 636 for receiving, under the control of an eighteenth state machine controller 640, the video information to be magnified. The image magnifier 632 uses a bi-directional interpolation method for expanding the inputted video data to a 96×96 image size. Each of the elements of the 96×96 frame is now 8-bit data words, in the case of a monochrome image, and 15-bit data words, in the case of a color image being transmitted. The bi-directional interpolation method essentially restores or decodes video data that had previously been removed as a result of the averaging that had been done by the spatial mode image compression unit 156.

To display the received images, the magnified video information is controllably applied to a video display interface 644, which includes a video display memory 648 into which the magnified video information is written. The digital video information stored in the video display memory 648 is fed to a digital-to-analog converter 652 for converting the digital video information back to an analog video signal that includes the video information. The signal conditioner and synchronization pulse generator 656 receives the analog video signal and adds synchronization pulses, namely, horizontal and vertical blanking pulses, color level adjusting signals and any other standard video information that is useful or necessary in properly displaying the inputted video information. The output of the pulse generator 656 is fed to an analog multiplexer 660 for subsequent transfer to an image display monitor CRT or LCD 664. The operation of the video display interface 644 is controlled by a nineteenth state machine controller 668, which electrically communicates with each of the components of the video display interface including the video display memory 648, the digital-to-analog converter 652, the signal conditioner and synchronization pulse generator 656 and the analog multiplexer 660. The nineteenth state machine controller 668 also controls the timing and transfer of the magnified or expanded video information from the thirteenth memory 636 for storage into the video display memory 648. In addition to the display of images received from a transmitting station, the image display monitor 664 is also able to display images being transmitted by the transmitting station. That is, instead of displaying received images, the image display monitor 664 can display transmitted images so that the sending party is able to see the images actually being transmitted. This capability is implemented using a video display mode selection switch 672, whose input is applied to the nineteenth state machine controller 668. When the switch 672 is in a first state, the image display monitor 664 displays the images being received from a transmitting station. When the switch 672 is in a second state, the image display monitor 664 displays images being transmitted. In that instance, the analog multiplexer 660 receives the amplified audio video signal from the video amplifier 140 of FIG. 3. The analog multiplexer 660 then acts to pass this video signal to the image display monitor 664, instead of the analog video signal that may be received from another video telephone transmitting station. In one embodiment, a display playback memory 674 is provided for storing expanded video data (see FIG. 2), which can be viewed later or stored for a record-keeping purpose.

Returning back to FIG. 6, a description of the expansion of the separated compressed audio information is now provided. The compressed audio information is being expanded simultaneously with the expansion of the compressed video and such expansion is controlled using the same state machine controllers 568, 584 as controlled certain of the expansion steps of the video information. The compressed but separated audio information, in accordance with the embodiment disclosed, includes 25 8-bit data points. This audio information is serially applied to an adder 680 of the difference restorer 552, which also includes a previous audio encoded data memory 684. The memory 684 stores previously received audio data and expands or restores audio data so that it corresponds to the audio data as it existed when it was inputted to the audio subtractor unit 322. Thus, the memory 684 includes audio data that was determined to be the same as previously sent audio data by the operation of the audio subtractor unit 322 and the memory 324. This stored audio data is added to the currently received audio data by the adder 680, under the control of the fourteenth state machine controller 568. The result of the addition is sent to a fourteenth first in/first out memory 688, also under the control of the fourteenth state machine controller 568. The adder operation expands the inputted audio information by a factor of two so that 50 8-bit data points are stored in the memory 688.

Under the control of the fifteenth state machine controller 584, the audio information from the fourteenth memory 688 is next controllably inputted to an 8-bit to 16-bit audio coefficients converter or multiplier, preferably a squarer, unit 700 that decodes each inputted 8-bit data point to a 16-bit data point. The multiplier unit 700 restores or reverses the audio information to the content it had when it was inputted to the audio square root extractor 320. Also under the control of the fifteenth state machine controller 584, the resulting 16-bit data points are next applied to an audio data coefficients restorer 704. The restorer 704 decodes the inputted audio data to output, in the desired embodiment, 256 16-bit data words having audio information. The coefficients restorer 704 essentially reverses the compression method utilizing the audio coefficients selector unit 316 so that expanded audio data is the result. Arithmetic and logical control of the restorer 704 in implementing the necessary steps to obtain the restored coefficients is achieved using the fifteenth state machine controller 584. A fifteenth first in/first out memory 708 electrically communicates with the restorer 704 and the restored coefficients are written into the fifteenth memory 708 in memory locations that can be defined as a one-dimensional 256×1 matrix (256 16-bit data words).

With reference to FIG. 8, to inverse transform the frequency domain voice data to the time domain, a one-dimensional inverse fast cosine transform unit 712 is provided for receiving the expanded audio information from the fifteenth memory 708. The inverse transformation unit 712 essentially reverses the cosine transformation performed by the fast cosine operator unit 296. The expanded audio information is inputted to a 16-bit multiplier and accumulator 716, which is used to implement the inverse transformation, together with data from the data base for one-dimensional inverse cosine transformation 720, which is predetermined data previously stored therein. In performing the inverse transformation, the data base 720 stores elements or numbers constituting the defined $[B]^T$ matrix. The inputted audio information can be defined as a [G] matrix that corresponds to the [E] matrix, previously determined when the audio data was transformed, but having some of the matrix elements of the [E] matrix zeroed out. The reproduced or regenerated audio data is defined as an [A'] matrix, which is determined from the relationship $[A']=[B^T]*[G]$. To arrive at which of the matrix elements of the [E] matrix are "zeroed out," steps are taken to determine the energy content associated with the matrix elements so that only a predetermined percentage of such energy content remains after the zeroing out process. A twentieth state machine controller **724** controls the inputting of the audio information to the multiplier and accumulator **716**, as well as the timing and transfer of data from the data base memory **720**. The twentieth state machine controller **724** also controls the operation and various steps conducted by the multiplier and accumulator **716** in performing the one-dimensional inverse cosine transformation. The time domain audio information produced as a result of the inverse cosine transformation is written into a sixth random access memory **728** under the control of the twentieth state machine controller **724**, which controller also monitors the contents of the memory **728** and controls which memory location that the time domain audio information should be written into. As a result, the sixth random access memory **728** contains 16-bit data points representative of audio information, with 256 such data points, in one embodiment, correlating with the transmission and reception of one frame (96×96 of pixels) of video information.

The expanded digital audio information can then be transmitted to a speaker and handset interface **732** for preparing or conditioning the digitized audio information so that the transmitted sounds can be reproduced at the receiving station. In particular, the interface **732** includes a sixteenth first in/first out memory **736** into which the 16-bit audio data words are serially written under the control of a twenty-first state machine controller **740**. Also pursuant to the control of the twenty-first state machine controller **740**, the digital audio information is converted to an analog audio signal using a digital-to-analog converter **744**. The analog output from the digital-to-analog converter **744**, under the control of the receiving party, can be transmitted to a handset speaker amplifier **748**, which amplifies the analog audio signal before transmission to the handset speaker **752** of the telephone handset **756**. The converted analog audio signal could instead be fed to an audio power amplifier **760**, which communicates with a loud speaker **764** so that more than one individual is able to hear the reproduced sounds using the audio information, which is part of the amplified analog audio signal. The telephone handset **756** also includes a microphone **768**, which corresponds to the microphone **260** associated with the telephone system of the transmitting station.

As can be understood from the foregoing relating to the compression of video information and audio information and its later expansion by a receiving station, high quality and accurate video images can be transmitted in substantially real time over ordinary voice grade telephone lines, having limited bandwidths. Although other specific embodiments could be implemented using the features of the present invention, in the embodiment described, the video information is first compressed by a factor of 9 using the image reduction unit **156**. It is then subject to a 0.8 factor of compression using the two-dimensional coefficients selector unit **224**. The video information is then further compressed by a factor of 2 using the video coefficients converter unit **232**. The video information is then compressed by an additional factor of about 2 using the subtractor unit **240**. Lastly, the video information is compressed by a factor of 2–5 times using the adaptive differential pulse coder unit **332**. As a result, the video data words are compressed by a total of 57–144 times. With respect to audio information compression, the audio coefficients selector unit **316** compresses the inputted audio information by a factor of about 5. The audio information is then further compressed by a factor of 2 using the audio square root extractor unit **320**. The audio subtractor unit **322** further compresses the audio information by a factor of 2. Since the audio information is also received by the adaptive differential pulse coding unit **332** as part of the mixed video/audio data, the audio information is also compressed by an additional factor of 2–5 times. When considered together, the entire compression of audio data is between about 40–102 times. The video information to be compressed is preferably sampled or selected at a rate that permits the viewer to see images as they occur in substantially real time, while avoiding sampling at a greater rate. It has been determined that a video frame rate of 7–7.5 frames/second achieves this objective. The video telephone system **100** is therefore able to sample video information at this rate and, together with the total video compression as well as the total audio compression, simultaneously transmit audio information and video information over ordinary telephone lines while still achieving high quality and accurate picture and voice reproduction at a telephone receiving station having the video telephone system **100**. Additionally, the video information and audio information is transmitted and received asynchronously relative to the functioning and operation of the various processing, compressing and expanding units employed by the present invention. That is, the asynchronous operation means that no system clock is required to synchronize or clock in video and audio information as such is initially received into their respective video and audio transmitting channels, rather, video and audio information is received at the same time based on what is being inputted to the camera device and microphone. Likewise, there is asynchronous transmission of the video and audio information over the telephone lines since the video and audio information is mixed together so that there is no synchronizing clock needed to synchronize the reception of video and audio data. However, the state machine controllers used in the video and audio transmitting channels and the state machine controllers used in the video and audio receiving channels are synchronized and must cooperate together so that the video information received by the display monitor and the audio information received by the speaker are generated so as to reproduce that video and audio information which was inputted at the same time to their respective transmitting channels.

Another embodiment for transmitting and receiving "compressed" audio data involves the use of a linear predictive coding (LPC) system. This system determines magnitudes of parameters using inputted, sampled speech, which parameters are used to synthesize or reconstruct the speech after the parameters have been transmitted to the receiving station. The speech parameters are: vocal tract or LPC coefficients; pitch period for N speech samples of speech; voiced or unvoiced speech; and the gains associated with each pitch period of N speech samples.

With reference to FIG. **9** and initially the analysis of LPC coefficients, the LPC system includes a LPC coder **800** that receives as its input the audio data stored in the audio data storage memory **288** of FIG. **1**. That is, instead of the audio data being inputted to the fast cosine operator unit **296** of FIG. **1**, in this embodiment, such data is inputted to the LPC coder **800**.

The LPC coder **800** implements a coding technique that is based on the premise that a sample of speech can be approximately defined as a linear combination of previous "p" speech samples, in accordance with the following relationship:

$$S(N)=\sum_{i=1}^{p} A(i)*S(N-i) \qquad [1]$$

Where:

S(N)=speech signal;

A(i)=predictor coefficients, with 1≦i≦p;

p=order of the system and a predetermined value.

In accordance with the foregoing, if the linear predictor coefficients or values of A(i), for i=1 to p, are known, then further speech sample values S(N) can be calculated. The linear predictive coding coder **800** computes these 1 through p predictor coefficients A(i).

In conjunction with the use of the LPC coder **800**, it receives digitized speech at a predetermined number of samples/second. The LPC coder **800** processes a predetermined number N of consecutive samples of audio data to determine a predetermined number "p" of linear predictor coefficients A(i). In one embodiment, the value of N can be between 120–1024, with the quality of regenerated speech being higher with a smaller N value but the compression becomes insufficient for a value N too small. A typical value of N is 207. Similarly, greater values for "p" result in better quality of regenerated speech, but at the expense of higher bandwidth requirements to transmit additional predictor coefficients. A typical value for "p" is 8.

With regard to determining the predictor coefficients A(i) by means of the LPC coder **800**, autocorrelation coefficients Rs(K) for a "frame" are determined. A "frame" corresponds to N samples of audio data. To determine these coefficients:

$$Rs(K)=\sum_{M=0}^{N-1-K} S(M)*S(M+K), K=0,1\ldots p \qquad [2]$$

where:

N=no. of samples in the frame

S(M)=speech signal samples

p=order of the system

From the determined Rs(K) values, Yule-Walker equations are employed:

$$\begin{bmatrix} Rs(0) & Rs(1) & \ldots & Rs(p-1) \\ Rs(1) & Rs(0) & \ldots & Rs(p-2) \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ Rs(p-1) & Rs(p-2) & \ldots & Rs(0) \end{bmatrix} \begin{bmatrix} A(1) \\ A(2) \\ \cdot \\ \cdot \\ \cdot \\ A(p) \end{bmatrix} = \begin{bmatrix} Rs(1) \\ Rs(2) \\ \cdot \\ \cdot \\ \cdot \\ Rs(p) \end{bmatrix} \qquad [3]$$

where:

Rs(K)=autocorrelation coefficients

A(i)=LPC coefficients

p=order of the system

The Yule-Walker equations are solved using Durbin's recursive solution as follows:

$$E^{[0]}=R(O) \qquad [4]$$

$$K(i)=\left[R(i)-\sum_{j=1}^{i-1} A(j)^{[i-1]}*Rs(i-j)\right]/E^{[i-1]}, 1\leqq i\leqq p \qquad [5]$$

$$A(i)^{[i]}=R(i) \qquad [6]$$

$$A(j)^{[i]}A(j)^{[i-1]}-K(i)*A(i-j)^{[i-1]} \qquad [7]$$

$$E^{[i]}=(1-K(i)^2)*E^{[i-1]} \qquad [8]$$

The nomenclature of the above equations, [4]–[8], includes the use of variables in parenthesis, e.g. (j), and variables at upper scripts found in brackets ([,]) e.g. [i]. Such nomenclature indicates an element in a matrix with the parenthesis term indicating the column and the bracketed term indicating the row, e.g., the jth term in the ith row.

The foregoing equations are solved recursively for i=1,2, . . . p to achieve the final solution:

$$A(j)=A(j)^{[p]}, 1\leqq j\leqq p \qquad [9]$$

Where A(j)'s are the linear predictor coefficients, which are found in the pth row of the solution matrix and can be redefined again as the A(i) coefficients.

With reference to FIG. 9 in implementing this recursive method, the digitized audio data is inputted to an auto correlation function generator **804** for automatically correlating successive input speech signals, which are represented by S(M) and S(M+i), to output a predetermined number of Rs(i) values, based on the predetermined value N (equation [2]).

In connection with determining the predictor coefficients themselves, the Rs(i) values are then inputted to a LPC coefficient calculator **808** that determines and outputs each of the LPC coefficients A(i). To accomplish this determination, the afore-defined equations [3]–[9] are implemented preferably using state machine techniques for rapid processing and solving of the equations.

In addition to their use in determining Rs(i) values and subsequently LPC coefficients A(i), the sampled speech data is also utilized in determining the pitch period. Specifically, the audio data samples S(M) are inputted to a sample magnitude sequence determinator **816**. This unit receives the inputted speech data and prepares it for autocorrelation thereof in finding the pitch period. The use of the determinator **816** is based on the recognition that a voiced speech signal is close to "periodic." An autocorrelation of the inputted speech data is a satisfactory technique for determining the period. Contrariwise, unvoiced speech is not periodic. Consequently, in the case in which the speech is unvoiced, the pitch period is set to zero to indicate to the receiving station that the frame of speech is unvoiced.

In the case in which the speech is voiced, the pitch period is calculated using a series of steps that together constitute a three-level center clipping function and which function uses, in part, the determinator **816**. In that regard, the sample magnitude sequence determinator **816** compares all of the inputted speech data S(M) with each other to determine a threshold value. The threshold value equals the greatest magnitude of all of the inputted N samples for a particular frame divided by a magnitude of two. After this magnitude of samples is determined, the sequence determinator **816** then compares each of the samples S(M) of the sequence S(N) with this magnitude and generates a Y(n) sequence. For example, if the sample S(i) of the sequence S (N) exceeds the threshold, the variable Y(i) of the sequence Y(N) is set to 1. If the sample S(i) is less than the negative of the threshold, the variable Y(i) is set to −1. If the sample S(i) meets neither of the two above conditions, then Y(i) is set to 0. Using the foregoing steps, the Y(N) sequence is generated and outputted by the sequence determinator **816**.

The next step in determining the pitch period involves the use of an autocorrelation function generator **824** that receives the input from the sequence determinator **816**. The autocorrelation function generator **824** calculates the autocorrelation of the Y(N) sequence, namely:

$$R(K) = \sum_{M=0}^{N-K-1} Y(n+M)^{*}Y(n+M+K) \qquad [10]$$

The R(K) outputs from the function generator **824** are then inputted to pitch detector **832** for determining the pitch period. That is, the pitch detector **832** compares each of the R(K) values in the interval K=25–85 with each other to determine the pitch period. The pitch period K relates to the time or that speech sample from which the voiced speech repeats itself. For example, if the largest value in the interval occurs at R(75), then it is known that the voiced signal repeats itself at each 75 samples of the frame (N samples in a frame). The interval values of 25–85 were found empirically to properly handle the relatively higher pitched voices of women (K=25) and the relatively lower pitched voices of men (K=85).

With regard to the determination of whether voiced or unvoiced audio data is currently being transmitted, the output of the pitch detector **832** is applied to a voiced/unvoiced detector **840**. The detector **840** uses the value of R(K) for the pitch period to determine whether or not the speech data is voiced or unvoiced. More specifically, detector **840** compares a determined magnitude with a pre-established value. If the determined magnitude is less than the pre-established value, the current frame of audio data is determined to be unvoiced; otherwise, the current frame is determined to be voiced. In making this calculation, in addition to the R(K) of the pitch period, the detector **840** also receives, as an input, the magnitude R(0). This magnitude is outputted by an autocorrelation function generator **836**. The magnitude R(0) represents the energy of the current frame of audio data and is determined by the following autocorrelation equation:

$$R(0) = \sum_{M=0}^{N-1} S(M)^{*}S(M) \qquad [11]$$

Where:

S(M)=speech signal samples

N=number of speech samples in the frame The value of the determined R(0) is used by the detector **840** by dividing its value into the magnitude of R(K) of the pitch period. If the result of this division is less than 0.30, it is concluded that the speech frame is unvoiced and if greater than or equal to 0.30, it is concluded that the current frame of audio data is voiced speech data. In the case in which it is voiced speech, the magnitude of the pitch period that was inputted to the voiced/unvoiced detector **840** is outputted to a compressed audio storage memory **842**, just as the LPC coefficients A(i) are also inputted to this storage memory **842**. As can be understood, no information or data bits need be provided to the memory **842** directed to whether or not the current speech data is voiced or unvoiced since the magnitude of the pitch period provides such information. That is, if the magnitude of the pitch period is other than 0, the speech data is voiced; otherwise, it is unvoiced.

The third speech parameter that is determined in compressing the frame of audio data is the gain associated with that frame. In that regard, a gain factor determinator **844** is provided and which receives inputs from the pitch detector **832** and the audio data storage memory **288**. The gain associated with voiced data is the energy in each pitch period. In connection with unvoiced data, it is the energy in each quarter of a frame. Preferably, the maximum number of different gains allowed for each frame having voiced data is 4 in order to meet the preferred bandwidth of 2400 bps for transmission of the audio data. If there are more than 4 pitch periods in a frame of voiced data, a selected number of gains for the greater than 4 pitch periods are transmitted, such as the gain associated with every other pitch period. In determining the gain for voiced frames, the following autocorrelation function is utilized:

$$\text{Gain} = G(K) = \sum_{M=0}^{\text{pitch period}-1} S(M)^{*}S(M) \qquad [12]$$

Where:

S(M)=digitized speech signal samples obtained from audio data storage memory **288**

Pitch period=the value of K found by determining the largest value of R(K) in the interval K=25–85 and inputted by the pitch detector **832**.

In the case in which unvoiced audio data is being transmitted, the output from the pitch detector **840** is used to provide the gain factor determinator **844** with the information that unvoiced speech is being transmitted and the pitch period of equation [12] should be set to 4. The magnitude of the gain outputted by the gain factor determinator **844** is also received by the compressed audio storage memory **842** so that all of the necessary speech parameters of LPC coefficients, pitch period (also contains voiced/unvoiced information) and gain, for a particular frame, are now stored or available for transmission.

With reference now to FIG. **11**, a more detailed schematic representation of the autocorrelation function generators **804, 824, 836** is illustrated. These generators **804, 824, 836** include a data sequence A **848** and a data sequence B **852**. Each of the data sequence A **848** and data sequence B **852** receives data to be correlated. In the case of the function generators **804, 836**, both data sequences A and B receive sampled speech data S(M). A state machine **856** controls the operation and outputting of the determined values of Rs(i) and R(0), respectively. The outputs from the sequence units are sent to a multiplier **860** that, in accordance with the correlation function of the generator **804**, multiplies together the previous and subsequent values of S(M) and S(M+K). In the case of generator **836**, current values of S(M) are squared or multiplied together. Continuing with the correlation function, the output of the multiplier **860** is sent to an adder **864** which adds the input and its previous output in accordance with the summing function associated with the function generators **804, 836**. The operation of the adder **864** is also controlled by the state machine **856**. When the correlation function is completed and the adding operation has performed "p" additions, the state machine **856** causes the output of the adder **864** to be received by a correlation coefficient memory **868**, which output corresponds to a Rs(i) or R(0) value. As previously described, the Rs(i) value is inputted to the LPC

value is coefficient calculator **808** while the R(0) inputted to the voiced/unvoiced detector **840**.

The function generator **824** is also represented schematically by FIG. **11**; however, its inputs are the Y(N) function, whose values are determined as previously described. The output of the adder **864** from generator **824** are the R(K) values.

Referring back to FIG. **9**, with regard to the transmission of the audio related information stored in the compressed audio storage memory **836**, such transmission is controlled by a twenty-second state machine controller **870** and a video and audio data mixer **872**. In one embodiment, the mixer **872** is a switch that has two operating states or positions that are under the control of the state machine controller **870**. The mixer **872**, in a first state, provides a path for audio information to the modulator unit 368. In the second position or state of the switch 870, the video data found in storage memory 244 is able to be transmitted to the mixer 872, to the modulator unit 368 and then to the telephone interface 392, when the LPC system is being utilized. In the case in which no LPC system is employed, and the fast cosine transform is utilized instead, mixed video and audio data is transmitted to the modulator unit 368 from the adaptive differential pulse coder 340, as previously described with reference to FIG. 1. In one embodiment, the mixer 872 is controlled to alternatively pass a video data bit and an audio data bit for each frame of N samples. Because each frame has more video bits than audio bits, after all of the alternated audio bits of a particular frame have been accessed from the memory 842 and sent to the mixer 870, then only remaining video bits associated with that particular frame are accessed and controllably transmitted. The transmission of this composite signal differs from that when the fast cosine transform embodiment is utilized since, in that embodiment, a number of bits that comprise the real number of the complex number having the video and audio data are transmitted together and then the imaginary data having a number of bits is transmitted together. That is, alternating video data (real number) bits and audio data (imaginary number) bits are transmitted.

In the preferred embodiment, data is sent at 9600 bits/second with about 7680 bits being associated with video and audio data. Of the 7680 bits, about 5280 are video bits and about 2400 bits are audio bits. Consequently, a somewhat greater than 2:1 ratio of video bits to audio bits must be controlled asynchronously and yet provide accurately correlated audio and image information at the receiving station. To achieve proper asynchronous operation, it is preferred that all of both the audio data and the video data for each frame (N samples) be sent by the mixer 872 before additional audio and video data is sent under the control of the state machine controller 870. This is accomplished in the above-noted preferred alternating video and audio bit fashion, although other sequencing could be employed. Briefly, qualitatively speaking, it is necessary that the video and audio data be transmitted or "mixed" in a way that permits the video image to be updated at the receiving station without loss or lack of correlation between the video and audio information. In the embodiment in which the video image is updated 7.5 times/second, the audio data must be transmitted to achieve this qualitative purpose and in an asynchronous manner.

Referring now to FIG. 10, the receiving station for receiving the transmitted compressed audio data from the coder 800 is illustrated. Like the previous embodiment, an LPC decoder 876 includes a telephone interface demodulator unit 444. In the embodiment having the LPC system, the output of the demodulator unit 444 is sent through a video/audio receiver switch 878. When the switch 878 is in a first position or state, audio information from the demodulator unit 444 is inputted to a receiver of compressed audio data 880. In conjunction with the N samples of audio data that were compressed by the LPC decoder 800, the receiver 880 receives and then separately outputs each of the three parameters of audio related information that was transmitted, namely: LPC coefficients, the values of the gain factor and the magnitude of the detected pitch period, which also indicates whether the data is voiced or unvoiced.

When video information is being outputted by the demodulator unit 444, the switch 878 is in a second position or state whereby the compressed video data is applied to the real image data memory 536 from which it can be processed to decompress the video data in accordance with the illustration and description associated with FIG. 2. In the case in which no LPC system is employed, the entire mixed video/audio data is sent to the adaptive differential pulse decoder unit 500, as also previously described and illustrated in connection with FIG. 2.

With regard to obtaining or "decompressing" audio data using the LPC decoder 876, each of the three outputs from the receiver of compressed audio data 880 is utilized. The magnitude of the pitch period is inputted to a twenty-third state machine controller 884 and an impulse generator 888. The state machine 884 controls the sending of the pitch period magnitude to the impulse generator 888 and also determines whether the data is voiced (pitch period not equal to zero) or unvoiced (pitch period equal to zero) using the inputted value of pitch period. The state machine 884 also controls a random noise generator 892 to cause it to output an a periodic signal when the audio data is unvoiced.

Depending upon whether or not the current audio data is voiced or unvoiced, the output of one of these two generators 888, 892 is applied to a gain factor circuit 896. The position of unvoiced/voiced switch 900 causes one of the outputs of the random noise generator 892 and impulse generator 888 to be received by the gain factor circuit 896. In a first state or position, the output of the random noise generator 892 is sent to the gain factor circuit 896, while in the second position or state of the switch 900, the output of the impulse generator 888 is sent to the gain factor circuit 896. Control over the state of the switch 900 is provided by an output signal from the state machine 884. Depending upon this state machine 884 output signal, the switch 900 is properly positioned. In the case of unvoiced audio data, the noise generator 892 outputs a sequence of random white noise to the gain factor circuit 896. In contrast, when voiced audio data is being sent, the impulse generator 892 outputs a train of impulses at the corresponding pitch period represented by the magnitude associated with the pitch period signal outputted by the receiver of compressed data audio 880. Regardless of whether it is unvoiced or voiced audio data, the gain factor circuit 896 causes the amplitude of the inputted signal to change to the amplitude determined by the inputted gain factor. The output of the gain factor circuit 896 is inputted to a time-varying digital filter 904, which also receives the signals representative of the predictor coefficients A(i) for the N samples of digitized audio data. The values of the predictor coefficients, together with the gain factor amplitude adjusted noise (unvoiced) or train (voiced), controls the outputting of the decompressed audio data. That is, the filter 904 accurately restores the correlated audio data that had been removed or compressed by the coder 800. FIG. 12 schematically illustrates in greater detail a known time-varying digital filter 904 that includes two channels, each of which receives the current output from the gain factor circuit 896. As represented in FIG. 12, the inputs to the successive stages of one of the channels is delayed over that in the other of the two channels. And, for each of the two channels, the predictor coefficients A(i) act as multipliers for the signal inputted to the particular stage. The outputs from each of the stages, $Y_r(N)$ and $U_r(N)$ are represented by the following equations:

$$y_r(N)=Y_{r-1}(N)+A_rU_{r-1}+(N-1) \qquad [13]$$

$$U_r(N)=U_{r-1}(N)+A_rY_{r-1}(N-1) \qquad [14]$$

where:

$$Y_1(N)=X_{r-1}(N)+A_1X(N-1) \qquad [15]$$

$$U_1(N)=A_1X(N)+X(N-1) \quad [16]$$

and where:

X(N)=output from the gain factor circuit

A_r=rth predictor coefficient

r=1 to p

The decompressed digital audio data outputted by the digital filter **904** is then applied to the circuit elements previously described in connection with the embodiment of FIG. 2. That is, the digital-to-analog converter **744** converts the digital audio data to an analog audio signal, which is amplified by the amplifier **748**. The output of the amplifier **748** is applied to the audio speaker **752**, which reproduces the unvoiced or voiced audio data transmitted by the transmitting station.

In one embodiment that utilizes the LPC decoder system, the audio data is digitized at eight thousand samples/second. The N consecutive samples of the data that are processed are 207 samples. The number of "p" predictor coefficients is 8 . From each of the 207 samples of audio data, 6 bits are generated representing the pitch period; 16 bits are generated representing the value of the 4 gain factor values (each gain factor value is represented by 4 bits); 40 bits are generated representing the p=8 five-bit predictor coefficients. A total of 62 bits are transmitted using pulse code modulation by the transmitting station to the receiving station, instead of 1656 bits (207×8 bits/sample) of digitized audio. The use of the LPC system results in the compression of audio data by a factor of about 26.7 (1656/62). As a consequence, audio data, instead of requiring a transmission capacity of 64,000 bits/second (8000 samples/second×8 bits/sample) , only requires approximately 2400 bits/second (64,000/26.7) of compressed audio data.

The foregoing discussion of the invention has been presented for purposes of illustration and description. Further, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, within the skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain the best modes presently known of practicing the invention and to enable others skilled in the art to utilize the invention in such, or other embodiments, and with the various modifications required by their particular applications or uses of the invention. It is intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.

What is claimed is:

1. A method for transmitting and receiving video and audio signals over an ordinary telephone line in substantially real time, comprising: generating at a transmitting station a video signal having video information;

- generating at said transmitting station an audio signal having audio information; producing a signal wherein said signal includes a mixture of compressed video information and compressed audio information, with said video and audio information being provided to form said signal in a manner that permits accurate restoration thereof at a receiving station and proper synchronization of said video information and said audio information; modulating said signal;
- transmitting said signal after said modulating step using an ordinary telephone line having a limited bandwidth in the range of 300-3,400 Hz;
- receiving said signal at a receiving station after having been sent over the ordinary telephone line;
- demodulating said signal after said receiving step; and
- reproducing said video information and said audio information at the receiving station using said signal.

2. A method, as claimed in claim **1**, wherein: said step of generating a video signal includes providing first means having a number of pixels with said number of pixels together comprising a frame and wherein said video signal is generated using a number of frames with an updating of frames being provided at a rate less than 30 frames per second.

3. A method, as claimed in claim **2**, wherein: said video signal is generated using a number of frames with an updating of frames being provided at a rate of about 7.5 frames per second.

4. A method, as claimed in claim **1**, wherein: said compressed video information and compressed audio information are provided using at least a first state machine means and ASIC means.

5. A method, as claimed in claim **1**, wherein: said step of producing includes compressing said video information and separately compressing said audio information.

6. A method, as claimed in claim **1**, wherein: said step of producing includes using a linear predictive coding apparatus to provide compressed audio information.

7. A method, as claimed in claim **6**, wherein: said step of producing includes using correlation function generator means for determining at least one of: predictor coefficients, pitch period and gain associated with said audio information.

8. A method, as claimed in claim **7**, wherein: said step of producing includes determining a pitch period associated with a predetermined number of samples of said audio information.

9. A method, as claimed in claim **7**, wherein: said step of producing includes determining whether said audio information is voiced or unvoiced.

10. A method, as claimed in claim **7**, wherein: said step of producing includes determining said gain factor using at least some of said audio information and said pitch period.

11. A method, as claimed in claim **7**, wherein: said step of producing includes determining said predictor coefficients using recursively solved equations and correlation function generator means.

12. A method, as claimed in claim **7**, wherein: said step of producing includes comparing sampled audio information with a threshold value to generate a sequence of values for use in determining said pitch period.

13. A method, as claimed in claim **7**, wherein: said step of producing includes correlating samples of said audio information to provide an output used in determining whether said audio information is voiced or unvoiced.

14. A method, as claimed in claim **1**, wherein: said step of producing includes controlling the sending of said compressed audio information and said compressed video information using state machine means.

15. A method, as claimed in claim **1**, wherein: said step of transmitting includes using substantially the same bandwidth to send both said video information and said audio information.

16. A method, as claimed in claim **1**, wherein: said step of transmitting includes asynchronously sending said modulated composite signal.

17. A method, as claimed in claim **1**, wherein: said step of reproducing includes inputting at said receiver station at least one of the following: predictor coefficients, pitch period and gain factor.

18. A method, as claimed in claim **17**, wherein: said step of reproducing includes controlling at least one of an impulse generator means and a random noise generator means, depending upon whether said audio information is voiced or unvoiced.

19. A method, as claimed in claim **18**, wherein: said step of reproducing includes using at least one of the value of said pitch period and state machine means to control transmission from said impulse generator means and said random noise generator means.

20. A method, as claimed in claim **18**, wherein: said step of reproducing includes outputting a train of impulses from said impulse generator means having a pitch period corresponding to said determined pitch period.

21. A method, as claimed in claim **18**, wherein: said step or reproducing includes outputting an a periodic signal from said random noise generator means when said audio information is unvoiced.

22. A method, as claimed in claim **18**, wherein: said step of reproducing includes inputting an output from one of said impulse generator means and said random noise generator means to gain factor circuit means for controlling the gain associated with an inputted signal.

23. A method, as claimed in claim **22**, wherein: said step of reproducing includes inputting said gain factor to said gain factor circuit means.

24. A method, as claimed in claim **17**, wherein: said step of reproducing includes inputting said predictor coefficients to time-varying digital filter means and using said predictor coefficients to restore said compressed audio information.

25. An apparatus for substantially simultaneously transmitting and receiving video and audio signals over an ordinary voice grade telephone line, comprising:

first means for generating video information;

second means for generating audio information;

third means for producing compressed video information and compressed audio information for transmission, in substantially real time, over an ordinary voice grade telephone line having a bandwidth in the range of 300–3,400 Hz, and said compressed video information and said compressed audio information being transmitted using the same bandwidth, one of said compressed video information and said compressed audio information being used as real numbers and the other one of said compressed video information and said compressed audio information being used as imaginary numbers, said third means including means for determining a difference between previously transmitted video information and current video information;

fourth means for reproducing video information and audio information from said compressed video information and said compressed audio information after transmission thereof;

fifth means for displaying images using said video information; and

sixth means for generating sounds using said audio information.

26. An apparatus, as claimed in claim **25**, wherein: said third means includes means for providing a composite signal having said video information and said audio information mixed together in a manner that permits accurate restoration thereof and proper synchronization between said video information and said audio information at a receiving station.

27. An apparatus, as claimed in claim **26**, wherein: said third means includes modulator means in which said composite signal is used to modulate a first carrier wave.

28. An apparatus, as claimed in claim **27**, wherein:

said modulated carrier wave is asynchronously transmitted over the ordinary voice grade telephone line.

29. An apparatus, as claimed in claim **25**, wherein:

said third means includes means for providing a single data stream of said compressed video information and said compressed audio information wherein both said compressed video information and said compressed audio information are adapted to be transmitted using the same bandwidth over the ordinary voice grade telephone line.

30. An apparatus, as claimed in claim **25**, wherein:

said third means includes means for correlating samples of said audio information.

31. An apparatus, as claimed in claim **30**, wherein:

said third means includes predictor coefficient calculator means for receiving outputs from said means for correlating and for determining predictor coefficients associated with said audio information using recursively solved equations.

32. An apparatus, as claimed in claim **25**, wherein:

said third means includes pitch period detecting means for determining a value of pitch period associated with a predetermined number of samples of said audio information.

33. An apparatus, as claimed in claim **32**, wherein:

said third means includes means for determining whether said audio information is voiced or unvoiced.

34. An apparatus, as claimed in claim **32**, wherein:

said third means includes gain factor determinator means for determining a gain factor associated with said audio information.

35. An apparatus, as claimed in claim **25**, wherein:

said third means includes a linear predictive coding apparatus that includes a linear predictive coding coder and a linear predictive coding decoder.

36. An apparatus, as claimed in claim **35**, wherein:

said linear predictive coding decoder includes impulse generator means for receiving a value of pitch period associated with audio information for outputting an impulse train having a pitch period corresponding to said pitch period value.

37. An apparatus, as claimed in claim **35**, wherein:

said linear predictive coding decoder includes random noise generator means for outputting a substantially a periodic signal when unvoiced audio information is being receiving by said decoder.

38. An apparatus, as claimed in claim **35**, wherein:

said linear predictive coding decoder includes gain factor circuit means for receiving a magnitude of gain factor and outputting a digital signal having a waveform dependent upon whether audio information is voiced or unvoiced and an amplitude depending upon the magnitude of said gain factor.

39. An apparatus, as claimed in claim **35**, wherein:

said linear predictive coding decoder includes time-varying filter digital means for receiving predictor coefficients and for outputting synthesized audio information that substantially represents said audio information generated by said second means.

* * * * *

US005515176A

United States Patent [19]

Galen et al.

[11] **Patent Number: 5,515,176**

[45] **Date of Patent: May 7, 1996**

[54] **INTERACTIVE FAX IMAGING**

[75] Inventors: **Peter M. Galen; David L. Burton; William E. Saltzstein; Lawrence Hileman**, all of McMinnville, Oreg.

[73] Assignee: **Hewlett-Packard Company**, Palo Alto, Calif.

[21] Appl. No.: **352,300**

[22] Filed: **Dec. 8, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 949,415, Sep. 21, 1992.

[51] **Int. Cl.⁶** **H04N 1/00**; H04N 1/387

[52] **U.S. Cl.** **358/403**; 358/450; 358/452; 128/904; 395/100; 395/114; 395/148

[58] **Field of Search** 358/400, 403, 358/406, 442, 444, 450, 452, 453, 443, 448; 128/696, 904; 395/100, 114, 117, 118, 135, 140, 147, 148, 149; 364/413.01, 413.02, 413.05, 413.06; 345/201

[56] **References Cited**

U.S. PATENT DOCUMENTS

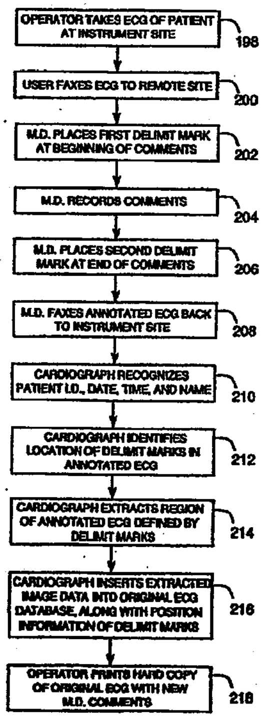
4,802,008	1/1989	Walling	358/406
4,827,330	5/1989	Walsh et al.	358/452
4,833,625	5/1989	Fisher et al.	345/201
5,111,306	5/1992	Kanno et al.	358/403
5,222,157	6/1993	Yoneda et al.	358/403
5,226,431	7/1993	Bible et al.	128/696

Primary Examiner—Scott A. Rogers
Assistant Examiner—Thomas D. Lee

[57] **ABSTRACT**

A remote interactive fax imaging system is disclosed. Stored data, including graphic data, is converted to fax format and transmitted to a remote site. The transmitted image includes machine-readable identification data for identifying the underlying database, and a blank dedicated comment field. At the remote site, a user reviews the faxed image and enters annotations within the dedicated field. The annotated image is faxed back to the originating site. At the originating site, the identifying data is read to associate the annotated image with the original underlying database. The dedicated field area of the return image is added into the data base, thereby forming a complete, annotated record without degrading the original data. The disclosed apparatus and methodology are especially useful, for example, for timely over-reading of electrocardiograph data by a physician at a location remote from the patient.

20 Claims, 6 Drawing Sheets



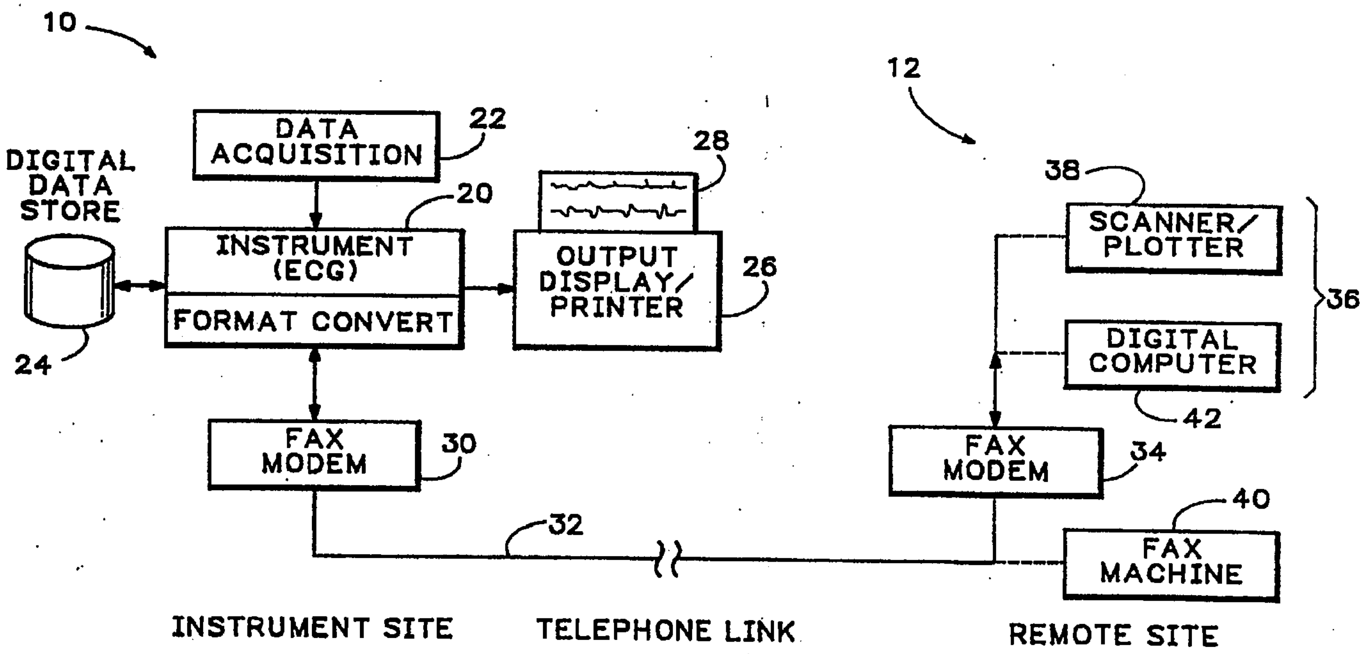
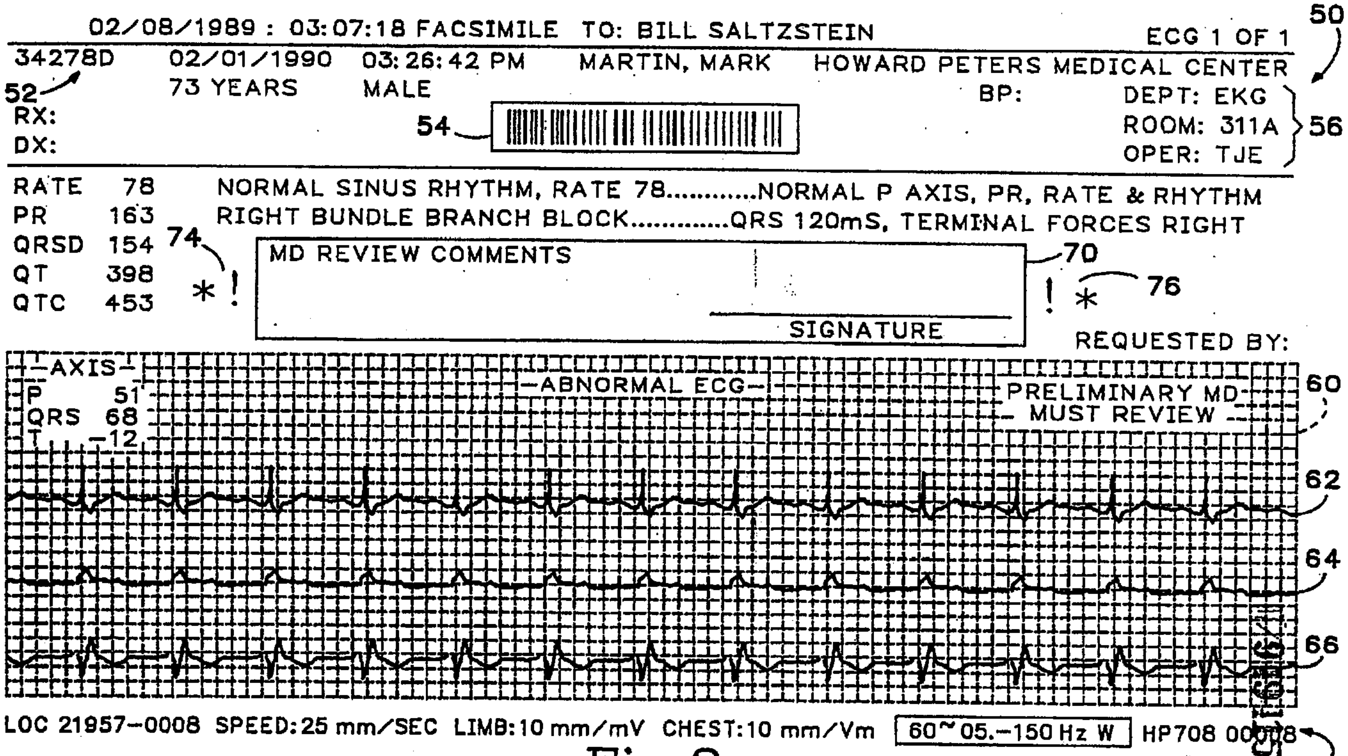

10
12
DIGITAL DATA STORE
24
DATA ACQUISITION
22
INSTRUMENT (ECG)
FORMAT CONVERT
20
28
OUTPUT DISPLAY/ PRINTER
26
FAX MODEM
30
32
38
SCANNER/ PLOTTER
DIGITAL COMPUTER
42
36
FAX MODEM
34
40
FAX MACHINE
INSTRUMENT SITE
TELEPHONE LINK
REMOTE SITE

Fig. 1



02/08/1989 : 03:07:18 FACSIMILE TO: BILL SALTZSTEIN ECG 1 OF 1

34278D 02/01/1990 03:26:42 PM MARTIN, MARK HOWARD PETERS MEDICAL CENTER

73 YEARS MALE BP: DEPT: EKG

RX: ROOM: 311A

DX: OPER: TJE

RATE 78 NORMAL SINUS RHYTHM, RATE 78............NORMAL P AXIS, PR, RATE & RHYTHM

PR 163 RIGHT BUNDLE BRANCH BLOCK.............QRS 120mS, TERMINAL FORCES RIGHT

QRSD 154

QT 398

QTC 453

MD REVIEW COMMENTS

SIGNATURE

REQUESTED BY:

AXIS

P 51

QRS 68

T -12

ABNORMAL ECG

PRELIMINARY MD MUST REVIEW

LOC 21957-0008 SPEED:25 mm/SEC LIMB:10 mm/mV CHEST:10 mm/Vm 60~05.-150 Hz W HP708 00008

Fig. 2

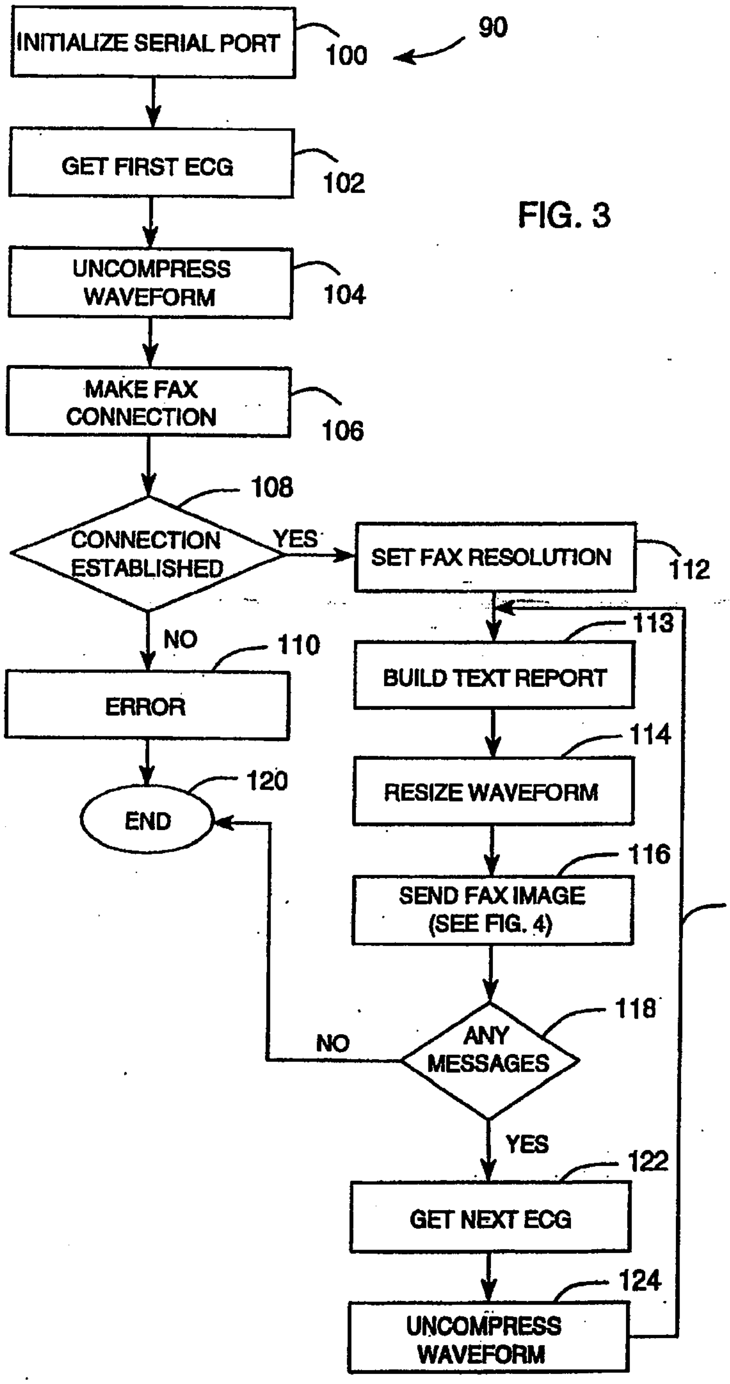

INITIALIZE SERIAL PORT
100
90
GET FIRST ECG
102
UNCOMPRESS WAVEFORM
104
MAKE FAX CONNECTION
106
108
CONNECTION ESTABLISHED
YES
SET FAX RESOLUTION
112
NO
110
ERROR
120
END
113
BUILD TEXT REPORT
114
RESIZE WAVEFORM
116
SEND FAX IMAGE (SEE FIG. 4)
126
118
NO
ANY MESSAGES
YES
122
GET NEXT ECG
124
UNCOMPRESS WAVEFORM

FIG. 3

FIG. 4

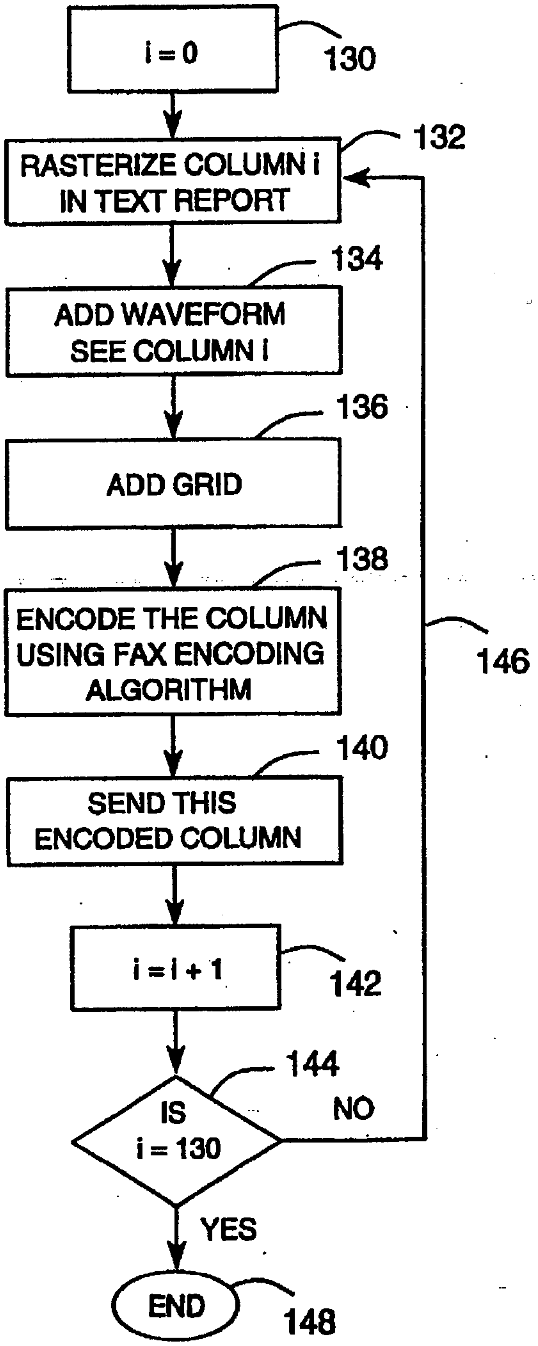

i = 0
130
RASTERIZE COLUMN i IN TEXT REPORT
132
ADD WAVEFORM SEE COLUMN i
134
ADD GRID
136
ENCODE THE COLUMN USING FAX ENCODING ALGORITHM
138
SEND THIS ENCODED COLUMN
140
i = i + 1
142
IS i = 130
144
NO
146
YES
END
148

FIG. 5

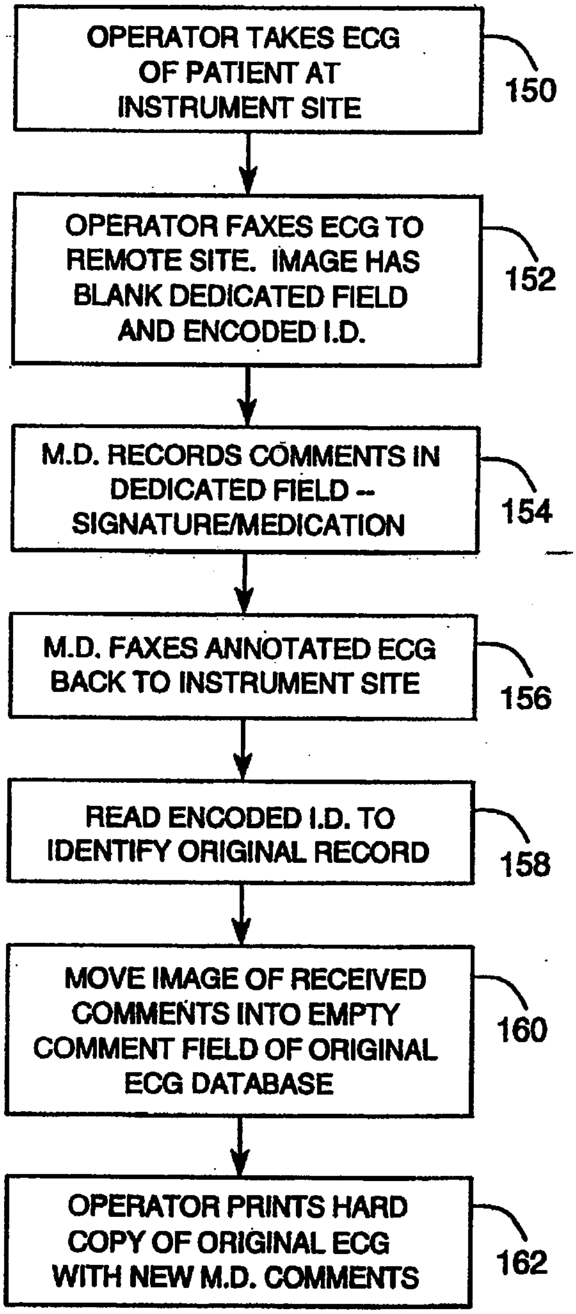
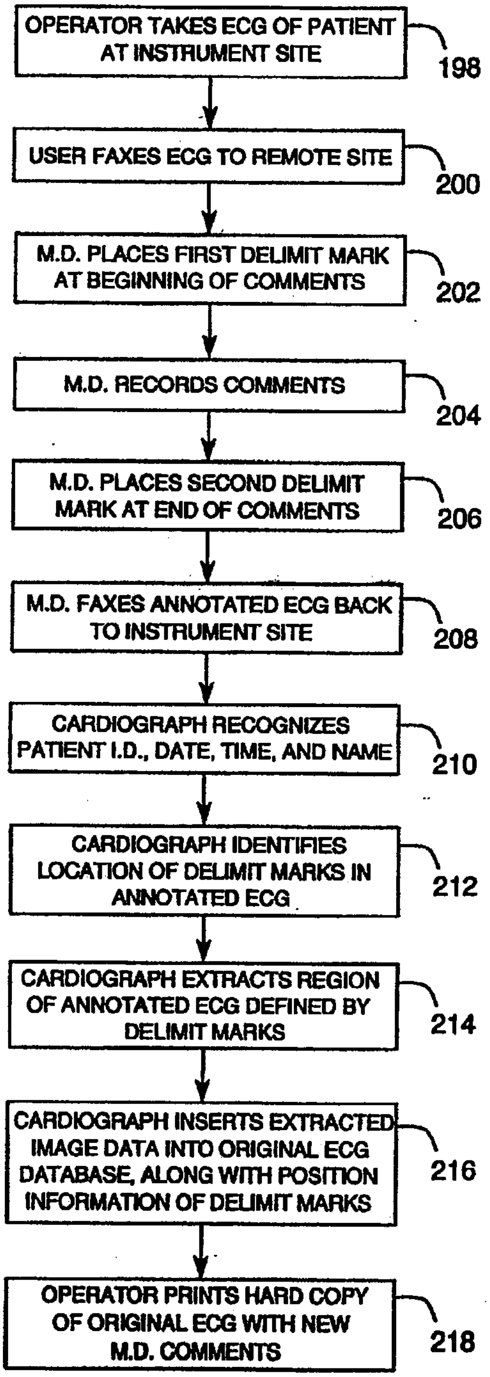

OPERATOR TAKES ECG OF PATIENT AT INSTRUMENT SITE
150
OPERATOR FAXES ECG TO REMOTE SITE. IMAGE HAS BLANK DEDICATED FIELD AND ENCODED I.D.
152
M.D. RECORDS COMMENTS IN DEDICATED FIELD -- SIGNATURE/MEDICATION
154
M.D. FAXES ANNOTATED ECG BACK TO INSTRUMENT SITE
156
READ ENCODED I.D. TO IDENTIFY ORIGINAL RECORD
158
MOVE IMAGE OF RECEIVED COMMENTS INTO EMPTY COMMENT FIELD OF ORIGINAL ECG DATABASE
160
OPERATOR PRINTS HARD COPY OF ORIGINAL ECG WITH NEW M.D. COMMENTS
162

FIG. 6


OPERATOR TAKES ECG OF PATIENT AT INSTRUMENT SITE
198
USER FAXES ECG TO REMOTE SITE
200
M.D. PLACES FIRST DELIMIT MARK AT BEGINNING OF COMMENTS
202
M.D. RECORDS COMMENTS
204
M.D. PLACES SECOND DELIMIT MARK AT END OF COMMENTS
206
M.D. FAXES ANNOTATED ECG BACK TO INSTRUMENT SITE
208
CARDIOGRAPH RECOGNIZES PATIENT I.D., DATE, TIME, AND NAME
210
CARDIOGRAPH IDENTIFIES LOCATION OF DELIMIT MARKS IN ANNOTATED ECG
212
CARDIOGRAPH EXTRACTS REGION OF ANNOTATED ECG DEFINED BY DELIMIT MARKS
214
CARDIOGRAPH INSERTS EXTRACTED IMAGE DATA INTO ORIGINAL ECG DATABASE, ALONG WITH POSITION INFORMATION OF DELIMIT MARKS
216
OPERATOR PRINTS HARD COPY OF ORIGINAL ECG WITH NEW M.D. COMMENTS
218

INTERACTIVE FAX IMAGING

This is a continuation, of application Ser. No. 07/949,415, filed 21 Sept. 1992.

FIELD OF THE INVENTION

This invention relates to digital communication of image data, preferably by facsimile ("fax") and, more specifically, relates to a remote interactive medical imaging system and method to allow review of medical image data, such as an electrocardiograph, at a site remote from the patient. Comments and annotations made by a reviewing physician at the remote site, such as diagnoses, treatment recommendations and medication prescriptions, are transmitted from the remote site by return fax, and the annotations are added back into the original electrocardiograph database without compromising the original image data.

Fax transmission of image data is now commonplace. One application of fax is transmission of medical waveform data for accessing off-site diagnostic expertise in a timely manner. For instance, emergency rooms or private physicians may require quick, expert electrocardiograph (ECG) diagnoses.

In the prior art, ECGs have been faxed to remote sites using conventional fax machines, which optically scan a hard copy print of the subject ECG. The optical scanning process results in reduced ECG quality at the receiving end, making accurate physician review difficult.

Better quality transmissions can be obtained by transmitting digital data representing the ECG image directly from the cardiograph (or from a digital storage device such as a floppy disk), thereby eliminating the intermediate optical scanning step. This direct transmission produces a faxed ECG copy of nearly original quality, i.e. of the same quality as a hard copy ECG printed locally. Direct digital ECG may be accomplished by configuring a digital cardiograph with suitable hardware and software, described in greater detail below, and coupling the system to a fax modem, or any CCITT Group 3 fax machine or the like. A commercial electrocardiograph system having direct digital fax capability is the Hewlett-Packard Model M1700A PageWriter XLi Cardiograph, equipped with the optional HP Model M1756A Direct Digital ECG Fax.

Once the facsimile medical data, for example an ECG copy, is received at a remote location, it would be desirable to obtain an appropriate record of the physician's review or "over reading" of that ECG copy. Good practices from both medical and legal viewpoints suggest that the reviewing physician's diagnosis be made in writing. It is particularly important, and often a legal requirement, that the physician's prescription for medications be in writing and signed by the physician. Moreover, it is critically important the physician's diagnosis or other comments, prescription of medications, signature and the like be accurately associated with the original ECG copy and thereby associated with the right patient.

A reviewing physician (at a remote site) may make notes and comments on an ECG hard copy itself, and then fax the annotated copy back to the originating site. This approach has several drawbacks. First, the ECG itself, having been faxed to the remote site and then return faxed, is degraded to where it is difficult, if not impossible, to interpret. Second, while the return annotated fax may be associated manually with the original record, this introduces a risk of error. Third, modifications or amendments to the original ECG database to reflect the reviewing physician's comments likewise must be entered manually. This leads to a further risk of error arising from visual interpretation of a facsimile of the reviewing physician's handwritten notes.

In view of the foregoing background, the need remains for communicating image data, such as an ECG, to a remote site for review, and receiving an annotated copy of the ECG by return fax, without degrading the image quality.

A need also remains for reliably associating such a return fax with the original record, to avoid treating a patient according to instructions intended for another patient, the results of which could be disastrous.

A need further remains for an accurate way to incorporate the offsite reviewing physician's diagnosis, treatment notes, prescriptions and the like into the original ECG database, so that the record is then complete, permanent and accurate.

SUMMARY OF THE INVENTION

The present invention includes a method of interactive imaging between an instrument site and a remote site. The process includes first recording an ECG of a patient at the instrument site. The recorded ECG data is stored in a digital database, the database also including unique identification data for identifying the database. This may include patient demographic data, and the date of time of recording, for example. The next step is converting the ECG data so as to form a fax image. Alphanumeric data, such as the identification data, is converted to bit map image form for inclusion in the fax image. The completed image is faxed to the remote site for review, such as over reading by a physician.

At the remote site, the image is annotated for example by inserting a comment indicating diagnosis or recommended treatment. Then the annotated ECG image is faxed back to the instrument site. At the instrument site, the method next calls for recovering the identification data from the annotated image to identify the database; and updating the identified database by moving a portion of the annotated image containing the comment into the identified database.

Another aspect of the invention calls for encoding the identification data into a machine-readable form, such as bar-code form. This has the advantage of facilitating recovery of the identification data after faxing from and back to the instrument site.

A further aspect of the invention calls for providing a blank dedicated area at a predetermined location within the fax format image for comments. Thus, annotating the fax image includes inserting a comment within the dedicated area. After the annotated image is received back at the instrument site, the system copies from the annotated image a region corresponding to the dedicated area and adds it to the database, thereby extracting the comment from the annotated image. In this way, the reviewing physician's comments are added to the database without overwriting or otherwise corrupting the original data.

The foregoing and other objects, features and advantages of the invention will become more readily apparent from the following detailed description of a preferred embodiment which proceeds with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an interactive fax imaging system according to the invention.

FIG. 2 is an illustration of a graphical image, here an ECG report, which is a product of the system of FIG. 1.

FIG. 3 is a flowchart of a fax transmission process for sending an ECG report.

FIG. 4 is a flowchart showing detail of the "send fax image" step 116 of the flowchart of FIG. 4.

FIG. 5 is a flowchart of an interactive fax imaging method for creating and modifying a database, such as an ECG database, so as to include dedicated field annotations made at a remote site.

FIG. 6 is flowchart of an interactive fax imaging method for creating and modifying a database, such as an ECG database, so as to include annotations entered within a region defined by delimiter characters on the corresponding ECG report.

Appendix A is an example of a computer program for rasterizing digital data.

Appendix B is a listing of a computer program for fax encoding rasterized digital data.

Appendix C is a listing of a computer program for converting the resolution of digital data to fax to a standard CCITT Group 3 fax resolution or format.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

1. Overview and Hardware Description

FIG. 1 is a block diagram of an interactive fax imaging system according to the present invention. The figure depicts a first set of equipment 10 located at an instrument site and a second set of equipment 12 to be located at a remote site. "Instrument site" means a site where data is acquired and/or stored. In the latter case, no original data acquisition apparatus need be present. In the embodiment illustrated, data acquisition apparatus is provided. Thus, an instrument 20 is located at the instrument site for acquiring data. Acquired data may be analog and/or digital, but in any event includes data which is usefully represented in graphic form for visual inspection, such as a voltage waveform. For example, instrument 20 may be an electrocardiograph (ECG) or electronic test equipment such as an oscilloscope. Suitable data acquisition apparatus 22 is coupled to instrument 20 to provide input data. In the case of an ECG instrument, the data acquisition apparatus 22 may include patient leads. In the case of electronic instrumentation, data acquisition apparatus 22 may include suitable input probes, A-to-D converters or a port coupled to a bus, such as an IEEE 488 interface bus, for interconnecting test equipment.

Instrument 20 is coupled to suitable output device 26 such as a video display terminal and/or a printer. Reference number 28 indicates a hard copy report produced by the printer. A digital data storage device such as a hard disk drive 24 is coupled to instrument 20 for storing acquired data. Floppy or optical disk, magnetic tape or other storage media may be used as well. Acquired data from a particular test or procedure, for example an ECG, is stored in a corresponding database.

Instrument 20 includes means (labeled "Format Convert") for converting stored data from a predetermined digital data storage format, called the internal format, into a standard fax format such as the CCITT Group 3 fax format. Format conversion preferably is carried out in software. The Appendices provide an example of computer programs to provide this function. This step may be omitted where digital communication other than fax is used. A fax modem 30 or the like is connected to instrument 20 for transmitting and receiving images in the fax format. The fax modem 30 is coupled over a telephone link 32 to provide communication with a selected remote site. Any number of remote sites may used. One (or more) remote sites is accessed by controlling the fax modem to dial the corresponding telephone number(s), as is known.

Apparatus 12 are located at a remote site and include a second fax modem 34 connected to the telephone link for fax communication with the instrument site. Although a conventional telephone link is suggested by the drawing, wireless telephone communication such as cellular technologies may be used. In fact, any means for image data communication is applicable. Fax communication is the presently preferred embodiment because of the widespread availability of fax equipment.

The remote site fax modem 34 is connected to suitable apparatus 36 for converting a received fax image to visual form for display to a user, and for faxing an image back to the instrument site. Or, a conventional fax machine 40 may be provided (which typically includes an internal fax modem). Fax modem 34 may be coupled to a scanner and plotter 38. The plotter could be used to provide a hard copy printout corresponding to a received fax image, and conversely, the scanner used to input a hard copy image for faxing to the instrument site.

Another alternative is a digital computer 42 coupled to fax modem 34 and having suitable software to allow both display and editing of graphical images, and faxing of such images via the fax modem 34. The fax modem may be internal to the digital computer. Other variations are possible, the essential functions being that the remote site is equipped (a) to receive a fax image (or "report") and display the corresponding report to a user; (b) modify or annotate the received report (which may be done manually), as explained further below and; (c) transmit the annotated report in fax format back to the instrument site.

2. Data Types and ECG Reports

At the instrument site, acquired data is stored in digital form in a database in instrument 20 (or data store 24). Various internal formats may be used for this purpose, depending on the particular application and the available hardware. To illustrate, acquired data may include one or more analog waveforms representing voltage measurements. Digital data representing each waveform may be formatted as a series of bytes in the database, each byte having a value corresponding to an instantaneous amplitude of the waveform, there being some predetermined time period per byte, or sample rate, so that the waveform can be reconstructed from the stored digital data. The particulars of analog-to-digital and digital-to-analog conversion are known, as well as various means for storing and compressing digital data, so these need not be discussed further. Another type of data is text, which may be stored by conventional means, such as ASCII encoding.

In the ECG example (below), text fields may include patient name, age, sex, blood pressure, etc. which we call demographics. A third type of data may be a grid for superimposing on waveform data. All three of these types of data are used in the preferred embodiment, as further described below, though the invention and its utility are not limited to any particular types of data or database formats.

FIG. 2 is an illustration of an electrocardiograph (ECG) report produced by the instrument site apparatus **10** of FIG. **1**. The term "report" as used herein means a visual representation of the contents of an underlying database. A report may appear in a screen display or a "hard copy". The illustrated ECG report **50** contains several items or fields of information. For example, it includes identification fields **52** that identify the patient by name, date of birth, patient number, etc. Additional identification fields specify the particular ECG procedure by the date and time at which it was recorded. Each such item of information is stored in a corresponding field in the underlying database. For alphanumeric identification information, the data may conveniently be stored in ASCII format.

Selected identification data is encoded into a form that is reliably machine-readable, such as a bar code field **54**. The bar code field **54** must contain sufficient information to uniquely identify the particular database underlying this ECG record. This is because the database will later be automatically updated based on information received by fax from a remote site. Since a bar code is graphical, it may be stored in the database, for example, in a bit-mapped format field. Alternatively, to save storage space, the bar code may be generated at fax transmission (or print) time. The bar code need not be stored in the database since it is redundant of other fields. Other machine-readable coding schemes may be used. The coding must provide for accurate identification of the ECG record even after it is faxed to the remote site and return-faxed to the instrument site.

The ECG **50** may also include additional fields **56** identifying the instrument by location and identifying the operator. Various other items of information shown on the ECG, such as the patient's heart rate, rhythm information and other ECG data will be useful to the reviewing physician at the remote site. Each of these items is stored in a corresponding field in the database as well. All of the alphanumeric or text portions of the report, taken together, are referred to hereinafter as the "text report".

ECG **50** further includes one or more voltage waveforms, for example waveforms **62**, **64**, **66** as is conventional for electrocardiographic data. A rectangular grid **60** is superimposed with the waveforms. Additional alphanumeric fields may be stored in the database and displayed in the ECG report, such as cardiograph settings for speed and lead sensitivity, etc. as indicated generally below grid **60** at reference numeral **68**.

3. Comment Fields

A dedicated field **70** is provided for a user at the remote site, for example a reviewing physician, to write comments based on her review of the ECG. Dedicated field **70** is a predefined area on the ECG report reserved for this purpose. It is left blank in the original ECG transmitted to the remote site. The reviewing physician's comments may include, for example, diagnosis, recommended treatment and/or prescribed medication. The size and shape of the dedicated field are not critical. A larger field allows for more comprehensive comments by the reviewing physician, but this advantage must be traded off against the corresponding loss in area available for display of waveforms and other patient data.

The comment field need not be fixed in size or positioned on the report in advance. It may be defined by the reviewer at the remote site. For example, a comment field may be defined by one or more delimit characters. For this purpose, the delimit character(s) must be predefined. For example, a predefined delimit character may be use to indicate one corner of a comment field. The dimensions of the field may be predefined, and the field will be assumed to be a rectangle extending from the corner indicated by the delimiter.

Alternatively, a first delimit mark may be used to indicated the beginning of the comment area, and a second delimit mark used to indicate the end of the comment area. To illustrate, referring to FIG. **2**, the comment field **70** is defined by a first delimit mark to the left of the field (asterisk followed by exclamation point) **74**, and a second delimit mark **76** to the right of the field, as shown (exclamation point followed by asterisk). In that case, the system assumes a predefined width of the comment field, for example one-half to one inch. Other methods of defining an area using one or more delimiters may be used. The selected delimiter(s) should be easily recognized by software, even if handwritten. Or, the delimiter may be applied using a preprinted adhesive label or a rubber stamp. In practice, a report probably would not include a dedicated field **70** and delimiters **74**,**76** defining the same field, as shown in the drawing. Both are shown in the same report here for illustration. However, a reviewer could add a delimited field if necessary, for example where the dedicated field is too small.

The reviewing physician's comments may be handwritten on a hard copy or otherwise inserted within the dedicated field **70**. Where the selected remote site equipment **12** includes a computer **42** for reviewing and editing the fax image on screen (see FIG. **1**), the reviewing physician may type remarks on the computer keyboard so as to insert them within the dedicated field **70**. Application software for editing a graphic image on a computer is known. Under some circumstances, however, it is preferable that the physician's remarks be handwritten and signed by the physician. This may be essential for creating a legal record of the physician's diagnosis and recommended treatment.

In the event that the reviewing physician defines a comment field that overlaps other data, several options may be implemented. For example: (1) ignore the comments outside a predefined maximum area; (2) overwrite other data to so as to display all of the physician's comments; (3) overwrite other data except within predefined "protected zones" which must be displayed in their original form. Other variations may be implemented, preferably in software. The system may be configurable so as to allow the user or operator to select among these or other options. Another extension is to provide permission protection of the underlying database. For example, the entire record may be "read only" except for a dedicated field. Or, selected remote sites (or physicians) could have write permission to alter other parts of the record. A physician then could elect to overwrite a non-essential part of the record with comments.

4. Fax Transmission Process

FIG. **3** is a flow diagram illustrating a fax transmission process according to the invention, for producing a report of the type illustrated by FIG. **2**. The method of FIG. **3** preferably is implemented in software which is arranged to control a microprocessor and associated circuitry or other apparatus such as a digital computer for executing a series of instructions. The first step **100** is to initialize a serial port, which is a hardware connection for coupling the instrument to the fax modem. The next step **102** is to read a first ECG or other digitally stored database. The database may be stored in RAM, on a hard disk, floppy disk or other digital storage medium. The digital data is uncompressed **104** if necessary. The particulars of this step will depend upon what compression algorithm, if any, is employed.

Next the fax modem is activated, step **106**, to establish a fax connection with a desired remote site via an appropriate telephone link. A test 108 determines whether or not a fax connection has been established. If not, an error routine 110 may make another attempt to establish a fax connection, try an alternate telephone number or notify the user of the problem. If no connection is established, the process ends 120.

If and when a fax connection is established, the fax resolution is set in step 112. The fax resolution is selected by a dialogue between the fax equipment at the two sites according to predetermined protocols such as the CCITT Group 3 standard. After the fax resolution has been determined, the next step is to build a text report 113. This step converts textual (alphanumeric) data, such as patient identification, etc., into suitable bit map image form, at the set resolution, using character generator techniques. The text report is formed so as to include a blank comment field reserved for comments (the dedicated field). The text report also includes identifying data in machine-readable form, such as a bar code strip, as noted above.

The next step 114 is to resize the waveform(s) so as to fully utilize the available fax resolution (determined in step 112 above). This step refers to the waveforms such as 62, 64 in FIG. 2. Next the fax image is transmitted 116 to the remote site. Details of sending the fax image are described below with regard to FIG. 4. Following transmission, a test 118 is executed to determine whether there are any messages from the fax modem. Such messages may indicate, for example, that part of the transmission was unsuccessful and should be resent. If there are no messages, the process is completed and ends at 120.

Step 122 is to load the next ECG from memory for processing. The ECG waveform is uncompressed 124 and then the steps of building a text report 112, resizing the waveform 114, and transmitting the fax image 116 are repeated, as indicated by the loop path 126 shown in the flowchart. Additional pages or ECGs thus may follow in the same transmission, without repeating the initial handshaking delay incurred in steps 108, 112.

5. Forming Fax Format Data

FIG. 4 shows detail of the sending fax image (step 116) of the flowchart of FIG. 3. In general, this process involves three planes of bit map image date—(1) text report; (2) waveforms; and (3) grid. All three planes of data are superimposed, one column at a time, to form data for fax transmission.

It is convenient to begin by defining a column counter "i" and initialize it to zero, step 130. The number of columns used or whether the fax page is divided into columns at all depends on the particular implementation and the size of available memory for processing. 130 columns is a convenient arrangement because a commonly used character size for text is 130 columns of text per line. Beginning in the first column, the first step is to write into that column a series of bits, in other words, a bitmap, of the corresponding portion of the text report, step 132. In other words, assuming that the text report comprises character data, rasterization involves converting each character into a dot matrix or bitmap form and writing that information into a suitable memory or buffer. This is done for the entire column which conveniently is 1728 dots or pixels in length, corresponding to the standard fine mode fax column.

The next step 134 is to add the waveform data corresponding to the current column into the buffer. If the waveform data is already stored in bitmap form, this is simply a matter of overlaying the corresponding portion of the waveform bitmap into the buffer. If the waveform data presently is stored in another form, such as a series of sample values, that data must first be transformed into bitmap format.

Next we add a grid, step 136. The entire grid may be stored as in bitmap form. However, since the grid is regular and predetermined, it may be more efficient use of memory space to provide for adding the grid into the buffer via a simple algorithm. Thus the waveform data and the grid are overlaid along with the text report to complete the bitmap image for the current column.

The next step is to encode the current column 138 for fax transmission. This may be done using known fax compression schemes, such as the modified Huffman Code, to reduce transmission time. Some fax encoding schemes operate on a single dot column at a time. In that event, this encoding step would be repeated for each dot of width of the current column. Other fax encoding schemes encode multiple columns at a time.

Then we transmit the fax encoded data, step 140. Ultimately, the current column of data is reduced to a series of single dot wide columns for serial transmission by fax modem, details of which are known.

Next we increment the column counter, 142, and test whether the counter equals the maximum column number, step 144. When that limit is reached, the fax transmission process is complete, and the process ends, 148. If the limit has not been reached, the process loops 146 back to the rasterization step 132, to begin building the next column of image data. Once again the text, waveform and grid data are overlaid to assemble the desired bitmap image.

An example of a computer program routine for rasterizing the digitally stored data to form fax data is shown in Appendix A. An example of a software routine for fax encoding the rasterized data is set forth in Appendix B. An example of software routine for changing resolution, i.e., resizing the waveform to conform to the fax resolution (step 114 in FIG. 3) is shown in Appendix C.

6. Overall Interactive Methodology with Dedicated Comment Field

FIG. 5 illustrates the overall methodology for using interactive fax imaging according to the invention. The process typically begins by an operator taking an ECG of a patient, step 150. However, the method is equally applicable to image data previously acquired and stored, for example in the data store 24 (FIG. 1). Next, the operator faxes the image, such as an ECG, to a selected remote site, step 152. The faxed image includes a blank comment field and encoded identification data, as discussed above and illustrated in FIG. 2.

A user at the receiving remote site, for example a physician ("M.D."), reviews the ECG, and records comments in the comment field, step 154. As noted, this may be done manually on a hard copy of the ECG, or by computer editing of the fax image. The resulting image we generally call an annotated image or, in the example, an annotated ECG. The annotated ECG is faxed back to the instrument (originating) site, step 156. If hard copy was used at the remote site, the annotated ECG may be scanned by a stand-alone scanner, a conventional fax machine, or the like, for return transmission.

Back at the instrument site, the incoming fax is first decoded to recover the annotated image (a bit map image). The instrument (or computer) next reads the encoded identification data, step 158, to identify the corresponding database from which ECG originated.

The next step is moving the reviewing physician's comments from the received fax into a comment field in the identified database, step 160. In other words, an image of the dedicated field 70 portion of the annotated (return) fax is added into the original database. The remainder of the annotated fax image may be discarded as that image has been degraded by the fax-and-return fax process and, in any event, the original data underlying the remainder of the image already exists in the database. Thus, the updated database now contains all of the original stored data, plus an image of the dedicated comment field recorded at the remote site. Finally, the operator may print out a hard copy of the now annotated ECG record, step 162.

It should be noted that the invention is applicable to single-site use as well. Even where the reviewing physician is local, and perhaps reviewed the ECG even as it was recorded, it is useful to have the physician record annotations and comments on the ECG, as described above, and add that image into the underlying database. This forms a complete, annotated record for subsequent storage, display or transmission for consultation, etc.

The new (annotated) ECG record has the same image quality as it did originally, as the image data has not been altered, except in the dedicated field. The dedicated field image is of acceptable quality because it has been faxed at most only once—from the remote site, where the comments originated, to the instrument site.

FIG. 6 illustrates an interactive fax imaging method in which delimiters are used to identify the location of the comment field.

Referring to FIG. 6, the method begins with acquisition of an ECG or data at the instrument site, step 198. A user faxes the ECG image to a remote site, step 200. In this case, the faxed ECG need not contain a predefined comment area. It should contain machine-readable identifying data, as discussed above.

At the remote site, the reviewing physician places a first delimit mark at the beginning of her comments, step 202, records comments, diagnoses, etc. (step 204), and finally, places a second delimit mark at the end of the comments, step 206. Thus annotated, the ECG is faxed back to the originating site, step 208.

At the originating site, the cardiograph or computer reads the identifying data and recognizes patient identification, date, time, etc. in order to uniquely associate this annotated fax with the corresponding data base (step 210). Next, the cardiograph identifies the location of the first and second delimit marks in the annotated ECG, step 212. Having done so, the system extracts a region of the annotated ECG image defined by the delimit marks. For example, assuming that the delimit marks appear more or less in the same horizontal line, the system may extract a strip of predetermined height along that line between the delimit lines (step 214). The next step is inserting the extracted image data into the original ECG database, along with position information of the delimit marks, step 216. Finally, as before, the operator may print a hard copy of the now annotated ECG, step 218.

Having illustrated and described the principles of our invention in a preferred embodiment thereof, it should be readily apparent to those skilled in the art that the invention can be modified in arrangement and detail without departing from such principles. We claim all modifications coming within the spirit and scope of the accompanying claims.

```
/* ::P  ey  ry
/************************************************************************
     $Logfile:   I:/quarry/fax/vcs/qscfxb10.c_v  $

     FILE NAME: QSCFXB10.C          MODULE: FaxBuildSlice

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                 All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   29 Jul 1992 20:51:10  $

     $Revision:   1.3  $

     NOTES:   C Source file
              Created by Lawrence Hileman
------------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb10.c_v  $
**
**     Rev 1.3   29 Jul 1992 20:51:10   Larry_H
** use a pointer, not a defined struct
**
**     Rev 1.2   20 Jun 1992 00:15:06   Larry_H
** function argument change
**
**     Rev 1.1   12 Jun 1992 13:28:28   Larry_H
** add 300 DPI
**
**     Rev 1.0   07 Aug 1991 21:32:00   Larry_H
** Initial revision.

*************************************************************/

#include        "QECLH005.H"    /* config defines */
#include        "qpcfxint.h"    /* Fax prototypes              */
#include        "qecfx010.h"    /* FAX resolutions and report types */

#include        "QTCFXV00.H"    /* slice defined */
#include        "QVCFXV00.H"    /* extern for slice */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

void FaxBuildSlice( col,res,PageNum,ReportType,Speed,Site )
int col,res,PageNum,ReportType,Speed,Site;
{
        check_point= FAX_FAX_BUILD_SLICE;

        if (res == SIZE_FOR_300_RESOLUTION)
                {
                ClearSlice( Slice,COLUMNS_PER_SLICE_300 );
```

```
                CopyOverlap( Slice,COLUMNS_PER_SLICE_300 );
                }
            else
                {
                ClearSlice( Slice,COLUMNS_PER_SLICE );
                CopyOverlap( Slice,COLUMNS_PER_SLICE );
                }

        PutTextIntoSlice( col, res, Slice );

        if (ReportType == CONFIG_PRT_EXT_MM)
                        return;

        if ((PageNum == 1) || ((PageNum == 2) && (Speed == 1)))
                {
                PutWaveFormIntoSlice( PageNum,col,res,Slice,Speed );
                AddGrid( Slice,col,res,Site );
                }
}
```

```
/* ::PL -ey -ry */
/***********************************************************
     $Logfile:   I:/quarry/fax/vcs/qscfxb15.c_v  $

     FILE NAME: QSCFXB15.C          MODULE: CopyOverlap

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                All rights reserved

     ************** HP CONFIDENTIAL **************

     $Date:   12 Jun 1992 13:30:34  $

     $Revision:   1.2  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-----------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb15.c_v  $
**
**     Rev 1.2   12 Jun 1992 13:30:34   Larry_H
** add 300 DPI
**
**     Rev 1.0   07 Aug 1991 21:32:28   Larry_H
** Initial revision.

************************************************************/

#include          "qpcfxint.h"    /* Fax prototypes              */
#include          "qecfx010.h"    /* FAX resolutions and report types */

#include          "QTCFXV00.H"    /* slice defined */

/* check point access */
#include          "QECLSJWL.H"    /* #define check point values */
#include          "qvcls02d.h"    /* extern unsigned short check_point */

void CopyOverlap( Fsl, lastcol )
struct  SLICE   *Fsl;
int lastcol;
{
        check_point= FAX_COPY_COL_17_TO_0;

        Fsl->SliceCol[ 0]=Fsl->SliceCol[lastcol]  ;     /* copy 17 into 1 */
        Fsl->SliceCol[ 1]=Fsl->SliceCol[lastcol+1];     /* copy 17 into 1 */
        Fsl->SliceCol[lastcol]  =Fsl->SliceCol[ 2];     /* copy cleared 2 to 17
        Fsl->SliceCol[lastcol+1]=Fsl->SliceCol[ 2];     /* copy cleared 2 to 17
}
```

```
/* ::PL -ey -ry */
/**************************************************************
     $Logfile:   I:/quarry/fax/vcs/qscfxb20.c_v  $

     FILE NAME: QSCFXB20.C         MODULE: ClearSlice

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   12 Jun 1992 13:33:24  $

     $Revision:   1.2  $

     NOTES:   C Source file
              Created by Lawrence Hileman
--------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb20.c_v  $
**
**    Rev 1.2   12 Jun 1992 13:33:24   Larry_H
** add 300 DPI
**
**    Rev 1.1   29 May 1992 12:20:16   Larry_H
** add slice size
**
**    Rev 1.0   07 Aug 1991 21:32:54   Larry_H
** Initial revision.

*************************************************************/

#include        "qpcfxint.h"    /* Fax prototypes              */
#include        "qecfx010.h"    /* FAX resolutions and report types */

#include        "QTCFXV00.H"    /* slice defined */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */


void ClearSlice( slc,col )
struct SLICE *slc;
int col;
{
        int i,j,k;
        check_point= FAX_CLEAR_SLICE;
        k=LENGTH_OF_LINE_300/4;
        for (i=0;i<k;i++)
                for (j=0;j<col;j++)
                        slc->SliceCol[j].LIntData[i]=0;
}
```

```
/* ::PL -ey -ry */
/************************************************************

      $Logfile:   I:/quarry/fax/vcs/qscfxb30.c_v  $

      FILE NAME: QSCFXB30.C         MODULE: PutTextIntoSlice

      SYSTEM: FAX
      SUBSYSTEM: Build Slice

      (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                 All rights reserved

      *************** HP CONFIDENTIAL ***************

      $Date:   21 Jul 1992 13:03:20  $

      $Revision:   1.8  $

      NOTES:   C Source file
               Created by Lawrence Hileman
-------------------------------------------------------------
      ORIGIN:  Cardiology Business Unit

      REVISIONS:
      $Log:   I:/quarry/fax/vcs/qscfxb30.c_v  $
**
**     Rev 1.8   21 Jul 1992 13:03:20   Larry_H
** remove unneeded include file
**
**     Rev 1.7   12 Jun 1992 15:34:46   Larry_H
** resolution mismatch, ok now
**
**     Rev 1.6   12 Jun 1992 14:08:44   Larry_H
** OOOOPS!!! into instead of in, ratts
**
**     Rev 1.5   12 Jun 1992 13:27:34   Larry_H
** added 300 DPI
**
**     Rev 1.4   29 May 1992 12:20:54   Larry_H
** add slice size
**
**     Rev 1.3   19 Nov 1991 10:49:46   Larry_H
** on 50mm/sec ECGs, do the filter box on the second page
**
**     Rev 1.2   25 Sep 1991 18:41:44   Larry_H
** remove bottom line, it just has garbage in it!!
**
**     Rev 1.1   08 Aug 1991 11:03:52   Larry_H
** fix problem with filter box
**
**     Rev 1.0   07 Aug 1991 21:33:26   Larry_H
** Initial revision.

************************************************************/

#include        "qpcfxint.h"    /* Fax prototypes               */

#include        "QECW9006.H"    /* defines for pr_text_block */
#include        "QVCW9006.H"    /* extern for pr_text_block */
```

```
#include        "QECFX010.H"    /* slice size defined */
#include        "QTCFXV00.H"    /* slice defined */

#include        "qeclh005.h"    /* Config defines              */
#include        "qtclh005.h"    /* Config structure defines    */
#include        "qvclh005.h"    /* Config variable defines     */

#include        "eeclj023.l"    /* Font Defines */
#include        "etclj023.h"    /* Font Structure */
#include        "evclj023.h"    /* Font Extern */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

static void PutTextIntoSlice200( int, struct SLICE * );
static void PutTextIntoSlice300( int, struct SLICE * );

void PutTextIntoSlice( col, res, Slice )
struct SLICE *Slice;
int col,res;
{
        if (res == SIZE_FOR_300_RESOLUTION)
                PutTextIntoSlice300( col, Slice );
            else
                PutTextIntoSlice200( col, Slice );
}

static void OrSliceValue( Slice, Col, Row, Byte )
struct SLICE *Slice;
int Col,Row;
unsigned char Byte;
{
        if ((Col < 0) || (Col >= COLUMNS_PER_SLICE_300))        return;
        if ((Row < 0) || (Row >= LENGTH_OF_LINE_300))           return;

        Slice->SliceCol[ Col ].CharData[ Row ]|=Byte;
}

static void PutTextIntoSlice200( col, Slice )
struct SLICE *Slice;
int col;
{
        unsigned char c,f,n;
        unsigned int i,j,k,row;
        int LLcol,LRcol;

        check_point= FAX_PUT_TEXT_INTO_SLICE;

        LLcol=LRcol=0;
        if (config.prt_interp.value == CONFIG_PRT_EXT_MM)
                {LLcol=90;LRcol=109;}
            else
                if (col < 110)  {LLcol= 89;LRcol=108;}
                    else        {LLcol=221;LRcol=240;}

        for (i=0;i<PR_MAX_LINES;i++)     /* all rows for this column */
            {
            c=(unsigned char) pr_text_block[i][col];
```

```
switch (c)
    {
    case 0xB3:       /* vertical bar */
            c=' ';
            Slice->SliceCol[ 8].LIntData[51-i]=0xffffffff;
            Slice->SliceCol[ 9].LIntData[51-i]=0xffffffff;
            if (i == 50)
                {
                if (col == LLcol)
                     for (j=10;j<16;j++)
                              Slice->SliceCol[j].LIntData[1]=0x000000C
                if (col == LRcol)
                     for (j=0;j<8;j++)
                              Slice->SliceCol[j].LIntData[1]=0x000000C
                }
            break;
    case 0xC4:       /* horizontal bar */
            c=' ';
            for (j=0;j<16;j++)
                     Slice->SliceCol[j].LIntData[51-i]=0x00800100;
            break;
    case 0xBF:       /* upper right */
            c=' ';
            Slice->SliceCol[ 8].LIntData[51-i]=0x0080ffff;
            Slice->SliceCol[ 9].LIntData[51-i]=0x0000ffff;
            for (j=0;j<8;j++)
                     Slice->SliceCol[j].LIntData[51-i]=0x00800100;
            break;
    case 0xDA:       /* upper left */
            c=' ';
            Slice->SliceCol[ 8].LIntData[51-i]=0x0000ffff;
            Slice->SliceCol[ 9].LIntData[51-i]=0x0080ffff;
            for (j=10;j<16;j++)
                     Slice->SliceCol[j].LIntData[51-i]=0x00800100;
            break;
    case 0xD9:       /* lower right */
            c=' ';
            Slice->SliceCol[ 8].LIntData[51-i]=0xffff0100;
            Slice->SliceCol[ 9].LIntData[51-i]=0xffff0000;
            for (j=0;j<8;j++)
                     Slice->SliceCol[j].LIntData[51-i]=0x00800100;
            break;
    case 0xC0:       /* lower left */
            c=' ';
            Slice->SliceCol[ 8].LIntData[51-i]=0xffff0000;
            Slice->SliceCol[ 9].LIntData[51-i]=0xffff0100;
            for (j=10;j<16;j++)
                     Slice->SliceCol[j].LIntData[51-i]=0x00800100;
            break;
    }

for (j=0;j<11;j++)
    {
    f=~((unsigned char)font[c].char_row[j]);
    for (k=0;k<8;k++)
            {
            row=((51-i)*4+(3-(j>>2)));
            n=((f&(0x80>>k))>>(7-k)) << (2*(j&3));
            Slice->SliceCol[k*2  ].CharData[row]|=n;
```

```
                          Slice->SliceCol[k*2  ].CharData[row]|=n<<1;
                          Slice->SliceCol[k*2+1].CharData[row]|=n;
                          Slice->SliceCol[k*2+1].CharData[row]|=n<<1;
                          }
                  }
             }

         /* add lower part of filter box */
         if ((col > LLcol) && (col < LRcol))
                 for (j=0;j<16;j++)
                         Slice->SliceCol[j].CharData[4]|=0xC0;

         /* add seperator line for banner */
         if (col < 122)
                 for (i=0;i<16;i++)
                         {
                         Slice->SliceCol[i].CharData[204]|=0x07;
                         Slice->SliceCol[i].CharData[205]|=0x80;
                         }

}

static void PutTextIntoSlice300( col, Slice )
struct SLICE *Slice;
int col;
{
        unsigned char c,f,b;
        unsigned int i,j,k,l,n,row,r;
        int LLcol,LRcol;

        check_point= FAX_PUT_TEXT_INTO_SLICE;

        LLcol=LRcol=0;
        if (config.prt_interp.value == CONFIG_PRT_EXT_MM)
                {LLcol=90;LRcol=109;}
            else
                if (col < 110)  {LLcol= 89;LRcol=108;}
                    else        {LLcol=221;LRcol=240;}

        for (i=0;i<PR_MAX_LINES;i++)     /* all rows for this column */
            {
            c=(unsigned char) pr_text_block[i][col];

            row= (49-i)*6+1;

            switch (c)
                {
                case 0xB3:       /* vertical bar */
                        c=' ';
                        for (k=0;k<6;k++)
                                {
                                OrSliceValue( Slice, 10, row+k, 0xff);
                                OrSliceValue( Slice, 11, row+k, 0xff);
                                OrSliceValue( Slice, 12, row+k, 0xff);
                                }
                        break;
                case 0xC4:       /* horizontal bar */
                        c=' ';
                        for (j=0;j<COLUMNS_PER_SLICE_300;j++)
                                {
```

```
                        OrSliceValue( Slice, j, row+2, 0x03);
                        OrSliceValue( Slice, j, row+3, 0x80);
                        }
                break;
        case 0xBF:      /* upper right */
                c=' ';
                OrSliceValue( Slice, 10, row  , 0xff);
                OrSliceValue( Slice, 10, row+1, 0xff);
                OrSliceValue( Slice, 10, row+2, 0xff);
                OrSliceValue( Slice, 11, row  , 0xff);
                OrSliceValue( Slice, 11, row+1, 0xff);
                OrSliceValue( Slice, 11, row+2, 0xff);
                OrSliceValue( Slice, 12, row  , 0xff);
                OrSliceValue( Slice, 12, row+1, 0xff);
                OrSliceValue( Slice, 12, row+2, 0xff);
                for (j=0;j<11;j++)
                        {
                        OrSliceValue( Slice, j, row+2, 0x03);
                        OrSliceValue( Slice, j, row+3, 0x80);
                        }
                break;
        case 0xDA:      /* upper left */
                c=' ';
                OrSliceValue( Slice, 10, row  , 0xff);
                OrSliceValue( Slice, 10, row+1, 0xff);
                OrSliceValue( Slice, 10, row+2, 0xff);
                OrSliceValue( Slice, 11, row  , 0xff);
                OrSliceValue( Slice, 11, row+1, 0xff);
                OrSliceValue( Slice, 11, row+2, 0xff);
                OrSliceValue( Slice, 12, row  , 0xff);
                OrSliceValue( Slice, 12, row+1, 0xff);
                OrSliceValue( Slice, 12, row+2, 0xff);
                for (j=11;j<COLUMNS_PER_SLICE_300;j++)
                        {
                        OrSliceValue( Slice, j, row+2, 0x03);
                        OrSliceValue( Slice, j, row+3, 0x80);
                        }
                break;
        case 0xD9:      /* lower right */
                c=' ';
                OrSliceValue( Slice, 10, row+3, 0xff);
                OrSliceValue( Slice, 10, row+4, 0xff);
                OrSliceValue( Slice, 10, row+5, 0xff);
                OrSliceValue( Slice, 11, row+3, 0xff);
                OrSliceValue( Slice, 11, row+4, 0xff);
                OrSliceValue( Slice, 11, row+5, 0xff);
                OrSliceValue( Slice, 12, row+3, 0xff);
                OrSliceValue( Slice, 12, row+4, 0xff);
                OrSliceValue( Slice, 12, row+5, 0xff);
                for (j=0;j<11;j++)
                        {
                        OrSliceValue( Slice, j, row+2, 0x03);
                        OrSliceValue( Slice, j, row+3, 0x80);
                        }
                break;
        case 0xC0:      /* lower left */
                c=' ';
                OrSliceValue( Slice, 10, row+3, 0xff);
                OrSliceValue( Slice, 10, row+4, 0xff);
                OrSliceValue( Slice, 10, row+5, 0xff);
```

```
                          OrSliceValue( Slice, 11, row+3, 0xff);
                          OrSliceValue( Slice, 11, row+4, 0xff);
                          OrSliceValue( Slice, 11, row+5, 0xff);
                          OrSliceValue( Slice, 12, row+3, 0xff);
                          OrSliceValue( Slice, 12, row+4, 0xff);
                          OrSliceValue( Slice, 12, row+5, 0xff);
                          for (j=11;j<COLUMNS_PER_SLICE_300;j++)
                                   {
                                   OrSliceValue( Slice, j, row+2, 0x03);
                                   OrSliceValue( Slice, j, row+3, 0x80);
                                   }
                          break;
                  }

             for (k=0;k<8;k++)
                  {
                  for (j=0;j<33;j++)
                          {
                          l=j/3;
                          f=~((unsigned char)font[c].char_row[l]);
                          r=(32-j)/8;
                          n=(32-j)-(r*8);
                          b=((f&(0x80>>k)) >> (7-k));
                          if (b == 0)     continue;
                          OrSliceValue( Slice, k*3  , row+r, (0x80>>n));
                          OrSliceValue( Slice, k*3+1, row+r, (0x80>>n));
                          OrSliceValue( Slice, k*3+2, row+r, (0x80>>n));
                          }
                  }
             }

        /* add lower part of filter box */
        if ((col > LLcol) && (col < LRcol))
                 for (j=0;j<COLUMNS_PER_SLICE_300;j++)
                          OrSliceValue( Slice, j, 0, 0xE0);
        if (col == LLcol)
                 for (j=11;j<COLUMNS_PER_SLICE_300;j++)
                          OrSliceValue( Slice, j, 0, 0xE0);
        if (col == LRcol)
                 for (j=0;j<11;j++)
                          OrSliceValue( Slice, j, 0, 0xE0);

}
```

```
/* ::PL -ey -ry */
/*****************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxb40.c_v  $

     FILE NAME: QSCFXB40.C          MODULE: Add Lead Seperators

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   21 Jul 1992 13:04:28  $

     $Revision:   1.2  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-------------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb40.c_v  $
**
**     Rev 1.2    21 Jul 1992 13:04:28    Larry_H
** remove unneeded include file
**
**     Rev 1.1    12 Jun 1992 13:34:40    Larry_H
** add 300 DPI
**
**     Rev 1.0    07 Aug 1991 21:33:50    Larry_H
** Initial revision.

*****************************************************************/

#include        "qpcfxint.h"    /* Fax prototypes            */
#include        "qecfx010.h"    /* FAX resolutions and report types */

#include        "QTCFXV00.H"    /* slice defined */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

void AddLeadSep( NewSam, OldSam, Slice0, Slice1 )
int NewSam;
int OldSam;
char *Slice0,*Slice1;
{
        int i,min,max;

        check_point= FAX_ADD_LEAD_SEP;

        if (NewSam < OldSam)
                {
                min=NewSam;
                max=OldSam;
```

```
                }
            else
                {
                min=OldSam;
                max=NewSam;
                }

        min-=45;
        max+=10;

        for (i=0;i<35;i++)
                {
                PutDot( Slice0  , min+i , WAVEFORM_HEIGHT_300 );
                PutDot( Slice0  , max+i , WAVEFORM_HEIGHT_300 );
                PutDot( Slice1  , min+i , WAVEFORM_HEIGHT_300 );
                PutDot( Slice1  , max+i , WAVEFORM_HEIGHT_300 );
                }
}
```

```
/* ::PL -ey -ry */
/************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxb50.c_v  $

     FILE NAME: QSCFXB50.C          MODULE: PutWaveformIntoSlice

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   24 Jul 1992 09:01:18  $

     $Revision:   1.5  $

     NOTES:   C Source file
              Created by Lawrence Hileman
------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb50.c_v  $
**
**    Rev 1.5   24 Jul 1992 09:01:18   Larry_H
** if the size is zero, don't print the line to the next point
**
**    Rev 1.4   26 Jun 1992 14:38:02   Larry_H
** fix for laser jet printing
**
**    Rev 1.3   12 Jun 1992 13:37:36   Larry_H
** add 300 DPI
**
**    Rev 1.2   04 Feb 1992 19:55:04   Larry_H
** if we have finished with this line of ECG, don't print another 16 columns
** of it
**
**    Rev 1.1   28 Jan 1992 08:51:56   Larry_H
** fix transmission problem with A.01 6x2 ecgs
**
**    Rev 1.0   07 Aug 1991 21:34:26   Larry_H
** Initial revision.

************************************************************/

#include        "QECLS01U.H"    /* TRUE */
#include        "QECLS01V.H"    /* FALSE */

#include        "qeclh014.h"    /* 11 second structure defines (NUM_11SEC_ENTRIE
#include        "qtclh013.h"    /* 11 second uncompressed ECG data struct*/
#include        "qvclh013.h"    /* 11 second uncompressed ECG variabel  */

#include        "qecls04h.h"    /* ec_extension defines         */
#include        "qtcls04h.h"    /* ec_extension structure       */
#include        "qvcls04h.h"    /* ec_extension variable        */

#include        "qeclh005.h"    /* config defines       */
```

```
#include        "qeci0007.h"    /* ID Header stuff              */
#include        "qtclh015.h"    /* ID Header structure          */
#include        "qvclh015.h"    /* ID Header variable           */

#include        "QECFX010.H"    /* SIZE_FOR_COURSE_RESOLUTION */
#include        "QECFXB50.H"    /* Dot Types */

#include        "QTCFXV00.H"    /* Slice define */

#include        "QVCFXV40.H"    /* LeadOrgs */
#include        "QVCFXV50.H"    /* LeadToPrint */

#include        "qpcfxint.h"    /* Fax prototypes               */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

void PutWaveFormIntoSlice( pagenum,col,res,Slice,Speed )
int pagenum,col,res,Speed;
struct SLICE *Slice;
{
        int point,nextpoint;
        int i,j,k,num,ltp,delta,Limit,ColPerSlc;
        static int index[6];
        static int lead[6],size[6];
        static int ltpp,config,OldSam[6];

        check_point= FAX_PUT_WAVEFORM_INTO_SLICE;

        if (col == 0)   /* Initialize */
                {
                config = (int)ec_extension.ecg_format;
                if (pagenum == 1)       ltpp=Speed;
                        else            ltpp=2;
                for (i=0;i<6;i++)
                        {
                        index[i]= 1;
                        lead[i]= 0;
                        ltp=LeadToPrint[ltpp][config][i][lead[i]];
                        size[i]= *wfcom_.ecg.lead[ltp];
                        OldSam[i]=LeadOrgs[config][i];
                        if (res == SIZE_FOR_300_RESOLUTION)
                                OldSam[i]+= OldSam[i]/2;
                        }
                }

        switch(res)
                {
                case SIZE_FOR_COURSE_RESOLUTION:
                        num=2;ColPerSlc=COLUMNS_PER_SLICE;Limit=WAVEFORM_HEIGHT;
                        break;
                case SIZE_FOR_FINE_RESOLUTION:
                        num=1;ColPerSlc=COLUMNS_PER_SLICE;Limit=WAVEFORM_HEIGHT;
                        break;
                case SIZE_FOR_300_RESOLUTION:
                        num=1;ColPerSlc=COLUMNS_PER_SLICE_300;Limit=WAVEFORM_HEI
                        break;
                }
```

```
for (i=0;i<6;i++)
    {
    if (LeadOrgs[config][i] == -1)                    continue;
    if (LeadToPrint[ltpp][config][i][lead[i]] == -1)      continue;

    for (j=0;j<ColPerSlc;j+=num)
        {
        ltp=LeadToPrint[ltpp][config][i][lead[i]];
        if (size[i] == 0)
                {
                lead[i]++;
                index[i]=1;
                ltp=LeadToPrint[ltpp][config][i][lead[i]];
                size[i]=*wfcom_.ecg.lead[ltp];
                nextpoint = ((wfcom_.ecg.lead[ltp][1])*4)/10;
                nextpoint+= LeadOrgs[config][i];
                if (res == SIZE_FOR_300_RESOLUTION)
                        nextpoint+= nextpoint/2;
                if (ltp == -1)
                        break;
                AddLeadSep( nextpoint,OldSam[i],Slice->SliceCol[j].CharD
                                                  ,Slice->SliceCol[j+1].Ch
                if (nextpoint > OldSam[i])
                        {
                        delta=(nextpoint-OldSam[i])/2;
                        for (k=1;k<=delta;k++)
                                PutWFDot( Slice,j,OldSam[i]+k,Limit );
                        }
                if (nextpoint < OldSam[i])
                        {
                        delta=(OldSam[i]-nextpoint+1)/2;
                        for (k=1;k<delta;k++)
                                PutWFDot( Slice,j,OldSam[i]-k,Limit );
                        }
                }

       size[i]--;

       point = LeadOrgs[config][i] +
               ((wfcom_.ecg.lead[ltp][index[i]++])*4)/10;
       if (res == SIZE_FOR_300_RESOLUTION)
               point+= point/2;

       PutWFDot( Slice,j,point,Limit );
       if (point > OldSam[i])
               {
               delta=(point-OldSam[i])/2;
               for (k=1;k<=delta;k++)
                       PutWFDot( Slice,j,point-k,Limit );
               }
       if (point < OldSam[i])
               {
               delta=(OldSam[i]-point+1)/2;
               for (k=1;k<delta;k++)
                       PutWFDot( Slice,j,point+k,Limit );
               }

       OldSam[i]=point;
```

```
                if (size[i] == 0)       continue;

                nextpoint = LeadOrgs[config][i] +
                            ((wfcom_.ecg.lead[ltp][index[i]])*4)/10;
                if (res == SIZE_FOR_300_RESOLUTION)
                        nextpoint+= nextpoint/2;
                if (point > nextpoint)
                        {
                        delta=(point-nextpoint)/2;
                        for (k=1;k<=delta;k++)
                                PutWFDot( Slice,j,point-k,Limit );
                        }
                if (point < nextpoint)
                        {
                        delta=(nextpoint-point+1)/2;
                        for (k=1;k<delta;k++)
                                PutWFDot( Slice,j,point+k,Limit );
                        }
                }
            }
}
```

```
;*************************************************************
;
;    $Logfile:   I:/quarry/fax/vcs/qsafxb60.asv  $
;
;    FILE NAME: QSAFXB600.ASM         MODULE: Put Dot
;
;    SYSTEM: FAX
;    SUBSYSTEM: Main
;
;    (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
;                All rights reserved
;
;    ************** HP CONFIDENTIAL **************
;
;    $Date:   12 Jun 1992 13:43:16  $
;
;    $Revision:   1.1  $
;
;    NOTES:   Asm Source file
;             Created by Lawrence Hileman
;-------------------------------------------------------------
;    ORIGIN:  Cardiology Business Unit
;
;    REVISIONS:
;    $Log:   I:/quarry/fax/vcs/qsafxb60.asv  $
;
;     Rev 1.1   12 Jun 1992 13:43:16   Larry_H
; add 300 DPI
;
;     Rev 1.0   07 Aug 1991 21:34:38   Larry_H
; Initial revision.
;
;************************************************************/

       assume  cs:codeseg
       assume  ds:dataseg
dataseg        segment dword rw use32 public 'data'
extrn          _check_point:DWORD
dataseg        ends

BYTES_PER_SLICECOL      equu     324

codeseg        segment dword er use32 public 'code'
               public  _PutDot
               align   4

;void PutDot( str, Index, Limit )
;char *str;
;int Index,Limit;
;{
;      register int data,byte,cnt;
;
;      check_point= FAX_PUT_DOT;
;
;      cnt=Index;
;      if (cnt < 1)           return;
;      if (cnt > Limit)       return;
;
;      data=0x80 >> (cnt&0x07);
;      cnt=cnt>>3;
```

```
;       str[cnt]|=(char) data;
;
;       check_point= FAX_PUT_DOT;
;}
_PutDot         proc    near

                push    ebp
                mov     ebp,esp
                push    ebx
                push    ecx
                push    edi

                mov     word ptr ds:_check_point, 1F2bh

                mov     ecx,dword ptr [ebp+12]
                cmp     ecx,1
                jl      PutDotEnd
                cmp     ecx,[ebp+16]
                jg      PutDotEnd

                mov     ebx,ecx
                shr     ebx,3
                and     ecx,07h
                mov     al,80h
                shr     al,cl

                mov     edi,[ebp+8]
                or      byte ptr [edi+ebx],al
PutDotEnd:
                mov     word ptr ds:_check_point, 1F2bh

                pop     edi
                pop     ecx
                pop     ebx
                pop     ebp

                ret

_PutDot         endp
codeseg         ends
                end
```

```
        PutDot( Slice->SliceCol[Col+1].CharData, Index+i, Limit );
        }
}
```

```
/* ::PL -ey -ry */
/***************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxb70.c_v  $

     FILE NAME: QSCFXB70.C          MODULE: AddGrid

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                  All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   24 Jul 1992 10:31:36  $

     $Revision:   1.5  $

     NOTES:   C Source file
              Created by Lawrence Hileman
---------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb70.c_v  $
**
**     Rev 1.5   24 Jul 1992 10:31:36   Larry_H
** remove log_errors
**
**     Rev 1.4   24 Jul 1992 09:40:58   Larry_H
** mix real and false grid, add partial real grid to false grid
**
**     Rev 1.3   20 Jun 1992 00:15:40   Larry_H
** add low grid option
**
**     Rev 1.2   12 Jun 1992 13:40:20   Larry_H
** add 300 DPI
**
**     Rev 1.1   19 Nov 1991 10:51:00   Larry_H
** when doing a 50mm/sec ECG, do 255 slices completely, then 2 columns in
** slice 256
**
**     Rev 1.0   07 Aug 1991 21:35:34   Larry_H
** Initial revision.

***************************************************************/

#include        "QECFX010.H"    /* SIZE_FOR_COURSE_RESOLUTION */

#include        "QECFXV60.H"    /* GRID_START */
#include        "QVCFXV60.H"    /* GridCols */

#include        "qeclh005.h"    /* Config defines              */
#include        "qtclh005.h"    /* Config structure            */
#include        "qvclh005.h"    /* Config variable             */

#include        "qeci0007.h"    /* ID Header stuff             */
#include        "qtclh015.h"    /* ID Header structure         */
#include        "qvclh015.h"    /* ID Header variable          */
```

```
/* ::PL -ey -ry */
/*************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxb65.c_v  $

     FILE NAME: QSCFXB65.C         MODULE: PutWFDot

     SYSTEM: FAX
     SUBSYSTEM: Build Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     ************** HP CONFIDENTIAL **************

     $Date:   21 Jul 1992 13:06:14  $

     $Revision:   1.2  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxb65.c_v  $
**
**    Rev 1.2   21 Jul 1992 13:06:14   Larry_H
** remove unneeded include file
**
**    Rev 1.1   12 Jun 1992 13:38:52   Larry_H
** add 300 DPI
**
**    Rev 1.0   07 Aug 1991 21:35:06   Larry_H
** Initial revision.

************************************************************/

#include        "QECFXB50.H"    /* Dot Types */
#include        "qecfx010.h"    /* FAX resolutions and report types */

#include        "QTCFXV00.H"    /* slice defined */

#include        "qpcfxint.h"    /* Fax prototypes              */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

void PutWFDot( Slice, Col, Index, Limit )
struct SLICE *Slice;
int Col,Index,Limit;
{
        int i;

        check_point= FAX_PUT_WF_DOT;

        for (i=0;i<3;i++)
                {
                PutDot( Slice->SliceCol[Col+i].CharData, Index+1, Limit );
```

```
#include        "QTCFXV00.H"    /* slice defined */
#include        "qpcfxint.h"    /* Fax prototypes                */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

void AddGrid( Slice,col,res,Site )
struct SLICE *Slice;
int col,res,Site;
{
        static short int TrueOnFalse;

        int i,j,row,k,l,m,Limit,size,rep;
        int G5m,Glm,Ghm,Gs,Ge;

        check_point= FAX_ADD_GRID;

        if (col == 0)   TrueOnFalse=FALSE_5MM_H;

        i=config.connection[Site].grid_on.value;

        if (i == CONFIG_GRID_ON)
                {
                switch(res)             /* Real Grid */
                        {
                        case SIZE_FOR_COURSE_RESOLUTION:
                                l=0;size=COLUMNS_PER_SLICE;rep=77;Limit=WAVEFORM
                                G5m=4;Ghm=40;Glm=8;Gs=GRID_START;Ge=GRID_END;
                                break;
                        case SIZE_FOR_FINE_RESOLUTION:
                                l=1;size=COLUMNS_PER_SLICE;rep=77;Limit=WAVEFORM
                                G5m=4;Ghm=40;Glm=8;Gs=GRID_START;Ge=GRID_END;
                                break;
                        case SIZE_FOR_300_RESOLUTION:
                                l=2;size=COLUMNS_PER_SLICE_300;rep=59;Limit=WAVE
                                G5m=6;Ghm=60;Glm=12;Gs=GRID_START_300;Ge=GRID_EN
                                break;
                        }
                }
            else
                {
                switch(res)             /* False Grid */
                        {
                        case SIZE_FOR_COURSE_RESOLUTION:
                                l=3;size=COLUMNS_PER_SLICE;rep=77;Limit=WAVEFORM
                                G5m=40;Ghm=40;Glm=8;Gs=GRID_START;Ge=GRID_END;
                                break;
                        case SIZE_FOR_FINE_RESOLUTION:
                                l=4;size=COLUMNS_PER_SLICE;rep=77;Limit=WAVEFORM
                                G5m=40;Ghm=40;Glm=8;Gs=GRID_START;Ge=GRID_END;
                                break;
                        case SIZE_FOR_300_RESOLUTION:
                                l=5;size=COLUMNS_PER_SLICE_300;rep=59;Limit=WAVE
                                G5m=60;Ghm=60;Glm=12;Gs=GRID_START_300;Ge=GRID_E
                                break;
                        }
                }
```

```
        m=size;
/*      if (id_header.plotting_speed[0] == '1') / 50mm/sec /
                (if (col == 256)        m=2;)
            else
                (if (col == 127)        m=11;)*/

        for (i=0;i<m;i++)
                {
                row=((col*size)+i)%rep;
                for (j=-1,k=0;GridCols[l%3][k][0] != -1;k++)
                        {
                        if (GridCols[l%3][k][0] == row)
                                (j=GridCols[l%3][k][1];break;)
                        }
                if (j == -1)    continue;       /* no grid on this line */

                switch(j){
                        case GRID_5MM:
                                if (l > 2)
                                    {
                                    if (TrueOnFalse != 0)
                                        {
                                        for (k=0;k<=Glm*FALSE_MM_V;k+=Ghm/10)
                                                PutDot( Slice->SliceCol[i].CharD
                                        }
                                    }
                                for (k=Gs;k<=Ge;k+=G5m)
                                        {
                                        PutDot( Slice->SliceCol[i].CharData,k,Li
                                        }
                                for (k=Gs+1 ;k<=Ge;k+=Ghm)
                                        PutDot( Slice->SliceCol[i].CharData,k,Li
                                for (k=Gs+Ghm-1;k<=Ge;k+=Ghm)
                                        PutDot( Slice->SliceCol[i].CharData,k,Li
                                if (TrueOnFalse > 0)    TrueOnFalse--;
                                break;
                        case GRID_F1MM:
                                if (l > 2)
                                    {
                                    if (TrueOnFalse != 0)
                                        {
                                        for (k=0;k<=Glm*FALSE_MM_V;k+=Glm)
                                                PutDot( Slice->SliceCol[i].CharD
                                        }
                                    break;
                                    }
                        case GRID_1MM:
                                for (k=Gs;k<=Ge;k+=Glm)
                                        PutDot( Slice->SliceCol[i].CharData,k,Li
                                break;
                        case GRID_FHMM:
                                if (l > 2)
                                    {
                                    if (TrueOnFalse != 0)
                                        {
                                        for (k=0;k<=Ghm*(FALSE_MM_V/5);k+=Ghm)
                                                PutDot( Slice->SliceCol[i].CharD
                                        }
                                    break;
                                    }
```

```
                        case GRID_HMM:
                                for (k=Gs;k<=Ge;k+=Ghm)
                                        PutDot( Slice->SliceCol[i].CharData,k,Li
                                break;

                        }
                }
}
```

```
/* ::PL -ey
/*****************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxs30.c_v  $

     FILE NAME: QSCFXS30.C         MODULE: Encode Strip In Slice

     SYSTEM: FAX
     SUBSYSTEM: Send Slice

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     ************** HP CONFIDENTIAL **************

     $Date:   29 May 1992 12:22:06  $

     $Revision:   1.1  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-----------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxs30.c_v  $
**
**     Rev 1.1   29 May 1992 12:22:06   Larry_H
** add slice size
**
**     Rev 1.0   07 Aug 1991 21:38:10   Larry_H
** Initial revision.

****************************************************************/

#include        "QECFXS40.H"    /* Define Line_Length */

#include        "qpcfxint.h"    /* Fax prototypes             */

#include        "QECFX010.H"    /* slice size defined */
#include        "QTCFXV00.H"    /* structure for slice */
#include        "QVCFXV10.H"    /* termiate and makeup codes */

/* check point access */
#include        "QECLSJWL.H"           /* #define check point values */
#include        "qvcls02d.h"           /* extern unsigned short check_point */

void EncodeStripInSlice( Colum, OutMsg, col, oind )
union SLICE_ROW *Colum;
unsigned char *OutMsg;
int col;
unsigned int *oind;
{
        int value,index,newind,delta,i;

        check_point= FAX_ENCODE_STRIP_IN_SLICE;

        if (col != 0)
                AddCodeToOutput( OutMsg,oind,MakeUpCode[0][40] );   /* EOL */
```

```
        for (index=0,newind=0,value=0;index<LINE_LENGTH;value=(value+1)&0x01)
                {
                newind=NextMatch( Colum->CharData, index, value );
                delta=newind-index;
                if (delta > 63)
                        {               /* add make-up code */
                        i=(delta/64)-1; /* number of 64's */
                        AddCodeToOutput( OutMsg,oind,MakeUpCode[value][i] );
                        delta=delta&0x3f;
                        }
                AddCodeToOutput( OutMsg,oind,TermCode[value][delta] );
                index=newind;
                }
}
```

```
;***************************************************************
;
;    $Logfile:   I:/quarry/fax/vcs/qsafxs40.asv  $
;
;    FILE NAME: QSAFXS40.ASM          MODULE: Add Code to output
;
;    SYSTEM: FAX
;    SUBSYSTEM: Main
;
;    (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
;                  All rights reserved
;
;    *************** HP CONFIDENTIAL ***************
;
;    $Date:   07 Aug 1991 21:38:22  $
;
;    $Revision:   1.0  $
;
;    NOTES:   Asm Source file
;             Created by Lawrence Hileman
;---------------------------------------------------------------
;    ORIGIN:  Cardiology Business Unit
;
;    REVISIONS:
;    $Log:   I:/quarry/fax/vcs/qsafxs40.asv  $
;
;     Rev 1.0   07 Aug 1991 21:38:22   Larry_H
;  Initial revision.
;
;**************************************************************/

        assume  cs:codeseg
        assume  ds:dataseg
dataseg         segment dword rw use32 public 'data'
extrn           _check_point:DWORD
dataseg         ends

codeseg         segment dword er use32 public 'code'
                public  _AddCodeToOutput
                align   4

;void AddCodeToOutput( OutMsg, OutIndex, Code )
;unsigned char *OutMsg,*Code;
;unsigned int *OutIndex;
;{
;       unsigned int byte,bit,i;
;       unsigned int intcode,cd;
;
;       check_point= FAX_ADD_CODE_TO_OUTPUT;
;
;       intcode=Code[1];intcode=intcode<<24;
;       if (Code[0] > 8)         {cd=Code[2];intcode+=(cd<<16);}
;
;       for (i=0;i<Code[0];i++)
;               {
;               byte=(*OutIndex)>>3;
;               bit=(*OutIndex)&0x07;
;               if ((intcode&(0x80000000>>i)) != 0)
;                       {
;                       OutMsg[byte]= OutMsg[byte]|(0x80>>bit);
```

```
;                       }
;               *OutIndex= (*OutIndex)+1;
;               }
;}

_AddCodeToOutput        proc    near

                push    ebp
                mov     ebp,esp
                push    esi
                push    edi
                push    ebx
                push    edx
                push    ecx

                mov     word ptr ds:_check_point, 1F34h

                mov     esi,[ebp+12]     ; address of index
                mov     edi,[esi]        ; index
                mov     edx,[ebp+8]      ; address of output string

                xor     eax,eax
                mov     ebx,[ebp+16]
                mov     ax,[ebx+1]
                xchg    ah,al
                shl     eax,16
                movsx   ecx,byte ptr [ebx]

TestBit:        or      eax,eax
                jns     Next

                push    ecx
                mov     ebx,edi
                shr     ebx,3
                mov     ecx,edi
                and     ecx,7
                mov     al,80h
                shr     al,cl

                or      byte ptr [edx+ebx],al

                pop     ecx

Next:           shl     eax,1
                inc     edi
                dec     ecx
                jnz     TestBit

                mov     [esi],edi

                mov     word ptr ds:_check_point, 1F34h

                pop     ecx
                pop     edx
                pop     ebx
                pop     edi
                pop     esi
                pop     ebp

                ret
```

```
_AddCodeToOutput        endp
Codeseg          ends
                 end
```

```
;************************************************************
;
;    $Logfile:   I:/quarry/fax/vcs/qsafxs50.asv  $
;
;    FILE NAME: QSAFXS50.ASM        MODULE: Next Match
;
;    SYSTEM: FAX
;    SUBSYSTEM: Main
;
;    (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
;                  All rights reserved
;
;    *************** HP CONFIDENTIAL ***************
;
;    $Date:   07 Aug 1991 21:38:34  $
;
;    $Revision:   1.0  $
;
;    NOTES:   Asm Source file
;             Created by Lawrence Hileman
;------------------------------------------------------------
;    ORIGIN:  Cardiology Business Unit
;
;    REVISIONS:
;    $Log:   I:/quarry/fax/vcs/qsafxs50.asv  $
;
;     Rev 1.0   07 Aug 1991 21:38:34   Larry_H
;  Initial revision.
;
;***********************************************************/

        assume  cs:codeseg
        assume  ds:dataseg
dataseg         segment dword rw use32 public 'data'
extrn           _check_point:DWORD
dataseg         ends

codeseg         segment dword er use32 public 'code'
                public  _NextMatch
                align   4

;int NextMatch( Array, Index, Value )          /* index is a bit index */
;char *Array;
;int Index,Value;
;{
;       unsigned int byte,bit,testbit;
;
;       check_point= FAX_NEXT_MATCH;
;
;       for (;Index<LINE_LENGTH;Index++)
;               {
;               byte=(unsigned int)(Index)>>3;
;               bit=Index&0x07;
;               testbit=Array[byte]&(0x80>>bit);
;               if (Value == 0)
;                       {
;                       if (testbit != 0)
;                               return(Index);
;                       }
;                    else
```

```
;                      {
;                      if (testbit == 0)
;                            return(Index);
;                      }
;               }
;       return(Index);
;}

_NextMatch      proc    near

                push    ebp
                mov     ebp,esp
                push    esi
                push    ebx
                push    edx
                push    ecx

                mov     word ptr ds:_check_point, 1F35h

                mov     esi,[ebp+8]
                mov     ebx,[ebp+12]
                mov     eax,ebx
                shr     ebx,3
                and     eax,07h
                mov     ecx,7
                sub     ecx,eax
                mov     al,[esi+ebx]
                cmp     dword ptr [ebp+16],0
                jz      LookForZeros
                jmp     LookForOnes

OnesLoop:       dec     ecx
                jns     LookForOnes

                inc     ebx
                mov     ecx,7
                cmp     ebx,216
                jz      Exit
                mov     al,[esi+ebx]

LookForOnes:    bt      eax,ecx
                jc      OnesLoop
                jmp     Exit


ZerosLoop:      dec     ecx
                jns     LookForZeros

                inc     ebx
                mov     ecx,7
                cmp     ebx,216
                jz      Exit
                mov     al,[esi+ebx]

LookForZeros:   bt      eax,ecx
                jnc     ZerosLoop

Exit:           shl     ebx,3
                mov     eax,7
                sub     eax,ecx
```

```
                add     eax,ebx

                mov     word ptr ds:_check_point, 1F35h

                pop     ecx
                pop     edx
                pop     ebx
                pop     esi
                pop     ebp

                ret

_NextMatch      endp
codeseg         ends
                end
```

```
/* ::PL --- -t
/***********************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxa00.c_v  $

     FILE NAME: QSCFXA00.C          MODULE: change sizes

     SYSTEM: FAX
     SUBSYSTEM: Algorythm

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
               All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   26 Jun 1992 14:39:42  $

     $Revision:   1.3  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-----------------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxa00.c_v  $
**
**     Rev 1.3   26 Jun 1992 14:39:42   Larry_H
** fix for long expantion strings > 5500
**
**     Rev 1.2   14 Feb 1992 15:10:36   Larry_H
** removed unnecessary log_errors
**
**     Rev 1.1   14 Feb 1992 08:08:22   Larry_H
** change how rythem leads are placed in wfcom
**
**     Rev 1.0   07 Aug 1991 21:29:42   Larry_H
** Initial revision.

***********************************************************************/

#include        "stdlib.h"     /* atoi prototype */

#include        "qeclh005.h"   /* Config defines               */
#include        "qecfx010.h"   /* FAX resolutions and report types */

#include        "qeci0007.h"   /* ID Header stuff              */
#include        "qtclh015.h"   /* ID Header structure          */
#include        "qvclh015.h"   /* ID Header variable           */

#include        "qeclh009.h"   /* uncompressed_ecg defines     */
#include        "qtclh009.h"   /* uncompressed_ecg struct      */
#include        "qvclh009.h"   /* uncompressed_ecg variable    */

#include        "qeclh014.h"   /* 11 second structure defines
#include        "qtclh013.h"   /* 11 second uncompressed ECG data struct
#include        "qvclh013.h"   /* 11 second uncompressed ECG variabel

#include        "QTCFXV00.H"   /* slice defined */
```

```
#include        "qpcfxint.h"    /* Fax prototypes               */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

#define EXTRA_SAMPLES   5
#define CUTOFF          1270

void ChangeSize( NewSize,config,RythStrip )
int NewSize,config;
char *RythStrip;
{
        int i,j,k,rs,si,so;

        check_point= FAX_CHANGE_SIZE;

        for (i=0;i<12;i++)
                {
                si=uncompressed_ecg.lead[i].sample_count;
                for (j=0,k=uncompressed_ecg.lead[i].data[si-1];j<EXTRA_SAMPLES;j
                        uncompressed_ecg.lead[i].data[si+j]=k;
                so=(si*NewSize)/250;
                ChangeSampleRate(uncompressed_ecg.lead[i].data,
                        wfcom_.ecg.lead[i],si,so);
                }

        /* acals */

        si=uncompressed_ecg.acal[0].sample_count;
        for (j=0,k=uncompressed_ecg.acal[0].data[si-1];j<EXTRA_SAMPLES;j++)
                uncompressed_ecg.acal[0].data[si+j]=k;
        so=(si*NewSize)/250;
        ChangeSampleRate(uncompressed_ecg.acal[0].data,
                        &wfcom_.ecg.lead[15][0],si,so);

        if ((config == CONFIG_AUTO_3X4) || (config == CONFIG_AUTO_6X2))
                return;

        /* rcals */
        si=uncompressed_ecg.rcal[0].sample_count;
        for (j=0,k=uncompressed_ecg.rcal[0].data[si-1];j<EXTRA_SAMPLES;j++)
                uncompressed_ecg.rcal[0].data[si+j]=k;
        so=(si*NewSize)/250;
        ChangeSampleRate(uncompressed_ecg.rcal[0].data,
                        &wfcom_.ecg.lead[16][0],si,so);

        /* rythem leads */
        if (config == CONFIG_AUTO_3X4_3R)
                {
                ChangeRythemLeadsFirst( NewSize );
                return;
                }

        /* must be 3x4 1R */

        rs=atoi(RythStrip);

        for (i=0,k=-1;(i<3)&&(k==-1);i++)
                {
```

```
        j=uncompressed_ecg.rhy_lead[i].lead_id;
        switch (j)
            {
            case CONFIG_LEAD_CODE_I:    if (rs==ECG_I)   k=i;break;
            case CONFIG_LEAD_CODE_II:   if (rs==ECG_II)  k=i;break;
            case CONFIG_LEAD_CODE_IIIP:
            case CONFIG_LEAD_CODE_IIIPP:
            case CONFIG_LEAD_CODE_III:  if (rs==ECG_III) k=i;break;
            case CONFIG_LEAD_CODE_AVR:  if (rs==ECG_AVR) k=i;break;
            case CONFIG_LEAD_CODE_AVL:  if (rs==ECG_AVL) k=i;break;
            case CONFIG_LEAD_CODE_AVFP:
            case CONFIG_LEAD_CODE_AVF:  if (rs==ECG_AVF) k=i;break;
            case CONFIG_LEAD_CODE_C1:
            case CONFIG_LEAD_CODE_V1:   if (rs==ECG_V1) k=i;break;
            case CONFIG_LEAD_CODE_C2:
            case CONFIG_LEAD_CODE_V2P:
            case CONFIG_LEAD_CODE_V2:   if (rs==ECG_V2) k=i;break;
            case CONFIG_LEAD_CODE_C3:
            case CONFIG_LEAD_CODE_V3:   if (rs==ECG_V3) k=i;break;
            case CONFIG_LEAD_CODE_C4:
            case CONFIG_LEAD_CODE_V4P:
            case CONFIG_LEAD_CODE_V4:   if (rs==ECG_V4) k=i;break;
            case CONFIG_LEAD_CODE_C5:
            case CONFIG_LEAD_CODE_V5P:
            case CONFIG_LEAD_CODE_V5:   if (rs==ECG_V5) k=i;break;
            case CONFIG_LEAD_CODE_C6:
            case CONFIG_LEAD_CODE_V6:   if (rs==ECG_V6) k=i;break;
            case CONFIG_LEAD_CODE_X:    if (rs==ECG_X) k=i;break;
            case CONFIG_LEAD_CODE_Y:    if (rs==ECG_Y) k=i;break;
            case CONFIG_LEAD_CODE_Z:    if (rs==ECG_Z) k=i;break;
            case CONFIG_LEAD_CODE_V3R:  if (rs==ECG_V3R) k=i;break;
            case CONFIG_LEAD_CODE_V4R:  if (rs==ECG_V4R) k=i;break;
            case CONFIG_LEAD_CODE_MAVRP:
            case CONFIG_LEAD_CODE_MAVR: if (rs==ECG_MAVR)k=i;break;
            case CONFIG_LEAD_CODE_V7:   if (rs==ECG_V7) k=i;break;
            case CONFIG_LEAD_CODE_VX1:  if (rs==ECG_VX1) k=i;break;
            case CONFIG_LEAD_CODE_VX2:  if (rs==ECG_VX2) k=i;break;
            case CONFIG_LEAD_CODE_VX3:  if (rs==ECG_VX3) k=i;break;
            case CONFIG_LEAD_CODE_VX4:  if (rs==ECG_VX4) k=i;break;
            }
        }
if (k == -1)    k=0;
si=uncompressed_ecg.rhy_lead[k].sample_count;
so=(si*NewSize)/250;
for (j=0,i=uncompressed_ecg.rhy_lead[k].data[si-1];j<EXTRA_SAMPLES;j++)
        uncompressed_ecg.rhy_lead[k].data[si+j]=i;
if (so > 5500)
        {
        si=CUTOFF;
        so=(si*NewSize)/250;

        ChangeSampleRate(uncompressed_ecg.rhy_lead[k].data,
                         wfcom_.ecg.lead[12],si,so);

        si=uncompressed_ecg.rhy_lead[k].sample_count-CUTOFF;
        so=(si*NewSize)/250;

        ChangeSampleRate(&uncompressed_ecg.rhy_lead[k].data[CUTOFF],
                         wfcom_.ecg.lead[13],si,so);
        }
```

```
            else
                {
                ChangeSampleRate(uncompressed_ecg.rhy_lead[k].data,
                                wfcom_.ecg.lead[12],si,so);
                }
}

void ChangeRythemLeadsFirst( NewSize )
int NewSize;
{
        int i,j,k,l,si,so;

        for (i=0;i<3;i++)
                {
                j=uncompressed_ecg.rhy_lead[i].lead_id;
                for (k=0;k<3;k++)
                        {
                        l=atoi(id_header.lead_map[15+k].lead_num);
                        if (l == j)     break;
                        }
                l= atoi(id_header.lead_map[15+k].chan);

                si=uncompressed_ecg.rhy_lead[i].sample_count;
                so=(si*NewSize)/250;
                for (j=0,k=uncompressed_ecg.rhy_lead[i].data[si-1];j<EXTRA_SAMPL
                        uncompressed_ecg.rhy_lead[i].data[si+j]=k;

                if (so > 5500)
                        {
                        si=CUTOFF;
                        so=(si*NewSize)/250;
                        }
                ChangeSampleRate(uncompressed_ecg.rhy_lead[i].data,
                                wfcom_.ecg.lead[12+l],si,so);
                }
}

void ChangeRythemLeadsSecond( NewSize )
int NewSize;
{
        int i,j,k,l,si,so;

        for (i=0;i<3;i++)
                {
                j=uncompressed_ecg.rhy_lead[i].lead_id;
                for (k=0;k<3;k++)
                        {
                        l=atoi(id_header.lead_map[15+k].lead_num);
                        if (l == j)     break;
                        }
                l= atoi(id_header.lead_map[15+k].chan);

                si=uncompressed_ecg.rhy_lead[i].sample_count - CUTOFF;
                so=(si*NewSize)/250;

                ChangeSampleRate(&uncompressed_ecg.rhy_lead[i].data[CUTOFF],
                                wfcom_.ecg.lead[12+l],si,so);
                }
}
```

```
/* ::PL -ey -ry */
/*****************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxa10.c_v  $

     FILE NAME: QSCFXA10.C          MODULE: Pair/Peak Pick Algorithm

     SYSTEM: FAX
     SUBSYSTEM: Algorythm

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
               All rights reserved

     ************** HP CONFIDENTIAL **************

     $Date:   26 Jun 1992 14:41:46  $

     $Revision:   1.3  $

     NOTES:   C Source file
              Created by Lawrence Hileman
------------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxa10.c_v  $
**
**     Rev 1.3   26 Jun 1992 14:41:46   Larry_H
** fix minor errors in final string
**
**     Rev 1.2   04 Feb 1992 19:53:50   Larry_H
** don't fill in with zero, just set last sample correctly
**
**     Rev 1.1   19 Nov 1991 10:47:04   Larry_H
** set the last few samples to zero before beginning.  On long runs, they may
** get off by one.
**
**     Rev 1.0   07 Aug 1991 21:30:14   Larry_H
** Initial revision.

*****************************************************************/

#include        "QECLS01U.h"    /* TRUE */
#include        "QECLS01V.h"    /* FALSE */

#include        "qpcfxint.h"    /* Fax prototypes           */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

/* refer to Rick Aparo's 2/July/90 paper for algorythm steps */
/* this algorythm works well for 250s/s->300s/s and 250s/s->200s/s */
/* all other changes in sample rate must be checked */

/* the new sample length is saved as the first short int in the out sample buffe

void ChangeSampleRate( InBuffer,OutBuffer,InSamples,OutSamples )
short int *InBuffer,*OutBuffer;
int InSamples,OutSamples;
```

```
{
        int Nn,Nd,in,io,CorCount,straddle,i;
        short int SavedSample,NewSample,PivotSample,InterSample;
        short int min,max,min1,max1;
        int ji,jf,ni,nf;

        check_point= FAX_CHANGE_SAMPLE_RATE;

        FindNumDen( InSamples,OutSamples,&Nn,&Nd );
        ni=Nn/Nd;nf=Nn%Nd;
        OutBuffer[0]=(short) OutSamples;

        for (i=0;i<3;i++)
                OutBuffer[OutSamples]=InBuffer[InSamples-1];

        ji=jf=0;CorCount=Nd;                    /* step 1 */

        SavedSample=InBuffer[0];                /* step 2 */
        PivotSample=InBuffer[0];
        NewSample=InBuffer[1];

        OutBuffer[1]=SavedSample;               /* step 3 */

        for (in=0,io=2;io<OutSamples;io++) /* all but last sample */
                {
                ji=0;                           /* step 4 */
                AddFloattoJ( &ji,&jf,ni,nf,Nd );
                CorCount--;
                if (CorCount == 0)
                        {
                        CorCount=Nd;
                        AddFloattoJ( &ji,&jf,0,Nd/2,Nd );
                        jf=0;
                        }
                min=PivotSample;min1=0;         /* step 5 */
                max=PivotSample;max1=0;
                FindMaxMin( &min,&min1,&max,&max1,&InBuffer[in+1],ji);
                in=in+ji;
                SavedSample=InBuffer[in];
                NewSample=InBuffer[in+1];

                straddle=FALSE;                 /* step 6 */
                if ((max > OutBuffer[io-1])&&(min < OutBuffer[io-1]))
                        straddle=TRUE;

                                                /* step 7 */
                if (straddle == FALSE)
                    {
                    if (jf == 0)
                        {                       /* step 8 */
                        if (max > OutBuffer[io-1])
                                OutBuffer[io]=max;
                            else
                                OutBuffer[io]=min;
                        PivotSample=SavedSample;
                        continue;
                        }
                    else
                        {                       /* step 9 */
                        InterSample= SavedSample +
```

```
                ((jf*(NewSample-SavedSample))/Nd);
        if ((!(InterSample>max))&&(!(InterSample<min)))
                {
                if (max > OutBuffer[io-1])
                        OutBuffer[io]=max;
                    else
                        OutBuffer[io]=min;
                PivotSample=InterSample;
                continue;
                }
        if (InterSample > max)  max=InterSample;
        if (InterSample < min)  min=InterSample;
                                /* step 10 */
        if (min >= OutBuffer[io-1])
                {
                OutBuffer[io]=max;
                PivotSample=InterSample;
                continue;
                }
        if (max <= OutBuffer[io-1])
                {
                OutBuffer[io]=min;
                PivotSample=InterSample;
                continue;
                }
        straddle=TRUE;
        }
    }
                                /* step 11, straddle=TRUE; */
ji=0;
AddFloattoJ( &ji,&jf,ni,nf,Nd );
CorCount--;
if (CorCount == 0)
        {
        CorCount=Nd;
        AddFloattoJ( &ji,&jf,0,Nd/2,Nd );
        jf=0;
        }
min1=min1-ni-1;
max1=max1-ni-1;
FindMaxMin( &min,&min1,&max,&max1,&InBuffer[in+1],ji);
in=in+ji;
SavedSample=InBuffer[in];
NewSample=InBuffer[in+1];

if (jf == 0)
        {
        if (max1 > min1)
                {
                OutBuffer[io++]=min;
                OutBuffer[io]=max;
                }
            else
                {
                OutBuffer[io++]=max;
                OutBuffer[io]=min;
                }
        PivotSample=SavedSample;
        continue;
        }
```

```
                InterSample= SavedSample+((jf*(NewSample-SavedSample))/Nd);
                i=0;
                if (nf > Nd/2)  i=1;
                if (InterSample > max)  {max=InterSample;maxl=2*ni+i+2;}
                if (InterSample < min)  {min=InterSample;minl=2*ni+i+2;}

                if (maxl > minl)
                        {
                        OutBuffer[io++]=min;
                        OutBuffer[io]=max;
                        }
                    else
                        {
                        OutBuffer[io++]=max;
                        OutBuffer[io]=min;
                        }
                PivotSample=InterSample;
                }
}

void AddFloattoJ( ji,jf,ni,nf,Nd )
int *ji,*jf,ni,nf,Nd;
{
        *jf=*jf+nf;
        *ji=*ji+ni;
        while (*jf >= Nd)
                {
                *ji=*ji+1;*jf=*jf-Nd;
                }
}
```

```
/* ::PL -ey -ry */
/*****************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxa20.c_v  $

     FILE NAME: QSCFX102.C         MODULE: Find Max and Min

     SYSTEM: FAX
     SUBSYSTEM: Algorythm

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
               All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   07 Aug 1991 21:30:38  $

     $Revision:   1.0  $

     NOTES:   C Source file
              Created by Lawrence Hileman
-----------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxa20.c_v  $
**
**    Rev 1.0   07 Aug 1991 21:30:38   Larry_H
** Initial revision.

*****************************************************************/

#include        "qpcfxint.h"    /* Fax prototypes              */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

/* refer to Rick Aparo's 2/July/90 paper for algorythm steps */

void FindMaxMin( min,minl,max,maxl,InBuffer,j)
short int *min,*max,*minl,*maxl;
short int *InBuffer;
int j;
{
        int i;

        check_point= FAX_FIND_MAX_MIN;
        for (i=0;i<j;i++)
                {
                if (InBuffer[i] > *max)
                        {
                        *max=InBuffer[i];
                        *maxl=(short)(i+1);
                        }
                if (InBuffer[i] < *min)
                        {
                        *min=InBuffer[i];
                        *minl=(short)(i+1);
                        }

                }
   }
```

```
/* ::PL -ey -ry */
/************************************************************

     $Logfile:   I:/quarry/fax/vcs/qscfxa30.c_v  $

     FILE NAME: QSCFXA30.C         MODULE: Find Numerator/demoniator

     SYSTEM: FAX
     SUBSYSTEM: Algorythm

     (C) COPYRIGHT HEWLETT-PACKARD COMPANY 1989
                   All rights reserved

     *************** HP CONFIDENTIAL ***************

     $Date:   07 Aug 1991 21:31:02  $

     $Revision:   1.0  $

     NOTES:   C Source file
              Created by Lawrence Hileman
--------------------------------------------------------------
     ORIGIN:  Cardiology Business Unit

     REVISIONS:
     $Log:   I:/quarry/fax/vcs/qscfxa30.c_v  $
**
**    Rev 1.0   07 Aug 1991 21:31:02   Larry_H
** Initial revision.

*************************************************************/

#include        "qpcfxint.h"    /* Fax prototypes              */

/* check point access */
#include        "QECLSJWL.H"    /* #define check point values */
#include        "qvcls02d.h"    /* extern unsigned short check_point */

/* this function will provide the closest reduced rational number as */
/* Num and Den. for 250->200 Num=5,Den=4. for 250->300 Num=5,Den=6 */

static int GCD( u,v )
int u,v;
{
        if (v == 0)     return( u );
        return( GCD( v, u%v ) );
}

void FindNumDen( InputSamples,OutputSamples,Num,Den )
int InputSamples,OutputSamples;
int *Num,*Den;
{
        int i;

        check_point= FAX_FIND_NUM_DEN;
        i= GCD( InputSamples, OutputSamples );

        *Num= InputSamples/i;
        *Den= OutputSamples/i;
}
```

We claim:

1. A method of interactive imaging comprising the steps of: providing a digital database at a physical location defining a database site;

forming an image comprising a representation of data stored in the database, the stored data including (1) a physiological waveform portion recorded for a particular patient, (2) identification data for uniquely identifying the database, and (3) a commentary portion for receiving diagnostic commentary pertaining to the physiological waveform data stored in the database;

automatically sizing and locating said commentary portion relative to said physiological waveform portion in a manner which prevents overlap of said commentary portion and said physiological waveform portion;

transmitting the image to the remote site;

at the remote site, annotating the image with diagnostic commentary pertaining to the data stored in the database;

transmitting that annotated facsimile image back to the database site; and

at the database site, recovering the identification data from the annotated facsimile image to identify the database and updating the identified database so as to include the diagnostic commentary pertaining to the data stored in the database without altering the previously stored data.

2. A method according to claim 1 wherein said transmitting the facsimile image includes:

establishing a fax connection between the database site and the remote site;

selecting a fax resolution based upon a fax protocol dialogue between the database site and the remote site;

converting the image to a fax format having the selected fax resolution; and

faxing the image to the remote site.

3. A method according to claim 2 wherein:

the stored data includes waveform data representable as a waveform; and

said forming an image includes resizing the waveform so as to fully utilize the selected fax resolution.

4. A method according to claim 2 wherein:

the stored data includes alphanumeric data; and

said forming an image includes converting the alphanumeric data to a bit map image form at the selected fax resolution, thereby forming a text report portion of the image for displaying the alphanumeric data in a graphic form at the remote site.

5. A method according to claim 4 wherein the alphanumeric data includes the identification data and the text report includes a blank dedicated field for receiving an annotation added to the image at the remote site.

6. A method according to claim 1 wherein updating the database includes:

determining a location of the diagnostic commentary pertaining to the data stored in the database in the annotated image;

extracting an image of the diagnostic commentary pertaining to the data stored in the database from the said location; and

storing the extracted image of the diagnostic commentary pertaining to the data stored in the database in the identified database.

7. A method according to claim 1 further comprising:

converting the stored identifying data into a machine-readable graphic form; and wherein:

said forming the image includes adding the graphic form identifying data into the image.

8. A method according to claim 7 wherein said converting step includes converting the identifying data into a bar-code format to facilitate reading the identifying data from the annotated image.

9. A method according to claim 1 wherein:

forming an image at the database site includes providing a blank dedicated field having a predetermined size and location within the image as the commentary portion for receiving diagnostic commentary pertaining to the data stored in the database;

said annotating step includes inserting a comment with the blank dedicated field at the remote site; and

updating the database includes extracting an image from a location in the annotated image corresponding to the said predetermined location, and storing the extracted image in the database, whereby the updated database includes both the data originally stored in the database and an image of the annotation.

10. A method of interactive imaging comprising the steps of:

forming an image comprising a representation of data stored in the database, the stored image including identification data for uniquely identifying the database, and a commentary portion for receiving diagnostic commentary pertaining to the data stored in the database;

establishing a fax connection between the database site and the remote site;

selecting a fax resolution based upon a fax protocol dialogue between the database site and the remote site;

partitioning the image to form a predetermined number of columns and, for each such column:

rasterizing a corresponding text report portion to form bit map data;

adding a corresponding waveform data portion to the bit map data;

fax encoding the column of bit map data for fax transmission, thereby faxing an image that includes both the text report portion and the waveform portion;

faxing the image to the remote site; and

at the remote site, annotating the image with diagnostic commentary pertaining to the data stored in the database and transmitting that annotated image back to the database site; and

at the database site, recovering the identification data from the annotated image to identify the database and updating the identified database so as to include the diagnostic commentary pertaining to the data stored in the database without altering the previously stored data.

11. A method according to claim 10 further comprising, for each column, adding data defining a corresponding portion of an overlay grid to the bit map data, so that the image includes a grid superimposed over the waveform.

12. A method of interactive imaging comprising the steps of:

providing a digital database at a physical location defining a database site;

forming an image at the database site, comprising a representation of data stored in the database, the stored data including identification data for uniquely identifying the database and a blank field commentary portion for receiving diagnostic commentary pertaining to the data stored in the database having a predetermined size and location within the image;

wherein the image includes a waveform portion;

selecting the dedicated field size and location so that the dedicated field commentary portion of the image does not overlap the waveform portion in the image transmitting the image to a site remote from the database;

at the remote site annotating the image with diagnostic commentary pertaining to the data stored in the database within the blank field commentary portion and transmitting that annotated image back to the database site; and

at the database site, recovering the identification data from the annotated image to identify the database and updating the identified data from the annotated image to identify the database updating the identified database so as to include the diagnostic commentary pertaining to the data stored in the database without altering the previously stored data whereby the updated database includes both the data originally stored in the database and an image of the annotation.

13. A method of interactive electrocardiograph imaging between an instrument site and a remote site, comprising the steps of:

recording an ECG of a patient at the instrument site;

storing the recorded ECG in a digital database, the database including unique identification data for identifying the database;

converting the ECG data so as to form a fax image;

adding the identification data to the fax image;

locating a diagnostic commentary portion in said fax image in a manner which avoids overlapping of said ECG;

faxing the fax image to the remote site for review;

at the remote site, annotating the fax image by inserting at least one diagnostic comment in said diagnostic commentary portion;

faxing the annotated ECG image back to the instrument site;

at the instrument site, recovering the identification data from the annotated image to identify the database; and

updating the identified database by moving a portion of the annotated image containing the at least one diagnostic comment into the identified database.

14. A method according to claim **13** further comprising encoding the identification data into a machine-readable bar-code form.

15. A method according to claim **13** further comprising providing a blank dedicated area as said diagnostic commentary portion at a predetermined location within the fax format image for the at least one diagnostic comment; and wherein

annotating the fax image includes inserting the at least one diagnostic comment within the dedicated area; and said moving step includes copying a portion of the annotated image corresponding to the said location into the database, thereby extracting the at least one diagnostic comment from the annotated image.

16. A method of interactive electrocardiograph imaging between an instrument site and a remote site comprising the steps of:

recording an ECG of a patient at the instrument site:

storing the recorded ECG in a digital database, the database including unique identification data for identifying the database:

converting the ECG data so as to form a fax image;

adding the identification data to the fax image:

faxing the fax image to the remote site for review;

inserting a predetermined first delimit mark on the fax image to indicate the start of a comment area for at least one diagnostic comment;

inserting a predetermined second delimit mark on the fax image to indicate an end of the comment area;

at the remote site, inserting the at least one diagnostic comment intermediate the first and second delimit marks;

faxing the annotated ECG image back to the instrument site;

at the instrument site, recovering the identification data from the annotated image to identify the database;

detecting the first and second delimit marks;

defining a comment area intermediate the detected delimit marks;

extracting an image of the at least one diagnostic comment area from the annotated image; and

writing the extracted image of the at least one diagnostic comment into the identified database.

17. A method according to claim **16** wherein said defining a comment area includes defining a generally rectangular strip located intermediate the detected delimit marks.

18. A method of interactive electrocardiograph imaging between an instrument site and a remote site, comprising the method steps of:

recording an ECG of a patient at the instrument site;

storing the recorded ECG in a digital database, the database including unique identification data for identifying the database;

converting the ECG data so as to form a fax image;

adding the identification data to the fax image;

faxing the fax image to the remote site for review;

inserting a predetermined delimit mark on the fax image to indicate a location of a comment area for the at least one diagnostic comment;

at the remote site, annotating the fax image by inserting at least one diagnostic comment;

faxing the annotated ECG image back to the instrument site;

at the instrument site, recovering the identification data from the annotated image to identify the database;

detecting the delimit mark;

defining a comment area having predetermined dimensions and extending from the indicated location;

extracting an image of the defined comment area from the annotated image; and

writing the extracted image of the comment into the identified database in order to update the database.

19. A system for remote interactive medical imaging via fax telecommunications, comprising:

an instrument for acquiring physiological input data from a patient defining a waveform;

digital data storage means coupled to the instrument for storing digital image data representing the waveform in a database;

means for storing alphanumeric data associated with the patient in the database;

means for converting the waveform image data and the alphanumeric data into a single bit map image and for including in the single bit map a diagnostic commentary field and for locating said diagnostic commentary field in a particular position relative to said waveform image data in order to avoid overlapping of said waveform image data;

means for converting the bit map image to form a first fax file without optical scanning; and

fax means coupled to the converting means for faxing the first fax file to a remote site for review.

20. A system according to claim 19 further comprising:

means at the remote site for receiving the first fax file;

means coupled to the receiving means for displaying the bit map image for examination by a user at the remote site;

means for annotating the displayed bit map image in the region of the diagnostic commentary field to form an annotated image;

means for converting the annotated image so as to form a second fax file for transmission back to the instrument site;

means at the instrument site for identifying the database from the annotated image; and

means for extracting the annotation from the diagnostic commentary field of the annotated image.

* * * * *

OIPE
JUN 0 7 2000
JC111
PATENT & TRADEMARK OFFICE

#7

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:

DAVID A. MONROE

Serial No. 09/006,073

Filed: January 12, 1998

Group Art Unit: 2722

Examiner: J. Pokrzywa

APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail, Express Mail No. EL285225617US, in an Express Mail envelope addressed to: COMMISSIONER OF PATENTS AND TRADEMARKS, Washington, D.C. 20231, this 7th. day of June, 2000.

Barbara Kobza
Barbara Kobza

RECEIVED
JUN 14 2000
TECH CENTER 2700

REQUEST FOR THREE-MONTH EXTENSION OF TIME

HONORABLE COMMISSIONER
OF PATENTS AND TRADEMARKS
Box: Fee
Washington, D.C. 20231

Sir:

Responsive to the Office Action dated December 7, 1999, a three-month extension of time is hereby requested in the above-identified application. The requisite extension fee of $435.00 is attached.

06/12/2000 TTRAN1 00000050 09006073
01 FC:217 435.00 OP

Application of
David A. Monroe

Serial No. 09/006,073

The Commissioner is hereby authorized to charge any additional fees in this application under 35 C.F.R. §1.16 or §1.17 to **Deposit Account No. 50-0259**. An additional copy of this Request for Extension of Time is attached.

Respectfully submitted,

Stephen F. Schlather
Registration No. 45,081

BRACEWELL & PATTERSON, L.L.P.
711 Louisiana, Suite 2900
Houston, Texas 77002
713- 221-1339
Attorney Docket No. 069834.000024

SCHLSF\069834\000001
HOUSTON\1133492.1

GAU 2722

BRACEWELL & PATTERSON L.L.P.
ATTORNEYS AT LAW

711 Louisiana Street, Suite 2900
Houston, Texas 77002-2781
Phone: 713.223.2900
Fax: 713.221.1212

OIPE JC111
JUN 07 2000
PATENT & TRADEMARK OFFICE

June 7, 2000

RECEIVED
JUN 14 2000
TECH CENTER 2700

Via Express Mail EL285225617US

Commissioner of Patents and Trademarks
Group Art Unit 2722
Attention: Examiner J. Pokrzywa
Washington, D.C. 20231

Re: **U.S. Patent Application: Apparatus For Capturing, Converting and Transmitting A Visual Image Signal Via A Digital Transmission System**
Serial No.: 09/006,073
Attorney Docket No.: 069834.000024

Dear Sir:

Enclosed for filing are the following documents:

1. Amendment and Response to December 7, 1999 Office Action;
2. Request for Three Month Extension of Time and check in the amount of $435.00 for a small entity;
3. Transmittal letter in duplicate; and
4. Postcard.

If any additional fees are required, please charge to deposit account 50-0259.

Very truly yours,

Bracewell & Patterson, L.L.P.

Stephen F. Schlather

SFS/az
Enclosures

SCHLSF\069834\000024
HOUSTON\1133412.1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#8/A
KD
6-16-00

OIPE
JUN 07 2000

In re Applicant: §
§
DAVID A. MONROE §
§
Filed: January 12, 1998 § Art Unit: 2722
§
Serial No.: 09/006,073 § Examiner: Pokrzywa, J.
§
For: APPARATUS FOR CAPTURING, § Docket No.: 069834.000024
CONVERTING AND TRANSMITTING §
A VISUAL IMAGE SIGNAL VIA A §
DIGITAL TRANSMISSION SYSTEM §

AMENDMENT AND RESPONSE

RECEIVED
JUN 14 2000
TECH CENTER 2700

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

This paper is filed in response to the Office Action of December 07, 1999.

IN THE SPECIFICATION

Page 11, Line 13: please delete "PCMCIA card 50" and insert therefore --PCMCIA card 72--.

Page 18, line 20: please delete "Fig. 8".

Page 21, line 24: please delete "ne" and insert therefore --new--.

IN THE CLAIMS

---

1. (Amended) A[n] self-contained wireless image processing system for capturing a visual image at a first location and transmitting it via cellular telephone to a remote receiving station, the image processing system comprising:

a. An [image capture device] analog color video camera;

b. A processor for generating a data signal representing the image, the processor comprising a convertor for converting the color analog signal to a gray scale, converting the gray scale to a suitable half-tone image and converting the half-tone image into a binary data signal;

c. A [communications device] integrated cellular telephone adapted for transmitting the binary data signal to the remote receiving station

d. a subprocessor for generating a Group-III facsimile compatible signal representing the [digital] binary data signal.

Please cancel claims 5-8.

Claim 9, line 1: please delete "further including" and insert therefore --wherein the cellular device includes--.

Claim 25, line 2: after "apparatus" insert --controls--.

Claim 27, line 2: after "plurality" insert --of--.

Please cancel claim 181.

Please cancel claim 190.

REMARKS

Applicant confirms the election of claims 1-28 and 181 and 190.

Claims 1, 2, 4, 12, 13, 16, 18, 20, 21 and 181 stand rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,546,194 (Ross). Applicant respectfully traverses the rejection.

Ross discloses an apparatus for receiving and converting a video image to a Group III fax format (col. 2/15-19). The converted video image may then be sent from the apparatus to a suitable Group III fax machine or the like. The Ross patent does not disclose the use of a cellular telephone to transmit the converted video image.

The claims of the present application have been amended to more accurately and fully reflect Applicant's invention. Claim 1 provides for the use of a cellular telephone for transmitting a converted video image via the Group III fax protocol. In order to sustain a rejection under 35 U.S.C. 102(b), a single prior art reference must disclose each and every claim element of the subject application. Here, the Ross reference specifically does not disclose the use of a cellular telephone to transmit data. Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of claims 1, 2, 4, 12, 13, 16, 18, 20, 21 and 181.

Claims 1, 2, 6-11, 15, 17, 19, 21-23 and 27 stand rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,550,646 (Hassan). Applicant respectfully traverses the rejection.

Hassan describes an apparatus for capturing, converting and sending black and white images (col. 1/54-60). The apparatus does not disclose a color conversion mechanism. To the contrary, Hassan specifically describes the use of a black and white CCD to generate an image having 16 possible grey levels, which is then dithered to produce an image which may be sent via fax (col. 3/58-64).

Applicant's invention specifically uses a color camera to obtain the original image and then processes the image by converting the color image to a gray scale, converting the gray scale to a half-tone image and then producing a binary data signal from the half-tone image. Hassan does not disclose these elements of Applicant's invention. Therefore, Applicant respectfully requests that the Examiner withdraw the rejection of claims 1, 2, 6-11, 15, 17, 19, 21-23 and 27.

Claims 1, 14, 24-26 and 190 stand rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Patent No. 5,689,300 (Shibata). Applicant respectfully traverses the rejection.

Shibata describes a teleconference system which makes it possible to hold an audio and video meeting between distant places connected by a communications network. Applicant asserts that the Examiner has not fully appreciated the differences between the Shibata system and the present invention. Shibata does not disclose a system which is capable of obtaining, converting and sending a color image via Group III fax. Rather, the system of Shibata only allows a simultaneous voice and data transfer via a Group III fax interface (col. 10/45 - col. 11/22; Fig. 5). The system may differentiate between audio and data signals provided to or from the fax modular jack 107, but is not capable of converting an image for transmission via the jack.

As previously described, Applicant's invention captures converts and transmits a color image to a remote location via the Group III fax protocol. As Shibata does not disclose or describe these elements of Applicant's claims, Applicant respectfully requests that the rejection of claims be withdrawn.

Claims 3 and 5 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Ross. Applicant respectfully traverses the rejection.

As detailed above, Ross does not teach Applicant's invention. There is no suggestion that the invention of Ross may include a cellular telephone for transmitting images. Therefore, Applicant respectfully requests that the rejection of claim 3 be withdrawn. Claim 5 is no longer the subject of the present application.

Claim 28 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Shibata in view of Hassan. Applicant respectfully traverses the rejection.

As detailed above, the invention of Hassan does not disclose, teach or suggest the conversion of images for transmission via the Group III fax protocol. Neither Hassan nor Shibata teach a system which includes an input device for controlling the processor configuration from a remote location. Therefore, even in combination these references do not teach, disclose or suggest Applicant's invention. Withdrawal of this rejection is therefore requested.

In summary, for reasons detailed above, it is submitted that all claims now present in the application are patentable over the prior art. Accordingly, allowance of all claims is submitted to be in order. Such action is respectfully requested.

Respectfully submitted,

Stephen Schlather
Reg. No. 45,081

BRACEWELL & PATTERSON, L.L.P.
711 Louisiana, Suite 2900
Houston, Texas 77002
713/221-1339
Fax 713/223-2141

CERTIFICATE UNDER 37 CFR 1.10

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail EL285225617US in an envelope addressed to: Commissioner of Patents, Washington, D.C., on June 7, 2000.

Barbara Kobza
Barbara Kobza

SCHLSF\058959\007010
HOUSTON\1118125.1

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Anl

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
09/006,073	01/12/98	MONROE D	58959.12

LM31/0829

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

EXAMINER	
POKRZYWA,J	
ART UNIT	**PAPER NUMBER**
2722	9

DATE MAILED: 08/29/00

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

PTO-90C (Rev. 2/95)
U.S. G.P.O. 2000 - 465-188/25288

1- File Copy

Office Action Summary

Application No.	Applicant(s)
09/006,073	Monroe, David A.
Examiner	**Group Art Unit**
Joseph Pokrzywa	2722

☒ Responsive to communication(s) filed on *Jun 7, 2000*.

☒ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire 3 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) *1-4 and 9-28* is/are pending in the application.

Of the above, claim(s) ______ is/are withdrawn from consideration.

☐ Claim(s) ______ is/are allowed.

☒ Claim(s) *1-4 and 9-28* is/are rejected.

☐ Claim(s) ______ is/are objected to.

☐ Claims ______ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☒ The drawing(s) filed on *Jan 12, 1998* is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ______ is ☐approved ☐disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ______.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ______.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of References Cited, PTO-892

☐ Information Disclosure Statement(s), PTO-1449, Paper No(s). ______

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

S. Patent and Trademark Office
'O-326 (Rev. 9-95) **Office Action Summary** Part of Paper No. 9

DETAILED ACTION

Response to Amendment

1. Applicant's amendment was received on 6/7/00, and has been entered and made of record. Currently, **claims 1 through 4, 9 through 28** are pending, with claims 29 through 180, 182 through 189, and 191 through 266 withdrawn from consideration, as being drawn to a non-elected invention.

Response to Arguments

2. Applicant's arguments with respect to claim 1 have been considered but are moot in view of the new ground(s) of rejection.

Drawings

3. The drawings remain objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character "81" has been used to designate both the hardwired personal computer in Fig. 4 and the data multiplexer circuit in Fig. 5, and reference character "83" has been used to designate both the communications interface module in Fig. 4 and the sync signal in Fig. 5. Correction is required.

4. The drawings remain objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description:

reference numeral "29", on page 10, line 11.

Correction is required.

5. The drawings remain objected to because of the problems addressed in the attached PTO-948, and because of:

in Fig. 4, PC modem protocol box "66" should read "68" as read on page 12, lines 27 and 28.

Correction is required.

Specification

6. The objection to the specification, as cited in the Office action dated 12/7/99, is overcome by the changes set forth in the amendment.

Claim Objections

7. The objection to the claims, as cited in the Office action dated 12/7/99, is overcome by the changes set forth in the amendment.

Claim Rejections - 35 USC § 112

8. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

9. **Claims 2 through 4, 9, 11 through 22, 24, 25, 27, and 28** are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

10. ***Claim 2*** recites the limitation "the communications device" in line 2. There is insufficient antecedent basis for this limitation in the claim.

11. ***Claim 3*** recites the limitation "said memory" in line 1. There is insufficient antecedent basis for this limitation in the claim.

12. ***Claim 4*** recites the limitation "the image capture device" in line 1. There is insufficient antecedent basis for this limitation in the claim.

13. ***Claim 9*** recites the limitation "the cellular device" in line 1. There is insufficient antecedent basis for this limitation in the claim.

14. ***Claim 11*** recites the limitation "the communications device" in line 3. There is insufficient antecedent basis for this limitation in the claim.

15. ***Claim 12*** recites the limitation "the image capture device" in line 2. There is insufficient antecedent basis for this limitation in the claim.

16. ***Claim 13*** recites the limitation "the communications device" in line 2. There is insufficient antecedent basis for this limitation in the claim.

17. *Claim 14* recites the limitation "the captured video signal" in lines 2 and 3. There is insufficient antecedent basis for this limitation in the claim.

18. *Claim 15* recites the limitation "said image data signal" in line 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

19. *Claim 16* recites the limitation "said image data signal" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

20. *Claim 17* recites the limitation "said image data signal" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

21. *Claim 18* recites the limitation "said image data signal" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

22. *Claim 19* recites the limitation "the image data signal" in line 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5

of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

23. *Claim 20* recites the limitation "the image data signal" in line 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

24. *Claim 21* recites the limitation "the image data signal" in line 2. There is insufficient antecedent basis for this limitation in the claim, as there is now a "data signal" mentioned in line 5 of claim 1, and a "binary data signal" mentioned in line 8 of claim 1, but not specifically an "image data signal".

25. *Claim 22* recites the limitation "the image data" in line 2. There is insufficient antecedent basis for this limitation in the claim.

26. *Claim 24* recites the limitation "the image capture device" in line 2. There is insufficient antecedent basis for this limitation in the claim.

27. *Claim 25* recites the limitation "said image capture device" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim.

28. *Claim 27* recites the limitation "said image capture device" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim.

29. *Claim 28* recites the limitation "said image capture device" in lines 1 and 2. There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections - 35 USC § 103

30. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

31. **Claims 1 through 4, 10 through 13, 15 through 17, 19, 21 through 23, and 27** are rejected under 35 U.S.C. 103(a) as being unpatentable over Creedon *et al.* (U.S. Patent Number 5,235,432, cited in the IDS filed 5/26/98) in view of Hassan *et al.* (U.S. Patent Number 5,550,646, cited in the Office action dated 12/7/99).

Regarding ***claim 1***, Creedon discloses a self-contained wireless image processing system (see Fig. 1, along with column 5, lines 11 through 16) for capturing a visual image at a first location (video source 106) and transmitting it via a cellular telephone network (column 5, lines 11 through 16) to a remote receiving station (facsimile receiver 110), with the system comprising an analog color video camera (video camera 106a, column 3, lines 54 through 64, and column 4, lines 31 through 44), a processor (the video signal processing section and the video signal conversion section 104) for generating a data signal representing the image (column 3, lines 65 through column 4, line 5, and column 4, lines 45 through 62), with the processor comprising a converter for converting the color analog signal to a gray scale (using the ADC 114, column 3, line 65 through column 4, line 5, and column 4, lines 31 through 44), converting the gray scale to a suitable half-tone image (dithering process of the pixel-to-pel converter 21, column 14, lines 50 through column 15, line 3), and converting the half-tone image into a binary data signal (column 1, line 53 through column 2, line 9, and column 12, line 67 through column 13, line 9), an integrated cellular telephone modem adapted for transmitting the binary data signal to the remote receiving station (column 4, line 66 through column 5, line 16), and a subprocessor (facsimile standard encoder 208) for generating a Group-III facsimile compatible signal representing the binary data signal (column 15, lines 4 through 13).

However, Creedon fails to specifically teach of transmitting the captured visual image via a *cellular telephone*, wherein an integrated *cellular telephone* is adapted for transmitting the binary data signal to the remote receiving station. Hassan discloses a wireless self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (column 1, lines 47 through 52, along with column 2, lines 43 through 61, and column 3, lines 10 through 20), with the system comprising a (device 110 in Fig. 1), a processor (microcontroller 205) for generating a data signal representing the image (column 3, lines 21 through 46), a cellular telephone (column 4, line 65 through column 5, line 9) adapted for transmitting the data signal to the remote receiving station (via fax modem 240, column 4, line 65 through column 5, line 9), and a subprocessor for generating a Group-III facsimile compatible signal representing the data signal (column 4, line 65 through column 5, line 9). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's teachings in Creedon's system. Creedon's system would become more versatile with the addition of Hassan's teachings, as the unit would be mobile, therein able to transmit anywhere cellular service is available, thereby not being stationary, as recognized by Hassan.

Regarding ***claim 2***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches of a memory (data memory RAM 154) for receiving and storing the data signal (column 5, line 45 through column 6, line 6), and the modem is adapted for recalling the stored data signal from memory (column 4, lines 57 through 65). However, Creedon is unclear if a cellular telephone is adapted for recalling the stored data signal from memory. Hassan discloses the system discussed above in claim 1, and further teaches of a memory for receiving and storing the data signal (RAM 207, column 3, lines 47 through 50), and wherein the cellular telephone (column 4, line 65 through column 5, line 9) is adapted for recalling the stored data signal from memory (column 5, lines 35 through 44, and column 5, lines 52 through 56). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's teachings in Creedon's system. Creedon's system would become more versatile with the addition of Hassan's teachings, as the unit would be mobile, therein able to transmit anywhere cellular service is available, thereby not being stationary, as recognized by Hassan.

Regarding ***claim 3***, Creedon and Hassan discloses the system discussed above in claim 1, wherein Creedon's system is adapted for selectively charging and discharging a random access medium (data memory RAM 154, column 5, line 55 through column 6, line 6). However, Creedon fails to teach if the random access medium is removable. Typically in the art, video cassettes and floppy disks are used are used for recording images, which are both inherently removable random access mediums. Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include a removable random access medium in Creedon's system. Creedon's system would easily be modified to include a removable random access medium since it is well known in the art, and desirable to have a removable RAM, as user's would be capable of taking the removed RAM to an alternate location for subsequent processing.

Regarding ***claim 4***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches that the analog color video camera is an analog camera (video camera 106a) for generating an analog image signal (column 3, lines 45 through 68), and there is further included an analog to digital converter for converting the analog image signal to a digital signal (ADC 114, column 3, line 65 through column 4, line 5).

Regarding ***claim 10***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy (column 1, lines 52 through 63, column 2, line 64 through column 3, line 4, and column 6, lines 22 through 42). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more user friendly with the addition of Hassan's teachings, as a user would be able to view a hardcopy of the video captured, as recognized by Hassan.

Regarding ***claim 11***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of the processor is adapted for generating a signal in any of a plurality of selected protocols (column 6, line 62 through column 7, line 2, column 3, lines 5 through 20, and column 4, line 65 through column 5, line 9) and wherein the cellular telephone (column 5, lines 1 through 9) is adapted for transmitting the signal in the proper protocol to a remote, compatible receiving station (column 2, lines 39 through 66). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more user friendly with the addition of Hassan's teachings, as a user would be able to transmit the image in various protocols, depending on the receiver, as recognized by Hassan.

Regarding ***claim 12***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches of the video camera is an analog video camera for generating a video signal (column 3, lines 45 through 68). Further, Creedon teaches that the processor comprises a sync detector (PLL 116) and a video address generator (column 4, lines 49 through 56) for synchronizing the digital signal with the analog signal for defining the beginning and end of the signal to define a still frame (column 3, line 65 through column 4, line 19), a random access memory (data memory RAM 154) for receiving and storing the converted, synchronized signal frame-by-frame (column 5, lines 55 through 65), a processor routine for converting the signals stored in the memory to a protocol adapted for transmission (column 4, line 45 through column 5, line 10) to a remote, compatible protocol receiving station (facsimile receiver 110), and a communications device (modem 156, RS-232 interface 158, or cellular telephone modem, column 4, line 66 through column 5, line 10) for transmitting the signal in the proper protocol to the compatible receiving station (column 5, line 66 through column 6, line 11).

Regarding ***claim 13***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches of the system being of modular construction (seen in Fig. 1), and the camera (video camera 106a, part of video source 106), the processor (video signal processing section 102 and video signal conversion section 104), and the cellular telephone are each independent, functional units (column 5, lines 11 through 16, wherein an inherent cellular phone would be attached to the cellular modem, wherein the cellular phone would be an independent, functional unit) which may be coupled to one another for defining the assembled system (seen in Fig. 1, column 3, lines 37 through 44).

Regarding ***claim 15***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches of a data processor (user interface 105) for creating a text data signal associated with the image data signal (column 5, lines 17 through 23).

Regarding ***claim 16***, Creedon and Hassan disclose the system discussed above in claim 2, and Creedon further teaches of the image data signal is stored in a raw video format (two field buffer 120, column 4, lines 9 through 11).

Regarding ***claim 17***, Creedon and Hassan disclose the system discussed above in claim 2, and Hassan further teaches of the image data signal is stored in a compressed format (column 4, lines 43 through 48, and column 6, lines 43 through 50). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more efficient with the addition of Hassan's teachings, as less memory would be needed to store the signal, as recognized by Hassan.

Regarding ***claim 19***, Creedon and Hassan disclose the system discussed above in claim 1, and Creedon further teaches of the remote receiving station is a standard bi-level facsimile machine (facsimile receiver 110, column 1, lines 53 through column 2, line 9, and column 3, lines 41 through 44) and the image data signal is generated in a standard bi-level facsimile machine format and protocol (column 4, line 66 through column 5, line 10).

Regarding ***claim 21***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of the remote receiving station is a color facsimile machine (column 7, line 1) and the image data signal is generated in a full color format and protocol (column 6, line 62 through column 7, line 2). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more user friendly with the addition of Hassan's teachings, as a user would be able to transmit the image in various protocols, depending on the receiver, as recognized by Hassan.

Regarding ***claim 22***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of the remote receiving station is a digital device and the image data is digital (column 4, line 65 through column 5, line 9). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more user friendly with the addition of Hassan's teachings, as a user would be able to transmit the image in various protocols, depending on the receiver, as recognized by Hassan.

Regarding ***claim 23***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of a self-contained power source for powering the system (column 5, lines 23 through 25). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more versatile with the addition of Hassan's teachings, as the unit would include a battery, thereby being mobile, as recognized by Hassan.

Regarding ***claim 27***, Creedon and Hassan disclose the system discussed above in claim 1, and Hassan further teaches of the camera may be controlled to capture a plurality of images in controlled order (column 6, lines 43 through 62). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more versatile with the addition of Hassan's teachings, as the system would be able to capture images in a short period of time, as recognized by Hassan.

32. **Claim 9** is rejected under 35 U.S.C. 103(a) as being unpatentable over Creedon *et al.* (U.S. Patent Number 5,235,432, cited in the IDS filed 5/26/98) in view of Hassan *et al.* (U.S. Patent Number 5,550,646, cited in the Office action dated 12/7/99), and further in view of Parulski *et al.* (U.S. Patent Number 5,666,159, cited in the Office action dated 12/7/99).

Regarding ***claim 9***, Creedon and Hassan disclose the system discussed above in claim 2, and Hassan further teaches of the system includes a view screen for viewing the captured and stored image (LCD display 215, column 4, lines 19 through 31). However, Hassan fails to specifically teach of the cellular telephone including a view screen for viewing the captured and stored image. Parulski discloses a self-contained wireless image processing system (see Figs. 1 through 9, along with column 2, line 42 through column 5, line 5) for capturing a visual image at a first location (still image, column 2, lines 58 through 60) and transmitting it via a cellular telephone (RF transmitter module 14) to a remote receiving station (receiver units, seen in Fig. 1), with the system comprising the cellular telephone including a view screen for viewing the captured and stored image (column 2, line 42 through column 5, line 5, and column 4, lines 26 through 40). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Parulski's teachings in Creedon and Hassan's system. Creedon and Hassan's system would become more user friendly with the addition of Parulski's teachings, as the user would be able to view the information which was captured, and which will be transmitted to a receiver.

33. **Claims 14, 24 through 26, and 28** are rejected under 35 U.S.C. 103(a) as being unpatentable over Creedon *et al.* (U.S. Patent Number 5,235,432, cited in the IDS filed 5/26/98) in view of Hassan *et al.* (U.S. Patent Number 5,550,646, cited in the Office action dated 12/7/99), and further in view of Shibata *et al.* (U.S. Patent Number 5,689,300, cited in the Office action dated 12/7/99).

Regarding ***claim 14***, Creedon and Hassan disclose the system discussed above in claim 1, but fail to teach of including an audio capture device. Shibata discloses a self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (column 2, line 22 through column 3, line 3), with the system comprising a camera (camera 1, column 6, lines 33 through 38), a processor for generating a data signal representing the image (control unit 26, column 5, line 64 through column 6, line 12, and column 6, lines 39 through 46), a communications device adapted for transmitting the data signal to the remote receiving station (G3-FAX modular jack 107 and G3-FAX interface 16, column 7, lines 10 through 25, and column 10, line 45 through column 11, line 21), and a subprocessor (multiplexor/demultiplexor 20) for generating a Group-III facsimile compatible signal representing the data signal (column 6, lines 13 through 24). Further, Shibata teaches of an audio signal capture device (hands-free microphone 14, handset 15, or external microphone 108) adapted for capturing an audio signal in correlation with the captured video signal (column 6, lines 47 through 65). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Shibata's teachings in Creedon and Hassan's system. Creedon and Hassan's system would be more versatile with the addition of Shibata's teachings, as receiver would be able to retrieve the video, along with a correlated audio signal, for a full indication of the event captured by the video camera.

Regarding ***claim 24***, Creedon and Hassan disclose the system discussed above in claim 1, but fail to teach of a control apparatus for remotely controlling operating functions of the camera. Shibata discloses a system which includes a control apparatus (control keyboard 2002, seen in Figs. 20A and 22) for remotely controlling operating functions of a camera (column 19, line 26 through column 12). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Shibata's teachings in Creedon and Hassan's system. Creedon and Hassan's system would be more user friendly with the addition of Shibata's teachings, as a user would be able to remotely control the operations of the camera.

Regarding ***claim 25***, Creedon, Hassan, and Shibata disclose the system discussed above in claim 24, and Shibata further teaches of the camera having a shuttered lens (column 15, lines 3 through 7, and camera 1, which outputs still pictures, column 8, lines 3 through 13) and where the control apparatus controlling any combination of lens direction, iris, focus, and shutter speed (column 11, lines 50 through 63, and column 19, lines 1 through 50). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Shibata's teachings in Creedon and Hassan's system. Creedon and Hassan's system would be more user friendly with the addition of Shibata's teachings, as a user would be able to remotely control the operations of the camera.

Regarding ***claim 26***, Creedon and Hassan disclose the system discussed above in claim 1, but fail to teach of an input device for controlling the processor from a remote location. Shibata discloses a system which includes an input device (control keyboard 2002, seen in Figs. 20A and 22) for controlling a processor configuration from a remote location (column 19, line 26 through column 12). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Shibata's teachings in Creedon and Hassan's system. Creedon and Hassan's system would be more user friendly with the addition of Shibata's teachings, as a user would be able to remotely control the operations of the system.

Regarding ***claim 28***, Creedon, Hassan, and Shibata disclose the system discussed above in claim 26, and Hassan further teaches of the camera may be controlled to capture a plurality of images in controlled order (column 6, lines 43 through 62). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Hassan's further teachings in Creedon's system. Creedon's system would become more versatile with the addition of Hassan's teachings, as the system would be able to capture images in a short period of time, as recognized by Hassan.

34. **Claims 18 and 20** are rejected under 35 U.S.C. 103(a) as being unpatentable over Creedon *et al.* (U.S. Patent Number 5,235,432, cited in the IDS filed 5/26/98) in view of Hassan *et al.* (U.S. Patent Number 5,550,646, cited in the Office action dated 12/7/99), and further in view of Ross (U.S. Patent Number 5,546,194, cited in the Office action dated 12/7/99).

Regarding ***claim 18***, Creedon and Hassan disclose the system discussed above in claim 2, but Creedon is unclear if the image data signal is stored in a half-tone format. Ross discloses a self-contained image processing system (see Fig. 1) for capturing a visual image and transmitting it to a remote receiving station, with the system comprising an analog video camera (video camera 10, column 3, lines 4 through 5), a processor (control system 22 in Fig. 1, or CPU 44 in Fig. 2) for generating a data signal representing the image (column 3, lines 20 through 29, and column 3, line 63 through column 4, line 20), a communications device (Group III fax transmitter 20 in Fig. 1, and fax modem 50 in Fig. 2) adapted for transmitting the data signal to the remote receiving station (column 2, lines 15 through 29, wherein the remote receiving station is inherently included in the system), and a subprocessor (Group III formatter 18) for generating a Group-III facsimile compatible signal representing the data signal (column 3, lines 30 through 52). Further, Ross teaches of the image data signal is stored in a half-tone format (column 3, lines 30 through 40). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Ross's teachings in Creedon and Hassan's system. Creedon's system would be more versatile with the addition of Ross's teachings, as a user would be able to transmit half-tone images which are stored in a memory, to a receiving gray-scale facsimile machine, as recognized by Hassan.

Regarding ***claim 20***, Creedon and Hassan disclose the system discussed above in claim 1, but Creedon is unclear if the remote receiving station is a gray-scale facsimile machine. Ross discloses the system wherein the remote receiving station is a gray-scale facsimile machine (column 3, lines 30 through 41, with the receiving station inherently receives the gray-scale image, thus being a gray-scale facsimile machine) and the image data signal is generated in a gray-scale format and protocol (column 3, lines 30 through 41). Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include Ross's teachings in Creedon and Hassan's system. Creedon's system would be more versatile with the addition of Ross's teachings, as a user would be able to transmit half-tone images which are stored in a memory, to a receiving gray-scale facsimile machine, as recognized by Hassan.

Citation of Pertinent Prior Art

35. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure:

Wertsberger (U.S. Patent Number 6,072,600) discloses a system wherein a camera is used to capture an image which is subsequently transmitted by facsimile.

Conclusion

36. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL.** See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

37. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Joe Pokrzywa whose telephone number is (703) 305-0146. The examiner can normally be reached on Monday through Friday from 8:00 a.m. to 4:30 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward Coles, can be reached on (703) 305-4712. The fax phone number for this Group is (703) 306-5406.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 305-3800/4700.

Joseph R. Pokrzywa
August 15, 2000

EDWARD L. COLES
SUPERVISORY PATENT EXAMINER
GROUP 2700

Notice of References Cited

Application No.	09/006,073
Applicant(s)	Monroe, David A.
Examiner	Joseph Pokrzywa
Group ~~Art Unit~~	2722
	Page 1 of 1

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUBCLASS
	A	5,546,194	8/1996	Ross	358	445
	B	5,550,646	8/1996	Hassan et al.	358	442
	C	5,689,300	11/1997	Shibata et al.	348	15
	D	5,666,159	9/1997	Parulski et al.	348	211
	E	5,235,432	8/1993	Creedon et al.	358	479
	F	6,072,600	6/2000	Wertsberger	358	479
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUBCLASS
	N						
	O						
	P						
	Q						
	R						
	S						
	T						

NON-PATENT DOCUMENTS

*		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	DATE
	U		
	V		
	W		
	X		

* A copy of this reference is not being furnished with this Office action.
(See Manual of Patent Examining Procedure, Section 707.05(a).)

S. Patent and Trademark Office
TO-892 (Rev. 9-95)

Notice of References Cited

Part of Paper No. 9

US005235432A

United States Patent [19]

Creedon et al.

[11] **Patent Number: 5,235,432**

[45] **Date of Patent: Aug. 10, 1993**

[54] **VIDEO-TO-FACSIMILE SIGNAL CONVERTER**

[76] Inventors: **Brendan G. Creedon**, 805 Pomona Ave., Albany, Calif. 94706; **Lou Katz**, 3317 Brunell Dr., Oakland, Calif. 94602

[21] Appl. No.: **796,634**

[22] Filed: **Nov. 22, 1991**

[51] **Int. Cl.**^{5} **H04N 1/04**

[52] **U.S. Cl.** **358/479**; 358/433; 358/442; 358/445; 358/455; 358/456; 358/457; 358/468

[58] **Field of Search** 358/400, 401, 405, 406, 358/426, 201.1, 261.2, 261.3, 261.4, 429, 430, 431, 432, 433, 434, 435, 436, 442, 443, 445, 455, 456, 457, 458, 465, 468, 471, 476, 479, 141, 142, 160; 382/54, 55

[56] **References Cited**

U.S. PATENT DOCUMENTS

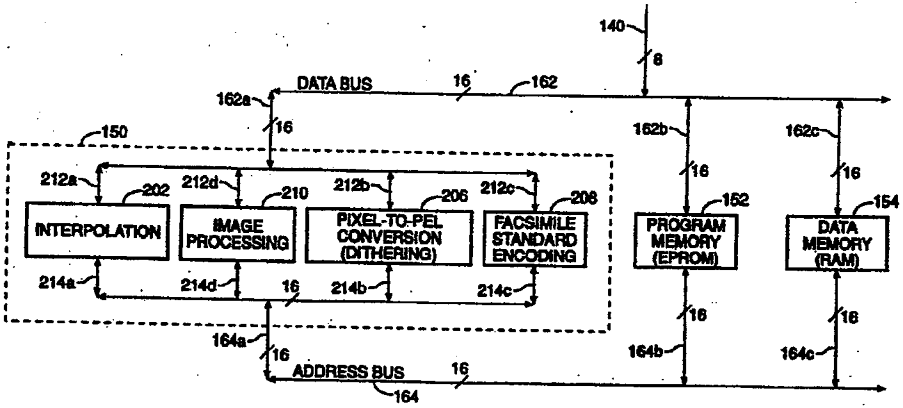
4,514,767	4/1985	Kubota et al.	382/54
4,720,849	1/1988	Tayama	358/401
4,802,008	1/1989	Walling	358/406
4,979,028	12/1990	Minematsu et al.	358/261.4
5,067,019	11/1991	Juday et al.	358/160

Primary Examiner—Edward L. Coles, Sr.
Assistant Examiner—Jerome Grant, II

[57] **ABSTRACT**

A video-to-facsimile signal converter includes means for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of the continuous tone video image. An analog-to-digital converter receives and converts an analog video signal to digital video data which is captured by a video data two-field buffer. A digital signal processor, in conjunction with a memory look-up table, processes the captured video data by: interpolating the video data from the video resolution up to a higher facsimile resolution; selectively enhancing the image by sharpening image edges; precompensating the interpolated video data by altering its contrast transfer function; and dithering the interpolated and precompensated video data to produce video pel data blocks which correspond to the original video pixel data blocks and have similar composite gray-scale values. A facsimile encoder then encodes the interpolated, precompensated and dithered video data in accordance with the CCITT Group 3 facsimile standard. A MODEM and data access arrangement couple the facsimile-encoded signal onto a telephone line for transmission to and reception by a facsimile receiver for simulating the original continuous tone video image.

26 Claims, 9 Drawing Sheets



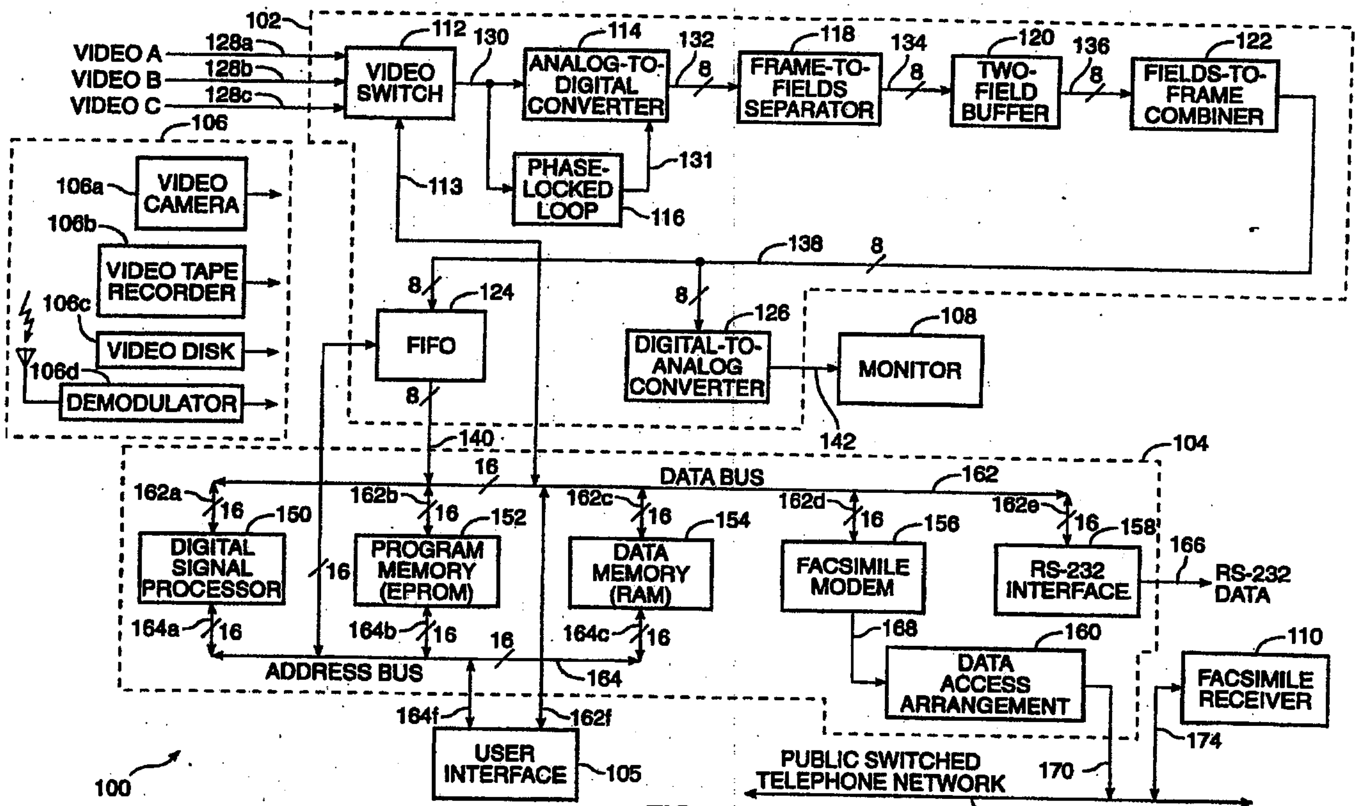

102
VIDEO A
VIDEO B
VIDEO C
128a
128b
128c
112
VIDEO SWITCH
130
114
ANALOG-TO-DIGITAL CONVERTER
132
8
118
FRAME-TO-FIELDS SEPARATOR
134
8
120
TWO-FIELD BUFFER
136
8
122
FIELDS-TO-FRAME COMBINER
106
106a
VIDEO CAMERA
106b
VIDEO TAPE RECORDER
106c
VIDEO DISK
106d
DEMODULATOR
113
PHASE-LOCKED LOOP
131
116
138
8
8
124
FIFO
8
8
126
DIGITAL-TO-ANALOG CONVERTER
108
MONITOR
142
140
104
16
DATA BUS
162
162a
16
150
DIGITAL SIGNAL PROCESSOR
162b
16
152
PROGRAM MEMORY (EPROM)
16
162c
16
154
DATA MEMORY (RAM)
162d
16
156
FACSIMILE MODEM
162e
16
158
RS-232 INTERFACE
166
RS-232 DATA
164a
16
164b
16
16
164c
16
ADDRESS BUS
164
168
160
DATA ACCESS ARRANGEMENT
110
FACSIMILE RECEIVER
174
164f
162f
USER INTERFACE
105
100
PUBLIC SWITCHED TELEPHONE NETWORK
170
172

FIG. 1

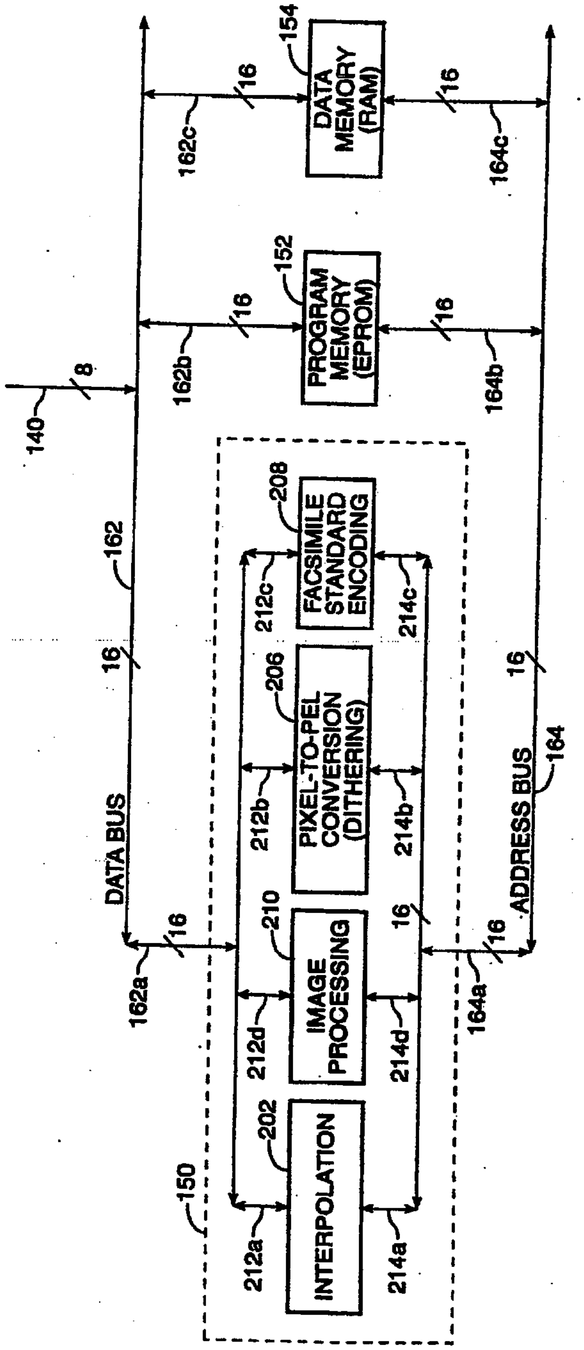

DATA MEMORY (RAM)
154
16
162c
16
164c
PROGRAM MEMORY (EPROM)
152
16
162b
16
164b
140
8
FACSIMILE STANDARD ENCODING
208
212c
214c
PIXEL-TO-PEL CONVERSION (DITHERING)
206
212b
214b
IMAGE PROCESSING
210
212d
214d
INTERPOLATION
202
212a
214a
150
DATA BUS
162
16
162a
16
16
ADDRESS BUS
164
16
164a
16

FIG. 2a

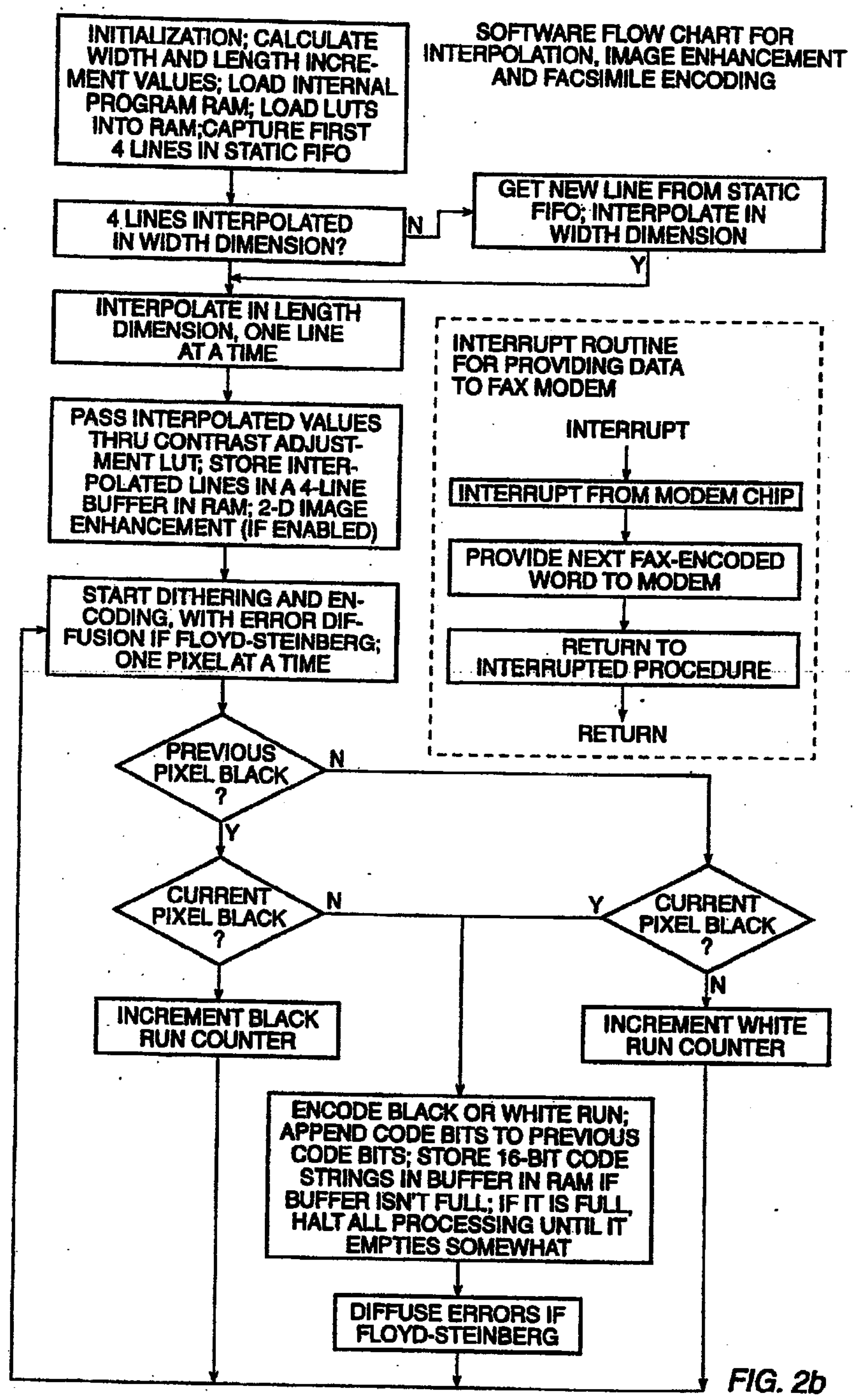

SOFTWARE FLOW CHART FOR INTERPOLATION, IMAGE ENHANCEMENT AND FACSIMILE ENCODING
INITIALIZATION; CALCULATE WIDTH AND LENGTH INCREMENT VALUES; LOAD INTERNAL PROGRAM RAM; LOAD LUTS INTO RAM;CAPTURE FIRST 4 LINES IN STATIC FIFO
4 LINES INTERPOLATED IN WIDTH DIMENSION?
N
GET NEW LINE FROM STATIC FIFO; INTERPOLATE IN WIDTH DIMENSION
Y
INTERPOLATE IN LENGTH DIMENSION, ONE LINE AT A TIME
PASS INTERPOLATED VALUES THRU CONTRAST ADJUSTMENT LUT; STORE INTERPOLATED LINES IN A 4-LINE BUFFER IN RAM; 2-D IMAGE ENHANCEMENT (IF ENABLED)
START DITHERING AND ENCODING, WITH ERROR DIFFUSION IF FLOYD-STEINBERG; ONE PIXEL AT A TIME
INTERRUPT ROUTINE FOR PROVIDING DATA TO FAX MODEM
INTERRUPT
INTERRUPT FROM MODEM CHIP
PROVIDE NEXT FAX-ENCODED WORD TO MODEM
RETURN TO INTERRUPTED PROCEDURE
RETURN
PREVIOUS PIXEL BLACK ?
N
Y
CURRENT PIXEL BLACK ?
N
Y
CURRENT PIXEL BLACK ?
N
INCREMENT BLACK RUN COUNTER
INCREMENT WHITE RUN COUNTER
ENCODE BLACK OR WHITE RUN; APPEND CODE BITS TO PREVIOUS CODE BITS; STORE 16-BIT CODE STRINGS IN BUFFER IN RAM IF BUFFER ISN'T FULL; IF IT IS FULL, HALT ALL PROCESSING UNTIL IT EMPTIES SOMEWHAT
DIFFUSE ERRORS IF FLOYD-STEINBERG

FIG. 2b

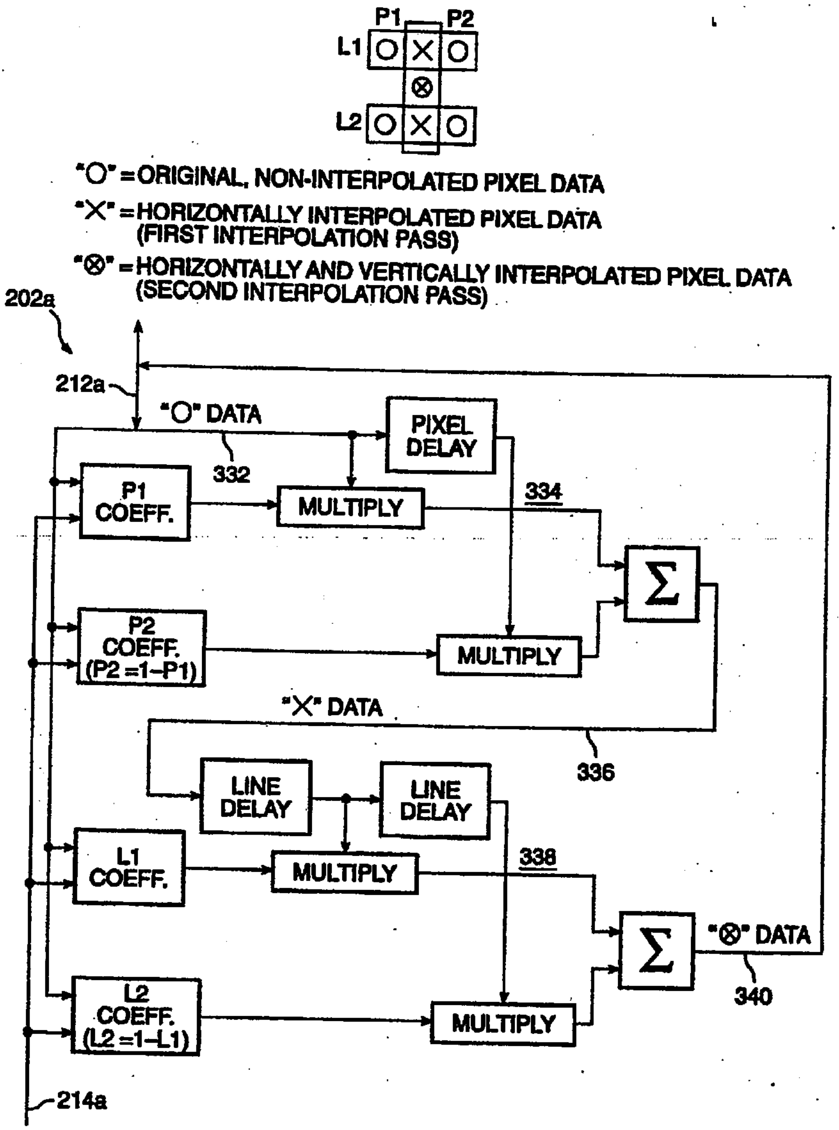
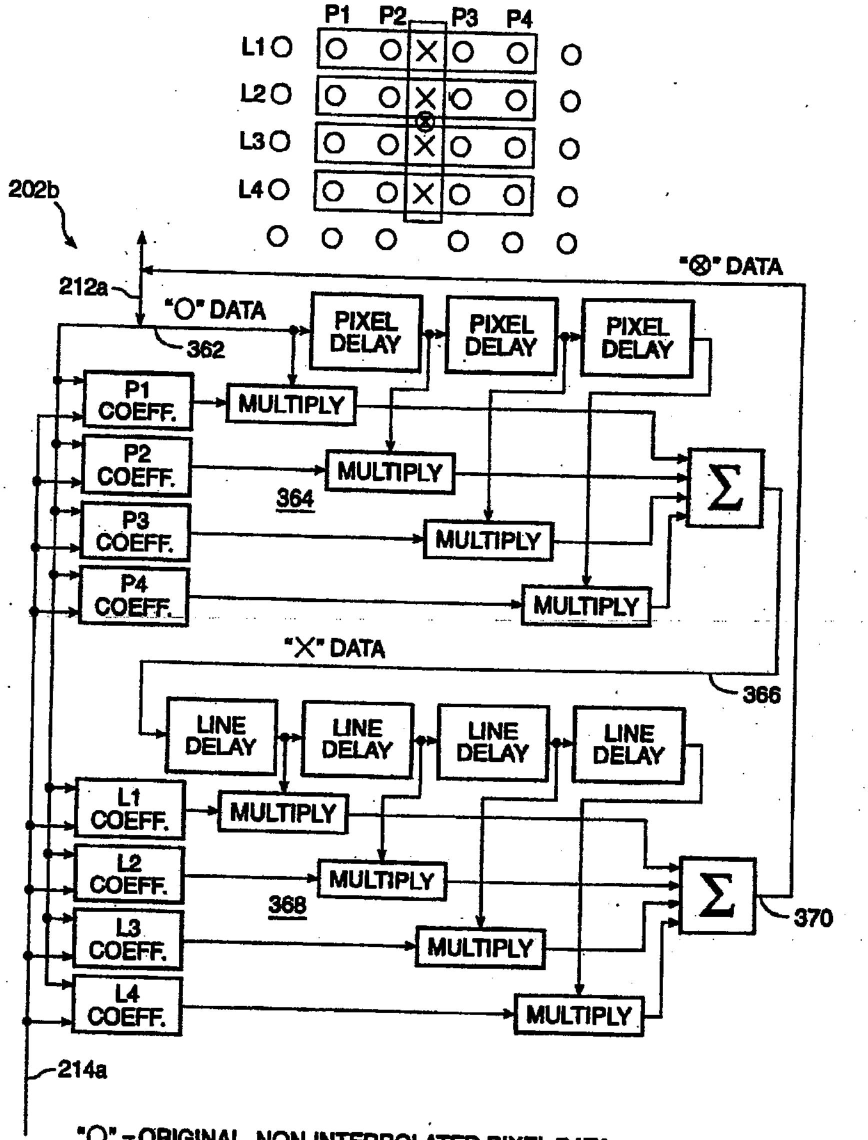

P1
P2
L1
L2
"O" = ORIGINAL, NON-INTERPOLATED PIXEL DATA
"X" = HORIZONTALLY INTERPOLATED PIXEL DATA (FIRST INTERPOLATION PASS)
"⊗" = HORIZONTALLY AND VERTICALLY INTERPOLATED PIXEL DATA (SECOND INTERPOLATION PASS)
202a
212a
"O" DATA
332
PIXEL DELAY
P1 COEFF.
MULTIPLY
334
Σ
P2 COEFF. (P2 = 1−P1)
MULTIPLY
"X" DATA
336
LINE DELAY
LINE DELAY
L1 COEFF.
MULTIPLY
338
Σ
"⊗" DATA
340
L2 COEFF. (L2 = 1−L1)
MULTIPLY
214a

FIG. 3a



"O" = ORIGINAL, NON-INTERPOLATED PIXEL DATA

"X" = HORIZONTALLY INTERPOLATED PIXEL DATA (FIRST INTERPOLATION PASS)

"⊗" = HORIZONTALLY AND VERTICALLY INTERPOLATED PIXEL DATA (SECOND INTERPOLATION PASS)

FIG. 3b

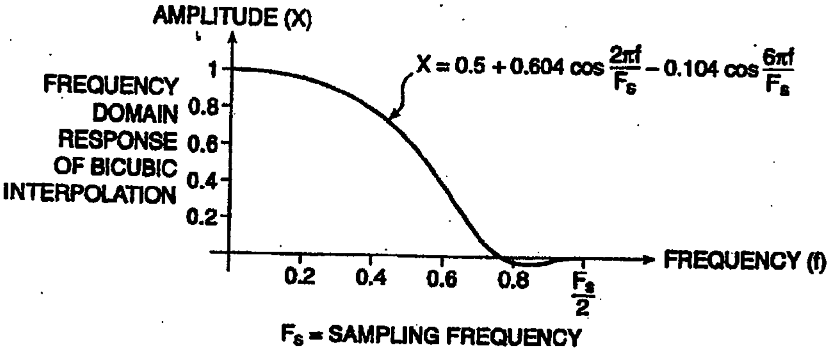
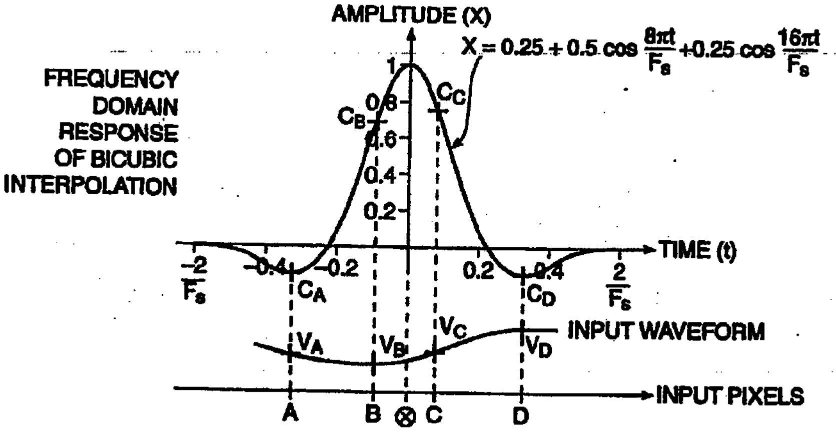


FIG. 3c



⊗ = $C_AV_A + C_BV_B + C_CV_C + C_DV_D$

F_s = SAMPLING FREQUENCY

C_m = INTERPOLATION COEFFICIENTS

V_m = INPUT PIXEL DATA (SAMPLES OF INPUT WAVEFORM TAKEN AT F_s)

FIG. 3d

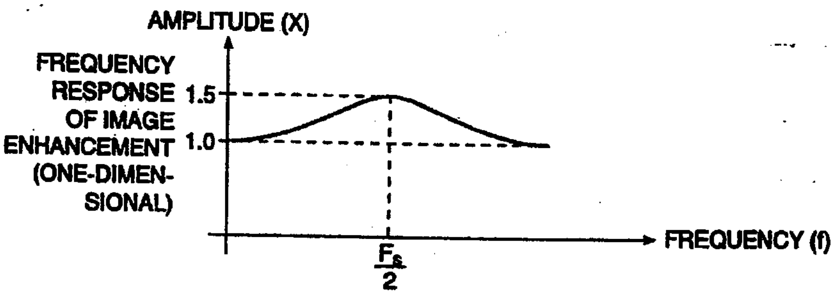
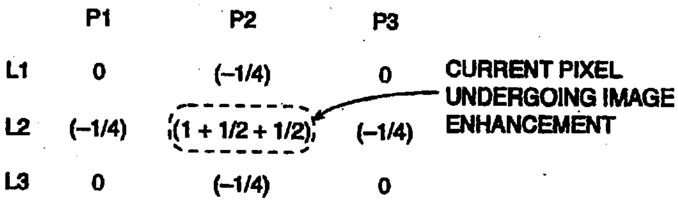


FIG. 4a



	P1	P2	P3
L1	0	(−1/4)	0
L2	(−1/4)	(1 + 1/2 + 1/2)	(−1/4)
L3	0	(−1/4)	0

CURRENT PIXEL UNDERGOING IMAGE ENHANCEMENT

FIG. 4b

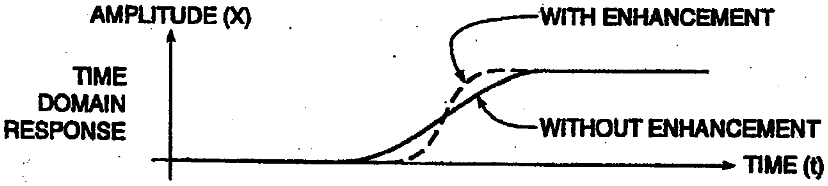


FIG. 4c

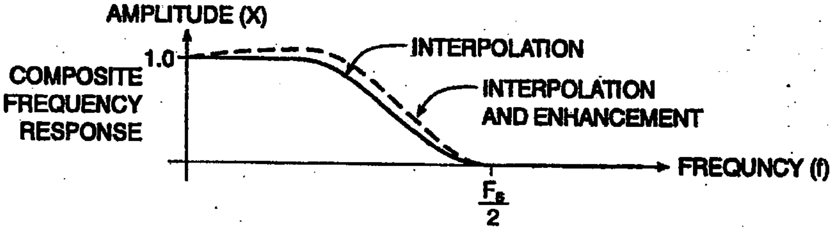


FIG. 4d

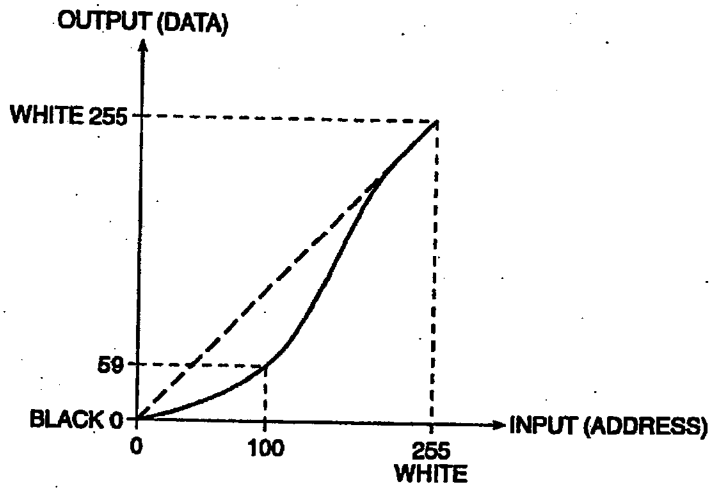

OUTPUT (DATA)
WHITE 255
59
BLACK 0
0
100
255
WHITE
INPUT (ADDRESS)

FIG. 5a

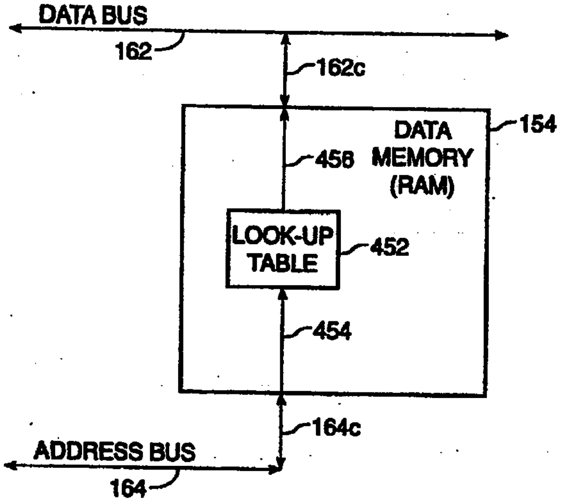

DATA BUS
162
162c
DATA
MEMORY
(RAM)
154
456
LOOK-UP
TABLE
452
454
164c
ADDRESS BUS
164

FIG. 5b

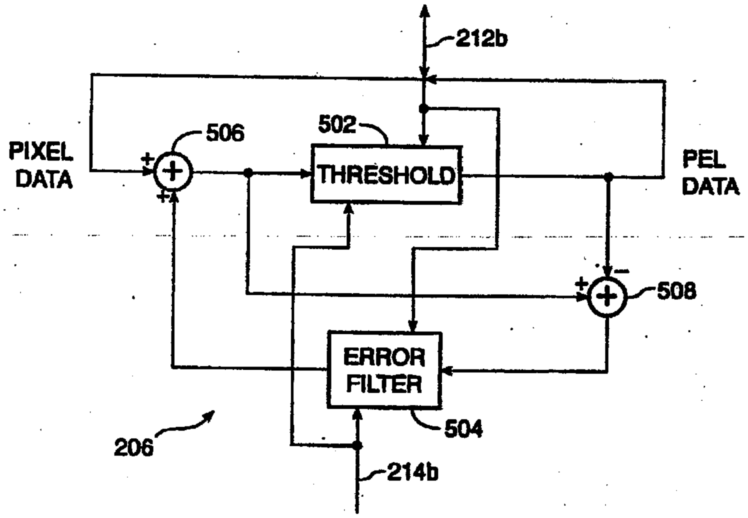

212b
502
506
PIXEL DATA
+
+
THRESHOLD
PEL DATA
+
−
508
ERROR FILTER
504
206
214b

FIG. 6

VIDEO-TO-FACSIMILE SIGNAL CONVERTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to video signal processors, and in particular, video signal processors for receiving and converting a video signal having multiple bits per pixel and representing a continuous tone video image to a facsimile signal having a single bit per pixel for transmission to and reception by a facsimile machine for producing a hard copy representation of the continuous tone video image.

2. Description of the Related Art

As the sophistication and capabilities of video system components such as video cameras and tape recorders have increased and their costs have decreased, uses for such components to capture and retain visual images in the form of video signals have increased in both number and form. Two uses in particular have become substantially more widespread. One use involves the capture and retention of visual images for use at a later time. Video signal recorders, such as video tape recorders, video cassette recorders or video disks, have served quite well for such uses. Another use involves the capture and transmission of video images for use at a distant, e.g. remote, location. This type of use has generally required some means of signal transmission to convey the video signal representing the visual image to the remote location. Such means of signal transmission typically include the use of some form of hard-wired video signal transmission medium, such as co-axial cable, or a radio frequency ("RF") transceiver. The former if often unwieldy or impractical, particularly over long distances, while the latter is often expensive and subject to restricted and heavily regulated RF spectrum allocations.

Other means for conveying video signals which has been used with some success are telephone networks. By converting the subject video signal to a digital video signal consisting of video pixel data and coupling it onto a telephone line via a modulator-demodulator ("MODEM"), the video information can be transmitted, albeit slowly, to many possible locations. At the receiving end, the video pixel data can be retrieved with another MODEM and processed as needed for viewing on a video monitor or storage on video tape. Alternatively, the video pixel data, if transmitted in accordance with an appropriate data standard, can be received by a facsimile machine and "reproduced" in the form of a hard copy printout.

However, such "reproduction" by a facsimile machine is not accurate. A video signal representing a continuous tone video image, when digitized, contains video pixel data (e.g. eight bits) representing the gray-scale values, or contrast range, of the continuous tone video image. However, a facsimile machine is capable of reproducing pel data (i.e. single bit) only, which may be thought of as a single bit per pixel. Accordingly, some form of "thresholding" is often performed to convert the video pixel data to video pel data for use by the facsimile machine. However, this generally results in a reproduced video image having a flat or grainy appearance. One technique which has been used with varying success to avoid this flat image appearance is "dithering." In "dithering," for each selected group of original pixels a group of corresponding pels is produced, which as a group, has a composite gray-scale value similar to that of the original group of pixels.

Accordingly, it would be desirable to have a video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal suitable for transmission to and reception by a commercial facsimile machine for more accurately "reproducing" the continuous tone video image by way of a hard copy printout.

SUMMARY OF THE INVENTION

A video-to-facsimile signal converter in accordance with the present invention receives and converts a video signal representing a continuous tone video image to a facsimile signal suitable for transmission to and reception by a facsimile receiver for simulating the continuous tone video image. The present invention includes means for selective data interpolation, image processing, signal contrast alteration, pixel-to-pel data signal conversion and encoding, as well as means for providing appropriate control signals for each of these operations.

The data interpolator, in accordance with a conversion control signal, receives and interpolates a pixel data signal representing the continuous tone video image by converting the size of the video image to a size appropriate for a facsimile printout. The image processor means selectively processes the pixel data signal to provide the desired image (e.g. sharpened, negative, contour-mapped) for printing out on a facsimile machine. The signal contrast alternation means, in accordance with a conversion control signal, receives and selectively alters the interpolated pixel data signal to selectively alter its contrast transfer function. The pixel-to-pel data signal converter, in accordance with a conversion control signal, receives and converts the interpolated and selectively altered pixel data signal to a pel data signal. The pel data signal has a composite gray-scale value when viewed over a block of pels which closely approximates the composite gray-scale value over the corresponding block of pixels. The encoder, in accordance with a conversion control signal, encodes the pel data signal according to a selected facsimile encoding standard to produce a facsimile standard signal. A preferred embodiment of the present invention uses a digital signal processor as the means for selective data interpolation, image processing, signal constrast alteration, pixel-to-pel data signal conversion and encoding, with a memory as the means for providing appropriate control signals for each of these operations.

These and other features and advantages of the present invention will be understood upon consideration of the following detailed description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a video system using a video-to-facsimile signal converter in accordance with the present invention.

FIG. 2A is a functional block diagram of a video-to-facsimile signal converter in accordance with the present invention.

FIG. 2B is a flowchart representing the video-to-facsimile signal conversion performed by the video-to-facsimile signal converter of FIG. 2A.

FIG. 3A is a functional block diagram of an exemplary bilinear interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3B is a functional block diagram of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3C illustrates the frequency domain response of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 3D illustrates the time domain response of an exemplary bicubic interpolation operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4A illustrates the frequency response of an exemplary image enhancement operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4B illustrates the two-dimensional filter coefficients for an exemplary image enhancement operation for the video-to-facsimile signal converter of FIG. 2A.

FIG. 4C illustrates the relative time domain responses for the video-to-facsimile signal converter of FIG. 2A with and without an image enhancement operation.

FIG. 4D illustrates the composite frequency responses for the video-to-facsimile signal converter of FIG. 2A with an interpolation operation only, and with both interpolation and image enhancement operations.

FIG. 5A illustrates an exemplary contrast alteration curve representing the transfer function of the contrast alteration operation of the video-to-facsimile signal converter of FIG. 2A.

FIG. 5B is a functional block diagram of an exemplary contrast alteration means for the video-to-facsimile signal converter of FIG. 2A.

FIG. 6 is a functional block diagram of the operation of an error diffusion algorithm used for a pixel-to-pel data conversion operation for the video-to-facsimile signal converter of FIG. 2A.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a video system 100 using a video-to-facsimile signal converter in accordance with the present invention includes a video signal processing section 102, a video signal conversion section 104 and a user interface 105. As discussed further below, normal operation of the video system 100 will include use of a video source 106, a video monitor 108 and a facsimile receiver 110.

The video processor section 102 includes a: video switch 112; analog-to-digital converter ("ADC") 114; phase-locked loop ("PLL") 116; frame-to-fields separator 118; two-field buffer 120; fields-to-frame combiner 122; first-in, first-out memory ("FIFO") 124; and digital-to-analog converter ("DAC") 126. The video switch 112 receives a plurality of video input signals 128*a*, 128*b*, 128*c*, which can be video signals in accordance with a number of formats (e.g. NTSC or PAL in color or monochrome), and a switch control signal 113. Any of these video input signals 128*a*, 128*b*, 128*c* can come from virtually any type of video source 106. The video source 106 can be of many different types, such as a video camera 106*a*, video tape recorder 106*b*, video disk player 106*c* or a demodulator 106*d* which receives some form of over-the-air video broadcast signal. The switch control signal 113, received from the video signal conversion section 104 (discussed further below), determines which video input signal 128*a*, 128*b*, 128*c* is selected.

The selected video signal 130 from the video switch 112 is received by the ADC 114 and PLL 116. The PLL 116, based upon its input video signal 130, generates a synchronization signal 131 for the ADC 114. The ADC 114 samples (at a sampling frequency F_S of approximately 9.7 MHz) and converts its input video signal 130 to a 8-bit wide digitized monochrome video signal 132. Each 8-bit word within this signal 132 represents a pixel, and therefore provides a 256-value gray-scale.

The digitized video signal 132 is received by the frame-to-fields separator 118. The frame-to-fields separator 118 allows the two fields which make up a video frame to be treated separately. Video data 134 representing both fields can be stored in the two-field buffer 120, and can provide a deinterlaced frame image. Alternatively, video data 134 representing one field (either odd or even) can be selected and used as the representation of the original video image. The buffered two-field video data 136 is received by the fields-to-frame combiner 122 for selective recombination. This allows for the display of either a correct, i.e. interlaced, two-field frame or a frame made up of two copies of one field (odd or even).

The video frame data 138 is received by the FIFO 124 and DAC 126. The FIFO 124 receives and stores several selected lines (as desired) from this video frame data 138 and provides corresponding, selectively delayed output video data 140 on a first-in, first-out basis. The DAC 126 converts the digital video frame data 138 to an analog video signal 142 for reception and display on a video monitor 108. This allows the user of the system 100 to view the video information which is being processed by the video processing section 102 and converted by the video converting section 104.

Although in the preferred embodiment described herein the digitized 132 and subsequently processed video signals 134, 136, 138 represent monochrome video information, it should be understood that the ADC 114 can alternatively be designed to sample and convert an analog color input video signal 130 to a digital color signal. For example, this digital color signal can include three 8-bit wide digitized video signals (in serial or parallel) which represent red, green and blue video information. Each group of three 8-bit words within such a color signal would represent the red, green and blue color components of a pixel. The color components could be those of any system used to represent color, such as RGB, YUV (PAL) or CYMK.

The video converter section 104 includes a: digital signal processor ("DSP") 150; program memory (e.g. EPROM) 152; data memory (e.g. RAM) 154; facsimile MODEM 156; RS-232 interface 158; and a data access arrangement ("DAA") 160. A data bus 162 is included for receiving the data 140 from the FIFO 124 (in the video processing section 102, as discussed above) and for transferring data among the DSP 150, program memory 152, data memory 154, facsimile MODEM 156 and RS-232 interface 158. An address bus 164 is included to allow the DSP 150 to address the FIFO 124, program memory 152 and data memory 154, as desired.

The data 140 from the FIFO 124, transferred via the data bus 162, is received by the DSP 150 for processing. As discussed further below, the DSP 150 processes this data in accordance with instructions received from the program memory 152 and data received from the data memory 154 via the data bus 162 and address bus 164. Once processed, the data is transferred via the data bus 162 to the facsimile MODEM 156 or RS-232 interface 158.

The RS-232 interface 158 encodes data received by it and provides an RS-232 data signal 166 for external use. The facsimile MODEM 156 converts (e.g. modulates) data received by it for transmission over a telephone line. The facsimile MODEM 156 provides this converted signal 168 to the data access arrangement 160, which in turn provides an appropriately coupled facsimile signal 170 for transmission over a telephone network 172. As discussed further below, a facsimile receiver 110, when appropriately addressed, receives a signal 174 from the telephone network 172 containing the video information to be simulated in the form of hard copy printout.

Interfaces other than the data access arrangement 160 which can be used include an acoustic coupler (not shown) for use with a public telephone or cellular telephone, and a cellular telephone MODEM (not shown) for communicating directly via the cellular telephone network frequencies.

The user interface 105 can be composed as desired of various devices. In a preferred embodiment, a numeric keypad and liquid crystal display ("LCD") are used, respectively, for inputting data or instructions and displaying data or status information. Alternatively, other devices can be used as desired, such as an alphanumeric keypad and a CRT video display screen.

Referring to FIG. 2A, the DSP 150 provides means for interpolation 202, image processing 210, pixel-to-pel conversion 206 and facsimile standard encoding 208 of the video data 140 received from the FIFO 124. Internal data bus interfaces 212a, 212b, 212c, 212d and address bus interfaces 214a, 214b, 214c, 214d provide access to and from the external data bus interface 162a and address bus interface 164a, respectively. This access allows the DSP 150 to receive instructions from the program memory 152 and data from the data memory 154, as well as address the memories 152, 154. As discussed further below, in a preferred embodiment, the interpolator 202, image processor 210, pixel-to-pel converter 206 and facsimile standard encoder 208 represent operations of software modules which are executed by the DSP 150 (discussed further below).

The interpolator 202 receives the video data 140 via the data bus 162 and data bus interfaces 162a, 212a and interpolates it in accordance with instructions received from the program memory 152 via the data bus 162 and data bus interfaces 162b, 162a, 212a (discussed further below). The image processor 210 selectively receives the interpolated data via the data bus interfaces 212a, 212d and processes it in accordance with instructions received from the program memory 152 via the data bus 162 and data bus interfaces 162b, 162a, 212d (discussed further below). The interpolated and image-processed data is transferred, via the data bus 162 and data bus interfaces 212d, 162a, 162c, to the data memory 154 for alteration of its contrast range, i.e. dot gain correction (discussed further below).

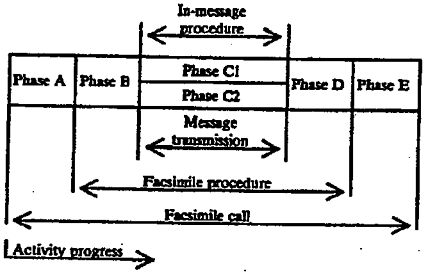
In accordance with instructions and data received from the program memory 152 and data memory 154 via the data bus 162 and address bus 164, respectively, the interpolated, image-processed and contrast-altered data is then retrieved from the data memory 154 via the data bus 162 and data bus interfaces 162c, 162a, 212b, and processed by the pixel-to-pel converter 206 for conversion to pel data (discussed further below). The pel data, i.e. dithered data, is transferred to the data memory 154 for temporary storage prior to its encoding by the facsimile standard encoder 208.

In accordance with instructions and data received from the program memory 152 and data memory 154 via the data bus 162 and address bus 164, respectively,

the pel data is then retrieved from the data memory 154 via the data bus 162 and data bus interfaces 162c, 162a, 212c, and encoded according to a facsimile standard. The facsimile standard-encoded pel data is then sent to the data bus 162 for transfer to the facsimile MODEM 156 or RS-232 interface 158.

In a preferred embodiment of the present invention, the facsimile standard encoding 208 is done in accordance with CCITT Group 3 (Recommendations T.4 and T.30). The time sequence of the facsimile standard-encoded pel data is as shown below in Chart 1.

CHART 1



During phase B of the above-identified time sequence, the initiation of and handshaking for the facsimile message can be performed in accordance with the capabilities of the sending and receiving equipment as outlined in Recommendation T.30, part of which is shown below in Table 1.

TABLE 1

CCITT Group 3 Facsimile Standard

Bit No.	From Receiver DIS/DTC	From Transmitter DCS
1	Transmitter - T.2 operation	
2	Receiver - T.2 operation	Receiver - T.2 operation
3	T.2 IOC = 176	T.2 IOC = 176
4	Transmitter - T.3 operation	
5	Receiver - T.3 operation	Receiver - T.3 operation
6	Reserved for future T.3 operation features	
7	Reserved for future T.3 operation features	
8	Reserved for future T.3 operation features	
9	Transmitter - T.4 operation	
10	Receiver - T.4 operation	Receiver - T.4 operation
11, 12	Data signalling rate	Data signalling rate
(0,0)	V.27 ter fallback mode	2400 bit/s V.27 ter
(0,1)	V.27 ter	4800 bit/s V.27 ter
(1,0)	V.29	9600 bit/s V.29
(1,1)	V.27 ter and V.29	7200 bit/s V.29
13	Reserved for new modulation system	
14	Reserved for new modulation system	
15	Vertical resolution = 7.7 line/mm	Vertical resolution = 7.7 line/mm (200 dpi)
16	Two dimensional coding capability	Two dimensional coding
17, 18	Recording width capabilities	Recording width
(0,0)	1728 picture elements along scan line length of 215 mm ± 1%	1728 picture elements along scan line length of 215 mm ± 1%
(0,1)	1728 picture elements along scan line length of 215 mm ±	2432 picture elements along

TABLE 1-continued

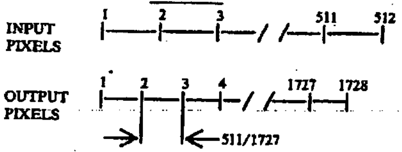
CCITT Group 3 Facsimile Standard

Bit No.	From Receiver DIS/DTC	From Transmitter DCS
	1% 2048 picture elements along scan line length of 255 mm ± 1% 2432 picture elements along scan line length of 303 mm ± 1%	scan line length of 303 mm ± 1%
(1,0)	1728 picture elements along scan line length of 215 mm ± 1% and 2048 picture elements along scan line length of 255 mm ± 1%	2048 picture elements along scan line 255 mm ± 1%
(1,1)	Invalid	Invalid
19, 20	Maximum recording length capability	Maximum recording length
(0,0)	A4 (297 mm)	A4 (297 mm)
(0,1)	Unlimited	Unlimited
(1,0)	A4 (297 mm) and B4 (364 mm)	B4 (364 mm)
(1,1)	Invalid	Invalid
21, 22 23	Minimum scan line time capability at the receiver	Minimum scan line time
(0,0,0)	20 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	20 ms
(0,0,1)	40 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	40 ms
(0,1,0)	10 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	10 ms
(1,0,0)	5 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	5 ms
(0,1,1)	10 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,1,0)	20 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,0,1)	40 ms at 3.85 1/mm: $T_{7.7} = \frac{1}{2} T_{3.85}$	
(1,1,1)	0 ms at 3.85 1/mm: $T_{7.7} = T_{3.85}$	0 ms
24	Extend field	Extend field
25	2400 bit/s handshaking	2400 bit/s handshaking
26	Uncompressed mode	Uncompressed mode
27	Error correction mode	Error correction mode
28	Set to "0"	Frame size 0 = 256 octets 1 = 64 octets
29	Error limiting mode	Error limiting mode
30	Reserved for G4 capability on PSTN	Reserved for G4 capability on PSTN
31	Unassigned	
32	Extend field	Extend field
33	Validity of bits 17, 18	Recording width
(0)	Bits 17, 18 are valid	Recording width indicated by bits 17, 18
(1)	Bits 17, 18 are invalid	Recording width indicated by this field bit information
34	Recording width capability 1216 picture elements along scan line length of 151 mm ± 1%	Middle 1216 elements of 1728 picture elements
35	Recording width capability 864 picture elements along scan line length of 107 mm ± 1%	Middle 864 elements of 1728 picture elements
36	Recording width capability 1728 picture elements along scan line length of 151 mm ± 1%	Invalid
37	Recording width capability 1728 picture elements along scan line length of 107 mm ± 1%	Invalid
38	Reserved for future recording width capability	
39	Reserved for future recording width capability	
40	Extend field	Extend field

Referring to FIG. 2B, a simplified software flowchart depicting these operations in accordance with the foregoing discussion is illustrated. This flowchart represents the sequence of operations performed by the DSP 150 in accordance with instructions stored within the program memory 152 (discussed further below).

The interpolation operation discussed above inserts new pixel data in between existing pixel data by interpolating adjacent pixel data, typically in a bilinear (two-dimensional linear) or bicubic (two-dimensional cubic) fashion. The two-dimensional interpolation (bilinear or bicubic) is performed in two one-dimensional passes, i.e. first horizontally (inter-pixel) and then vertically (inter-line). For example, in the case where 512 pixels on each line are to be expanded to 1728 pixels, the original 512 pixels are first interpolated horizontally to produce 1728 pixels with a concommittant reduction in the individual pixel spacing (i.e. to 5111727), as depicted below in Chart 2.

CHART 2



For bilinear interpolation of each interpolated pixel N, where N∈{0,1,2, . . . ,1727}, adjacent input pixels P and P+1 are used, where P=INT[N(511)/1727)], and INT(X/Y)=integer value of the quotient X/Y. Thus, in the case of the 1000th pixel, i.e. N=1000, pixel 295 (INT[1000(511)/1727)]=295) and pixel 296 (INT[1000(511)/1727)]+1=296) are used. Since the quotient [1000(511)/1727)]=295.89, the interpolation can be done within the DSP 150 via the simple computation:

$$N=(\text{PIXEL } \#295)(1-0.89)+(\text{PIXEL } \#296)(0.89)$$

Alternatively, a look-up table within the data memory 154 can be used, wherein a finite number of interpolation coefficients can be stored for use as needed. An exemplary table of bilinear interpolation coefficients for the present invention are listed below in Table 2. In the foregoing example for N=1000, entry #7 from Table 2 would be used, i.e. coefficients 0.109375 and 0.890625, selected as follows:

$$\begin{aligned}(P+1)-[N(511)/1727)] &= 296-[1000(511)/1727)]\\ &= 296-295.89\\ &= 0.11\end{aligned}$$

$$\begin{aligned}0.11(\#\text{ of coefficient entries}) &= 0.11(64)\\ &= 7.11\end{aligned}$$

Nearest integer to 7.11 = 7

where:

N=(PIXEL #295)(0.109375)+(PIXEL #296)(0.890625)

TABLE 2

BILINEAR INTERPOLATION COEFFICIENTS					
Entry	L_A	L_B	Entry	L_A	L_B
0	0.0	1.0	32	0.5	0.5
1	0.015625	0.984375		0.515625	0.484375
2	0.03125	0.96875		0.53125	0.46875
3	0.046875	0.953125	35	0.546875	0.453125
4	0.0625	0.9375		0.5625	0.4375
5	0.078125	0.921875		0.578125	0.421875
6	0.09375	0.90625		0.59375	0.40625
7	0.109375	0.890625		0.609375	0.390625
8	0.125	0.875	40	0.625	0.375
9	0.140625	0.859375		0.640625	0.359375
10	0.15625	0.84375		0.65625	0.34375
	0.171875	0.828125		0.671875	0.328125
	0.1875	0.8125		0.6875	0.3125
	0.203125	0.796875	45	0.703125	0.296875
	0.21875	0.78125		0.71875	0.28125
15	0.234375	0.765625		0.734375	0.265625
	0.25	0.75		0.75	0.25
	0.265625	0.734375		0.765625	0.234375
	0.28125	0.71875	50	0.78125	0.21875
	0.296875	0.703125		0.796875	0.203125
20	0.3125	0.6875		0.8125	0.01875
	0.328125	0.671875		0.828125	0.171875
	0.34375	0.65625		0.84375	0.15625
	0.359375	0.640625	55	0.859375	0.140625
	0.375	0.625		0.875	0.125
25	0.390625	0.609375		0.890625	0.109375
	0.40625	0.59375		0.90625	0.09375
	0.421875	0.578125		0.921875	0.078125
	0.4375	0.5625	60	0.9375	0.0625
	0.453125	0.546875		0.953125	0.046875
30	0.46875	0.53125		0.96875	0.03125
31	0.484375	0.515625	63	0.984375	0.015625

Referring to FIG. 3A, the operation of an exemplary bilinear interpolator *202a* is depicted. Incoming, non-interpolated pixel data 332, received via the data bus interface *212a*, is horizontally interpolated by a horizontal linear interpolator 334. The horizontally interpolated pixel data 336 is received and vertically interpolated by a vertical linear interpolator 338. The horizontally and vertically interpolated pixel data 340 is then available for transfer to the data memory 154 for temporary storage, as discussed above. The pixel coefficients P1, P2, L1, L2 (discussed above) are selectively provided in accordance with instructions and addressing received via the data bus interface *212a* and address interface *214a* from the program memory 152 and data memory 154.

Referring to FIG. 3B, the operation of an exemplary bicubic interpolator *202b* is depicted. Incoming, non-interpolated pixel data 362, received via the data bus interface *212a*, is horizontally interpolated by a horizontal cubic interpolator 364. The horizontally interpolated pixel data 366 is received and vertically interpolated by a vertical cubic interpolator 368. The horizontally and vertically interpolated pixel data 370 is then available for transfer to the data memory 154 for temporary storage, as discussed above. The pixel coefficients P1, P2, P3, P4, L1, L2, L3, L4 (discussed further below) are selectively provided in accordance with instructions and addressing received via the data bus interface *212a* and address interface *214a* from the program memory 152 and data memory 154.

It should be understood that the time delays represented by the "pixel delay" blocks in FIGS. 3A and 3B are not required as discrete elements or operations if the original, non-interpolated pixel data is retrieved from the data memory 154 at the appropriate times. Further, the time delays represented by the "line delay" blocks are not required as discrete elements or operations if the horizontally interpolated pixel data is temporarily stored in and retrieved from the data memory 154 at the appropriate times.

Using the example discussed above for bilinear horizontal interpolation of 511 pixels to 1728 pixels, bicubic horizontal interpolation of interpolated pixel N uses adjacent input pixels P−1, P, P+1 and P+2, where P=INT[N(511)/1727)], and INT(X/Y)=integer value of the quotient X/Y. Thus, in the case of the 1000th pixel, i.e. N=1000, pixel 294 (INT[1000(511)/1727)]−1=294), pixel 295 (INT[1000(511)/1727)]=295), pixel 296 (INT[1000(511)/1727)]+1=296) and pixel 297 (INT[1000(511)/1727)]+2=297) are used.

The bicubic interpolation coefficients are stored in the data memory 154 for access and use by the DSP 150 as needed. An exemplary table of bicubic interpolation coefficients for the present invention are listed below in Table 3. In accordance with the discussion above for the example of N=1000, entry #7 from Table 3 would be used, i.e. the four coefficients −0.0072528, 0.100095, 0.978025 and −0.070867 (selected as shown above).

TABLE 3

BICUBIC INTERPOLATION COEFFICIENTS				
Entry	C_A	C_B	C_C	C_D
0	0.0	0.0	1.0	0.0
1	−0.000150545	0.0125718	0.999548	−0.0119695
2	−0.000601546	0.0257377	0.998194	−0.0233
3	−0.0013511	0.0394882	0.995939	−0.0340764
4	−0.00239604	0.0538123	0.992789	−0.0442049
5	−0.00373195	0.0686975	0.988748	−0.0537132
6	−0.00535317	0.0841302	0.983823	−0.0626003
7	−0.0072528	0.100095	0.978025	−0.070867
8	−0.00942276	0.116575	0.971363	−0.078515
9	−0.0118537	0.133553	0.963848	−0.0855479
10	−0.0145353	0.15101	0.955496	−0.0919704
	−0.0174559	0.168924	0.94632	−0.0977885
	−0.0206028	0.187275	0.936338	−0.10301
	−0.0239622	0.206039	0.925566	−0.107643
	−0.0275194	0.225192	0.914025	−0.111698
15	−0.0312586	0.24471	0.901734	−0.115185
	−0.0351631	0.264565	0.888716	−0.118118
	−0.0392151	0.284731	0.874995	−0.12051
	−0.0433963	0.305179	0.860593	−0.122376
	−0.0476873	0.325881	0.845537	−0.12373
20	−0.0520681	0.346806	0.829853	−0.124591
	−0.0565178	0.367923	0.813569	−0.124975
	−0.0610151	0.389202	0.796713	−0.124901
	−0.065538	0.41061	0.779316	−0.124388
	−0.0700639	0.432114	0.761406	−0.123456
25	−0.0745699	0.453682	0.743015	−0.122127
	−0.0790326	0.475278	0.724175	−0.120421
	−0.0834282	0.496871	0.704918	−0.118361
	−0.0877326	0.518424	0.685278	−0.115969
	−0.0919218	0.539904	0.665287	−0.113269
30	−0.0959713	0.561275	0.64498	−0.110284
	−0.0998566	0.582503	0.62439	−0.107037
	−0.103553	0.603553	0.603553	−0.103553
	−0.107037	0.62439	0.582503	−0.0998566
	−0.110284	0.64498	0.561275	−0.0959713
35	−0.113269	0.665287	0.539904	−0.0919218
	−0.115969	0.685278	0.518424	−0.0877326
	−0.118361	0.704918	0.496871	−0.0834282
	−0.120421	0.724175	0.475278	−0.0790326
39	−0.122127	0.743015	0.453682	−0.0745699
40	−0.123456	0.761406	0.432114	−0.0700639
41	−0.124388	0.779316	0.41061	−0.065538
	−0.124901	0.796713	0.389202	−0.0610151
	−0.124975	0.813569	0.367923	−0.0565178
	−0.124591	0.829853	0.346806	−0.0520681
45	−0.12373	0.845537	0.325881	−0.0476873

TABLE 3-continued

BICUBIC INTERPOLATION COEFFICIENTS				
Entry	C_A	C_B	C_C	C_D
	−0.122376	0.860593	0.305179	−0.0433963
	−0.12051	0.874995	0.284731	−0.0392151
	−0.118118	0.888716	0.264565	−0.0351631
	−0.115185	0.901734	0.24471	−0.0312586
50	−0.111698	0.914025	0.225192	−0.0275194
	−0.107643	0.925566	0.206039	−0.0239622
	−0.10301	0.936338	0.187275	−0.0206028
	−0.0977885	0.94632	0.168924	−0.0174559
	−0.0919704	0.955496	0.15101	−0.0145353
55	−0.0855479	0.963848	0.133553	−0.0118537
	−0.078515	0.971363	0.116575	−0.00942276
	−0.070867	0.978025	0.100095	−0.0072528
	−0.0626003	0.983823	0.0841302	−0.00535317
	−0.0537132	0.988748	0.0686975	−0.00373195
60	−0.0442049	0.992789	0.0538123	−0.00239604
	−0.0340764	0.995939	0.0394882	−0.0013511
	−0.02333	0.998194	0.0257377	−0.000601546
63	−0.0119695	0.999548	0.0125718	−0.000150545

Referring to FIG. 3C, the filtering effect of the bicubic interpolation in the frequency domain is shown. The amplitude versus frequency function is similar to that of a low-pass filter. During bicubic interpolation, the product of this function and the function representing the frequency response of the incoming pixel data provides the output, i.e. interpolated, pixel data.

Referring to FIG. 3D, the filtering effect of the bicubic interpolation in the time domain is shown. Also shown are the graphical relationships between the input pixels and the corresponding interpolation coefficients' values. Here in FIG. 3D, input pixels A, B, C, and D would correspond to pixels **294**, **295**, **296** and **297**, respectively, as discussed in the example above. During bicubic interpolation, the convolution of this function and the incoming pixel data provides the output, i.e. interpolated, pixel data ($C_AV_A+C_BV_B+C_CV_C+C_DV_D$).

The image processing **210** performed can be of several various types, such as video data inversion, contour mapping or contrast manipulation. Video data inversion would provide for a "negative" image. Contour mapping would involve the application of multiple thresholds to the video data for providing an image with more of a stepped gray-scale, or for allowing the detection of changes in a scene being monitored using simple comparison techniques. One form of contrast manipulation can involve the changing of the video data contrast transfer function to expose image details otherwise hidden in shadows or a dark scene.

In a preferred embodiment of the present invention, the image processing **210** performed is image enhancement, which is done in two dimensions. As seen in FIG. 4A, the one-dimensional frequency response of the image enhancement is amplification of data signal amplitudes at the frequencies closely adjacent to half of the sampling frequency ($F_S/2$) of the ADC **114**. As seen in FIG. 4B, a two-dimensional filter is used where, in both the horizontal and vertical filtering, the current input pixel data undergoing enhancement is multiplied by a coefficient of 2.0 and the immediately adjacent horizontal and vertical pixels' data are each multiplied by a coefficient of −0.25. The sum of these products provides the image-enhanced pixel data.

Referring to FIG. 4C, the effect of the image enhancement can be seen in the time domain. The edges of an image are sharpened in the sense that data amplitude transitions are rendered more steep, i.e. faster. The effect in the frequency domain, as shown in FIG. 4D, is to increase the frequency at which the response begins to roll of, i.e. increase the effective low-pass filter bandwidth as compared to that of interpolation only (discussed above).

Referring to FIG. 5A, an exemplary output versus input transfer function is illustrated graphically for the contrast alteration, or dot gain correction, process performed by the DSP **150**, program memory **152** and data memory **154**, as discussed above (FIG. 2A). As seen in FIG. 5A, the transfer function, normally a linear output versus input relationship, is selectively altered to cause input pixel information having medium gray-scale values to be darkened. This type of altered transfer function can be computed or derived semi-empirically to give the best results with a gray-scale ramp input as the test image. Further, this type of altered transfer function represents the inverse of the typical nonlinear characteristics of a typical facsimile printing mechanism, thereby providing a form of precompensation for the video image data to be printed thereby.

Referring to FIG. 5B, a preferred implementation of the aforementioned contrast alteration process includes a look-up table **452** which is constructed within a portion of the data memory **154**. The interpolated pixel data **454** is received via the address bus **164** and address bus interface **164c** and serves as the input address(es) for the look-up table **452**. The accessed data **456** has values which are in accordance with the desired transfer function, as discussed above (FIG. 5A). This data **456** is conveyed via the data bus interface **162c** to the data bus **162** for transfer to the DSP **150** and conversion by the pixel-to-pel converter **206** as discussed above (FIG. 2A).

It should be understood that, since the look-up table **452** uses only a portion of the data memory **154** and that portion need not necessarily begin at address location "zero," the input addresses, i.e. the interpolated pixel data **454**, can include an address offset. The address offset would increment the address values appropriately to access that portion of the data memory **154** constituting the look-up table **452**. The address offset can be generated and added to the interpolated pixel data **454** by the DSP **150**, with the result placed onto the address bus **164**.

As initially discussed above, the pixel-to-pel converter **206** receives and converts pixel data to pel data. This process, often referred to as "dithering," can be performed in accordance with a number of techniques. Three techniques, as discussed below and represented in Matrices 1-3 below, involve using a: 45° Classical Screen (Matrix 1); Line Screen (Matrix 2); or Spiral Dot Screen (Matrix 3). A more detailed discussion regarding these techniques can be found in R. Ulichney, "Digital Halftoning," pp. 77-126, MIT Press 1987 (incorporated herein by reference).

Referring to Matrix 1 below, the 45° Classical Screen mimics the 50-100 lines per inch screen traditionally used in printing a continuous tone image in newspapers or magazines. The triangularly-shaped numerical arrays are replicated over the entire image, thereby giving a superimposed screen which alternates from light to dark, 50-100 times per inch. The number within the numerical arrays are threshold values to which the 8-bit pixel's gray-scale value are compared one at a time to resolve 19 (Matrix 1(a)) or 33 (Matrix 1(b)) gray levels.

The incoming pixel data is compared with the corresponding threshold value within the superimposed threshold numerical array, and if the pixel value is less than the threshold value, a black dot is printed. Conversely, if the pixel value is greater than the threshold value, no black dot is printed. In this way, each pixel (8-bit) is converted to a pel (1-bit) which the receiving facsimile machine **110** (FIG. 1) can print out either as a black dot, or as the absence of a black dot. The resulting image, now seen through the superimposed Classical Screen, consists of pels, i.e. 1-bit pixels.

MATRIX 1:
Threshold Arrays for 45° Classical Screens

(a) M = 3 (19 levels of gray with 8-bit pixel values over range of 0–255)

			134			
		27	175	243		
	54	40	187	202	216	
134	162	148	121	94	108	134
	243	229	81	13	27	
		216	67	54		
			134			

(b) M = 4 (33 levels of gray with 8-bit pixel values over range of 0–255)

				147				
			78	217	225			
		16	85	209	248	240		
	54	62	116	186	202	194	140	
147	163	155	132	109	93	101	124	147
	225	233	178	39	31	23	78	
		240	171	47	8	16		
			140	70	54			
				147				

Referring below to Matrix 2, the Line Screen operates similarly to the Classical Screen, except that the superimposed screen is at 0°, rather than 45°. This will produce a final image which is more coarse, but will reduce the transmission time since the facsimile standard encoding (discussed further below) operates along lines. The Line Screen tends to concentrate dots along lines, whereas the Classical Screen concentrates them in a 45° orientation.

MATRIX 2:
Threshold Array for Line Screen

(37 levels of gray with 8-bit pixel values over range of 0–255)

				⋮				
	249	235	221	214	228	242	249	
	166	152	138	131	145	159	166	
	83	69	55	48	62	76	83	
. . .	42	28	14	7	21	35	42	. . .
	125	111	97	90	104	118	125	
	208	194	180	173	187	201	208	
	249	235	221	214	228	242	249	
				⋮				

Referring below to Matrix 3, the Spiral-Dot Screen operates in accordance with the foregoing discussion, with the superimposed screen oriented at 45°. This screen tends to create circular regions of varying intensity, similar to a picture oriented in a typical newspaper.

MATRIX 3:
Threshold Array for Spiral-Dot Screen

(26 levels of gray with 8-bit pixel values over range of 0–255)

			⋮				
	207	217	226	236	246	207	
	197	69	79	89	98	197	
. . .	187	59	10	20	108	187	. . .
	177	49	39	30	118	177	
	167	158	148	138	128	167	
	207	217	226	236	246	207	
			⋮				

The foregoing screen approaches in accordance with Matrices 1–3 compare each unmodified pixel within the image with a threshold value which varies depending upon the current pixel's position within the video image. Referring below to Matrix 4, a preferred embodiment of the present invention uses a technique in which error diffusion is performed in accordance with the Floyd-Steinberg error propagation theory. Floyd-Steinberg error diffusion differs from the foregoing screen approaches in that while each pixel is compared to a fixed threshold, the pixel value being compared consists of its original value plus an error value propagated from surrounding pixels. When the current pixel value is greater than the threshold, the error value is equal to 255 subtracted from the current pixel value. If the current pixel value is less than the threshold, the error value is zero.

MATRIX 4: Error Filter Values

$$\left(\frac{1}{16}x\right)\begin{matrix} & \cdot & 7 \\ 3 & 5 & 1 \end{matrix}$$

Floyd and Steinberg (1975)
(rectangular grid)
("·" represents the current pixel)

Referring to FIG. 6, the pixel-to-pel converter **206** performs pixel-to-pel conversion in accordance with the Floyd-Steinberg theory, which can be visualized as shown. The pixel data (interpolated, contrast-altered and selectively image-enhanced), received from the data memory **154** (FIG. 2A) via the data bus interface *212b*, is converted to pel data using a threshold **502**, error filter **504**, input adder **506** and output adder **508**. As seen above in Matrix 4, to propagate the pixel error in accordance with the Floyd-Steinberg theory, 7/16ths of the error value is added to the next pixel on the same line, 3/16ths of the error value is added to the pixel on the line below and one pixel position to the left, 5/16ths of the error value is added to the pixel directly below, and 1/16th of the error value is added to the pixel below and to the right, as shown. The effect of the Floyd-Steinberg error diffusion is to approximate a gray-scale value, or tone, within a region by producing the approximate number of black dots which correspond to the gray-scale value of the original image, with the dots spread as randomly as possible so that no particular structure is visible.

As initially discussed above, the facsimile standard encoding of the pel data is in accordance with the CCITT Group 3 (Recommendation T.4) facsimile standard. In a preferred embodiment of the present invention, the facsimile standard encoder 208 (FIG. 2A) also performs one-dimensional modified Huffman encoding upon the pel data. One-dimensional modified Huffman encoding is advantageous in that small numbers of binary digits can be used to represent long runs of black or white pels.

Each line of data is composed of a series of variable length code words, each of which represents a run length of either all white or all black picture elements. The white and black runs alternate, and a total of 1728 picture elements represent one typical horizontal scan line of 215 mm length. To maintain synchronization, all data lines begin with a white run length code word. However, if the actual scan line begins with a black run, a white run length of zero will be sent. The black or white run lengths, up to a maximum of one scan line (1728 picture elements or "pels") are defined by the code words in Tables 4 and 5 below.

The code words are of two types: (1) Terminating Codes; and (2) Make-Up Codes. Each run length is represented by either a Terminating Code word, or a Make-Up Code word followed by a Terminating Code word. Run lengths in the range of 0–63 pels are encoded with their appropriate Terminating Code word from Table 4. As shown in Table 4, there are different code words for black and white run lengths.

TABLE 4

Terminating Codes

White run length	Code Word	Black run length	Code Word
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

Run lengths in the range of 64–1728 pels are encoded first by the Make-Up Code word from Table 5 representing the run length which is equal to or shorter than that required, followed by the Terminating Code word from Table 4 representing the difference between the required run length and the run length represented by that Make-Up Code.

TABLE 5

Make-Up Codes

White run length	Code Word	Black run length	Code Word
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	0000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101
EOL	000000000001	EOL	000000000001

Run lengths greater than 1728 pels are encoded first by the Make-Up Code word from Table 6 representing the run length which is equal to or shorter than that required, followed by the Terminating Code word from

Table 4 representing the difference between the required run length and the run length represented by that Make-Up Code.

TABLE 6

Make-Up Codes
Note: For machines which accommodate larger paper widths while maintaining the standard horizontal resolution the following Make-Up Code set is provided:

Run length (black and white)	Make-Up Codes
1792	00000001000
1856	00000001100
1920	00000001101
1984	000000010010
2048	000000010011
2112	000000010100
2176	000000010101
2240	000000010110
2304	000000010111
2368	000000011100
2432	000000011101
2496	000000011110
2560	000000011111

As discussed above, the program memory 152 (FIG. 1) provides the instructions for the DSP 150 to carry out its data processing functions (FIGS. 2A and 2B). An exemplary listing of the software for providing those instructions in accordance with the foregoing discussion and figures is included below in Appendix A preceding the claims.

Various other modifications and alterations in the structure and method of operation of this invention will be apparent to those skilled in the art without departing from the scope and spirit of this invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments.

APPENDIX A

```
ASSEMBLY CODE FOR CORE PROCESSING FOR VIDEO TO FAX CONVERSION.
(Using the ADSP2105 DSP chip).

Operation;

External hardware captures 4 lines (4x512) or 4 columns (4x480) of pixels,
depending on whether rotation is disabled, or enabled.  The data is
stored in a static 2kx8 FIFO.  If rotation is enabled, the data needs
to be deinterleaved from its 4-byte vertical grouping; this is done
as data is transferred from the SFIFO to SRAM.

The 4 lines of data are interpolated from 480 to 1728 (or 1576);
whenever a new line is required, it is read from the SFIFO into the
circular 4x480 (or 4x512) buffer addressed by i7.  For simplicity,
4 new lines are grabbed after each transfer into SRAM.  (Note; sometimes,
several lines are read from the SFIFO, as at the start of a frame or
when decimation is required for A6 size).

The 4 interpolated lines are held in the circular buffer addressed by i5.
These are accessed to create the final interpolated fax width and length
resolution lines, which are stored in a 2x1728 (or 1576) circular buffer
addressed by i1. This buffer is only required for Floyd-Steinberg error
diffusion.

Optional image enhancement (under user control can then be performed).
This consists of a 2-D filter with a high-frequency boost to
enhance edges.

The pixels are then contrast-adjusted, using a look-up table, to
compensate for nonlinearities in the fax machine at the receiving
end.

Each interpolated fax resolution pixel is dithered, either by line or
classical screen (simple comparison) or with Floyd-Steinberg error
diffusion, at which point the white/black runlength is incremented./
If the color toggles at the current pixel, the runlength up to the
current pixel is encoded using Huffman 1-D encoding.  If the
number of new code bits plus the code bits left over from the last
encoding operation is 16 or more, the 16 most-significant are moved
to the huffman-encoded output buffer, where they can be picked up
whenever there is a modem interrupt.


Index registers;
i0      width interpolation coeffs, 128 entries, stored in ext RAM or
        length interpolation coeffs, 128 entries, stored in ext RAM
i1      2 interpolated lines, for error diffusion (2x1728 or 2x1576),
        always operate on the old half, and propagate onto the new half
i2      Floyd-Steinberg or screen coeffs, 4 or more, stored internally
```

```
i3        dot gain correction, 256 entries, stored in ext RAM
i4        bit count for Huffman encoding, also ext RAM huffman code table
          (364 words, 128 each for white and black, 54 each for white and
          black makeup)
i5        current fax output line (i.e fax resolutions), 4x1728 or 4x1576
i6        huffman encoded output buffer, several kwords
i7        current video input line (i.e video resolutions), 4x480 or 4x512

Modify values for index registers;
m0        0
m1        1
m2        -1
m3        128/3 = 32 (required for interpolation coeffs)
m4        1728 (or whatever line to line offset is)
m5        -1728
m6        480 (or 512 depending on rotation on or off)
m7        -480 (or -512)

Length values for index registers;
l0        1k (? length of buffer for fax output)
l1        4x480 or 4x512, for video input data
l2        4x1728 or 4x1576, for intermediate fax width resolution lines
l3        2x1728 or 2x1576, for Floyd-Steinberg error diffusion buffer

cntr      1728 or 1576 (the number of pixels to be interpolated to).  cntr
          decrements, and is used to index lines or columns of pixels, so that
          the first pixel is at an address offset into SRAM of 1728, rather
          than at 0.  cntr is used both during transfer from static FIFO to
          SRAM, and during interpolation.

{
************************************************************
                      INTERPOLATION

Bicubic interpolation, with the data stored externally in
SRAM, the width interpolation coefficients stored internally
in program RAM, and the length interpolation coefficients
transferred from external RAM or EPROM to internal program RAM
at the start of each new fax output line (this means both
coefficient and data loading during each MAC instruction, since
the PMD and the DMD busses are used).

Data and coefficients are in 1.15 format, of which only the 8
msb are significant (the lower 8 are zeroed at power on and are
generally ignored).

2-pass, with interpolation in the width direction, then in the
length direction, is more efficient (requires fewer instructions)
than 1-pass, which is a 4x4 kernel at each output pixel.  However,
it does require storage of 4 fax-width lines.

Calling parameters;
        cntr                current fax width pixel number
        phase_w             fax width phase increment
Return parameters;

************************************************************
Fax width interpolation;
This loop may be required more than once if decimating, or at
the start of a field.  It converts the input line (at 480 or 512)
to fax_w (1728 or 1576), using cubic interpolation.  The
interpolated lines are stored in the circular buffer addressed
by i5, which is 4 lines (4x1728 or 1576) long.  Take data from
buffer i7, and store it in buffer i5.
************************************************************
}

        cntr=dm(fax_w);            fax_w=1728 or 1576
        i5=dm(interp_prev);        i5=previous pointer to buffer
                                   (i.e. will add new line after last
                                   new line)
        ay0=dm(input_prev);        ay=prev pointer to input i7 buffer

        do width until ce;         loop for fax width
```

```
        mx0=cntr;               cntr=current output pixel number
        my0=phase_w;            phase_w=phase increment, from RAM
        mr=mx0*my0;             current output pix location
        ar=mr1+ay0-1;           mr1=integer part = nearest input pixel
                                on the left-hand side of current output posn
        i7=ar;                  i7 points to the first interp pixel
        ay0=w_interp_st+31;     ax=address of 31th entry in coeff table
                                (the right-most posn of the first coeff to be
                                used)
        sr0=mr0 lshift by -11;  shift fract part of output pix location from
                                16 bits to 5 bits (value is 0 to 31, which
                                equals 128/4)
        ar=ay0-sr0;             ar=address of interp coeff for first pixel
                                (i.e. 0 to 31th entry in coeff table)
        i0=ar;                  i0 points to first interp coeff (in internal
                                program RAM)

        mr=0,mx0=dm(i7,m1),my0=pm(i0,m1); mx=first pixel, my=first coeff
        cntr=3;
        do w_int until ce;      loop 4 times
w_int:  mr=mr+mx0*my0,mx0=dm(i7,m1),my0=pm(i0,m1);        multiply-accumulate i:
                                                          width direction
        if mv sat mr;           saturate if necessary


width:  dm(i5,m1)=mr1;          store interpolated value in i5

        dm(interp_prev)=i5;     store pointer to i5 for next time around
        dm(input_prev)=i7;      store pointer to i7 for next time around

}
************************************************************
Fax length interpolation
This loop is required once per fax line out.  It converts from 4 lines
(stored in buffer i5) of width fax_w, to one line (stored in buffer i1)
of width fax_w.  The loop is fax_w long (i.e. do entire line of fax
resolution width at the one time).  Before storing interpolated back
into i1 buffer, use the dot gain lookup table (i3) to give the
correct gray-scale image.
************************************************************
}
        cntr=dm(fax_w);         fax_w=1728 or 1576
        i1=dm(interp_prev);     i1=previous pointer to buffer
        i5=dm(i5_start_adr);    i5=beg of 4x1728 intermediate buffer
        ay0=dm(len_coef_start_adr); ay0=start of length coeffs

        mx0=cntr;               cntr=current output pixel number
        my0=phase_l;            phase_l=phase increment, from RAM
        mr=mx0*my0;             current output pix location
        af=ay0+31;              ar=address of 31th entry in coeff table
                                (the right-most posn of the first coeff to be
                                used)
        sr0=mr0 lshift by -11;  shift fract part of output pix location from
                                16 bits to 5 bits (value is 0 to 31, which
                                equals 128/4)
        ar=af-sr0;              ar=address of interp coeff for first pixel
                                (i.e. 0 to 31th entry in coeff table)
        i0=ar;                  i0 points to first interp coeff (in internal
                                program RAM)

        ar=dm(i0,m3);           move the 4 length coeffs into int prog RAM
        pm(l_coeff0)=ar;
        ar=dm(i0,m3);
        pm(l_coeff1)=ar;
        ar=dm(i0,m3);
        pm(l_coeff2)=ar;
        ar=dm(i0,m0);
        pm(l_coeff3)=ar;

        do width until ce;      loop for fax width
        mr=0,mx0=dm(i5,m4),my0=pm(c0); mx=first pixel, my=first coeff
        mr=mr+mx0*my0,mx0=dm(i5,m4),my0=pm(c1); multiply-accumulate in
        mr=mr+mx0*my0,mx0=dm(i5,m4),my0=pm(c2); width direction
        mr=mr+mx0*my0,mx0=dm(i5,m5),my0=pm(c3);
```

```
        modify(i5,m5);          bring i5 back to 1st line in i5
        modify(i5,m5);
        modify(i5,m1);          step i5 to the next pixel on the 1st line

        if mv sat mr;           saturate if necessary

{
************************************************************
        IMAGE ENHANCEMENT

Similar'to interpolation, except 2-D kernal, with amount
of enhancement possibly under user control.  Not written yet.

************************************************************

************************************************************
        DOT GAIN CORRECTION (CONTRAST ADJUSTMENT)
************************************************************
}
        ay0=dm(dot_gain_start); ay0= start of dot gain lookup table in ext RA
        sr0=mr1 lshift by -8;   shift right by 8 because use only 8 bits
        ar=sr0+ay0;             compute address for lookup table
        i3=ar;                  store in index register
        mr1=dm(i3,m0);          get corrected value

width:  dm(i1,m1)=mr1;          store interpolated value in i1

        dm(interp_prev)=i1;     store pointer to i1 for next time around


{

************************************************************
                        DITHERING

Compare to a threshold; if > threshold, then pixel is white, if <
threshold, pixel is black.
Note;   data is in 1.15 format, so when a pixel exceeds the FS
        threshold, 255 is subtracted from it (actually 255*256).
        Using 1.15 format allows saturation logic to work properly.

Calling parameters;
        prev    =-1             if previous bit was black (<thresh)
                =0              if previous bit was white (>thresh)
        i1                      just-calculated interpolated pixel
Return parameters;

Do entire line of fax_w pixels.  Do dithering and encoding.
************************************************************
}
        i1=dm(fs_prev);                 i1=previous pointer to buffer with
                                        interpolated, dot-gained pixels
        cntr=dm(fax_w);                 iterate fax_w times
        do loop1 until ce;

        ay0=dm(thresh);                 ay0=threshold
        ax0=dm(prev);                   recall prev from int RAM
        abs(ax0);                       to get AS status
        if neg jump was_b;
        if pos jump was_w;

was_b:  ax0=dm(i1,m0);                  ax0=current pixel from RAM
        ar0=ax0-ay0;                    ar0>0 if white, <0 if black
                                        (status is latched until below)
        if lt jump still_b;             still black, otherwise white
        ar0=ax0-255*256;                create error value
        if av sat ar;                   saturate if necessary
        av=0;                           clear overflow bit
        dm(i1,m0)=ar0;                  store in RAM
        dm(prev)=m0;                    change prev to 0 (white)
        ax0=182;                        offset for black codes = 182
        jump encode;                    toggling from black to white

still_b:modify (i4,m1);                 increment black run count
        jump diffuse;
```

```
was_w:  ax0=dm(i1,m0);                    ax0=current pixel from RAM
        ar0=ax0-ay0;                      ar0>0 if white, <0 if black
                                          (status is latched until below)
        if ge jump still_w;               still white
        ax0=0;                            offset for white codes = 0
        dm(prev)=m2;                      change prev to -1
        jump encode;                      toggling from white to black

still_w: ar0=ax0-255*256;                 create error value
        if av sat ar;                     saturate if necessary;
        av=0;                             clear overflow bit
        dm(i1,m0)=ar0;                    store in RAM
        modify (i4,m1);                   increment white count
        jump diffuse;

{
*************************************************************
                          ENCODING

1-D huffman encoding, with table stored in RAM as 185 2-word entries,
with 1st word = bit count for code word, 2nd word = code.  Calculate the
address into the huffman table as if it were 1-word entries, then
adjust for 2-word entries before adding the table starting address.

Calling parameters;
        ax0                     offset for white/black codes (0 or 182)
        i4                      bit count
        prev                    already toggled, so 0 if black, -1
                                if white
        huff_bits_left          code word is left-justified in sr1, with
                                this number of bit posns free to the rhs
        prev_code               bits left over from previous code, left-
                                justified
Return parameters;
        fax buffer              new 16-bit encoded value added (if
                                appropriate)
*************************************************************
}
encode: si=i4;                            check to see if need makeup codes
                                          (i4=run length > 63)
        sr0=lshift si by +6;              logical shift by 6 = divide by 64
        ay0=si;                           ay=run length
        af=pass 0;                        af=0
        ar=sr0+0;                         need sign status
        if gt af=64;                      if sr0>0, need offset to makeup codes
        ax1=63;                           mask for run length
        ar=ax1 AND ay0;                   mask run length < 64
        af=ar+af;                         ar=run length + makeup
        ar=ax0+af;                        ar=run length + makeup + b/w offset
        sr0=lshift ar by -1;              sr0=2xar, because table = 2-word entr
        ay0=dm(huff_start);               ay=huffman code table etart address
        ar=sr0+ay0;                       offset into huffman code table
        i4=ar;                            store huffman pointer in index reg

        sr1=dm(prev_code);                sr1=code bits left from prev codeword
        si=dm(i4,m1);                     si=Huffman code word from RAM
        sr=sr or lshift si, ay0=dm(huff_bits_left);     left shift si and
                                                        or with present sr
        ax0=dm(i4,m0);                    read in code word length from RAM
        ar=ay0-ax0;                       new code word length in sr
        if neg jump huff_out;             if pos, still have bits posns spare

        dm(huff_bits_left)=ar0;           # of bit posns free for next code
        dm(prev_code)=sr1;                sr1=code bits to save until next word
        jump diffuse;
huff_out: ax0=i6;                         check that not overwriting buffer; ax
                                          pointer for writing buffer
        ay0=fax_buf_out;                  ay=pointer for reading buffer
        ar=ax0-ay0;
        if eq jump fax_buf_error;         if equal, about to overwrite buffer;
                                          jump to error-handling routing
                                          (wait until buffer empties)

        dm(i6,m1)=sr1;                    write sr1 to fax output buffer
        ar0=16+ar0;                       ar0 is -ve, result is spare bit posns
```

```
        dm(huff_bits_left)=ar0;          # of bit posns free for next code
        dm(prev_code)=sr0;               sr0=code bits to save until next wor
        jump diffuse;                    jump to error diffusion


{
************************************************************
                         ERROR DIFFUSION

Floyd Steinberg error diffusion;
                      0      7
               3      5      1
Calling parameters;
        i1=current pixel (value or value-255)
        i2=start of error coeffs
Return parameters;
        i2=start of error coeffs
************************************************************
}

diffuse:mx0=dm(i5,m1);                   mx=current error
        my0=dm(i2,m1);                   my=error mult (7/16)
        mr=dm(i5,m0);                    mr=next pixel, m0=0
        mr=mr+mx0*my0, my0=dm(i2,m1);    mr=next pixel+error, my=error mult(3/1
        if mv sat mr;                    saturate if necessary
        dm(i5,m4)=mr;                    store next pixel in RAM (or use
                                             ax0=mr)
        mr=dm(i5,m0);                    mr=pixel from next line
        mr=mr+mx0*my0, my0=dm(i2,m1);    mr=pixel+error, my=error mult(5/16)
        if mv sat mr;                    saturate if necessary
        dm(i5,m1)=mr;                    store in RAM

        mr=dm(i5,m0);                    mr=pixel from next line
        mr=mr+mx0*my0, my0=dm(i2,m1);    mr=pixel+error, my=error mult(1/16)
        if mv sat mr;                    saturate if necessary
        dm(i5,m1)=mr;                    store in RAM

        mr=dm(i5,m0);                    mr=pixel from next line
        mr=mr+mx0*my0;                   mr=pixel+error;
        if mv sat mr;                    saturate if necessary
        dm(i5,m5)=mr;                    store in RAM, i5=current pix next time
loop1:  i3=first_fs_compt;               set i3 back to point to the first comp

        fs_prev=i1;                      store current pointer to RAM for use
                                         next time
```

What is claimed is:

1. A video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal converter comprising:

data interpolator means for receiving an interpolation instruction signal and in accordance therewith receiving and interpolating a pixel data signal representing a continuous tone video image, wherein said received pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on a contrast transfer function for said continuous tone video image;

data alteration means for receiving and selectively altering said interpolated plurality of image pixel data within said interpolated pixel data signal to selectively alter said contrast transfer function gray-scale value;

pixel-to-pel data converter means for receiving a conversion instruction signal and in accordance therewith receiving and converting said interpolated and selectively altered pixel data signal to a pel data signal, wherein said pel data signal includes at least one pel data block having a composite pel data block gray-scale value, and wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar;

encoder means for receiving an encoding instruction signal and in accordance therewith receiving and encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal; and

instruction source means for providing said interpolation, conversion and encoding instruction signals.

2. A video-to-facsimile signal converter as recited in claim 1, wherein said data interpolator means comprises a digital signal processor coupled to said instruction source means for receiving said interpolation instruction signal and in accordance therewith receiving and interpolating said pixel data signal.

3. A video-to-facsimile signal converter as recited in claim 1, wherein said data alteration means comprises a memory look-up table for receiving said interpolated plurality of image pixel data within said interpolated pixel data signal as input addresses therefor and for

outputting said interpolated and altered pixel data signal as output data therefrom.

4. A video-to-facsimile signal converter as recited in claim 1, wherein said pixel-to-pel data converter means comprises a digital signal processor coupled to said instruction source means and said data alteration means for receiving said conversion instruction signal and in accordance therewith receiving and converting said interpolated and altered pixel data signal to said pel data signal.

5. A video-to-facsimile signal converter as recited in claim 1, wherein said encoder means comprises a digital signal processor coupled to said instruction source means for receiving said encoding instruction signal and in accordance therewith receiving and encoding said pel data signal in accordance with CCITT Group 3 to produce said facsimile standard signal.

6. A video-to-facsimile signal converter as recited in claim 1, further comprising video signal receiver means for receiving a video signal representing said continuous tone video image and providing said pixel data signal.

7. A video-to-facsimile signal converter as recited in claim 6, further comprising video signal source means for providing said video signal representing said continuous tone video image.

8. A video-to-facsimile signal converter as recited in claim 6, wherein said video signal receiver means comprises an analog-to-digital converter and a video data buffer coupled to said data interpolator means for receiving, digitizing and buffering an analog video signal representing said continuous tone video image, and for providing said pixel data signal.

9. A video-to-facsimile signal converter as recited in claim 1, further comprising signal converter means for receiving and converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

10. A video-to-facsimile signal converter as recited in claim 9, wherein said signal converter means comprises a facsimile MODEM coupled to said encoder means for receiving and modulating said facsimile standard signal to provide said facsimile transmission signal for transmission to and reception by a facsimile receiver.

11. A video-to-facsimile signal converter as recited in claim 9, further comprising telephone network interface means for receiving and coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

12. A video-to-facsimile signal converter as recited in claim 11, wherein said telephone network interface means comprises a data access arrangement coupled to said signal converter means for receiving and coupling said facsimile transmission signal onto a telephone line.

13. A video-to-facsimile signal converter for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal converter comprising:

digital signal processor means for receiving a pixel data signal representing a continuous tone video image, wherein said received pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on an original contrast transfer function for said continuous tone video image, and for receiving a plurality of conversion instruction signals and in accordance therewith:

interpolating said plurality of image pixel data,

outputting said interpolated plurality of image pixel data,

receiving a plurality of selectively altered image pixel data which corresponds to said interpolated plurality of image pixel data and has a selectively altered contrast transfer function gray-scale value which is selectively dissimilar to said original contrast transfer function gray-scale value,

dithering said plurality of selectively altered image pixel data to produce a pel data signal including at least one pel data block having a composite pel data block gray-scale value, wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar, and

encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal;

look-up table means for receiving said outputted, interpolated plurality of image pixel data and for providing said plurality of selectively altered image pixel data; and

memory means for providing said plurality of conversion instruction signals.

14. A video-to-facsimile signal converter as recited in claim 13, further comprising video signal receiver means for receiving a video signal representing said continuous tone video image and providing said pixel data signal.

15. A video-to-facsimile signal converter as recited in claim 14, further comprising video signal source means for providing said video signal representing said continuous tone video image.

16. A video-to-facsimile signal converter as recited in claim 14, wherein said video signal receiver means comprise an analog-to-digital converter and a video data buffer coupled to said digital signal processor means for receiving, digitizing and buffering an analog video signal representing said continuous tone video image, and for providing said pixel data signal.

17. A video-to-facsimile signal converter as recited in claim 13, further comprising signal converter means for receiving and converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

18. A video-to-facsimile signal converter as recited in claim 17, further comprising telephone network interface means for receiving and coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

19. A video-to-facsimile signal converter as recited in claim 18, wherein said telephone network interface means comprises a data access arrangement coupled to said signal converter means for receiving and coupling said facsimile transmission signal onto a telephone line.

20. A video-to-facsimile signal converter as recited in claim 17, wherein said signal converter means comprises a facsimile MODEM coupled to said digital signal processor means for receiving and modulating said facsimile standard signal to provide said facsimile transmission signal for transmission to and reception by a facsimile receiver.

21. A video-to-facsimile signal conversion method for receiving and converting a video signal representing a continuous tone video image to a facsimile signal for

transmission to and reception by a facsimile receiver for simulation of said continuous tone video image, said video-to-facsimile signal conversion method comprising the steps of receiving a plurality of conversion instruction signals and in accordance therewith:

receiving a pixel data signal representing a continuous tone video image, wherein said pixel data signal includes at least one pixel data block having a plurality of image pixel data with a composite pixel data block gray-scale value which represents a gray-scale value on a contrast transfer function for said continuous tone video image;

interpolating said pixel data signal;

selectively altering said interpolated plurality of image pixel data within said interpolated pixel data signal to selectively alter said contrast transfer function gray-scale value;

converting said interpolated and selectively altered pixel data signal to a pel data signal, wherein said pel data signal includes at least one pel data block having a composite pel data block gray-scale value, and wherein said composite pixel data block gray-scale value and said composite pel data block gray-scale value are selectively similar; and

encoding said pel data signal in accordance with a selected facsimile encoding standard to produce a facsimile standard signal.

22. A video-to-facsimile signal conversion method as recited in claim 21, further comprising the steps of:

receiving an analog video signal representing said continuous tone video image; and

digitizing and buffering said analog video signal to provide said pixel data signal.

23. A video-to-facsimile signal conversion method as recited in claim 21, wherein said step of converting said interpolated and altered pixel data signal to said pel data signal comprises dithering said pixel data signal.

24. A video-to-facsimile signal conversion method as recited in claim 21, further comprising the step of converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver.

25. A video-to-facsimile signal conversion method as recited in claim 24, further comprising the step of coupling said facsimile transmission signal into a telephone network for transmission to and reception by a facsimile receiver.

26. A video-to-facsimile signal conversion method as recited in claim 24, wherein said step of converting said facsimile standard signal to a facsimile transmission signal for transmission to and reception by a facsimile receiver comprises modulating said facsimile standard signal to provide said facsimile transmission signal.

* * * * *

US006072600A

United States Patent [19]

Wertsberger

[11] **Patent Number: 6,072,600**

[45] **Date of Patent: Jun. 6, 2000**

[54] **FACSIMILE CAMERA DEVICE**

[76] Inventor: **Shalom Wertsberger**, 30 Fern La., South Portland, Me. 04106

[21] Appl. No.: **08/789,816**

[22] Filed: **Jan. 28, 1997**

Related U.S. Application Data

[60] Provisional application No. 60/010,833, Jan. 30, 1996.

[51] **Int. Cl.**^{7} **H04N 1/00**; H04N 1/04; H04N 5/225

[52] **U.S. Cl.** **358/479**; 358/400; 358/906; 358/909.1; D14/118; D16/229

[58] **Field of Search** 348/211, 552, 348/273–275, 336, 333, 231, 371, 376, 212, 213, 14, 15, 17; 379/100.01, 100.02; 455/557; 396/419, 428; 358/479, 906, 909.1, 408, 481, 400; 382/284; D16/214, 220, 229, 244; D14/118

[56] **References Cited**

U.S. PATENT DOCUMENTS

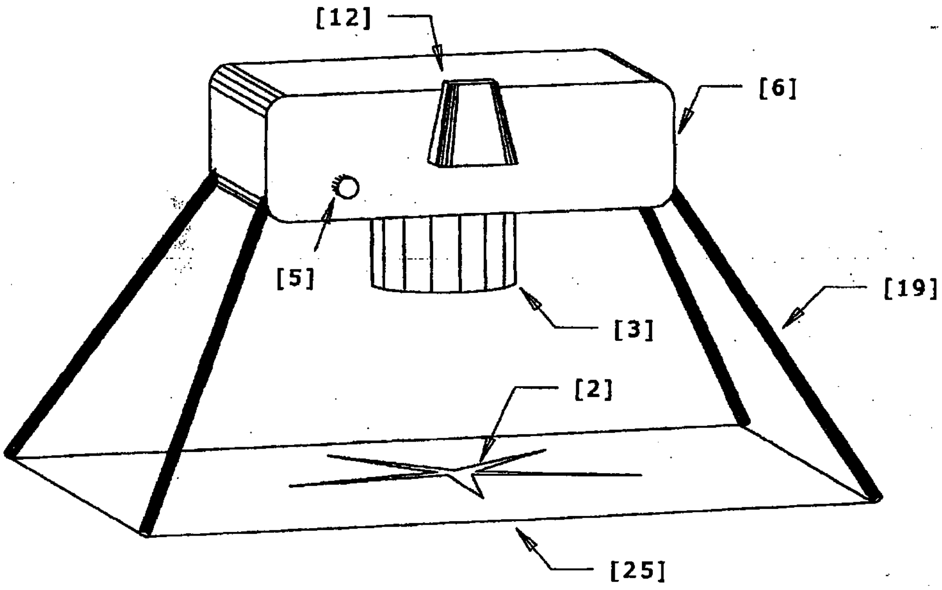
4,926,249	5/1990	Ichihara et al.	358/75
4,939,580	7/1990	Ishikawa et al.	358/229
5,003,398	3/1991	Suzuki .	
5,077,612	12/1991	Mergrgardt .	
5,193,012	3/1993	Schmidt .	
5,235,432	8/1993	Creedon et al. .	
5,587,735	12/1996	Ishida et al.	348/14
5,619,257	4/1997	Reele et al.	348/64
5,666,159	9/1997	Parulski et al.	348/211
5,917,553	6/1999	Honey et al.	348/578

Primary Examiner—Kimberly A. Williams
Attorney, Agent, or Firm—Saltamar Innovations

[57] **ABSTRACT**

A portable, compact Fax Camera Device comprised of a still electronic camera circuitry and an image sensor especially adapted for facsimile, with integrated facsimile communication device, this invention is designed and built specifically for the acquisition and communication of facsimile images in such aspects as resolution, aspect ratios, optical design, mounting capability, tight integration of facsimile circuitry, and capability of receiving facsimile images. The Fax Camera allows easy capturing of fax images from books without the need for photocopying, easy photography type capture of real world objects, as well as convenient regular page image capture and transmission. For regular page and book images, the invention is equipped with collapsible mounting device constructed to allow easy and accurate focus and provides a frame for predetermined size documents. The invention also includes a display device to allow viewing and editing of captured fax images. The tight integration of still electronic photography and facsimile communication capabilities create a light, portable, and flexible fax communication device.

16 Claims, 7 Drawing Sheets



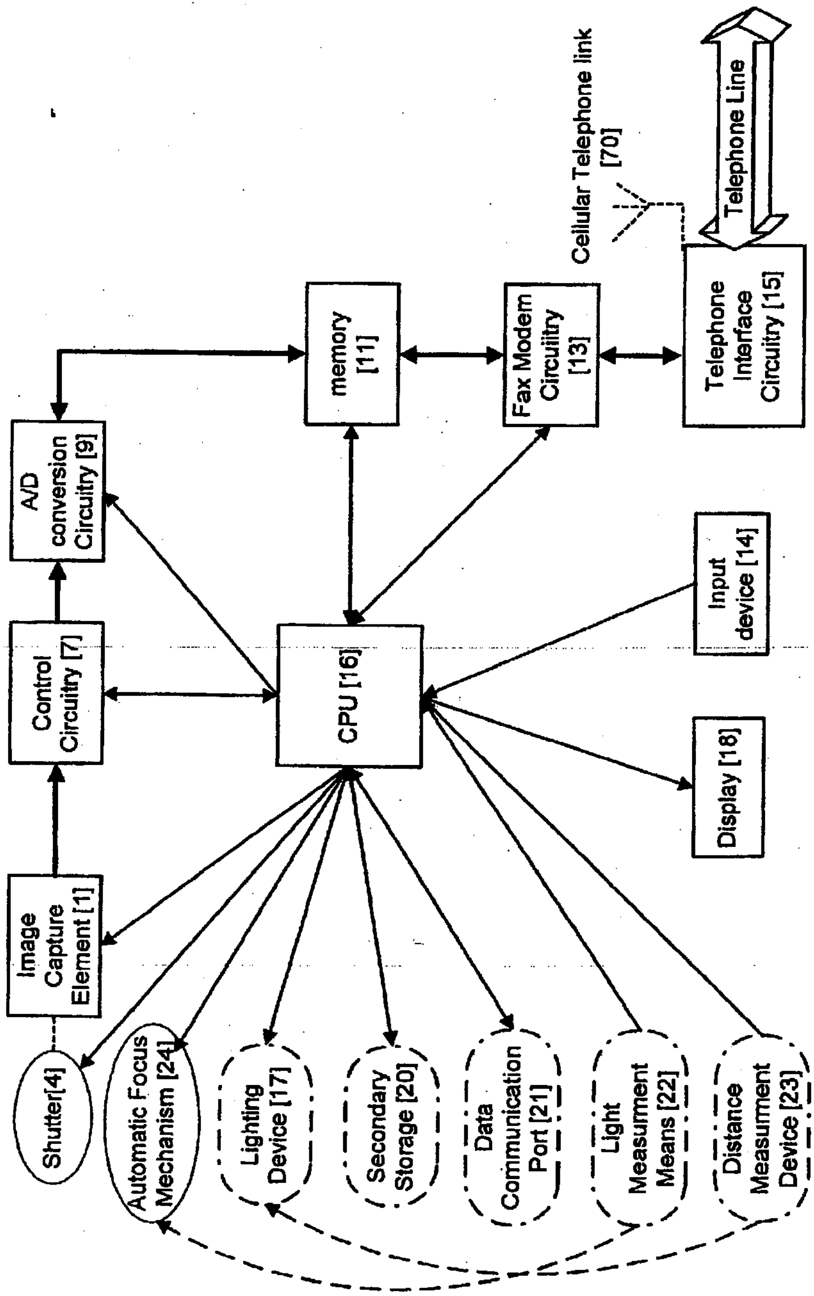


Image Capture Element [1]
Control Circuitry [7]
A/D conversion Circuitry [9]
memory [11]
Fax Modem Circuitry [13]
Telephone Interface Circuitry [15]
Cellular Telephone link [70]
Telephone Line
CPU [16]
Input device [14]
Display [18]
Shutter[4]
Automatic Focus Mechanism [24]
Lighting Device [17]
Secondary Storage [20]
Data Communication Port [21]
Light Measurment Means [22]
Distance Measurment Device [23]

Fig. 1

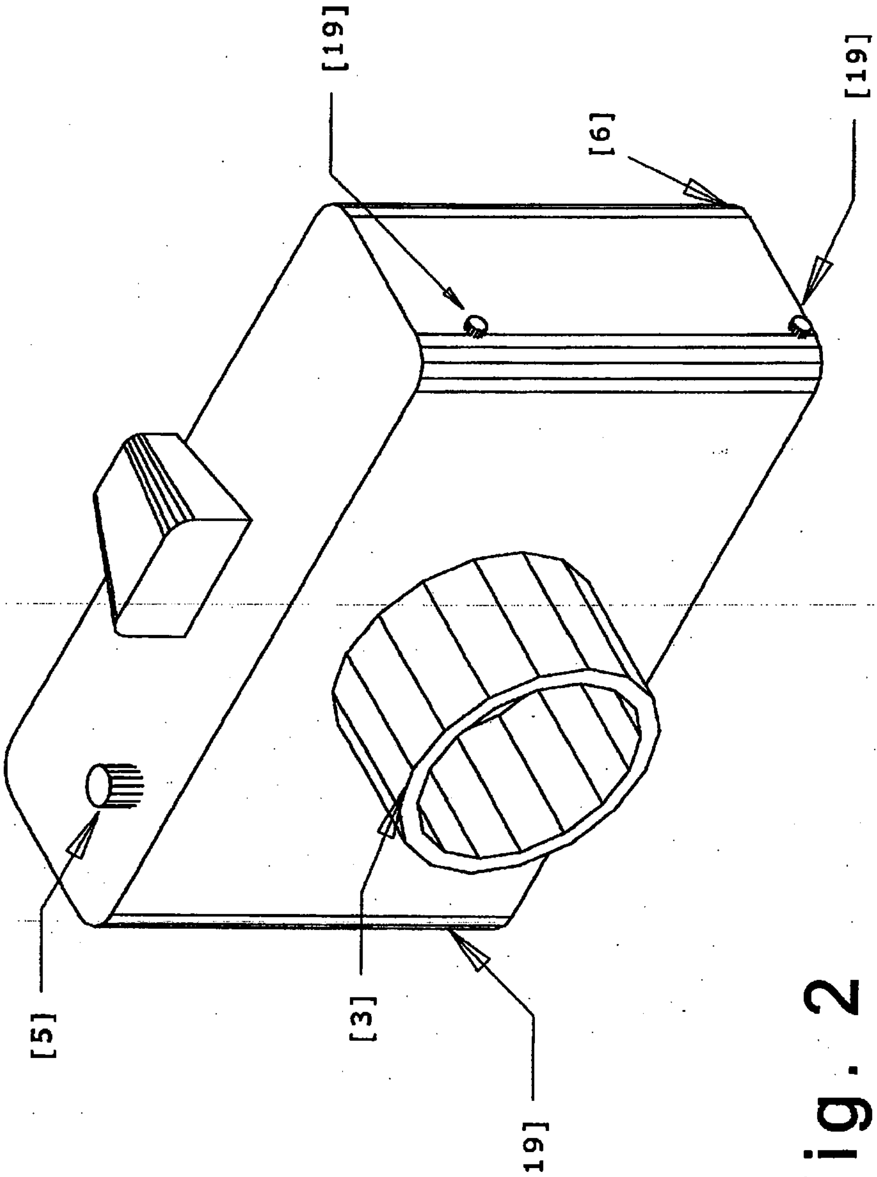


Fig. 2

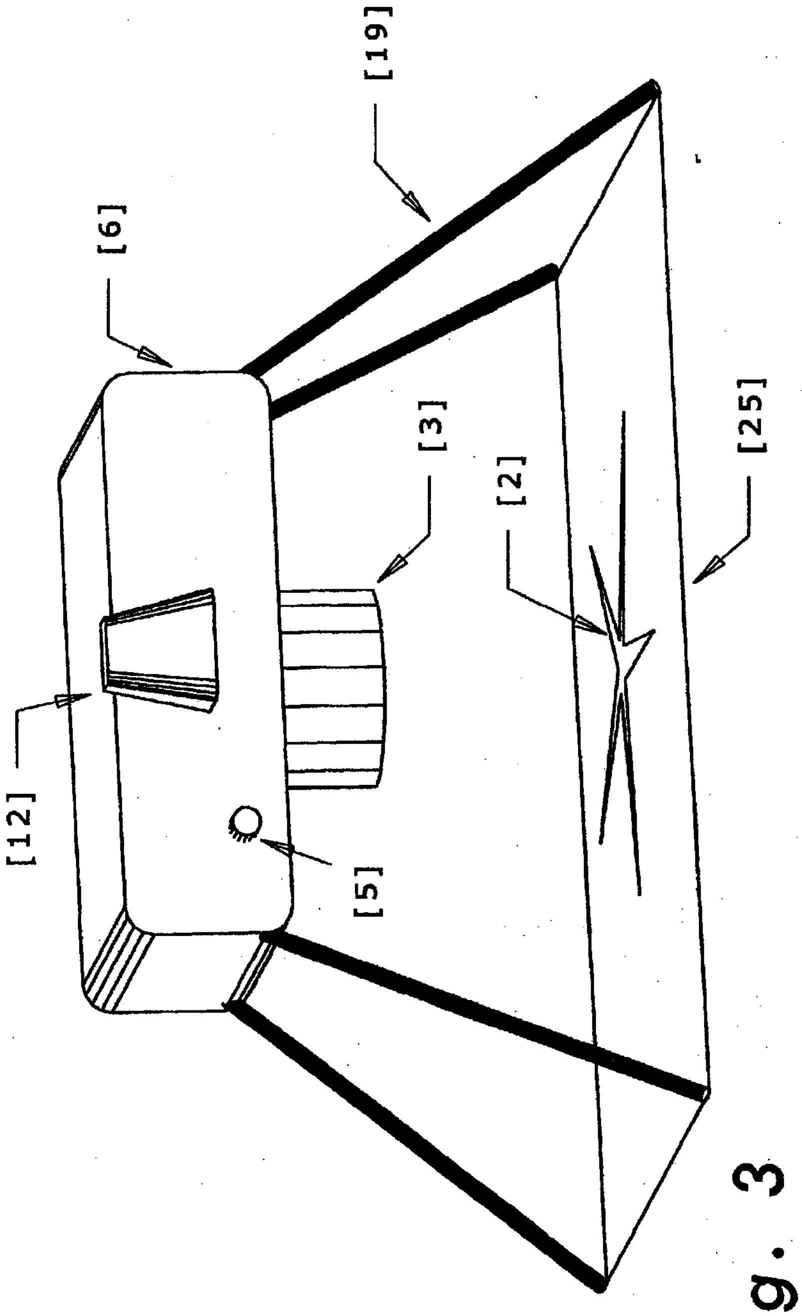


Fig. 3

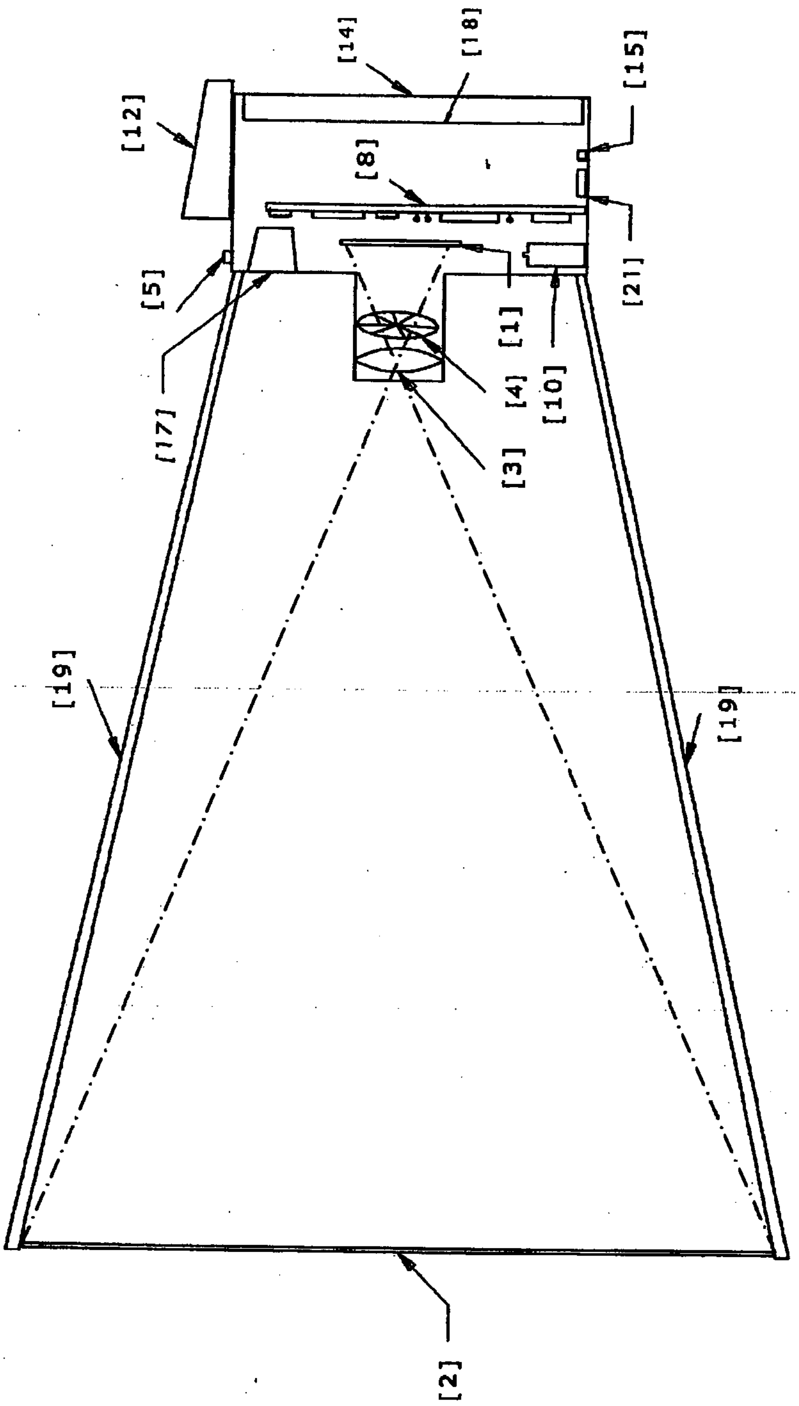


Fig. 4

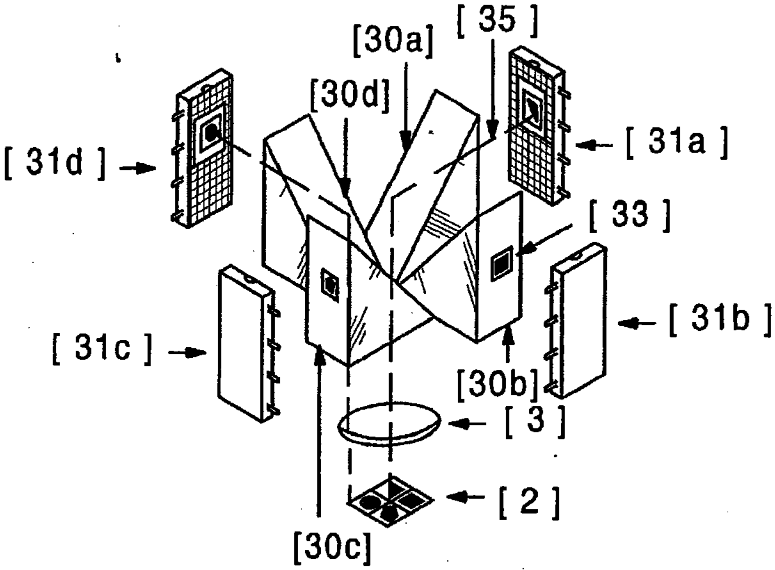

[30a]
[35]
[30d]
[31d]
[31a]
[33]
[31c]
[31b]
[30b]
[3]
[2]
[30c]

FIG. 5

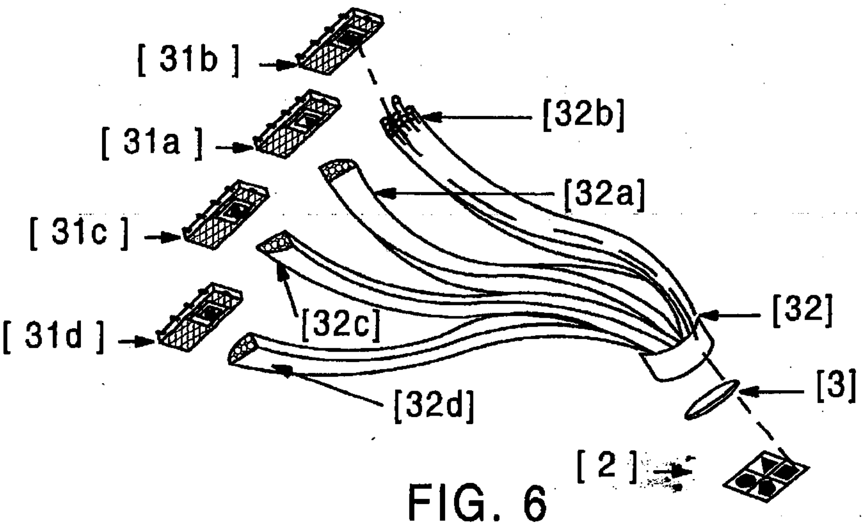

[31b]
[32b]
[31a]
[32a]
[31c]
[32c]
[32]
[31d]
[3]
[32d]
[2]

FIG. 6

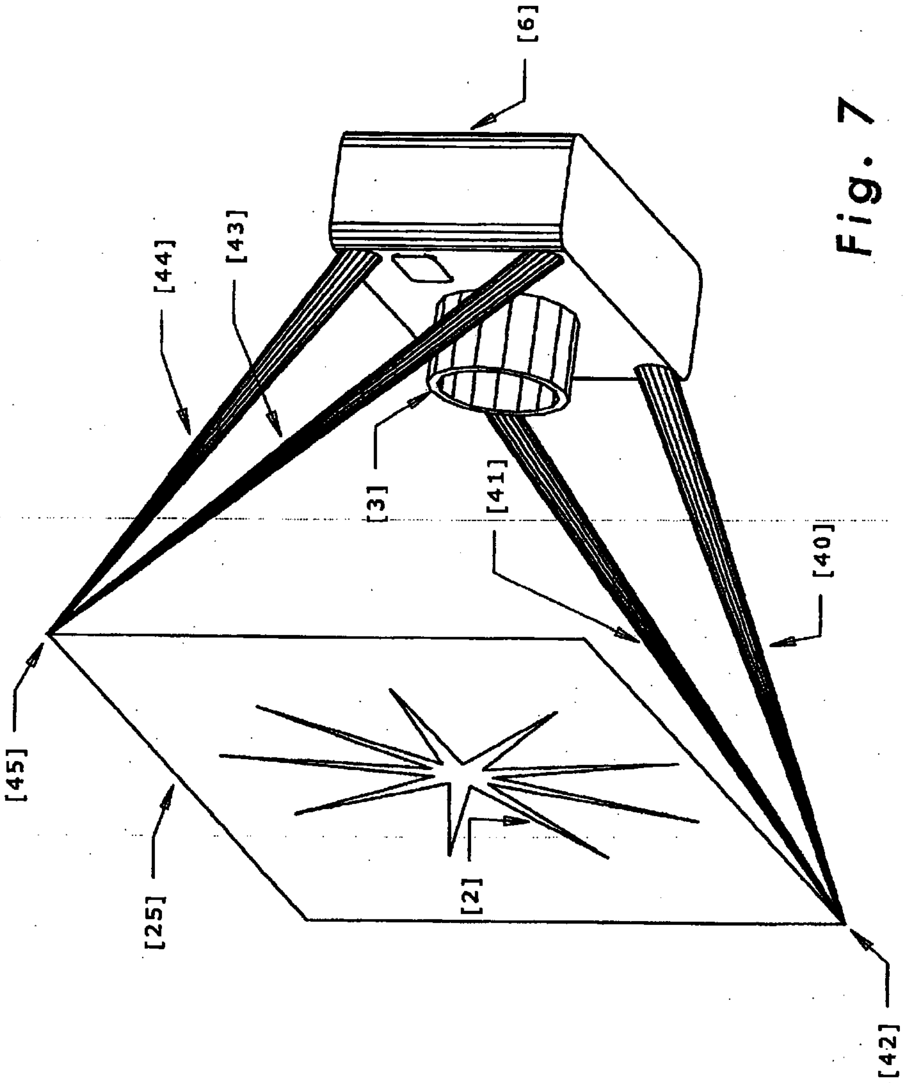


Fig. 7

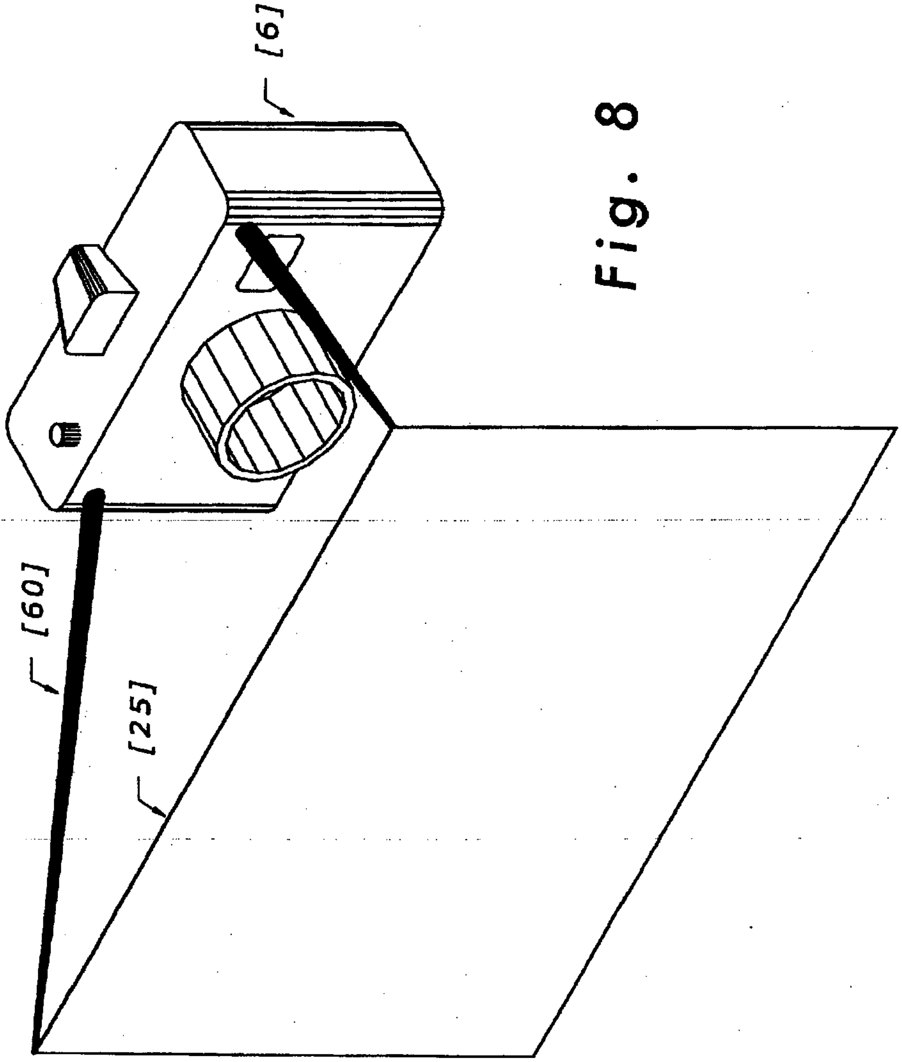


Fig. 8

FACSIMILE CAMERA DEVICE

RELATED APPLICATION

This application claims the benefit of U.S. provisional application Ser. No. 60/010,833 filled Jan. 30, 1996.

FIELD OF THE INVENTION

The invention relates to facsimile equipment in general and more particularly to a electronic still camera constructed and adapted for facsimile image capture, storage and transmission.

BACKGROUND OF INVENTION

Facsimile (popularly known as fax) equipment has become a common method of relaying information in today's business world. Most fax machines built today fall into one of two major groups: computer based and standalone fax machines. Computer based technology can be as compact and versatile as the computer equipment itself. In terms of usability as fax equipment it can send most computer files designed to be printed on any printer. However in order for the computer to send images that were not originally generated by the computer, the image has to be scanned, digitized, or otherwise converted to a computer readable form. This necessitates additional scanning equipment whenever external printed or photographed material is to be transmitted by fax.

Dedicated standalone fax machines are for the most part built around a static line image capture element that requires the image to be printed on paper that is then transported through the fax machine. During this process, a static line image capture element senses the image and transmits it to the receiving fax machine, or saves it for later transmission. Most standalone fax machines can feed only single pages of paper, of standard dimensions such as US letter and legal size paper or ISO A4 size paper. If the material to be transmitted is from a book or of non standard dimensions, the user must first photocopy the image onto a single sheet of paper of the proper dimensions, and only then use the fax machine to transmit the picture. Additionally, if a picture of real world objects is to be transmitted, the object needs to be photographed and then the photograph needs to be transmitted to paper or computer readable form before it can be transmitted via a regular standalone fax machine or a computer based fax device.

Additionally, standalone fax machines are relatively large and bulky, thus limiting their portability. Light, portable fax equipment can find many uses particularly by traveling business people.

Still video photography allows capture of images of varying formats and seem to be a perfect fit for the problems of varying sources of the image. Still video can also be made highly portable. There are various implementations of still video equipment commonly available from companies like Kodak, Sony and Canon, and various aspects of the art are disclosed in numerous US patents and other publications. Methods of improving still video performance were described in detail in U.S. Pat. No. 5,003,398 (Suzuki, Mar. 26, 1991) and methods of storing image data in non volatile memory were described in U.S. Pat. No. 5,077,612 (Megrgardt et al., Dec. 31, 1991). Still video photography equipment, however, is designed and geared towards high resolution color photography, primarily for display on television or a computer monitor. Most current still video camera units call for 24 bit color resolution at a different

aspect ratio and different resolution than that required by facsimile standards such as ITU T.4.

There are in existence such methods as described by U.S. Pat. No. 5,193,012 (Schmidt, Mar 9, 1993) to convert real time output of a still video camera signals to a fax compatible output, and same disclosure describes various devices such as the Image Data Corporation PhotoPhone, and other devices and methods for transmitting captured video images or for translation and conversion of video images into fax compatible form. Similarly, U.S. Pat. No. 5,235,432 (Creedon et al., Aug. 10, 1993) teaches a method for converting video signals to facsimile signal. These former disclosures dictate the use of an interim device or method to convert from common, television oriented video output to fax compatible format, mostly as an adaptation of an existing still video camera. Those attempts show the need for generating fax signals from a still video-like device, however, the starting point of those former devices is the common, television oriented video signal. The above described methods call for interpolation of the video data. When applied to a page of written material for example, this interpolation process may cause loss of clarity of the printed data.

Therefor there is a clear need for a fax equipment device, designed specifically as facsimile equipment, comprising an image capturing device designed specifically to standard facsimile resolution and aspect ratio, with fax transmitting capability directly integrated with the device, and proper mounting and focusing equipment that will make the device easily usable as a light portable fax camera.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a light, portable fax camera device to satisfy the needs described above. The invention aim is for a portable device capable of easy capture of images of regular (e.g. US letter size or ISA A4 size) sheets of paper or documents for transmission as fax. It is also an object of this invention to allow capturing of image data from sources other than regular documents such as books, magazines, etc. without reproduction of the above images to a sheet of paper, prior to transmission of that image to a remote fax machine. Additionally, it is an object of this invention to allow photography, in a manner similar to regular photography, of any object whereby the image of the photographed object may be transmitted as fax without the need for film, or the need to print the photograph, or transfer the photograph to a computer, or video tape recorder or any similar intermediate steps.

It is also an object of the current invention to allow reception of incoming fax messages and store them for viewing, retransmitting, or printing using external printer.

The current invention, hereafter the Fax Camera, describes an electronic still camera-like device coupled with fax transmission circuitry, and supporting circuitry. The Image Capture Device [1] is constructed of one or more CCD (Charge Coupled Device) planar image sensors, constructed with a resolution, color resolution, aspect ratio, and other aspects, essentially similar to the image aspects requirements of fax standards such as ITU T.4 or any other applicable fax standard.

The Image Capture Element[1] captures the image projected upon it by a lens system[3]. The output of the image capture element is converted to digital signals by an Analog to Digital (A/D) circuitry[9] and stored in Memory[11]. The stored image may then be transmitted via the coupled fax modem circuitry[13] to a remote fax machine, or transferred to a computer or printer via a Data Communication Port [21], or a storage device[20].

The most common images sent by fax today are images of letter size paper documents. To best fit the Fax Camera for that purpose, the invention is provided with Mounting Support[19], attached to and collapsible toward or into the fax camera enclosure[6]. The Mounting Support is constructed to allow the camera to face a surface where a sheet of paper may be placed for image capture, as a preparation for transmission. The Mounting Support also assists the user in proper placement and alignment of the paper documents to be faxed. The ends of the Mounting Support[19] create a virtual frame[25] of the proper size, e.g. ITU A4 size, indicating proper document placement. Additionally, to further facilitate capturing documents, the Lens System is constructed with a preset position. When the Lens System is set to that position, the lens is best focused to capture an image placed in the plane of, and inside the virtual frame[25] created by the Mounting Support. Images from books, or other paper or essentially flat images are taken similarly, whereby the virtual frame[25] provides an easy reference as to the size of the captured image. Other methods of placing an image at predetermined distance are off-course possible, and two of them are depicted in FIG. 7 and FIG. 8.

The optical system is constructed in a manner that allows minimal distortion of a flat image when the image placed in the Virtual Frame[25]. This may be achieved by proper optical design where the periphery of the lens field of view is not used for image capture, or by placement of special geometry lens elements into the optical system.

In order to facilitate data entry the Fax Camera incorporates an input device [14] such as a keypad to allow manual entry of telephone numbers and other pertinent data. The Fax Camera may also incorporate a display device, such as an LCD (Liquid Crystal Display) display, to allow the user to view and edit image data, display incoming fax images, and program and control the Fax Camera operation.

Other conveniences such as a flash lighting device, an automatic focus mechanism, automatic exposure mechanism and others described below may be added to the Fax Camera to enhance usability.

These and other aspects of the invention will be apparent from the following description of the invention.

GENERAL DESCRIPTION OF DRAWINGS

FIG. 1 is a block diagram of the invention, showing data and control flow.

FIG. 2 is a perspective physical illustration of the invention

FIG. 3 is a physical illustration of the device showing the Mounting Support [19] extended, and the invention ready to acquire an image[2].

FIG. 4 depicts the optical principle of the invention.

FIG. 5 depict an alternative method for implementing the Image Capture Element[1]

FIG. 6 depict another alternative implementation of the Image Capture Element [1]

FIG. 7 shows a distance measurement and placement method as an alternative to Mounting Support[19].

FIG. 8 presents another alternative method for placement of a sheet of paper at proper distance for full page image capture.

PREFERRED EMBODIMENT OF THE INVENTION

Electrical Construction

The preferred embodiment will utilize a special monochrome frame transfer CCD image sensor with a pixel resolution of substantially 1728×2287 or somewhat larger, as the Image Capture element [1]. (It should be noted that smaller resolutions are both supported by ITU standards, and that electronic manipulation can easily provide for lower resolution. Similarly, a smaller pixel count may be used to allow for unprintable edges of image. It is however desirable to maintain an aspect ratio substantially similar to 1728×2287 pixels.) Thus the Image Capture Element[1] support at least a one to one correlation between Image Capture element pixels and T.4 pels, at a resolution of 7.7 lines/millimeter on an A4 sheet of paper. The Image Capture Element [1] is placed so that light reflected from the image [2] passes through the optical Lens System[3] and hits the Image Capture Element[1].

A solenoid operated shutter device[4] is placed between the Image Capture Element[1] and the Lens System[3] to allow the Image Capture Element [1] to stay dark between image acquisition cycles. The shutter device solenoid is operated under the control of the CPU[16].

A Trigger [5] operates a switch that indicates to the CPU[16] to begin an image capture cycle. In an alternative implementation, the trigger function may be initiated by a remote control device.

The Image Capture Element [1] is connected to and accepts control and timing signals from the Control Circuitry [7]. The control circuitry provides timing and control signals required by the Image Capture Element [1] as well as conditioning, anti blooming, 'black' current handling, and amplification of the image signal output of the Image Capture Element [1] to a level and format appropriate to provide image data to the A/D Conversion Circuitry [9]. The Control Circuitry[7] is made similar in design and components to current still video and camcorder designs, but with timing conformant to the characteristics of the Image Capture Element [1] employed. The reader is referred to standard literature and to manufacturer literature such as Texas Instruments Area Array Image Sensor Products catalog from 1994 for control circuitry reference. Obviously specific timing, rows, column and voltage variables should be modified as dictated by the details of the Image Capture Element CCD.

The A/D conversion circuitry[9] is built to accept the image data and synchronization (sampling) signals from the Control Circuitry[7] and transforms the image data into digital data suitable for storage in Memory Means [11].

The A/D Conversion Circuitry is built to accept image signal from the separate pixels of Image Capture Element [1] and sampling synchronization signals from the control circuitry, and transform the image data into a level similar for digital processing. The conversion performed by the A/D Conversion Circuitry[9] is a simple bi-level conversion, representing each pixel as a single bit value of 1 or 0.

Fax Modem Circuitry[13] is commonly available from manufacturers such as Rockwell, Cirrus Logic, Yamaha, and others. The Fax Modem Circuitry[13] is built and connected in a manner that allows the CPU to control its operation, i.e. to send and receive data and status information to the Fax Modem[13] and to send commands to initiate a fax session with a remote unit, transmit a fax image from memory[11], or receive a fax from a remote fax machine and store it in memory.

The Fax Modem Circuitry[13] is connected to Telephone Interface Circuitry [15] that allows the Fax Camera to connect to a public switched telephone network, or a cellular telephone communication link. Additionally, cellular telephone circuitry[70] may be built into the fax camera to provide self contained communications capability.

The CPU [16] is also connected to an Input Device[14] and to an LCD Display Device to allow entry of user commands, telephone numbers, etc. The input device[14] in the preferred embodiment is implemented as a touch sensitive screen placed over an LCD Display Device[18] and utilizes the LCD Display Device under the CPU[16] control to provide labeling of the appropriate function of the input device. The LCD Display Device[18] is connected to the CPU[16] and is capable of displaying text and graphics. The Display Device[18] is also utilized to display captured or received images or parts thereof. It is also used to facilitate entering alphanumeric data to be included in the sent facsimile image, to display pertinent status information, or to facilitate programming the Fax Camera operation.

Power for the operation of the Fax Camera is provided by an internal battery[10]. The battery may be rechargeable type or non rechargeable type.

A PCMCIA device interface is built into the Fax Camera Device in the preferred implementation, to allow storage of image into a PCMCIA secondary storage device constructed of FLASH-ROM[20] or magnetic storage disk.

A Lighting Device [17], such as a photographic flash is controlled by the CPU[16] to facilitate image capturing at low ambient light levels, and provide consistent and predictable lighting for page image capturing.

An embedded Data Communications Port [21], such as an IEEE RS-232 conformant serial port is embedded in the preferred implementation of the Fax Camera to allow direct communication between the Fax Camera and a computer or a printer.

Physical Construction

The preferred implementation of the Fax Camera Device is fitted into a housing[6], similar to commercially available common cameras.

Four telescoping legs, comprising the Mounting Support [19], are attached to the Housing[6], constructed to extend and pivot from the housing[6] and to mechanically lock in the extended position to provide mounting support that places the fax camera at a predetermined distance from the photographed image[2]. The Mounting Support is constructed so that when extended and resting against a mounting surface such as a table, it creates a virtual frame[25] defined by the contact points of the support legs with the supporting surface. The virtual frame[25] is of a size equivalent or slightly greater than the size of ITU A4 paper sheet. The frame distance from the Enclosure[6] is computed or experimentally determined, so that if the Lens System[3] is placed at the page image acquisition preset position, the Lens System[3] is focused on the virtual frame[25] plan, with the frame essentially filling its field of view, allowing minimal distortion, full page capture, and best focus of acquired document image.

The Lens System [3] is placed in the front side of the Housing[6] and is constructed to allow focusing an Image [2] reflection on the Image Capture Element [1]. The Lens System [3] is also constructed with a Page Image Acquisition preset position to allow easy focus, for optimal capture of a full A4 or US Letter size page when such a page is placed in the virtual frame[25] defined by the ends of Mounting Support [19]. The Lens System[3] is also constructed to allow continuous focusing on any object at variable distances from the Fax Camera. In this embodiment the Lens System[3] is detachable from the housing[6], to allow mounting of different type of lenses. The Lens System [3] also includes an iris device to provide aperture control.

A shutter Device [4] is placed in the light path between the Lens System[3] and the Image Capture Device[1].

Electronic circuitry is placed on one or more Printed Circuit Boards[8], and housed inside the camera enclosure.

A Display Device[18] and a touch sensitive screen used as Input Device[14] are placed at the back of the housing. The Input Device is placed on top of the Display Device[18], so that the Display Device may be utilized as a background for the transparent Input Device[14].

A Trigger Button[5] is placed on top of the Fax Camera. The trigger is constructed to close a switch and provides, when depressed, a signal to the CPU[1] to begin the image acquiring cycle. The trigger may be operated remotely by mechanical means, such as a cable, to reduce movement of the Fax Camera during image capture.

Operation of the Invention

The Fax Camera may acquire an image in one of two modes: Page Image Acquisition mode or Variable Distance mode. The difference between the two modes is primarily in the focusing stage of operation.

In the Page Image Acquisition mode the user extends the support means [19] and pivot the telescoping legs to form a four legged support. When fully extended, the legs form a virtual frame[25] rectangle similar in size to an ITU A4 page. The user then places the object to be transmitted between the support legs. The user also places the Lens System[3] in its Page Image Acquisition mode preset position.

In Variable Focus Mode, the user points the Fax Camera at the image to be captured, and uses an optical focus mechanism to set the focus of the Lens System[3]. The support means[19] may or may not be used while operating in this mode.

From here on the operation of the invention is similar in the Page Image Acquisition mode and the Variable Distance mode.

The user then presses the trigger[5], thus initiating the image scan. The CPU[16], upon receiving of the electrical signal from the Trigger[5], commands the control circuitry [7] to clear any charges in the Image Capture Element and prepare the element for image acquisition. Once the Image Capture Element[1] is ready to receive image data, the CPU [16] activates the shutter device[4], and if desired, the lighting device[17]. Once a time period sufficient for the Image Capture Element[1] to capture the image has elapsed, the shutter device[4] has completed its operation, and the CPU initiates a command to the Control Circuitry[7] to scan the data from the Image Capture Element[1] and transfer it to the A/D Conversion Circuitry[9]. The A/D Conversion Circuitry[9] converts each pixel to logic level bit, and transfer the data to the CPU[16]. The CPU then compress the data according to the method described in ITU standard T.4 and stores it in memory[11]. Once the data is stored in memory[11], the image capture is complete.

In an alternative embodiment the image data may be first stored in Memory[11] using the CPU[16] or direct memory access, and later compressed and stored back in Memory [11]. In yet another alternative embodiment, the image data is stored uncompressed, and the image data is compressed only before or during fax sending operation.

When the captured image is to be transmitted, the fax camera is attached to a telephone line via the Telephone Interface Circuitry[15]. The operator utilizes the input device[14] to enter a telephone number (or use a number previously stored in memory) and initiate the fax transmission. The CPU [16] then instructs the Fax Modem Circuitry [13] to initiate the call, and negotiate with the remote fax machine according to standard communication specifications (e.g. ITU T.30). The CPU[16] then transfers the image data to the Fax Modem Circuitry[13] that transmits the data to the remote fax receiver.

The device may also be attached to a telephone line to receive fax data. The Fax Modem Circuitry transfers the received fax data to memory[11] and the display device[18] is utilized to display the incoming fax as a whole or in parts.

Utilizing the input device, a user may transfer image data, captured or received, to a printer utilizing the Data Communications Port[21], or transfer image data to Secondary Storage[20]. The user may also add text to the stored image by entering the text on the Input Device[14]. The usage, in this embodiment, of a touch sensitive screen as the Input Device [14] allows the user to enter direct graphical data such as handwriting or diagrams. Such input will be done using 'pen' technology as is well known in the art (e.g. Apple Computers Newton). Such user entered data may constitute the fax image, added to a fax image or be superimposed on a captured or received image.

Note that a number of images may be stored in memory, the exact number depending on the amount of memory installed in the fax camera device and the complexity of the stored images.

Alternative Embodiments

While the ideal Image Capture Element[1] is a single CCD of appropriate resolution, the Image Capture Element may be implemented by many methods, such as:

Multiple, CCD Image Sensors[30], each with resolution lower than that needed for a full page scan, arranged to provide each element with a portion of the image. When combined, the images from the separate Image Sensors create an image data set similar in resolution and aspect ratio to the single Image Capture Element[1] described above. An example of such a split sensor device is depicted in FIG. 5. The optical splitter divides the image projected by the Lens System[3] into four quadrants. The splitter is constructed of four right angle prisms [*30a*, *30b*, *30c*, and *30d*] placed so that the base faces of the prisms facing the Lens System[3] are placed in close proximity to one another in a single plane perpendicular to the axis of the Lens System[3]. Thus each prism receive only a single quadrant of the projected image. Reflected light from the image[2] passes through the Lens System[35] and is reflected by the hypotenuse face of each corresponding prism to the corresponding image quadrant via the second base face[33] of the prism, and onto respective individual Image Sensors[31].

An additional method for providing a split sensor device is shown in FIG. 6. The splitting of the image is achieved by bundling of a large number of optical fibers [32] behind the Lens System[3], and dividing of the optical fiber bundle into multiple branches[*32a*, *b*, *c*, and *d*], so that each branch conducts light from its corresponding quadrant onto the corresponding CCD Image Sensor[*31a*, *b*, *c* and *d*].

In both the above implementations a sequencing program or circuitry is needed, to reconstitute the full image data by recombining the image data from the individual CCD elements [30]. In the arrangements of FIG. 5 and FIG. 6 for example, the recombination circuit or software will attach data for each corresponding scan line from the top left Image Sensor [*31a*] to the top corresponding line from the right Image Sensor[*31b*], until all active scan lines in the respective Image Sensor[31] are exhausted, thus reconstructing the top portion of the image frame. Similarly image data is recomposed from Image Sensors[*31d*] and [*31c*], thus completing the image acquisition as if the image data was acquired by a single CCD image sensor of a larger resolution.

It should be noted that many other ways exist to split the image data, such as creating an area image sensor where the image sensitive area is close to two edges of the device, thus allowing grouping of a number of sensors in close proximity to one another, obviating the need for a separate optical splitter. Other obvious methods for optical splitting of the image include use of mirrors (e.g. instead of prisms [30]), dichroic splitters, etc. It is also apparent that while FIG. 5 and FIG. 6 depict four CCD Image Sensors[*31a*, *31b*, 31*c*, and *31d*], with minor changes to the optical splitter as many CCD elements as desired may be connected and their respective image signal recomposed to achieve the required resolution.

Another alternative to making the Image Capture Element [1] is placing one or more commercially available CCD Array Image Area Sensors (e.g. similar to device TC215 manufactured by Texas Instruments), on a moveable platform whose movement in one, two or three dimensions is controlled by piezo electric, magnetic, electromagnetic, electromechanical or otherwise mechanical actuators. Such a sensor could generate a single image in multiple scan passes, each scan pass capturing a different part, or interlace, of the image. The image parts may then be recombined by software or by proper placement of the separate images captured in memory so that the separate parts will create a full image. In another implementation, a line image sensor may be placed on a movable platform placed in Lens System[3] focal plane and moved linearly (e.g. in an arrangement similar to focal plane shutter in a single lens reflex camera) or pivoted to perform image scan to acquire the image.

In all the above described alternative methods for construction of the Image Capture Element [1], a color sensitive image sensor may be substituted, to allow the transmission of color facsimile.

Various methods of electronic resolution enhancement such as duplicating adjacent lines or data interpolation between pixels may be employed in order to reduce cost of manufacturing of the Image Capture element[1].

In order to reduce image distortion, a separate Lens System may be substituted for the page image capture preset setting of the fax camera, or alternatively an additional lens or lenses may be added by sliding, rotating or otherwise inserting the additional lens into the optical path between the image being captured [2] and the Image Capture Element [1].

Optionally, the display device[18] may be used as an electronic view finder, by eliminating the Shutter Device[4], or by allowing pre acquisition exposure and transferring the image from the image Capture Element [1] to the display device[18].

The Display Device[18] may also be used to edit the image prior to transmission, superimpose multiple images stored in memory, or to add text data on, or in addition to, the image. Such feature will facilitate transmitting facsimile cover pages.

It is also clear to those skilled in the art that many methods exist for constructing the Mounting Support[19], e.g. using a separate support member, not attached to the camera, or the use of a foldable and collapsible support frame, or similar common support means.

The Mounting Support may be eliminated completely if desired, and its functionality replaced by focused light beams, as depicted in FIG. 7. In this implementation, light beams are focused on at least two vertices of the Virtual Frame[25]. At least two light beams are used for each vertex. The light beam emanates from the Fax Camera and is focused by a lens (not shown). The lens focal point is at a vertex of the Virtual Frame[25]. Simple geometry dictates that the two points of light [40] and [41] will converge and focus only at the vertex point[42] thus providing an easy mechanism for the user to identify the vertex location. Similarly, light beams [43] and [44] convergence point determine the second vertex of the Virtual Frame[25]. A third, similar vertex designator will be sufficient to define the Virtual Frame[25].

Yet anther method to facilitate capture of a full page image capture is placing support beams [60] supporting a sheet of paper suspended between them as depicted in FIG. 8.

Other items common in photography such as light measurement [22] means, distance measuring device[23] and automatic focus mechanism [24] may be attached to the Fax Camera device. Such additions may operate under the control of the CPU[16] or partially independently e.g. a distance measurement device that directly controls automatic focus actuator.

Whereas the present invention has been described in particular relation to the drawing attached thereto, and what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. a fax camera comprising:

a) an image capture sensor mounted substantially in a focal plane of an optical focusing system, for transforming light reflected from an image into an electrical signal;

b) a memory device for storing data representing said electrical signal;

c) a facsimile signal transmission device for transmitting said electrical signal to a facsimile machine, said facsimile transmission device also capable of receiving image data from a remote facsimile machine;

d) an input device for receiving user input;

e) one or more programmable controllers for receiving input from said input device and for controlling said image capture sensor and facsimile signal transmission device; and,

f) means for defining a virtual frame in predetermined distance and orientation to said image capture sensor to define a page frame for photography and transmission of an object to a remote facsimile machine.

2. The fax camera of claim 1 wherein said means for defining a virtual frame comprises mounting support constructed to support said fax camera on a surface, wherein said focusing system is substantially oriented towards said surface.

3. The fax camera of claim 2 wherein said mounting support is collapsible.

4. The fax camera of claim 1 wherein said means for defining a virtual frame comprises a page frame support device for locating a printed image at selected predetermined distance and orientation from said focusing system.

5. The fax camera of claim 1 wherein said means for defining a virtual frame comprises means for directing at least two beams of light to converge at a vertex point outside and in front of said image capture sensor, wherein a multiplicity of said vertex points define a virtual frame at a predetermined distance and orientation from said image capture sensor.

6. The fax camera of claim 1 wherein said programmable controller is adapted to selectively transmit one or more of said stored images via said facsimile transmission device.

7. The fax camera of claim 1 wherein said facsimile transmission device is adapted to receive a facsimile image from a remote facsimile device, and wherein said programmable controller is adapted to receive said facsimile image and store said image in said memory device.

8. The fax camera of claim 1 further comprising a display device constructed to operate under control of said programmable controller.

9. The fax camera of claim 8 wherein said display device is constructed to display an image stored in said memory device.

10. The fax camera of claim 9 wherein said programmable controller is constructed to display user input data superimposed on said image.

11. The fax camera of claim 1 further comprising a photographic flash device.

12. The fax camera of claim 1 wherein said image capture sensor comprises:

a) a movable image sensor for capturing successive partial images;

b) an actuator for moving said image sensor between successive partial image captures; and

c) wherein said programmable controller is constructed to interleave data from said successive image captures into a single frame data.

13. The fax camera of claim 1 further comprising a digital communications port.

14. The fax camera of claim 1 wherein said image capture sensor comprises plurality of area array image sensors and an image splitting device for distributing light reflected from an image to said area array image sensors.

15. A fax camera comprising:

a) an enclosure;

b) an optical focusing system comprising one or more lens elements;

c) an image capture sensor mounted within said enclosure substantially in a focal plane of said optical focusing system for transforming light reflected from an image into an electrical signal;

d) a memory device for storing data representing said electrical signal of one or more images;

e) a facsimile signal transmission device for transmitting said electrical signal to a facsimile machine, said transmission device also capable of receiving image data from a remote facsimile machine;

f) an Input device for receiving user input;

g) one or more programmable controllers for receiving input from said input device and for controlling said image capture sensor and facsimile signal transmission device;

h) collapsible mounting support to support said fax camera on a surface, said mounting support defining a virtual frame at a predetermined distance and orientation from said image capture sensor; and

i) a display device capable of displaying images and user input, and constructed to operate under the control of said programmable controller wherein said programmable controller is adapted to display image data stored in said memory device, and data entered via said input device.

16. The fax camera of claim **15** wherein said means for defining a virtual frame comprises multiple means for directing at least two beams of light to converge at a vertex point outside and in front of said image capture sensor, wherein a multiplicity of said vertex points define a virtual frame at a predetermined distance and orientation from said image capture sensor.

* * * * *

OIPE JC134
FEB 2 1 2001
PATENT & TRADEMARK OFFICE

2622
#10
3-2-01

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:

DAVID A. MONROE

Serial No.: 09/006,073

Filed: January 12, 1998

For: APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: COMMISSIONER OF PATENTS AND TRADEMARKS, Washington, D.C. 20231, this 21st. day of February, 2001.

Barbara Kobza
Barbara Kobza

RECEIVED
MAR 0 2 2001
Technology Center 2600

REQUEST FOR THREE-MONTH EXTENSION OF TIME

HONORABLE COMMISSIONER
OF PATENTS AND TRADEMARKS
Box: Fee
Washington, D.C. 20231

Sir:

Responsive to the Office Action dated August 29, 2001 a three-month extension of time is hereby requested in the above-identified application. The requisite extension fee of $445.00 is attached.

2/28/2001 EHAILE1 00000015 09006073
1 FC:217 445.00 OP

21

Application of
David A. Monroe

Serial No. 09/006,073

The Commissioner is hereby authorized to charge any additional fees in this application under 35 C.F.R. §1.16 or §1.17 to **Deposit Account No. 50-0259**. An additional copy of this Request for Extension of Time is attached.

Respectfully submitted,

Stephen F. Schlather
Registration No. 45,081

BRACEWELL & PATTERSON, L.L.P.
711 Louisiana, Suite 2900
Houston, Texas 77002
(713) 221-1339
Fax (713) 223-2141
Attorney Docket No. 069834.000024

NW

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

NW

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
09/006,073	01/12/98	MONROE D	58959.12

WM31/0410

BRACEWELL & PATTERSON
SOUTH TOWER PENNZOIL PLACE
711 LOUISANA STREET SUITE 2900
HOUSTON TX 77002-2781

EXAMINER	
POKRZYWA,J	
ART UNIT	**PAPER NUMBER**
2622	11

DATE MAILED: 04/10/01

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

PTO-90C (Rev. 2/95)
U.S. G.P.O. 2000 · 465-188/25268

1- File Copy NS

Notice of Abandonment	**Application No.** 09/006,073	**Applicant(s)** MONROE, DAVID A.	
	Examiner Joseph R. Pokrzywa	**Art Unit** 2622	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

This application is abandoned in view of:

1. ☒ Applicant's failure to timely file a proper reply to the Office letter mailed on *29 August 2000*.
   - (a) ☐ A reply was received on _____ (with a Certificate of Mailing or Transmission dated _____), which is after the expiration of the period for reply (including a total extension of time of _____ month(s)) which expired on _____.
   - (b) ☐ A proposed reply was received on _____, but it does not constitute a proper reply under 37 CRF 1.113 (a) to the final rejection. (A proper reply under 37 CRF 1.113 to a final rejection consists only of: (1) a timely filed amendment which places the application in condition for allowance; (2) a timely filed Notice of Appeal (with appeal fee); or (3) a timely filed Request for Continued Examination (RCE) in compliance with 37 CFR 1.114).
   - (c) ☒ No reply has been received.

2. ☐ Applicant's failure to timely pay the required issue fee and publication fee, if applicable, within the statutory period of three months from the mailing date of the Notice of Allowance (PTOL-85).
   - (a) ☐ The issue fee and publication fee, if applicable, was received on _____ (with a Certificate of Mailing or Transmission dated __), which is after the expiration of the statutory period for payment of the issue fee (and publication fee) set in the Notice of Allowance.
   - (b) ☐ The submitted fee of $_____ is insufficient. A balance of $_____ is due. The issue fee required by 37 CFR 1.18 is $_____. The publication fee, if required by 37 CFR 1.18(d), is $_____.
   - (c) ☐ The issue fee and publication fee, if applicable, has not been received.

3. ☐ Applicant's failure to timely file new formal drawings as required by, and within the three-month period set in, the Notice of Allowability (PTO-37).
   - (a) ☐ Proposed new formal drawings were received on _____ (with a Certificate of Mailing or Transmission dated _____), which is after the expiration of the period for reply.
   - (b) ☐ The proposed new formal drawings filed on _____ are not acceptable and the period for reply has expired.
   - (c) ☐ No proposed new formal drawings have been received.

4. ☐ The letter of express abandonment which is signed by the attorney or agent of record, the assignee of the entire interest, or all of the applicants.

5. ☐ The letter of express abandonment which is signed by an attorney or agent (acting in a representative capacity under 37 CFR 1.34(a)) upon the filing of a continuing application.

6. ☐ The decision by the Board of Patent Appeals and Interference rendered on _____ and because the period for seeking court review of the decision has expired and there are no allowed claims.

7. ☐ The reason(s) below:

EDWARD COLES
SUPERVISORY PATENT EXAMINER

J.S. Patent and Trademark Office
TO-1432 (Rev. 9-00)

Notice of Abandonment

Part of Paper No. 11

DETAILED ACTION

Abandonment

1. This application is abandoned in view of applicant's failure to submit a reply to the Office Action mailed on 8/29/00 within the required period for reply.

Conclusion

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Joe Pokrzywa whose telephone number is (703) 305-0146. The examiner can normally be reached on Monday-Friday, 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward L. Coles can be reached on (703) 305-4712. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 306-5406 for regular communications and (703) 306-5406 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 305-4700.

Joseph R. Pokrzywa
Examiner
Art Unit 2622

jrp
April 3, 2001

EDWARD COLES
SUPERVISORY PATENT

01-06-03

1453 #12 9200

OIPE JAN 0 3 2003 PATENT & TRADEMARK OFFICE

PTO/SB/64 (10-01)
Approved for use through 10/31/2002. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION FOR REVIVAL OF AN APPLICATION FOR PATENT ABANDONED UNINTENTIONALLY UNDER 37 CFR 1.137(b)	Docket Number (Optional) P-121817.02.024

First named inventor: David A. Monroe

Application No.: 09/006,073 Group Art Unit: 2622

Filed: January 12, 1998 Examiner: J. Pokrzywa

Title: Apparatus For Capturing, Converting and Transmitting A Visual Image Signal Via A Digital Transmission System.

Attention: Office of Petitions
Assistant Commissioner for Patents
Box DAC
Washington, D.C. 20231

NOTE: If information or assistance is needed in completing this form, please contact Petitions Information at (703)305-9282.

The above-identified application became abandoned for failure to file a timely and proper reply to a notice or action by the United States Patent and Trademark Office. The date of abandonment is the day after the expiration date of the period set for reply in the Office notice or action plus any extensions of time actually obtained.

APPLICANT HEREBY PETITIONS FOR REVIVAL OF THIS APPLICATION

NOTE: A grantable petition requires the following items:
(1) Petition fee;
(2) Reply and/or issue fee;
(3) Terminal disclaimer with disclaimer fee -- required for all utility and plant applications filed before June 8, 1995; and for all design applications; and
(4) Statement that the entire delay was unintentional.

1. Petition fee
☐ Small entity - fee $_____ (37 CFR 1.17(m)). Applicant claims small entity status. See 37 CFR 1.27.

☒ Other than small entity - fee $1,300.00 (37 CFR 1.17(m))

2. Reply and/or fee

A. The reply and/or fee to the above-noted Office action in the form of a continuing application as provided by 37 CFR 1.137(c) (identify type of reply):
☐ has been filed previously on _____.
☒ is enclosed herewith.

B. The issue fee of $ _____
☐ has been paid previously on _____.
☐ is enclosed herewith.

[Page 1 of 2]

Burden Hour Statement: This form is estimated to take 1.0 hour to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

~~01/07/2003 ANABI1 00000015 09006073~~
~~01 FC:1453 1300.00 OP~~
~~Void date: 01/07/2003 ANABI1~~
~~01/07/2003 ANABI1 00000015 09006073~~
~~01 FC:1453 -1300.00 OP~~

RECEIVED
JAN 1 6 2003
OFFICE OF PETITIONS

01/07/2003 ANABI1 00000016 09006073 1300.00 OP
01 FC:1453

3. Terminal disclaimer with disclaimer fee

☒ Since this utility/plant application was filed on or after June 8, 1995, no terminal disclaimer is required.

☐ A terminal disclaimer (and disclaimer fee (37 CFR 1.20(d)) of $_____ for a small entity or $_____ for other than a small entity) disclaiming a period equivalent to the period of abandonment is enclosed herewith (see PTO/SB/63).

4. Statement. The entire delay in filing the required reply from the due date for the required reply until the filing of a grantable petition under 37 CFR 1.137(b) was unintentional. [NOTE: The United States Patent and Trademark Office may require additional information if there is a question as to whether either the abandonment or the delay in filing a petition under 37 CFR 1.137(b) was unintentional (MPEP 711.03(c)(III)(C) and (D))].

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

1-3-03
Date

Signature

Telephone
Number: (210) 978-7700

Richard R. Ruble, Reg. 45,720
Typed or printed name

JACKSON WALKER L.L.P.
112 E. Pecan St., Suite 2100
San Antonio, Texas 78205
Address

Enclosures:
☒ Fee Payment
☒ Reply
☐ Terminal Disclaimer Form
☐ Additional sheets containing statements establishing unintentional delay
☐ Other : _____

CERTIFICATE OF MAILING OR TRANSMISSION [37 CFR 1.8(A)]

I hereby certify that this correspondence is being:

☒ deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Box DAC, Washington, D.C. 20231.

☐ transmitted by facsimile on the date shown below to the Patent and Trademark Office at (703) 308-6916.

Express mail
EL692001045US

Bianca Grossweiler
Signature

Date
1-3-03

Bianca Grossweiler
Typed or printed name of person signing certificate

PALM INTRANET

Day : Thursday
Date: 3/6/2003
Time: 09:15:05

Continuity Information for 09/006073

Parent Data

No Parent Data

Child Data

09790381 is a division of 09006073
[redacted]
PCT/US99/00664 is a continuation of 09006073

Appln Info | Contents | Petition Info | Atty/Agent Info | **Continuity Data** | Foreign Data | Inventors | Ad

Search Another: Application# Search **or Patent#** Search

PCT / / Search **or PG PUBS #** Search

Attorney Docket # Search

To go back use Back button on your browser toolbar.

Back to PALM | ASSIGNMENT | OASIS | Home page

PALM INTRANET

Day : Monday
Date: 3/3/2003
Time: 16:00:59

Application Number Information

Application Number: 10/336470 Assignments
Filing Date: 01/03/2003
Effective Date: **01/03/2003**
Application Received: **01/06/2003**
Patent Number:
Issue Date: **00/00/0000**
Date of Abandonment: **00/00/0000**
Attorney Docket Number: **P-121817.02.043(DIV)**
Status: **19 /APPLICATION UNDERGOING PREEXAM PROCESSING**
Confirmation Number: **8448**

Examiner Number: **00000 /**
Group Art Unit: **2622**
Class/Subclass: **358/ .**
Lost Case: **NO**
Interference Number:
Unmatched Petition: **NO**
L&R Code: Secrecy Code:**1**
Third Level Review: **NO**
Secrecy Order: **NO**
Status Date: **01/08/2003**

Title of Invention: **APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM**

Bar Code	Location	Location Date	Chrg to Loc	Charge to Name	Emp. ID	Infra Loc
10336470	**03C0 OIPE - MISSING PARTS-CENTRAL FILES, CP6 LOBBY**	**02/10/2003**		**No Charge to Name**	**BGEBREIGZIABIHER**	

Appln Info Contents | Petition Info | Atty/Agent Info | Continuity Data | Foreign Data | Inventors

Search Another: Application# ☐ Search **or Patent#** ☐ Search

PCT / ☐ / ☐ Search **or PG PUBS #** ☐ Search

Attorney Docket # ☐ Search

Bar Code # ☐ Search

To go back use Back button on your browser toolbar.

Back to PALM | ASSIGNMENT | OASIS | Home page

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

Paper No. 13

Bracewell & Patterson
South Tower Pennzoil Place
711 Louisana Street, Suite 2900
Houston, TX 77002-2781

COPY MAILED
MAR 1 1 2003
OFFICE OF PETITIONS

In re Application of :
David A. Monroe :
Application No. 09/006,073 :
Filed: January 12, 1998 :
Attorney Docket No. P-121817-02.024 :

ON PETITION

This is a decision on the petition under 37 CFR 1.137(b), filed January 3, 2003, to revive the above-identified application.

The above-identified application became abandoned for failure to reply within the meaning of 37 CFR 1.113 in a timely manner to the final Office action mailed August 29, 2000, which set a shortened statutory period for reply of three(3) months. A three (3) months extension of time under the provisions of 37 CFR 1.136(a) was obtained. Accordingly, the application became abandoned on March 1, 2001.

It is not apparent whether the person signing the statement of unintentional delay was in a position to have firsthand or direct knowledge of the facts and circumstances of the delay at issue. Nevertheless, such statement is being treated as having been made as the result of a reasonable inquiry into the facts and circumstances of such delay. See 37 CFR 10.18(b) and Changes to Patent Practice and Procedure; Final Rule Notice, 62 Fed. Reg. 53131, 53178 (October 10, 1997), 1203 Off. Gaz. Pat. Office 63, 103 (October 21, 1997). In the event that such an inquiry has not been made, petitioner must make such an inquiry. If such inquiry results in the discovery that it is not correct that the entire delay in filing the required reply from the due date for the reply until the filing of a grantable petition pursuant to 37 CFR 1.137(b) was unintentional, petitioner must notify the Office.

There is no indication that the person signing the instant petition was ever given a power of attorney or authorization of agent to prosecute the above-identified application. If the person signing the instant petition desires to receive future correspondence regarding this application, the appropriate power of attorney or authorization of agent must be submitted. While a courtesy copy of this decision is being mailed to the person signing the instant petition, all future correspondence will be directed to the address of currently of record until such time as appropriate instructions are received to the contrary.

This application is being revived solely for purposes of continuity. As continuity has been established by this decision, the application is again abandoned in favor of continuing application No. 10/125,321.

Telephone inquiries concerning this decision should be directed to Cheryl Gibson-Baylor at (703)308-5111, or in her absence, Sherry Brinkley at (703)305-9220.

The application file is being forwarded to Technology Center 3700, Art Unit 3749.

Cheryl Gibson Baylor

Cheryl Gibson-Baylor
Petitions Examiner
Office of Petitions
Office of the Deputy Commissioner
for Patent Examination Policy

Sherry Brinkley

Sherry Brinkley
Petitions Examiner

cc: Richard R. Ruble
Jackson, Walker LLP
112 E. Pecan St., Suite 2100
San Antonio, Texas 78205

PTO/SB/68 (06-09)
Approved for use through 07/31/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

REQUEST FOR ACCESS TO AN ABANDONED APPLICATION UNDER 37 CFR 1.14

Bring completed form to:
File Information Unit, Room 2E04
2900 Crystal Drive
Arlington, VA 22202-3514

Telephone: (703) 308-2733

In re Application of

Application Number	Filed
09/006073	Jan 12, 1998

Paper No. 14

I hereby request access under 37 CFR 1.14(a)(1)(iv) to the application file record of the above-identified ABANDONED application, which is not within the file jacket of a pending Continued Prosecution Application (CPA) (37 CFR 1.53(d)) and which is identified in, or to which a benefit is claimed, in the following document (as shown in the attachment):

United States Patent Application Publication No. ____________, page, ________ line ________,

United States Patent Number 7365871, column ________, line, ________ or

WIPO Pub. No.________________, page ________, line ________.

Related Information About Access to Applications Maintained in the Image File Wrapper System (IFW) and Access to Pending Applications in General

A member of the public, acting without a power to inspect, cannot order applications maintained in the IFW system through the FIU. If the member of the public is entitled to a copy of the application file, then the file is made available through the Public Patent Application Information Retrieval system (Public PAIR) on the USPTO internet web site (www.uspto.gov). Terminals that allow access to Public PAIR are available in the Public Search Room. The member of the public may also be entitled to obtain a copy of all or part of the application file upon payment of the appropriate fee. Such copies must be purchased through the **Office of Public Records** upon payment of the appropriate fee (37 CFR 1.19(b)).

For published applications that are still pending, a member of the public may obtain **a copy** of: the file contents; the pending application as originally filed; or any document in the file of the pending application.

For unpublished applications that are still pending:

(1) If the benefit of the pending application is claimed under 35 U.S.C. 119(e), 120, 121, or 365 in another application that has: (a) issued as a U.S. patent, or (b) published as a statutory invention registration, a U.S. patent application publication, or an international patent application publication in accordance with PCT Article 21(2), a member of the public may obtain a copy of: the file contents; the pending application as originally filed; or any document in the file of the pending application.

(2) If the application is incorporated by reference or otherwise identified in a U.S. patent, a statutory invention registration, a U.S. patent application publication, or an international patent application publication in accordance with PCT Article 21(2), a member of the public may obtain **a copy** of the pending application as originally filed.

RECEIVED
NOV 06 2009
File Information Unit

S. Gonzalez
Signature

11 : 6 · 09
Date

Sal Gonzalez
Typed or printed name

Registration Number, if applicable

703 · 579 · 1820
Telephone Number

~~FOR PTO USE ONLY~~

Approved by: ________

Initials

Unit: ________

File Information Unit
NOV 06 2009
RECEIVED

This collection of information is required by 37 CFR 1.11 and 1.14. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **BRING TO: File Information Unit, Room 2E04, 2900 Crystal Drive, Arlington, Virginia.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

US007365871B2

(12) **United States Patent**
Monroe

(10) **Patent No.: US 7,365,871 B2**
(45) **Date of Patent: Apr. 29, 2008**

(54) **APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM**

(76) Inventor: **David A. Monroe**, 740 Lincoln Center, 7800 1H-10 West, San Antonio, TX (US) 78230

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/336,470**

(22) Filed: **Jan. 3, 2003**

(65) **Prior Publication Data**

US 2004/0001214 A1 Jan. 1, 2004

Related U.S. Application Data

(62) Division of application No. 09/006,073, filed on Jan. 12, 1998, now abandoned.

(51) **Int. Cl.**
G06K 1/00 (2006.01)
H04N 1/00 (2006.01)

(52) **U.S. Cl.** **358/1.15**; 358/402; 358/403; 358/407

(58) **Field of Classification Search** 358/1.15, 358/402, 403, 407, 442, 468, 474
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,642,492	A	6/1953	Hammond, Jr.	348/24
3,251,937	A	5/1966	Hoag	358/410
3,751,159	A	8/1973	Fisher	355/20
3,864,514	A	2/1975	Lemelson	358/409
4,074,324	A	2/1978	Barrett	358/296
4,163,283	A	7/1979	Darby	
4,179,695	A	12/1979	Levine et al.	
4,197,536	A	4/1980	Levine	
4,516,125	A	5/1985	Schwab et al.	
4,530,014	A	7/1985	D'Alayer de Costemore D'Arc	386/119
4,652,926	A	3/1987	Withers et al.	347/226
4,688,244	A *	8/1987	Hannon et al.	377/58
4,831,438	A	5/1989	Bellman, Jr. et al.	
4,845,629	A	7/1989	Murge	
4,857,912	A	8/1989	Everett, Jr. et al.	
4,884,132	A *	11/1989	Morris et al.	358/479
4,891,650	A	1/1990	Sheffer	
4,910,692	A	3/1990	Outram	

(Continued)

FOREIGN PATENT DOCUMENTS

EP	220752	5/1987

(Continued)

OTHER PUBLICATIONS

Anonymous, "New & Old: Web-ready Camera Server, LAN Video Connects", Security Distributing & Marketing; Apr. 1998; 28, 5; p. 58.

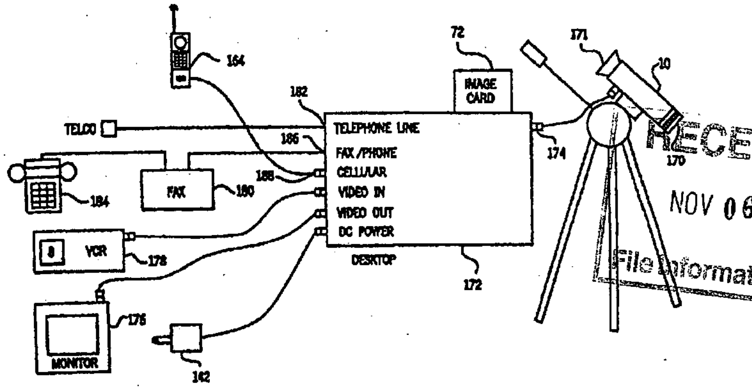
(Continued)

Primary Examiner—Houshang Safaipour

(57) **ABSTRACT**

An image capture, conversion, compression, storage and transmission system provides a data signal representing the image in a format and protocol capable of being transmitted over any of a plurality of readily available transmission systems and received by readily available, standard equipment receiving stations. In its most comprehensive form, the system is capable of sending and receiving audio, documentary and visual image data to and from standard remote stations readily available throughout the world.

15 Claims, 73 Drawing Sheets



ATTACH
DISK/FICHE
ENVELOPE
HERE

(RIGHT SIDE)

[redacted]

SEAR

Class	Sub.	Date	Exmr.
358	400 407 442 445 471	8/10/99	JP
348	14 17 18 19 143 155 207 211 441		
379	100.01 100.02 100.05 100.09 100.13 100.15 100.16 100.17 102.01 106.01		

NOTES
(INCLUDING SEARCH STRATEGY)

	Date	Exmr.
CONSULTED W/ JEROME GRANT	11/16/99	JP
SEARCHED RELATED PCT CASE	8/10/99	JP
SEARCHED EAST (NOT ATTACHED)	11/15/99	JP
SEARCHED EAST (ATTACHED)	8/14/00	JP

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.

(RIGHT OUTSIDE)

ISSUE SLIP STAPLE AREA (for additional cross references)

POSITION	INITIALS	ID NO.	DATE
FEE DETERMINATION			
O.I.P.E. CLASSIFIER		58	3-4-98
FORMALITY REVIEW	DM	72223 69599	4/6/98 07-16-98

INDEX OF CLAIMS

✔ .... Rejected		N	.... Non-elected
= .... Allowed		I	.... Interference
— (Through numeral) Canceled		A	.... Appeal
÷ .... Restricted		0	.... Objected

Claim		Date									
Final	Original	11/29/99	8/15/00								
	1	✓	✓								
	2	✓	✓								
	3	✓	✓								
	4	✓	✓								
	~~5~~	✓									
	~~6~~	✓									
	~~7~~	✓									
	~~8~~	✓									
	9	✓	✓								
	10	✓	✓								
	11	✓	✓								
	12	✓	✓								
	13	✓	✓								
	14	✓	✓								
	15	✓	✓								
	16	✓	✓								
	17	✓	✓								
	18	✓	✓								
	19	✓	✓								
	20	✓	✓								
	21	✓	✓								
	22	✓	✓								
	23	✓	✓								
	24	✓	✓								
	25	✓	✓								
	26	✓	✓								
	27	✓	✓								
	28	✓	✓								
	29	N									
	30	N									
	31	N									
	32	N									
	33	N									
	34	N									
	35	N									
	36	N									
	37	N									
	38	N									
	39	N									
	40	N									
	41	N									
	42	N									
	43	N									
	44	N									
	45	N									
	46	N									
	47	N									
	48	N									
	49	N									
	50	N									

Claim		Date									
Final	Original	11/29/99									
	51	N									
	52	N									
	53	N									
	54	N									
	55	N									
	56	N									
	57	N									
	58	N									
	59	N									
	60	N									
	61	N									
	62	N									
	63	N									
	64	N									
	65	N									
	66	N									
	67	N									
	68	N									
	69	N									
	70	N									
	71	N									
	72	N									
	73	N									
	74	N									
	75	N									
	76	N									
	77	N									
	78	N									
	79	N									
	70	N									
	81	N									
	82	N									
	83	N									
	84	N									
	85	N									
	86	N									
	87	N									
	88	N									
	89	N									
	90	N									
	91	N									
	92	N									
	93	N									
	94	N									
	95	N									
	96	N									
	97	N									
	98	N									
	99	N									
	100	N									

Claim		Date									
Final	Original	11/29/99									
	110	N									
	112	N									
	113	N									
	114	N									
	115	N									
	116	N									
	117	N									
	118	N									
	119	N									
	110	N									
	111	N									
	112	N									
	113	N									
	114	N									
	115	N									
	116	N									
	117	N									
	118	N									
	119	N									
	120	N									
	121	N									
	122	N									
	123	N									
	124	N									
	125	N									
	126	N									
	127	N									
	128	N									
	129	N									
	130	N									
	131	N									
	132	N									
	133	N									
	134	N									
	135	N									
	136	N									
	137	N									
	138	N									
	139	N									
	140	N									
	141	N									
	142	N									
	143	N									
	144	N									
	145	N									
	146	N									
	147	N									
	148	N									
	149	N									
	150	N									

If more than 150 claims or 10 actions staple additional sheet here

(LEFT INSIDE)

JC560 U.S. PTO
09/006073
01/12/98

PATENT APPLICATION

09006073

INITIALS
APR 02 98 ST

CONTENTS

	Date received (Incl. C. of M.) or Date Mailed	[redacted]	Date received (Incl. C. of M.) or Date Mailed
1. Application 8 papers.		42.	
2. LTR RE DEC	4/13/98	43.	
3. Dec/Surcharge	07.08.98	44.	
4. Ext of time	07.08.98	45.	
5. Print Out	5-26-98	46.	
12-6 6. Rej (3 mos)	10-7-99	47.	
7. Ext (3)	6-7-00	48.	
8. Amdt A	6-7-00	49.	
-28 9. Final Rej (3 mos)	8-28-00	50.	
10. Ext of time (3)	2-21-01	51.	
4 11. [illegible]ANDONED	4-10-01	52.	
12. PET 1.137 (b)	01-03-03	53.	
13. Petition Granted	03/11/03	54.	
14. Request for Access	11/6/09	55.	
15.		56.	
16.		57.	
17.		58.	
18.		59.	
19.		60.	
20.		61.	
21.		62.	
22.		63.	
23.		64.	
24.		65.	
25.		66.	
26.		67.	
27.		68.	
28.		69.	
29.		70.	
30.		71.	
31.		72.	
32.		73.	
33.		74.	
34.		75.	
35.		76.	
36.		77.	
37.		78.	
38.		79.	
39.		80.	
40.		81.	
41.		82.	

(FRONT)