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<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	60719
		Application Number	
Title of Invention	APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM		
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<b>Title of the Invention</b>	APPARATUS FOR CAPTURING, CONVERTING AND TRANSMITTING A VISUAL IMAGE SIGNAL VIA A DIGITAL TRANSMISSION SYSTEM		
<b>Attorney Docket Number</b>	60719	<b>Small Entity Status Claimed</b>	<input type="checkbox"/>
<b>Application Type</b>	Nonprovisional		
<b>Subject Matter</b>	Utility		
<b>Suggested Class (if any)</b>		<b>Sub Class (if any)</b>	
<b>Suggested Technology Center (if any)</b>			
<b>Total Number of Drawing Sheets (if any)</b>	73	<b>Suggested Figure for Publication (if any)</b>	
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Prior Application Status	Pending	<input type="button" value="Remove"/>	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	10336470	2003-01-03
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**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**

[0001] This application is a divisional application of and claims priority from a non-provisional United States Application entitled Apparatus For Capturing, Converting And Transmitting A Visual Image Signal Via A Digital Transmission System, Serial No. 09/006,073, having a filing date of January 12, 1998; the specification and drawings of which are hereby incorporated by reference.

### **BACKGROUND OF THE INVENTION**

#### **FIELD OF THE INVENTION**

[0002] 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**

[0003] 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.

[0004] 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.

[0005] 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.

[0006] Still video equipment has recently become available from vendors such as Kodak, Canon and Sony, and is again primarily used by 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.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] 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**

[0011] 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.

[0012] 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.

[0013] 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.

**[0014]** 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.

**[0015]** 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.

**[0016]** 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.

**[0017]** 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.

**[0018]** 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 outjack to a remote device or via a cellular telephone, land line telephone, wireless radio or other communication system.

**[0019]** 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.

**[0020]** 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.

**[0021]** 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.

**[0022]** 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.

**[0023]** Where desired, the system also includes camera operation control capability through the use of 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.

**[0024]** 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.

**[0025]** 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.

[0026] The remote device may also be used 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.

[0027] 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.

[0028] 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 be 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] Other objects and features will be readily apparent from the drawings and detailed description.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] Fig. 5 is an exemplary schematic diagram supporting the configurations shown in each of Figs. 1-4.

[0043] Figs. 6A, 6B, and 6C, are block diagrams of the physical components of desktop, portable and comprehensive console embodiments of the invention, respectively.

[0044] 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 Frassinio design).

[0045] Figs. 8A-8L (Formerly Fig. 12) comprises a schematic diagram for an exemplary embodiment of the circuit for supporting the subject invention.

[0046] Fig. 9 is a diagram of the various triggering sequence options.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0047] 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 configurations is *identical* , but *stationary configurations do not need a battery.*

[0048] 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.

[0049] 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.

**[0050]** 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.

[0051] 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 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.

[0052] The configuration of Fig. 3 incorporates all of the features of Figs. I 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.

[0053] 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.

**[0054]** 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.

**[0055]** 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 93 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.

**[0056]** 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 microprocessor or 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.

**[0057]** 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.

**[0058]** 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.

[0059] 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.

[0060] 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.

[0061] 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.

**[0062]** 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.

**[0063]** 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.

**[0064]** 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.

[0065] 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.

[0066] 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.

[0067] 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 illustrate the subject invention as incorporated in a standard 35 millimeter type camera housing.

[0068] 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.

[0069] 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.

[0070] 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. 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.

[0071] 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.

[0072] 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 I 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 10-17 of buffer 352 are also connected to the processor bus.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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.

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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 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.

[0084] 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.

[0085] 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.

[0086] 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.

[0087] 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.

[0088] 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:  $t_1, t_2 \dots t_n$ , with a sample at each time interval, as indicated by  $S_1 \dots S_n$ . For purposes of illustration, the triggering event occurs at time interval  $t_{10}$ . 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.

[0089] 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.

[0090] 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:

467 8006

1. 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.
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 1~~, further including a subprocessor for generating a Group-III facsimile compatible ~~signal~~ representing the digital signal.
6. The image processing system of claim 1, wherein the subprocessor comprises:
  - a. A gray scale bit map;
  - b. A half tone converter; and
  - c. A binary bit map.

7. The image processing system of claim 1, wherein there is further included an integrated wireless telephone associated with the communications device.
8. The image processing system of claim 1, further comprising a housing for housing all of the elements of the system in an integrated body.
9. The image processing system of claim 1, wherein said image capture device is a digital camera.
10. The image processing system of claim 2, further including a view screen for viewing the captured and stored image.
11. The image processing system of claim 5, further including a facsimile receiving device associated locally with the system for providing a local printer for reproducing the captured image in hard copy.
12. 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.
13. 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.
- 14. The image processing system of claim 13, 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.
- 15. The image processing system of claim 13, 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.
- 16. The image processing system of claim 13, further including a local facsimile receiving system associated with the modem for providing local hard copy of the stored image signals in the memory.
- 17. The image processing system of claim 16, further including a switching device for selectively activating and deactivating the local facsimile receiving system.
- 18. The image processing system of claim 13, further including an integral viewer for viewing the images stored in the memory.
- 19. The image processing system of claim 13, wherein the memory is a removable memory medium which may be selectively removed from the system.
- 20. The image processing system of claim 19, wherein the removable memory medium comprises a PCMCIA card memory.
- 21. 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.

22. 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.
23. The image processing system of claim 1, further comprising a data processor for creating a text data signal associated with said image data signal.
24. The image processing system of claim 23, further including an input device for providing text data to the data processor.
25. The image processing system of claim 24, wherein said input device is user controlled.
26. The image processing system of claim 25, wherein said user controlled input device is an integral keyboard.
27. The image processing system of claim 24, said input device comprising a real time clock.
28. The image processing system of claim 24, said input device comprising a global positioning system.
29. The image processing system of claim 2, wherein said image data signal is stored in a raw video format.
30. The image processing system of claim 2, wherein said image data signal is stored in a compressed format.
31. The image processing system of claim 2, wherein said image data signal is stored in a half-tone format.

32. 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.
33. 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.
34. 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.
35. The image processing system of claim 1, wherein the remote receiving station is a digital device and the image data is digital.
36. The image processing system of claim 1, further comprising a self-contained power source for powering the system.
37. The image processing system of claim 36, 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.
38. The image processing system of claim 37, 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.
39. The image processing system of claim 38, wherein the power initiation device is user controlled.
40. The image processing system of claim 38, further including a trigger device for activating the power initiation device.
41. The image processing system of claim 40, wherein the trigger device is a timer.

42. The image processing system of claim 40, wherein the trigger device is triggered by the presence of an image to be captured.



FIG. 1

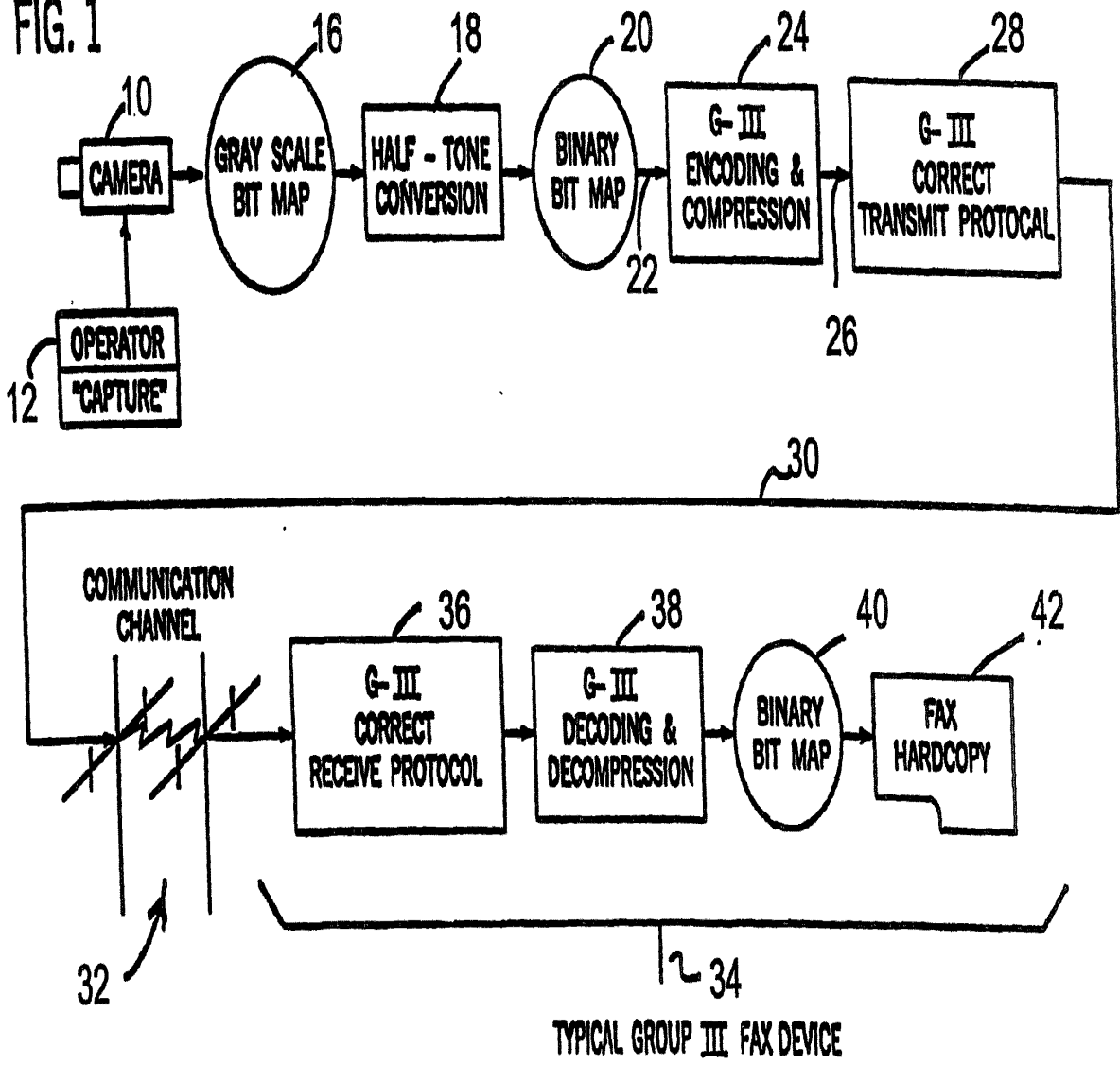
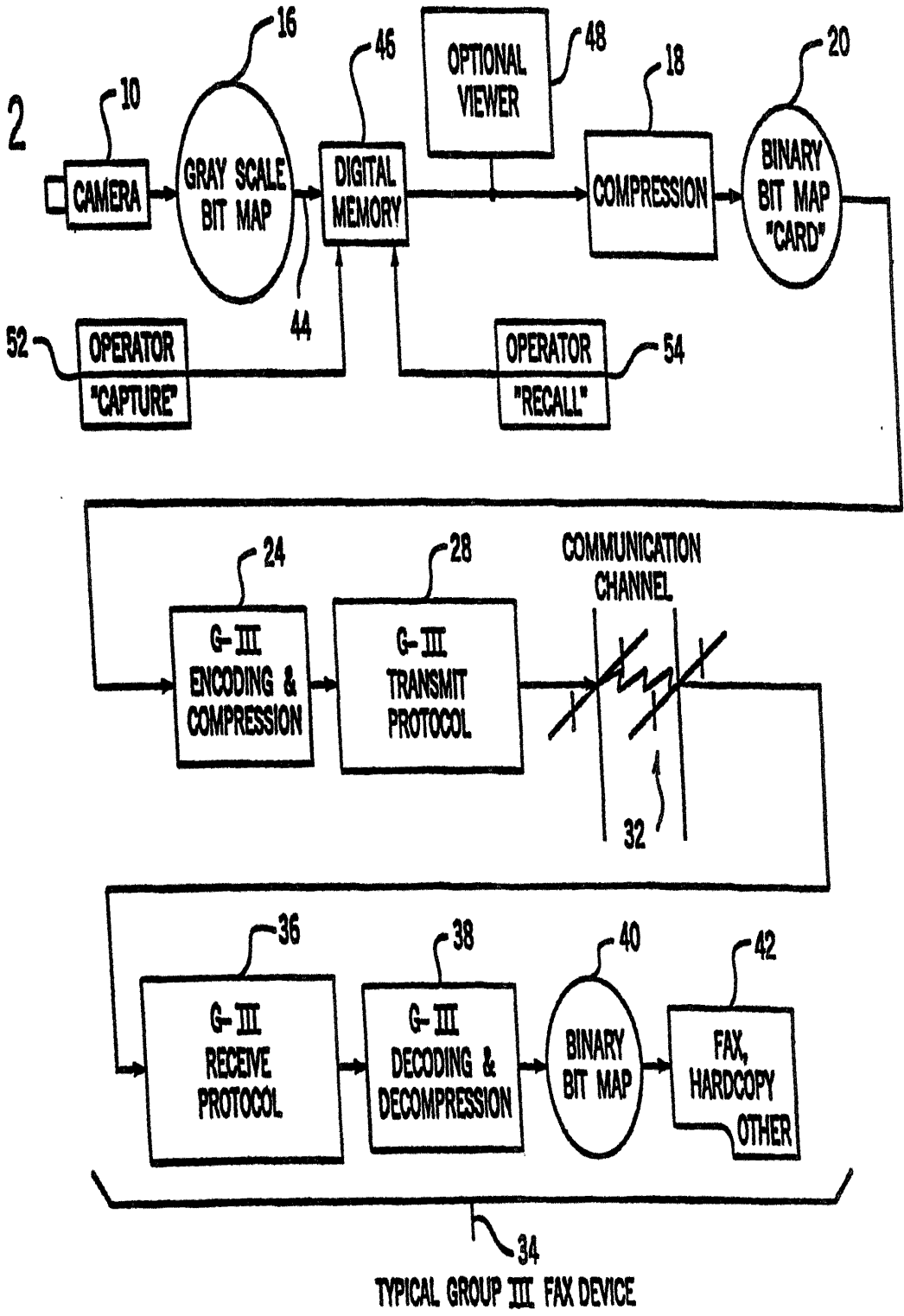


FIG. 2



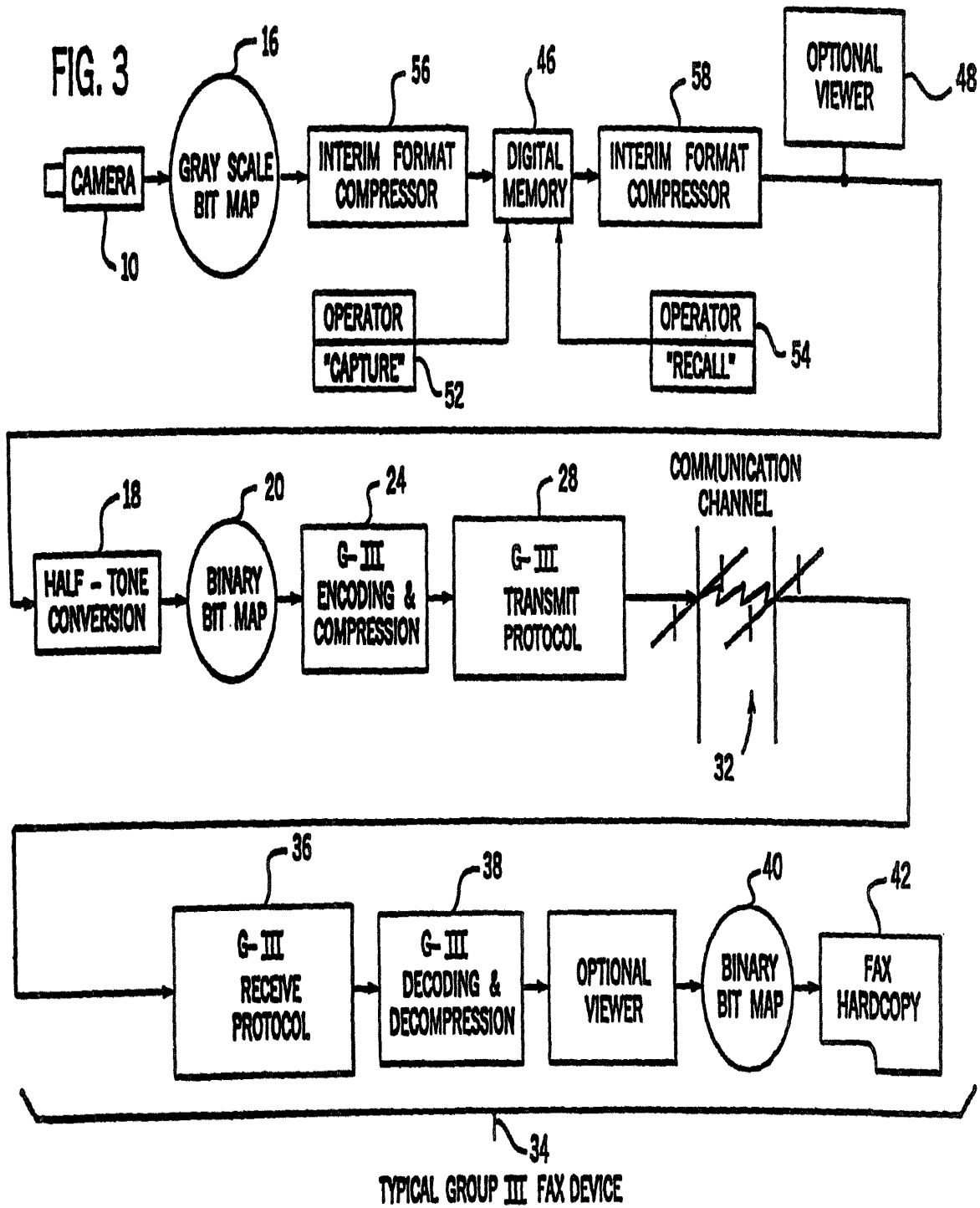
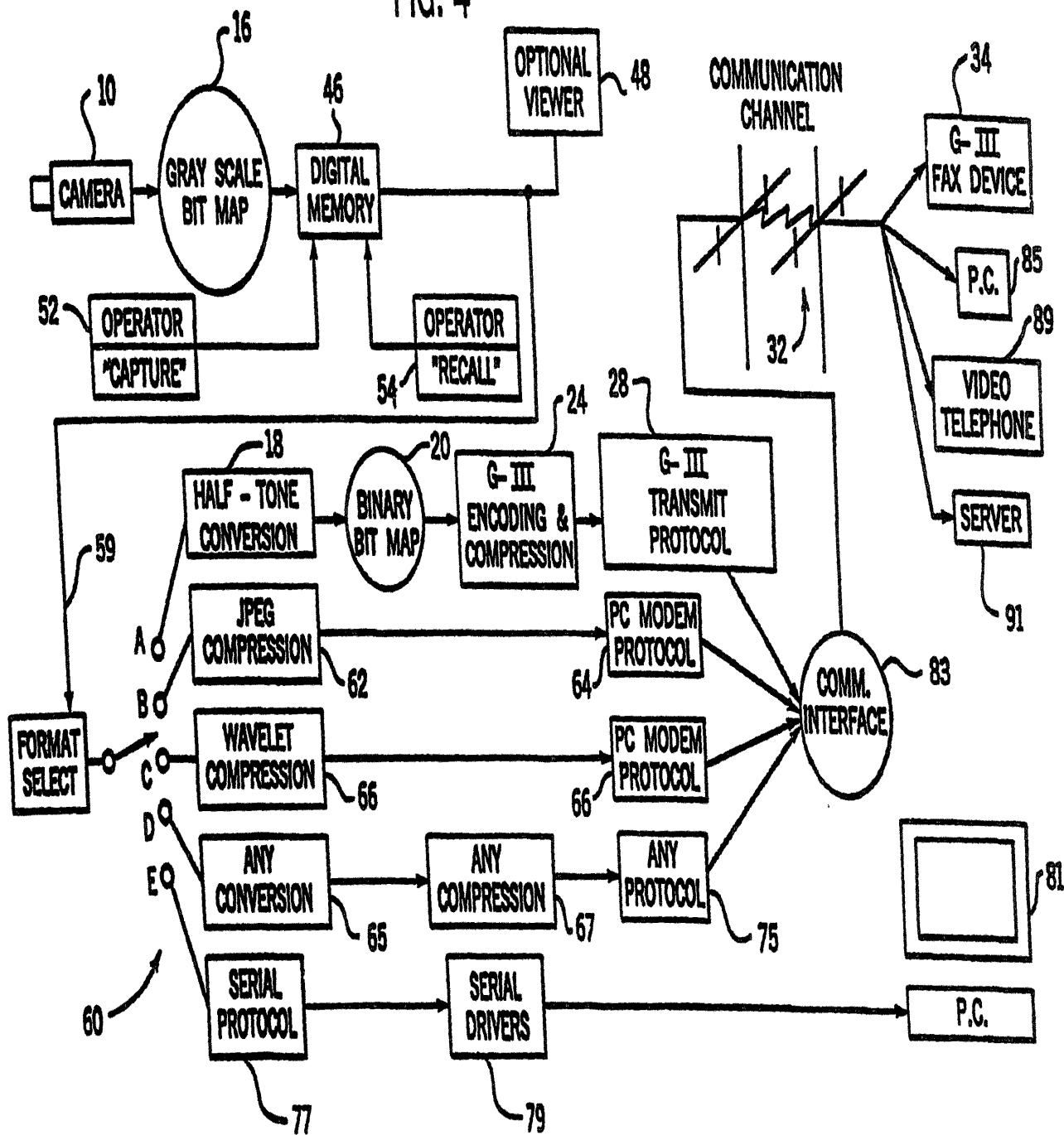


FIG. 4



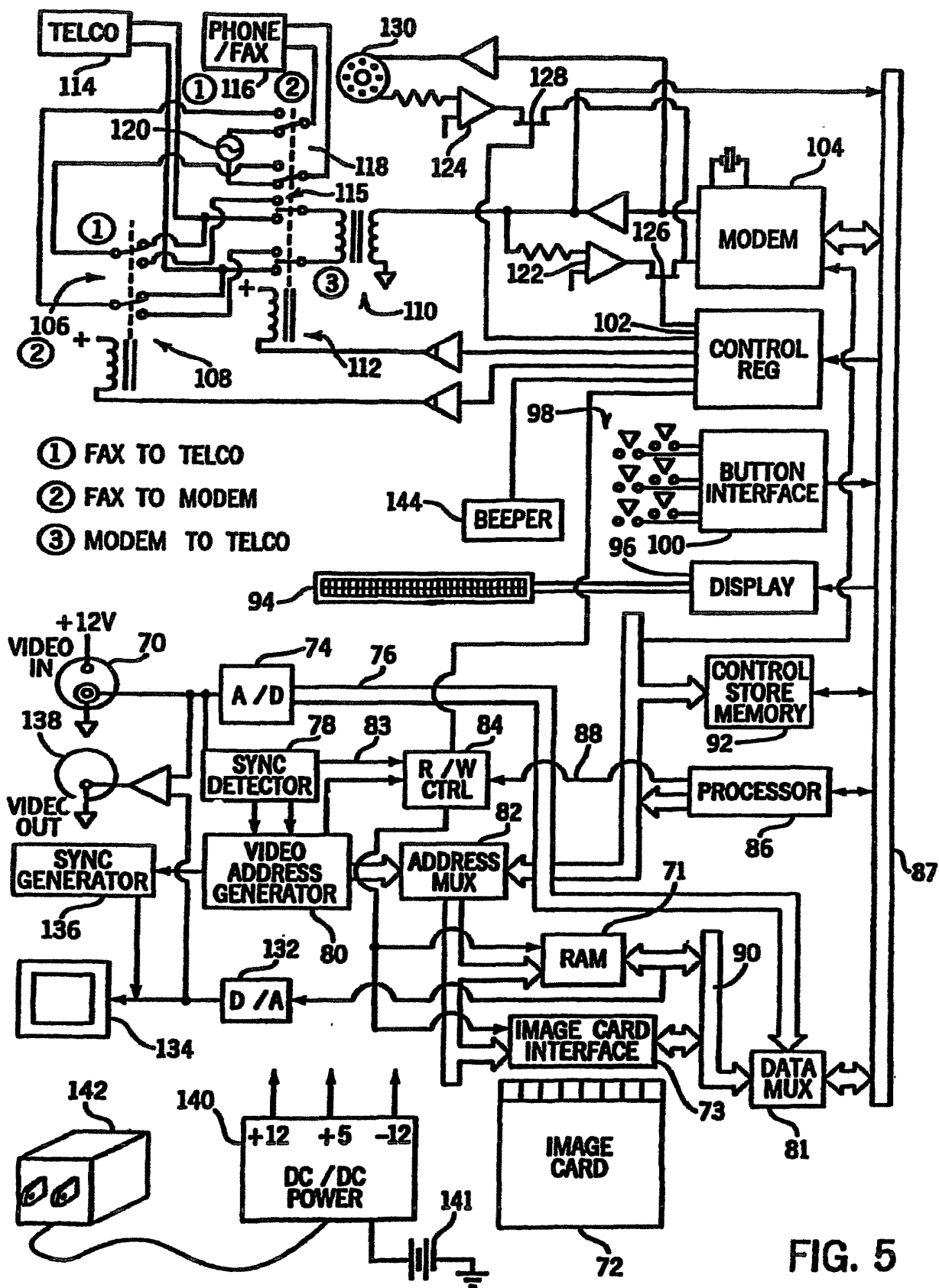


FIG. 5

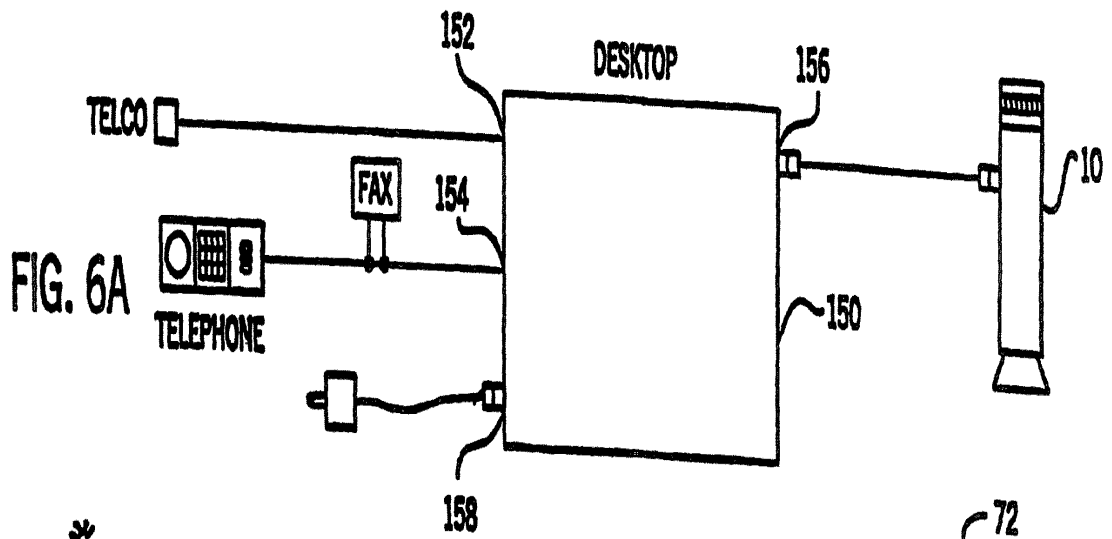


FIG. 6A

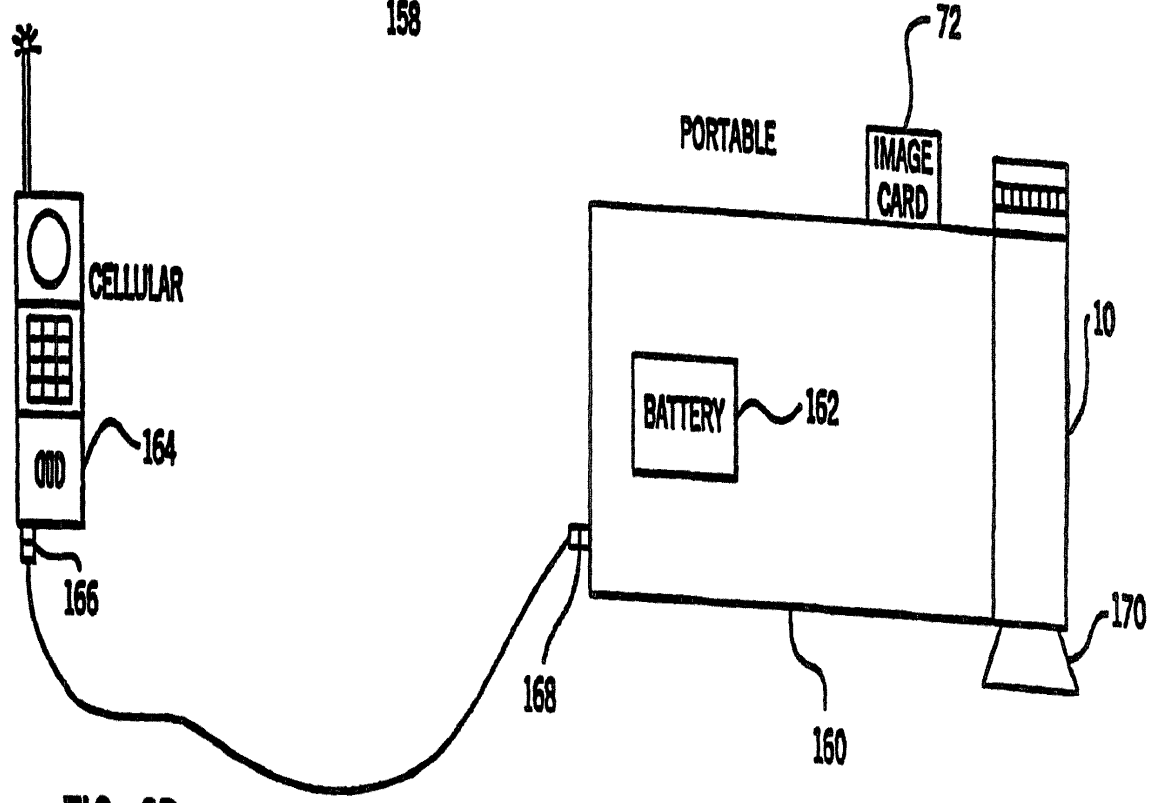


FIG. 6B

FIG. 6C

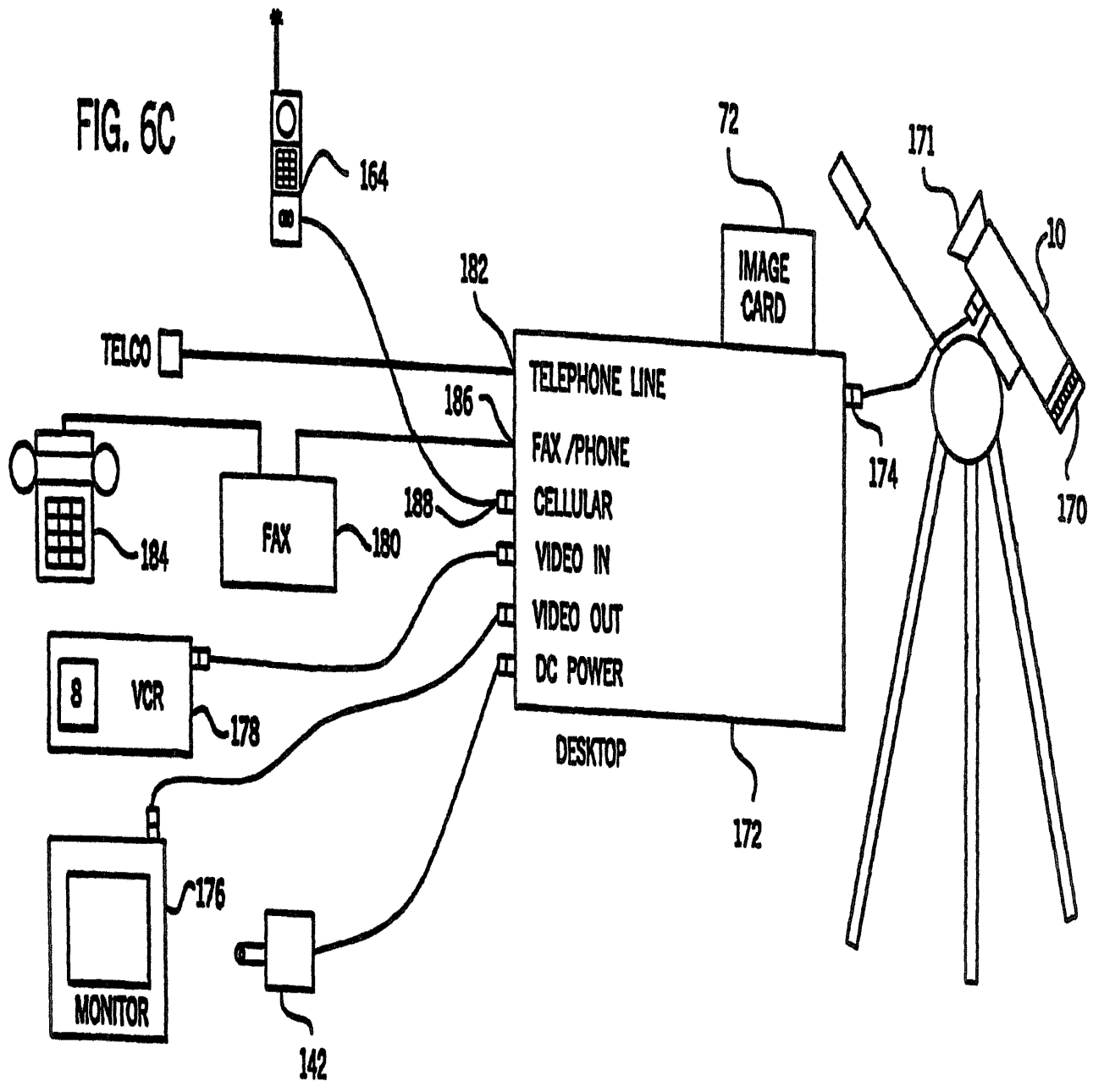


FIG. 7A

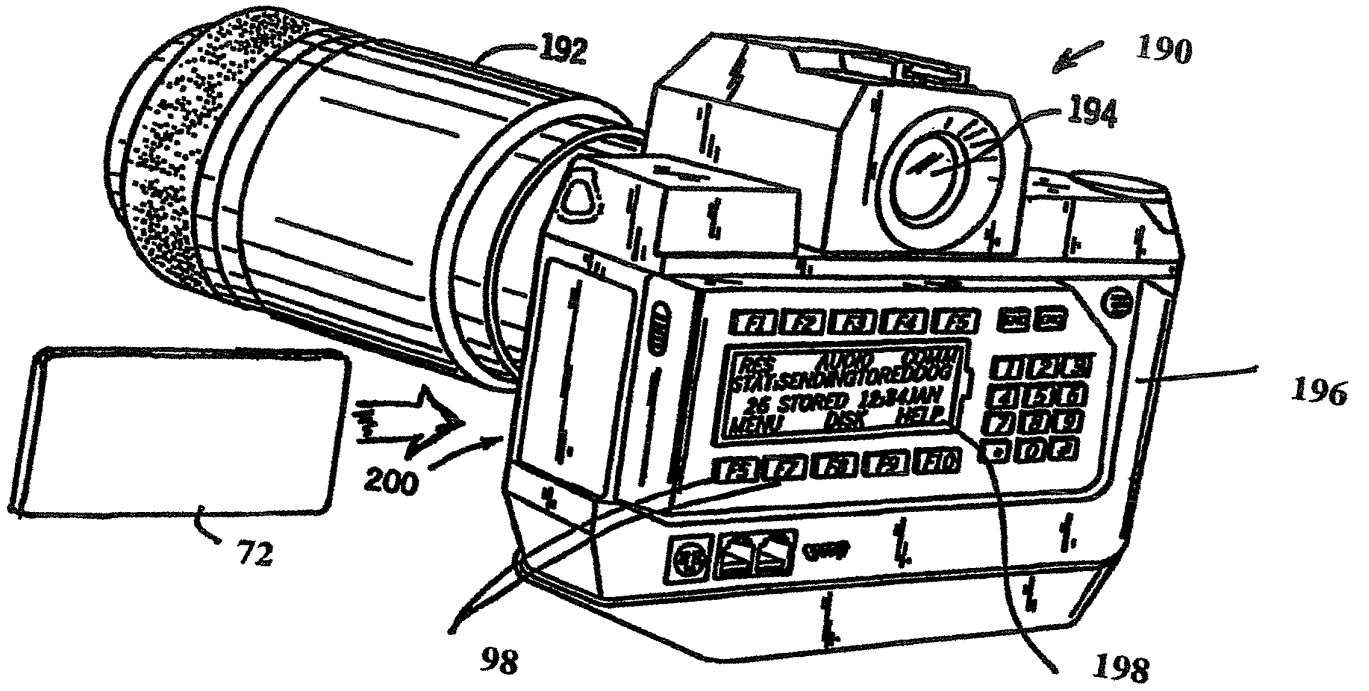


FIG. 7B

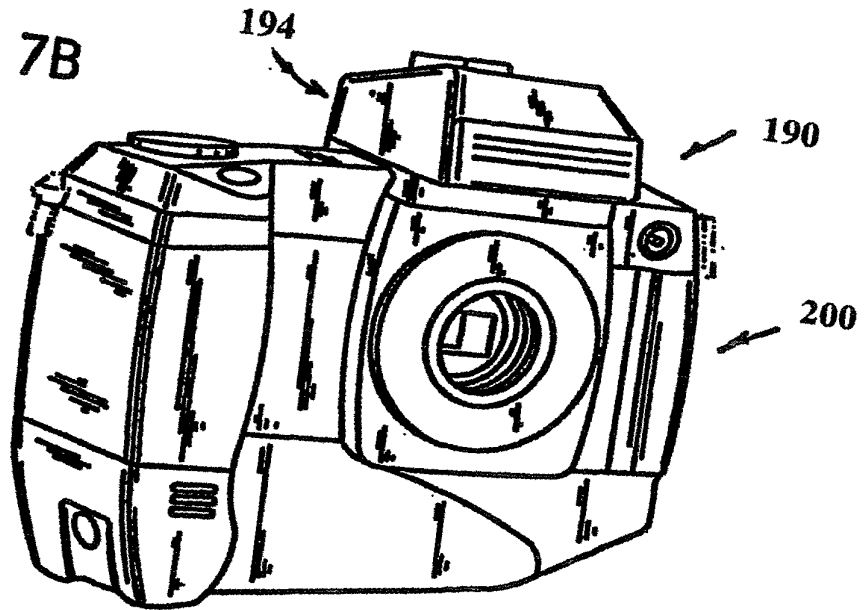




FIG. 8A-1

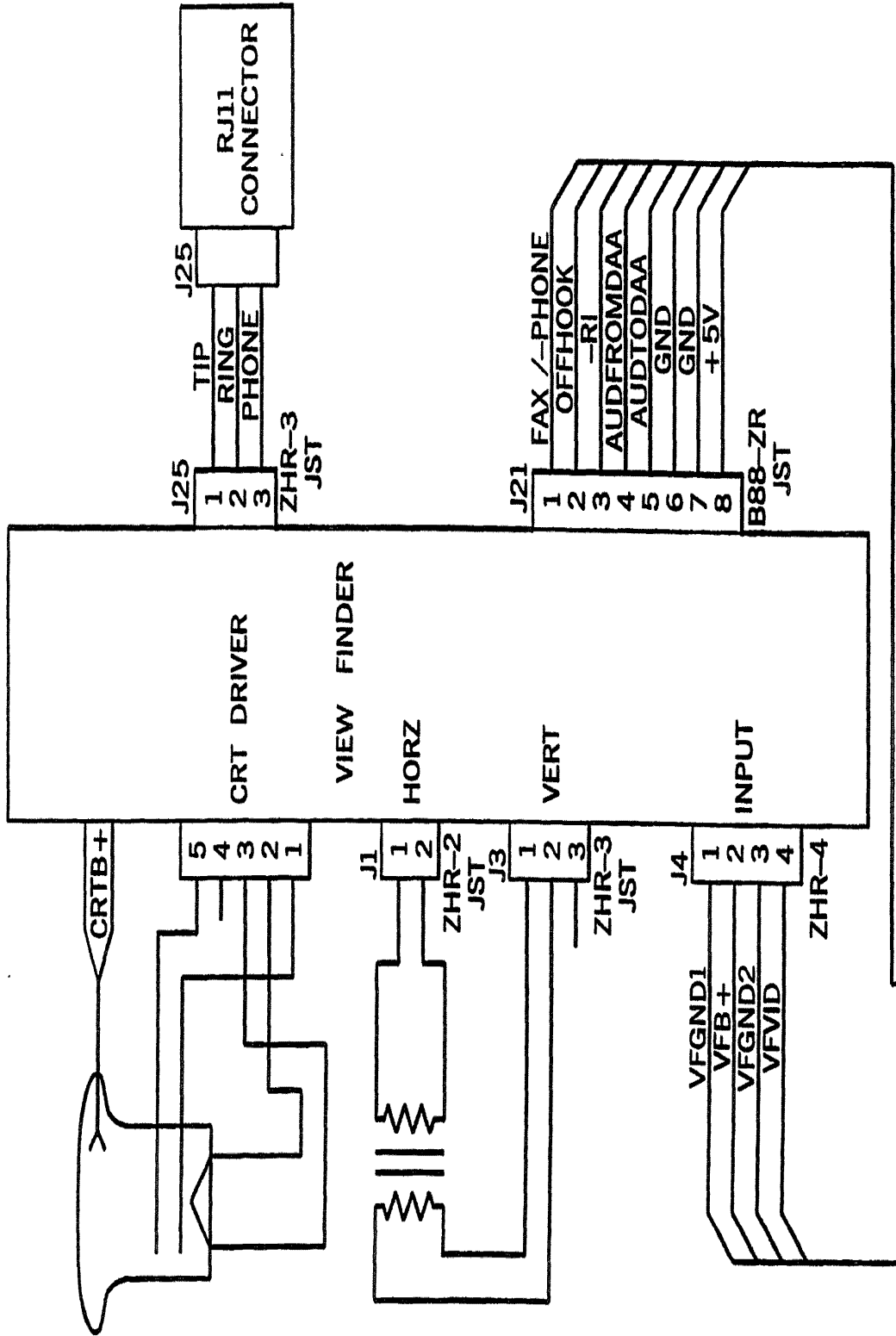
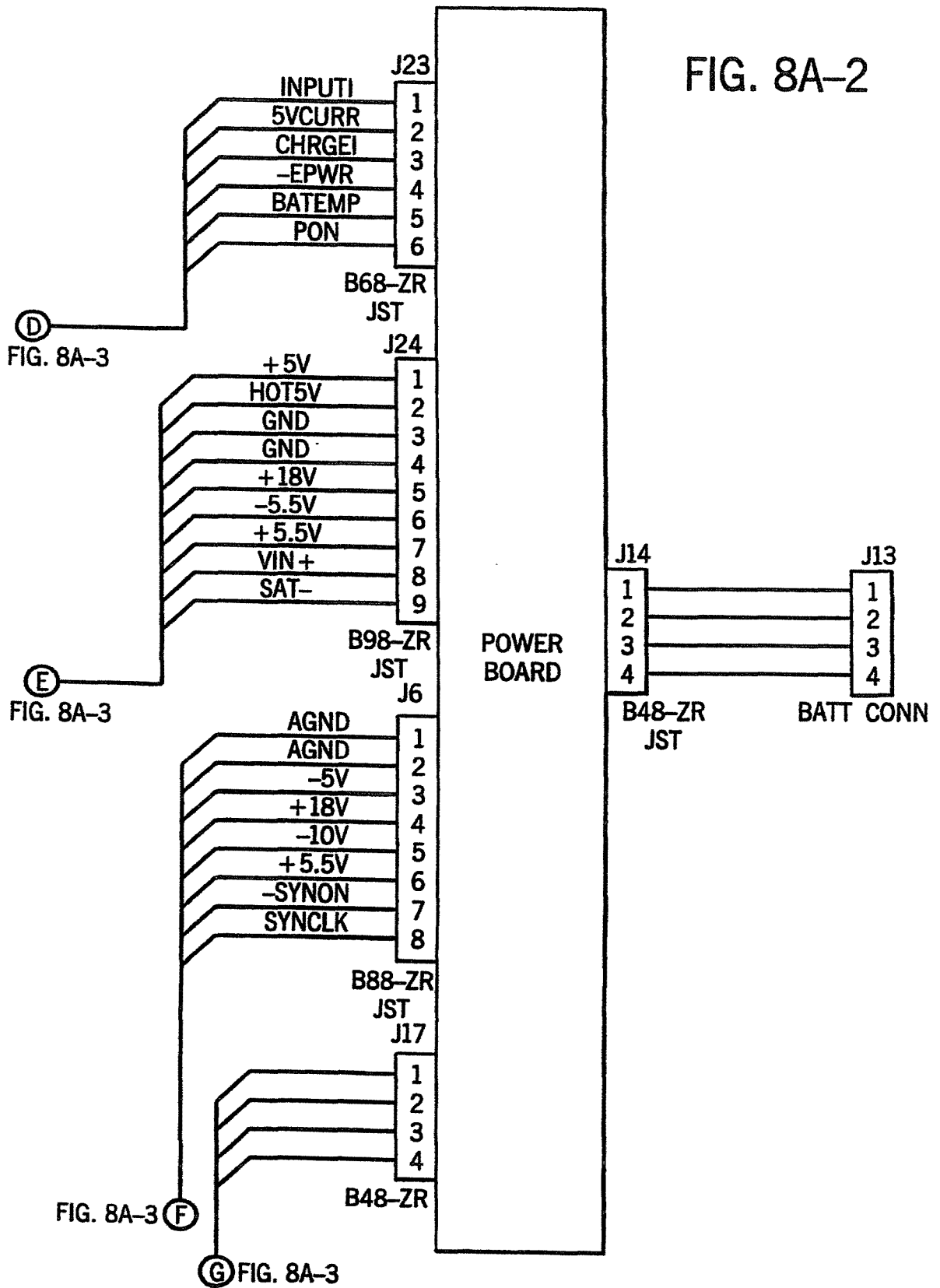


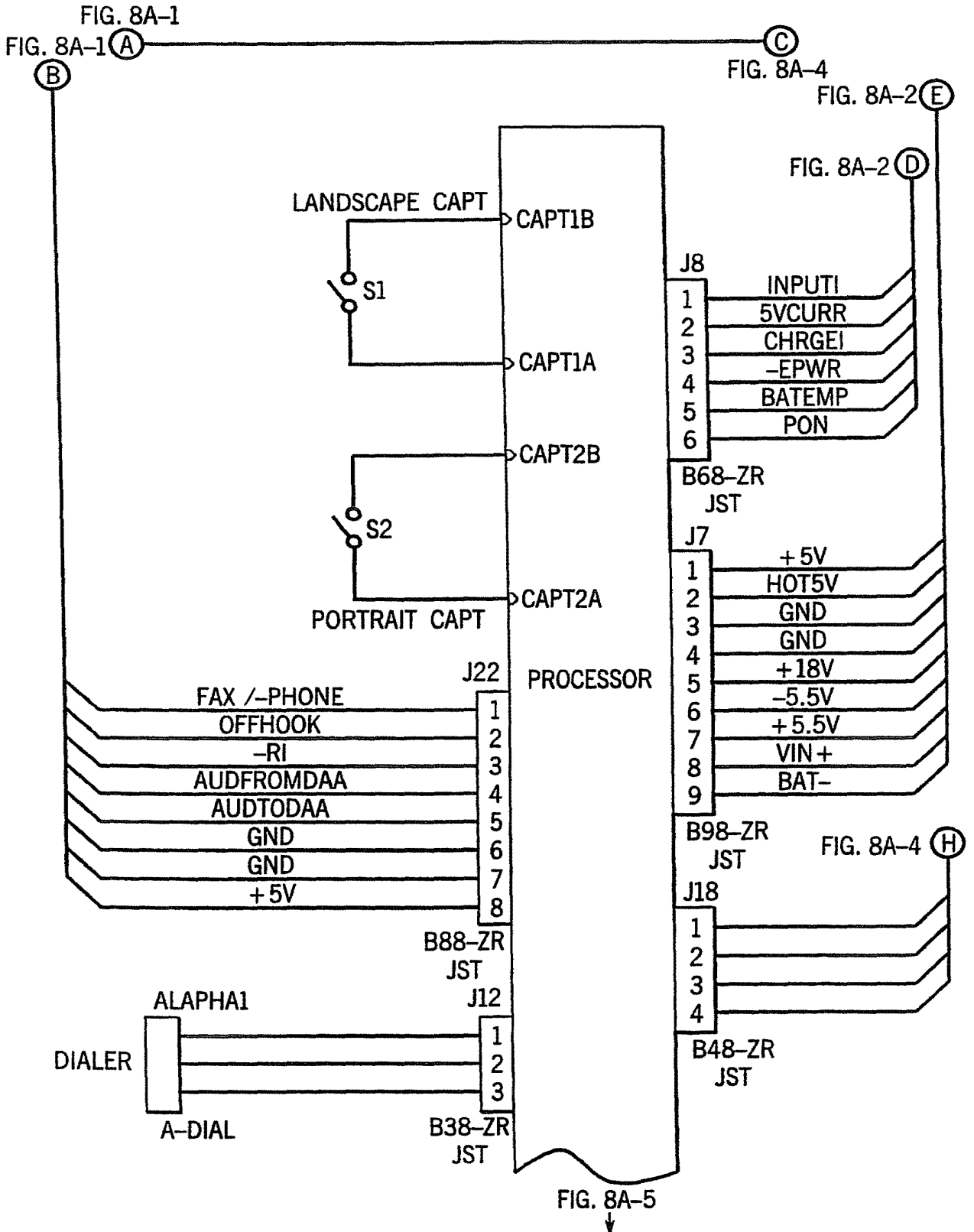
FIG. 8A-3

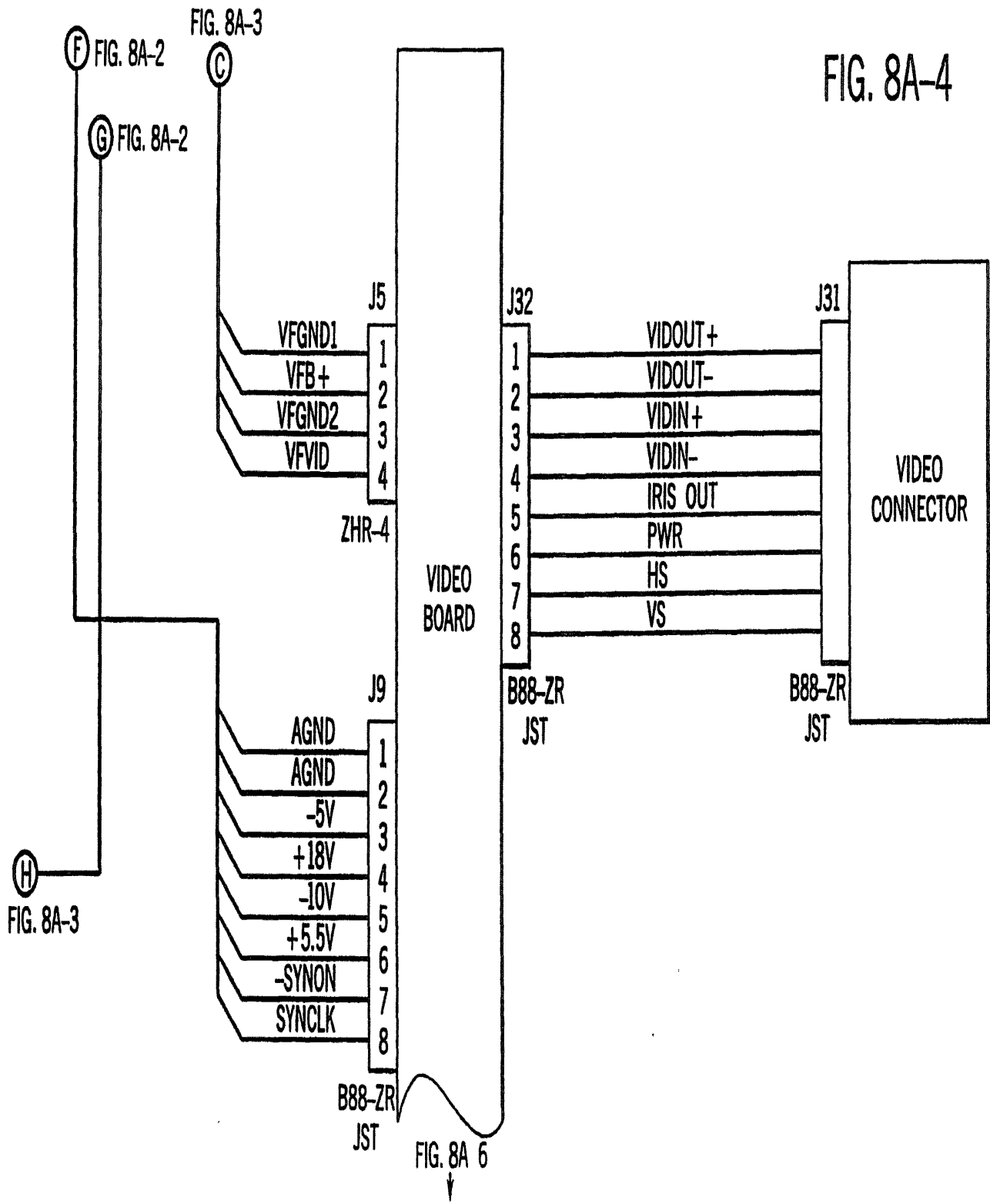
FIG. 8A-3

FIG. 8A-2



# FIG. 8A-3





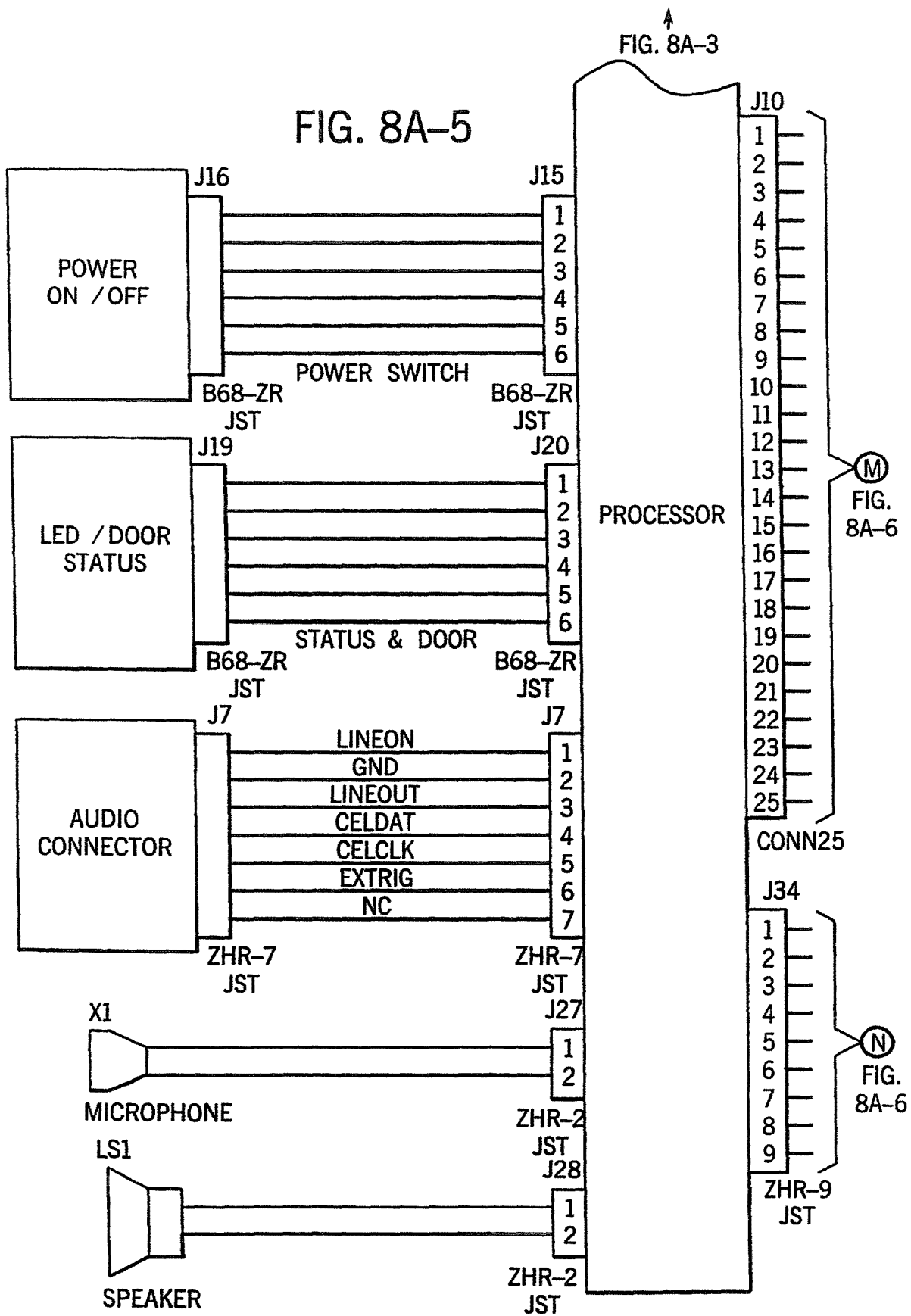


FIG. 8A-6

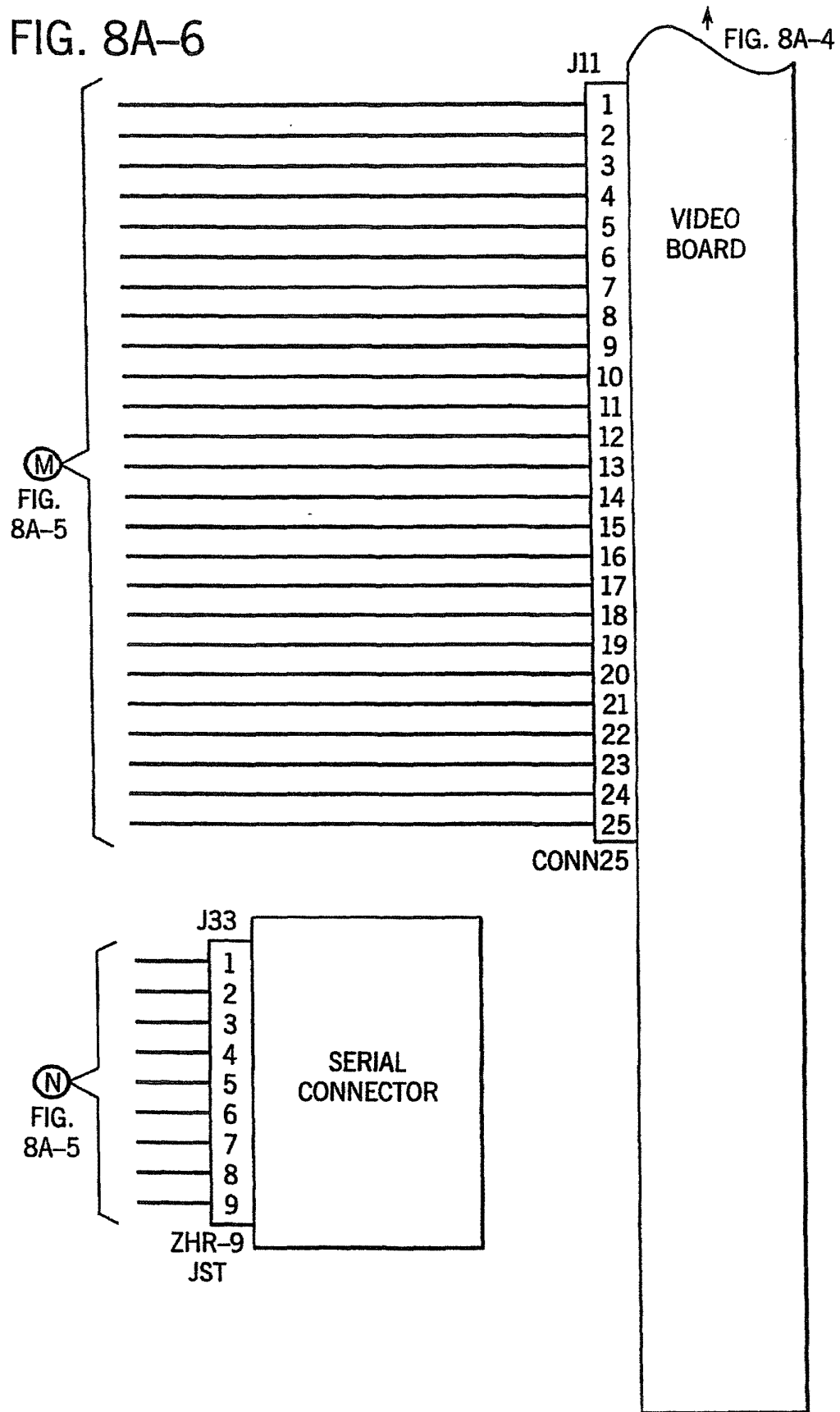


FIG. 8B-1

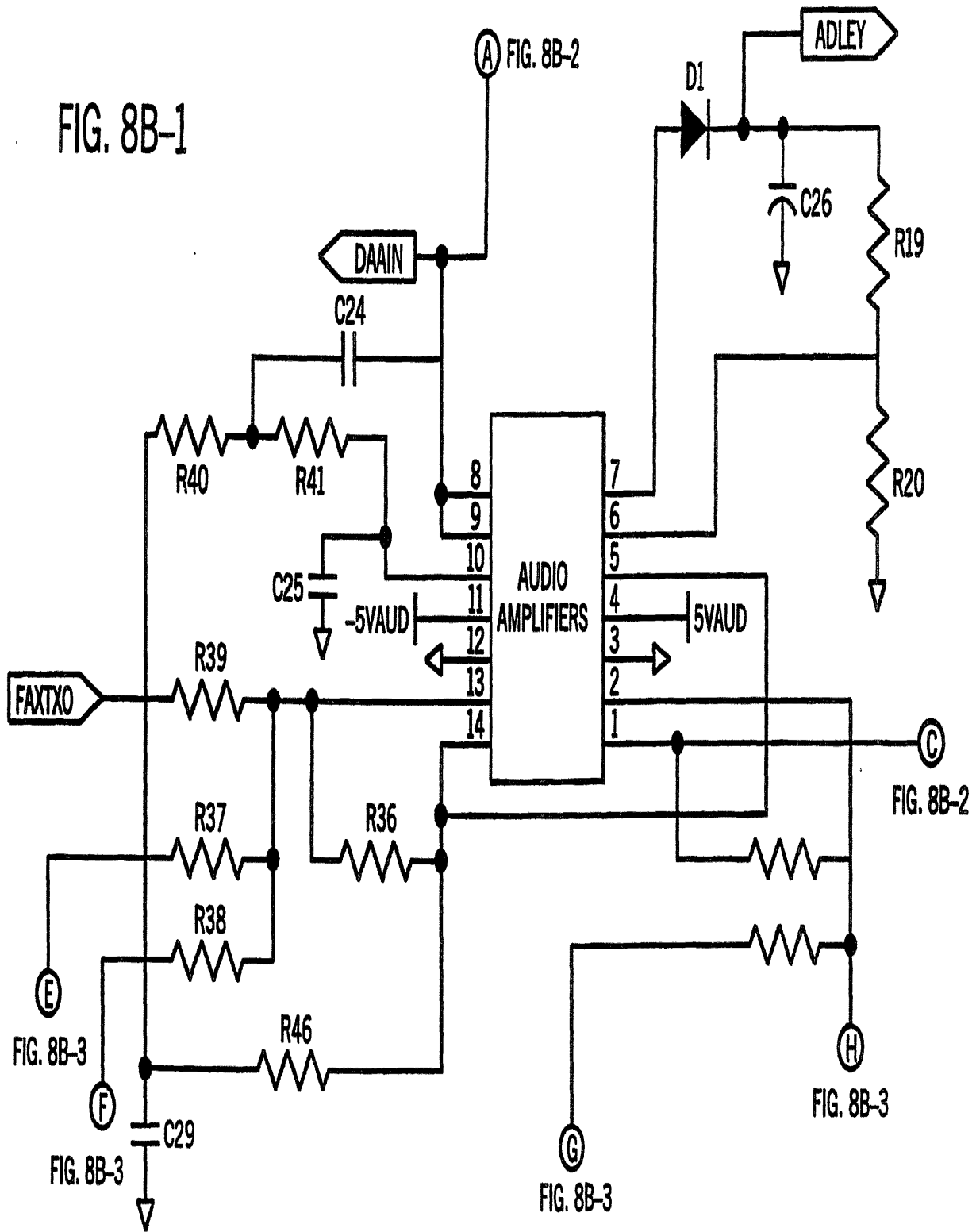






FIG. 8B-3

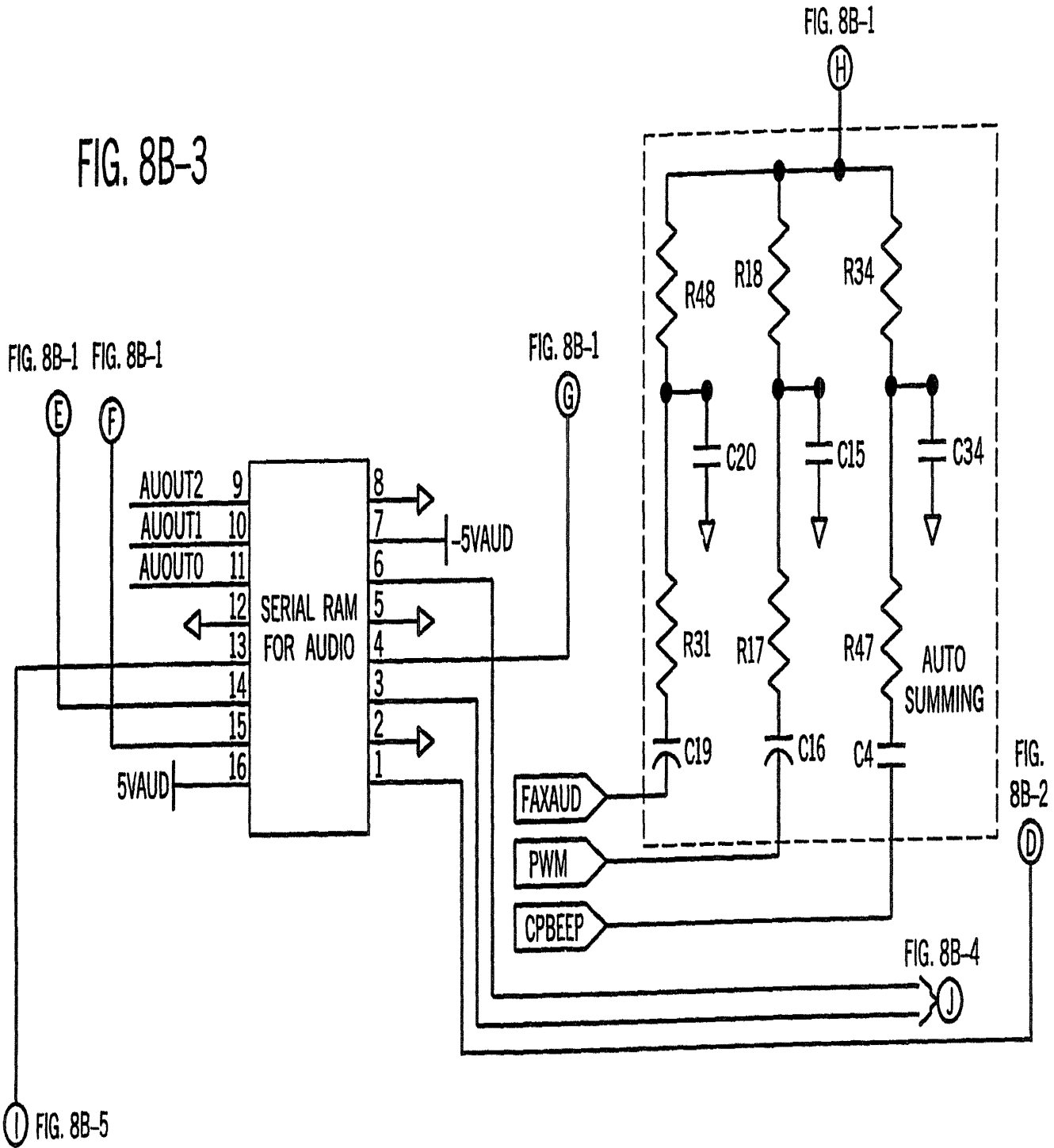


FIG. 8B-4

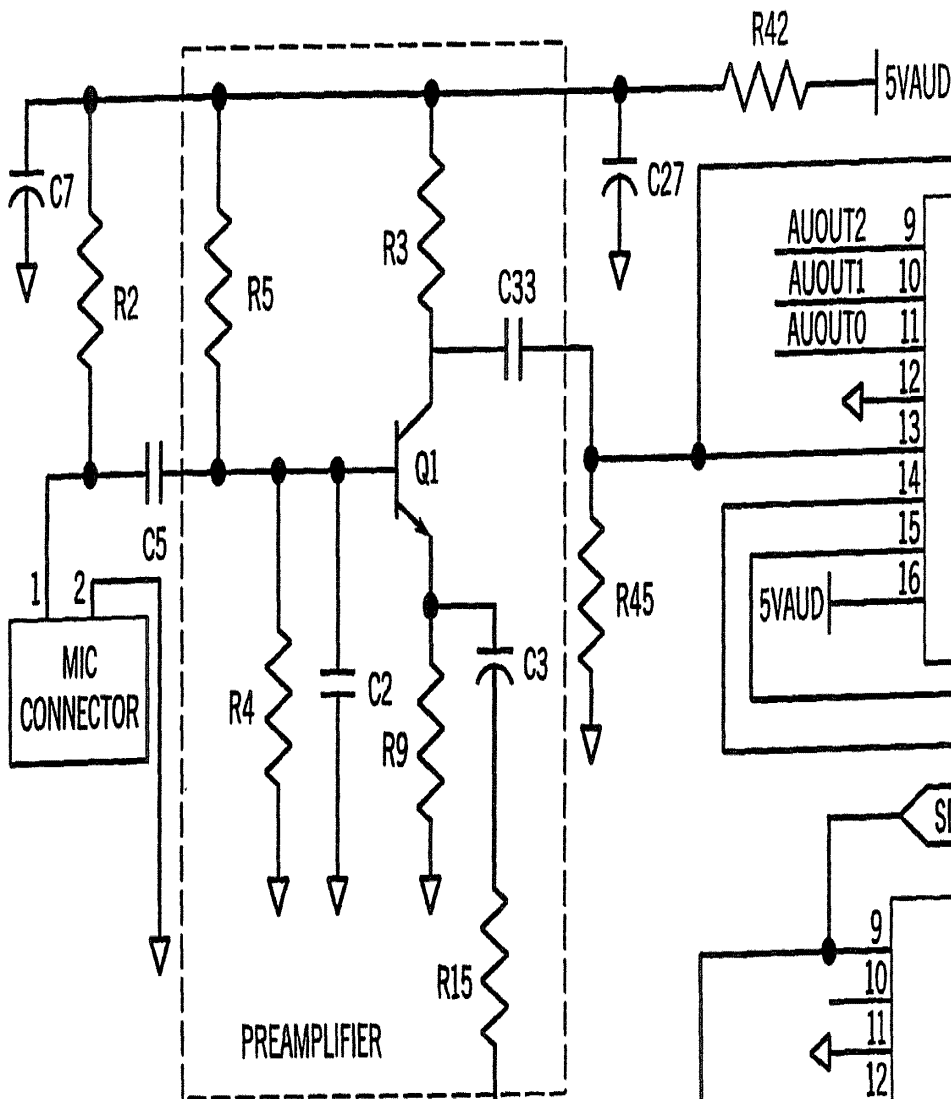


FIG. 8B-2 (B)

FIG. 8B-3

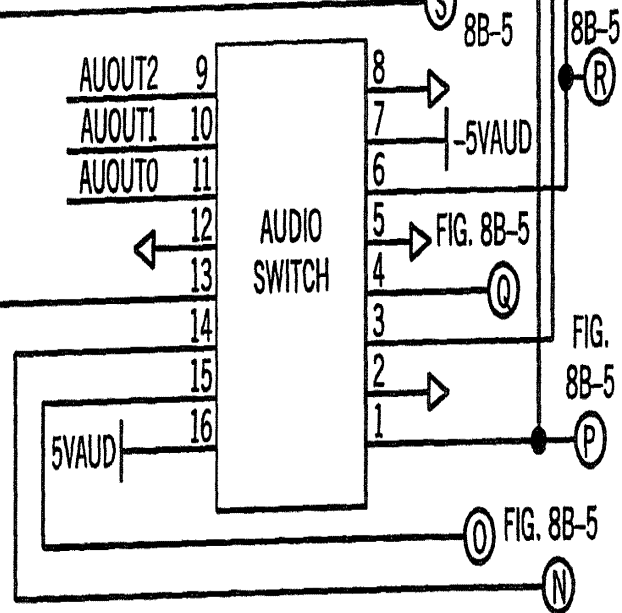


FIG. 8B-5

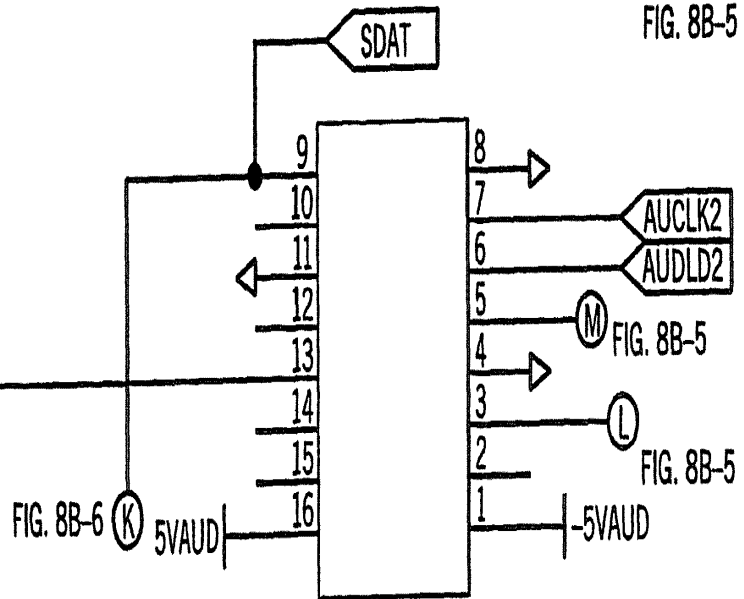


FIG. 8B-5

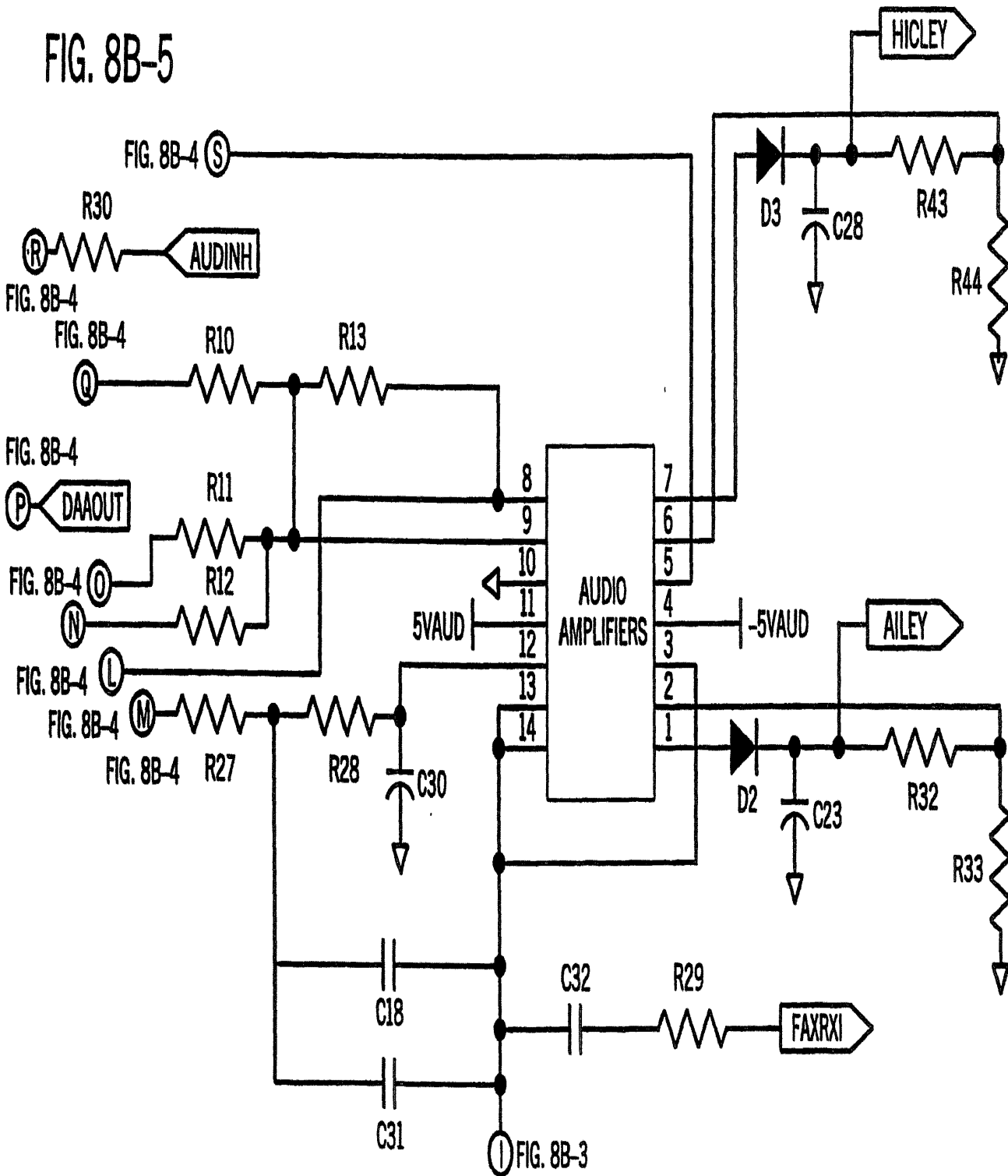


FIG. 8B-6

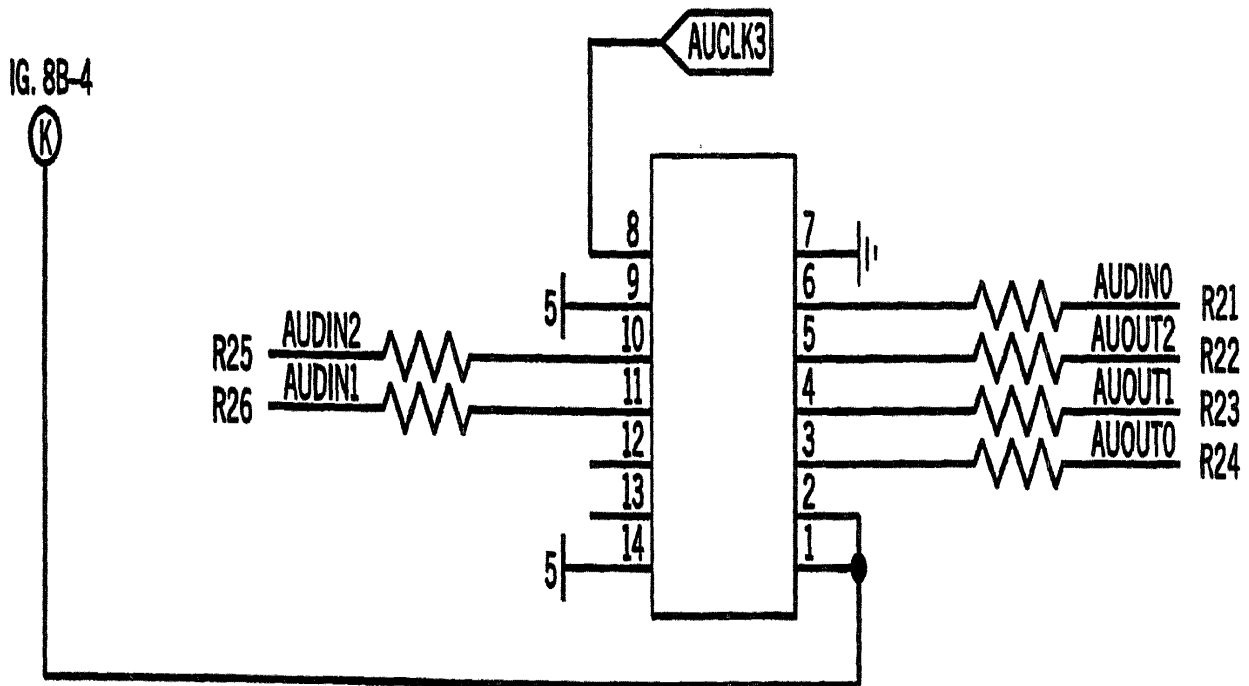
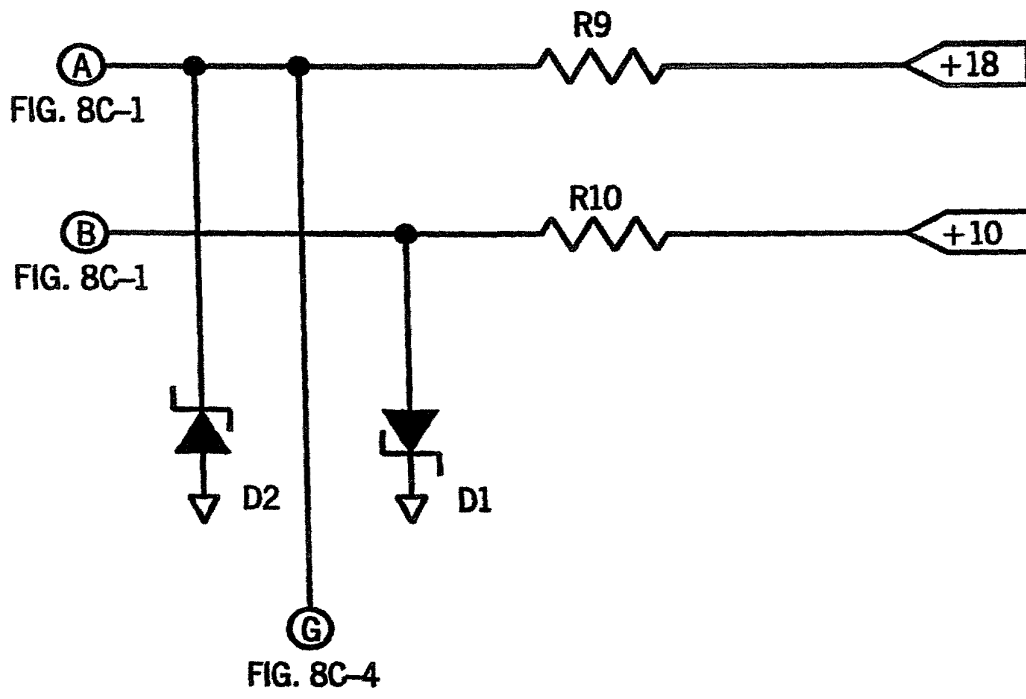




FIG. 8C-2



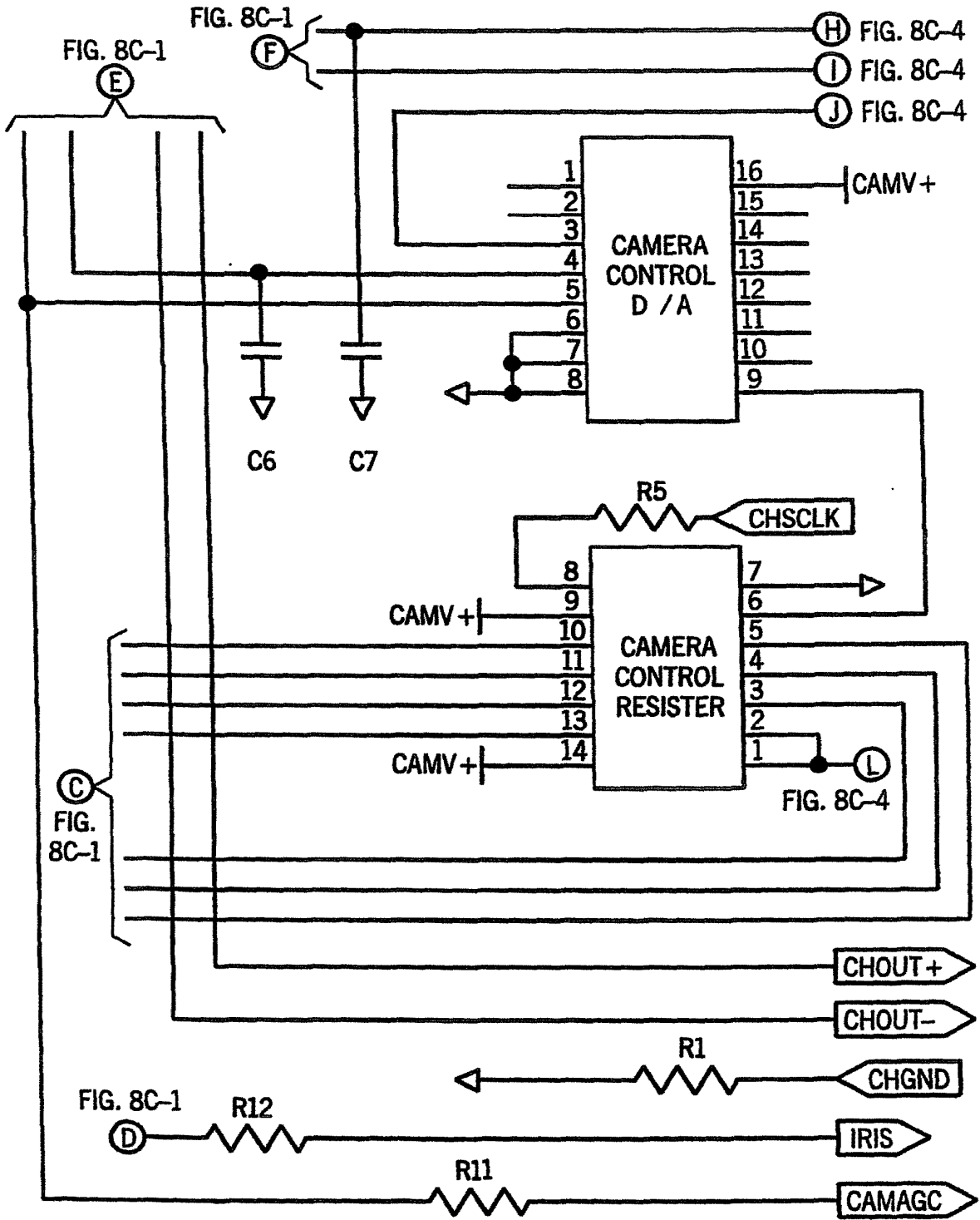


FIG. 8C-3

FIG. 8C-4

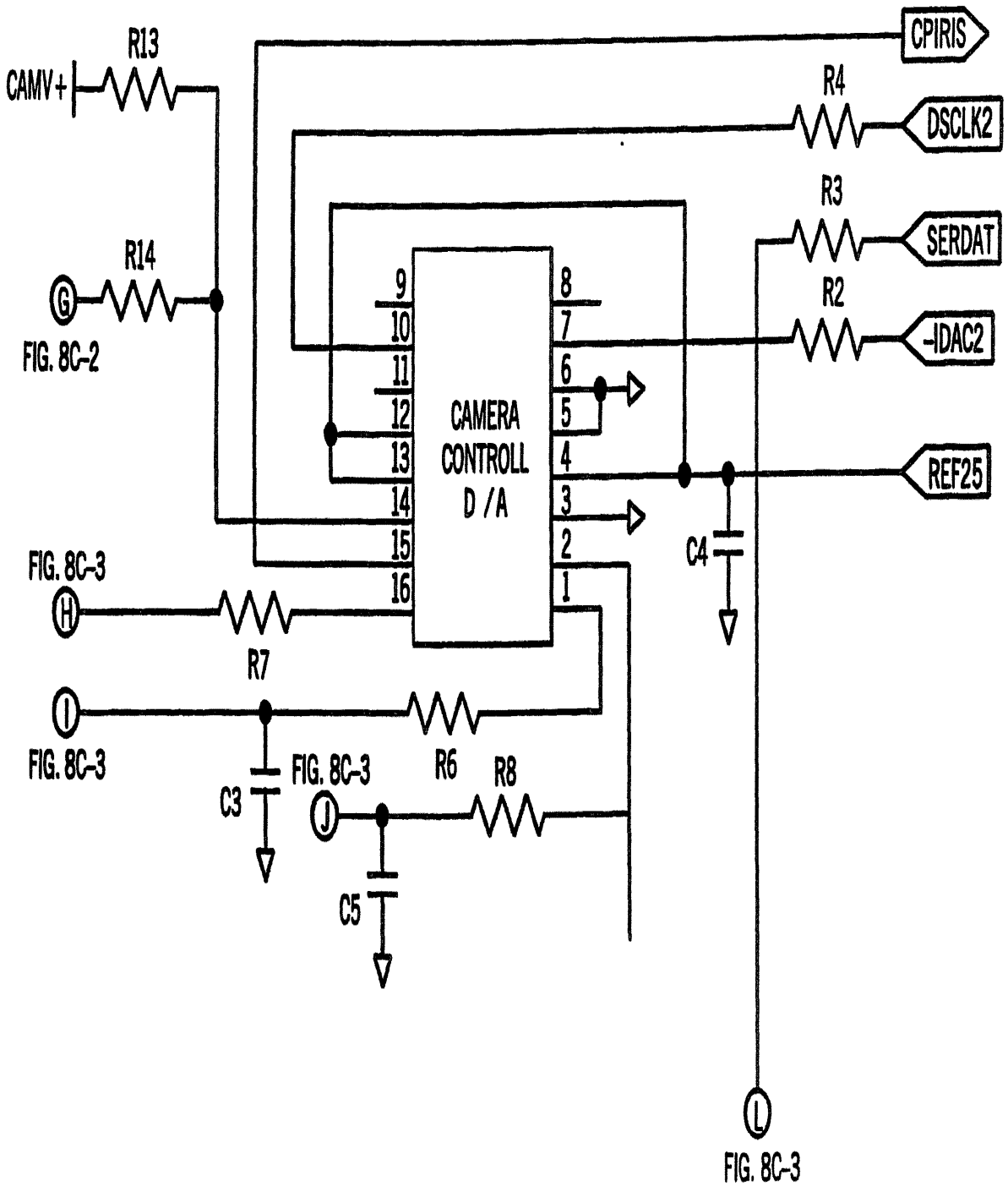




FIG. 8D-1

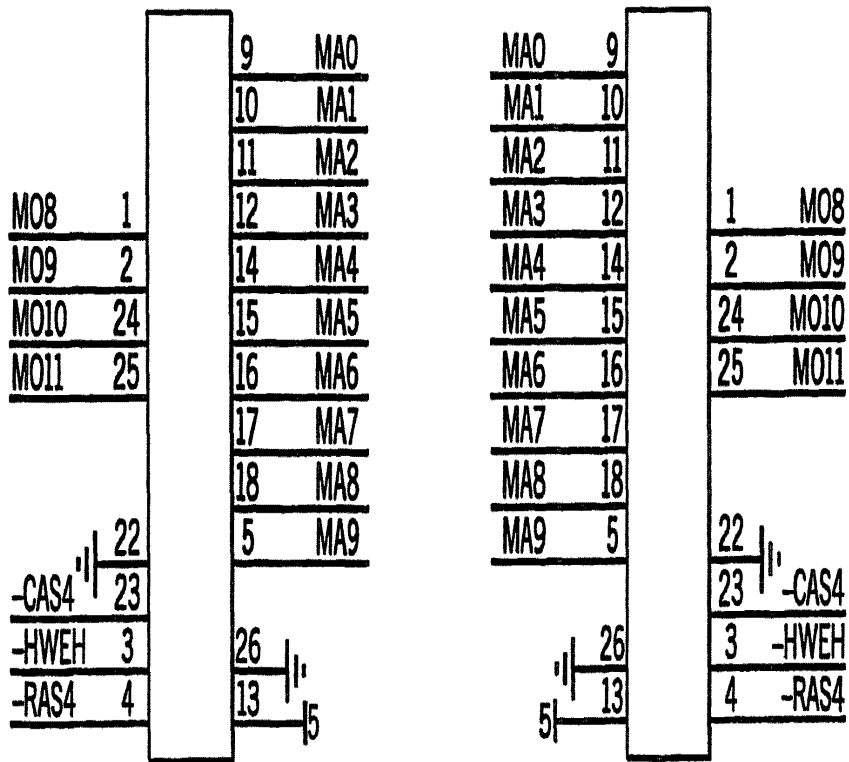
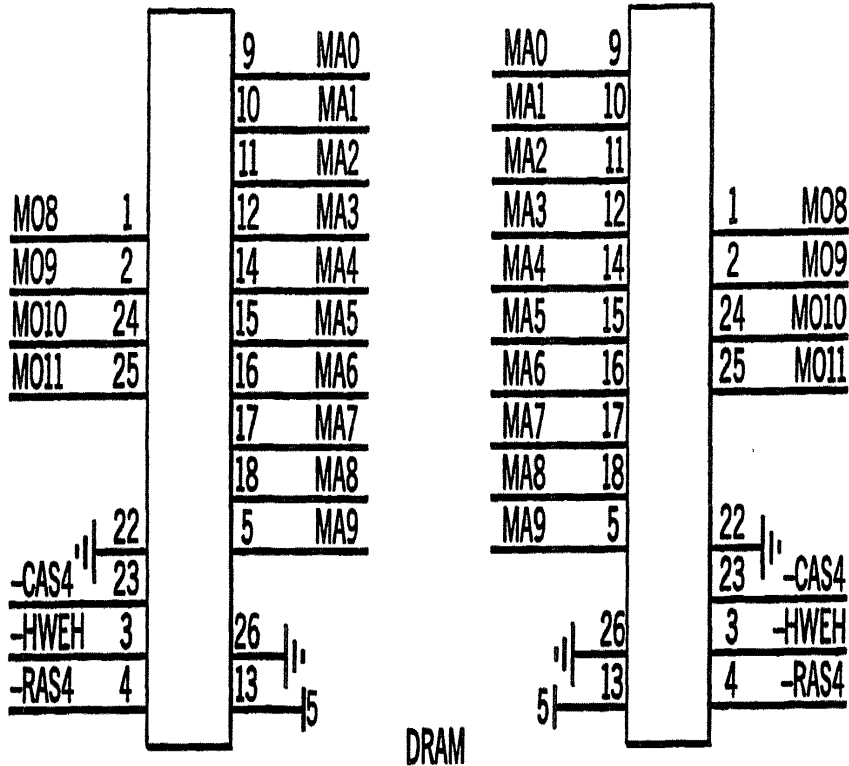
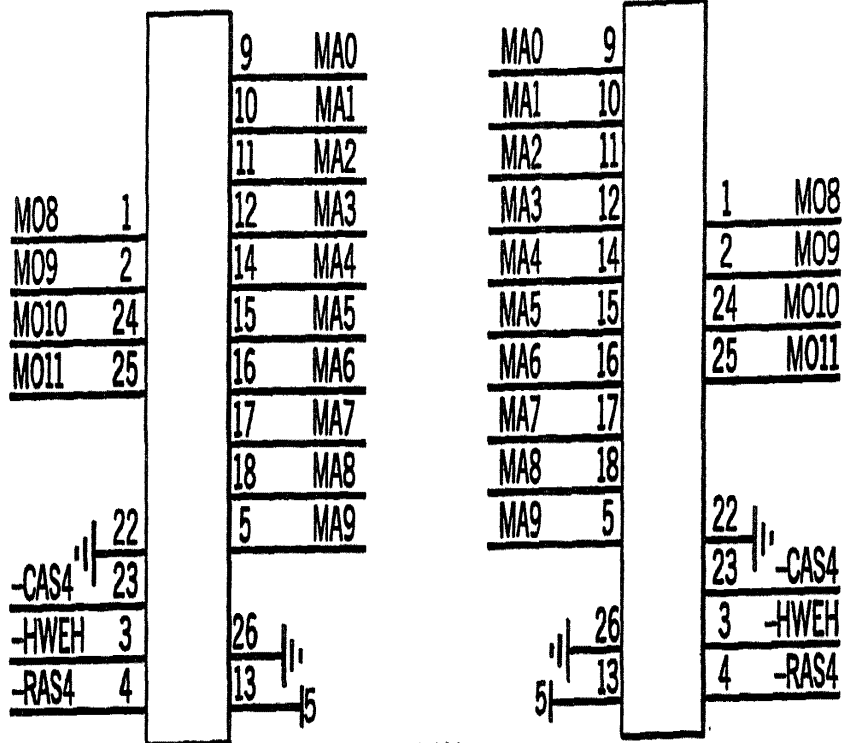


FIG. 8D-2



DRAM

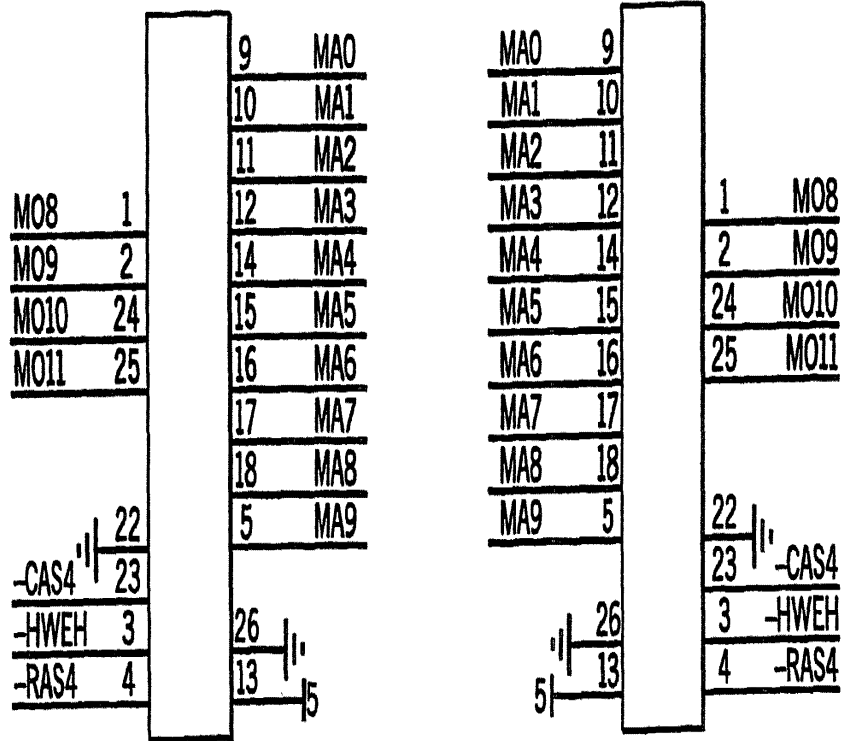


FIG. 8D-3

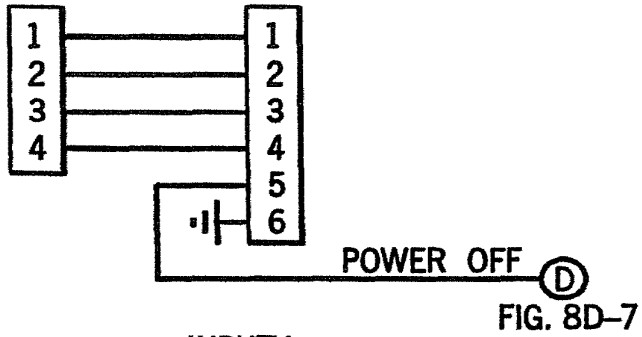


FIG. 8D-7

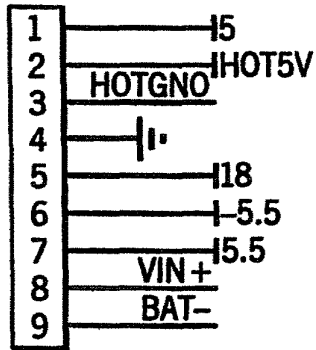
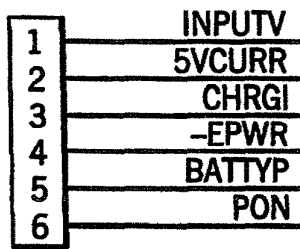


FIG. 8D-4

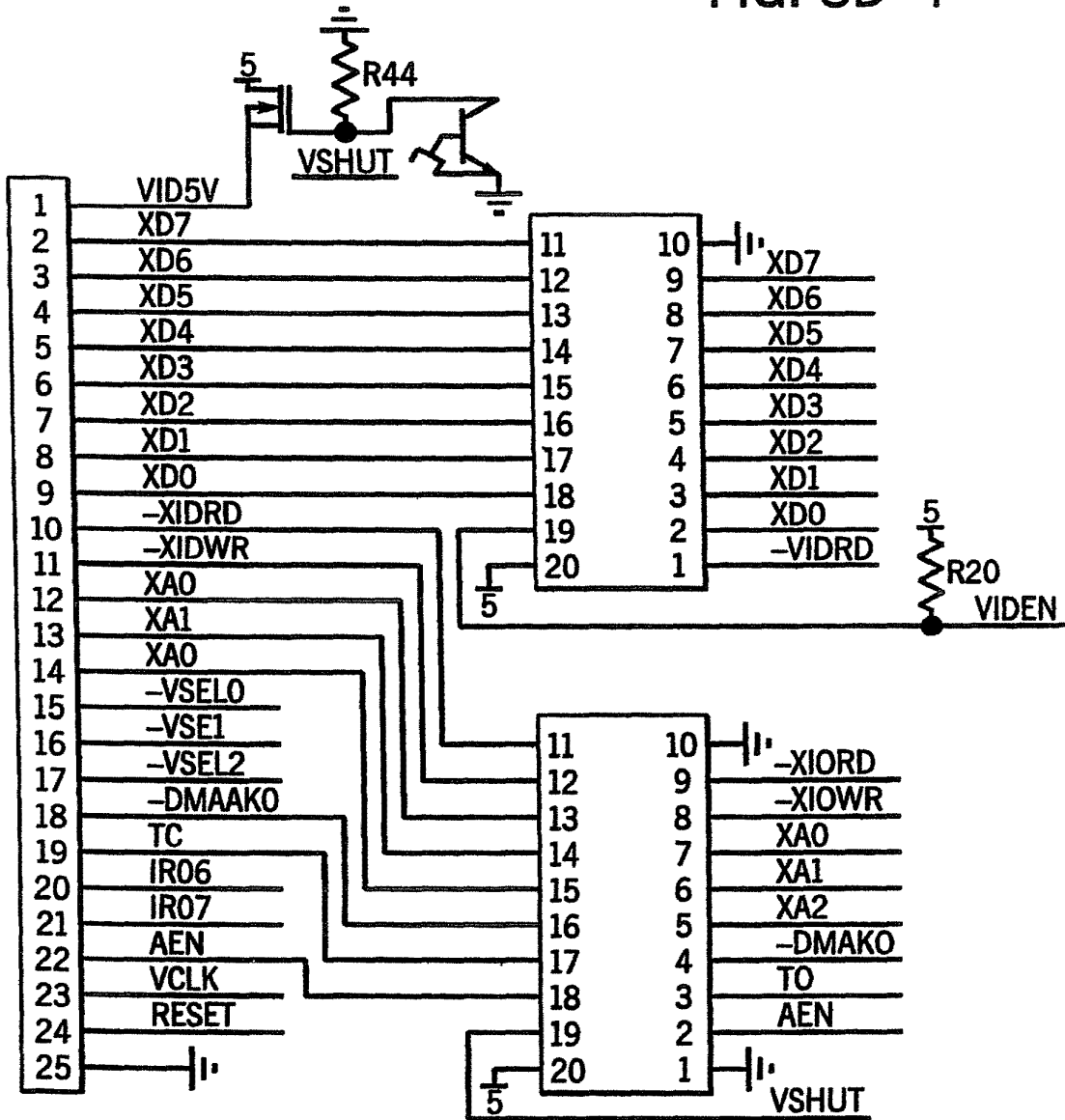


FIG. 8D-5

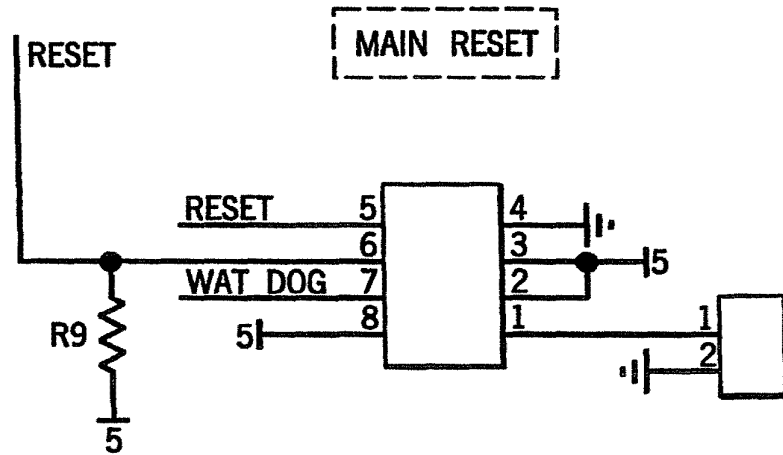


FIG. 8D-6

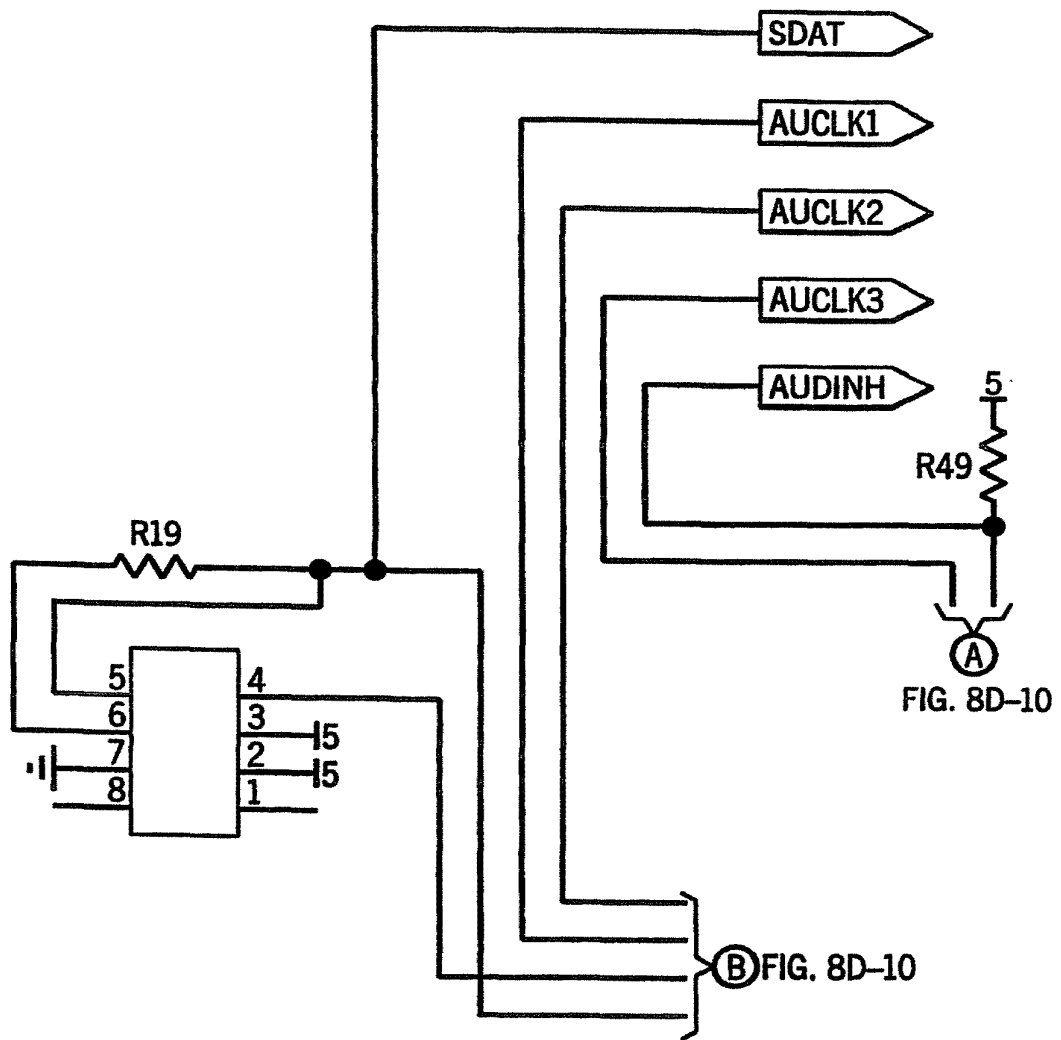


FIG. 8D-7

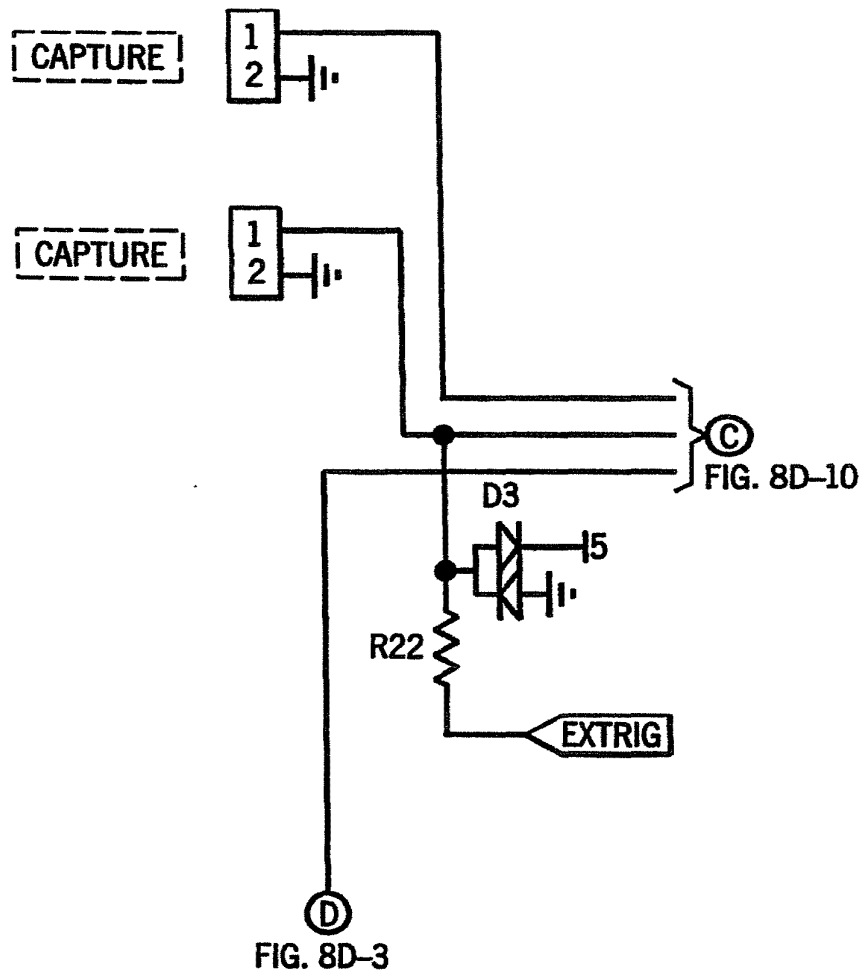


FIG. 8D-8

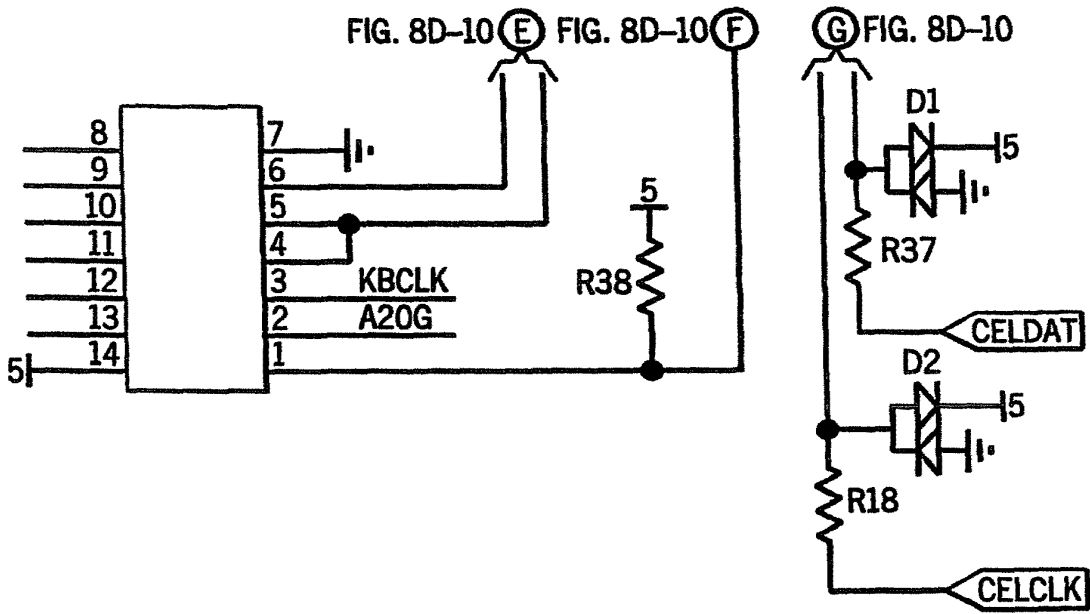




FIG. 8D-9

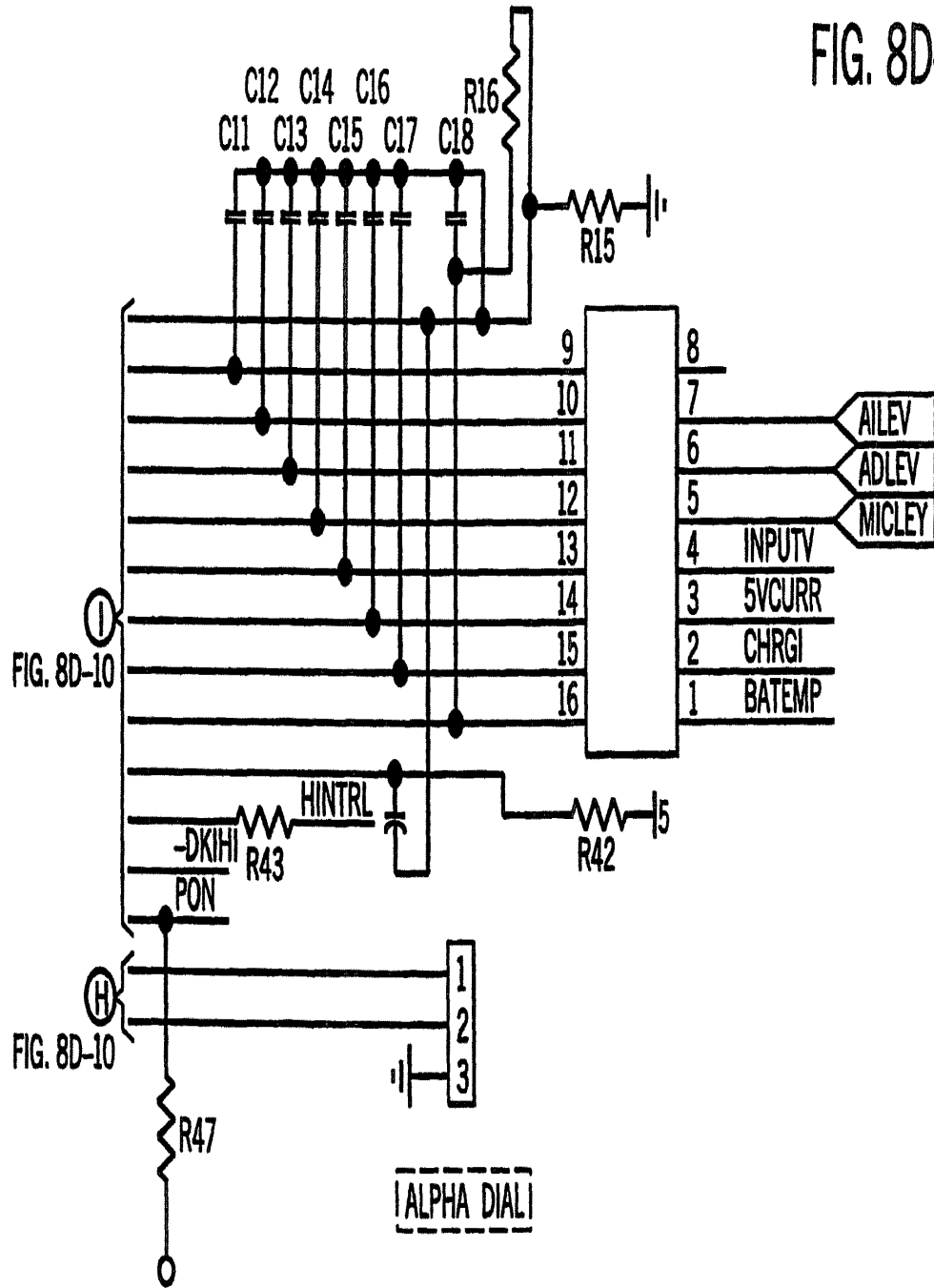


FIG. 8D-10

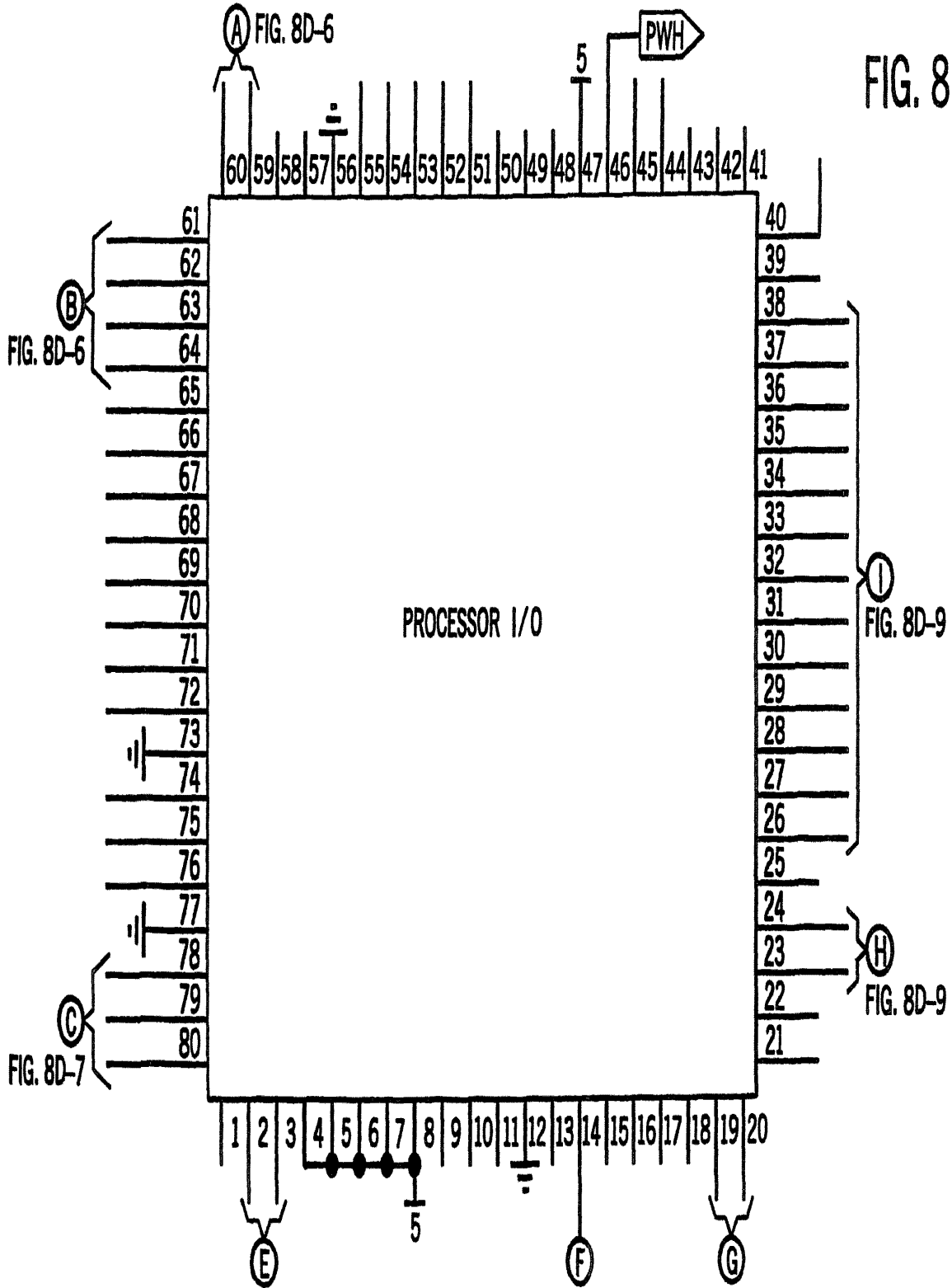


FIG. 8D-11

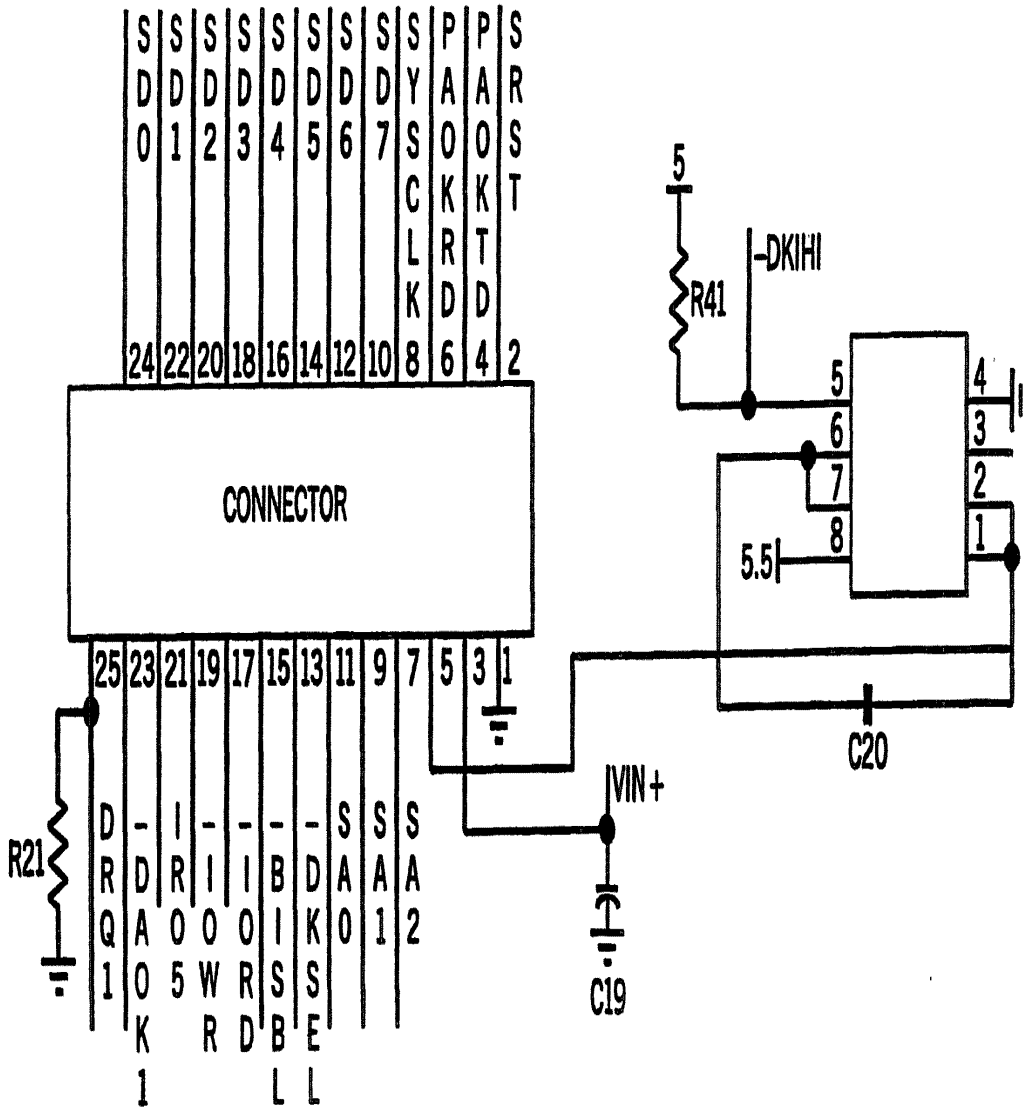


FIG. 8D-12

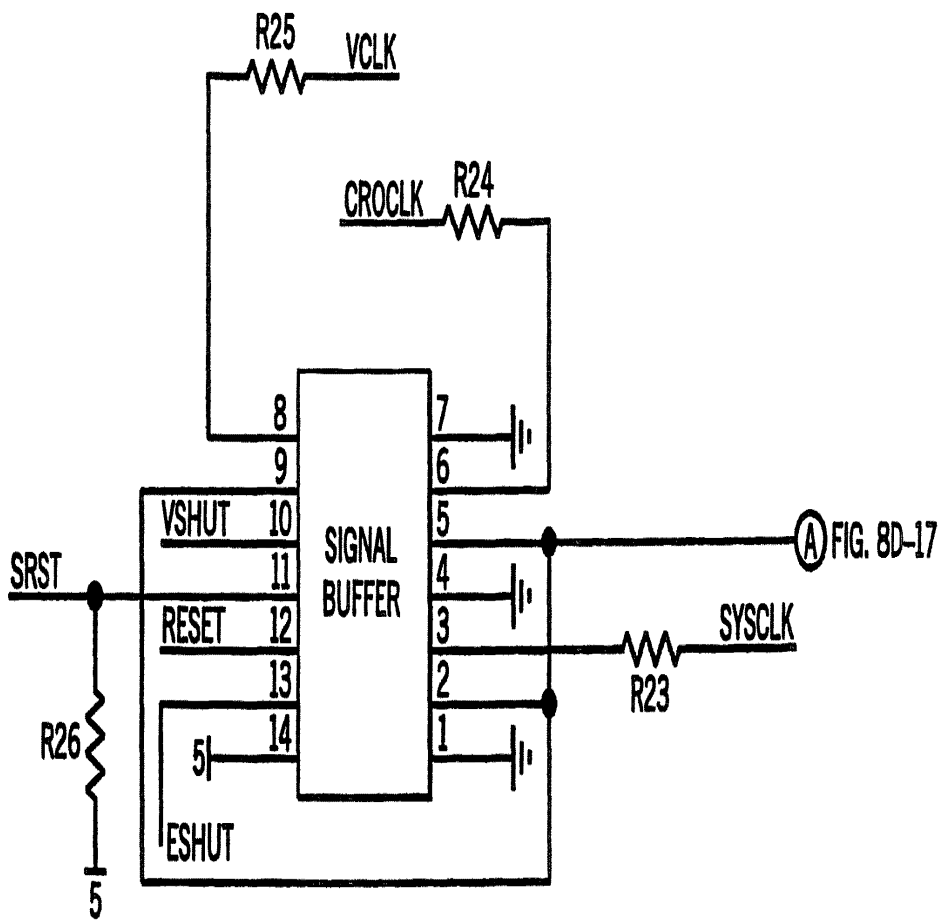


FIG. 8D-13

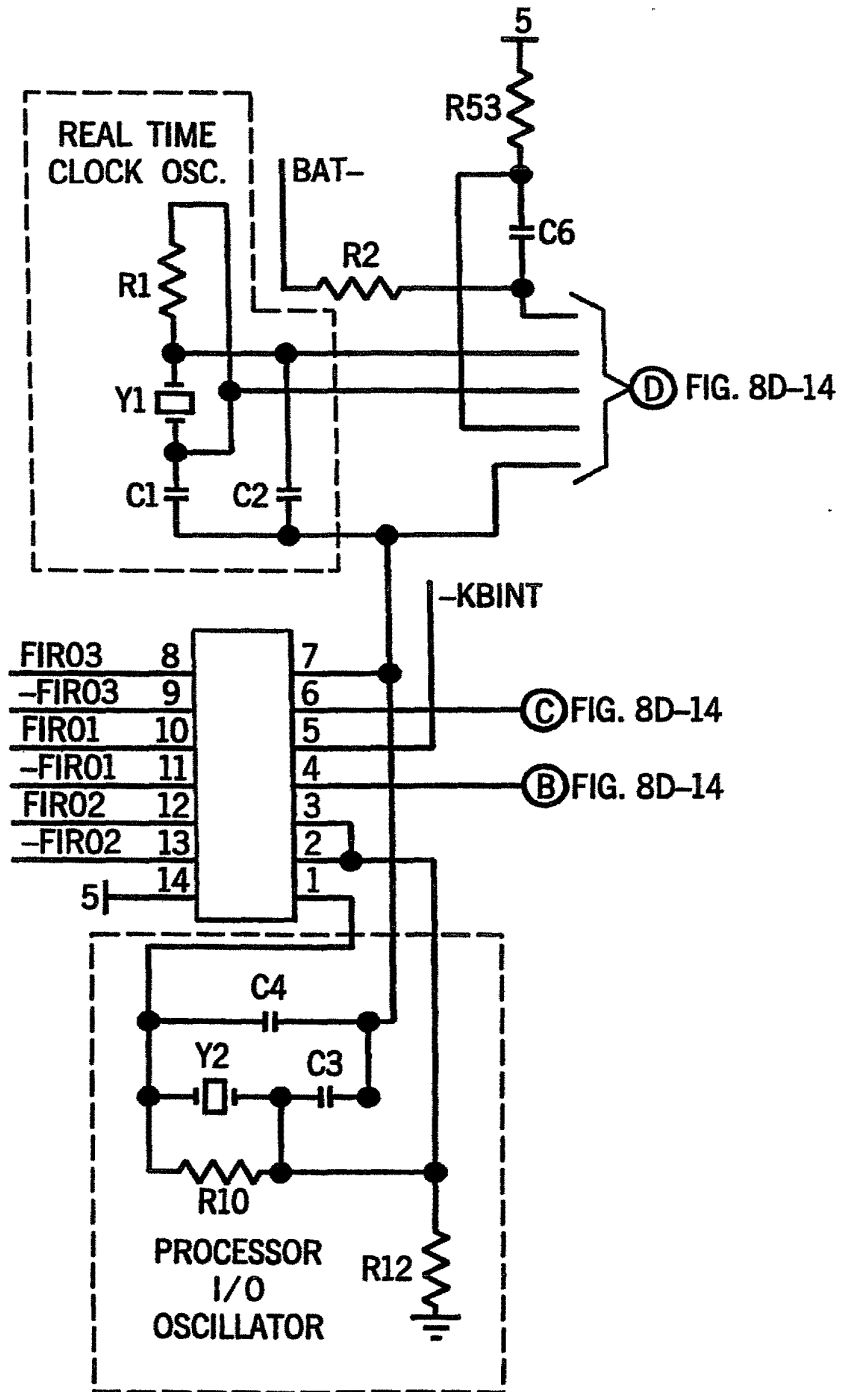


FIG. 8D-14

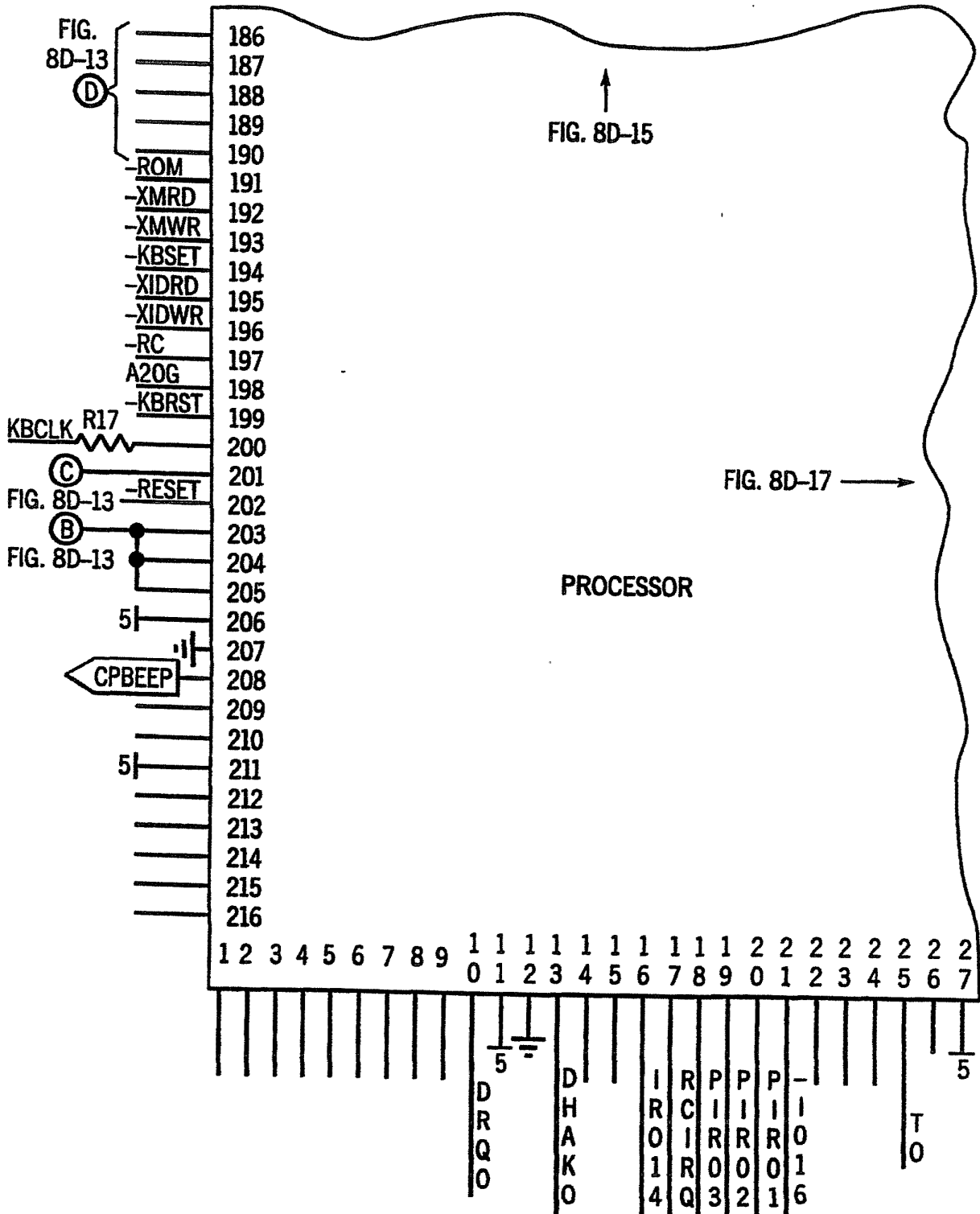








FIG. 8D-17

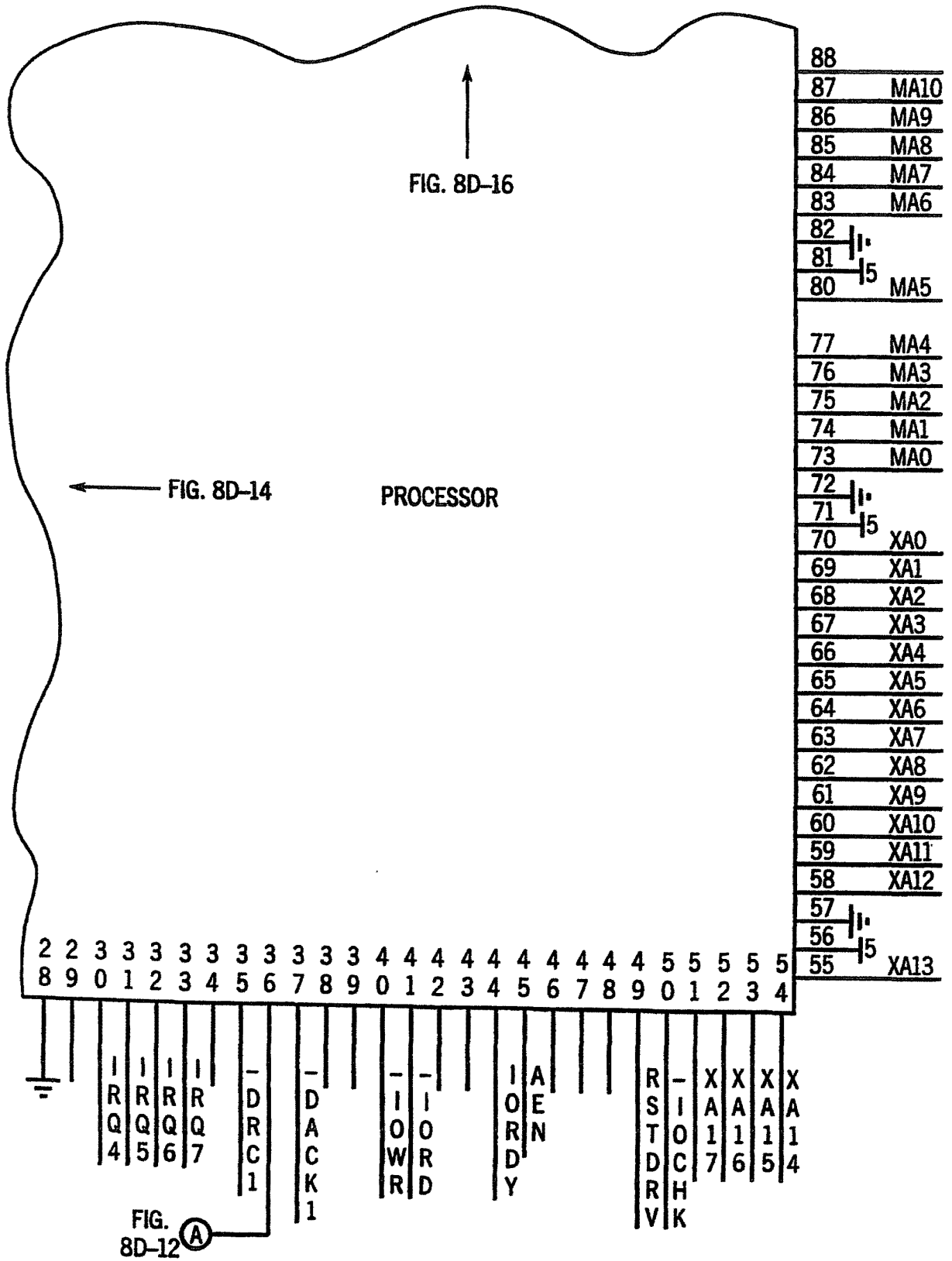


FIG. 8D-18

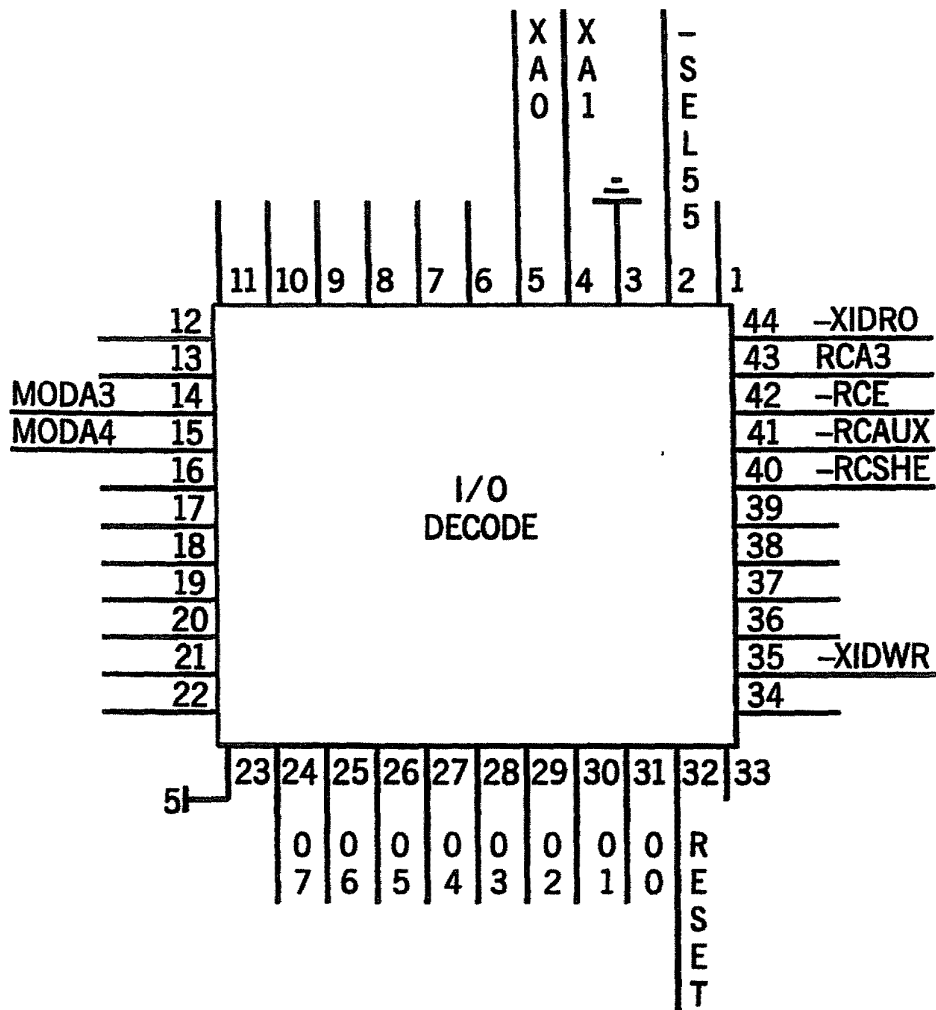
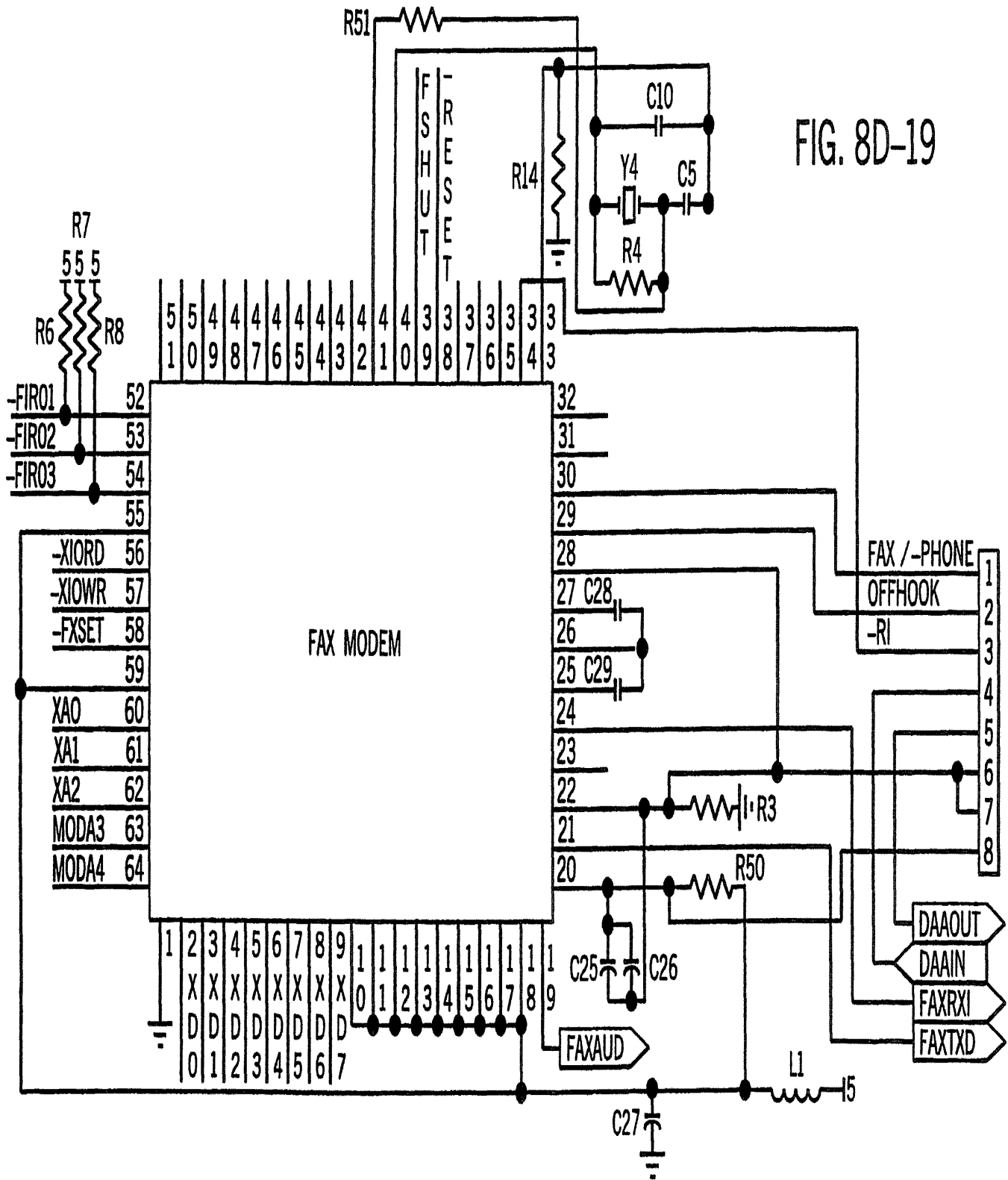


FIG. 8D-19



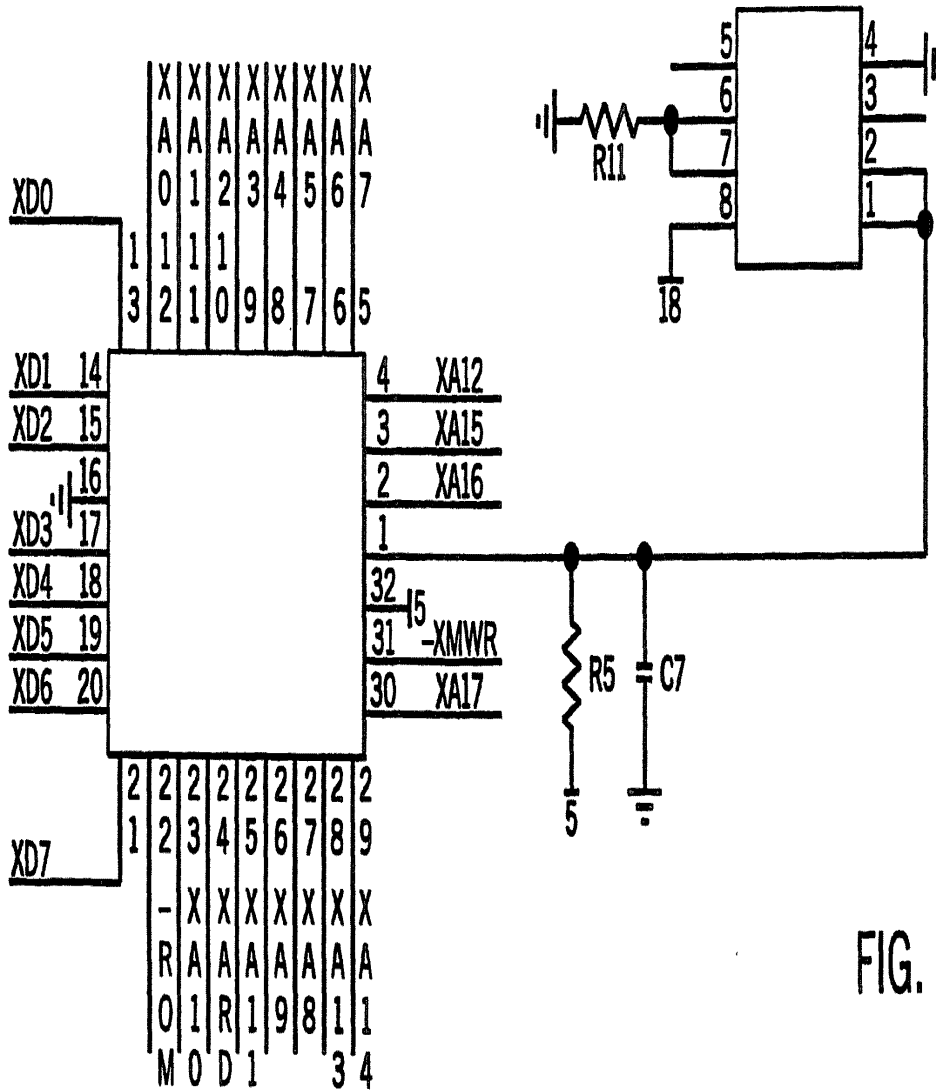


FIG. 8D-20

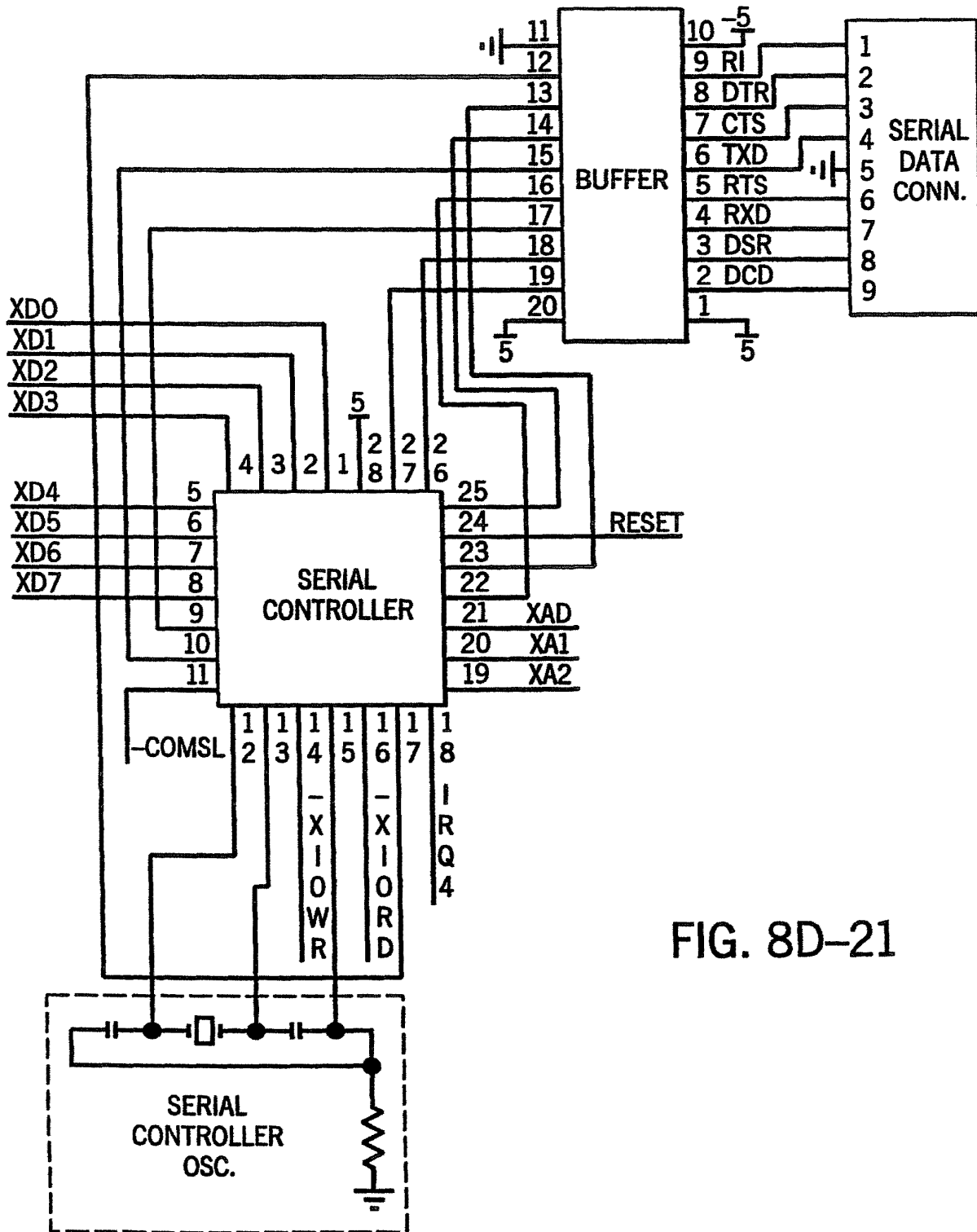


FIG. 8D-21

FIG. 8D-22

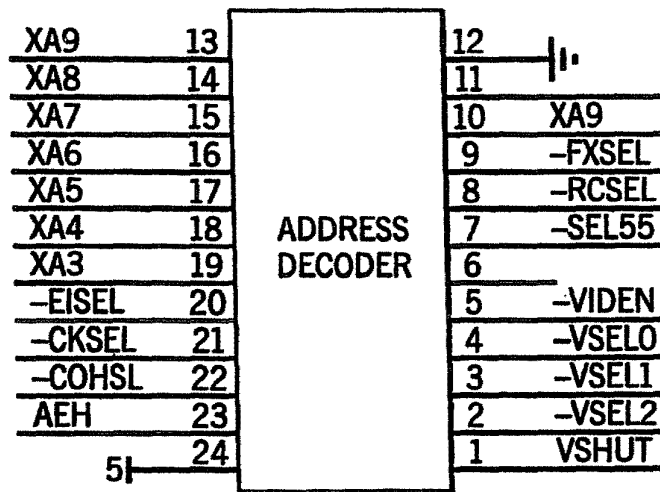


FIG. 8D-23

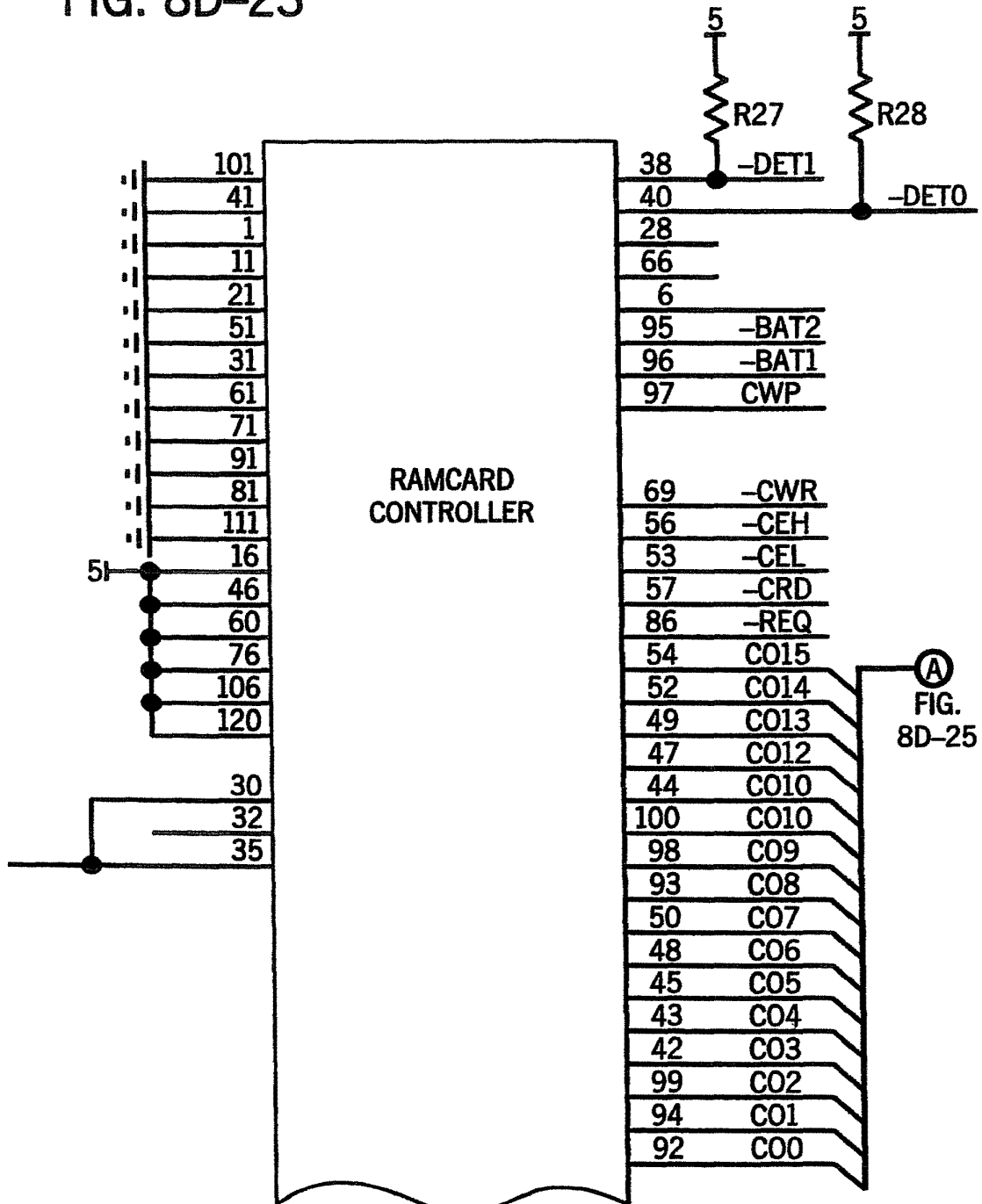


FIG. 8D-24



(A)  
FIG.  
8D-25

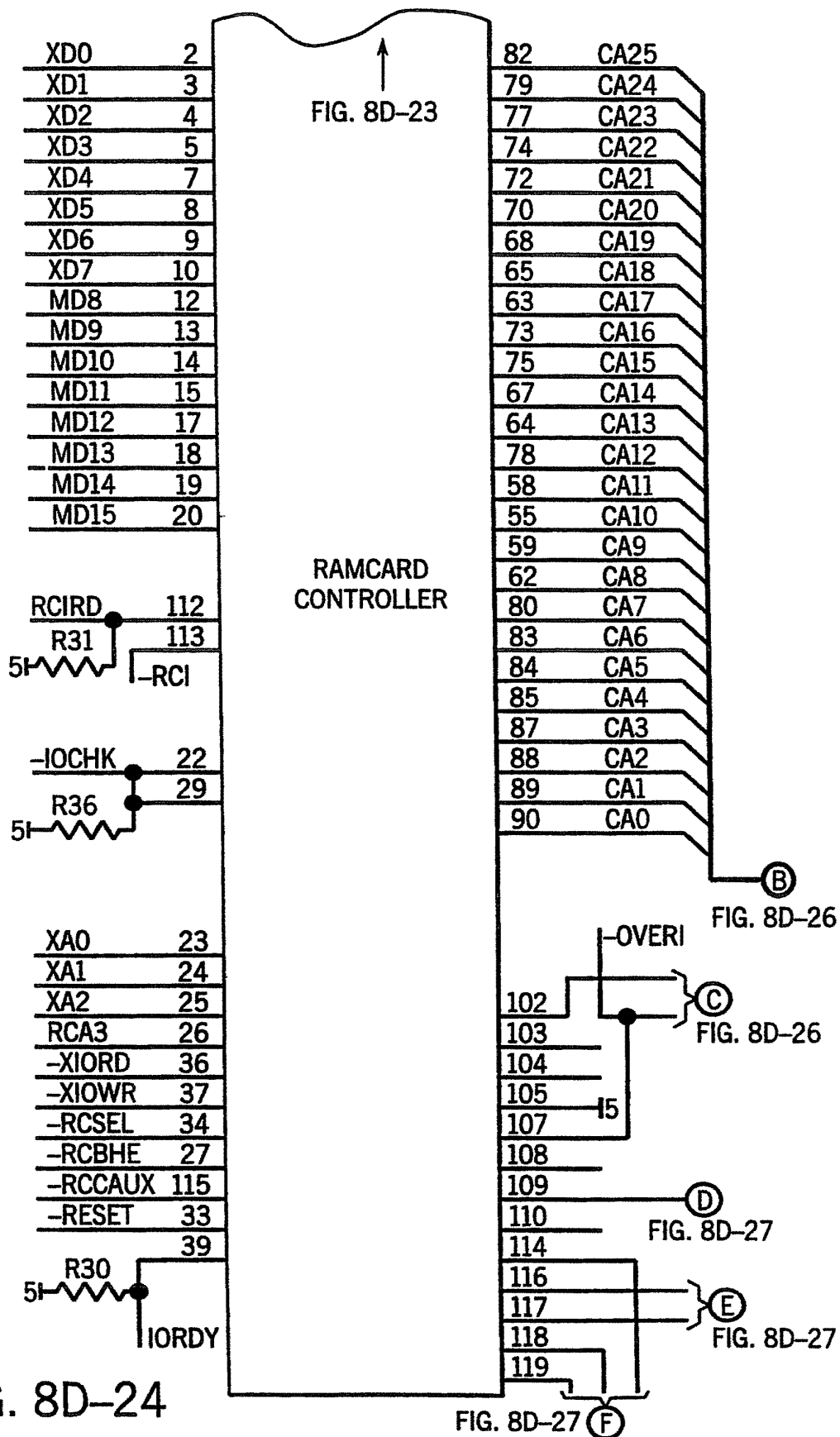


FIG. 8D-24

FIG. 8D-27



FIG. 8D-25

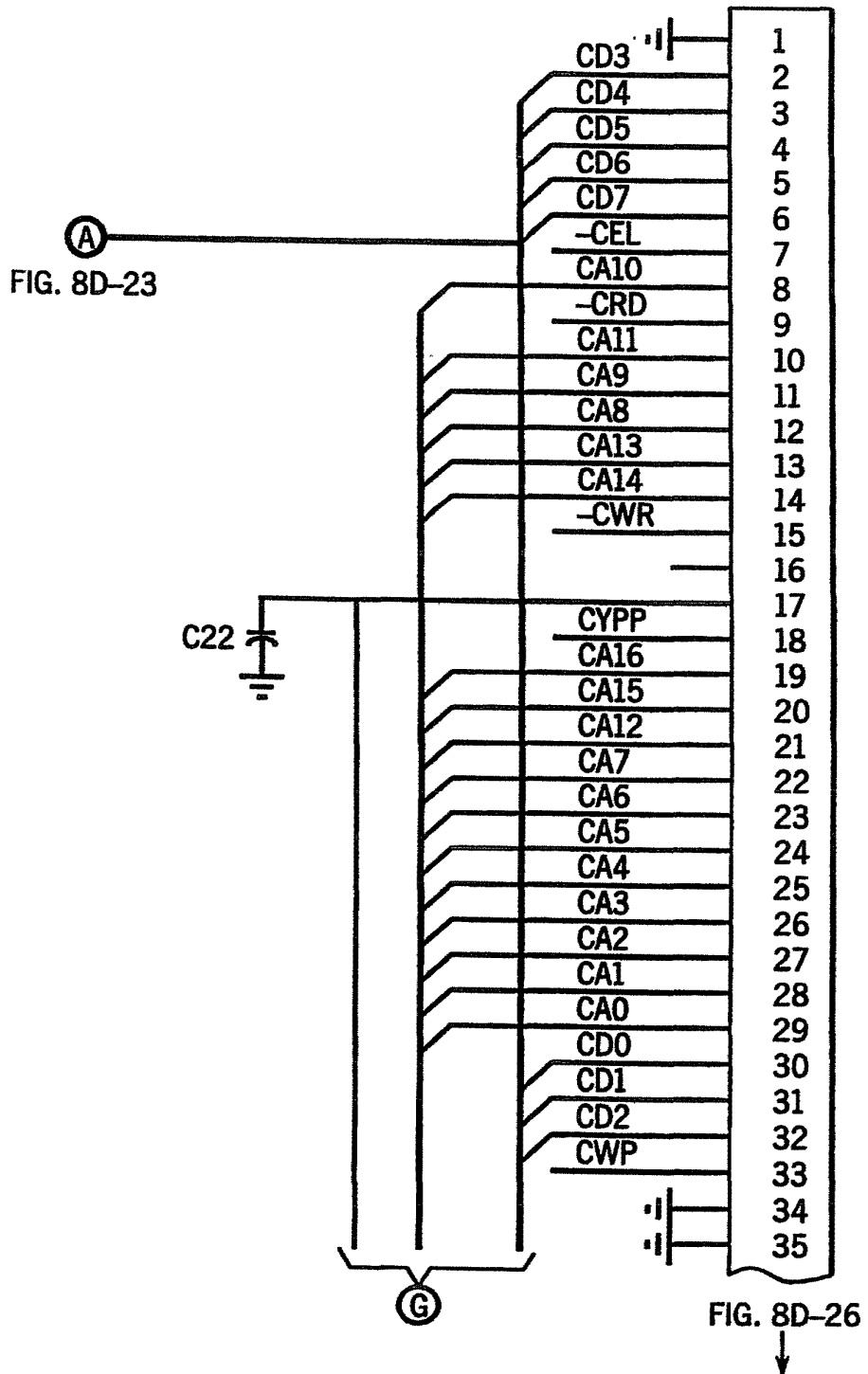


FIG. 8D-26

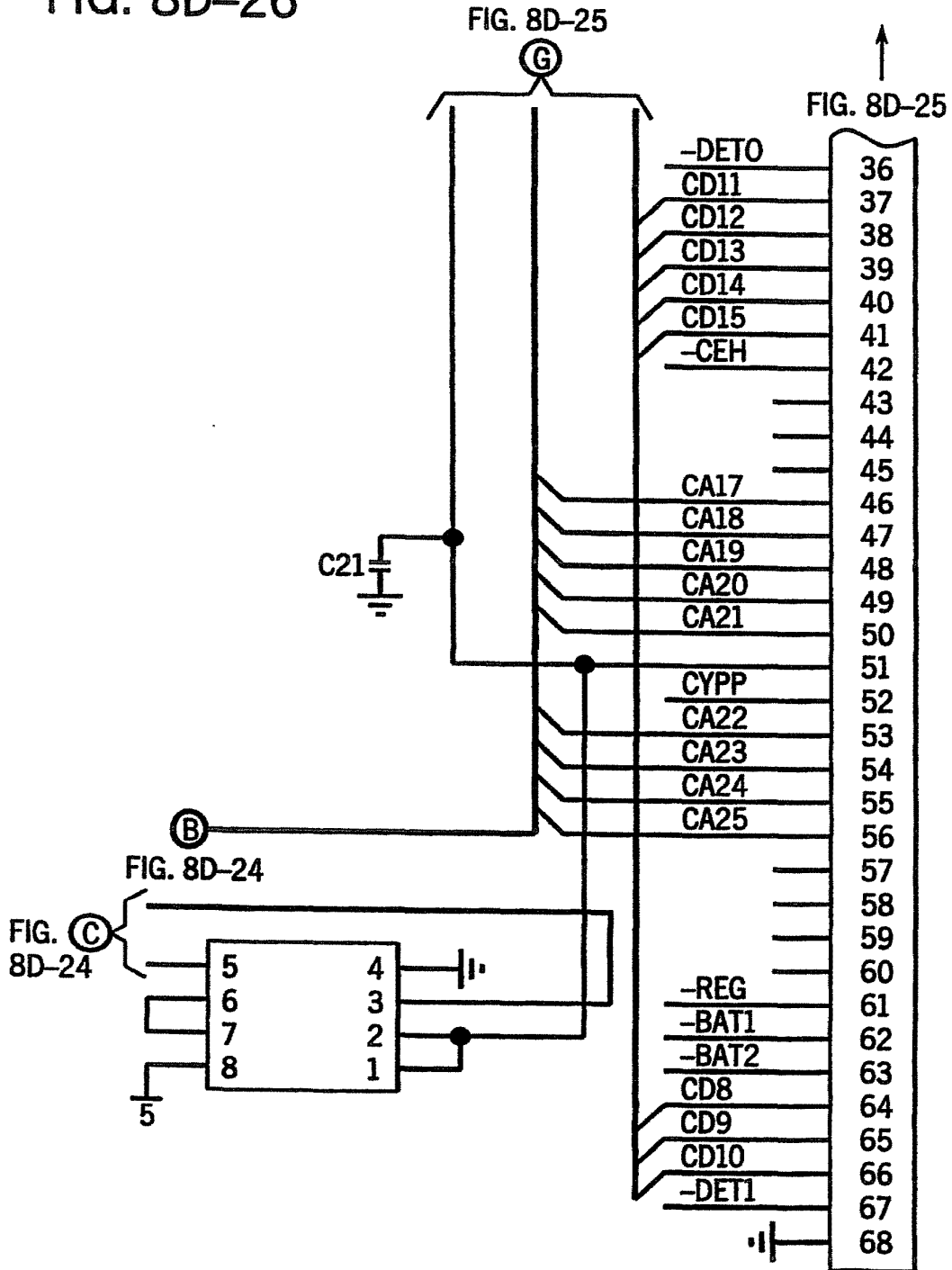


FIG. 8D-27

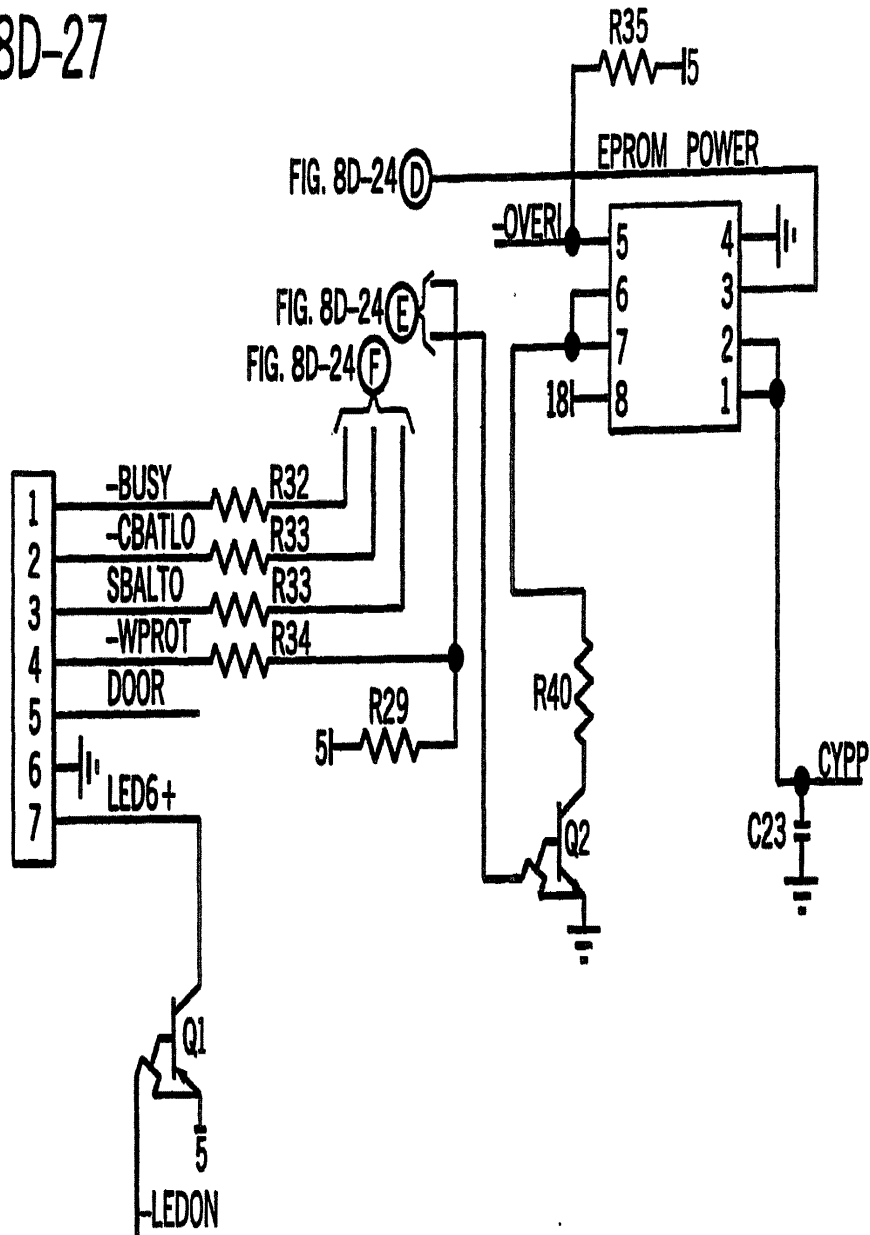


FIG. 8D-28

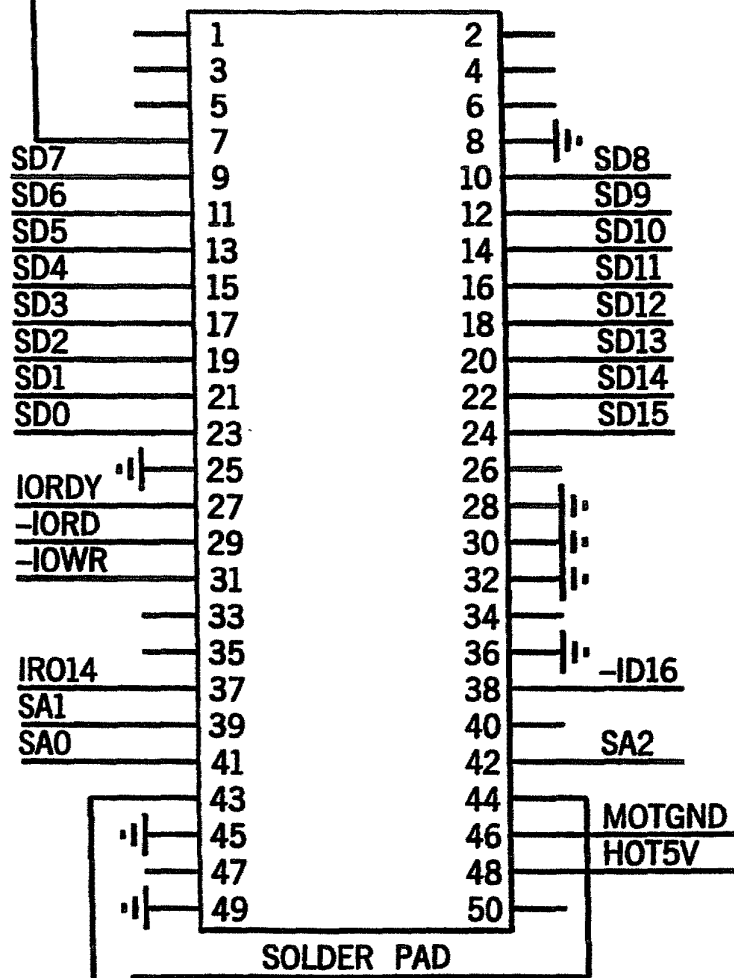
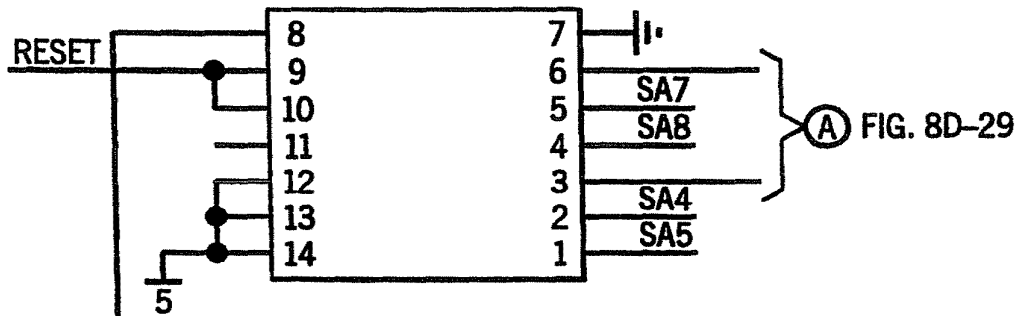


FIG. 8D-29 (B)

FIG. 8D-29

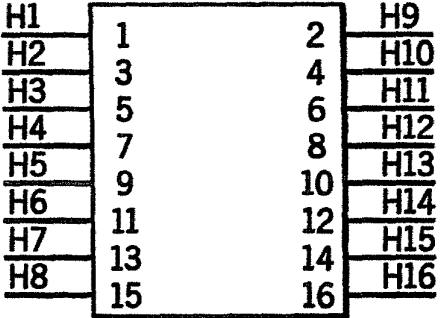
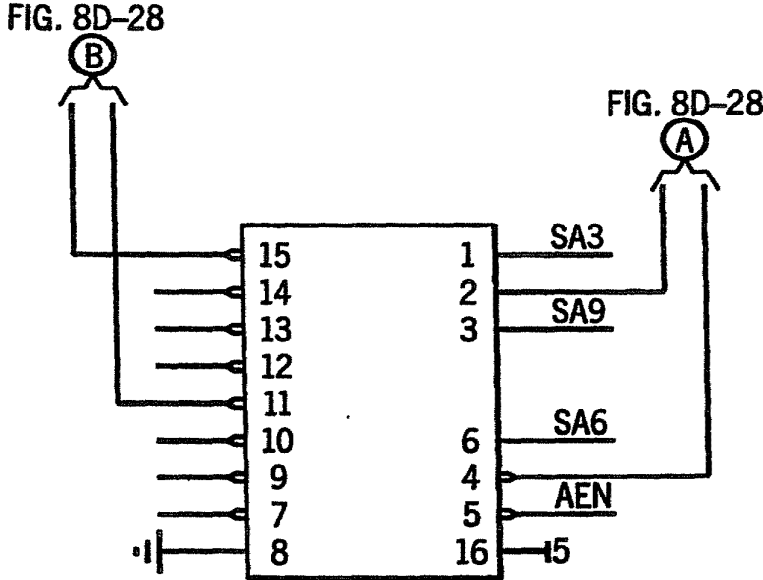


FIG. 8D-30

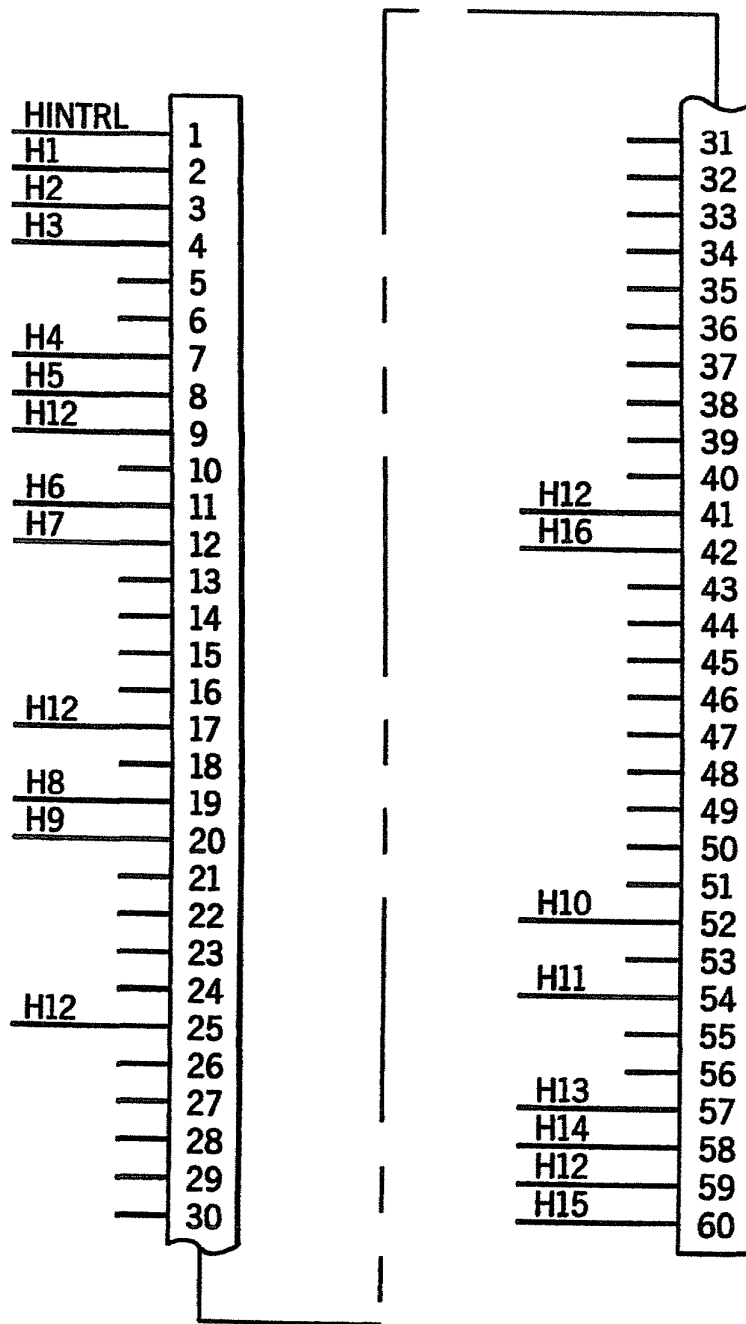


FIG. 8E-1

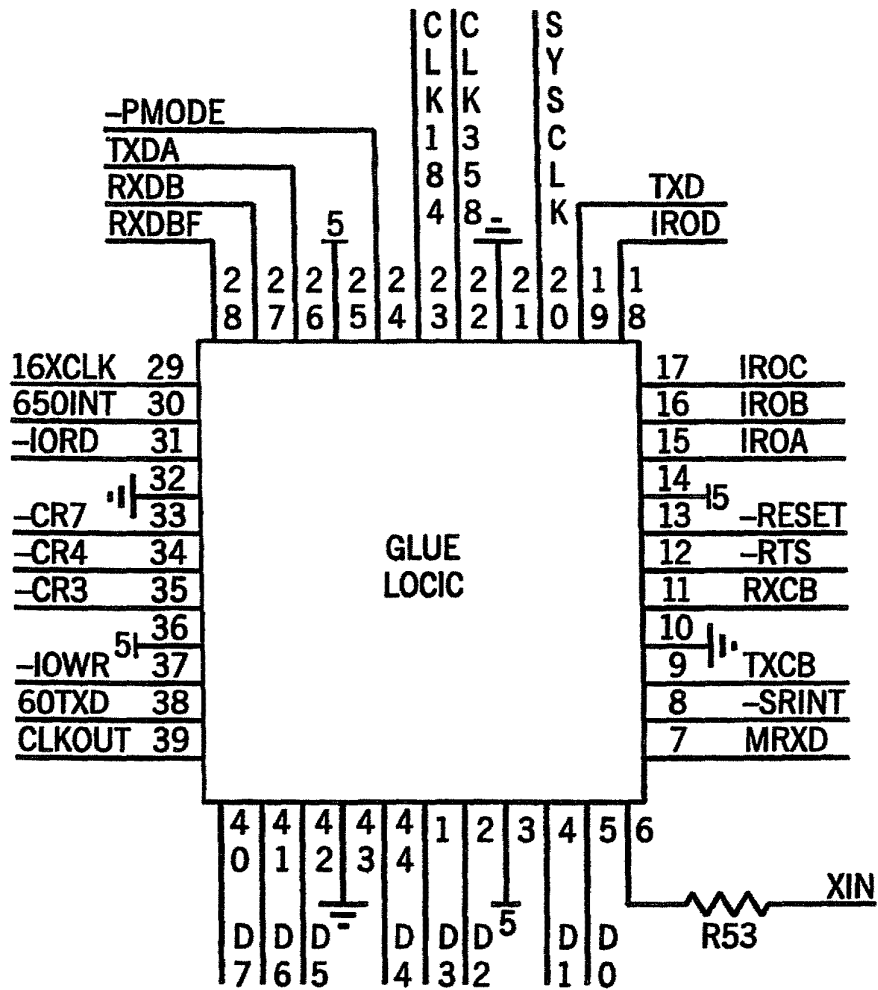


FIG. 8E-2

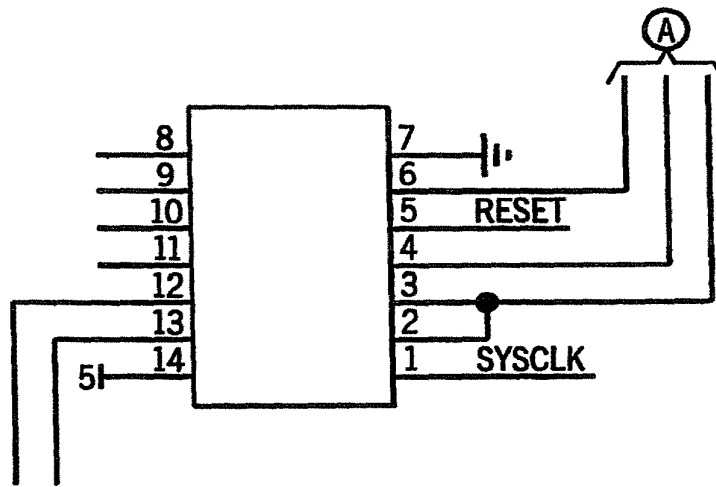




FIG. 8E-3

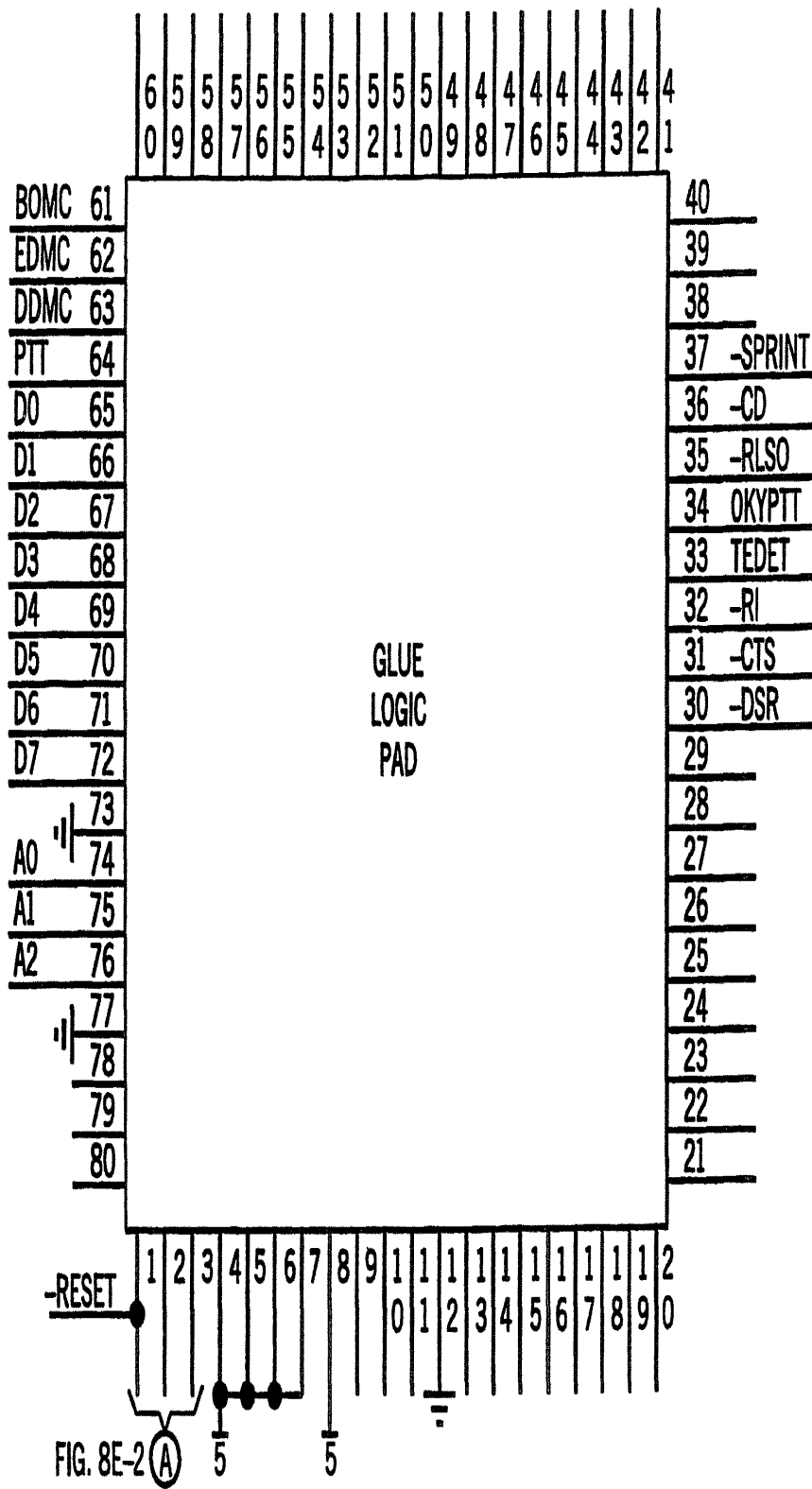


FIG. 8E-4

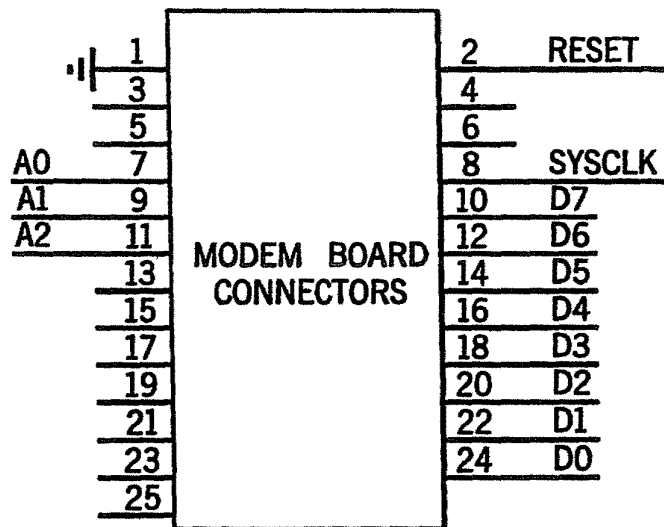


FIG. 8E-5

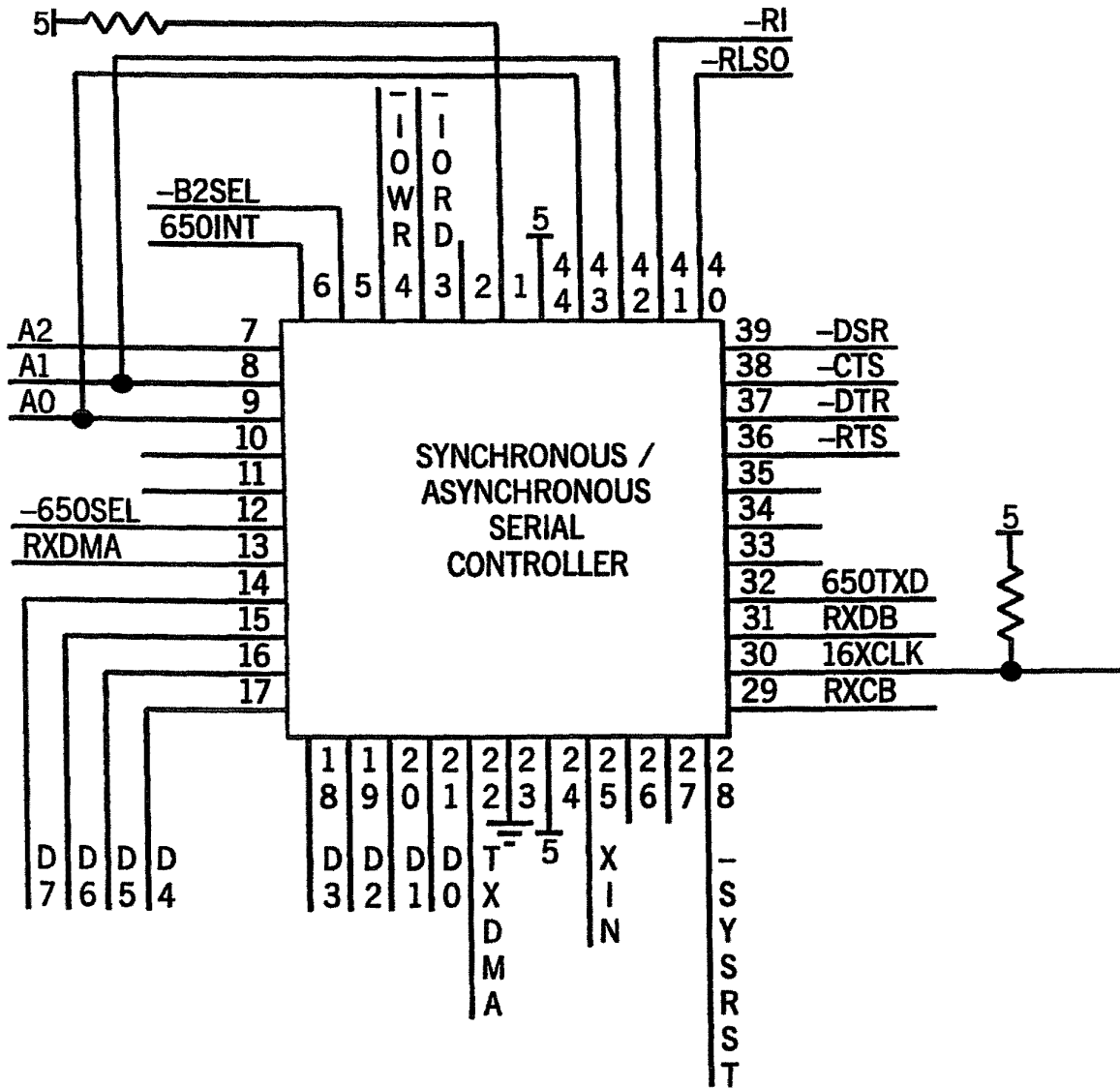
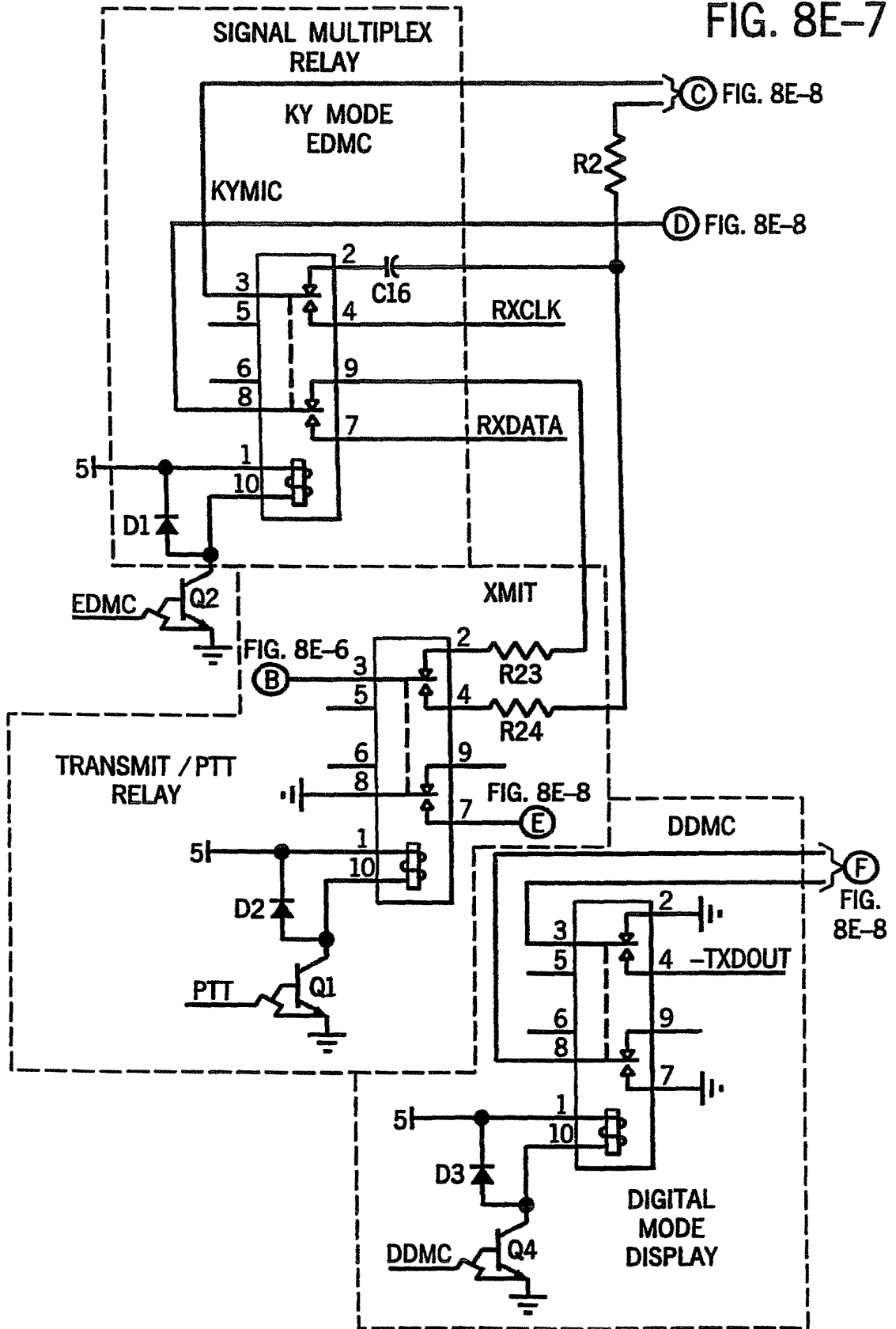




FIG. 8E-7



+

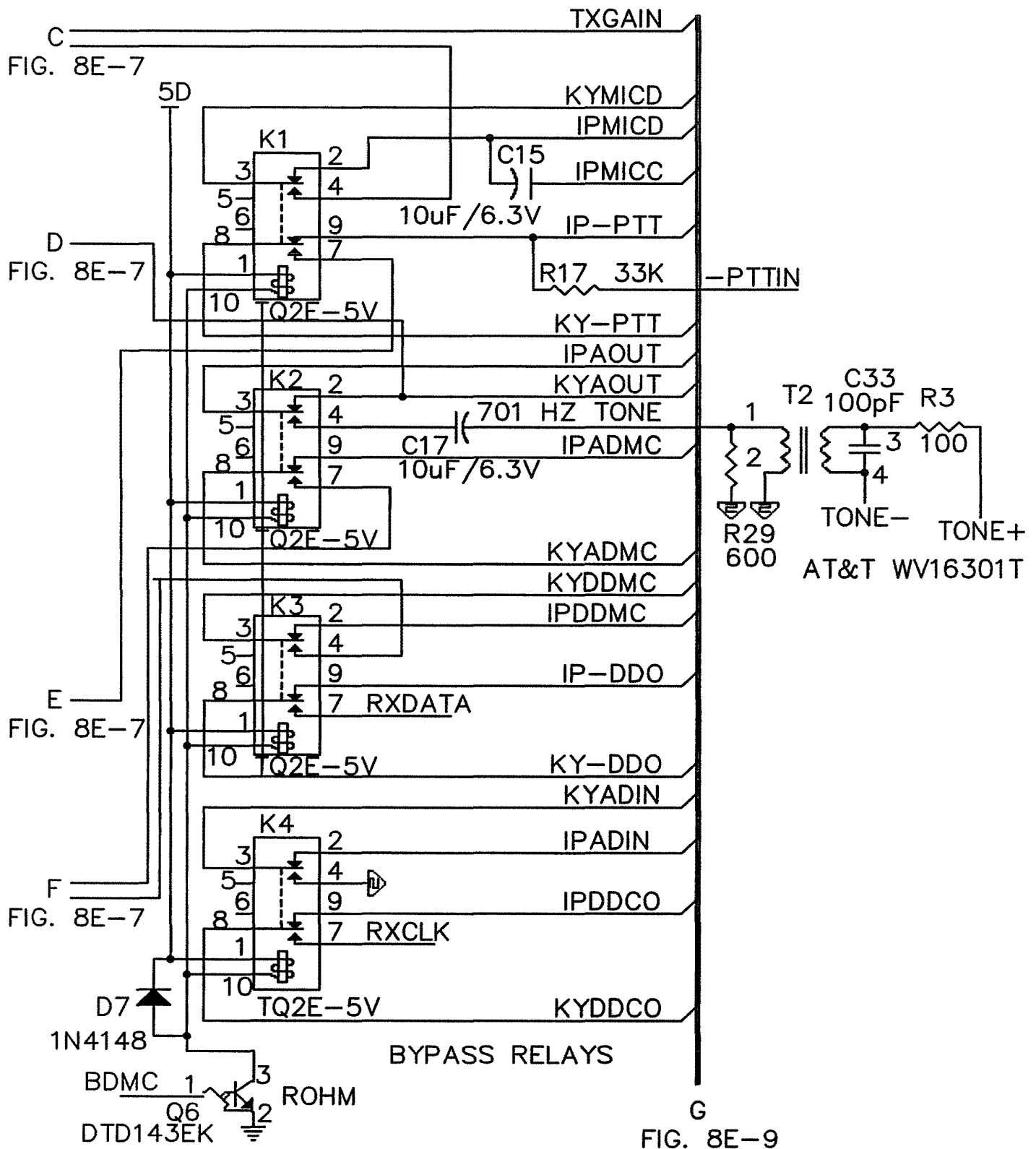


FIG. 8E-9

FIG. 8E-8

Ⓒ FIG. 8E-8

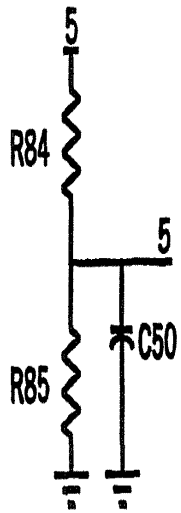
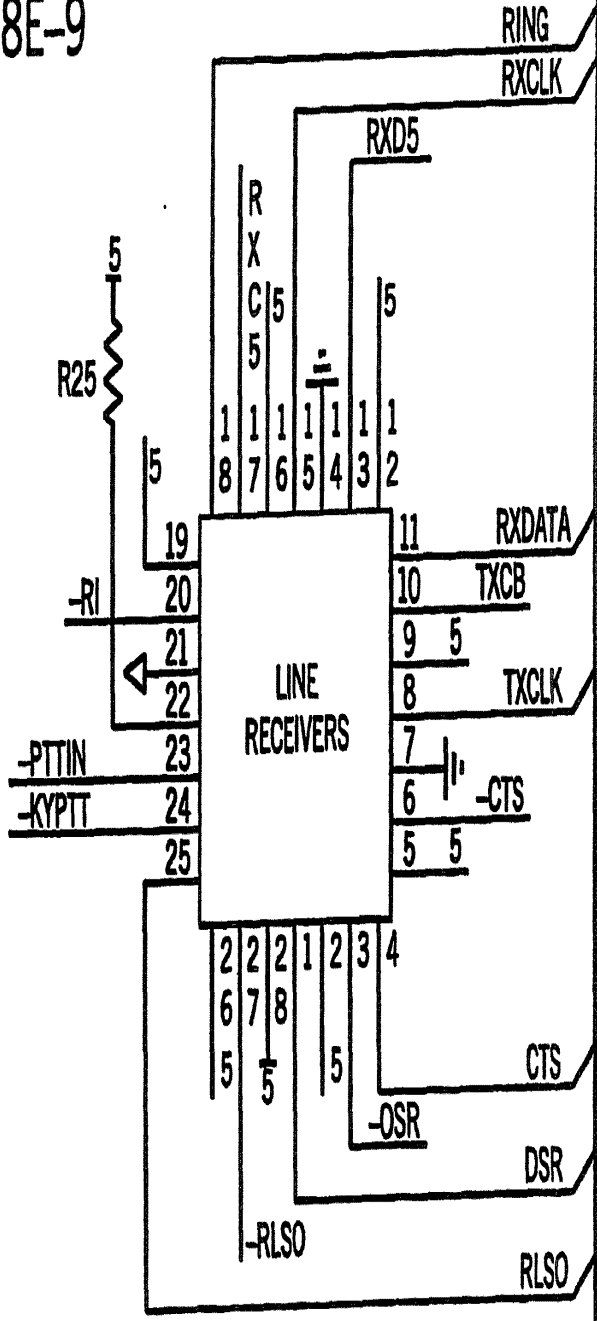


FIG. 8E-9



Ⓓ FIG. 8E-10

FIG. 8E-10

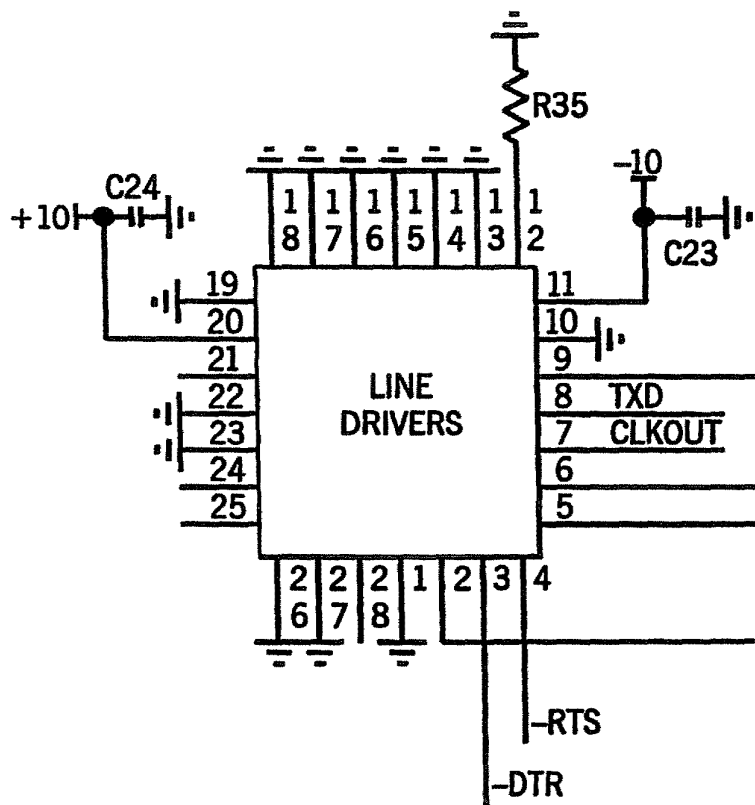


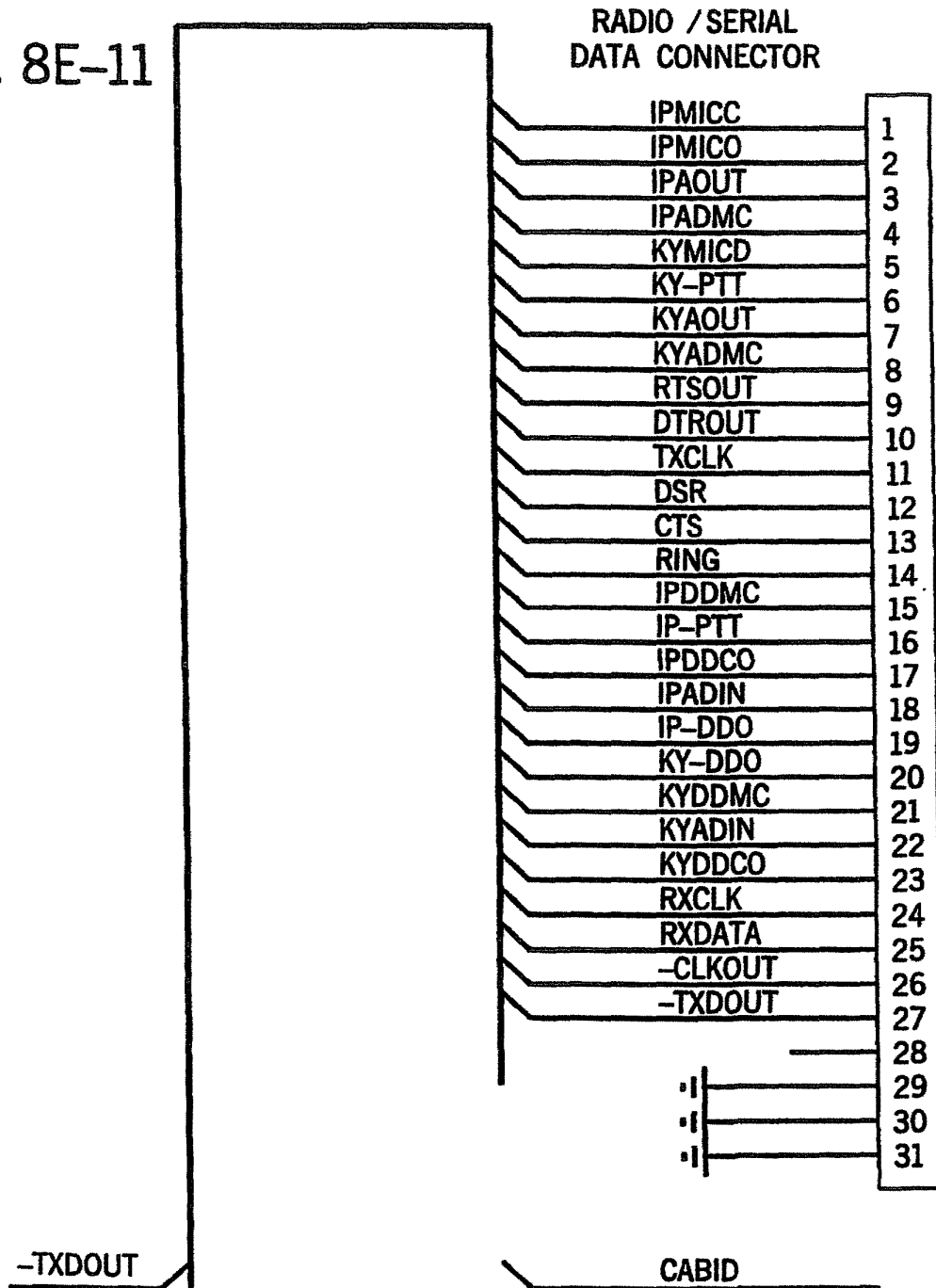
FIG. 8E-11



FIG. 8E-9

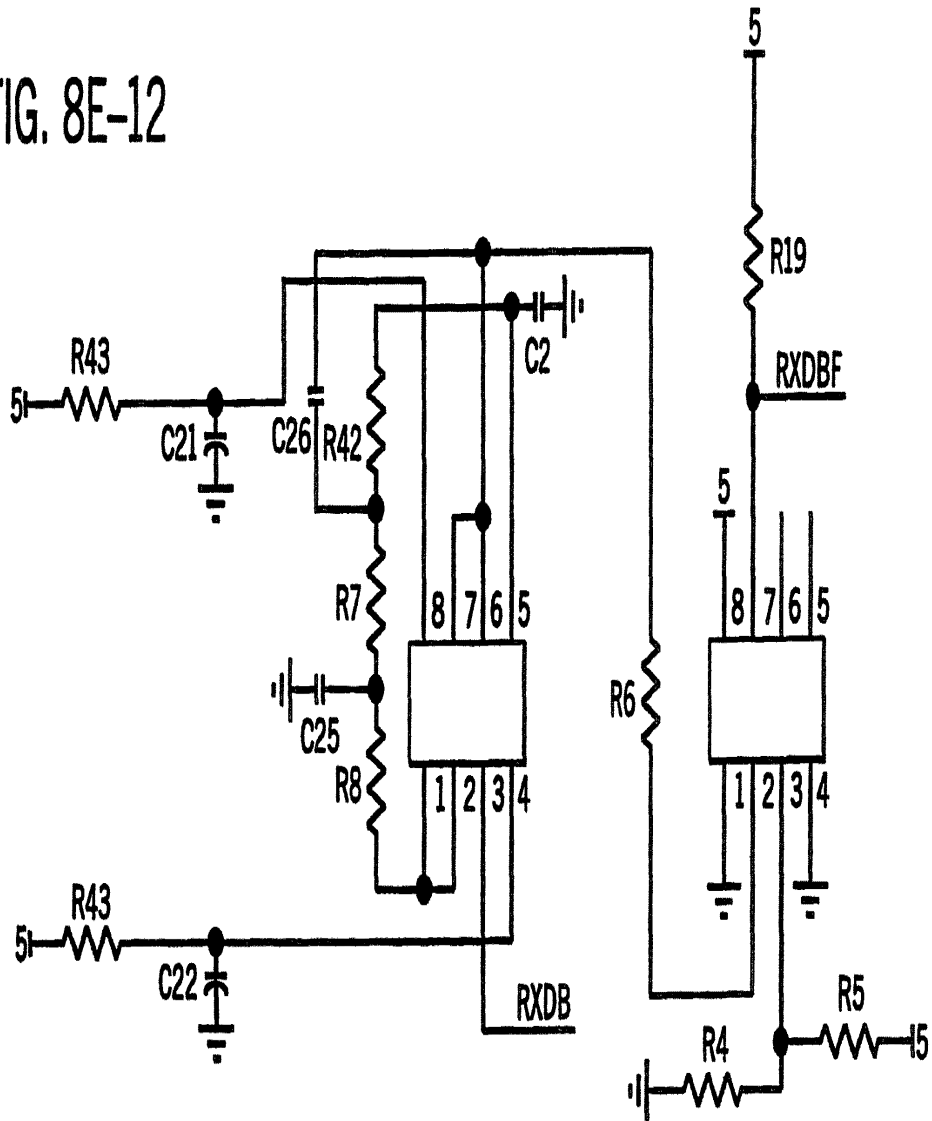


FIG. 8E-11



① FIG. 8E-10

FIG. 8E-12



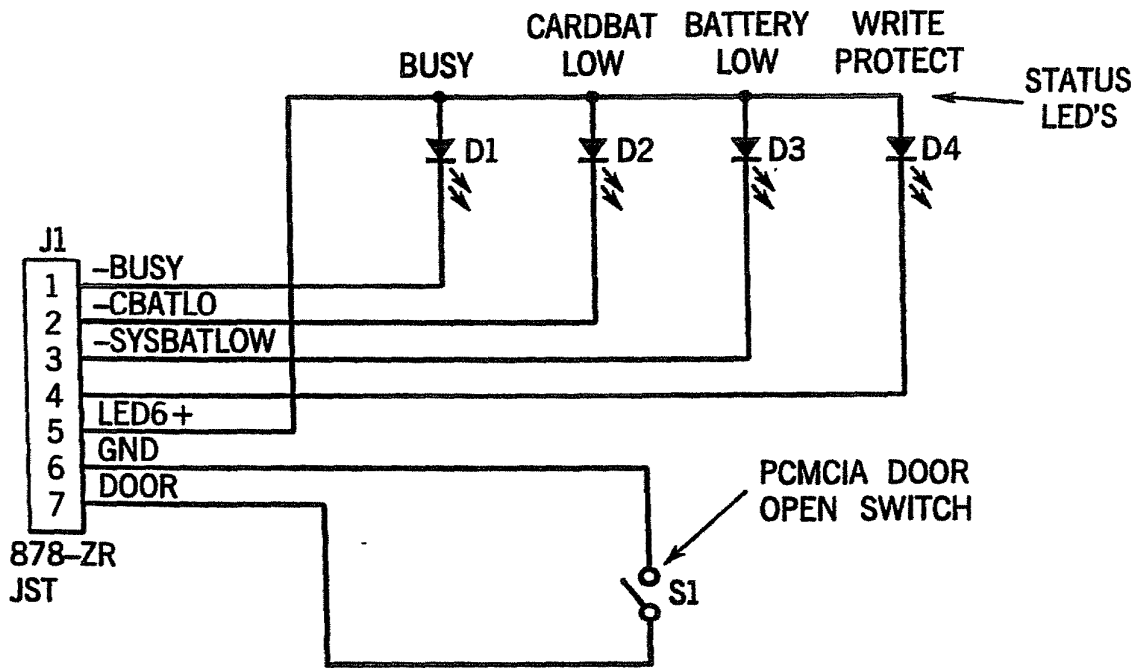


FIG. 8F

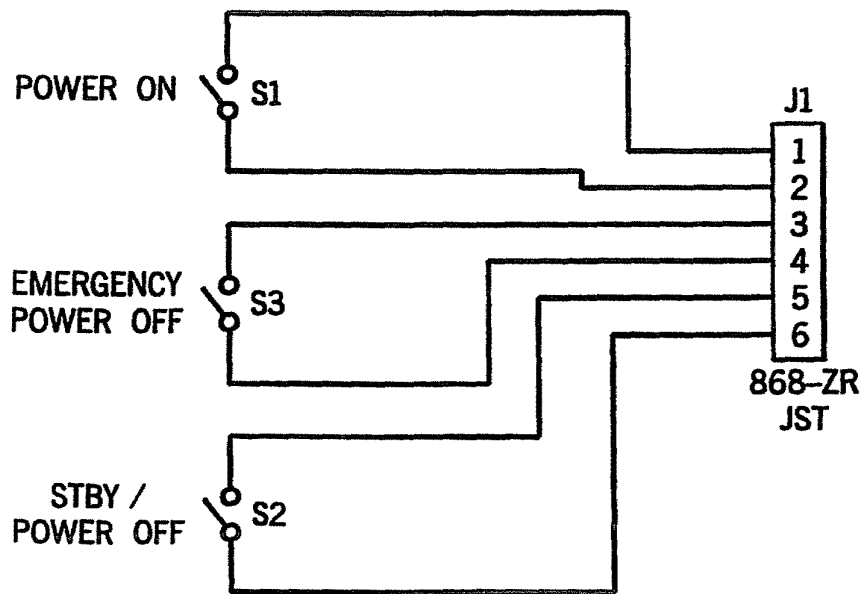


FIG. 8G

PUSH BUTTON SWITCHES

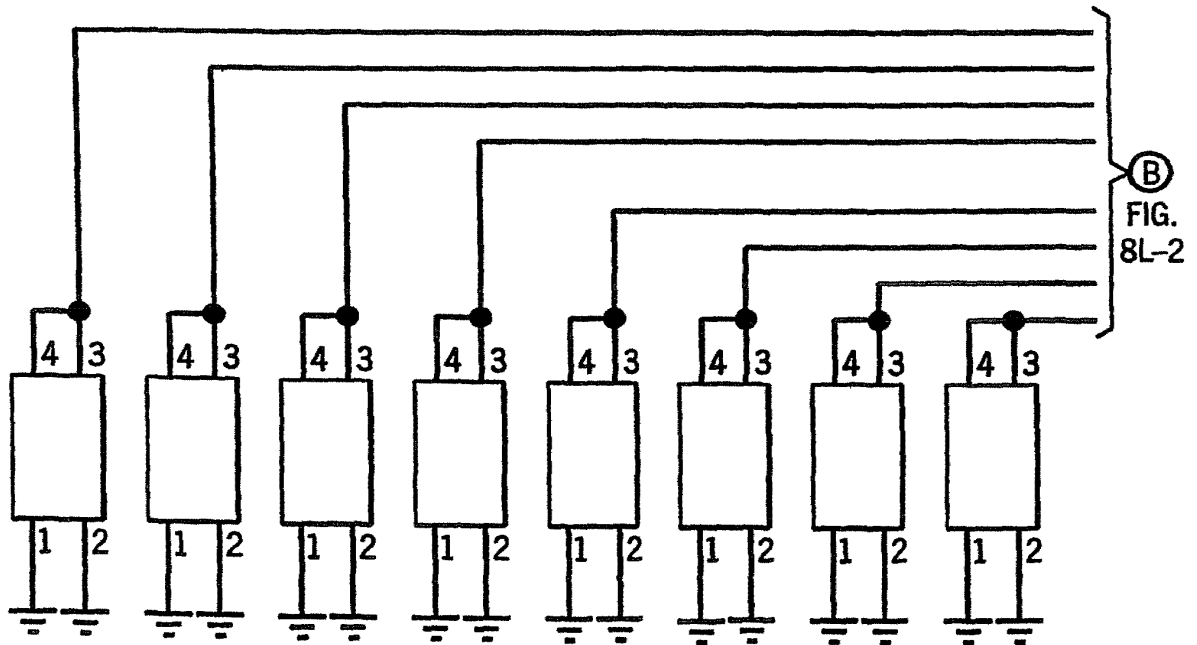
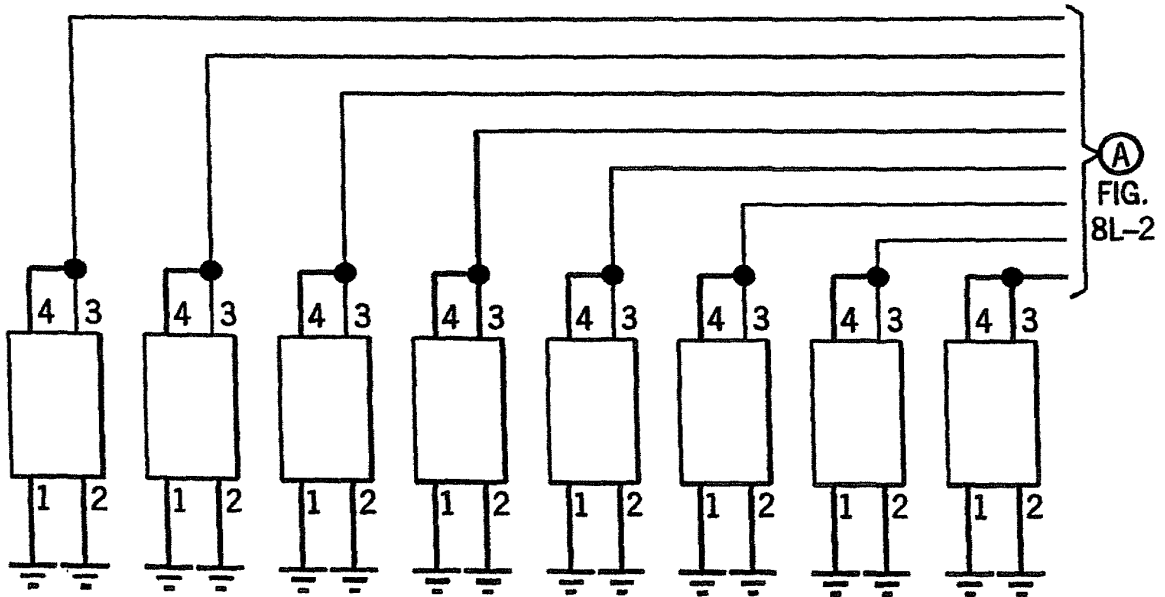


FIG. 8L-1

FIG. 8L-2

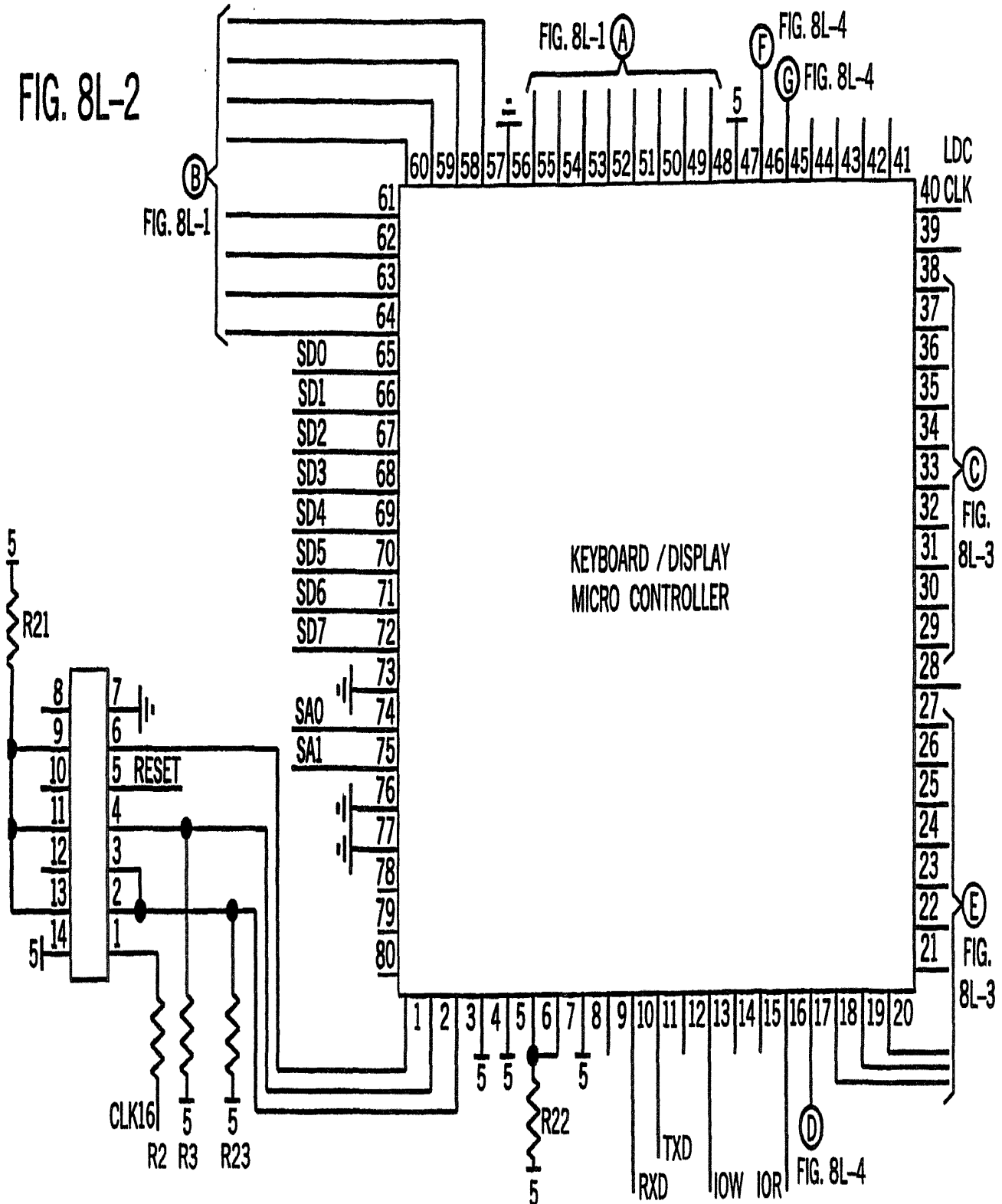
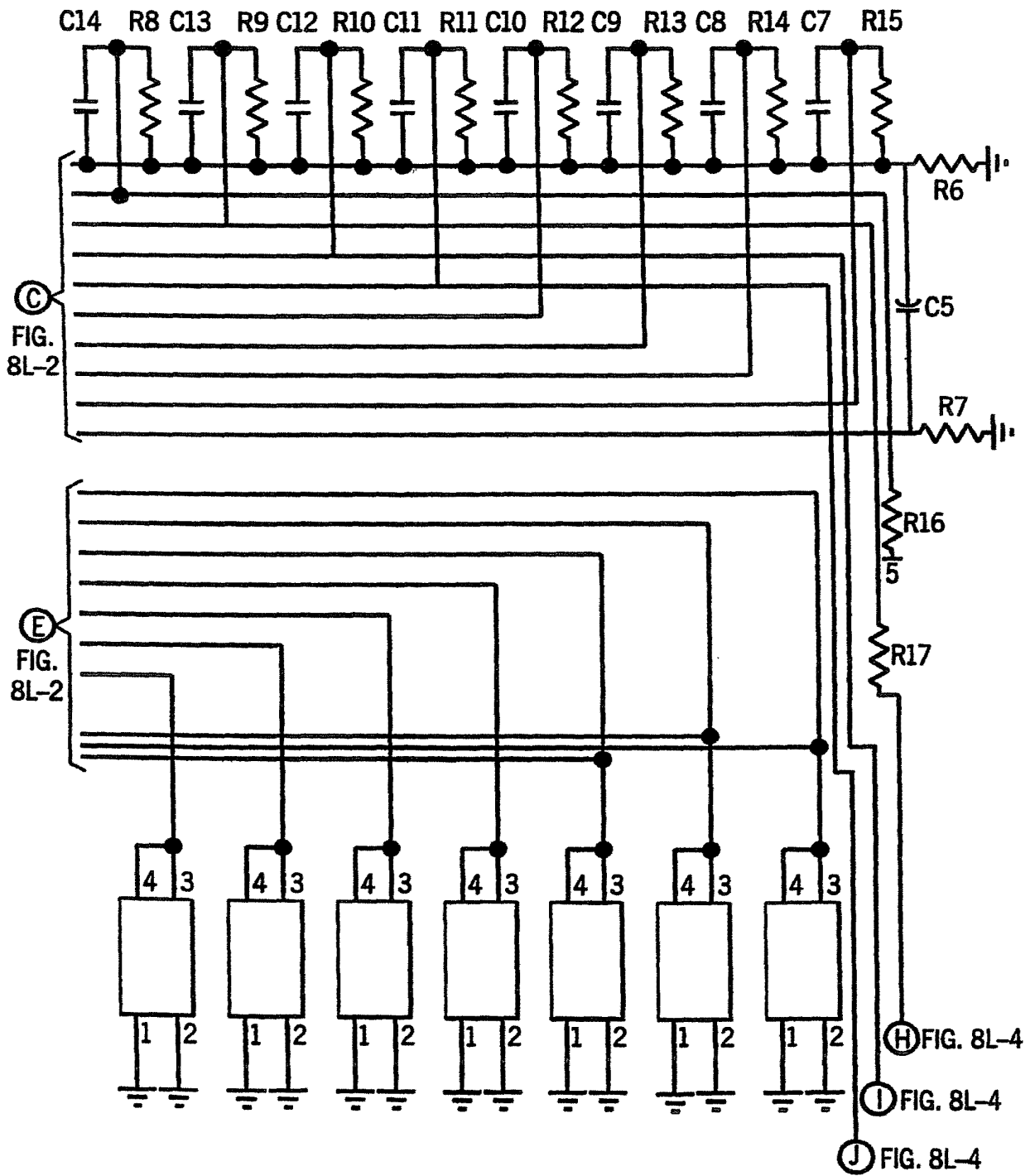


FIG. 8L-3



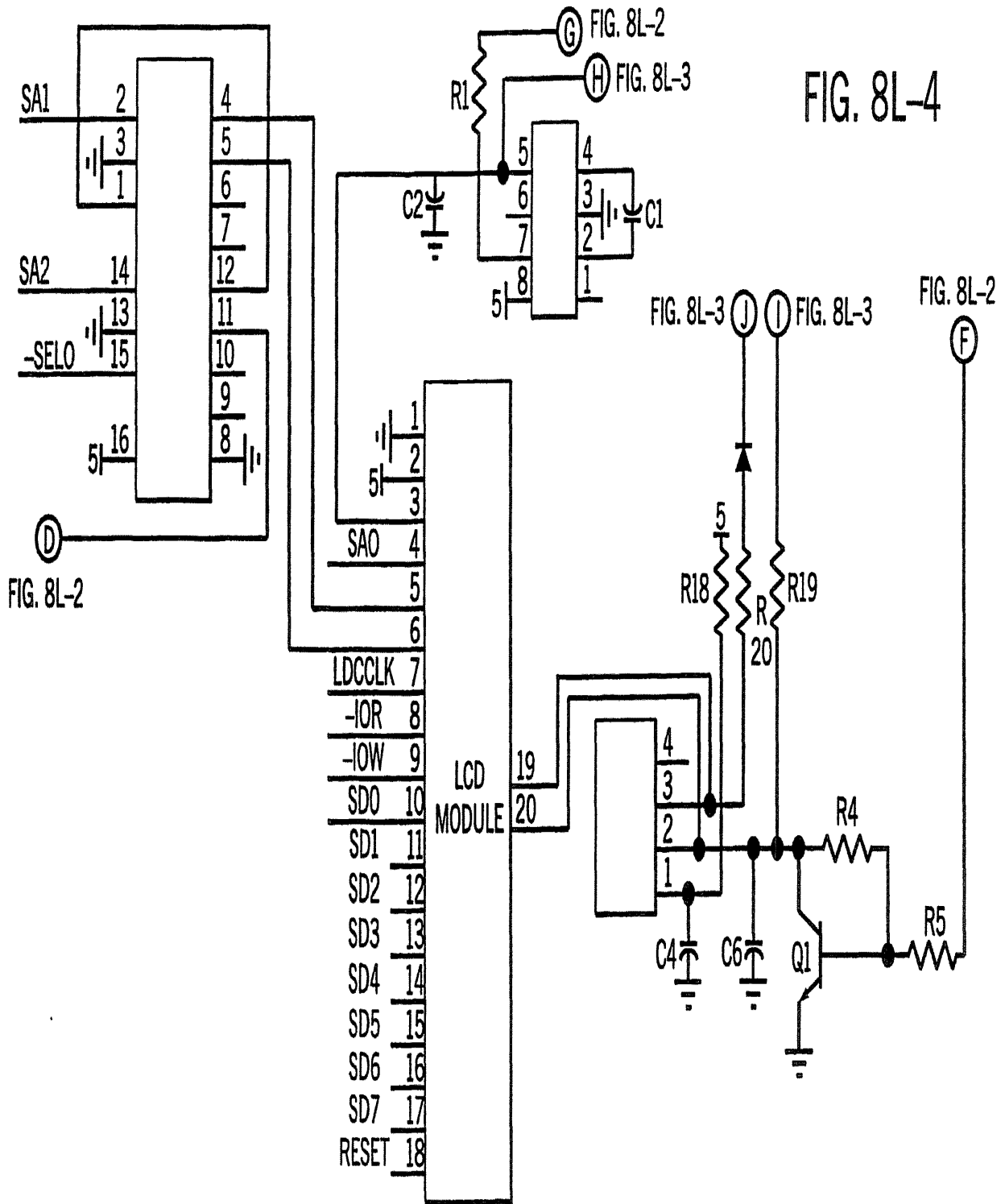
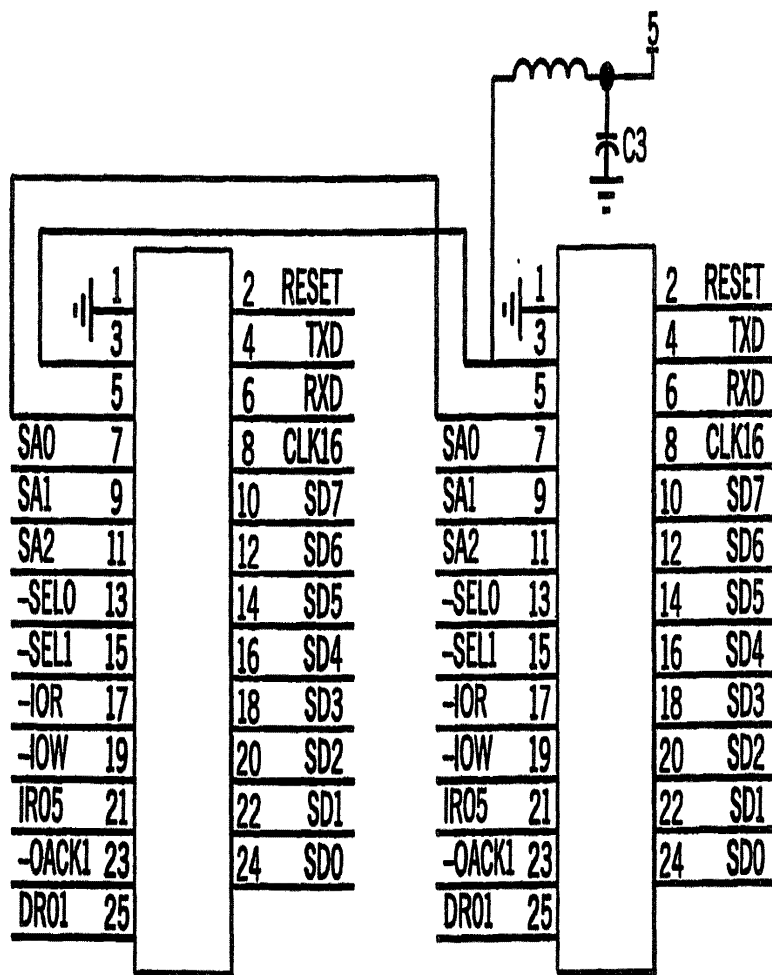


FIG. 8L-5



KEYBOARD / DISPLAY  
INTERFACE CONNECTORS



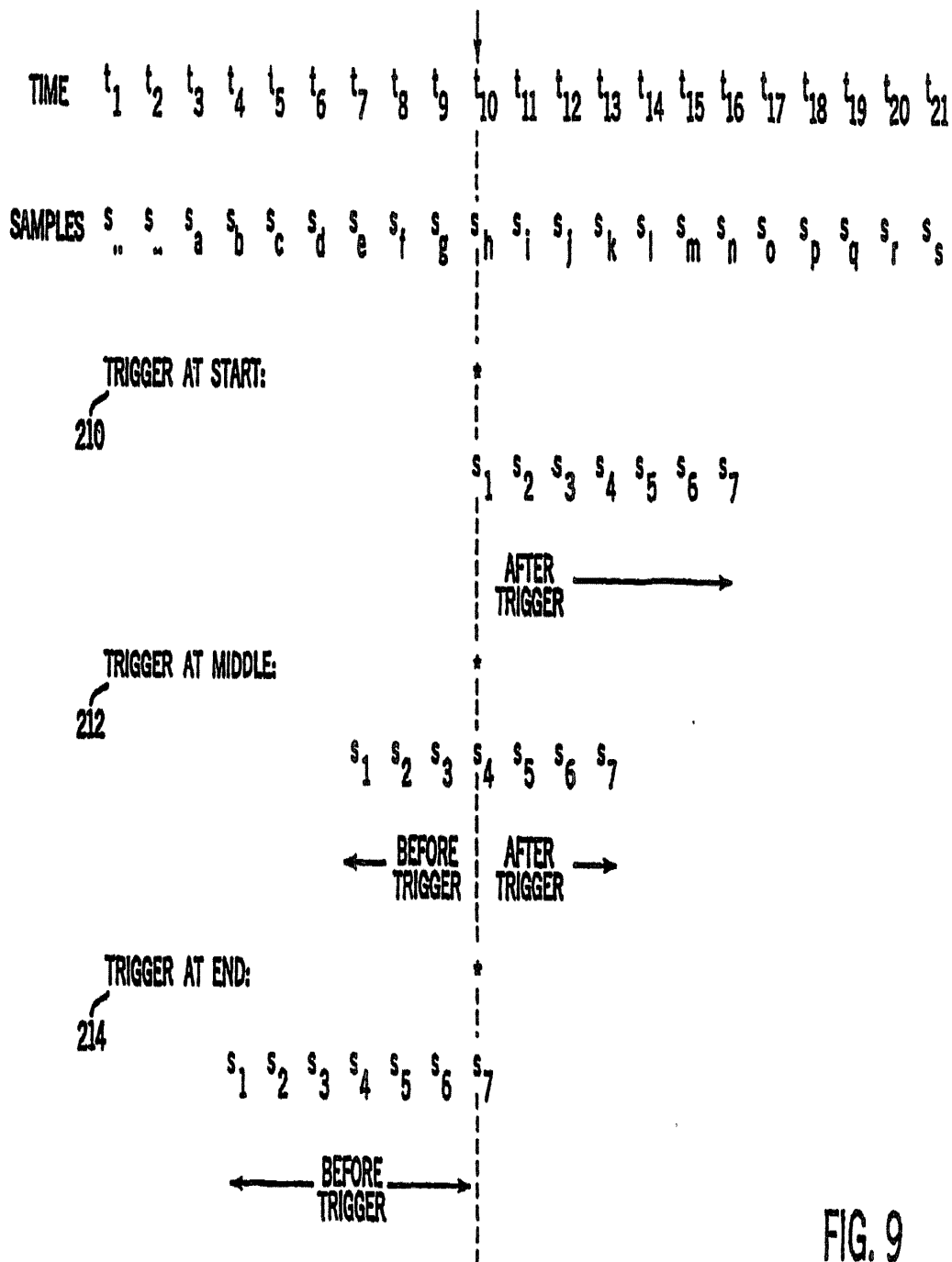


FIG. 9

## ABSTRACT

[0091] 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.

Attorney Docket No. P-121817.2,<sup>42</sup>43(DIV)

**COMBINED DECLARATION AND POWER OF ATTORNEY**

As a below-named inventor, I hereby declare that:

This is a divisional application.

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

I believe 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 is attached hereto.

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

I acknowledge my duty to disclose information which is material to the examination and patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) 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(s) and the national or PCT international filing date of this application.

U.S. Application Serial No. 09/006,073, filed January 12, 1998

**POWER OF ATTORNEY**

I hereby appoint the following attorneys to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

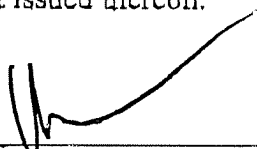
Richard R. Ruble, Reg. #45,720;  
Mark H. Miller, Reg. #29,197;  
William B. Nash, Reg. #33,743;  
Thomas E. Sisson, Reg. #29,348.

Robert C. Curfiss, Reg. #26,540;  
Daniel D. Chapman, Reg. #32,726;  
Cline H. White, Reg. #45,213;

Direct all correspondence and telephone calls to:

Robert C. Curfiss  
JACKSON WALKER L.L.P.  
112 E. Pecan Street, Suite 2100  
San Antonio, Texas 78205  
(210) 978-7700

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.



\_\_\_\_\_, Inventor  
David A. Monroe, Inventor

Date: 1/3/02

Residence: San Antonio, Texas  
Citizenship: United States  
Post Office Address: 740 Lincoln Center, 7800 IH-10 West, San Antonio, Texas 78230



## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>				
<b>Filing Date:</b>				
<b>Title of Invention:</b>	Apparatus for Capturing, Converting and Transmitting a Visual Image Signal Via A Digital Transmission System			
First Named Inventor/Applicant Name:	David A Monroe			
<b>Filer:</b>	Jeffrey Darryl Hunt			
<b>Attorney Docket Number:</b>	60719			
Filed as Large Entity				
<b>Utility Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
Utility application filing	1011	1	300	300
Utility Search Fee	1111	1	500	500
Utility Examination Fee	1311	1	200	200
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
<b>Extension-of-Time:</b>				
<b>Miscellaneous:</b>				
<b>Total in USD (\$)</b>				<b>1000</b>

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	1405387
<b>Application Number:</b>	11617509
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	4247
<b>Title of Invention:</b>	Apparatus for Capturing, Converting and Transmitting a Visual Image Signal Via A Digital Transmission System
<b>First Named Inventor/Applicant Name:</b>	David A Monroe
<b>Customer Number:</b>	67589
<b>Filer:</b>	Jeffrey Darryl Hunt
<b>Filer Authorized By:</b>	
<b>Attorney Docket Number:</b>	60719
<b>Receipt Date:</b>	28-DEC-2006
<b>Filing Date:</b>	
<b>Time Stamp:</b>	17:43:37
<b>Application Type:</b>	Utility

### Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$ 1000
RAM confirmation Number	694
Deposit Account	

### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
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1	Application Data Sheet	60719_ADS.pdf	37493	no	4
<b>Warnings:</b>					
<b>Information:</b>					
This is not an USPTO supplied ADS fillable form					
2	Specification	60719_spec.pdf	1625090	no	26
<b>Warnings:</b>					
<b>Information:</b>					
3	Claims	60719_clm.pdf	243986	no	6
<b>Warnings:</b>					
<b>Information:</b>					
4	Drawings	60719_drw.pdf	2177038	no	73
<b>Warnings:</b>					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
<b>Information:</b>					
5	Abstract	60719_abst.pdf	17585	no	1
<b>Warnings:</b>					
<b>Information:</b>					
6	Oath or Declaration filed	60719_oath.pdf	101139	no	2
<b>Warnings:</b>					
<b>Information:</b>					
7	Preliminary Amendment	60719_pa.pdf	313243	no	1
<b>Warnings:</b>					
<b>Information:</b>					
8	Fee Worksheet (PTO-06)	fee-info.pdf	8394	no	2
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			4523968		

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

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PATENT APPLICATION FEE DETERMINATION RECORD					11/617,509	
Substitute for Form PTO-875						
<b>APPLICATION AS FILED – PART I</b>						
(Column 1)			(Column 2)		(Column 3)	
FOR	NUMBER FILED	NUMBER EXTRA				
BASIC FEE (37 CFR 1.16(a), (b), or (c))						
SEARCH FEE (37 CFR 1.16(k), (l), or (m))					<b>300</b>	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))					<b>500</b>	
TOTAL CLAIMS (37 CFR 1.16(i))	<b>20</b>	minus 20 =			<b>200</b>	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	<b>1</b>	minus 3 =				
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR					
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))						
* If the difference in column 1 is less than zero, enter "0" in column 2.						
<b>APPLICATION AS AMENDED – PART II</b>						
(Column 1)			(Column 2)		(Column 3)	
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		
	Total (37 CFR 1.16(i))	*	Minus **	=		
	Independent (37 CFR 1.16(h))	*	Minus ***	=		
	Application Size Fee (37 CFR 1.16(s))					
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
(Column 1) (Column 2) (Column 3)						
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		
	Total (37 CFR 1.16(i))	*	Minus **	=		
	Independent (37 CFR 1.16(h))	*	Minus ***	=		
	Application Size Fee (37 CFR 1.16(s))					
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
(Column 1) (Column 2) (Column 3)						

SMALL ENTITY		OTHER THAN SMALL ENTITY	
RATE (\$)	FEE (\$)	RATE (\$)	FEE (\$)
			<b>300</b>
			<b>500</b>
			<b>200</b>
X\$25=		X\$50	
X\$100=		X\$200=	
N/A		N/A	
TOTAL		TOTAL	<b>1000</b>

SMALL ENTITY		OTHER THAN SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
X =		X =	
X =		X =	
N/A		N/A	
TOTAL ADD'T FEE		TOTAL ADD'T FEE	

SMALL ENTITY		OTHER THAN SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
X =		X =	
X =		X =	
N/A		N/A	
TOTAL ADD'T FEE		TOTAL ADD'T 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.

This collection of information is required by 37 CFR 1.16. 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 1.14. 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. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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<b>PATENT APPLICATION FEE DETERMINATION RECORD</b> Substitute for Form PTO-875	<b>11/617,509</b>
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APPLICATION AS FILED – PART I			SMALL ENTITY		OTHER THAN SMALL ENTITY	
	(Column 1)	(Column 2)				
FOR	NUMBER FILED	NUMBER EXTRA	RATE (\$)	FEE (\$)	RATE (\$)	FEE (\$)
BASIC FEE (37 CFR 1.16(e), (b), or (c))						300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))						500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))						200
TOTAL CLAIMS (37 CFR 1.16(f))	20	minus 20 =	X\$25=		X\$50	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1	minus 3 =	X\$100=		X\$200=	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR					
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			N/A		N/A	
			TOTAL		TOTAL	1000

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

APPLICATION AS AMENDED – PART II					SMALL ENTITY		OTHER THAN SMALL ENTITY	
	(Column 1)	(Column 2)	(Column 3)					
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))	20	Minus	42	X =		X =	
	Independent (37 CFR 1.16(h))	1	Minus	2	X =		X =	
	Application Size Fee (37 CFR 1.16(s))							
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))				N/A		N/A	
					TOTAL ADD'T FEE		TOTAL ADD'T FEE	

	(Column 1)	(Column 2)	(Column 3)					
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))		Minus	**	X =		X =	
	Independent (37 CFR 1.16(h))		Minus	***	X =		X =	
	Application Size Fee (37 CFR 1.16(s))							
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))				N/A		N/A	
					TOTAL ADD'T FEE		TOTAL ADD'T 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.

This collection of information is required by 37 CFR 1.16. 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 1.14. 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. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Table with 8 columns: APPLICATION NUMBER, FILING or 371(c) DATE, GRP ART UNIT, FIL FEE REC'D, ATTY.DOCKET.NO, DRAWINGS, TOT CLAIMS, IND CLAIMS. Row 1: 11/617,509, 12/28/2006, 2625, 1000, 60719, 73, 20, 1

CONFIRMATION NO. 4247

FILING RECEIPT

67589
MOORE LANDREY
1609 SHOAL CREEK BLVD
AUSTIN, TX78701

Date Mailed: 02/02/2007

Receipt is acknowledged of this regular Patent Application. It will be considered in its order and you will be notified as to the results of the examination. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please mail to the Commissioner for Patents P.O. Box 1450 Alexandria Va 22313-1450. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).

Applicant(s)

David A Monroe, San Antonio, TX;

Assignment For Published Patent Application

E-Watch Inc., San Antonio, TX

Power of Attorney:

Robert Curfiss--26540 Cline White--45213
Mark Miller--29197 Richard Ruble--45720
Thomas Sisson--29348
Daniel Chapman--32726
William Nash--33743

Domestic Priority data as claimed by applicant

This application is a CON of 10/336,470 01/03/2003

Foreign Applications

If Required, Foreign Filing License Granted: 02/01/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is US11/617,509

Projected Publication Date: 05/17/2007

Non-Publication Request: No

Early Publication Request: No

**Title**

Apparatus for Capturing, Converting and Transmitting a Visual Image Signal Via A Digital Transmission System

**Preliminary Class**

358

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FEB 13 2007

PAGE 25/47 \* RCVD AT 2/13/2007 3:11:23 PM [Eastern Standard Time] \* SVR:USPTO-EFXXRF-5/22 \* DNIS:2738300 \* CSID:5123208906 \* DURATION (mm-ss):08-32

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PTO/SB/97 (09-06)

Approved for use through 03/31/2007. OMB 0651-0031

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

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on February 13, 2007  
Date

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Registration Number, if applicable

512-499-8900  
Telephone Number

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I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 2.73(b).

I hereby appoint:

Practitioners associated with the Customer Number:

67589

OR

Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents, attached to this form in accordance with 37 CFR 2.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 2.73(d) to:

The address associated with Customer Number:

67589

OR

Firm or Individual Name

Address

City

State

Zip

Country

Telephone

Email

Assignee Name and Address:

E-watch, Inc  
 Lincoln Center, Ste 700  
 7800 IH 10 West  
 San Antonio TX 78230

A copy of this form, together with a statement under 37 CFR 2.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 2.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee.

Signature

*David A. Moore*

Date

12/22/2006

Name

David A. Moore

Telephone

210-349-2000

Title

President

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 36 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 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 the 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. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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**STATEMENT UNDER 37 CFR 3.73(b)**

Applicant/Patent Owner: David A. Monroe

Application No./Patent No.: 11/617,509 Filed/Issue Date: 12/28/06

Entitled: Apparatus for Capturing, Converting and Transmitting a Visual Image Signal Via a Digital Transmission System

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FEB 13 2007

E-Watch, Inc., a corporation,  
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

- 1.  the assignee of the entire right, title, and interest, or
- 2.  an assignee of less than the entire right, title and interest  
(The extent (by percentage) of its ownership interest is \_\_\_\_\_ %)

in the patent application/patent identified above by virtue of either:

A.  An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

OR

B.  A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

- 1. From: The Tefelis Group, Inc. To: E-Watch, Inc.  
The document was recorded in the United States Patent and Trademark Office at Reel 016824, Frame 0514, or for which a copy thereof is attached.
- 2. From: David A. Monroe To: The Tefelis Group, Inc.  
The document was recorded in the United States Patent and Trademark Office at Reel 016722, Frame 0239, or for which a copy thereof is attached.
- 3. From: \_\_\_\_\_ To: \_\_\_\_\_  
The document was recorded in the United States Patent and Trademark Office at Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

Additional documents in the chain of title are listed on a supplemental sheet.

As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

[Signature] \_\_\_\_\_ January 30, 2007  
Signature Date

Jeffrey D. Hunt, Reg. No. 38,189 \_\_\_\_\_ 512-499-8900  
Printed or Typed Name Telephone Number

Attorney Moore Landrey, L.L.P., Customer #67589  
Title

This collection of information is required by 37 CFR 3.73(b). 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 36 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. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/617,509	12/28/2006	David A Monroe	60719

67589  
 MOORE LANDREY  
 1609 SHOAL CREEK BLVD  
 AUSTIN, TX 78701

**CONFIRMATION NO. 4247**  
**\*OC000000022708498\***  
 \*OC000000022708498\*

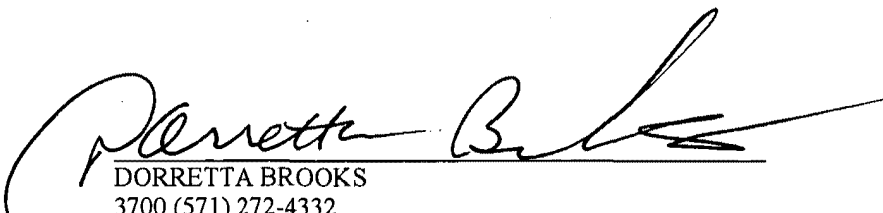
Date Mailed: 03/01/2007

**NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 02/13/2007.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

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OFFICE COPY



APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/617,509	12/28/2006	David A Monroe	06-0719

**CONFIRMATION NO. 4247**

67589  
MOORE LANDREY  
1609 SHOAL CREEK BLVD  
AUSTIN, TX78701

**Title:** Apparatus for Capturing, Converting and Transmitting a Visual Image Signal Via A Digital Transmission System

**Publication No.** US-2007-0109594-A1

**Publication Date:** 05/17/2007

### NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publicly available Searchable Databases via the Internet at [www.uspto.gov](http://www.uspto.gov). The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at [www.uspto.gov](http://www.uspto.gov) using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <http://pair.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 703-305-3028.

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Pre-Grant Publication Division, 703-605-4283



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/617,509	12/28/2006	David A Monroe	06-0719	4247
67589	7590	10/04/2007	EXAMINER	
MOORE LANDREY 1609 SHOAL CREEK BLVD AUSTIN, TX 78701			SAFAIPOUR, HOUSHANG	
			ART UNIT	PAPER NUMBER
			2625	
			MAIL DATE	DELIVERY MODE
			10/04/2007	PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

**Office Action Summary**

Application No.

11/617,509

Applicant(s)

MONROE, DAVID A

Examiner

Houshang Safaipour

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1)  Responsive to communication(s) filed on \_\_\_\_\_.
- 2a)  This action is **FINAL**.
- 2b)  This action is non-final.
- 3)  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.

**Disposition of Claims**

- 4)  Claim(s) \_\_\_\_\_ is/are pending in the application.  
4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5)  Claim(s) \_\_\_\_\_ is/are allowed.
- 6)  Claim(s) 1-42 is/are rejected.
- 7)  Claim(s) \_\_\_\_\_ is/are objected to.
- 8)  Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9)  The specification is objected to by the Examiner.
- 10)  The drawing(s) filed on 28 December 2006 is/are: a)  accepted or b)  objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11)  The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12)  Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a)  All b)  Some \* c)  None of:  
1.  Certified copies of the priority documents have been received.  
2.  Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
3.  Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- 1)  Notice of References Cited (PTO-892)
- 2)  Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3)  Information Disclosure Statement(s) (PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- 4)  Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_
- 5)  Notice of Informal Patent Application
- 6)  Other: \_\_\_\_\_

## DETAILED ACTION

### *Specification*

1. The disclosure is objected to because of the following informalities:

In paragraph 0051, line 13, PCMCIA card 50" should read PCMCIA card 72".

Appropriate correction is required.

### *Drawings*

2. 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. Corrected drawing sheets in compliance with 37 CFR 1.121 (d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.
3. 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", in paragraph 0049, line 18. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended

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replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

4. The drawings are objected to because in Fig. 4, PC modem protocol box "66" should read "68", as read in paragraph 0053, lines 20 and 21. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.



***Claim Objections***

5. Claims 3 and 5 are objected to because of the following informalities:

In claim 3, line 1, "claim 1" should read "claim 2", as reference is made to "said memory", introduced in claim 2;

In claim 5, line 1, "claim 1" should read "claim 4", as reference is made to "the digital signal", introduced in claim 4. Appropriate correction is required.

***Claim Rejections - 35 USC § 102***

6. 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.

7. Claims 1, 2, 4-12, 21, 23-27, and 30-36 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 (device 110 in Figs. 1 and 2) for capturing a visual image and transmitting it to a remote receiving station (see abstract, column 1, lines 47 through 52, column 2, lines 43 through 61, and column 3, lines 10 through 20), with the system comprising an image capture device (CCD 203, column 3, lines 21 through 67), a processor (microcontroller 205) for generating a data signal representing the image (column 3, lines 21 through 67), a communications device (facsimile interface 219) adapted for transmitting the data signal to the remote receiving station (column 4, line 65 through

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column 5, line 9), and a wireless transmission system between the communications device and the compatible receiving station (column 2, lines 4 through 54, and column 3, lines 10 through 20, with the fax modem 240, being "applied as an input to the transmitter section of a cellular telephone", as read in column 5, lines 7 through 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), and wherein the communications device is adapted for recalling the stored data signal from memory (column 4, lines 24 through 64).

Regarding claim 4, Hassan discloses the system discussed above in claim 1, and further teaches of the image capture device is an analog camera (lens assembly 201 on a CCD 203) for generating an analog image signal (column 3, lines 21 through 67), and there is further included an analog to digital converter for converting the analog image signal to a digital signal (column 3, line 47 through column 4, line 67).

Regarding claim 5, Hassan discloses the system discussed above in claim 4 (as understood by the examiner), and further teaches of a subprocessor for generating a Group-III facsimile compatible signal representing the digital signal (column 4, line 65 through column 5, line 9).

Regarding claim 6, Hassan discloses the system discussed above in claim 1, and further teaches that the subprocessor comprises a gray scale bit map, a halftone converter, and a binary bit map (see abstract, column 1, lines 54 through 63, and column 3, lines 47 through 67).

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Regarding claim 7, Hassan discloses the system discussed above in claim 1, and further teaches of an integrated wireless telephone associated with the communications device (column 2, lines 4 through 54).

Regarding claim 8, 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 (column 2, lines 39 through 66).

Regarding claim 9, Hassan discloses the system discussed above in claim 1, and further teaches that the image capture device is a digital camera (column 2, lines 39 through 67, and column 3, lines 21 through 46).

Regarding claim 10, Hassan discloses the system discussed above in claim 1, and further teaches of a view screen for viewing the captured and stored image (LCD display 215, column 4, lines 19 through 64).

Regarding claim 11, Hassan discloses the system discussed above in claim 5, 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 2, line 66 through column 3, line 4, and column 4, line 65 through column 5, line 22).

Regarding claim 12, Hassan discloses the system discussed above in claim 1, and further teaches that 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 (column 4, line 65 through column 5, line 10).

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Regarding claim 21, Hassan discloses the system discussed above in claim 1, and further teaches that the system is of modular construction (see Fig. 2), and the camera (CCD 203), the processor (microcontroller 205), and the communications device (fax interface 219) are each independent, functional units (column 3, line 21 through column 5, line 9) which may be coupled to one another for defining the assembled system (see Fig. 2).

Regarding claim 23, Hassan discloses the system discussed above in claim 1, and further teaches of a data processor for creating a text data signal associated with the image data signal (column 4, lines 19 through 64).

Regarding claim 24, Hassan discloses the system discussed above in claim 23, and further teaches of an input device for providing text data to the data processor (keypad 211, column 4, lines 1 through 64).

Regarding claim 25, Hassan discloses the system discussed above in claim 24, and further teaches that the input device is user controlled (column 4, lines 1 through 64).

Regarding *claim 26*, Hassan discloses the system discussed above in claim 25, and further teaches that the user controlled input device is an integral keyboard (keypad 211, column 4, lines 1 through 18).

Regarding claim 27, Hassan discloses the system discussed above in claim 24, and further teaches that the input device comprises a real time clock (column 4, lines 24 through 42).

Regarding *claim 30*, Hassan discloses the system discussed above in claim 2, and further teaches that the image data signal, is stored in a compressed format (column 3, lines 47 through 54).

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Regarding claim 31, Hassan discloses the system discussed above in claim 2, and further teaches that the image data signal is stored in a half-tone format (column 3, lines 37 through 67).

Regarding claim 32, Hassan discloses the system discussed above in claim 1, and further teaches that the remote receiving station is a standard bi-level facsimile machine and the image data signal is generated in a gray-scale format and protocol (column 3, lines 50 through 67, column 4, line 65 through column 5, line 9, and column 6, line 62 through column 7, line 2).

Regarding claim 33, Hassan discloses the system discussed above in claim 1, and further teaches that the remote receiving station is a gray-scale facsimile machine and the image data signal is generated in a gray-scale format and protocol (column 3, lines 50 through 67, column 4, line 65 through column 5, line 9, and column 6, line 62 through column 7, line 2).

Regarding claim 34, Hassan discloses the system discussed above in claim 1, and further teaches that the remote receiving station is a color facsimile machine and the image data signal is generated in a full color format and protocol (column 3, lines 50 through 67, column 4, line 65 through column 5, line 9, and column 6, line 62 through column 7, line 2).

Regarding claim 35, Hassan discloses the system discussed above in claim 1, and further teaches that the remote receiving station is a digital device and the image data is digital (column 2, line 45 through column 3, line 33, and column 4, line 65 through column 5, line 9).

Regarding claim 36, 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).

8. Claims 1-3 are rejected under 35 U.S.C. 102(e) as being anticipated by Wertsberger (U.S. Patent Number 6,072,600).

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Regarding claim 1, Wertsberger discloses a self-contained image processing system (see Figs. 1 and 2) for capturing a visual image and transmitting it to a remote receiving station (see abstract, column 2, line 50 through column 3, line 25), with the system comprising an image capture device (CCD image sensor 1, column 4, lines 5 through 47), a processor (CPU 16) for generating a data signal representing the image (column 4, lines 20 through 58), a communications device (fax modem circuitry 13) adapted for transmitting the data signal to the remote receiving station (column 4, lines 48 through 67), and a wireless transmission system (telephone interface circuitry 15) between the communications device and the compatible receiving station (column 5, lines 1 through 6).

Regarding claim 2, Wertsberger discloses the system discussed above in claim 1, and further teaches of a memory for receiving and storing the data signal (memory means 11, and secondary storage 20), and wherein the communications device is adapted for recalling the stored data signal from memory (column 4, lines 48 through 67, and column 5, lines 24 through 27).

Regarding *claim 3*, Wertsberger discloses the system discussed above in claim 2 (as understood by the examiner), and further teaches that the memory is a removable RAM and wherein the system is adapted for selectively charging and discharging the memory (column 5, lines 24 through 27).

9. Claims 1, 21, and 36-42 are rejected under 35 U.S.C. 102(e) as being anticipated by Parulski *et al.* (U.S. Patent Number 5,666,159).

Regarding claim 1, Parulski discloses a self-contained image processing system (see Figs. 1, 2, and 7-9) for capturing a visual image and transmitting it to a remote receiving station (see abstract), with the system comprising an image capture device (camera module 10, column

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3, lines 6 through 40), a processor (pen-based computer 12) for generating a data signal representing the image (column 3, lines 27 through column 4, line 6), a communications device (RF transmitter module 14) adapted for transmitting the data signal to the remote receiving station (column 4, lines 4 through 25), and a wireless transmission system between the communications device and the compatible receiving station (column 4, lines 7 through 25).

Regarding claim 21, Parulski discloses the system discussed above in claim 1, and further teaches that the system is of modular construction (see Fig. 1), and the camera (camera module 10), the processor (pen-based computer 12), and the communications device (RF transmitter module 14) are each independent, functional units which may be coupled to one another for defining the assembled system (see Figs. 1-3).

Regarding claim 36, Parulski discloses the system discussed above in claim 1, and further teaches of a self-contained power source for powering the system (column 3, lines 41 through 60).

Regarding claim 37, Parulski discloses the system discussed above in claim 36, and further teaches that the 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 (column 3, lines 41 through 56).

Regarding claim 38, Parulski discloses the system discussed above in claim 37, and further teaches of 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 (column 3, lines 41 through 56).

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Regarding claim 39, Parulski discloses the system discussed above in claim 38, and further teaches that the power initiation device is user controlled (column 3, lines 41 through 56).

Regarding claim 40, Parulski discloses the system discussed above in claim 38, and further teaches of a trigger device for activating the power initiation device (column 3, lines 41 through 56).

Regarding claim 41, Parulski discloses the system discussed above in claim 40, and further teaches that the trigger device is a timer (see Fig. 5, and column 3, lines 33 through 60, whereby the flash 24 is equivalent to a timer, as it waits a predetermined amount of time to charge before firing).

Regarding *claim 42*, Parulski discloses the system discussed above in claim 40, and further teaches that the trigger device is triggered by the presence of an image to be captured (column 3, lines 41 through 60).

#### ***Claim Rejections - 35 USC § 103***

10. 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 negated by the manner in which the invention was made.

11. Claims 13-18, and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hassan *et al.* (U.S. Patent Number 5,550,646 and further in view of Ross (U.S. Patent Number 5,546,194).

Regarding claim 13, Hassan discloses the system discussed above in claim 1, but fails to expressly disclose if the image capture device is an analog video camera for generating a video



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signal. 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). Continuing, Ross teaches that 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).

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Hassan & Ross are combinable because they are from the same field of endeavor, that being systems that transmit images from a camera to a destination via facsimile transmission. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to include the analog video camera that transmits a video signal, which is taught by Ross, in the system of Hassan. The suggestion/motivation for doing so would have been that Hassan's system would become usable in more formats, as recognized by Ross in column 1, thereby increasing the system's desirability. Therefore, it would have been obvious to combine the teachings of Ross with the system of Hassan to obtain the invention as specified in claim 13.

Regarding claim 14, Hassan and Ross disclose the system discussed above in claim 13, and Hassan further teaches that 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 (column 4, line 65 through column 5, line 9).

Regarding *claim 15*, Hassan and Ross disclose the system discussed above in claim 13, and Hassan further teaches of a hardwired transmission system associated with the modem and a switching device for selecting in the alternative either the hardwired or the wireless transmission system (column 3, lines 10 through 17, and column 4, line 65 through column 5, line 9).

Regarding claim 16, Hassan and Ross disclose the system discussed above in claim 13, and Hassan further teaches of a local facsimile receiving system associated with the modem for providing local hard copy of the stored image signals in the memory (column 4, line 65 through column 5, line 22, and column 6, lines 10 through 21).

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Regarding claim 17, Hassan and Ross disclose the system discussed above in claim 16, and Hassan further teaches of a switching device for selectively activating and deactivating the local facsimile receiving system (column 6, lines 10 through 21).

Regarding claim 18, Hassan and Ross disclose the system discussed above in claim 13, and Hassan further teaches of an integral viewer for viewing the images stored in the memory (LCD display 215, column 4, lines 19 through 64).

Regarding claim 29, Hassan discloses the system discussed above in claim 2, but fails to expressly disclose if the image data signal is stored in a raw video 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 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). Continuing, Ross teaches of a memory for receiving and storing the data signal (RAM 38, column 3, line 65 through column 4, line 11), and that the image data signal is stored in a raw video format (column 3, line 63 through column 4, line 51).

Hassan & Ross are combinable because they are from the same field of endeavor, that being systems that transmit images from a camera to a destination via facsimile transmission.

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At the time of the invention, it would have been obvious to a person of ordinary skill in the art to include the analog video camera that transmits a video signal, which is taught by Ross, in the system of Hassan.

The suggestion/motivation for doing so would have been that Hassan's system would become usable in more formats, as recognized by Ross in column 1, thereby increasing the system's desirability.

Therefore, it would have been obvious to combine the teachings of Ross with the system of Hassan to obtain the invention as specified in claim 29.

12. Claims 19 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hassan *et al.* (U.S. Patent Number 5,550,646), in view of Ross (U.S. Patent Number 5,546,194) and further in view of Wertsberger (U.S. Patent Number 6,072,600).

Regarding claims 19 and 20, Hassan and Ross disclose the system discussed above in claim 13, but fail to expressly disclose if the memory is a removable memory medium which may be selectively removed from the system, with the removable memory medium comprising a PCMCIA card memory.

Wertsberger discloses a self-contained image processing system (see Figs. 1 and 2) for capturing a visual image and transmitting it to a remote receiving station (see abstract, column 2, line 50 through column 3, line 25), with the system comprising an image capture device (CCD image sensor 1, column 4, lines 5 through 47), a processor (CPU 16) for generating a data signal representing the image (column 4, lines 20 through 58), a communications device (fax modem circuitry 13) adapted for transmitting the data signal to the remote receiving station (column 4, lines 48 through 67), and a wireless transmission system (telephone interface circuitry 15)

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between the communications device and the compatible receiving station (column 5, lines 1 through 6). Continuing, Wertsberger teaches of a memory for receiving and storing the data signal (memory means 11, and secondary storage 20), and wherein the communications device is adapted for recalling the stored data signal from memory (column 4, lines 48 through 67, and column 5, lines 24 through 27). Further, Wertsberger teaches that the memory is a removable memory medium which may be selectively removed from the system (column 5, lines 24 through 27), with the removable memory medium comprises a PCMCIA card memory (column 5, lines 24 through 27).

Hassan, Ross & Wertsberger are combinable because they are each from the same field of endeavor, that being systems that transmit images from a camera to a destination via facsimile transmission.

At the time of the invention, it would have been obvious to a person of ordinary skill in the art to include the removable PCMCIA card memory, which is taught by Wertsberger, in the system of Hassan and Ross.

The suggestion/motivation for doing so would have been that the system of Hassan and Ross would become more user-friendly, since allowing a user to load data on a portable, removable memory would aid the user's options of data storage, as recognized in column 5 by Wertsberger.

Therefore, it would have been obvious to combine the teachings of Wertsberger with the system of Hassan and Ross to obtain the invention as specified in claims 19 and 20.

13. Claim 22 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hassan *et al.* (U.S. Patent Number 5,550,646) in view of Shibata *et al.* (U.S. Patent Number 5,689,300).

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Regarding claim 22, Hassan discloses the system discussed above in claim 1, but fails to expressly disclose if an audio signal capture device adapted for capturing an audio signal in correlation with the captured video signal.

Shibata discloses a self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (see Figs. 1, 8A, and 8B, and abstract), which includes an audio signal capture device adapted for capturing an audio signal in correlation with a captured video signal (column 17, lines 12 through 51).

Hassan & Shibata are combinable because they are from the same field of endeavor, that being systems that transmit images from a camera to a destination via facsimile transmission.

At the time of the invention, it would have been obvious to a person of ordinary skill in the art to include the teachings of capturing an audio signal, recognized by Shibata, in the system of Hassan.

The suggestion/motivation for doing so would have been that Hassan's system would become more convenient for a user, as the user would be able to communicate audio information along with video information, as recognized by Shibata in column 17.

Therefore, it would have been obvious to combine the teachings of Shibata with the system of Hassan to obtain the invention as specified in claim 22.

14. Claim 28 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hassan *et al.* (U.S. Patent Number 5,550,646) in view of Bradley *et al.* (U.S. Patent Number 5,995,041).

Regarding claim 28, Hassan discloses the system discussed above in claim 24, but fails to expressly disclose if the input device comprises a global positioning system.

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Bradley discloses a self-contained image processing system for capturing a visual image and transmitting it to a remote receiving station (column 2, line 42 through column 3, line 6, and column 7, line 43 through column 8, line 30), with the system comprising an image capture device (column 7, line 43 through column 8, line 24), a processor (500, column 8, line 64 through column 10, line 2), a communications device adapted for transmitting a data signal to the remote receiving station (column 2, line 57 through column 3, line 6), and a wireless transmission system between the communications device and the compatible receiving station (see Figs. 1-3). Further, Bradley teaches that an input device comprises a global positioning system (column 2, lines 42 through 61).

Hassan & Bradley are combinable because they are from the same field of endeavor, that being systems that transmit images from a camera to a destination via facsimile transmission. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to include Bradley's teachings of using a global positioning system in the system of Hassan.

The suggestion/motivation for doing so would have been that Hassan's system would become more user-friendly with the addition of Bradley's GPS teachings, since the user would automatically know the coordinates of where he is located, as recognized by Bradley in column 2.

Therefore, it would have been obvious to combine the teachings of Bradley with the system of Hassan to obtain the invention as specified in claim 28.

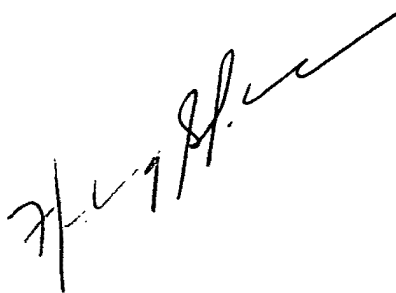
**Conclusion**

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Houshang Safaipoor whose telephone number is (571)272-7412. The examiner can normally be reached on Mon.-Fri. from 6:00am to 2:30pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Moore can be reached on (571)272-7437. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Houshang Safaipoor  
Patent Examiner  
September 24, 2007





<b>Notice of References Cited</b>	Application/Control No. 11/617,509	Applicant(s)/Patent Under Reexamination MONROE, DAVID A	
	Examiner Houshang Safaipoor	Art Unit 2625	Page 1 of 1

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*	Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
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*	B US-4,688,244	08-1987	Hannon et al.	377/58
*	C US-5,550,646	08-1996	Hassan et al.	358/442
*	D US-6,072,600	06-2000	Wertsberger, Shalom	358/479
*	E US-5,666,159	09-1997	Parulski et al.	348/211.2
*	F US-5,995,041	11-1999	Bradley et al.	342/357.1
*	G US-5,546,194	08-1996	Ross, Jay B.	358/445
*	H US-5,689,300	11-1997	Shibata et al.	348/14.07
	I US-			
	J US-			
	K US-			
	L US-			
	M US-			

**FOREIGN PATENT DOCUMENTS**

*	Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N				
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**NON-PATENT DOCUMENTS**

*	Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)				
	U				
	V				
	W				
	X				

\*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)  
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

**Index of Claims**



Application/Control No.

11/617,509

Examiner

Houshang Safaipoor

Applicant(s)/Patent under Reexamination

MONROE, DAVID A

Art Unit

2625

√	Rejected
=	Allowed

-	(Through numeral) Cancelled
+	Restricted

N	Non-Elected
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A	Appeal
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Claim		Date									
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**Search Notes**



Application/Control No.

11/617,509

Examiner

Houshang Safaipoor

Applicant(s)/Patent under Reexamination

MONROE, DAVID A

Art Unit

2625

**SEARCHED**

Class	Subclass	Date	Examiner
358	1.15	9/20/2007	HS
	402		
	403		
	407		
	442		
	468		
	474		

**SEARCH NOTES  
(INCLUDING SEARCH STRATEGY)**

	DATE	EXMR
Used search and references from parent application 10/330,470	9/20/2007	HS

**INTERFERENCE SEARCHED**

Class	Subclass	Date	Examiner

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**INFORMATION DISCLOSURE  
STATEMENT BY APPLICANT**

(Use as many sheets as necessary)

Sheet 1 of 7

**Complete if Known**

Application Number	11/617,509
Filing Date	December 28, 3006
First Named Inventor	David A Monroe
Art Unit	2625
Examiner Name	
Attorney Docket Number	06-0719

**U. S. PATENT DOCUMENTS**

Examiner Initials*	Cite No. <sup>1</sup>	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code <sup>2</sup> (if known)			
		US- 4,163,283	07-31-1979	Darby	
		US- 4,179,695	12-18-1979	Levine, et al	
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Examiner Initials*	Cite No. <sup>1</sup>	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T <sup>6</sup>
		Country Code <sup>3</sup> -Number <sup>4</sup> -Kind Code <sup>5</sup> (if known)				
		JP9-251599	04-16-1999	Mastake, et al		
		JP11-160424	06-18-1999	Tenpei		
		JP6-301898	10-28-1994	Hoover		
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		EP209,397	07-07-1993	Murga, et al		
		EP220,752	05-06-1987	Julin, et al.		

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SignatureDate  
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		<b>Application Number</b>	11/617,509
		<b>Filing Date</b>	December 28, 3006
		<b>First Named Inventor</b>	David A Monroe
		<b>Art Unit</b>	2625
		<b>Examiner Name</b>	
<b>Sheet</b>	7	<b>of</b>	7
		<b>Attorney Docket Number</b>	06-0719

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. <sup>1</sup>	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T <sup>2</sup>
		April, 1966, Apollo Unified S-Band System, NASA-Goddard Space Flight Center, Greenbelt, Maryland	
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		2000, ViaNet 3000 Administrator's Manual Version 1.1- NetXpress Video by TELEXIS, Kanata, Ontario, Canada	
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		1999 ViaNet 3000 Administrator Manual Version 1.0 - NetXpress Video by TELEXIS, Kanata, Ontario, Canada	
		1999 ViaNet 3000 Instruction Manual Operator's Revision 1 - NetXpress Video by TELEXIS, Kanata, Ontario, Canada	

<b>Examiner Signature</b>	<b>Date Considered</b>	
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## PATENT ABSTRACTS OF JAPAN

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(51)Int.Cl.

E03F 7/00  
G01C 7/00  
G06F 17/60  
G09B 29/00

(21)Application number : 09-251599

(71)Applicant : TOKYO GAS CO LTD

(22)Date of filing : 17.09.1997

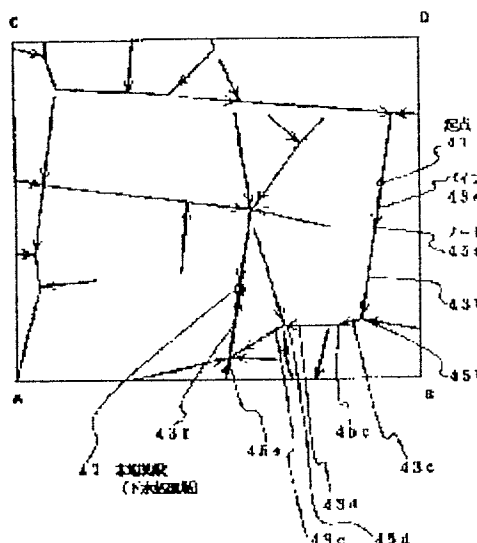
(72)Inventor : TOYOSHIMA MASATAKE  
MORIYAMA TAKASHI

### (54) NETWORK TRACKING DEVICE, NETWORK TRACKING METHOD AND RECORDING MEDIUM

(57)Abstract:

**PROBLEM TO BE SOLVED:** To automatically extract a downstream area and an upstream area of a sewage mapping system by holding a node data group, specifying a starting point, and extracting a downstream side node up to reaching a terminal facility by starting from a node.

**SOLUTION:** When the passage number reduces in the downstream direction, data of a node searching file of an object mesh is developed in a work file, and the content is displayed on a display. A starting point 41 is picked by imparting a click by a mouse or coordinate data, and the vicinity of a node 45 is designated as the starting point 41. Next, a first node 45a in the vicinity of the stating point 41 is extracted, and a downstream side node 45b is extracted. Next, the fact that the node 45b is a terminal facility 47 is confirmed, and the whole nodes 45 extracted up to the terminal facility 47 from the starting point 41 are emphatically displayed on the display by changing a color. Therefore, in a sewage mapping system, a downstream area and an upstream area when a certain place is used as the starting point 41, can be automatically extracted.



LEGAL STATUS

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[Date of sending the examiner's decision of rejection] 09.08.2005

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[Patent number]

[Date of registration]

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G 0 8 G 7/00

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G 0 8 G 7/00

技術表示箇所

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(71) 出願人 000004237

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東京都港区芝五丁目7番1号 日本電気株式会社社内

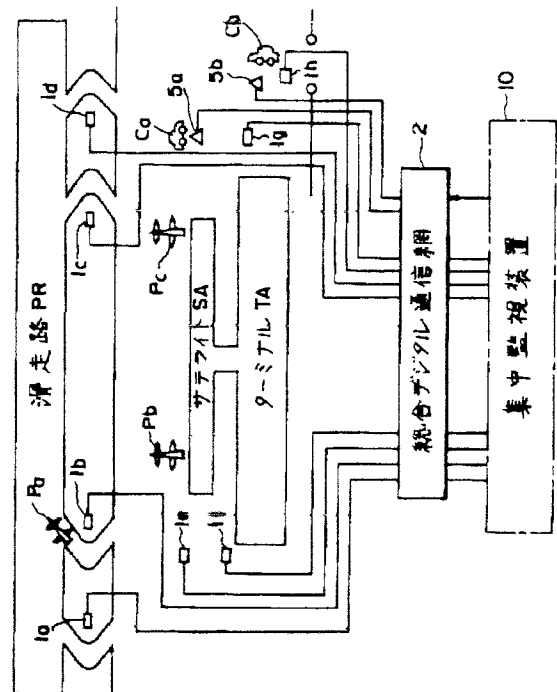
(74) 代理人 弁理士 渡辺 喜平

(54) 【発明の名称】 空港内交通監視システム

(57) 【要約】

【課題】 空港内の航空機及び作業車両の走行にかかる管制業務を自動化し、かつ、走行を一括管理して、管制業務の負担を軽減し、空港内の安全かつ円滑な運航を確保する。

【解決手段】 航空機 P a ~ P c 及び作業車両 C a , C b がバーコードリーダー 1 a ... 1 h を通過した際のデータを、総合デジタル通信網 2 を通じて集中監視装置 1 0 に伝送する。集中監視装置 1 0 では航空機 P a ~ P c 及び作業車両 C a , C b の情報を一括して編集し、スポット割当処理装置 2 1 で最も効率の良いスポット情報とリンクする処理を行って、スポットコントロール及び誘導路の走行許可を決定する。この情報が自動的に無線通信を通じて該当する航空機に送信される。また、作業車両 C a , C b が航空機 P a ~ P c の円滑な運航に支障をきたすか否かを判断する。この判断情報を立入制限表示装置 5 a , 5 b で表示して作業車両 C a , C b の不用意な進入を防止する。





#### 【特許請求の範囲】

【請求項1】 空港内を走行する航空機及び作業車両に取り付けられ、この航空機及び作業車両を識別するためのバーコードプレートと、

前記バーコードプレートのデータを読み取るために前記空港内に設置される複数のバーコードリーダーと、  
前記バーコードリーダーで読み取ったデータを伝送する伝送装置と、

前記伝送装置と接続されて作業車両の立ち入り制限を表示する立入制限表示装置と、

前記伝送装置を通じて伝送されたデータを編集し、この編集データに基づいて、前記航空機に対するスポットコントロール情報を自動的に無線送信するとともに、前記立入制限表示装置での前記作業車両の通行制限を表示する制御を行う集中監視装置と、

を備えることを特徴とする空港内交通監視システム。

【請求項2】 前記請求項1記載の空港内交通監視システムにおいて、

前記集中監視装置として、

前記伝送装置を通じて伝送されたデータを編集する中央情報処理装置と、

前記中央情報処理装置で編集されたデータに基づいて航空機に対するスポットコントロール情報を自動的に無線送信するスポットコントロール無線送信装置と、前記中央情報処理装置で編集したデータに基づいて作業車両の通行制限を表示する制御を行う車両通行制限装置と、  
を備えることを特徴とする空港内交通監視システム。

【請求項3】 前記請求項1記載の空港内交通監視システムにおいて、

前記伝送装置が、空港内に設置された前記バーコードリーダーで読み取ったデータを総合デジタル通信網で伝送することを特徴とする空港内交通監視システム。

【請求項4】 前記請求項2記載の空港内交通監視システムにおいて、

前記集中監視装置における中央情報処理装置、無線送信装置及び車両通行制限装置がローカルエリアネットワークで接続されてデータ送受信を行うことを特徴とする空港内交通監視システム。

【請求項5】 前記請求項2記載の空港内交通監視システムにおいて、

前記集中監視装置における中央情報処理装置に接続される場面監視ディスプレイを備え、この場面監視ディスプレイに前記中央情報処理装置で編集したデータを画面表示することを特徴とする空港内交通監視システム。

#### 【発明の詳細な説明】

##### 【0001】

【発明の属する技術分野】本発明は、バーコードによる空港内交通監視システムに関し、特に航空管制業務における空港内監視の自動化及び省力化を図る空港内交通監視システムに関する。

##### 【0002】

【従来の技術】現在、空港ではランプの点滅によるランプコントロールや無線による管制情報によって、航空機及び作業車両に対するスポットコントロールや誘導路の走行許可などを管理している。いずれもスポット割当の表示や空港内で航空機の走行に支障がないかを人の判断で確認し、その状態を航空機のパイロットへ無線連絡して管理を行っている。また、空港制限区域内を走行する各種の作業車両は、所定の入場申請を行った後に、運転手が走行に関する規則に基づいて走行している。

【0003】この空港内交通監視システムに関連する提案として特開平5-201311号公報に記載の「移動体所在検索システム」が知られている。この従来例は交差点などの複数の定位置に、それぞれバーコード読取部を設けて移動体の走行状態を検出している。

##### 【0004】

【発明が解決しようとする課題】しかしながら、上記従来例の前者の空港内交通監視システムでは、航空機の誘導を人の判断で管理しているため、管制作業の負担が大きく、安定した管制作業に困難を伴うものとなっている。

【0005】例えば、航空機のスポット割り当ては、効率的な自動化が図られているが、パイロットへの情報提供が全て人による無線連絡で行われているため、その負担が大きいという欠点がある。

【0006】また、航空機及び作業車両の走行状況が自己申告及び管制の目視確認によって判断されるため、交通量の多い空港では完全な把握が困難である。すなわち、航空機及び作業車両の一括した管理が出来ないため、その管理時間が多大になるという欠点もあった。また、後者の特開平5-201311号の従来例は、移動体の移動を検出しているが、この構成では航空機及び作業車両の管理を行うことは出来ない。

【0007】本発明は、このような従来の技術における課題を解決するものであり、空港内の航空機及び作業車両の走行管制業務が自動化されるとともに、航空機及び作業車両の走行が一括管理でき、その管制業務の負担が軽減されるとともに、空港内の安全かつ円滑な運航が確保できる空港内交通監視システムの提供を目的とする。

##### 【0008】

【課題を解決するための手段】上記課題を達成するために、請求項1記載の発明の空港内交通監視システムは、空港内を走行する航空機及び作業車両に取り付けられ、この航空機及び作業車両を識別するためのバーコードプレートと、バーコードプレートのデータを読み取るために空港内に設置される複数のバーコードリーダーと、バーコードリーダーで読み取ったデータを伝送する伝送装置と、伝送装置と接続されて作業車両の立ち入り制限を表示する立入制限表示装置と、伝送装置を通じて伝送されたデータを編集し、この編集データに基づいて、航空機

に対するスポットコントロール情報を自動的に無線送信するとともに、立入制限表示装置での作業車両の通行制限を表示する制御を行う集中監視装置とを備える構成としてある。

【0009】請求項2記載の空港内交通監視システムは、集中監視装置として、伝送装置を通じて伝送されたデータを編集する中央情報処理装置と、中央情報処理装置で編集されたデータに基づいて航空機に対するスポットコントロール情報を自動的に無線送信するスポットコントロール無線送信装置と、中央情報処理装置で編集したデータに基づいて作業車両の通行制限を表示する制御を行う車両通行制限装置とを備える構成としてある。

【0010】請求項3記載の空港内交通監視システムは、伝送装置が、空港内に設置されたバーコードリーダーで読み取ったデータを総合デジタル通信網で伝送する構成としてある。

【0011】請求項4記載の空港内交通監視システムは、集中監視装置における中央情報処理装置、無線送信装置及び車両通行制限装置がローカルエリアネットワークで接続されてデータ送受信を行う構成としてある。

【0012】請求項5記載の空港内交通監視システムは、集中監視装置における中央情報処理装置に接続される場面監視ディスプレイを備え、この場面監視ディスプレイに中央情報処理装置で編集したデータを画面表示する構成としてある。

【0013】このような構成の請求項1, 2, 4, 5記載の発明の空港内交通監視システムは、空港内を走行する航空機及び作業車両に取り付けられるバーコードプレートのデータ、例えば、航空会社、便名、作業内容などを登録した識別データ(ID)を複数のバーコードリーダーで読み取って編集している。この編集データに基づいて、航空機に対して自動的にスポットコントロール情報を無線送信するとともに、作業車両の通行制限などを表示している。

【0014】したがって、航空機の誘導路走行からスポットへのコントロールが自動化される。また、運航の支障となる作業車両の不用意な走行が自動的に制限される。すなわち、これらを従来例のように人の判断を通じて行わず、空港内の航空機及び作業車両の走行にかかる管制業務が自動化される。また、航空機及び作業車両の走行が一括管理されて、管制業務の負担が軽減されるとともに、空港内の安全かつ円滑な運航を確保できるようになる。

【0015】請求項3記載の空港内交通監視システムは、バーコードリーダーで読み取ったデータを総合デジタル通信網で伝送しているため、広大な空港で既存の通信網が利用できるようになる。

【0016】

【発明の実施の形態】次に、本発明の空港内交通監視システムの実施の形態を図面を参照して詳細に説明する。

図1は本発明の空港内交通監視システムの実施形態における構成を示す模式図である。図1において、ここでの空港には滑走路PR、サテライトSA及びターミナルTAなどを有しており、誘導路を航空機Pa, Pb, Pc及び作業車両Ca, Cbが走行する。この航空機Pa~Pcの下部にそれぞれの航空会社、便名などを登録した識別データ(ID)であるバーコードプレートが取り付けられている。

【0017】作業車両Ca, Cbにも、作業内容及び車両番号等を示す識別データ(ID)のバーコードプレートが取り付けられている。また、誘導路、エプロン、制限区域ゲート及び場周道路の各所に航空機Pa~Pc及び作業車両Ca, Cbの識別データ(ID)を読み取り、かつ、データ伝送部を備えたバーコードリーダー1a, 1b, 1c, 1d, 1e, 1hが埋設されている。

【0018】このバーコードリーダー1a~1hが総合デジタル通信網(ISDN)2に接続されている。さらに、作業車両Ca, Cbの立ち入り制限を点灯などで表示する立入制限表示装置5a, 5bが総合デジタル通信網2に接続されている。また、総合デジタル通信網2には、データ通信処理を行う集中監視装置10が接続されている。

【0019】図2は図1中の集中監視装置10の構成を示すブロック図である。図2の集中監視装置10には、バーコードリーダー1a~1hから航空機Pa~Pc及び作業車両Ca, Cbの識別データ(ID)を読み取ったデータが総合デジタル通信網2を通じて入力されるインタフェース(I/F)装置13が設けられている。また、I/F装置13を通じてデータを取り込み、かつ、処理データを送出する中央情報処理装置14が設けられている。

【0020】さらに、集中監視装置10には、中央情報処理装置14に接続されてデータ送受信を行うためのローカルエリアネットワーク(LAN)15と、中央情報処理装置14に接続されて場面監視状態を画面表示する場面監視ディスプレイ16が設けられている。さらに、航空機のスポット割当の表示処理を行うスポット割当処理装置21と、中央情報処理装置14に接続されて航空機の誘導を処理する航空機誘導装置22とが設けられている。

【0021】また、航空機誘導装置22で処理した航空機の誘導情報にかかる無線送受信を行う無線通信施設23a及びアンテナ23bと、立入制限表示装置5a, 5bでの作業車両Ca, Cbに対する立ち入り制限の表示制御を行う立入制限制御装置31とが設けられている。

【0022】次に、この実施形態の動作について説明する。図1及び図2において、航空機Pa~Pc及び作業車両Ca, Cbがバーコードリーダー1a~1hを通過した際の読み取りデータが、総合デジタル通信網2を通じて図2に示す集中監視装置10に伝送される。

【0023】図2に示す集中監視装置10では、データがインターフェース装置13から中央情報処理装置14に伝送され、ここで航空機Pa～Pc及び作業車両Ca, Cbの情報を一括して編集する。この編集されたデータは場面監視ディスプレイ16で画面表示されるとともに、スポット割当処理装置21で、最も効率のよいスポット情報とリンクする処理が行われる。さらに、航空機誘導装置22でスポットコントロール、及び、誘導路の走行許可が決定される。この情報は自動的に無線通信施設23a、アンテナ23bを通じて該当する航空機(Pa～Pc)に無線送信される。

【0024】立入制限制御装置31は中央情報処理装置14からの編集データに基づいて、作業車両Ca, Cbが航空機Pa～Pcの円滑な運航に支障をきたすか否かを判断する。立入制限制御装置31からは、主に作業車両Ca, Cbに対する立ち入り制限情報が出力される。この立ち入り制限情報はインターフェース装置13及び総合デジタル通信網2を通じて空港内の車両走行経路の各所に設置されている立入制限表示装置5a, 5に伝送される。この立入制限表示装置5a, 5の表示によって作業車両Ca, Cbの不用意な進入が防止される。

【0025】

【発明の効果】以上の説明から明らかなように、請求項1, 2, 4, 5記載の発明の空港内交通監視システムによれば、空港内を走行する航空機及び作業車両に取り付けられるバーコードプレートの識別データ(ID)を複数のバーコードリーダーで読み取って編集し、この編集データに基づいて、航空機に対して自動的にスポットコントロール情報を無線送信するとともに、作業車両の通行制限などを表示している。

【0026】これによって、航空機の誘導路走行からスポットへのコントロールが自動化され、運航の支障とな

る作業車両の不用意な走行が自動的に制限できるようになる。すなわち、空港内の航空機及び作業車両の走行にかかる管制業務が自動化され、また、航空機及び作業車両の走行が一括管理でき、管制業務の負担が軽減されるとともに、空港内の安全かつ円滑な運航を確保できるようになる。

【0027】請求項3記載の空港内交通監視システムによれば、バーコードリーダーで読み取ったデータを総合デジタル通信網で伝送しているため、広大な空港で既存の通信網が利用できるようになる。

【図面の簡単な説明】

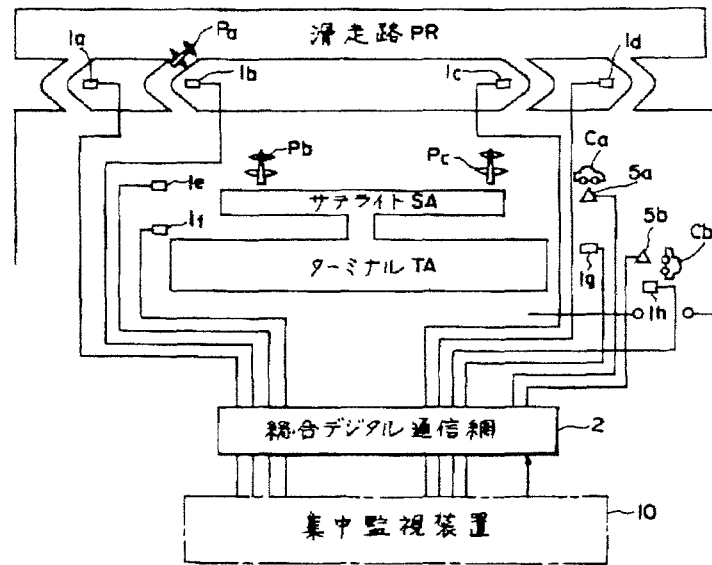
【図1】本発明の空港内交通監視システムの実施形態における構成を示す模式図である。

【図2】図1中の集中監視装置10の構成を示すブロック図である。

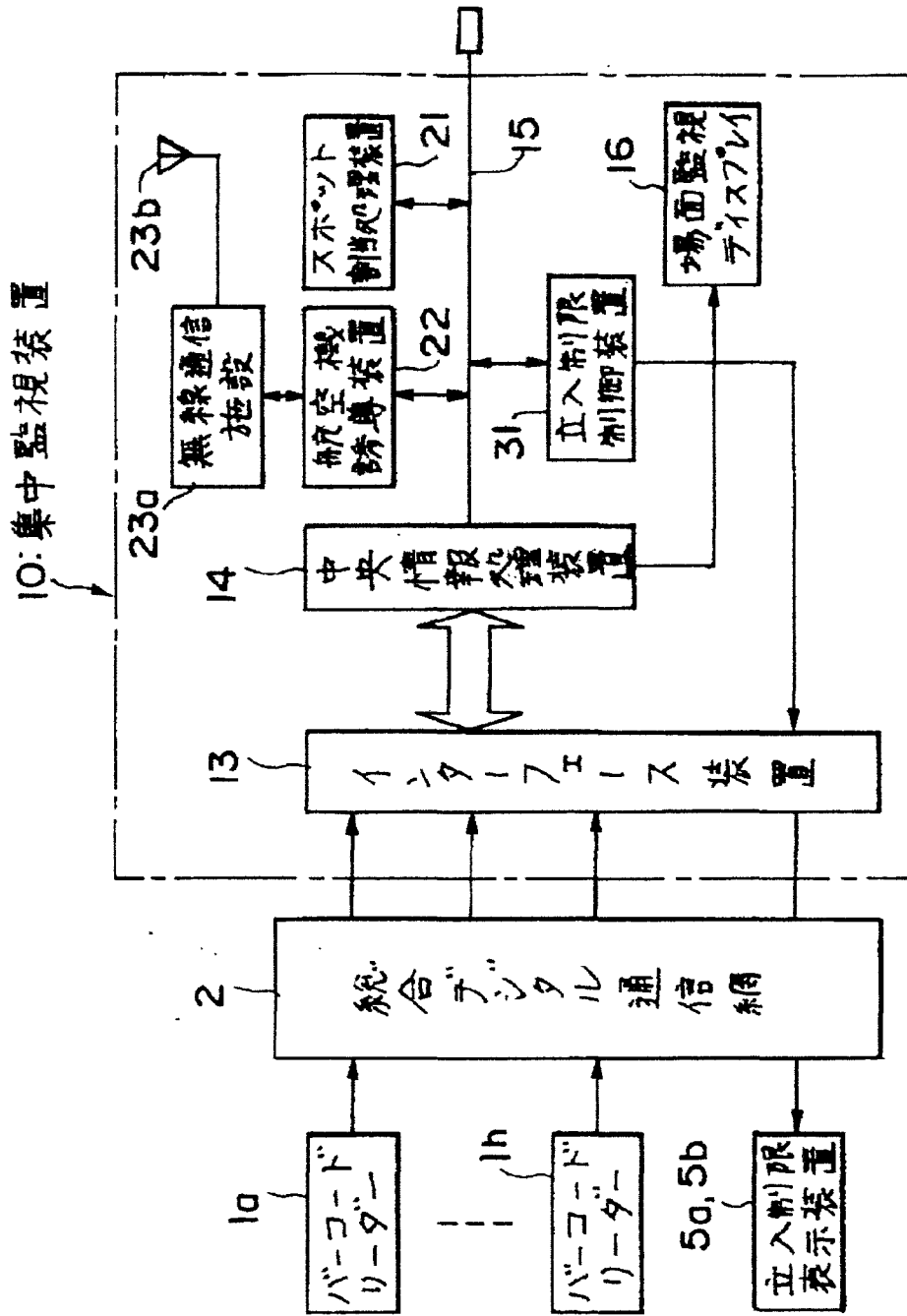
【符号の説明】

- 1a～1h バーコードリーダー
- 2 総合デジタル通信網
- 5a, 5b 立入制限表示装置
- 10 集中監視装置
- 13 インタフェース装置
- 14 中央情報処理装置
- 15 ローカルエリアネットワーク
- 16 場面監視ディスプレイ
- 21 スポット割当処理装置
- 22 航空機誘導装置
- 23a 無線通信施設
- 23b アンテナ
- 31 立入制限制御装置
- Ca, Cb 作業車両
- Pa～Pc 航空機

【図1】



[図2]



## PATENT ABSTRACTS OF JAPAN

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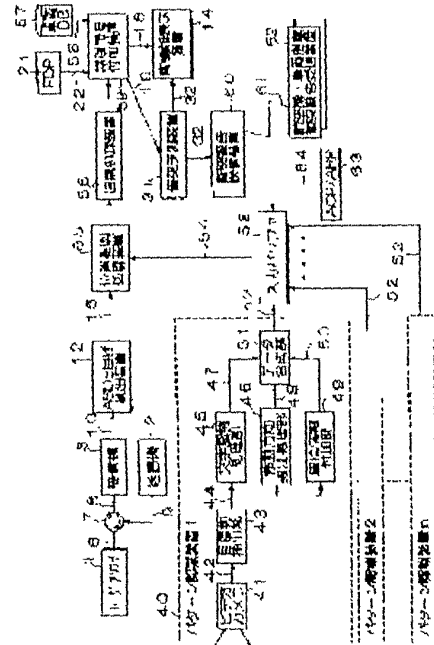
(22)Date of filing : 27.11.1997 (72)Inventor : KONDOU TENPEI

### (54) AIRPORT GROUND SURFACE MONITOR DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an airport ground surface monitor device which can reduce control operations by an air-traffic controllers and increase safety in an airport ground surface, by recognizing positions and identification numbers of all airplanes and vehicles moving on the airport ground surface in a congested state and automatically sending a collision alarm to objects which may possibly collide.

SOLUTION: The flight names, vehicle numbers, moving directions, and positions of all the airplanes and vehicles on the airport ground surface are recognized by using image data of video cameras 41 installed at different places on the airport and character recognition by image processing and displayed while correlated with an airport ground surface detection radar. Further, this device is equipped with a collision alarm transmission device 60 which automatically sends a collision alarm to the airport ground surface and an airplane/ vehicle-mounted collision alarm reception device 62 which receives the information and generates an alarm.



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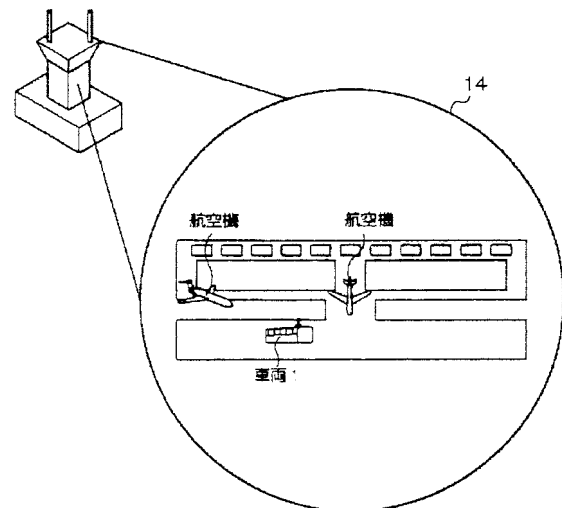
(74) 代理人 弁理士 高橋 詔男 (外4名)

(54) 【発明の名称】 空港面監視装置

(57) 【要約】

【課題】 過密化する空港面において空港面を移動する全ての航空機及び車両の位置と識別番号を認識し、衝突の可能性ある対象物に対して衝突警報を自動的に発することにより、航空管制官の管制業務の軽減及び空港面の安全性を高めることができる空港面監視装置を提供する。

【解決手段】 空港面の数箇所に設置したビデオカメラ41の画像データと画像処理による文字認識を用いて、空港面を移動する全ての航空機や車両の便名や車両番号、移動方向、及び位置を認識し、空港面探知レーダとの相関を取って表示する。また、衝突警報を空港面に自動的に発信する衝突警告送信装置60と、発信された情報を受けて警告を発する航空機・車両搭載衝突警告受信装置62を有している。





【特許請求の範囲】

【請求項1】 (a) 空港面を移動する航空機や車両等の目標物を探知する空港面探知レーダと、

(b) 前記目標物を撮影するビデオカメラと、  
前記ビデオカメラが撮影した画像より前記目標物を抽出する目標物抽出部と、

前記目標物より前記目標物の識別番号を認識する文字認識処理部と、

前記目標物より前記目標物の移動方向を識別する移動方向識別処理部と、

前記目標物より前記目標物の座標を求める座標情報付加部と、

前記文字認識処理部、前記移動方向識別処理部、及び前記座標情報付加部とからそれぞれに出力されたデータを合成し、第1の目標物データを出力するデータ合成部と、

からなる複数のパターン認識装置と、

(c) 前記第1の目標物データを蓄積する入力バッファと、

(d) 前記空港面探知レーダの出力に基づいて得られる第2の目標物データと前記入力バッファに蓄積された第1の目標物データの位置相関を取る位置相関処理装置と、

(e) 前記第1の目標物データ及び前記処理相関処理装置の出力に基づく画像を表示する表示装置と、  
を具備してなる空港面監視装置。

【請求項2】 航空機に関する情報を蓄えたデータベース及び車両に関する情報を蓄えたデータベースを具備し、前記文字認識処理部で得たデータに対応する情報を前記データベースから引き出し、その情報を前記表示装置に表示することを特徴とする請求項1記載の空港面監視装置。

【請求項3】 前記表示装置へ出力されるデータに基づいて、航空機や車両が衝突する可能性を予測し、衝突の可能性がある場合に衝突警告情報を出力する衝突予測装置と、前記衝突警告情報を入力し、空港面に前記衝突警告情報を発信する衝突警告送信装置と、航空機や車両に搭載され前記衝突警告送信装置が発信した前記衝突警告情報を受信して衝突警告を発する航空機・車両搭載衝突警告受信装置とを具備することを特徴とする請求項1または請求項2に記載の空港面監視装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、空港面の管制作業を支援する空港面監視装置に係わり、特に画像認識処理及び文字認識処理を用いて、管制作業の負荷の軽減や警報の自動化を図った空港面監視装置に関する。

【0002】

【従来の技術】図5は空港面探知レーダ (Airport Surface Detecting Equipment、以下ASDEという) を多

機能化した空港面監視装置のブロック図である。符号1は空港面を探知するレーダアンテナ、2はレーダ電波を発信するための送信機、3は送信機2によって送信された電波が反射して戻ってきた電波を受信する受信機、6は送信機2または受信機3が送信または受信する電波、7はレーダアンテナ1から受信した電波と送信機2から送信する電波とを切り替えるサーキュレータ、8は受信機3が受信する受信電波である。符号9は送信機2が送信する送信電波、10は受信機3によって受信された極座標の受信信号、12はASDEの受信信号10から方位及び距離のレーダエコーの連続性を判定し目標を検出するASDE目標検出装置、15はASDE目標検出装置12で検出した目標の方位及び距離を示す信号である。符号13はASDE検出目標にコールサイン等の識別符号を付加する識別符号付加装置、14は空港面内を移動する航空機や車両を表示する高機能表示装置、16は航空機の識別番号を表示するための表示データ信号である。

【0003】符号17はレーダエコーに基づいて空港周辺空域にある航空機の進入及び出発の管制を行う1次監視レーダ (Airport surveillance Radar、以下ASRという) 及び地上からの質問装置 (インタロゲータ) より符号パルスを送信し、航空機の応答装置 (トランスポンダ) により特定の符号パルスで応答し、これを受信解読して識別する2次監視レーダ (Secondary Surveillance Radar、以下SSRという)、18はASR/SSRのレーダエコーから目標を検出するASR/SSR目標検出装置、19はASR/SSRのレーダエコーであるASR/SSR受信信号、20はASR/SSR目標検出装置18によって検出された航空機の位置及びSSRによる応答信号等を航空機に割り当てたコードであるビーコンコード情報である。

【0004】符号21は航空機の飛行ルート、便名、機体番号等のデータベースを有する飛行計画情報処理装置 (Flight Data Processing、以下FDPという)、22はFDPによるデータ信号である。符号24は全地球測位システム (Global Positioning System、以下GPSという) を搭載した車両において自己の位置と識別符号を送信する車両搭載GPS送信機、23は車両搭載GPS送信機24による位置及び識別符号を受信し検出する車両目標検出装置、26は車両位置及び車両番号の通信電波、25は車両の位置と車両番号を付加するための車両位置及び車両番号情報である。

【0005】符号27は可視カメラまたは遠赤外線カメラ等の光学式センサ、28は光学式センサが出力する画像データ、29は画像処理によるブラインド目標検出装置、30はブラインド位置に移動する航空機等の目標位置信号である。符号31は衝突予測装置、32は衝突警報信号、33はSSRモードS受受信機、34は受信信号、35は位置標定装置、36は標定位置及びビーコン

コード信号である。

【0006】次に動作を説明する。レーダアンテナ1は送信機2によって送信された電波を空港面内に発射する。受信機3は空港面内を移動する航空機等のレーダエコーを受信する。受信機3によって受信された極座標の受信信号10からASDE目標検出装置12により航空機を目標物として自動的に検出し、目標物の方位及び距離信号15を出力する。

【0007】着陸した航空機に対して識別番号を付加するためASR/SSR17を用いる。ASR/SSR目標検出装置18はASR/SSR17による受信信号に基づいて航空機の位置及びビーコンコード情報の信号20を出力する。但し、SSRからビーコンコードとASDEの検出位置の相関を得るためにはASR/SSRとASDEの探知領域が重複している必要がある。すなわち、SSRにおいて着陸機のビーコンコードを取得し、SSRにて検出ができていない間にASDEとの相関を取り、ビーコンコードを移管する。

【0008】FDP21は航空機の飛行ルート、便名等のデータベースを有し、フライトプランのデータ信号22を出力する。

【0009】車両は、ASDEで検出されるが、FDP21から識別番号を得ることはできないため車両搭載GPS送信機24からGPSで算出される自車両の位置と車両固有に割り当てられた車両番号を送信する。車両位置検出装置23はその信号26を受信し、車両位置及び車両番号情報25を出力する。

【0010】ASDEレーダの死角となる領域では光学式センサを用いる。光学式センサ27はエプロン照明灯や空港ビルに設置されレーダアンテナ1で死角となる領域を映し出し、ブラインド目標検出装置29にて撮像画像をパターン認識する画像処理を用いて航空機を検出して空港内の経度と緯度に換算して目標位置をブラインド目標位置信号30として出力する。

【0011】出発航空機に識別番号を付加するためにはSSRモードS質問信号を利用する。SSRモードSが搭載されている航空機は、個別質問が可能であるためにSSRモードS質問信号を与えその応答信号をSSRモードS受信機33で受信し、受信信号34として位置標定装置35に出力する。位置標定装置35は、航空機位置及びビーコンコードを検出し、これらの信号36を出力する。

【0012】識別符号付加装置13にてこれらの信号15、20、22、30、36中の同一目標に対し、位置相関処理、追尾処理を行い、25からの信号をもとに識別番号付加処理を行い、高機能表示装置14に航空機及び車両の表示を行う。識別符号付加装置13における処理後、衝突予測処理装置31にて航空機や車両の衝突予測を行い同時に高機能表示装置14に表示させることも可能である。

【0013】

【発明が解決しようとする課題】図5に示す空港面監視装置にあっては、有視界飛行方式(Visual Flight Rules、以下VFRという)の航空機はそのビーコンコードが固有でないことがあるためにASR/SSRのビーコンコード20とFDP21より航空機を識別することはできない場合がある。また、SSRモードSの応答用機器の電源は、離陸直前に投入し、着陸直後に切断することになっているため、出発機の識別は滑走路の上のみで有効であり、誘導路を移動中の出発機は識別ができない。SSRモードSは最新式の大型航空機にのみ搭載されているために、小型の航空機や年月を経た古い型の航空機は識別することができない。さらに、レーダ等の死角になっている場所は可視カメラ等を用いた光学センサによって航空機の探知を行うが航空機の存在が分かるのみで航空機の識別はできないために識別番号を付加することはできない。このような理由により、空港面にいる航空機全てに識別番号を付加することはできず、識別番号の付加されていない航空機については管制官が直接無線通信によって識別し、管制を行うことになるために管制官の負荷が高くなるという問題がある。

【0014】また、車両の識別は空港を走行する全ての車両に車両搭載GPS送信機を搭載する必要がある。一般にGPS受信機はその測位誤差は100m程度あり、さらに空港を走行する車両の形状は特殊なものが多く、GPSのアンテナの取付位置で測位誤差に大きく影響するため、後付けによってアンテナを設置するのは困難である。ASDEとGPSからの測位結果の相関から識別するにしても、過密化している空港において数十m程度に近接している車両の識別には、GPS受信機の誤差を考慮すると限界がある。また、航空機や車両の衝突予測を行い、表示装置に危険な状態を表示しても、過密した空港面を管制する航空管制官は負荷が高いため、見逃す可能性が十分にあり、航空機や車両に対する指示が遅れることも有り得る。

【0015】本発明は、このような事情に鑑みてなされたもので、過密化する空港面において空港面を移動する全ての航空機及び車両の位置と識別番号を認識し、衝突の可能性のある対象物に対して衝突警報を自動的に発することにより、航空管制官の管制業務の軽減及び空港面の安全性を高めることができる空港面監視装置を提供することを目的とする。

【0016】

【課題を解決するための手段】請求項1に記載の発明は、空港面を移動する航空機や車両等の目標物を探知する空港面探知レーダと、前記目標物を撮影するビデオカメラと、前記ビデオカメラが撮影した画像より前記目標物を抽出する目標物抽出部と、前記目標物より前記目標物の識別番号を認識する文字認識処理部と、前記目標物より前記目標物の移動方向を識別する移動方向識別処理

部と、前記目標物より前記目標物の座標を求める座標情報付加部と、前記文字認識処理部、前記移動方向識別処理部、及び前記座標情報付加部とからそれぞれに出力されたデータを合成し、第1の目標物データを出力するデータ合成部とからなる複数のパターン認識装置と、前記第1の目標物データを蓄積する入力バッファと、前記空港面探知レーダの出力に基づいて得られる第2の目標物データと前記入力バッファに蓄積された第1の目標物データの位置相関を取る位置相関処理装置と、前記第1及び第2の目標物データを表示する表示装置とを備え、前記位置相関処理装置において位置相関が取れた第1及び第2の目標物データは同一の目標物として表示装置に表示し、位置相関が取れなかった目標物は第1の目標物データ及び第2の目標物データをそれぞれ単独で表示装置に表示することを特徴としている。

【0017】請求項2に記載の発明は、航空機に関する情報を蓄えたデータベース及び車両に関する情報を蓄えたデータベースを具備し、前記文字認識処理部で得た目標物データに対応する情報を前記データベースから引き出し、その情報を表示装置に表示することを特徴としている。

【0018】請求項3に記載の発明は、前記移動方向識別処理部及び前記座標情報付加部で得た目標物データを基に、航空機や車両が衝突する可能性を予測し、衝突の可能性がある場合に衝突警告情報を出力する衝突予測装置と、前記衝突警告情報を入力し、空港面に前記衝突警告情報を発信する衝突警告送信装置と、航空機や車両に搭載され前記衝突警告送信装置が発信した前記衝突警告情報を受信して衝突警告を航空機や車両に伝達する航空機・車両搭載衝突警告受信装置とを具備し、空港面で衝突の可能性のある航空機や車両に対して自動的に衝突警告を発することを特徴としている。

【0019】

【発明の実施の形態】以下、本発明の一実施形態による空港面監視装置を図面を参照して説明する。図1は同実施形態のブロック図である。この図において、符号40はパターン認識装置であり、パターン認識装置40の前を通過する航空機や車両を撮影するため可視光や赤外線等を用いた光学式のビデオカメラ41と、得られた画像から航空機や車両を目標物として抽出する目標物抽出部43と、目標物から機体番号や車両識別番号を認識する文字認識処理部45と、抽出した目標物の移動方向を識別する移動方向識別処理部46と、目標物の位置座標を付加する座標情報付加部49と、文字認識処理部45と移動方向識別処理部46と座標情報付加部49とからそれぞれに出力されたデータを同一のデータとして合成するデータ合成部51とからなる。

【0020】符号42はビデオカメラ41より出力された画像データあり、符号44は目標物抽出部43で抽出した目標物をデジタル化した画像デジタルデータであ

る。符号47は機体番号または車両識別番号情報である。符号48は移動方向識別処理部46で処理した移動方向情報である。符号50は座標情報付加部で処理した座標位置情報である。符号52は目標物に関する情報をデータ合成部51で同一のデータ合成した目標物情報である。符号53は複数のパターン認識装置40からの情報を蓄積し、必要に応じて目標物識別情報54を出力する入力バッファである。符号63はASDEの処理にあるACP (Azimuth Count Pulse、以下ACPという)、ARP (Azimuth Reference Pulse、以下ARPという)であり、符号64はACP/ARP63より出力され、目標物識別情報54を出力するタイミングを取る信号である。

【0021】符号55はASDE目標検出装置12より出力された目標物の方位及び距離信号15と目標物識別情報54との位置相関を取り、これらのデータを合成する位置相関処理装置である。符号56は位置相関処理装置55で相関が取れた目標物について追尾処理を行う追尾処理装置である。符号57は車両識別番号に対応する車両に関する情報(所属会社名や車型等)をデータベース化して記録した車両データベース(以下データベースをDBという)である。符号59はFDP21と車両DB57の情報58から追尾処理が終了した目標物に対して識別符号を付加する識別符号付加装置である。

【0022】図2は同実施形態の空港内のレイアウト図である。この図において、符号40は上述したパターン認識装置である。パターン認識装置40は誘導路、滑走路及び空港内の道路の交差点やランプ周辺を出入りする航空機や車両の全体像がビデオカメラ41の撮影視野内に収まるように数カ所に設置する。このような設置を行うことにより空港内の要所に存在する航空機や車両を撮影することができる。また、航空機の機体側面には各国における機体の登録番号を示す機体番号を記されており、車両にはアルファベットや数字等からなる車両固有の識別番号が記されている。ビデオカメラ41は、撮影視野内に存在する航空機や車両の機体番号や識別番号を十分に読み取り、判別できる程度の解像度を有する。図3は同実施形態の高機能表示装置14における画面の表示例である。

【0023】次に、図1を参照して、動作を説明する。パターン認識装置40の前を通過する航空機や車両をビデオカメラ41により撮影し、画像データ42を出力する。画像データ42は目標物抽出部43に入力し、デジタルのデータに変換する。変換したデジタルデータに画像処理を施してデータ中の航空機や車両を目標物領域として抽出し、その結果を目標情報として付加し、画像デジタルデータ44として、文字認識処理部45、移動方向識別処理部46、及び座標情報付加部49へそれぞれ出力する。

【0024】文字認識処理部45では、画像デジタルデ

ータ44の目標物領域からさらに航空機の機体番号や車両の車両識別番号の領域を抽出する。次にその領域には機体番号や車両識別番号が存在するので、それらの番号はアルファベットや数字で記されているなどの法則を基に画像処理によるパターン認識処理を用いてその領域に記されている機体番号や車両識別番号を認識する。識別した情報は機体番号または車両識別番号情報47としてデータ合成部51へ出力する。また、移動方向識別処理部46は、画像デジタルデータ44の目標物領域の画像上の位置と、記憶しておいた直前の画像上の位置と、パターン認識装置40の設置位置及び方向とから目標物の移動方向を識別する。識別した情報は移動方向情報48としてデータ合成部51へ出力する。また、座標情報付加部49は、画像デジタルデータ44の目標物領域の中心座標を求め、パターン認識装置40の設置位置及び方向とから、目標物の位置座標を求める。求めた情報は座標位置情報50としてデータ合成部51へ出力する。なお、文字認識処理部45、移動方向識別処理部46、及び座標情報付加部49は同時進行で処理を行う。

【0025】データ合成部51では機体番号または車両識別番号情報47、移動方向情報48、及び座標位置情報を1つの情報に合成して、目標物情報52として入力バッファ53へ出力する。複数のパターン認識装置40から出力する目標物情報52をパターン認識装置40毎に整理して入力バッファ53に蓄積する。入力バッファ53はACP/ARP63のトリガ信号64と同期を取り、目標物識別情報54を順次出力する。

【0026】位置相関処理装置55は、目標識別情報54を入力バッファ53より入力して得た航空機や車両の目標物のデータに対してASDE目標検出装置12で検出された目標物の方位及び距離信号15との相関を解析して同一であるものに対して機体番号や車両識別番号等のタグを付加する。相関を解析した結果、同一の目標物が見つからなかった場合、すなわち、ASDE目標検出装置12からの情報のみだった場合か、またはパターン認識装置40からの情報のみだった場合は、それぞれ単独の情報のみで処理を続行する。

【0027】タグを付加した航空機や車両は、追尾処理装置56で移動方向情報を用いて追尾処理を行い、誘導路や滑走路、空港内道路やランプ上を出入りする目標物のカウントを行うことで数量の把握をする。次に、各目標に付加されているタグは機体番号や車両識別番号であり、管制官が通常用いている識別情報ではないために、航空機であれば便名に、車両であれば会社名や車両名等に変換して表示する。識別符号付加装置59で各目標物に付加されているタグをキーワードとしてFDP21や車両DB57より目標物の便名または車両名等を検索して一致するものがあれば目標物に付加されているタグに検索した結果を追加して表示データ信号16とする。検索した結果FDP21や車両DB57にキーワードに指

定したタグに対応する登録事項が見つからなかった場合はタグに追加処理は行わず、表示データ信号16とする。表示データ信号16は、高機能表示装置14に表示する。図3は高機能表示装置14に表示データ16を表示したイメージ図である。

【0028】また、表示データ信号16は衝突予測装置31に入力し、各目標物の移動方向を解析して衝突予測処理を行い、衝突の可能性があると判断した場合は衝突警報信号32として高機能表示装置14に表示データ信号16の表示結果に重ね合わせて表示する。

【0029】次に図4を参照して、他の実施形態を説明する。図4において、符号60は衝突警告送信装置であり、符号62は各航空機及び車両に搭載した航空機・車両搭載衝突警告受信装置である。

【0030】次に動作を説明する。衝突予測装置31で航空機や車両等が衝突の可能性があると判断がされ、衝突警報信号32が出力された場合、衝突警告送信装置60は衝突警報信号32を入力し、衝突警告情報61として空港面にその情報を自動的に発信する。衝突警告情報61には衝突の可能性があると判断された航空機の機体番号または車両の車両識別番号と、衝突する可能性があると判断された相手の航空機の型式または車両の車種等と、相手の相対方位と、相手までの相対距離が含まれる。衝突警告情報61を受信した全ての航空機・車両搭載衝突警告受信装置62は、受信した情報の中に自機の機体番号または自車両の車両識別番号が含まれていないかを判別し、含まれていればその情報を音などでパイロットや運転手に伝達する。

【0031】

【発明の効果】以上説明したように、請求項1記載の発明によれば、空港面を移動する全ての航空機や車両を深知し、さらに識別符号を付加した状態で高機能表示装置に表示できるという効果が得られる。また、全ての航空機を表示できるために、航空管制官は航空機と直接無線で交信をして識別するという作業を行わないで済むため管制業務を行う際の負荷を低減できるという効果が得られる。

【0032】また、請求項2の発明によれば、航空管制官に分かりやすい、航空機の便名や車両名といった表現の識別符号で高機能表示装置に表示できるため、表示を見ながら管制業務を行う際の負荷を低減できるという効果が得られる。

【0033】また、請求項3の発明によれば、航空管制官が高機能表示装置に表示された衝突警報を見逃すことなどによって対応が遅れても衝突の可能性のある航空機や車両に対して警告を自動的に伝達することができるという効果が得られる。

【図面の簡単な説明】

【図1】本発明の一実施形態の構成を示すブロック図である。

【図2】同実施形態におけるパターン認識装置40の配置を示すレイアウト図である。

【図3】同実施形態における高機能表示装置14の表示画面イメージ図である。

【図4】本発明の他の実施形態の構成を示すブロック図である。

【図5】従来の空港面監視装置の構成を示すブロック図である。

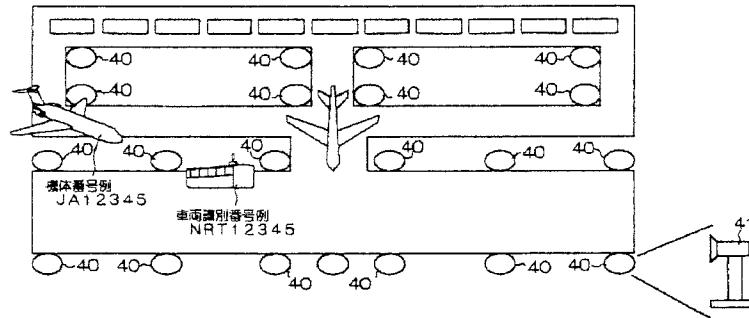
【符号の説明】

- 14・・・高機能表示装置
- 16・・・表示データ信号
- 21・・・飛行計画情報処理装置（FDP）
- 22・・・飛行計画情報
- 31・・・衝突予測装置
- 32・・・衝突警報信号
- 40・・・パターン認識装置
- 41・・・ビデオカメラ
- 42・・・画像データ
- 43・・・目標物抽出部
- 44・・・画像デジタルデータ
- 45・・・文字認識処

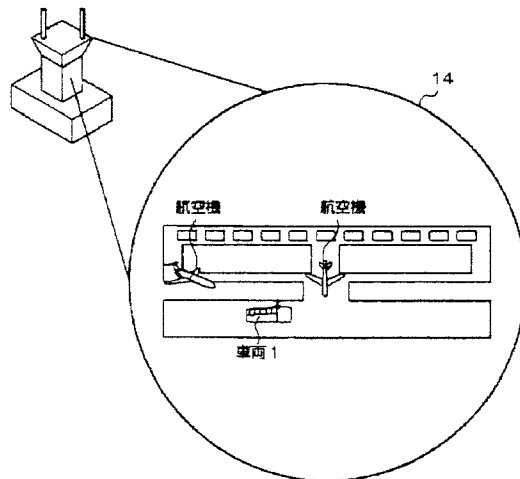
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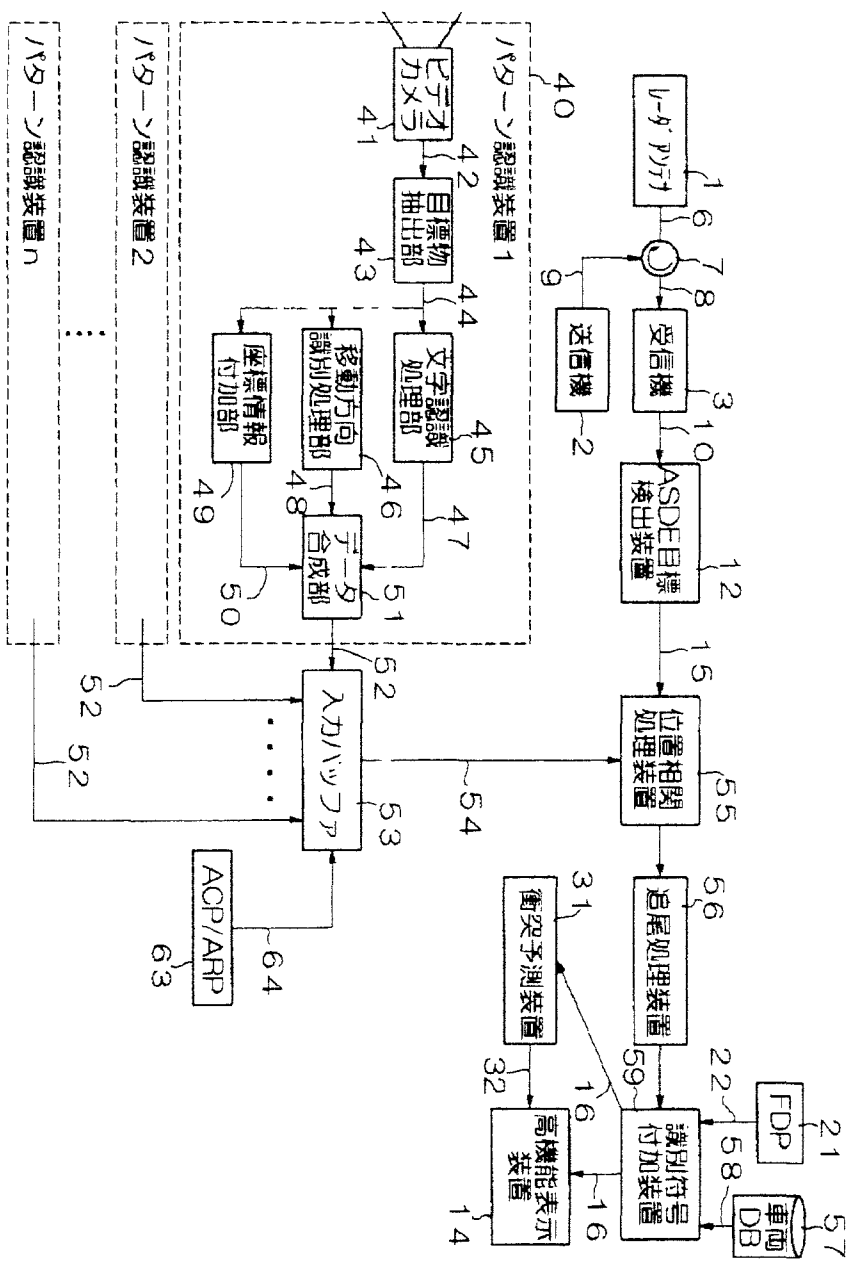
- 46・・・移動方向識別処理部
- 47・・・車両識別番号情報
- 48・・・移動方向情報
- 49・・・座標情報付加部
- 50・・・座標位置情報
- 51・・・データ合成部
- 52・・・目標物情報
- 53・・・入力バッファ
- 54・・・目標物識別情報
- 55・・・位置関連処理装置
- 56・・・追尾処理装置
- 57・・・車両データベース
- 58・・・車両データ
- 59・・・識別符号付加装置
- 60・・・衝突警告送信装置
- 61・・・衝突警告情報
- 62・・・航空機・車両搭載衝突警告受信装置
- 63・・・ACP/ARP
- 64・・・ACP/ARPトリガ信号

【図2】

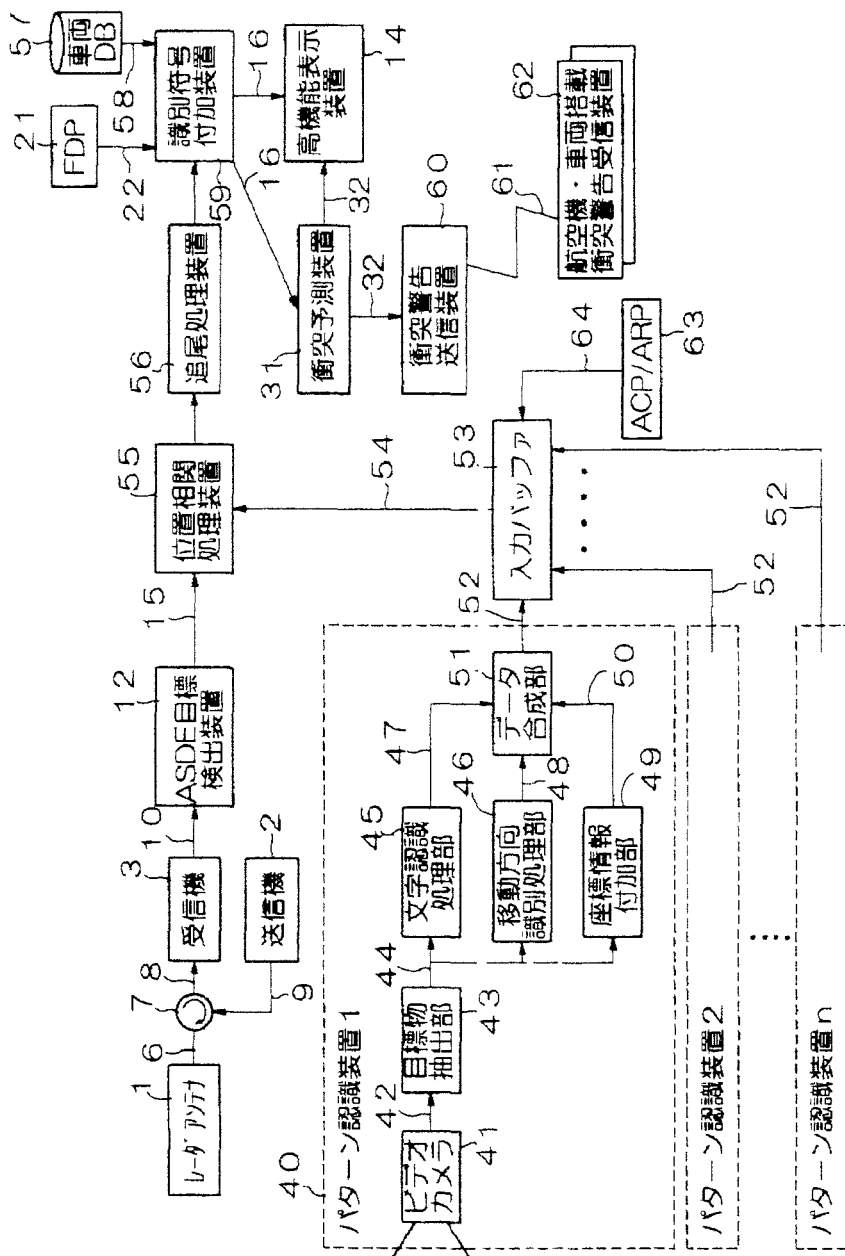


【図3】



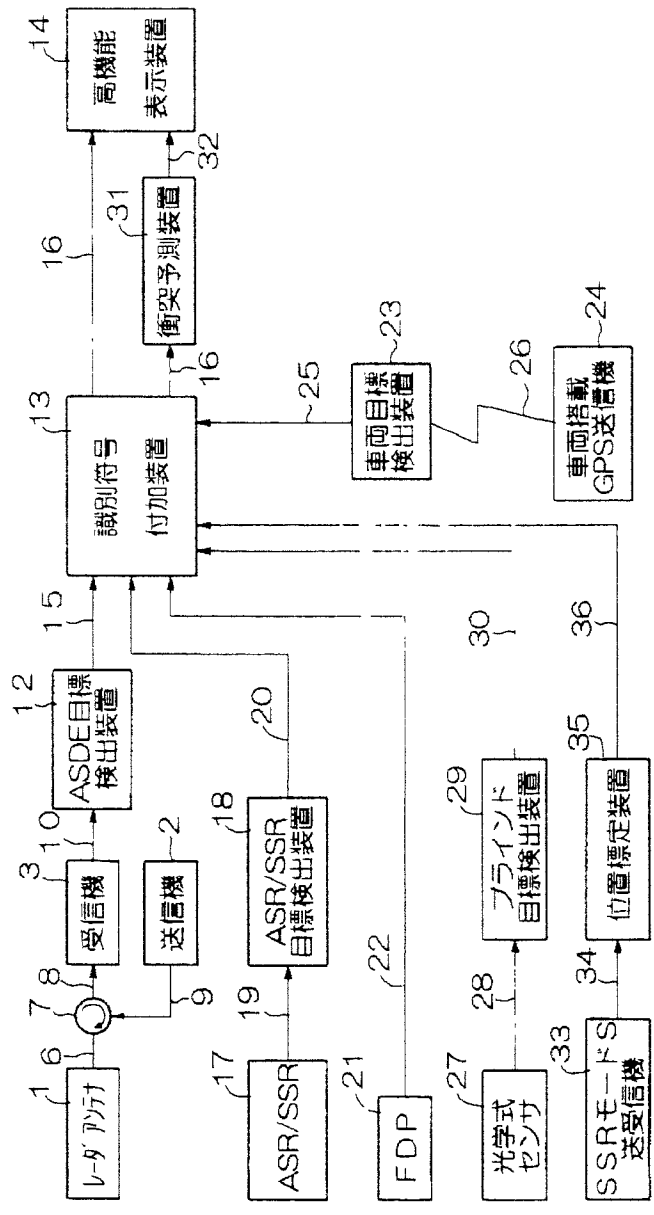


図二



【図4】

【図5】





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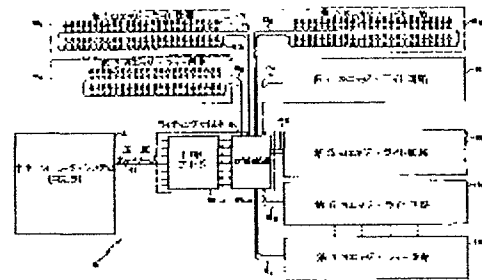
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(54) AIRPORT INTRUSION EVASION SYSTEM

(57)Abstract:

PURPOSE: To provide the system for evading the intrusion of an aircraft or other vehicles into a runway or taxiway of an airport.

CONSTITUTION: Edge light assemblies 201-n are arranged along the runway and taxiway and a sensor is arranged at each edge light assembly 201-n. The output of each sensor reaches a microprocessor in the edge light assembly 201-n and is further sent to a central computer system 12. The data is processed by this central computer system 12 and the state of the whole ground traffic on the airport is graphically displayed on a display unit in a control tower.



LEGAL STATUS

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application converted registration]

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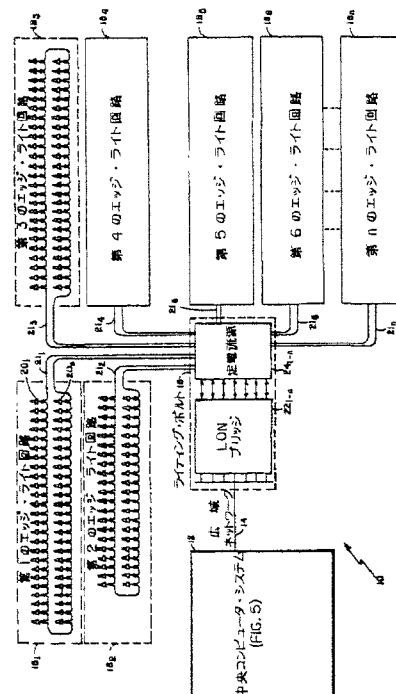
(74)代理人 弁理士 湯浅 恭三 (外6名)

(54)【発明の名称】 空港侵入回避システム

(57)【要約】

【目的】 空港における滑走路や誘導路への航空機及びその他の車両の侵入回避システムを提供する。

【構成】 滑走路及び誘導路に沿ってエッジ・ライト・アセンブリ 20<sub>1-n</sub> を配置し、各エッジ・ライト・アセンブリ 20<sub>1-n</sub> にセンサ 50 を配置する。各センサ 50 の出力は、エッジ・ライト・アセンブリ 20<sub>1-n</sub> 内のマイクロプロセッサ 44 に至り、更に中央コンピュータ・システム 12 に送られる。データはこの中央コンピュータ・システム 12 で処理されて、管制塔のディスプレイ 30 に空港の地上交通全体の状況がグラフィック表示される。



【特許請求の範囲】

【請求項1】 空港侵入回避システムであって、それぞれが複数のライト・アセンブリ手段を備えた、空港における複数のライト回路と、前記複数のライト回路のそれぞれと前記ライト・アセンブリ手段のそれぞれとに電力を提供する手段と、前記ライト・アセンブリ手段のそれぞれにおいて前記空港の地上交通を感知する手段と、前記ライト・アセンブリ手段のそれぞれから受信したデータを処理する手段と、前記ライト・アセンブリ手段のそれぞれと前記処理手段との間のデータ通信を提供する手段と、を備えており、前記処理手段は、前記地上交通を表しそれぞれが方向及び速度データを表示させるシンボルを有する前記空港のグラフィック表示を提供する手段を備え、前記処理手段は、前記感知手段から受信したデータに従って空港侵入の生起を予測する手段を備え、更に、空港管制官又は航空機パイロットに、前記予測された空港侵入について警告する手段を備えていることを特徴とする空港侵入回避システム。

【請求項2】 請求項1記載の空港侵入回避システムであって、前記ライト回路のそれぞれが、前記空港の誘導路又は滑走路のエッジに沿って配置されていることを特徴とする空港侵入回避システム。

【請求項3】 請求項1記載の空港侵入回避システムであって、前記感知手段が赤外線検出器を備えていることを特徴とする空港侵入回避システム。

【請求項4】 請求項1記載の空港侵入回避システムであって、前記ライト・アセンブリ手段が、前記電力提供手段の前記ラインに結合され、前記空港をライティングするライト手段と、前記感知手段と、前記ライト手段と、前記感知手段と、前記データ通信手段とに結合され、前記ライト・アセンブリ手段に処理と通信と制御とを提供し、前記空港の前記ライト手段の複数のライティング・パターンを制御するマイクロプロセッサ手段と、を備えており、前記データ通信手段は、前記マイクロプロセッサ手段と前記電力提供手段の前記ラインとに結合されていることを特徴とする空港侵入回避システム。

【請求項5】 請求項4記載の空港侵入回避システムであって、前記ライト・アセンブリ手段が、前記マイクロプロセッサ手段に結合され前記ライト手段の光の強度を検出するフォトセル手段を更に備えていることを特徴とする空港侵入回避システム。

【請求項6】 請求項4記載の空港侵入回避システムであって、

前記ライト・アセンブリ手段が、前記マイクロプロセッサ手段に結合されたストローブ・ライトを更に備えていることを特徴とする空港侵入回避システム。

【請求項7】 請求項1記載の空港侵入回避システムであって、前記処理手段が故障許容動作のための冗長コンピュータを備えていることを特徴とする空港侵入回避システム。

【請求項8】 請求項1記載の空港侵入回避システムであって、前記地上交通を表す前記シンボルが、航空機又は車両のタイプを指示する形状を有するアイコンを含むことを特徴とする空港侵入回避システム。

【請求項9】 請求項1記載の空港侵入回避システムであって、前記処理手段が、前記ライト・アセンブリ手段から受信した前記データに従って、前記空港の前記グラフィック表示上の前記シンボルの位置を決定することを特徴とする空港侵入回避システム。

【請求項10】 請求項1記載の空港侵入回避システムであって、前記処理手段が、地上クリアランス命令に基づく前記地上交通の、前記グラフィック表示上に示されている将来経路を決定することを特徴とする空港侵入回避システム。

【請求項11】 請求項1記載の空港侵入回避システムであって、空港侵入の生起を予測する前記処理手段が、前記地上交通の位置と方向と速度とを、前記空港に対する所定のセパレーション・ミニマムと比較する手段を備えていることを特徴とする空港侵入回避システム。

【請求項12】 請求項1記載の空港侵入回避システムであって、前記電力提供手段が、前記複数のライト回路のそれぞれに個別のラインを提供する定電流電力手段と、前記定電流電力手段に結合され、前記定電流電力手段の各ラインに対して、前記処理手段への通信チャネルを提供するネットワーク・ブリッジ手段と、を備えていることを特徴とする空港侵入回避システム。

【請求項13】 請求項1記載の空港侵入回避システムであって、前記警告手段が、スピーカに接続されたスピーチ統合ユニットを備えていることを特徴とする空港侵入回避システム。

【請求項14】 請求項1記載の空港侵入回避システムであって、前記警告手段が、無線送信機に接続されたスピーチ統合ユニットを備えていることを特徴とする空港侵入回避システム。

【請求項15】 空港侵入回避システムであって、それぞれが複数のライト・アセンブリ手段を備えた、空

港における複数のライト回路と、  
前記複数のライト回路のそれぞれに個別のラインを提供する定電流電力手段と、  
前記定電流電力手段に結合され、前記定電流電力手段のそれぞれに対して、前記処理手段への通信チャンネルを提供するネットワーク・ブリッジ手段と、  
前記ライト・アセンブリ手段のそれぞれにおいて前記空港の地上交通を感知する赤外線検出器手段と、  
前記ライト・アセンブリ手段のそれぞれから受信した地上交通データを処理する手段と、  
前記ライト・アセンブリ手段のそれぞれと前記処理手段との間の前記電力提供手段のライン上のデータ通信を提供する手段と、を備えており、  
前記処理手段は、前記ライト・アセンブリ手段から受信した前記地上交通データに従って配置された前記地上交通を表しそれぞれが方向及び速度データを表示させるシンボルを有する前記空港のグラフィック表示を提供する手段を備え、  
前記処理手段は、前記感知手段から受信した前記地上交通データに従って空港侵入の生起を、前記地上交通データの位置と方向と速度とを前記空港に対する所定のセパレーション・ミニマムと比較することを含んで予測する手段を備え、更に、  
空港管制官又は航空機パイロットに、前記予測された空港侵入について警告する手段を備えていることを特徴とする空港侵入回避システム。

【請求項 16】 請求項 15 記載の空港侵入回避システムであって、  
前記ライト回路のそれぞれが、前記空港の誘導路又は滑走路のエッジに沿って配置されていることを特徴とする空港侵入回避システム。

【請求項 17】 請求項 15 記載の空港侵入回避システムであって、前記ライト・アセンブリ手段が、  
前記電力提供手段の前記ラインに結合され、前記空港をライティングするライト手段と、  
前記赤外線検出器感知手段と、  
前記ライト手段と、前記感知手段と、前記データ通信手段とに結合され、前記ライト・アセンブリ手段に処理と通信と制御とを提供し、前記空港の前記ライト手段の複数のライティング・パターンを制御するマイクロプロセッサ手段と、を備えており、  
前記データ通信手段は、前記マイクロプロセッサ手段と前記定電流電力提供手段の前記ラインとに結合されていることを特徴とする空港侵入回避システム。

【請求項 18】 請求項 17 記載の空港侵入回避システムであって、  
前記ライト・アセンブリ手段が、前記マイクロプロセッサ手段に結合され前記ライト手段の光の強度を検出するフォトセル手段を更に備えていることを特徴とする空港侵入回避システム。

【請求項 19】 請求項 17 記載の空港侵入回避システムであって、  
前記ライト・アセンブリ手段が、前記マイクロプロセッサ手段に結合されたストロブ・ライトを更に備えていることを特徴とする空港侵入回避システム。

【請求項 20】 請求項 15 記載の空港侵入回避システムであって、  
前記処理手段が故障許容動作のための冗長コンピュータを備えていることを特徴とする空港侵入回避システム。

【請求項 21】 請求項 15 記載の空港侵入回避システムであって、  
前記地上交通を表す前記シンボルが、航空機又は車両のタイプを指示する形状を有するアイコンを含むことを特徴とする空港侵入回避システム。

【請求項 22】 請求項 15 記載の空港侵入回避システムであって、  
前記処理手段が、地上クリアランス命令に基づく前記地上交通の、前記グラフィック表示上に示されている将来経路を決定することを特徴とする空港侵入回避システム。

【請求項 23】 請求項 15 記載の空港侵入回避システムであって、  
前記警告手段が、スピーカに接続されたスピーチ統合ユニットを備えていることを特徴とする空港侵入回避システム。

【請求項 24】 請求項 15 記載の空港侵入回避システムであって、  
前記警告手段が、無線送信機に接続されたスピーチ統合ユニットを備えていることを特徴とする空港侵入回避システム。

【請求項 25】 空港侵入回避システムを提供する方法であって、  
それぞれが複数のライト・アセンブリ手段を備えた、空港における複数のライト回路を提供するステップと、  
前記複数のライト回路のそれぞれに電力を提供するステップと、  
前記ライト・アセンブリ手段のそれぞれにおける手段を用いて前記空港の地上交通を感知するステップと、  
前記ライト・アセンブリ手段のそれぞれから受信したデータをコンピュータ手段において処理するステップと、  
前記地上交通を表しそれぞれが方向及び速度データを表示させるシンボルを有する前記空港のグラフィック表示を提供するステップと、  
前記コンピュータ手段と前記ライト・アセンブリ手段のそれぞれとの間のデータ通信を提供するステップと、  
前記感知手段から受信したデータに従って空港侵入の生起を予測するステップと、  
空港管制官又は航空機パイロットに、前記予測された空港侵入について警告するステップと、  
を含むことを特徴とする方法。

【請求項26】 請求項25記載の方法であって、前記空港の前記地上交通を感知する前記ステップが、前記マイクロプロセッサ手段と前記電力ラインとに結合されたライト手段を用いて前記空港をライティングするステップと、感知手段を提供するステップと、前記ライト手段と、前記感知手段と、データ通信手段とに結合されたマイクロプロセッサ手段を用いて、前記ライト・アセンブリ手段内の処理と通信と制御とを実行するステップと、前記マイクロプロセッサ手段と前記電力ラインとの間に前記データ通信手段を結合するステップと、を含むことを特徴とする方法。

【請求項27】 請求項25記載の方法であって、データを処理する前記ステップが、故障許容のための冗長コンピュータを動作させるステップを含むことを特徴とする方法。

【請求項28】 請求項25記載の方法であって、電力を提供する前記ステップが、定電流電力手段を用いて、前記複数のライト回路のそれぞれに個別のラインを提供するステップと、ネットワーク・ブリッジ手段を用いて、前記定電流電力手段の各ラインに対して、前記コンピュータ手段への通信チャンネルを提供するステップと、を含むことを特徴とする方法。

【請求項29】 請求項25記載の方法であって、前記地上交通を表すシンボルを含むグラフィック表示を提供する前記ステップが、さまざまな形状のアイコンを用いて航空機又は車両のタイプを指示するステップを含むことを特徴とする方法。

【請求項30】 請求項25記載の方法であって、前記ライト・アセンブリ手段のそれぞれからの前記データを処理する前記ステップが、前記データに従って前記空港の前記グラフィック表示上の前記シンボルの位置を決定するステップを含むことを特徴とする方法。

【請求項31】 請求項25記載の方法であって、空港侵入の生起を予測するステップが、地上クリアランス命令に従って前記地上交通の将来経路を決定し、前記グラフィック表示上に前記将来経路を示すステップを含むことを特徴とする方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、空港での地上衝突回避システムに関し、更に詳しくは、主に空港の誘導路や滑走路上で航空機又はその他の車両の運動を監視・管制・予測する装置及び方法に関する。

【0002】

【従来の技術】現在、空港における航空機の地上での制御は、管制塔にいる航空交通の管制官によって視覚的になされている。視覚条件が悪い場合には、管制官が空港

内のすべての地上領域を見渡すのが、しばしば不可能となる。視覚条件が悪い間は、地上表面におけるレーダが空港全体をカバーすることの助けとなるが、このレーダは、滑走路侵入問題の解決において重要な役割を果たすものの、この問題全体を解消することはできない。滑走路侵入は、「空港における地上の航空機、車両、人間又はそれ以外の物体に関わる任意の事象であって、衝突の危険を生じる、又は、離陸中、離陸準備中、着陸中又は着陸準備中の航空機との離間の喪失を結果的に生じる事象」と定義される。米国連邦行政局（FAA）は、全米の上位100箇所の空港の中の29の空港における地上表面レーダのコストを正当化し得るだけだとの評価を下している。しかし、そのようなレーダでは、位置情報が与えられるだけであって、管制官に航空機との衝突の可能性を警告することはできない。

【0003】従来技術では、航空機が誘導路上のある地点に達する時刻を感知するのに航空機の管制及びモニタリング・システムが用いられ、このシステムが、スイッチングライトのオンオフを制御して滑走路にどの時点で侵入可能であるかをパイロットに指示する。このシステムは、マイクロ波センサ情報を管制塔のコンピュータに送る。このコンピュータには、空港の照明を制御しディスプレイ又は管制パネルを介して空港での照明に関する故障情報をオペレータに提供するソフトウェアが備わっている。このようなシステムが、米国オハイオ州コロンバス市にあるジューメンス社の関連会社であるADB-ALNACO社の製作によるバイディレクショナル・シリーズ・7・トランシーバ（BRITTEE）の販売情報で説明されている。しかし、このシステムでは、空港の地上領域にあるすべての車両の位置は示されず、車両侵入の可能性が検出及び回避され得ない。

【0004】空港の地上交通管制への広く知られたアプローチは、Kバンドなどの高い周波数で動作する走査レーダを使用して妥当な明瞭度（definition）及び解像度（resolution）を得るというものである。空港における現在使用されているこのタイプの地上交通管制装置は、当該技術においては、空港地上検出装置（ASDE）として知られている。しかし、この装置は監視を与えるだけであり、地上にある航空機の離散的な識別は得られない。また、比較的高いアンテナ塔と、その上の比較的大型の回転アンテナ・システムとが必要になる。

【0005】空港の地上監視への別のアプローチは、Arnold M. Levineに1974年3月18日に発行され、米国ニューヨーク州ニューヨーク市のInternational Telephone and Telegraph社に譲渡された米国特許第3872474号で説明されているシステムである。このシステムは、LOCAR（Localized Cable Rader）と称され、滑走路ランプ又は誘導路の対

向する側に沿って並び、限定されたレンジを有し時系列化された、一連の小さな低電力の幅の狭いパルスを送信するレーダから成っている。Arnold M. Levineに1980年4月8日に発行された別の米国特許第4197536号には、空中交通管制ラジオビーコン・システム(ATCRBS)と計器着陸システム(ILS)とを備えた航空機のための空港の地表識別及び管制システムが説明されている。しかし、これらのアプローチは、高価であって特別なケーブルが必要であり、また、航空機及びその他の車両上に備え付ける識別目的のための高価な装置も必要になる。

【0006】特定のタイプの車両に対する特有(ユニーク)な車輪の構成によって与えられる「足跡」の特有な特性を識別することによって航空機のタイプなどの車両識別をするアプローチが、Gerald R. Smith外に1975年3月18日に発行され、米国ジョージア州アトランタのCadre社に譲渡された米国特許第3872283号で説明されている。

【0007】空港における赤外線センサを用いた監視、誘導及び消火のための自動化システムが、Maria V. Z. Murgaに1989年7月4日に発行された米国特許第4845629号に説明されている。この赤外線センサは、飛行レーンに沿って配置され、その出力信号はコンピュータによって処理されて、当該飛行レーンに沿った航空機の移動に関する情報を提供する。位置検出器が与えられて、誘導路や格納エリアにおける航空機の位置を検出する。しかし、このシステムでは、滑走路及び誘導路に沿ったエッジ・ライトとそれに伴う配線に関しての教示はなく、起り得る車両侵入を検出し回避することができない。

【0008】本発明が上記の従来技術の短所を克服して低コストの空港侵入回避システムを提供する態様は、以下の説明から明らかになるであろう。

【0009】

【発明の概要】したがって、空港において可能性のある航空機又は車両侵入を検出するシステムを提供することが本発明の目的である。

【0010】滑走路及び誘導路に沿ってエッジ・ライト・アセンブリと関連するワイアリングとを用いて、低コストの空港侵入回避システムを提供することもまた、本発明の目的である。

【0011】方向及び速度データを含むすべての地上交通の位置を示す空港のグラフィック表示を生じる空港侵入回避システムを提供することもまた、本発明の目的である。

【0012】空中交通管制官又は航空機のパイロットに音声上の警告を発する空港侵入回避システムを提供することもまた、本発明の目的である。

【0013】これらの目的は、空港侵入回避システムであって、それぞれが複数のライト・アセンブリ手段を備

えた空港における複数のライト回路と、前記複数のライト回路のそれぞれと前記ライト・アセンブリ手段のそれぞれとに電力を提供する手段と、前記ライト・アセンブリ手段のそれぞれにおいて前記空港の地上交通を感知する手段と、前記ライト・アセンブリ手段のそれぞれから受信したデータを処理する手段と、前記ライト・アセンブリ手段と前記処理手段とのそれぞれの間のデータ通信を提供する手段と、を備えており、前記処理手段は、前記地上交通を表しそれぞれが方向及び速度データを表示させるシンボルを有する前記空港のグラフィック表示を提供する手段を備え、前記処理手段は、前記感知手段から受信したデータに従って空港侵入の生起を予測する手段を備え、更に、空港管制官又は航空機パイロットに、前記予測された空港侵入について警告する手段を備えていることを特徴とする空港侵入回避システムを提供することによって、達成される。前記ライト回路のそれぞれは、前記空港の誘導路又は滑走路のエッジに沿って配置されている。前記感知手段は赤外線検出器を備えている。前記ライト・アセンブリ手段は、前記電力提供手段の前記ラインに結合され前記空港をライティングするライト手段と、前記感知手段と、前記ライト手段と前記感知手段と前記データ通信手段とに結合され前記ライト・アセンブリ手段に処理と通信と制御とを提供し前記空港の前記ライト手段の複数のライティング・パターンを制御するマイクロプロセッサ手段とを備えており、前記データ通信手段は、前記マイクロプロセッサ手段と前記電力提供手段の前記ラインとに結合されている。前記ライト・アセンブリ手段は、前記マイクロプロセッサ手段に結合され前記ライト手段の光の強度を検出するフォトセル手段を更に備えている。前記ライト・アセンブリ手段は、前記マイクロプロセッサ手段に結合されたストローブ・ライトを更に備えている。前記処理手段は故障許容動作のための冗長コンピュータを備えている。前記地上交通を表す前記シンボルは、航空機又は車両のタイプを指示する形状を有するアイコンを含む。前記処理手段は、前記ライト・アセンブリ手段から受信した前記データに従って、前記空港の前記グラフィック表示上の前記シンボルの位置を決定する。前記処理手段は、地上クリアランス命令に基づく前記地上交通の、前記グラフィック表示上に示されている将来経路を決定する。空港侵入の生起を予測する前記処理手段は、前記地上交通の位置と方向と速度とを、前記空港に対する所定のセパレーション・ミニマムと比較する手段を備えている。電力提供手段は、前記複数のライト回路のそれぞれに個別のラインを提供する定電流電力手段と、前記定電流電力手段に結合され前記定電流電力手段の各ラインに対して前記処理手段への通信チャネルを提供するネットワーク・ブリッジ手段と、を備えている。前記警告手段は、スピーカに接続されたスピーチ統合ユニットを備え、また、無線送信機に接続されたスピーチ統合ユニットを備えて

いる。

【0014】本発明の目的は、更に、空港侵入回避システムを提供する方法であって、それぞれが複数のライト・アセンブリ手段を備えた空港における複数のライト回路を提供するステップと、前記複数のライト回路のそれぞれに電力を提供するステップと、前記ライト・アセンブリ手段のそれぞれにおける手段を用いて前記空港の地上交通を感知するステップと、前記ライト・アセンブリ手段のそれぞれから受信したデータをコンピュータ手段において処理するステップと、前記地上交通を表しそれぞれが方向及び速度データを表示させるシンボルを有する前記空港のグラフィック表示を提供するステップと、前記コンピュータ手段と前記ライト・アセンブリ手段のそれぞれとの間のデータ通信を提供するステップと、前記感知手段から受信したデータに従って空港侵入の生起を予測するステップと、空港管制官又は航空機パイロットに、前記予測された空港侵入について警告するステップと、を含むことを特徴とする方法によって達成される。前記空港の前記地上交通を感知する前記ステップは、前記マイクロプロセッサ手段と前記電力ラインとに結合されたライト手段を用いて前記空港をライティングするステップと、感知手段を提供するステップと、前記ライト手段と、前記感知手段と、データ通信手段とに結合されたマイクロプロセッサ手段を用いて、前記ライト・アセンブリ手段内の処理と通信と制御とを実行するステップと、前記マイクロプロセッサ手段と前記電力ラインとの間に前記データ通信手段を結合するステップと、を含む。データを処理する前記ステップは、故障許容のための冗長コンピュータを動作させるステップを含む。電力を提供する前記ステップは、定電流電力手段を用いて前記複数のライト回路のそれぞれに個別のラインを提供するステップと、ネットワーク・ブリッジ手段を用いて前記定電流電力手段の各ラインに対して前記コンピュータ手段への通信チャネルを提供するステップと、を含む。前記地上交通を表すシンボルを含むグラフィック表示を提供する前記ステップは、さまざまな形状のアイコンを用いて航空機又は車両のタイプを指示するステップを含む。前記ライト・アセンブリ手段のそれぞれからの前記データを処理するステップは、前記データに従って前記空港の前記グラフィック表示上の前記シンボルの位置を決定するステップを含む。空港侵入の生起を予測するステップは、地上クリアランス命令に従って前記地上交通の将来経路を決定し、前記グラフィック表示上に前記将来経路を示すステップを含む。

【0015】

【実施例】図1には、空港車両侵入回避システム10のブロック図が示してあり、このシステムは複数のライト回路18<sub>1-n</sub>を有し、この各ライト回路18<sub>1-n</sub>は、ワイアリング21<sub>1-n</sub>を介してライティング・ボルト16に接続した複数のエッジ・ライト・アセンブリ20

<sub>1-n</sub>を備えている。ライティング・ボルト16は、広域ネットワーク14を介して中央コンピュータ・システム12に接続する。エッジ・ライト・アセンブリ20<sub>1-n</sub>のそれぞれは、赤外線(IR)検出器車両センサ50(図2)を有している。

【0016】エッジ・ライト・アセンブリ20<sub>1-n</sub>は、一般的に、空港の滑走路及び誘導路の側面に沿って平均で100フィートの間隔で配置し、単一導体の直列エッジ・ライト・ワイアリング21<sub>1-n</sub>によってライティング・ボルト16に相互接続する。各エッジ・ライト・アセンブリ20<sub>1-n</sub>は、ワイアリング21<sub>1-n</sub>を介して、ライティング・ボルト16内に配置した定電流源24<sub>1-n</sub>によって電力を供給される。

【0017】図1及び図2を参照すると、エッジ・ライト・アセンブリ20<sub>1-n</sub>と中央コンピュータ・システム12との間の通信は、エッジ・ライト・ワイアリング21<sub>1-n</sub>と広域ネットワーク14とを相互接続するLONブリッジ22<sub>1-n</sub>によって達成されている。各エッジ・ライト・アセンブリ20<sub>1-n</sub>に配置されたマイクロプロセッサ44からの情報は、電力線モデム54を介してエッジ・ライト・ワイアリング21<sub>1-n</sub>に結合される。LONブリッジ22<sub>1-n</sub>は、エッジ・ライト回路18<sub>1-n</sub>からのメッセージ情報を、ワイアリング21<sub>1-n</sub>を介して広域ネットワーク14に転送する。広域ネットワーク14は、中央コンピュータ・システム12への送信経路を与える。これらの回路素子は、また、中央コンピュータ・システム12から各エッジ・ライト・アセンブリ20<sub>1-n</sub>の中のマイクロプロセッサ44への帰還経路通信リンクを与える。エッジ・ライト・アセンブリ20<sub>1-n</sub>と中央コンピュータ・システム12との間のデータ通信のための装置及び方法には、たとえば無線技術など、これ以外の当業者に公知のものがあるが、エッジ・ライト・ワイアリング21<sub>1-n</sub>上のデータ通信を与えるこの実施例が、現在の空港については低コストのシステムを提供する。LONブリッジ22<sub>1-n</sub>は、カリフォルニア州パロアルトのEchelon社製造の装置によって具体化され得る。広域ネットワーク14は、標準的なイーサネット又はファイバ分散型データ・インターフェース(FDDI)素子を用いて当業者によって実現され得る。定電流源24は、コネチカット州ウィンスローのCrouse-Hinds社製造の装置によって具体化され得る。

【0018】次に図2及び図3を参照すると、図3は、エッジ・ライト・アセンブリ20<sub>1-n</sub>の図解を示している。エッジ・ライト・アセンブリ20<sub>1-n</sub>は、白熱灯40と車両センサ50を備えた電子エンクロージャ43の上部に設置された光学ストロブ・ライト・アセンブリ48とを含むベゼル(bazel)を有している。電子エンクロージャ43は、ベース・サポート56から延長する管状のシャフトの頂部に位置している。白熱ランプ



40を有するライト・アセンブリ・ベゼルとベース・サポート56とは、コネチカット州ウィンスローのCruse-Hinds社製造の装置によって具体化され得る。

【0019】電子エンクロージャ43の内部のブロック図が図2に示されており、エッジ・ライト・ワイアリング21<sub>1-n</sub>に接続された結合変圧器53を含んでいる。結合変圧器53は、ランプ制御トリアック42を介して白熱ランプ40に、また、マイクロプロセッサ電源52に電力を供給し、更に、結合変圧器53は、エッジ・ライト・ワイアリング21<sub>1-n</sub>を介して、電力線モデム54とLONブリッジ22<sub>1-n</sub>との間にデータ通信経路を供給する。マイクロプロセッサ44は、エッジ・ライト・アセンブリ20<sub>1-n</sub>を制御する内部ソフトウェア・プログラムを動かすためのコンピュータ電力を供給する。マイクロプロセッサ44は、マイクロプロセッサ電源52によって電力を供給されている。また、マイクロプロセッサ44に接続されているものには、ランプ制御トリアック42、ランプ監視フォトセル46、光学ストロブ・ライト・アセンブリ48、車両センサ50、及び、データ通信モデム54がある。マイクロプロセッサ44は、白熱エッジランプ40の照度と光学ストロブ・ライト・アセンブリ48とを制御するのに用いられる。各ライト・アセンブリ20<sub>1-n</sub>でマイクロプロセッサ44を使用することによって、フィールド上の各ライトに対する完全にアドレス指定可能な制御が可能になる。マイクロプロセッサ44は、ニューロン(Neuron商標登録)・チップと呼ばれるカリフォルニア州94304パロアルトのEchelon社製造のVLSIデバイスによって具体化され得る。

【0020】更に図2において、この実施例のセンサ50は、赤外線(IR)検出器を備えているが、他の実施例では、近接検出器、CCDカメラ、マイクロ波運動検出器、インダクタンス・ループ、又は、レーザ・ビーム等の他のデバイスを含み得る。マイクロプロセッサ44の中のプログラムが、センサ50から受け取ったセンサ・データの最初のフィルタリングを行い、また、そのデータを中央コンピュータ・システム12に送信する。センサ50は、次の機能を実行しなければならない。すなわち、静止目標を検出する、移動目標を検出する、滑走路又は誘導路の幅の少なくとも半分のレンジを有する、低電力であり、誤警報を感知しない、の機能である。このシステム設計は、ただ1つのタイプのセンサだけに依存しない。センサの融合的な機能が中央コンピュータ・システム12の内部で実行されるので、あらゆるタイプのセンサからのデータ入力が受け入れられ得る。各センサは、エアフィールド上で生起していることの異なった見方を中継して、中央コンピュータ・システム12がそれらを組み合わせる。このシステムで使用できるセンサには広い幅がある。新たなセンサのタイプが使用可能に

なった際には、そのセンサをこのシステムに、最小限の困難だけで、組み入れることができる。用いられた最初のセンサは、圧電ストリップの周囲に取り付けられたIR近接検出器である。これらは、家庭で熱及び(又は)動きが検出されたときに、フラッドライトを点灯するのに使用されるセンサの種類である。センサ出力がアナログ信号を提供する場合には、この技術分野で公知のA/Dコンバータを用いて、マイクロプロセッサ44とのインターフェースとする。

【0021】使用できる他の近接検出器は、マイクロ波ガン(Gunn)ダイオード発信器の周囲におかれる。これらは、現在、侵入アラーム、ドア・オープナ、距離測定、衝突警告、鉄道スイッチング等の応用例で使用されている。これらのタイプのセンサには短所がある。それは、これらのセンサが受動素子ではなく、空港の他の装置と抵触しないように周波数を選択する手間がかかるからである。最後に、誘導路上のホールド位置線等の場所では、ソリッド・ステート・レーザと検出器との組み合わせを、隣接する誘導路のライトの間に使用することができる。これらのセンサ・システムは、中断された際には航空機の前輪の位置を識別し得るビームを生じる。このタイプの検出器は、車両の絶対的な位置が必要である場所で使用される。レーザ・ビームは、マイクロプロセッサ44によって変調されて検出器がいかなる他の漂遊放射によって妨害されることが防止される。

【0022】図2及び図4において、空港の滑走路64又は誘導路の一部が示されており、複数のエッジ・ライト・アセンブリ20<sub>1-8</sub>が滑走路及び誘導路の両側に沿って配置され、さまざまなサイズの航空機又は車両60、62を検出する。破線は、滑走路64又は誘導路の両側に沿って配置された各エッジ・ライト・アセンブリ20<sub>1-8</sub>に設置されたセンサ50がカバーできるエリアを表し、この滑走路64又は誘導路上を移動するいかなる航空機60、62又はそれ以外の車両の検出を保証する。センサ50を含むエッジ・ライト・アセンブリ20<sub>1-n</sub>は、空港全体が車両の運動に対して反応するように、相互に論理的に接続されている。ノード間の通信は、車両の位置を確認し識別するように行われる。それがいったん行われれば、メッセージは、車両位置を報告する中央コンピュータ・システム12に送られる。エッジ・ライト・アセンブリ(センサ電子ユニット43を含まず)と誘導路電力ワイアリングが、現在でも、空港の誘導路、滑走路及びオープンエリアに沿って存在しているので、新たなケーブル設置の間に滑走路や誘導路を閉鎖する不都合や費用なしで、センサ電子ユニット43を、既存のエッジ・ライト及び誘導路電力ワイアリングに、容易に加えることが可能である。

【0023】図1、図5、図8及び図9において、中央コンピュータ・システム12は、一般に、空港の管制塔又はターミナルエリアに置かれ、広域ネットワーク14

によって、ライティング・ボルト16内のLONブリッジ22<sub>1-n</sub>に相互接続されている。中央コンピュータ・システム12は、故障に備えて2つの冗長コンピュータすなわち第1のコンピュータ26及び第2のコンピュータ28、ディスプレイ30、スピーチ合成ユニット29、31、警報ライト34、キーボード27、及び、スピーチ認識ユニット33を備えており、これらの構成要素は、すべて、情報の移動のために広域ネットワーク14によって相互接続されている。この2つのコンピュータ26、28は、エッジ・ライト・アセンブリ20<sub>1-n</sub>内に置かれたマイクロプロセッサ44を用いて通信する。エッジ・ライト・アセンブリ20<sub>1-n</sub>のマイクロプロセッサ44から受け取られたデータは、冗長コンピュータ26、28上で動くセンサ融合ソフトウェア・モジュール101(図9)への入力として用いられる。コンピュータ26、28で動作するセンサ融合ソフトウェア・モジュール101の出力は、CRTディスプレイ30を駆動するのに用いられ、このディスプレイは、図8に示した空港の滑走路及び誘導路上の各車両の位置を表示する。中央コンピュータ・システム12は、ニューヨーク州ホワイトプレーンズのIBM社製造のデバイスによって実現される。広域ネットワーク14は、カリフォルニア州サンタクララの3Com社製造のデバイスによって実現される。スピーチ合成ユニット29、31及びスピーチ認識ユニット33は、マサチューセッツ州ケンブリッジのBBN社製造のデバイスによって実現される。

【0024】スピーチ合成ユニット29は、スピーカ32に結合される。限定された情報がスピーチ合成ユニット29に広域ネットワーク14を介して送られて、空中交通管制官に音声上の警報を与える可能性を提供する。スピーチ合成ユニット31は、アンテナ39を有する無線機37に結合されており、パイロットに音声上の警報を与える可能性を提供する。空中交通管制官からパイロットへの声による命令は、マイクロフォン35によって捕捉され、無線機36とアンテナ38を介してパイロットに送られる。この実施例では、タップが作られ、スピーチ情報は、無線機36と、管制官が用いる限定された空中交通管制用語を認識するようにプログラムされているスピーチ認識ユニット33との両方に送られる。この用語とは、航空会社名、航空機の種類、0~9の数、誘導路及び滑走路の名前、「ホールド・ショート(hold short)」、「急げ(expedite)」、「通路を譲れ(give way to)」などのいくつかの簡単なフレーズである。スピーチ認識ユニット33の出力は、コンピュータ26、28に与えられる。

【0025】再度図2において、電力線モデム54は、エッジ・ライト・ワイアリング21<sub>1-n</sub>上にマイクロプロセッサ44へのデータ通信経路を与える。この2つの経路は、複数のエッジ・ライト・アセンブリ20<sub>1-n</sub>と中央コンピュータ・システム12との間を命令及び管制

情報を移動させるのに用いられる。電力線モデム54内の電力線トランシーバ・モジュールは、データ・チャネルを提供するのに用いられる。これらのモジュールは、データ・チャネルを作るのに搬送波電流アプローチを用いている。100~450KHzの帯域の搬送波周波数で動作する電力線モデムは、多くのメーカーから出ている。これらのモデムは、ディレクト・シーケンス・スプレッド・スペクトル変調を用いて、最高で毎秒10000ビットのデータ速度のデジタル通信経路を提供する。これらは、行われた放射に対するFCC電力線搬送波の条件に適合し、55dBまでの電力線減衰で動作し得る。この電力線モデム54は、カリフォルニア州94304パロアルトのEchelon社製造の、PLT-10電力線トランシーバ・モジュールと呼ばれるデバイスによって実現される。

【0026】データ・チャネルは、データ・ネットワークで用いられるオープン・システム・インターコネクション(OSI)プロトコルの輸送層又は最下層を提供する。マイクロプロセッサ44を実現するニューロン・チップは、7層のOSIプロトコルを実現するのに必要なすべてのファームウェア(firmware)を含んでいる。適切な媒体を介して相互に接続される場合には、ニューロン・チップは、フォワード・エラー訂正、エラー・チェック及び見落としメッセージの自動的再送信(ARQ)を備えた確実な衝突感知複数アクセス(CSMA)プロトコルを用いて、自動的に相互に通信する。

【0027】命令及び管制情報は、データ・パケットの中に置かれ、ネットワーク上を7層OSIプロトコルにしたがって送られる。マイクロプロセッサ44によって発生され中央コンピュータ・システム12に向けられたすべてのメッセージは、ネットワーク・ブリッジ22によって電力線21<sub>1-n</sub>を介して受け取られ、広域ネットワーク14上を中央コンピュータ・システム12に送られる。

【0028】マイクロプロセッサ44のニューロン・チップは、3つのプロセッサ(図示せず)と、完全な6層OSIをサポートするのに必要なファームウェアとを含む。ユーザは、アプリケーション・コードに対してプロセッサの1つを配分される。残りの2つのプロセッサは、アプリケーション・プログラムに、ネットワークの中のすべての他のニューロン・チップへのアクセスを与える。このアクセスが、ローカル・オペレーティング・ネットワーク略してLONを作り出す。LONは、ハイレベルな広域ネットワークLANとして考えることができる。本発明の実現にニューロン・チップを使用することは、そうでなければ開発が必要になるカスタム・ハードウェアやソフトウェアの量を減らすことになる。

【0029】エッジ・ライト・アセンブリ20<sub>1-n</sub>のセンサ電子ユニット43からのデータは、既存の空港の誘

導路ライティング電力ワイアリング21を介して中央コンピュータ・システム12に結合される。既存のエッジ・ライト電力ラインを使用してセンサ・データをLONネットワークに伝達することには、多くの利点がある。既に指摘したように、既存のエッジ・ライトを再使用することで、新たなケーブルを設置するために滑走路及び誘導路を開鎖する必要などなく、システムのコストを押さえることができる。

【0030】ニューロン・チップは、エッジ・ライト・アセンブリ20<sub>1-n</sub>がアプリケーションのレベルで自動的に相互に通信することを可能にする。これは、個々のニューロン・チップが相互にデータを交換できるようにするネットワーク変数によって達成される。各ニューロンCプログラムは、ローカル及びネットワークの両方の変数を有している。ローカルな変数は、ニューロン・プログラムによって、スクラッチパッド・メモリとして使われる。ネットワーク変数は、ニューロン・プログラムによって、ネットワーク出力変数又はネットワーク入力変数の2つの方法の中の1つとして使われる。両方の種類の変数ともに、初期化、評価、ローカルな修正が可能である。違いは、ネットワーク出力変数がいったん修正されると、ネットワーク・メッセージが、当該出力変数にリンクした各ネットワーク入力変数に自動的に送られることにある。この変数の連関（リンク）は、設置時になされる。ニューロン・チップがネットワーク入力変数の新たな値を受け取るとすぐに、コードがベクトル化されて、ネットワーク入力変数の値に基づく適切な動作がなされる。このプログラムの利点は、このメッセージ交換形式が、メッセージ交換コードが埋め込まれたニューロンのオペレーティング・システムの一部であるために、全体として透明であることである。

【0031】次に図6において、11のネットワーク変数が、エッジ・ライト・アセンブリ20<sub>1-n</sub>の各マイクロプロセッサ44のセンサ・プログラムに対して識別される。センサ50の関数は、2つの出力変数を有しており、すなわち、prelimdetect70とconfirmed\_detect72とである。ここでのアイデアは、センサ50が運動を検出したら常に、1つの出力をトリガさせることである。他方の出力は、ローカル・センサと滑走路を横断するエッジ・ライト上のセンサが運動を特定しなければトリガしない。検出が確認された場合にだけ、信号は中央コンピュータ・システム12に与えられる。確認のこの技術が誤警報を減少させるのを助け、隣接するセンサ50が、他方のセンサprelimdetect出力70を受け取るの用いられるadj\_prelim\_detect78と呼ばれる入力センサを有するというこの技術を実現する。これ以外の入力変数として、upstream\_detect74とdownstream\_detect76とがあり、隣接するセンサをつなげる際に使用される。必要なの

は、detector\_sensitivity80入力だけであり、これは、中央コンピュータ・システム12が用いて、センサ50の検出能力を制御する。

【0032】白熱ライト40は、2つのネットワーク変数を必要とし、1つは入力変数であり、他方は出力変数である。入力変数light\_level84はライトの輝度を制御するのに用いられる。レンジは、オフあるいは0パーセントから完全なオンあるいは100パーセントまですべてである。この0~100パーセントのレンジは、0.5パーセントのステップで作られる。エッジ・ライト・アセンブリ20<sub>1-n</sub>もまたフォトセル46を含んでいるから、出力変数light\_failure84が作成されて、ランプが所望の輝度を獲得していないことを知らせる。

【0033】ストロブ・ライト48は、3つの入力変数を必要とする。ストロブ・モード86変数は、OFF、SEQUENTIAL、又はALTERNATIVEのフラッシュ・モードを選択するのに用いられる。2つのフラッシュ・モードは、判明なパターンが生成されることを要求するから、2つの入力変数であるactive\_delay88とflash\_delay90とが用いられて、ストロブ・フラッシュの時間を合わせる。これらの個々の遅延ファクタを設定しニューロン・チップをグループでアドレス指定することによって、たった1つの命令でフィールド・ストロブ・パターンが可能になる。

【0034】図7においては、滑走路の両側に配置された複数のエッジ・ライト・アセンブリ20<sub>1-n</sub>に対するネットワーク変数の相互接続のブロック図が示されており、エッジ・ライト・アセンブリ20<sub>1-n</sub>のそれぞれは、マイクロプロセッサ44を含んでいる。マイクロプロセッサ44の中の各ニューロン・プログラムが、あるネットワーク入力及び出力変数を用いて設計される。ユーザは、入力が供給され出力が使用されることを想定して、マイクロプロセッサ44の中のニューロン・チップのためのコードを書く。実際のネットワークを作成するために、ユーザは、ソフトウェア・リンカを用いて個別のノードを相互接続することによってネットワークを「ワイアアップ」しなければならない。結果的な分散プロセスは、図解形式によって最もよく示すことができるが、ネットワーク相互接続マトリックスの一部が、図7に示されている。センサ・ノード44<sub>1</sub>のprelimdetect70出力が、誘導路の反対側のセンサ・ノード44<sub>4</sub>のadj\_primary\_detect92入力に接続されている。これは、実際の検出を確証し、誤った報告を削除するための手段として使用される。これらの2つのノード44<sub>1</sub>、44<sub>4</sub>の間の通信リンクは、分散処理の一部である。この2つのノードは、中央コンピュータ・システム12に関係することなく、それらの間で通信を行う。自動モードで動作中である

か、又は、管制官によって指令を受ける場合には、システムは、音声及び視覚的な指示を介してパイロットに警告する。

【0035】図1及び図4において、中央コンピュータ・システム12は、車両が各エッジ・ライト・アセンブリ20<sub>1-n</sub>におけるセンサ50からセンサ50へと通過するにつれて、車両の運動を追跡する。レーダの自動追跡アルゴリズムの変動を使用することによって、システムは、センサ50の読み取りに基づいて、すべての航空機又は車両の位置、速度及び移動方向を追跡できる。新たな車両が、搭乗ゲートを離れる又は着陸することによって、システムの中に入る。未知の車両も、自動的に追跡される。誘導路及び滑走路のライトは通常(図4及び図7に示すように)車道上で相互に横断しているので、各エッジ・ライト・アセンブリ20<sub>1-n</sub>のマイクロプロセッサ44は、接触を報告する前に自らのセンサ50の入力を組み合わせて一致させるようにプログラムされている。更なる微調整は、マイクロプロセッサ44に、自らの両側のエッジ・ライト・アセンブリ20<sub>1-n</sub>によって、そのセンサ50が車両を検出したかどうかを見るようにチェックさせることである。これによって、車両は、誘導路を移動していくにつれて、各エッジ・ライト・アセンブリ20<sub>1-n</sub>のセンサ電子ユニット43からセンサ電子ユニット43へと手渡されていくことが可能になる。これによって、また、車両位置の報告が一貫したものになることが保証される。車両の速度は、センサ間の距離とセンサ・パターンと検出の間の時間とを用いて計算できる。

【0036】図5及び図8において、ディスプレイ30は、空港のグラフィック表示を提供するカラーモニターであり、その一部は図8に示してある。これは、空港の地図を冗長コンピュータ26、28にデジタル形式で格納することによって達成される。ディスプレイ30は、各誘導路及び滑走路又はそれ以外の空港の地上エリアに沿ったエッジ・ライト・アセンブリ20<sub>1-n</sub>に設置されたセンサ50によって検出される際に、航空機又は車両の位置を示す。空港表面上のすべての航空機又は車両はアイコンとして表示され、これらアイコンの形状は、車両のタイプによって決定される。車両の位置は、スクリーン上のアイコンの位置によって示される。車両の方向は、アイコンの向き又はアイコンから出ている矢印によって示される。車両の状態は、アイコンの色によって表される。管制官のマイクロフォン35を介して入力される地上クリアランス命令によって提供される車両の将来の経路は、ディスプレイ30上の色のついたラインとして示される。各ライト回路18<sub>1-n</sub>における各エッジ・

ライト20<sub>1-n</sub>を含むすべてのフィールド・ライトの状態は、ディスプレイ30上の色を介して示される。

【0037】オブジェクト指向型ソフトウェアの使用によって、空港のモデルを作成する基礎が与えられる。自動継承性のために、データ構造が各オブジェクトに対していったん定義され次に当該オブジェクトの各瞬間に対して自動的に複製されることが可能になる。自動フローダウンは、データベースの要素はタイプエラーでは破壊されないことを保証する。また、コードが規則的(レギュラー)であり構造を有していることも保証される。ルールに基づくオブジェクト指向型プログラミングによれば、解読不可能な「スパゲッティ・コード」を作成してしまうのは難しい。オブジェクト指向型プログラミングは、滑走路、誘導路、航空機及びセンサが、オブジェクトとして直接にデコードされるのを可能にする。これらの各オブジェクトは、属性(アトリビュート)を含む。これらのアトリビュートには、滑走路22RやフライトUA347のように固定されているものがあり、また、車両状態及び位置のような変数もある。

【0038】従来のプログラミングでは、1つのオブジェクトのアトリビュートはデータ構造において記述され、当該オブジェクトの挙動はこれらのデータ構造上で動作する手順として記述された。オブジェクト指向型プログラミングは、重点をシフトさせ、第1にデータ構造に焦点を合わせ、手順には単に二次的に考える。更に重要なことに、オブジェクト指向型プログラミングによれば、自然な態様でプログラムを解析し設計できる。われわれは、滑走路及び航空機の挙動又はデータ構造に焦点を合わせるのではなく、滑走路及び航空機について考える。

【0039】表1及び表2は、対応するアトリビュートを備えたオブジェクトのリストである。但し、ここで、表1と表2とは一体のものであって、便宜的に切り離しただけである。滑走路侵入問題にとって重要な各物理的オブジェクトが、モデル化されている。基本的な航空機又は車両追跡アルゴリズムが、プログラム設計言語(PDL)で表3及び表4に示されている。但し、ここで、表3と表4とは一体のものであって、便宜的に切り離しただけである。センサ融合、侵入回避及び安全警告を扱うアルゴリズムが、中央コンピュータ・システム12及びセンサのマイクロプロセッサ44の両方を使用して分散システムとして実現されるのではあるが、1つのプログラムにおいて示されている。

【0040】

【表1】

表 1

オブジェクト	アトリビュート	説明
センサ	位置	センサのX及びY座標
	回路	交流ワイアリング回路の名称及び数
	Unique_address	当該センサ及びその相手のネット・アドレス
	Lamp_intensity	0.5%のステップで0%~100%
	Strobe_status	ブリンク速度/オフ
	Strobe_delay	開始信号から
	Sensor_status	検出/非検出
	Sensor_type	赤外線、レーザ、近接、その他
	滑走路	名称
位置		センターラインの開始点のX及びY座標
長さ		フィート単位
幅		フィート単位
方向		北からの度合
状態		Not_active, active_takeoff, active_landing, alarm
センサ(MY)		当該滑走路に沿ったライト/センサのリスト
交点(MY)		交点のリスト
車両		滑走路上の車両のリスト

【表 2】

表 2

オブジェクト	アトリビュート	説 明
誘導路	名称	誘導路の名称
	位置	中央線の開始のX及びY座標
	長さ	フィート単位
	幅	フィート単位
	方向	北からの程度
	状態	非アクティブ、アクティブ、アラーム
	センサ(MV)	交点のリスト
	Hold_Locations	保持位置のリスト
	車両 (MV)	滑走路上の車両のリスト
交点	名称	交点の名称
	位置	2本のセンターラインの交叉
	状態	空/占領済
	センサ(MV)	交点境界を作るセンサのリスト
航空機	航空会社	ユナイテッド
	モデル	727-200
	Tail-number	N3274Z
	Empty_weight	9.5トン
	Freight_weight	2.3トン
	Fuel_weight	3.2トン
	Top_speed	598mph
	V1_speed	100mph
	V2_speed	140mph
	加速	0.23g's
	加速	0.34g's

MV = 多変数又はアレー

【表 3】

表 3

```
while (forever)
| if (edge light shows a detection)
| | if (adjacent light also shows a detection sensor fusion)
| | | /* CONFIRMED DETECTION */
| | | if (previous block showed a detection)
| | | | /* ACCEPT HANDOFF */
| | | | Update aircraft position and speed
| | | else
| | | | /* MAY BE AN ANIMAL OR SERVICE TRUCK */
| | | | Alert operator to possible incursion
| | | | /* MAY BE AN AIRCRAFT ENTERING THE SYSTEM */
| | | | Start a new track
| | else
| | | Request status from adjacent light
| | | if (Adjacent light is OK)
| | | | /* NON CONFIRMED DETECTION */
| | | else
| | | | Flag adjacent light for repair
| | | endif
| | endif
| endif
```

【表4】

表 4

```

| if (Edge light loses a detection AND status is OK)
| | if (Next block showed a detection)
| | | /* PROPER HANDOFF */
| | else
| | | if (vehicle speed > = takeoff)
| | | | Handoff to departure control
| | | else
| | | | /* MISSING HANDOFF */
| | | | Alert operator to possible incursion
| | | endif
| | endif
| endif
| /* CHECK FOR POSSIBLE COLLISIONS */
| for (all tracked aircraft)
| | Plot future position
| | if (position conflict)
| | | Alert operator to possible incursion
| | endif
| endif
| Update display

```

endwhile

再び図1及び図2において、誘導路のライティング強度の制御は、通常、ライト全部を同じ直列回路上に置きその回路を流れる電流を規整することによってなされる。この実施例では、ランプ40の強度は、ライト・アセンブリ20<sub>1-n</sub>内に配置されたマイクロプロセッサ44に、ライト強度値を伴うメッセージを送ることによって制御されている。このメッセージによって、強度設定が、0.5パーセントのステップでの0~100パーセントの幅で許容されることになる。ライト出力をチェックするフォトセル46の使用は、バルブが応答しないならば帰還信号が送られることを可能にする。これは、ライトに関してメンテナンス報告を発生する。ストローブ・ライト48は、マイクロプロセッサ44のプログラム制御の下で、更なるオプションの可能性を提供する。エッジ・ライト・アセンブリ20のマイクロプロセッサ44のそれぞれは、個別にアドレス指定可能である。これは、フィールド上のすべてのランプが中央コンピュータ・システム12によって個別に制御可能であることを意味している。

【0041】システム10は、プログラムして、滑走路

64上に配置されたエッジ・ライト・アセンブリ20<sub>1-n</sub>内のストローブ・ライト48を使用することによって、アクティブ滑走路指示器を提供し、アプローチ・ライト「ラビット」ストローブ・パターンを連続させることが可能である。このライティング・パターンは、地表が着陸のために解放された際にオンして、航空機が着陸した後で、オフすることができる。交差する誘導路に沿って滑走路に接近してきたパイロットは、明瞭かつ曖昧でない方法で、滑走路はアクティブであるから交差してはならないと警告をうける。

【0042】侵入が検出された場合には、メイン・コンピュータ26、28が滑走路のストローブ・ライト48を「ラビット」パターンから滑走路の両側で手旗信号方式で交互に点滅するパターンにスイッチできる。このパターンへのスイッチは、到着するパイロットには、追い払うもので周回飛行をせよとの信号として解釈され得る。ストローブのパターンへの突然のスイッチは、飛行乗務員に瞬時に受け取られて、着陸手順を中止するのに間に合う。

【0043】カテゴリIIIの天候条件の間は、滑走路と



誘導路との視界が共に非常に悪い。現在では無線に基づいた着陸システムが用いられており、航空機を最終的なアプローチから滑走路に導く。いったん誘導路に至ると、空港ターミナルに到着するためにどの誘導路を使用すべきか必ずしも明らかではない。システム10では、メイン・コンピュータ26、28が、誘導路ランプ40を、カテゴリIIIの天候条件の間の地上で航空機を誘導する手段として制御する。誘導路ランプ40の強度は遠隔制御できるので、航空機の直前のランプを、ターミナルへその航空機を誘導する手段として強めたり点滅させることができる。

【0044】また、「ラビット」パターンの短いシーケンスを航空機の直前の誘導路ストロープにプログラムすることもできる。交点では、望まない経路ではランプがオフにされているか、又は、誘導路の進むべきセクションの入り口が点滅してパイロットにその方向を向かせるかがなされる。優れたシステムでは、もちろんのこと、航空機の直前にあるライトだけが制御されて、フィールド上のすべてのそれ以外のランプは通常モードのままに保たれる。

【0045】図9には、システム10（図1及び図5に示されている）の内部でのデータの流に関するブロック図が示されている。ソフトウェア・モジュールが示され、これが、中央コンピュータ・システム12のコンピュータ26、28内のデータを処理するのに用いられる。空港における航空機及びその他の車両の追跡は、コンピュータ26、28内にあるセンサ融合ソフトウェア・モジュール101の制御の下に行われる。センサ融合ソフトウェア・モジュール101は、複数のセンサ50からデータを受け取るが、個々のセンサ50は各エッジ・ライト・アセンブリ20<sub>1-n</sub>内に配置されていて検出された熱のレベルを報告し、ソフトウェア・モジュール101が、この情報を規則に基づく（rule based）人工知能を利用して合成し、空港におけるすべての地上交通の完全な画像を中央コンピュータ・システム12のディスプレイ30上に作成する。

【0046】追跡アルゴリズムは、放射の周辺の背景レベルよりも高い熱レベルを検出したセンサ50の第1の報告に基づき、追跡を開始する。この検出は、次に、第1の報告をしたセンサから進路を挟んで向き合っているセンサによって報告される熱レベルをチェックすることによって確認される。この第2の読み取りは、検出された車両を確認するのに用いられ、誤警報が回避される。車両が確認されると、第1の報告をしたセンサに隣接するセンサが、その検出された熱レベルの変化に関して質問される。隣接センサの中の1つが熱レベルの上昇を検出すると、直ちに車両の方向ベクトルを定めることができる。このプロセスは、車両がセンサからセンサへと、図7に示されるようなバケツリレーの方式で手渡されて行くように、継続する。車両の速度は、隣接するセンサ

間の車両検出の時間を計算することによって、おおよそ決定できる。この情報は、システムのデータベースからの各センサについての情報と組み合わせられて、目標の速度が計算される。高温の排気やジェット噴射が原因で、車両の後方にあるセンサは、すぐには背景レベルには戻らないこともある。この条件のために、アルゴリズムは、最初の4つのセンサ（誘導路の各側に2つ）だけを使用して車両の位置を計算する。車両は、進路のセンターライン上の第1の4つの報告を行うセンサの間にあると、常に想定される。

【0047】車両識別を、その位置で車両を識別できる自動化されたソースによって、手動又は自動で、追跡に付加できる。例としては、特定の滑走路上に次に着陸する航空機の、予めの知識である。車両が検出システムを去ると追跡も終了する。これは、2つの場合の内の1つとして起こる。第1は、車両がセンサ50のカバーするエリアから出た場合である。これは、車両追跡がゲートウェイ・センサの方向に移動し、ゲートウェイ・センサがコンタクトを失った後で検出が不足することにより決定される。検出システムを去る第2の場合は、追跡がセンサ・アレーの中間で失われる場合である。これは、航空機が出発する又は車両が草地に入り込むときに起こる。離陸のシナリオは、検出が失われる直前の車両の速度を計算することによって決めることができる。車両速度が上昇し回転速度を超えると、航空機が離陸したものと考えられる。そうでなければ、車両は草地に入り込んだものと考えられ、アラームが鳴る。

【0048】図5及び図9では、地上クリアランス・ルーティング機能を、コンピュータ26、28上で動いている地上クリアランス承諾確認装置ソフトウェア・モジュール103に従って、スピーチ認識ユニット33が実行する。このソフトウェア・モジュール103は、車両識別ルーチン、クリアランス経路ルーティング、クリアランス・チェック・ルーチン、及び、経路チェック・ルーチンを含む。

【0049】車両識別ルーチンは、スピーチ認識ユニット33から航空会社名とフライト番号（たとえば、デルタ374便）とを受け取るのに用いられ、ディスプレイ30上の空港のグラフィック表示上の当該航空機のアイコンを指し示す。

【0050】クリアランス経路ルーチンは、管制官の言葉の残余を聞き取り、空港を示すディスプレイ30上にクリアランスのグラフィック表示を与える。

【0051】クリアランス・チェック・ルーチンは、他のクリアランス及び車両との抵触の可能性のために、クリアランス経路をチェックする。抵触が見つかった場合には、侵入を引き起こす可能性のある経路の一部が、明滅する赤色で指し示され、音声による指示がスピーカ32を介して管制官に与えられる。

【0052】経路チェック・ルーチンは、クリアランス

経路がコンピュータ26、28に入力された後でセンサ50によって検出された車両の実際の経路をチェックし、何らかの逸脱に関して実際の経路を監視する。このルーチンが車両が指定されたコースから外れていることを検出した場合には、空港のグラフィック表示上の車両のアイコンは点滅し、音声による指示がスピーカー32を介して管制官に与えられ、またオプションであるが、無線機により車両のオペレータにも指示が与えられる。

【0053】空港車両侵入回避システム10は、コンピュータ26、28上で動いている衝突検出ソフトウェア・モジュール104内に存在する安全論理ルーチンの制御の下に動作する。安全論理ルーチンは、追跡装置ソフトウェア・モジュール102の位置プログラムを介して、センサ融合ソフトウェア・モジュール101からデータを受け取り、この情報を、規則に基づく人工知能を利用することによって解釈し、衝突や滑走路侵入の可能性を予測する。この情報は、次に、中央コンピュータ・システム12によって用いられて、管制塔の管制官、航空機のパイロット及びトラックのオペレータに、滑走路への侵入可能性に対する警告を与える。管制塔の管制官は、スピーカー32からのコンピュータ合成音声によるメッセージと共に、ディスプレイ30によって警告を受ける。地上交通は、交通ライト、フラッシュするライ

```
If (Runway_Status=Active),  
    then (Stop_Bar_Lights=RED) .
```

である。これは非常に単純で、簡単な規則である。この規則は、いかにしてRunway\_Statusが作られるか以外は、いかなる余分の知識も必要としない。次

```
If (Departure=APPROVED) or (Landing=IMMINENT),  
    then (Stop_Bar_Lights=RED) .
```

侵入検出のための別の規則とは、

```
If (Runway_Status=Active) and (Intersection=OCCUPIED),  
    then (Runway_Incursion=TRUE) .
```

次に、滑走路及び誘導路の交点が占領されていることを

```
If (Intersection_Sensor=DETECT),  
    then (Intersection=OCCUPIED) .
```

航空機が位置確保停止(Hold Position stop)をすることを予測するためには、次の規則が

```
If (Aircraft_Stopping_Distance>Distance_to_Hold_Position),  
    then (Intersection=OCCUPIED) .
```

プログラムの残りの部分に影響を与えないで規則の付加が可能であることを示すために、管制塔の管制官たちにシステム10のデモンストレーションをした後で、彼らが、自分たちで地上における安全違反を見つけた場合のためにこの規則に基づくソフトウェアに優位する「緊急

```
If (Panic_button=PRESSED),
```

ト、停止バー、その他の警告ライト34、ランプ40、48、及び、コンピュータ発生音声による無線機36を介しての放送によって警告される。

【0054】知識に基づく(knowledge based)問題はファジー問題とも呼ばれ、この問題の解決は、プログラム論理と、デシジョンツリー(decision tree)を動的に作り出すインターフェース手段(interface engine)との両者に依存し、特定の場面に於いてどちらの方法が最も適切であるかの選択が考慮される。規則に基づくシステムは、可能な応用例の範囲を拡大する。このシステムによれば、設計者たちは、判断や経験を組み入れることができるし、問題群全体を横断する一貫した解決アプローチをとることが可能になる。

【0055】規則に基づく侵入検出ソフトウェアのプログラミングは、非常に簡単なものである。規則は英語で書かれていて、専門家たち、ここでは管制塔の関係者とパイロットが、理解可能なレベルでシステムを検討することができる。規則に基づくシステムのもう1つの特徴は、規則が独立していることである。これらの規則は、コードの他の部分に影響を与えずに、付加、削除、修正が可能である。これは、スクラッチ(scratch)から作られたコードに関してはほとんど不可能である。我々が使用する規則の一例は、

に、Runway\_Statusに影響を与える規則をいくつか作ってみる。

【0056】

検出する規則は、

作られる。すなわち、

ボタン」を管制塔に設けてほしいと決定したと想定してみよう。ボタンを新たに設置すること以外に、次のもう1つの規則を加えるというのが唯一の変更である。すなわち、

then (Runway\_Incursion=TRUE) .

中央の規則に基づくコンピュータ・プログラムが作成し、理解し、修正することに関して非常に簡単であることが容易に理解されよう。侵入のタイプが定義されると、システム10は、より多くの規則を付加することによってグレードの向上が可能である。

【0057】再び図9において、ブロック図が、システム10（図1）内部の機能的成分間のデータの流れを示している。車両は、エッジ・ライト・アセンブリ20<sub>1-n</sub>のそれぞれにおけるセンサ50によって検出される。この情報は、エッジ・ライト・ワイアリング21<sub>1-n</sub>を介してLONネットワーク上を運ばれ、LONブリッジ22<sub>1-n</sub>に至る。個々のメッセージ・パケットは、次に、WANインターフェース108に達する広域ネットワーク（WAN）14上を、冗長コンピュータ26、28まで送られる。冗長コンピュータ26、28に到着した後では、メッセージ・パケットは、メッセージ・パーサー・ソフトウェア・モジュール100によってチェックされ、照合される。メッセージの内容は、次に、センサ融合ソフトウェア・モジュール101に送られる。センサ融合ソフトウェア・モジュール101は、空港にあるすべてのセンサ50の状態を追跡するのに用いられる。このソフトウェア・モジュールは、空港からのデータをフィルタし、照合して、メモリにセンサ・アレーの代表的な画像を格納する。この情報は、ディスプレイ30によって直接利用され、どのセンサが応答しており、また、追跡装置ソフトウェア・モジュール102によって用いられているかが示される。追跡装置ソフトウェア・モジュール102は、センサ状態の情報を用いて、どのセンサ50の報告が実際の車両に対応するかを判断する。更に、センサの報告及び状態が変化するにつれて、追跡装置ソフトウェア・モジュール102は車両の運動を識別して、目標位置及び方向出力を生じる。この情報は、ディスプレイ30によってスクリーン上に適切な車両アイコンを表示するのに用いられる。

【0058】車両の位置及び方向は、また、衝突検出ソフトウェア・モジュール104によっても用いられる。このモジュールは、地上のすべての車両をチェックして、それらの予想されるコースをプロットする。いずれかの2つの目標が交差する経路にいる場合には、このソフトウェア・モジュールは、ディスプレイ30、警告ライト34、対応するスピーカ32に結合されたスピーチ合成ユニット29、及び、アンテナ39に結合した無線機37に結合されたスピーチ合成ユニット31を使ってオペレータに警告を伝える。

【0059】更に図9において、目標所在及び位置データを更に利用するのは、地上クリアランス承諾確認装置ソフトウェア・モジュール103である。このソフトウェア・モジュール103は、スピーチ認識ユニット33を介しての管制官のマイクロフォン35からの地上クリ

アランス命令を受け取る。クリアランスがなされたルートがいったん決定されると、それは地上クリアランス承諾確認装置ソフトウェア・モジュール103に格納され、車両が実際にとるルートと比較するのに用いられる。追跡装置ソフトウェア・モジュール102から受け取った情報が車両は指定されたコースから外れていることを示す場合には、このソフトウェア・モジュール103は、ディスプレイ30、警告ライト34、スピーカ32に結合されたスピーチ合成ユニット29、及び、アンテナ39に結合した無線機37に結合されたスピーチ合成ユニット31を使ってオペレータに警告を伝える。

【0060】キーボード27は、キーボード・パーサー・ソフトウェア・モジュール109に接続されている。命令がこのキーボード・パーサー・ソフトウェア・モジュール109によって確認されると、それは、ディスプレイ30のオプションを変更し、センサ及びネットワーク・パラメータを再構成するのに用いられる。ネットワーク構成データベース106は、これらの再構成命令によって更新される。この情報は、次に、命令メッセージ発生器107によってLONメッセージ・パケットに向けられ、WANインターフェース108及びLONブリッジ22<sub>1-n</sub>を介して、エッジ・ライト・アセンブリ20<sub>1-n</sub>に送られる。

【0061】これで、好適実施例の説明を終わる。しかし、この発明の技術思想から離れることなく多くの修正や改変が当業者には明白であろう。従って、本発明の範囲は、冒頭の特許請求の範囲によってのみ画定されるものとする。

#### 【図面の簡単な説明】

【図1】空港車両侵入回避システムの発明のブロック図である。

【図2】エアフィールド・ライティング・システムのエッジ・ライトに結合されたセンサ電子ユニットを示すエッジ・ライト・アセンブリのブロック図である。

【図3】センサ電子ユニットの上部に位置するエッジ・ライトを示すエッジ・ライト・アセンブリの図解である。

【図4】ここに示した様々なサイズの航空機を検出するために、滑走路又は誘導路の両側に沿って配置された複数のエッジ・ライト・アセンブリを有する、エアフィールドの滑走路又は誘導路の図解である。

【図5】図1に示した中央コンピュータ・システムのブロック図である。

【図6】エッジ・ライト・アセンブリのマイクロプロセッサと、センサ、ライト及びストロブ・ライトとのインターフェースのためのプログラミングに用いられる11個のネットワーク変数である。

【図7】滑走路又は誘導路に沿って位置するセンサ電子ユニットをそれぞれが含む、滑走路の両側に配置された

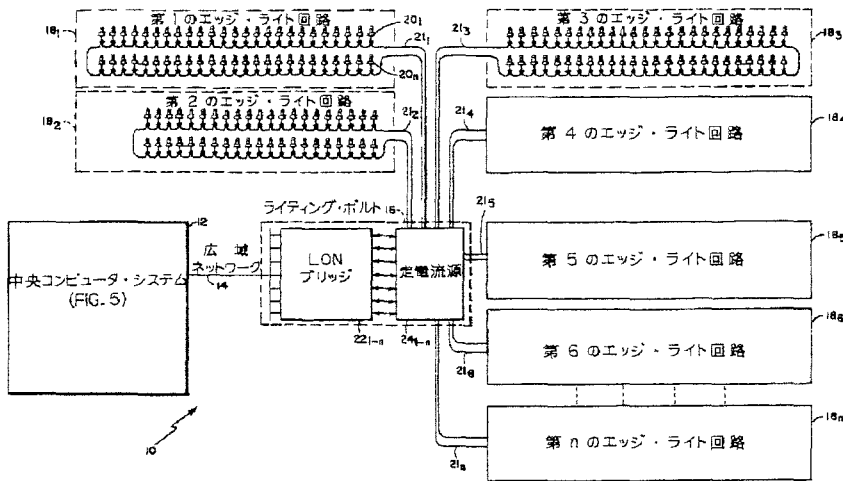
複数のエッジ・ライト・アセンブリのためのネットワーク変数の相互接続を示している。

【図8】 管制塔にいるオペレータの見た空港の一部分における典型的な誘導路/滑走路のグラフィック表示であり、この表示は、滑走路及び誘導路にそって配置され

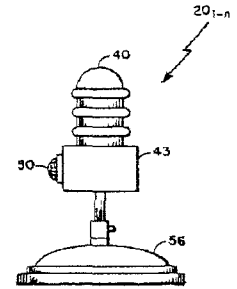
たエッジ・ライト・アセンブリに設置されたセンサによって検出された車両の位置を示している。

【図9】 図1及び図5に示したシステム内のデータの流れのブロック図である。

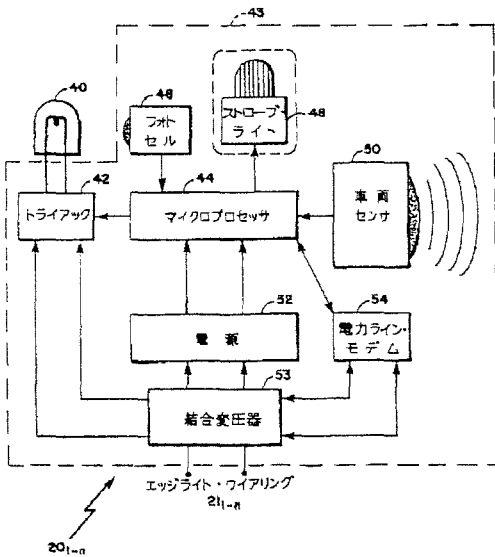
【図1】



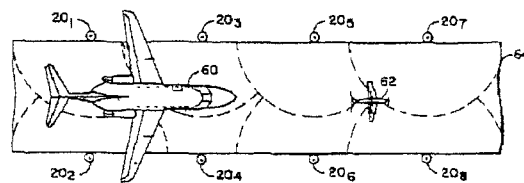
【図3】



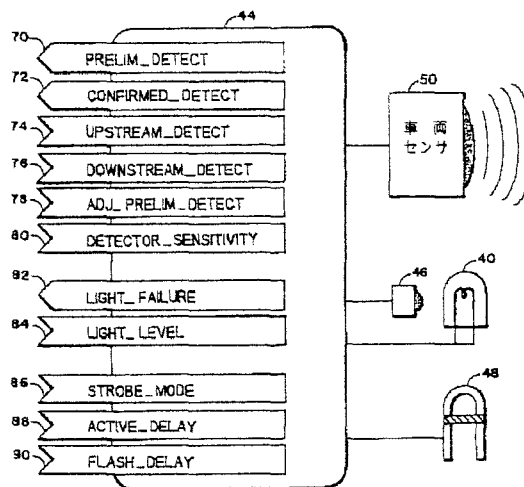
【図2】



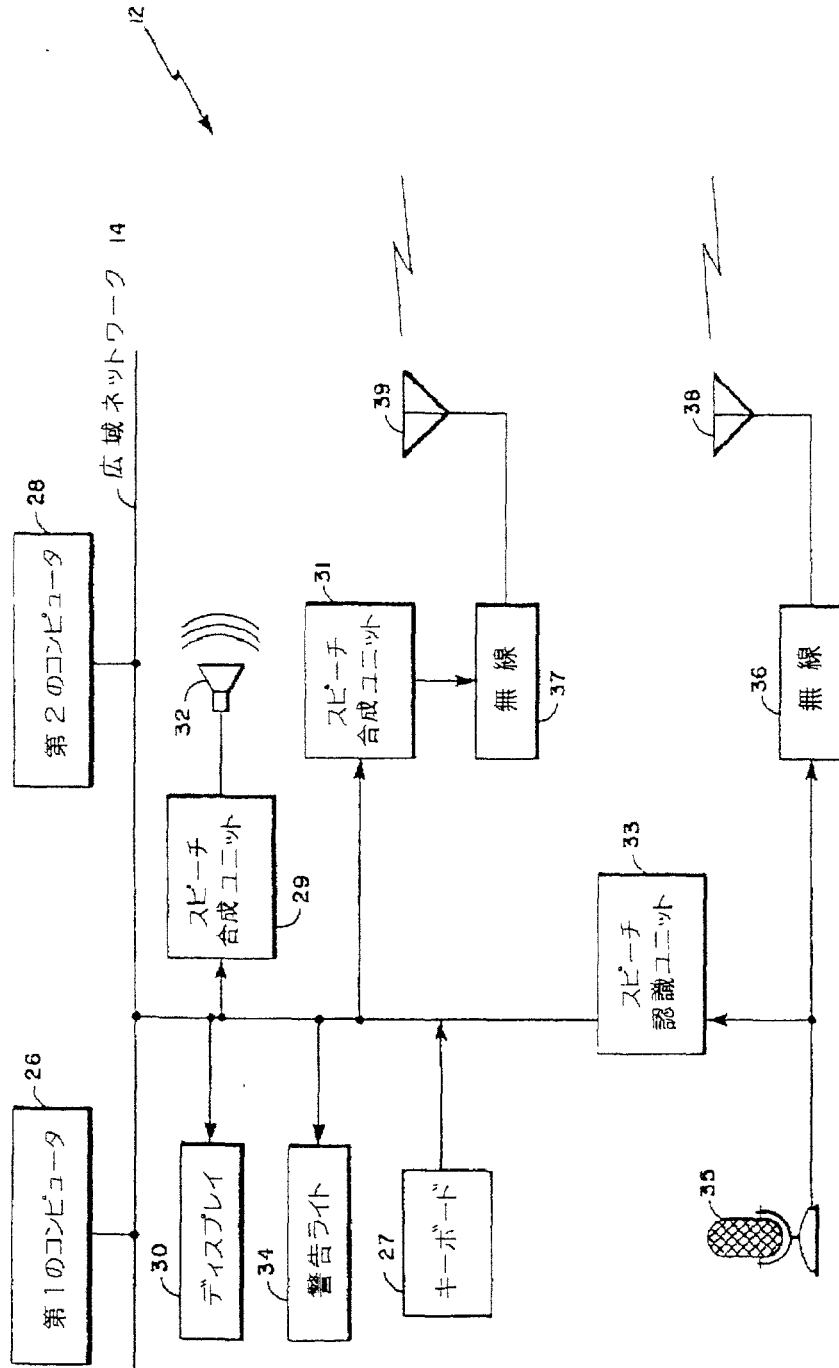
【図4】



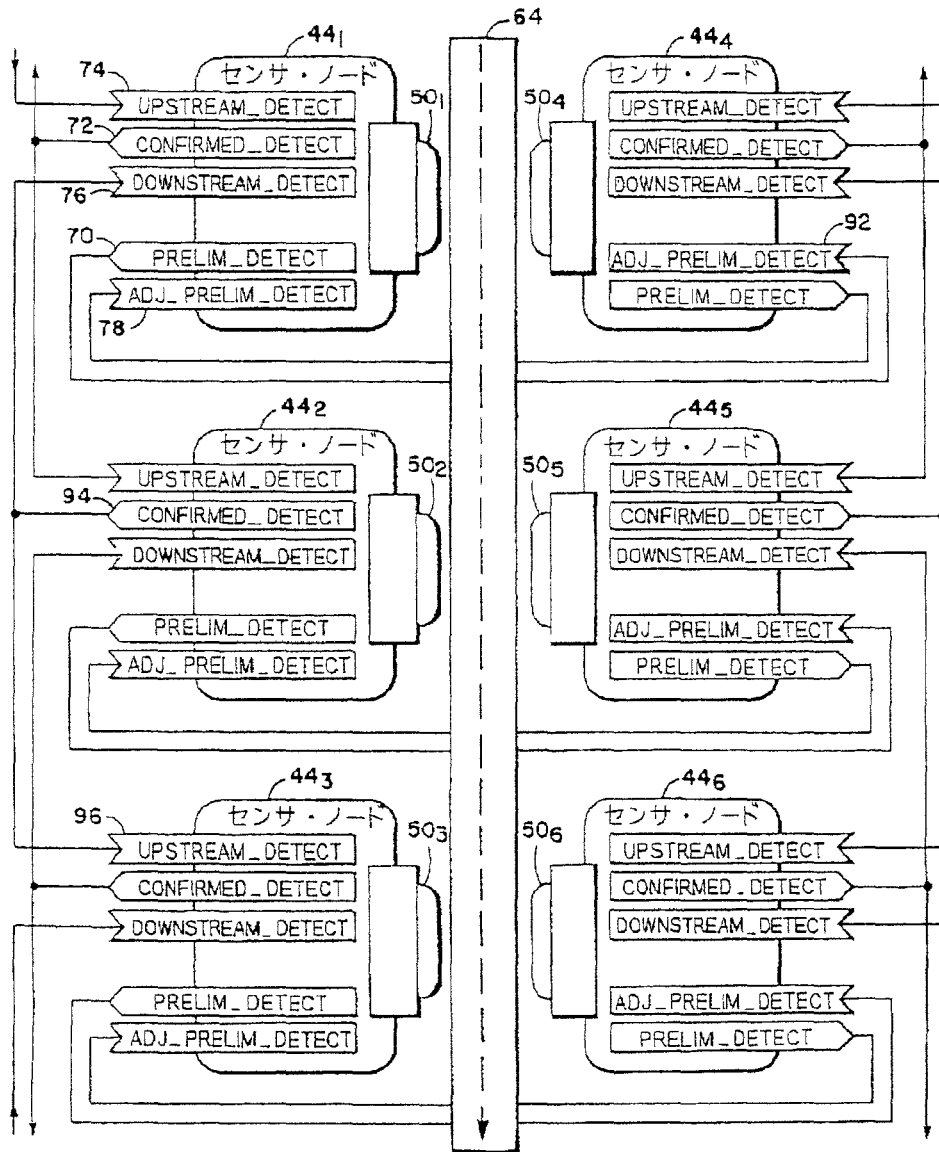
【図6】



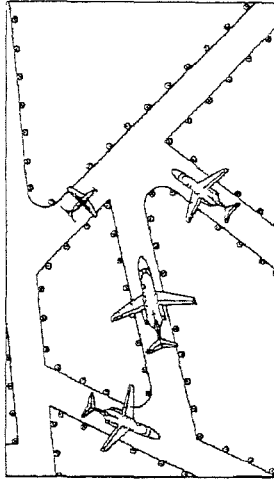
【図5】



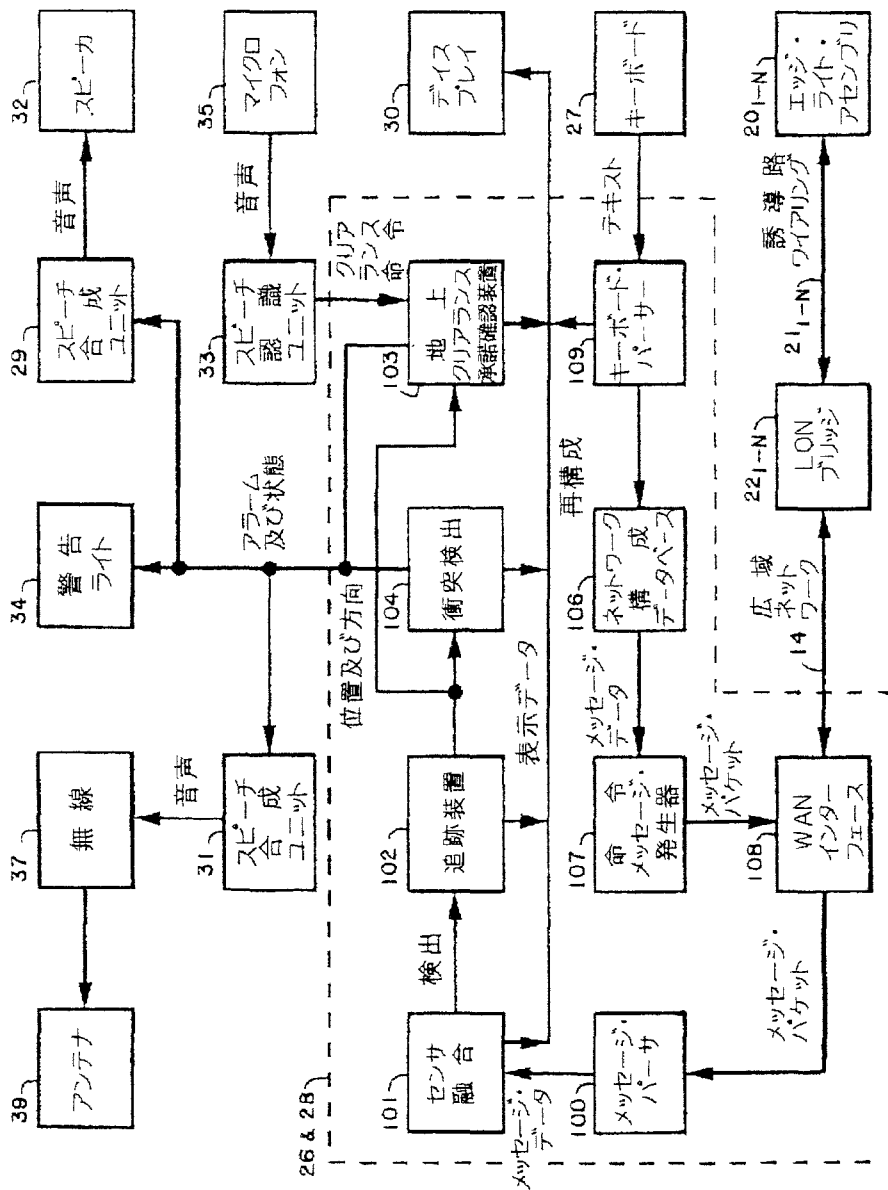
【図7】



【 8 】



【図9】





# PATENT ABSTRACTS OF JAPAN

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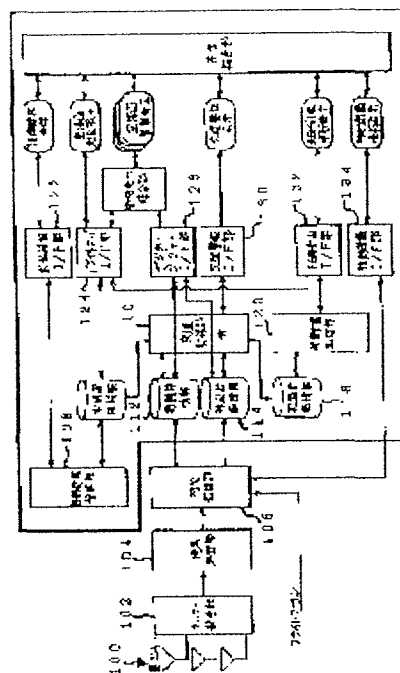
(22)Date of filing : 10.04.1996 (72)Inventor : HASEGAWA TAKAYUKI  
KIMURA HIROSHI

## (54) SYSTEM FOR MONITORING TRAFFIC OF OBJECTS MOVING ON GROUND OF AIRPORT

(57)Abstract:

PROBLEM TO BE SOLVED: To more safely monitor the traffic of objects moving on the ground of an airport by issuing an alarm, only when a monitor level set based on the state of jamming and the condition of a visual range is higher than a threshold value at the time of detecting any abnormal state.

SOLUTION: A sensor integrating part 102 is provided, inputs from plural sensors 100 are integrated by the sensor integrating part 102, and the respective moving objects are extracted. Then, the coordinate data of respective moving objects extracted by the sensor integrating part 102 are supplied to a tracking processing part 104, and the moving objects are monitored. Such a device is provided with a jamming state detecting means for the airport, a visual range condition detecting means for detecting the visual range conditions, a monitor level setting means for setting the monitor level based on the jamming state and the visual range condition, and a warning means for issuing the alarm, only when the set monitor level is higher than the prescribed threshold value at the time point of detecting the abnormal state. Thus, the alarm is effectively suppressed by changing the threshold value.



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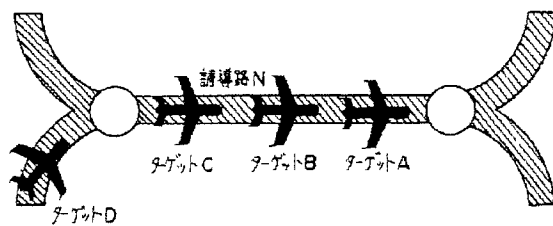
(74) 代理人 弁理士 吉田 研二 (外2名)

(54) 【発明の名称】 空港面移動体交通監視装置

(57) 【要約】

【課題】 空港面上の移動体の交通監視をより安全に行うことが可能な空港面移動体交通監視装置を提供する。

【解決手段】 各誘導路毎に、その誘導路を同時に共用可能な移動体数がシステムの記憶装置内に記憶されている。そして、在る移動体Dがこれから進入使用とする誘導路を使用している移動体数が、その誘導路の共用可能な移動体数と等しい場合には、新たな移動体Dの進入は制限され、移動体Dは待ち状態となる。例えば、誘導路の共用可能な移動体数が3であり、既に移動体A、B、Cが誘導路内に存在するときは新たな移動体Dは待たされるのである。



【特許請求の範囲】

【請求項1】 空港の混雑状態検出手段と、  
視程条件を検出する視程条件検出手段と、  
前記混雑状態と、前記視程条件とに基づき、監視レベルを設定する監視レベル設定手段と、  
異常状態を検出した場合、前記設定された監視レベルが所定のしきい値より高い時にのみ警報を出力する警報出力手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項2】 空港における移動体が移動する経路である経路計画の候補を格納する候補記憶手段と、  
各移動体に対して、その移動体が利用する経路計画を前記候補記憶手段から読み出し、この読み出した経路計画の内、最適な経路計画を算出する最適経路計画算出手段と、

前記最適経路計画算出手段により算出された最適な経路計画を各移動体に対して割り当てる割り当て手段と、  
を含むことを特徴とする空港面移動体交通監視装置。

【請求項3】 前記最適経路計画算出手段は、少なくとも、前記移動体の移動開始地点及び終了地点に基づき、前記最適な移動経路を算出する開始終了地点考慮手段、  
を含むことを特徴とする請求項2記載の空港面移動体交通監視装置。

【請求項4】 空港における移動体が履行する経路計画の履行状況を監視する空港面移動体交通監視装置において、

前記経路計画を履行する前記移動体の個数を記憶する経路計画状態記憶手段、を含み、

前記最適経路算出手段は、

前記経路計画状態記憶手段に記憶されている前記移動体数を参照し、この移動体数がその経路計画の同時利用可能移動体数より小さい経路計画のみを、前記移動体に割り当てる第1選択割り当て手段、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項5】 空港における移動体が履行する経路計画の履行状況を監視する空港面移動体交通監視装置において、

前記経路計画を履行する前記移動体の個数を記憶する経路計画状態記憶手段、を含み、

前記最適経路算出手段は、

前記経路計画状態記憶手段に記憶されている前記移動体数を参照し、この経路計画に含まれる誘導路を利用する予定の移動体数を誘導路毎に記憶する誘導路混雑状態把握手段と、

前記誘導路混雑状態把握手段に記憶されている前記移動体数を参照し、この移動体数がその誘導路の同時利用可能移動体数より小さい誘導路のみを含む経路計画のみを、前記移動体に割り当てる第2選択割り当て手段と、  
を含むことを特徴とする請求項2記載の空港面移動体交通監視装置。

【請求項6】 空港における移動体に割り当てられた経路計画が変更された場合に、変更前の経路計画と、変更後の経路計画とに共通に含まれる共通設備を検索する共通設備検索手段と、

前記変更前の経路計画の前記共通設備までの経路と、前記変更後の経路計画の前記共通設備から終了地点までの経路とを、結合して新たな経路計画を作成する新規経路計画作成手段と、

前記作成された新規経路計画を前記移動体に新たに割り当てる新規経路計画割り当て手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項7】 空港における移動体が、前記移動体毎に割り当てられた経路計画であって、前記移動体が移動すべき設備の順序情報を含む経路計画を、前記対応する移動体が正しく履行しているか否かを監視する装置において、

前記移動体が現在移動している設備と、その移動体が現在実施している経路計画中の設備と、を比較する比較手段と、

前記比較手段の比較の結果、不一致の場合には警告を発行する警告発行手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項8】 空港面の所定の移動体が新たに誘導路に進入しようとする場合に、前記誘導路の共用可能移動体数と、現在前記誘導路を使用している移動体数とを比較する比較手段と、

前記比較手段による比較の結果、前記共用可能移動体数の方が大きい場合にのみ、前記所定の移動体が新たに前記誘導路に進入することを許可する進入許可手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項9】 空港面の所定の移動体が誘導路を移動する場合に、前記誘導路における前記移動体の進行方向側の端部である第1交通ノードの交通ノード属性情報として、進入禁止状態を設定する進入禁止状態設定手段と、  
前記誘導路に対し、前記第1交通ノードから他の移動体が進入しようとした場合に、前記第1交通ノードに進入禁止状態が設定されている場合には、前記他の移動体の進入を禁止する進入禁止手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項10】 2個の誘導路が近接しているため、一方の誘導路の第1の交通ノードから移動体が進入し、他方の誘導路の第2の交通ノードから移動体が進入した場合に、衝突が発生する関係にある前記第1及び第2の交通ノードに同一グループを設定するグループ設定手段と、

空港面の所定の移動体が誘導路を移動する場合に、前記誘導路における前記移動体が向かっている方向側の端部である第3交通ノードと同一グループが設定されている他の交通ノードの交通ノード属性情報として、進入禁止状態を設定する進入禁止状態設定手段と、

前記誘導路に対し、前記他の交通ノードから他の移動体が進入しようとした場合に、前記交通ノードに進入禁止の属性が設定されている場合には、前記他の移動体の進入を禁止する進入禁止手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項11】 移動体の位置を検出する移動体位置検出手段と、

滑走路を含む一定の領域であって、滑走路に対し進入する移動体の監視を開始する領域である滑走路監視レベルエリアに、移動体が進入した場合であって、他の移動体がこの滑走路監視レベルエリアに存在しない場合には、その滑走路を前記滑走路レベルエリアに進入した前記移動体に占有させる占有状態設定手段と、

滑走路を含む一定の領域であって、滑走路に対し進入する移動体に対し警報を発行する基準領域である警報レベルエリアに、前記移動体が進入した場合であって、他の移動体が既に前記滑走路を占有している場合には、警報を発行する警報発行手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項12】 移動体の位置を検出する移動体位置検出手段と、

交差点を含む一定の領域であって、滑走路に対し進入する移動体の監視を開始する領域である交通監視レンジに、移動体が進入した場合であって、他の移動体がこの交差点に存在しない場合にのみ、前記交差点を前記交通監視レンジレベルに進入した移動体に占有させる占有状態設定手段と、

交差点の領域を意味する一定の領域であって、交差点に対し進入する移動体に対し警報を発行する基準領域である範囲レンジに、前記移動体が進入した場合であって、他の移動体が既に前記交差点を占有している場合には、警報を発行する警報発行手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【請求項13】 空港面のデジタルマップを表示するデジタルマップ表示手段と、

各誘導路の混雑状態を検出する混雑状態検出手段と、前記各誘導路の中心線の太さを、前記混雑状態検出手段によって検出された前記各誘導路の混雑状況に比例して変化させて表示する中心線表示手段と、

を含むことを特徴とする空港面移動体交通監視装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、空港における移動体の交通監視に関する。特に、管制官の交通監視を補助し、管制官のワークロードを減少しうる空港面移動体交通監視システムに関する。

【0002】

【従来の技術】従来、空港の移動体の交通監視には、種々の装置が用いられているが、最終的な航空機に対する指示は管制官による音声によって行われている場合がほ

とんどである。そのため、離発着量が増大してくると、管制官による航空機等の円滑な誘導が困難になる場合が生じる。

【0003】このような問題に対処するため、管制官の交通監視を補助する種々の装置が提案されている。

【0004】例えば、特開昭53-131698号公報には、交差点におけるインターロック機能により、交差点における衝突を防止する装置が開示されている。又、移動体検出器の検出信号に基づいて、最適経路を選定し、この選定に基づく指令を自動的にボイス合成器にによって発信しうる管制システムが開示されている。

【0005】又、特開平2-208800号公報には、誘導路の交差点間の区間の入り口と出口にセンサを設け、その区間内の航空機数を計数することが可能な装置が開示されている。航空機数が計数できるため、円滑な地上交通制御を行うことが可能であるとされている。

【0006】又、特開平3-144800号公報には、エプロンから誘導路へ、誘導路からエプロンへとスルーした航行援助を行うことができ、管制官の負担を軽減させることが可能な装置が開示されている。

【0007】又、特開平4-49500号公報には、着陸時の離脱誘導路及び走行ルートを最適に自動決定でき、管制官の負担軽減及び空港の安全性の向上、運用効率の向上を図ることを可能とする装置が開示されている。

【0008】又、特開平4-302400号公報には、交差点における移動体の管制を行い、衝突を防止しうる装置が開示されている。

【0009】又、特開平6-336712号公報には、空港のタクシーウェイにおける衝突防止システムが開示されている。

【0010】特に、衝突を防止するという点に関しては、以下の従来技術が知られている。

【0011】例えば、特開平4-170000号公報には、空港滑走路に出る手前の誘導路上にあるストップバー灯等の点灯を行い、管制官の負担を軽減しつつ、航空機の衝突の発生を確実に防止しうる装置について開示されている。

【0012】又、特開平4-245400号公報には、空港の誘導路から滑走路への進入口付近に接地され、滑走路への進入禁止・許可を航空機の機長へ表示する信号灯等を含む装置が開示されている。この装置によれば、管制官の業務負担の減少が図れると記載されている。

【0013】又、特開平5-469500号公報には、滑走路に他の航空機がいることを、着陸しようとする航空機のパイロットに灯火により知らせることが可能な装置が開示されている。

【0014】又、特開平5-131997号公報には、自動的に誘導灯の点灯・消灯制御を行うことにより、管制官の誤判断を防止しうる装置が開示されている。

【0015】又、特開平5-159200号公報には、先行航空機が誘導路中に存在する場合には後続航空機を誘導路に進入させることのないフェールセーフ性の高い航空誘導表示装置が開示されている。

【0016】又、特開平5-155100号公報には、空港内及びその周辺の航空機の所在位置を、種々の機器を用いて表示管制することにより、管制官の負担を軽減しうる装置が開示されている。

【0017】又、特開平5-197900号公報には、飛行場における案内標識板であって、光表示素子が埋め込まれて、信頼性が向上した案内標識板が開示されている。

【0018】又、特開平7-37200号公報には、誘導路に存在する障害物の識別確度を向上した装置が開示されている。

【0019】

【発明が解決しようとする課題】このように種々の装置が空港面における交通監視のために提案されている。

【0020】しかしながら、異常状態が発生した場合に、その異常のレベル、危険度のレベルに応じて警報を発行するか否かを決定しうる交通監視装置は従来は存在しなかった。

【0021】又、空港内において各移動体の経路計画は管制官により割り当てられていたが、これを自動的に割り当てる装置は未だ存在していない。

【0022】又、空港において各移動体に割り当てられた経路計画に変更が生じた場合、現在履行している経路計画から変更後の経路計画に円滑に移行することは困難であった。

【0023】又、空港において各移動体が割り当てられた経路計画をそれに従って履行しているか否かを監視する装置は未だ実現されていなかった。

【0024】さらに、誘導路を利用している移動体の個数を考慮して交通監視を行うことは従来は困難であった。

【0025】又、空港の誘導路は全て一方通行であるため、誘導路の一端からある移動体が進出した場合は、他端からの他の移動体の進入を禁止しなければならない。しかし、このような禁止を効率的に行える監視装置は未だ実現されていない。

【0026】又、近接している誘導路においては、ある誘導路を移動体を使用している場合に、その近接する誘導路を他の移動体を使用すると2個の移動体はその側面において衝突する可能性がある。このようないわゆる横方向の衝突防止を効果的に実行することは従来困難である。

【0027】又、滑走路や交差点等への進入を排他的に行うことにより衝突を防止することが知られているが、占有状態と警報の発行とを1つの領域を基準にしているため、円滑な交通監視をすることができなかった。

【0028】又、空港面の誘導路の混雑状況を効率的に

把握することも困難であった。

【0029】本発明は、上記課題に鑑みなされたものであり、その目的は、空港面における交通に異常が発生した場合に発生する警報の発行を、監視レベルに応じて抑止可能な装置を提供することである。

【0030】又、本発明の他の目的は、移動体毎に経路情報を自動的に割り付けることが可能な装置を提供することである。

【0031】本発明の他の目的は、経路計画がどのように履行されているか否かを監視しうる装置を提供することである。

【0032】本発明の他の目的は、経路計画が天候の変化などにより途中で変更された場合、例えば滑走路の変更などの場合にも円滑な経路計画の変更が可能な装置を提供することである。

【0033】

【課題を解決するための手段】第1の本発明は、上記課題を解決するために、空港の混雑状態検出手段と、視程条件を検出する視程条件検出手段と、前記混雑状態と、前記視程条件とに基づき、監視レベルを設定する監視レベル設定手段と、異常状態を検出した場合、前記設定された監視レベルが所定のしきい値より高い時のみ警報を発行する警報発行手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0034】警報発行手段は、所定のしきい値より監視レベルが高いときのみ警報を出力するため、所定のしきい値を上昇させることにより、警報を発行しにくくすることが可能である。

【0035】尚、混雑状態は、例えば、誘導路中のその時点の空港面上に存在する飛行機数又は、当空港に離発着する予定の飛行計画の推移で判断する等の手法が好適である。又、上記所定のしきい値は、時間帯によって変化させることも好適である。例えば、夜間はしきい値を下げ、監視レベルの僅かな上昇でも警報を発行するようにし、一方、昼間は警報を発行しにくくすることも好適である。

【0036】又、視程に関しては、操作者が視程を計測し、本発明の装置に入力した後、視程条件検出手段によって一定の視程条件に変換するのが好適であるが、視程そのものを検出する手段を設け、自動的に視程条件を算出する構成としても良い。

【0037】第2の本発明は、上記課題を解決するために、空港における移動体が移動する経路である経路計画の候補を格納する候補記憶手段と、各移動体に対して、その移動体を利用しうる経路計画を前記候補記憶手段から読み出し、この読み出した経路計画の内、最適な経路計画を算出する最適経路計画算出手段と、前記最適経路計画算出手段により算出された最適な経路計画を各移動体に対して割り当てる割り当て手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0038】割り当て手段が自動的に経路計画を割り当てる。この割り当てられた経路計画は、航空機のパイロットに自動で伝達するのも好適であり、又、割り当てられた経路計画を管制官が読み上げるにより音声でパイロットに伝達することも好適である。

【0039】又、前記最適経路計画算出手段は、少なくとも、前記移動体の移動開始地点及び終了地点に基づき、前記最適な移動経路を算出する開始終了地点考慮手段、を含むことを特徴とするのも好適である。

【0040】このような構成により、開始地点と終了地点とに基づき、自動的に候補となる経路計画を迅速に検索可能である。

【0041】又、第2の本発明では、経路計画が自動的に割り当てられる構成を示したが、空港における移動体が移動する経路である経路計画の候補を格納する候補記憶手段と、移動体に対して、その移動体を利用する経路計画を前記候補記憶手段から読み出し、この読み出した経路計画を表示する表示手段と、を含むことを特徴とする空港面移動体交通監視装置とすることも好適である。

【0042】単に1個以上の候補を表示するだけでも、管制官に係る候補から所望の経路計画を選ぶことにより、管制官の大幅な負担の軽減を図ることが可能である。

【0043】尚、この表示は、例えばリスト表示とすることが好適であり、又、この表示手段は、前記読み出した経路計画を最適である順序、例えば、所用時間が短い順序などの優先順序に基づき表示を行うことも可能である。このような表示をすることにより、管制官は最適な経路計画を容易に選択することが可能である。

【0044】又、この表示には、その経路計画を現在利用している（その経路計画が現在割り当てられている）移動体の個数も併せて表示するのも管制官に対する好適な判断材料の提示となる。

【0045】第3の本発明は、上記課題を解決するために、前記最適経路計画算出手段は、少なくとも、前記移動体の移動開始地点及び終了地点に基づき、前記最適な移動経路を算出する開始終了地点考慮手段、を含むことを特徴とする第2の本発明の空港面移動体交通監視装置である。

【0046】第3の本発明によれば、このような構成により、開始地点と終了地点とに基づき、自動的に候補となる経路計画を迅速に検索可能である。

【0047】第4の本発明は、上記課題を解決するために、空港における移動体が履行する経路計画の履行状況を監視する空港面移動体交通監視装置において、前記経路計画を履行する前記移動体の個数を記憶する経路計画状態記憶手段、を含み、前記最適経路算出手段は、前記経路計画状態記憶手段に記憶されている前記移動体数を参照し、この移動体数とその経路計画の同時利用可能移

動体数より小さい経路計画のみを、前記移動体に割り当てる第1選択割り当て手段、を含むことを特徴とする空港面移動体交通監視装置である。

【0048】このように、第4の本発明によれば、第1選択割り当て手段はその経路計画を同時に使用できる移動体数に鑑みて経路情報の割り当てを行ったので、誤って、特定の経路計画のみが混雑してしまうことがない。

【0049】第5の本発明は、上記課題を解決するために、空港における移動体が履行する経路計画の履行状況を監視する空港面移動体交通監視装置において、前記経路計画を履行する前記移動体の個数を記憶する経路計画状態記憶手段、を含み、前記最適経路算出手段は、前記経路計画状態記憶手段に記憶されている前記移動体数を参照し、この経路計画に含まれる誘導路を利用する予定の移動体数を誘導路毎に記憶する誘導路混雑状態把握手段と、前記誘導路混雑状態把握手段に記憶されている前記移動体数を参照し、この移動体数とその誘導路の同時利用可能移動体数より小さい誘導路のみを含む経路計画のみを、前記移動体に割り当てる第2選択割り当て手段と、を含むことを特徴とする請求項2記載の空港面移動体交通監視装置である。

【0050】このように、第2選択割り当て手段はその経路計画に含まれる誘導路が、その誘導路を同時に使用できる移動体数以上の移動体に既に使用されている場合には、その経路計画は割り当ての候補からはずしている。そのため、特定の誘導路のみが混雑してしまうという状況を防止することが可能である。

【0051】尚、経路計画の選択手段（選択割り当て手段）として、航空機の型式又は、後方乱気流区分に基づき、選択を行う手段を採用することも好適である。

【0052】ここで、航空機の型式は、飛行計画（フライトプラン）で示される。経路計画候補に使用可能な航空機のクラス情報が、例えば後述する図21の経路計画情報テーブルに保持されるように構成するのが好ましい。

【0053】航空機の型式に関する説明図が図57に示されている。この図に示されるように、出発機の場合に、小型機は、離陸に要する滑走路長は短くてすむが、大型機は長い。このため、滑走路への進入地点が異なり、経路も変化する。

【0054】さらに経路計画の選択手段は、経路計画上の走行経路の交差のチェックも行うのが好ましい。

【0055】第6の本発明は、上記課題を解決するために、空港における移動体に割り当てられた経路計画が変更された場合に、変更前の経路計画と、変更後の経路計画とに共通に含まれる共通設備を検索する共通設備検索手段と、前記変更前の経路計画の前記共通設備までの経路と、前記変更後の経路計画の前記共通設備から終了地点までの経路とを、結合して新たな経路計画を作成する新規経路計画作成手段と、前記作成された新規経路計画

を前記移動体に新たに割り当てる新規経路計画割り当て手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0056】このように、第6の本発明によれば新規経路計画作成手段が、変更前の経路計画と、変更後の経路計画とを合成し、新規経路計画を作成するので、経路計画の変更を円滑に行うことが可能である。

【0057】第7の本発明は、上記課題を解決するために、空港における移動体が、前記移動体毎に割り当てられた経路計画であって、前記移動体が移動すべき設備の順序情報を含む経路計画を、前記対応する移動体が正しく履行しているか否かを監視する装置において、前記移動体が現在移動している設備と、その移動体が現在実施している経路計画中の設備と、を比較する比較手段と、前記比較手段の比較の結果、不一致の場合には警告を発行する警告発行手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0058】第7の本発明においては、比較手段によって、経路計画と実際に移動している設備の内容とが比較される。その結果、異常状態を迅速に検出可能である。

【0059】第8の本発明は、上記課題を解決するために、空港面の所定の移動体が新たに誘導路に進入しようとする場合に、前記誘導路の共用可能移動体数と、現在前記誘導路を使用している移動体数とを比較する比較手段と、前記比較手段による比較の結果、前記共用可能移動体数の方が大きい場合のみ、前記所定の移動体が新たに前記誘導路に進入することを許可する進入許可手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0060】第8の本発明の進入許可手段は、誘導路の共用可能移動体数以上の個数の移動体の誘導路への進入を許可しないため、誘導路の混雑を未然に防止することが可能である。

【0061】又、空港面の誘導路毎にその誘導路を使用している使用中移動体数と、その誘導路を使用しうる最大の移動体数と、を記憶する記憶手段と、所定の誘導路に移動体が新たに進入した場合に、前記所定の誘導路を使用している前記使用中移動体数を1インクリメントするインクリメント手段と、前記所定の誘導路から移動体が離脱した場合に、前記所定の誘導路を使用している前記使用中移動体数を1デクリメントするデクリメント手段と、を含むことを特徴とする第8の本発明の空港面移動体交通監視装置とすることも好適である。

【0062】このように、誘導路毎に、その誘導路への移動体の進入及び誘導路からの離脱に際して、使用している移動体数の管理を行っているため、誘導路の混雑をより正確に防止可能である。

【0063】上記第8の本発明においては、航空機等の移動体の大きさを考慮していないが、実際にはその航空機のエンジンの後風（バックブラスト）等を考慮するの

が望ましい。例えば、大型の旅客機の後ろに小型のビジネスジェット機等が近接して位置すると、大型の旅客機の風の影響を大きく受けてしまい、安全な移動が困難になる場合も生じるのである。係る場合は単なる移動体の個数の合計ではなく、一定の重み付けを行った重みづけ合計値を用いるのが望ましい。

【0064】第9の本発明は、上記課題を解決するために、空港面の所定の移動体が誘導路を移動する場合に、前記誘導路における前記移動体の進行方向側の端部である第1交通ノードの交通ノード属性情報として、進入禁止状態を設定する進入禁止状態設定手段と、前記誘導路に対し、前記第1交通ノードから他の移動体が進入しようとした場合に、前記第1交通ノードに進入禁止状態が設定されている場合には、前記他の移動体の進入を禁止する進入禁止手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0065】空港面の誘導路は何れかの方向に常に一方通行であるため、誘導路に移動体が存在する場合には、その移動体の移動方向と逆の進行方向の移動体はその誘導路に進入することはできない。

【0066】第10の本発明は、上記課題を解決するために、2個の誘導路が近接しているため、一方の誘導路の第1の交通ノードから移動体が進入し、他方の誘導路の第2の交通ノードから移動体が進入した場合に、衝突が発生する関係にある前記第1及び第2の交通ノードに同一グループを設定するグループ設定手段と、空港面の所定の移動体が誘導路を移動する場合に、前記誘導路における前記移動体が向かっている方向側の端部である第3交通ノードと同一グループが設定されている他の交通ノードの交通ノード属性情報として、進入禁止状態を設定する進入禁止状態設定手段と、前記誘導路に対し、前記他の交通ノードから他の移動体が進入しようとした場合に、前記交通ノードに進入禁止の属性が設定されている場合には、前記他の移動体の進入を禁止する進入禁止手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0067】このように、進入方向によっては衝突が生じてしまう任意の誘導路に対してグループを設定することにより、近接している誘導路上で移動体が近接しているため衝突が生じてしまうことを防止することができる。

【0068】尚、グループ化は上記関係にある全ての2個の誘導路に対して行われるが、3個の交通ノードに対して纏めて1個のグループ化を行っても良い。

【0069】第11の本発明は、上記課題を解決するために、移動体の位置を検出する移動体位置検出手段と、滑走路を含む一定の領域であって、滑走路に対し進入する移動体の監視を開始する領域である滑走路監視レベルエリアに、移動体が進入した場合であって、他の移動体がこの滑走路監視レベルエリアに存在しない場合には、



その滑走路を前記滑走路レベルエリアに進入した前記移動体に対し占有させる占有状態設定手段と、滑走路を含む一定の領域であって、滑走路に対し進入する移動体に対し警報を発行する基準領域である警報レベルエリアに、前記移動体が進入した場合であって、他の移動体が既に前記滑走路を占有している場合には、警報を発行する警報発行手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0070】本発明においては、滑走路をいわゆる排他使用するための「占有」状態の判断のための基準となるエリアと、警報を発行するためのいわゆる禁止エリアとしてのエリアと、2個に分けて監視を行っている。そのため、進入の禁止と警報の発行等を効率よく行うことが可能である。

【0071】第12の本発明は、上記課題を解決するために、移動体の位置を検出する移動体位置検出手段と、交差点を含む一定の領域であって、滑走路に対し進入する移動体の監視を開始する領域である交通監視レンジに、移動体が進入した場合であって、他の移動体がこの交差点に存在しない場合のみ、前記交差点を前記交通監視レンジレベルに進入した移動体に占有させる占有状態設定手段と、交差点の領域を意味する一定の領域であって、交差点に対し進入する移動体に対し警報を発行する基準領域である範囲レンジに、前記移動体が進入した場合であって、他の移動体が既に前記交差点を占有している場合には、警報を発行する警報発行手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0072】本発明は、滑走路の排他使用と同様の原理を交差点に対して行ったものであり、その作用は上記第11の本発明とほぼ同様である。

【0073】第13の本発明は、上記課題を解決するために、空港面のデジタルマップを表示するデジタルマップ表示手段と、各誘導路の混雑状態を検出する混雑状態検出手段と、前記各誘導路の中心線の太さを、前記混雑状態検出手段によって検出された前記各誘導路の混雑状況に比例して変化させて表示する中心線表示手段と、を含むことを特徴とする空港面移動体交通監視装置である。

【0074】本発明によれば、各誘導路の中心線がその混雑度に比例した太さで表示されるため、操作者が各誘導路の混雑状況を視覚的に把握可能である。

【0075】

【発明の実施の形態】以下、本発明の好適な実施の形態を図面に基づいて説明する。

【0076】A. 本実施の形態の基本構成

図1には、本実施の形態に係る空港面移動体交通監視システムの主要な構成を表す構成ブロック図が示されている。

【0077】図1に示されているように、本システムは航空機や車両などの移動体の位置を検出するための各種

センサ100を有している。この各種センサ100は、空港面及び空港周辺に存在する各種移動体を検出するためのセンサであって、例えばASDE (Airport Surface Detection Equipment)、ASR/SSR、GPS、モードS等が使用される。さらに、局所的にEOカメラ、地中埋め込みセンサ等も活用可能である。

【0078】空港面の構造は複雑であり、このため一種類のセンサですべての移動体を検出することは困難であることが多いと考えられる。このため、複数のセンサを使用して移動体の監視を行うことが好ましい。しかしながら、このように複数のセンサを使用して移動体の監視を行った場合には、1個の移動体の複数のセンサにより検出されてしまうなどの問題が発生する。そのため、本実施の形態に係る空港面移動体交通監視システムにおいてはセンサ統合部102を設け、このセンサ統合部102において複数のセンサ100からの入力統合し、個々の移動体の抽出を行っている。

【0079】センサ統合部102において抽出された個々の移動体はその座標データが追尾処理部104に供給される。追尾処理部104においては、レーダのような一定周期で対象物のデータを検出するスキャンセンサを使用して移動体を監視する場合に、前回のスキャンで検出した移動体と今回のスキャンで検出した移動体とが同一の移動体であるか否かについて判定が行われる。このような判定をすることによって、移動体の移動を監視することが可能である。

【0080】追尾処理部104において、移動していく移動体のそれぞれについて移動状態が関連処理部106に報告される。この関連処理部106においては追尾している移動体が何であるかを判定する。一般的に、移動体が航空機である場合には、移動体に対応して飛行計画(フライトプラン)が作成される。フライトプランはその移動体を識別するためのコールサイン情報などを保持しているため、追尾している移動体がどのフライトプランに対応するかを照合することが可能である。そして、この照合の結果、対応するフライトプランと移動体とを関係づけることにより、関連の処理が行われる。照合の方法としては、一般的にはビーコンコードによる照合が好適である。このビーコンコードは、航空機が空港に着陸する際、あらかじめSSRにより航空機のトランスポンダからビーコンコードを取得することが行われている。なお、空港面上では、航空機以外の移動体や、フライトプランの無い航空機移動体(例えばスポットから格納庫へ移動するなど飛行を伴わない移動)が存在し得る。

【0081】設備情報管理部108は、空港設備情報のデータ管理を行う。この空港設備は空港面上にどのような設備が存在するかを表す情報であり、例えば滑走路や誘導路、各種のスポット及び格納庫等が管理されている。

る。

【0082】交通監視部110は、移動体情報112、移動計画情報（フライトプラン）114、空港設備情報116、経路計画情報118の各種情報に基づき、空港面上に存在する移動体の交通監視を行う。

【0083】ここで、移動体情報112は、各移動体が空港面上に位置する位置と、その移動体の名称などからなる情報である。また移動計画情報114は、いわゆるフライトプランを意味する。さらに、空港設備情報116は、設備情報管理部108によって管理される空港設備の情報である。また、経路計画情報118は空港面上における移動体の移動経路の候補の情報である。すなわち、この情報は各移動体に割り当てられる経路計画の候補が多数含まれている情報である。

【0084】経路計画処理部120は、経路計画情報のデータ管理を行う。上述したように、経路計画情報118は、航空機に割り当てられる経路計画の候補の情報であり、経路計画はあらかじめ経路パターンが作成され、格納されているものである。経路計画処理部120はこの候補となる経路のパターンを処理する部分である。

【0085】設備情報I/F部122は、設備情報の参照、また設備情報の変更のためのユーザインタフェース機能を提供する。この設備情報I/F部122によって構成されるユーザインタフェース機能を用いて、操作者は空港の設備に変更が生じた場合に、その変更を空港設備情報116に反映させることが可能である。

【0086】デジタルマップI/F部124は、空港設備情報116に基づいて、デジタルマップを画面に描画すると共に、マウス等のポインティングデバイス等によるデジタルマップ状の設備の選択を可能としている。このデジタルマップは空港面上のいわば地図を表し、航空機等の移動体の位置を表す際のベースとなる地図を表示装置に表示するものである。また、ポインティングデバイス等により設備の選択を可能とすることにより、空港における設備に変更が生じた場合などの場合に、その設備の属性情報などを変更することが可能となる。

【0087】デジタルターゲットI/F部126は、移動体情報112に基づいてデジタルターゲットを描画すると共に、ポインティングデバイス等によりデジタルターゲットの選択を可能とする。ここでデジタルターゲットとは、移動体の情報をデジタル情報としたものであり、上述したデジタルマップと共に画面に表示されることにより、移動体が空港面上のどの位置に位置するのかが操作者（管制官等）に明確に示すことが可能である。また、その移動体の詳細な情報を知る場合などにおいて、ポインティングデバイス等によってそのデジタルターゲットを選択することにより、詳細な情報などを得ることが可能である。

【0088】管制表示統合部128は、デジタルマップとデジタルターゲットを重畳して表示部に表示する。こ

れによって、上述したように空港面の地図と移動体とを重畳して表示することにより移動体の位置が視覚的に明確に把握されるものである。この管制表示統合部128は、画面の中心位置や、画面の拡大/縮小等の表示属性をデジタルマップとデジタルターゲットの間において統合する働きを有する。

【0089】交通警報I/F部130は、交通警報表示を行う。例えば、追尾している移動体が割り当てられた経路計画を外れて移動している場合などの異常状態が検出された場合に、この交通警報I/F部130が警報を表示画面に表示する。

【0090】経路計画I/F部132は、経路計画候補属性情報や、経路計画状態情報などについて帳票形式の表示を行う。

【0091】移動計画I/F部134は、移動計画属性情報に関し、同様に帳票形式の表示を表示部に行う。

【0092】本システムにおけるデータ

空港設備情報の構成と、各データとの関連を表す説明図が図2に示されている。なお、空港設備情報は設備情報、エリア情報、設備/エリア形状情報、交通ノード情報、交通ノードグループ情報、ゾーン情報、メッシュ情報により構成されている。

【0093】本実施の形態において、設備とは、ターゲットが移動するために使用する空港面上の個々の設備をいう。設備情報は、個々の設備に関する属性を示し、具体的には設備種別情報テーブル200、設備属性情報テーブル202、交差点情報テーブル204、誘導路情報テーブル206によって示されるものである。設備種別情報テーブル200は、設備種別ごとの情報であり、設備属性情報テーブル202には、個々の設備の属性情報を表す。一方、交差点情報テーブル204及び誘導路情報テーブル206は、交差点や誘導路の設備対応にそれぞれ設備種別に固有の情報を保持している。

【0094】なお、設備には建造物、誘導路、滑走路、スポット、交差点の種類が本システムにおいては取り扱われている。

【0095】(1) エリア情報

エリアとは、空港面及び空港周辺のある位置範囲を有する一定の閉じた図形（閉図形）と、係る図形の範囲内で有効である上下限高度を用いて表される一定の範囲をいう。この閉空間の内側におけるターゲットの振る舞いや、表示形態などに対する規約を定義することを各エリアごとに可能としている。本システムにおいてはエリアには複数の種類があり、さらに1種類のエリアは複数の閉空間により構成されることを可能としている。また、閉空間同士は種類を問わず位置的な重なりが許可されており、このエリアを表す閉図形は例えば多角形またはある点を中心とした2レンジ2アジマスで表現される扇形によって定義することが可能である。ここで、ある点を中心とした円は2レンジ2アジマスの扇形の特殊な形と

して表すことが可能である。

#### 【0096】(2) エリア／設備形状情報

エリア／設備形状情報は、エリア／設備の形状に関する情報であり、図2に示すように、エリア／設備形状情報テーブル208により表現される。エリア／設備の形状は、1個以上の図形により表現され、1個のエリアや設備の形状を、複数の図形の組み合わせで構成することを本システムにおいては許容している。

#### 【0097】(3) デジタルターゲット表示制御情報

デジタルターゲット表示制御情報210は、設備やエリア内に存在するターゲットのデジタルターゲット表示を制御する情報である。これは、管制官に誤解を招くような表示を補正すると共に、必要な情報のみをフィルタリングすることにより、管制官のオーバロードを抑えることを目的とする。

#### 【0098】(4) 交通ノード情報

交通ノードは、交差点において当該交差点に接続する各誘導路に対応して自動的に生成される。交通ノードとは、一つの誘導路の両端をいう。換言すれば、誘導路は二つの交差点を結ぶ線分であり、ある交差点は複数の誘導路の端点の集合である。誘導路から見たこの端点が交通ノードと呼ばれるのである。例えば、三本の誘導路が合流する交差点は三個の交通ノードの集合となる。交差点と誘導路との関係を表す図が例えば図3に示されている。また、誘導路と交差点、及び交通ノードの関係を説明する説明図が図4に示されている。

【0099】交通ノードに関する情報は、交通ノード状態情報テーブル212、及び交通ノード所属交通ノードグループ属性情報214等により構成されている。交通ノード状態情報テーブル212は、個々の交通ノードに関する現在の状態を表し、各交差点の設備識別子と、誘導路の設備識別子の複合キーにより参照が行われる。さらに、交通ノード状態情報テーブル212は、当該交通ノードが所属する交通ノードグループ数、及び当該交通ノードをユニークに識別するための交通ノード識別子の情報を保持している。一方、交通ノード所属交通ノードグループ情報テーブルは、交通ノードが所属する交通ノードグループに対応してそれぞれインスタンスを保持しており、交通ノード識別子をキー情報として参照が行われる。交通ノード所属交通ノードグループ情報テーブルは、ある交通ノードが所属するすべての交通ノードグループが識別子、及び交通ノードグループ状態設定マスク値を保持する。

#### 【0100】(5) 交通ノードグループ情報

交通ノードグループ情報は、隣接して存在する誘導路について、航空機の横方向離隔距離を確保するために、2個以上の交通ノードをグループ化したものである。このように、2個以上の交通ノードをグループ化することにより、そのグループに交通ノードが含まれる誘導路に対し一定の進入制限を行うことを実現することができる。

#### 【0101】(6) ゾーンデータ

本実施の形態に係る空港面移動体交通監視システムにおいては、空港面のデジタルマップを一定のゾーンに分けて管理している。これは、空港面及びその周辺を比較的大きなグリッドに区切り、個々のグリッドに含まれる設備、エリアの識別子を保持するのである。このようなデータを、本実施の形態においてはゾーンデータと呼んでいる。1個のグリッドに含まれる設備、エリアは、複数個保持可能であり、さらに複数のグリッドにまたがる設備エリアは、それぞれのグリッド情報に登録されている。個々のグリッドは、ゾーングリッド識別番号により識別され、ゾーングリッド識別番号は、座標演算により導出される。このゾーンデータは、空港面のデジタルマップ描画の際、その描画すべき設備を抽出するために用いられる。

#### 【0102】(7) メッシュデータ

メッシュデータ216は、空港面及びその周辺の座標毎にインスタンスを保持している。具体的には、本実施の形態において用いられている各種センサ100の解像度単位でその座標がどのような場所であるのかを識別するためのデータである。すなわち、個々の座標毎に当該座標の存在する設備識別子及びエリアIN/OUT情報を保持するデータである。このメッシュデータ216は監視対象であるターゲットの現在位置における設備、エリアIN/OUT情報を知るために用いられている。

#### 【0103】(8) 移動体情報

また、移動体情報が空港面及び空港周辺に現在存在する個々の移動体に関する属性情報として本実施の形態において用いられている。

#### 【0104】(9) 移動計画情報

また、本実施の形態において、移動計画情報とは具体的なフライトプランを意味するが、一方において、空港面上では航空機以外の移動体やフライトプランのない航空機移動体（例えばスポットから格納庫へ移動するなど飛行を伴わない移動）が存在する。そのため、これらのフライトプランのない航空機移動体に関する情報も含むのが移動計画情報である。

#### 【0105】(10) 経路計画情報

経路計画情報は、経路計画の候補に関する情報であることは既に説明した。個の経路計画情報は、経路計画の候補の例えば属性情報、現在状態情報、及び誘導路毎の混雑状況に関する情報など、が本実施の形態においては保持されている。

【0106】(11) 以下、具体的な空港設備情報のテーブルやデータの内容について図面に基づいて説明する。

【0107】図5には、設備種別情報テーブル200の具体的な項目を表す説明図が示されている。この設備種別情報テーブルは、設備種別毎の主にデジタルマップ表示に関する各種の属性情報を保持し、1個の設備種別が

1個のインスタンスに対応する。この図に示されているように、設備種別情報テーブル200には、エリア/設備種別、最小表示倍率、最大表示倍率、デジタルマップ表示色、デジタルマップぬりつぶし区分、表示デジタルマップ区分を項目として有している。ここで、この表において、アスタリスクが付されているエリア/設備種別がこのテーブルを検索する際のキー項目として設定されている。

【0108】図6には、設備属性情報テーブル200の具体的な内容を表す説明図が示されている。設備属性情報テーブル200は、個々の設備ごとの属性情報を示し、1個の設備が1個のインスタンスに対応し、存在するすべての設備に関する情報を保持するものである。この図に示されているように、設備属性情報テーブル200には、エリア/設備種別、設備識別子、設備名称、交通監視を行う最低交通密度レベル、交通監視を行う最低視程条件レベル、共用可能ターゲット数、現在状態、現在使用中ターゲット数、経路計画自動割当実施最大交通密度レベル、経路計画自動割当実施最大視程条件レベル、デジタルターゲット表示制御情報識別子、等の各項目を有するテーブルである。この内、アスタリスクが付されているエリア/設備種別、設備識別子、の2つの項目がこのテーブルを検索する際のキー項目に設定されている。

【0109】図7には、交差点情報テーブル204の具体的な内容を表す説明図が示されている。交差点情報テーブル204は、設備種別が交差点である設備について、設備属性情報テーブル202に加えて以下の付加情報を保持する表である。この図に示されているように、交差点情報テーブル204は、設備識別子、交差点位置情報、交差点範囲レンジ、交差点交通監視レンジ、占有中移動体識別子、の各項目を有している。この内、アスタリスクが付されている設備識別子がこのテーブルを検索する際のキー項目として設定されている。

【0110】図8には、誘導路情報テーブル206の具体的な内容についての表が示されている。誘導路情報テーブル206は、設備種別が誘導路である設備について、設備属性情報テーブル202に加えて、以下の付加情報を保持するものである。すなわち、この図に示されているように、設備識別子、交通ノード(1)識別子、交通ノード(2)識別子、の各項目を有するテーブルである。この内、設備識別子がこのテーブルを検索する際のキー項目に設定されている。

【0111】図9には、エリア種別情報テーブル219の具体的な内容を表す説明図が示されている。この図に示されているように、エリア種別情報テーブル219は、エリア種別に関する情報を保持しており、具体的にはエリア/設備種別、エリア判定キー、デジタルターゲット表示制御情報識別子、の各項目を有するテーブルである。そして、アスタリスクが付されているエリア/設

備種別の項目は、このテーブルを検索する際のキー項目として設定されている。

【0112】図10には、エリア/設備形状情報テーブル208の具体的な内容を表す説明図が示されている。このエリア/設備形状情報テーブル208は、以下に示すように各エリア/設備の形状を1個以上の図形により表現し、1個のエリアや設備の形状を複数の図形の組み合わせによって構成することを可能としている。この図に示されているように、エリア/設備形状情報テーブルは、エリア/設備種別、設備識別子、図形識別子、図形形状区分、図形座標情報、有効高度上限値、有効高度下限値、有効ヘディング、有効ヘディング誤差、の各項目を有するテーブルである。この内、アスタリスクが付されているエリア/設備種別、設備識別子、図形識別子の3個の項目は、このテーブルを検索する際のキー項目として設定されている。

【0113】図11には、デジタルターゲット表示制御情報テーブル210の具体的な内容の説明図が示されている。デジタルターゲット表示制御情報テーブル210は、設備やエリア内に存在するターゲットのデジタルターゲット表示を制御する情報が格納されている。この情報は、管制官に誤解を招くような表示を補正すると共に、必要となる情報のみをフィルタリングすることにより管制のオーバーロードを押さえることを目的とする。この図に示されているように、デジタルターゲット表示制御情報識別子、有効レンジスケール上限値、有効レンジスケール下限値、リーダ方向、進入機タグ表示形式、出発機タグ表示形式、通過機タグ表示形式、地上移動体タグ表示形式、進入機サブレス情報、出発機サブレス情報、通過機サブレス情報、地上移動体サブレス情報、予測位置採用要否、ヘディング補正採用要否、予測位置採用最低速度条件、予測位置採用ヘディング条件基準値、予測位置採用ヘディング条件誤差範囲、の各項目を有するテーブルである。そして、アスタリスクが付されているデジタルターゲット表示制御情報識別子がこのテーブルを検索する際のキー項目として設定されている。このテーブルは、図6設備属性テーブル、図9エリア種別情報テーブルより指され当該設備を使用中、あるいは当該エリア内に存在する航空機に関するデジタルターゲットの表示形態を規定し、後述する空港面管制表示の見易さを向上することを目的とする。

【0114】図12には、交通ノード状態情報テーブル212の具体的な内容を表す説明図が示されている。交通ノード状態情報テーブル212は、図12に示されているように対応誘導路の設備識別子、対応交差点の設備識別子、交通ノード識別子、現在状態、所属交通ノードグループ数、の各項目を有するテーブルである。そして、アスタリスクが付されている対応誘導路の設備識別子、対応交差点の設備識別子の2つの項目がこのテーブ

ルを検索するためのキー項目として設定されている。

【0115】図13には、交通ノード所属交通ノードグループ情報テーブルの具体的な内容を表す説明図が示されている。交通ノード所属交通ノードグループ情報テーブルは、ある交通ノードが所属する交通ノードグループに関する属性情報を示すものであり、この図に示されているように、交通ノード識別子、所属交通ノードグループ識別子、交通ノードグループ状態設定マスク値、の各項目を有するテーブルである。そして、交通ノード識別子と、所属交通ノードグループ識別子とが、アスタリスクが付されているように、このテーブルを検索する際のキー項目に設定されている。

【0116】図14には、交通ノードグループ属性情報テーブル218の具体的な内容についての説明図が示されている。交通ノードグループ属性情報テーブル218は、交通ノードグループの属性を示す情報であり、1個の交通ノードグループが1個のインスタンスに対応する。この図に示されているように、交通ノードグループ属性情報テーブル218は、交通ノードグループ識別子、交通ノードグループ状態、の各項目を有している。そして、交通ノードグループ識別子が、アスタリスクが付されているように、このテーブルを検索する際のキー項目として設定されている。

【0117】図15には、メッシュデータ216の具体的な内容を表す説明図が示されている。メッシュデータ216は、空港面、及びその周辺の座標ごとにインスタンスを保持し、個々の座標ごとに当該座標に存在する設備識別子、及びエリアIN/OUT情報を保持するものである。この図に示されているように、メッシュデータ216は、位置座標、設備識別子、エリアIN/OUT状態を項目として含んでいる。そして、アスタリスクが付されている位置座標が、このテーブルをアクセスする際のキー項目として設定されている。

【0118】次に、移動体情報の各テーブルの具体的な内容について説明する。

【0119】図16には、移動体属性情報テーブルの具体的な内容についての説明図が示されている。この移動体属性情報テーブルは、移動体の現在の属性情報を示し、現在存在する移動体に対応してインスタンスを保持するものである。この図に示されているように、移動体属性情報テーブルは、移動体識別子、現在位置座標、現在速度、現在高度、ヘディング予測位置座標、応答ピーコンコード、移動計画識別子、割当経路計画数、経路計画識別子、現在履行中経路計画移動順序番号、現在仕様中設備、エリアIN/OUT状態、交通監視警報状態、交通監視ホールド指示状態、交通監視ホールド指示開始時刻、の各項目を有するテーブルである。これらの項目のうち、移動体識別子がこのテーブルを検索する際のキー項目に設定されている。

【0120】図17には、航跡情報テーブルの具体的な

内容についての説明図が示されている。航跡情報テーブルは、移動体の過去一定時間分の位置とヘディングに関する情報を示すものであり、移動体毎に複数のインスタンスを保持している。この情報は、移動体の位置情報を受けるとに追加され、さらに一定周期で監視され、不要なインスタンスをガベージコレクションの対象としている。

【0121】航跡情報テーブルは、図17に示されているように、移動体識別子、過去時刻、位置座標、ヘディング、の各項目を有するテーブルである。この内、アスタリスクが付されている移動体識別子、及び過去時刻の2つの項目が、このテーブルを検索する際のキー項目として設定されている。

【0122】図18には、経路計画割当状態情報テーブルの具体的な内容についての説明図が示されている。経路計画割当状態情報テーブルは、移動体に対して割り当てられている経路計画を示すテーブルである。1個の移動体には本システムにおいては複数の経路計画を割り当てることが可能であり、経路計画を割り当てられている移動体毎に複数のインスタンスを保持可能である。図18に示されているように、この経路計画割当状態情報テーブルは、移動体識別子、経路計画履行順序番号、経路計画識別子、の各項目を有するテーブルである。また、アスタリスクの付されている移動体識別子、及び経路計画履行順序番号の2つの項目が、このテーブルを検索する際のキー項目として設定されている。

【0123】次に、移動計画情報の具体的な内容について説明する。

【0124】図19には、移動計画情報テーブルの具体的な内容についての説明図が示されている。移動計画情報テーブルは、移動計画の属性情報を示し、移動計画に対応してインスタンスを保持する。図19に示されているように、移動計画情報テーブルは、移動計画識別子、フライトプラン情報、スポット情報、空港面移動開始時刻、空港面移動終了時刻、空港面移動開始地点、空港面移動終了地点、の各項目からなるテーブルである。この内、アスタリスクが付されている移動計画識別子がこのテーブルを検索する際のキー項目として設定されている。

【0125】次に、空港運用情報についてその内容を説明する。

【0126】図20には、空港運用情報テーブルの具体的な内容についての説明図が示されている。空港運用情報テーブルは、交通監視に関する現在の空港運用の状態に関する情報が保持されている。この図20に示されているように、空港運用情報テーブルは、交通密度レベル、視程条件、現在移動体数、交通密度レベル2移動体数、交通密度レベル3移動体数、現在選択中経路計画グループ、の各項目を有するテーブルである。

【0127】次に、経路計画情報118の内容について

説明する。

【0128】図21には、経路計画情報テーブルの具体的な内容についての説明図が示されている。経路計画情報テーブルは、経路計画候補の属性を示し、経路計画候補ごとにインスタンスを保持する。図21に示されているように、経路計画情報テーブルは、経路計画識別子、経路計画名称、移動監視地点、移動終了地点、選択優先順位、同時利用可能移動体数、使用可能航空機クラス上下限值、標準走行所用時間、経路計画グループ識別子、自動割当選択/禁止、自動割当可能移動形態の各項目を有するテーブルである。そして、経路計画識別子がこのテーブルを検索する際のキー項目として設定されている。

【0129】図22には、経路計画使用設備情報テーブルの具体的な内容についての説明図が示されている。経路計画使用設備情報テーブルは、経路計画候補ごとに経路計画候補中で使用されている誘導路設備の情報を示すものである。この図22に示されているように、経路計画使用設備情報テーブルは、経路計画識別子、移動順序番号、仕様設備識別子、進入交通ノードの各項目を有するテーブルである。そして、経路計画識別子、移動順序番号、の2つの項目は、このテーブルを検索する際のキー項目として設定されている。

【0130】図23には、経路計画状態テーブルの具体的な内容を表す説明図が示されている。経路計画状態テーブルは、経路計画候補毎に、経路計画候補の移動体への現在の割当状態の情報を保持するものである。図23に示されているように、経路計画状態テーブルは、経路計画識別子、現在使用中移動体数、実績走行所要時間、使用可否状態、使用可否最終チェック時刻の各項目を有するテーブルである。そして、経路計画識別子がこのテーブルを検索する際のキー項目として設定されている。

【0131】図24には設備混雑状態情報テーブルの具体的な内容についての説明図が示されている。設備混雑状態情報テーブルは、経路計画が使用する設備について設備毎の使用状況に関する情報を保持するものである。図24に示されているように、設備混雑状態情報テーブルは、設備識別子、通過予定移動体数、進入交通ノード、の各項目を有するテーブルである。そして、アスタリクスが付されている設備識別子が、このテーブルを検索する際のキー項目として設定されている。

#### 【0132】表示画面の内容

本実施の形態に係る空港面移動体交通監視システムにおいては、空港面を含むデジタルマップを表示し、このデジタルマップ上に移動体の位置及びその移動体の属性などを表示することが可能である。さらに、移動体の交通監視を行うのに役立つ以下の表示を行っている。

#### 【0133】(1) 設備情報表示

本システムにおいてはデジタルマップ上に現れる各種設備の設備情報表示を行っている。この設備情報表示は、

空港面上の個々の設備及びエリアに関する属性情報の表示、及びこの属性情報を追加、変更、削除などの操作を操作者に提供する。

#### 【0134】(2) 空港面地図表示

また、上述したように本システムにおいては空港面地図の表示を行う。この空港面地図は単に表示するだけでなく設備に変更が生じた場合や、新たな設備が設けられた場合などにおいて、空港面地図の作成編集するための機能を提供するものである。

#### 【0135】(3) 空港面管制表示

さらに、本システムにおいては空港面管制表示を操作者に対して行う。この空港面管制表示は、空港における管制官が空港面上の交通管制を行うための表示画面であり、デジタルマップとデジタルターゲットを重畳した表示である。

#### 【0136】(4) 交通警報表示

さらに、本システムにおいては移動体が移動計画に基づき移動していない場合などを管制官に知らせるべく交通警報表示を行っている。この交通警報表示は、現在発行されている交通警報を表示するものである。

#### 【0137】(5) 経路計画情報表示

また、本システムは上述した経路計画や移動計画を表示することも可能である。この経路計画を表示する経路計画表示は、その経路計画の属性情報や経路計画の状態情報を表示するものである。

#### 【0138】(6) 移動計画情報表示

また移動計画の情報を表示する移動計画情報表示は、移動計画の属性情報や移動計画の状態情報を表示するものである。

【0139】(7) この様に、本システムにおいては、空港面の地図であるデジタルマップを中心として種々の表示を行うことが可能である。

【0140】例えば、図25には、空港に航空機が着陸している状態を表す画面の説明図が示されている。図25に示されているように、空港のタクシーウェイ上をB747型機が移動している様子が図25に示されている。なお、図25において、16L、16Rや、34Lなどは滑走路の番号を表す。また、22も滑走路の番号を表す。

【0141】図26には、図25の状態から航空機B747がスポットに到着した状態を表している。このとき、滑走路34Rからは新たな航空機が着陸している様子が画面に表示されている。

【0142】図27は、表示倍率を小さくし、この空港を含むより広い範囲を画面に表示した場合の説明図が示されている。このように、表示倍率を小さくした場合には、これからこの空港に到着しようとする航空機でありB747や、DC10などを画面に表示することができ。また、この空港から出発した航空機A300や、B747などが画面に表示されている。なお、図27にお

いてはこの空港からの距離を表すため円が示されている。

【0143】図28には、デジタルマップを中心とする本システムの表示画面が回転されて表示しているところを表す説明図である。この様に、本システムの表示画面においては、その表示対象を任意の角度に回転して表示することが可能である。さらに、本実施の形態において特徴的なことは管制官が向いている方向が常に画面の上方向となるようにこの画面の回転が制御されていることである。このように、常に管制官が向いている方向が画面の上方向となるように画面を回転させることにより、常に実際の空港と画面との対応を正確にとることが可能となる。

【0144】例えば、管制官が今自分が向かっている方向の角度をキーボードなどにより本システムに入力することにより、本システムにおいてその入力された角度が上方向となるように画像を回転させることが可能である。なお、画像を回転させることは、従来からそのアルゴリズムは良く知られていることである。

【0145】本実施の形態に係る空港面移動体交通監視システムにおいては、空港面を表すデジタルマップの上に、各移動体や、その移動体の名称などを表示可能であることは上記図25から図28において説明してきた。本システムにおいては、このように移動体の名称だけでなく各設備の名称、例えば誘導路や各スポット滑走路の名称などを適宜表示させることが可能である。図29には、このように各誘導路や滑走路の名称をデジタルマップに重ねて表示した場合の例が示されている。このように、各設備の名称を表示させることにより、管制官は、現在航空機などの移動体がどの位置にいるのかを正確に把握することが可能である本システムにおいては、同様に航空機が停止するスポットの番号も表示することが可能である。すべてのスポットの番号を表示した例が図30に示されている。

【0146】また、本システムにおいては表示する部分の座標を変えることも可能である。図31には、画面に表示される中心をずらした場合の表示の例が示されている。これによって、空港の周囲の様子をも併せて知ることが可能である。

【0147】図32も、本システムに係る画像表示の例である。ここでは、6個の航空機が移動体として表示されており、これらの航空機の型式や、便名なども併せて表示されている。

【0148】図33には、本システムの画面の表示の例が示されている。ここに示されているように、本システムにおいては画面の一部を拡大表示することも可能である。例えば、図33においては、JAL555のB767型機が離陸する様子を拡大した図が画面の一部に表示されている。この様に、画面の一部を拡大表示することにより、より正確な情報を得ることが可能である。

【0149】B. 経路計画の自動割り当て

上述したように、経路計画は空港内部における移動体の移動経路を表すものであるが、この経路計画は原則として管制官の指示により割り当てが行われる。しかしながら、全てのターゲットに対して個々に管制官が経路計画を割り当てる操作は、管制官にとってオーバーロードとなることが想定される。例えば、空港がそれほど混雑しておらず、視程条件が良好である場合には、ある程度自動で割り当てることが可能であると考えられる。また、移動開始地点の設備毎に自動割り当て可能な設備と不可能な設備もあることが予想される。さらに、経路計画の候補毎に自動割り当て可能な計画と困難な計画もあることが考えられる。

【0150】そこで、本実施の形態に係るシステムにおいては、経路計画の自動割り当てを行い得るように構成すると共に、この機能の有効/無効モードを保持し、管制官の操作によりこの両者のモードをダイナミックに切り替えることを可能とするように構成している。

【0151】本システムに係る経路計画の自動割り当てに先立って、空港運用情報テーブルの更新が逐次行われている。この動作をフローチャートを用いて説明する。

【0152】この動作は本システムにおいて特徴的な動作である監視・警報の抑止を行うためのものであり、具体的な動作が図34、図35などに示されている。

【0153】監視・警報の抑止

管制官の無駄なワークロードを減らすためには、誤警報を極力減らす必要がある。

【0154】誤警報は、管制官に対する無駄な負荷を増大させるだけでなく、管制官やパイロットに誤った認識を与え、移動の非効率化、事故につながる危険な状態を引き起こす可能性がある。管制官、及びパイロットは各々に認められている行為を自己の責任で遂行することを許容されるべきである。天候等の悪化により、空港の運用条件が悪化するのに伴い、管制官、及びパイロットの自己裁量に委ねられる行為は制限され、逆に空港の運用条件が改善するのに伴い、管制官、及びパイロットに対する自己裁量の制限は解除される。

【0155】交通監視に関しても、これに従い、空港の運用条件が良好である場合の空港面移動は、管制官、及びパイロットの自己裁量に委ねられ、空港の運用条件が悪化するのに伴い、交通監視を強化する。

【0156】さらに、設備によって、交通監視レベルの調整を必要とする場合がある。例えば視程が悪化してもタワー直下に見える誘導路においては、交通監視が不要であるかもしれない。又、この逆に視程条件が良くても、密接した誘導路でパイロットが航空機の間隔を十分にとりにくいような場所では空港における交通監視レベルによらず常時交通監視を行う必要がある。

【0157】このため、空港における交通監視レベルとは別に、共用資源毎に交通監視レベルを設定することを

可能とするのが望ましい。

【0158】交通監視は、空港情報テーブルに保持する現在の視程条件レベル、及び交通密度レベルと、設備属性情報テーブルに保持する交通監視を行う最低視程条件レベル、最低交通密度レベルとの比較により、当該設備上にあるターゲットを監視の対象とするか否かを決定する。

#### 【0159】空港の交通密度レベル、視程条件レベルの設定

空港全体の交通密度レベル、及び視程条件レベルは、空港運用情報テーブルに保持する。視程条件レベルは、本システムにオンラインで気象条件を取り込むことにより、自動設定も可能であるが、管制官によって設定変更することによって変更を行う。

【0160】交通密度については、現在の航空面上に存在する移動体数を計数することにより、把握することができる。

【0161】図34には移動体数を更新するフローチャートが示されている。

【0162】まず、ステップS34-1において移動体情報の受信処理が行われる。これは、新たに空港に到着した航空機などに関し、その航空機のビーコンコードなどからその移動体の属性を受信する処理である。

【0163】ステップS34-2においてはその移動体为新規移動体であるか否かが検査される。もし新規移動体である場合には次のステップS34-4に処理が移行し移動体の削除であるか否かが検査される。その結果、移動体の削除である場合にはステップS34-5において空港運用情報テーブルから現在の移動体数が1デクリメントされる。

【0164】一方、上記ステップS34-2において新規移動体ではないと判断される場合には、ステップS34-3において空港運用情報テーブルの現在移動体数をインクリメントする。

【0165】このようにして、現在空港において監視対象となっている移動体の個数が常に把握される。

【0166】図35には、交通密度を監視する際の動作を表すフローチャートが示されている。

【0167】まずステップS35-1においては空港運用情報テーブルにおいて現在の移動体数が交通密度レベル2の移動体数より多いか否かが計算される。この結果現在の移動体数の方が多い場合にはステップS35-3に移行し、現在の移動体数の方が小さい場合にはステップS35-2に処理が移行する。

【0168】ステップS35-2においては空港運用情報テーブル内の交通密度レベルとしてレベル1が設定される。

【0169】一方、ステップS35-3においては空港運用情報テーブル内の現在の移動体数が交通密度レベル3の移動体数より多いか否かが計算される。この結果、

現在の移動体数が交通密度レベル3より多い場合にはステップS35-5に処理が移行し、空港運用情報テーブル内の交通密度レベルがレベル3に設定される。

【0170】一方、ステップS35-3において現在の移動体数が交通密度レベル3の移動体数より小さい場合にはステップS35-4において交通密度レベルがレベル2に設定されるのである。

【0171】このようにして、現在の交通密度レベルを常に把握することにより、本システムによる自動割当を行うことが可能か、または管制官による手動による割当が好適であるかの判断の基準とすることができる。

【0172】また、本実施の形態に係るシステムにおいては交通密度レベルなどの条件に基づき、交通監視を行うか否かが自動的に切り替えることも可能である。このような場合の切替の動作が図36のフローチャートに示されている。

【0173】まず、ステップS36-1において、メッシュサーチが行われる。このメッシュサーチは、移動体のXY座標をキーにしてメッシュデータをサーチし、当該移動体が使用中の設備が何であるかを判定する処理である。

【0174】次に、ステップS36-2において、設備属性情報テーブル202のサーチが行われる。このサーチによって、移動体が使用中の設備属性情報を得ることができる。

【0175】ステップS36-3においては、設備属性情報テーブル202の交通監視実施最低交通密度レベルが、空港運用情報テーブル内の交通密度レベルより小さいか否かが検査される。係る検査の結果、小さい場合にはステップS36-4に処理が移行し、一方、交通監視実施最低交通密度レベルの方が大きい場合にはステップS36-5に移行し、このステップS36-5において交通監視を行う旨が決定される。

【0176】一方、ステップS36-4において設備属性情報テーブル内の交通監視実施最低視程条件レベルが空港運用情報テーブル内の視程条件レベルより小さいか否かが検査される。係る検査の結果、交通監視実施最低視程条件レベルの方が小さい場合には、ステップS36-6に処理が移行し交通監視を行わない旨が決定される。一方、交通監視実施最低視程条件レベルが大きい場合には上記ステップS36-5において交通監視を行う旨が決定される。

【0177】以上のような動作により、本実施の形態に係るシステムにおいては空港内部を移動する移動体数及び空港内の交通密度レベルを自動的に判断していると共に、これらの情報に基づいて交通監視を行うか行わないかがこれも自動的に判断することが可能である。

#### 【0178】経路計画割当の実際

実際に経路計画を割り当てる場合には、まず自動割当機能が有効である場合において、移動開始地点の設備毎の



属性として保持する経路計画自動割当可否情報に基づいて自動割当可否判定を行い、自動割当が可能である場合には、移動開始地点、移動終了地点の両地点に基づき経路計画を検索する。

【0179】次に、経路計画候補の採用可否判定が行われる。上記検索により得られた経路計画候補の採用可否を判定する。検索により得られた経路計画の候補は、複数個存在する可能性がある。このように経路計画の候補として複数個あった場合には、選択の優先順位に従って採用可否の判定を行う。この採用可否の条件は例えば以下に示すような条件が考えられる。

【0180】まず1つ目の条件は経路計画自体の自動割当選択/禁止区分が選択状態であることが条件とされる。

【0181】また、2つ目の条件としては、抽出した経路計画候補について経路計画状態テーブルの現在使用中のターゲット数と、経路計画情報テーブルの同時利用可能ターゲット数とを比較し、現在使用中のターゲット数が同時利用可能ターゲット数より少ないことが条件とされる。

【0182】3つ目の条件としては、経路計画の自動割当移動形態と、割当対象である移動体の移動形態が一致することである。特に航空機クラスによる条件を考慮した割当を行うことが好適である。航空機のクラスは例えば図21に示されている。

【0183】さらに、この経路計画の候補が使用するそれぞれの誘導路が以下の条件を満足することも必要とされる。

【0184】まず進入交通ノードと設備混雑状態テーブルの当該誘導路の進入交通ノードが一致していなければならない。また、当該誘導路が進入禁止状態にないことも条件とされる。例えば、図37に示されているように経路Aが既にいずれかのターゲットに割り当てられているような場合には、経路Bを別のターゲットに割り当てることはできない。従ってこの場合、経路Aと経路Bとが交わる部分の交通ノード進入禁止状態に設定し、係る経路Bが別のターゲットに割り当てられないように設定されるのである。

【0185】図38には、このような経路計画の自動割当の具体的な動作を表すフローチャートが示されている。

【0186】まず、ステップS38-1において経路計画の自動割当が現在有効であるか否かが検査される。この結果、有効でない場合には、ステップS38-4において経路計画の自動設定は中止される。一方、経路計画の自動割当が有効である場合にはステップS38-2に処理が移行する。

【0187】ステップS38-2においては、設備属性情報テーブル202内の経路計画自動割当最低交通密度レベルが、空港運用情報テーブル内の交通密度レベルよ

り小さいか否かが検査される。この検査の結果、経路計画自動割当最低交通密度レベルの方が大きい場合には、経路計画の自動設定はできないものと判断し、ステップS38-4において経路計画の自動割当が中止される。一方、経路計画自動割当最低交通密度レベルが、空港運用情報テーブルの交通密度レベルよりも小さい場合には、ステップS38-3に処理が移行する。

【0188】ステップS38-3においては、設備属性情報テーブル202内の経路計画自動割当最低視程条件レベルが、空港運用情報テーブル内の視程条件レベルより小さいか否かが検査される。この検査の結果、経路計画自動割当最低視程条件レベルの方が大きい場合には経路計画自動設定は不可能であると判断し、ステップS38において経路計画自動設定が中止される。一方、空港運用情報テーブルの視程条件レベルの方が経路計画自動割当最低視程条件レベルよりも大きい場合には、ステップS38-5に処理が移行する。

【0189】ステップS38-5においては、経路計画の抽出が行われる。すなわち、移動体の移動開始地点と移動終了地点とに基づいて、経路計画情報テーブルから経路計画候補を検索する。この経路計画情報テーブルには、上述した経路計画情報118が格納されている。

【0190】次に、ステップS38-6において、上記ステップS38-5において抽出した全ての経路計画候補について選択優先度順に以下のステップS38-7及びステップS38-8、ステップS38-9、ステップS38-10の処理が行われる。なお、これらのステップS38-7～ステップS38-10までの処理を行った結果抽出した経路計画候補のいずれもが設定不可である場合には、上述したステップS38-4に処理が移行し経路計画自動設定は中止される。

【0191】さらに、ステップS38-7においては経路計画情報の自動割当選択/禁止情報が、「選択」に設定されているか否かが検査される。この検査の結果、「選択」が設定されていない場合には、上記ステップS38-6に処理が移行し、選択優先度順に次の経路計画候補についてステップS38-7からステップS38-10までの処理が行われる。

【0192】一方、ステップS38-7において、自動割当選択/禁止情報に「選択」が設定されている場合には、次のステップS38-8に処理が移行する。このステップS38-8においては、その経路計画情報の同時利用可能移動体数が経路計画情報の現在使用中移動体数より大きいかが検査される。この検査の結果、同時利用可能移動体数の方が小さい場合には、その経路計画情報を設定することは不可能であると判断し、上記ステップS38-6に処理が移行し、選択優先度順に次の経路計画情報についてステップS38-7～ステップS38-10までの処理が行われる。一方、ステップS38-8において同時利用可能移動体数の方が現在使用中移

動体数より大きい場合には、次のステップS38-9に処理が移行する。

【0193】ステップS38-9においては、経路計画情報の使用可能移動形態が、その移動体の移動形態と等しいか否かが検査される。この検査の結果、等しくない場合には、その経路計画候補は、現在設定の対象である移動体には設定不可能であると判断し、上記ステップS38-6に処理が移行し、次の経路計画候補について処理が行われる。一方、ステップS38-9において使用可能移動形態が移動体の移動形態と等しい場合には、以下のステップS38-10に処理が移行する。

【0194】ステップS38-10においては、全ての経路計画に含まれる誘導路について以下のステップS38-11、ステップS38-12、ステップS38-13、ステップS38-14の処理が行われる。

【0195】まず、ステップS38-11においては、この経路計画に含まれる誘導路が設備混雑状態テーブルに登録済みか否かが検査される。この検査の結果、未だ登録されていない場合には、設備混雑状態テーブルに、この誘導路を追加し、通過予定移動体数を1に設定する。また、進入交通ノードに対し所定の設定が行われる。

【0196】一方、上記ステップS38-11において使用誘導路が設備混雑状態テーブルに登録済みである場合には、ステップS38-13に処理が移行する。このステップS38-13においては、設備混雑状態の進入交通ノードが誘導路の進入交通ノードであるか否かが検査される。この検査の結果、両者が不一致である場合には、その経路計画の候補の割当はできないものと判断し、上記ステップS38-6に処理が戻る。一方、両者が一致する場合には、割当が可能であると判断し、ステップS38-14に処理が移行する。

【0197】ステップS38-14においては、現在検査対象である誘導路が進入禁止状態か否かが検査される。この検査の結果、進入禁止状態ではない場合にはこの誘導路を利用することは可能であると判断し、上記ステップS38-10に処理が移行し、その経路計画に含まれる誘導路の次の誘導路について処理が行われる。一方、当該誘導路が進入禁止状態である場合にはその誘導路を含む経路計画を設定することは不可能であると判断し、上記ステップS38-6に再び処理が移行する。

【0198】以上のようにして、ステップS38-10において現在設定の候補として考えられている経路計画の全ての誘導路が利用可能である場合に、また設備混雑状態テーブルに所望の登録が行われた後、ステップS38-15に処理が移行し経路計画の自動決定が行われる。

#### 【0199】経路計画状態監視

以上のようにして経路計画が割り当てられるわけであるが、本実施の形態におけるシステムにおいては経路計画

の状態について以下のような監視を行っている。この監視の結果、現在の経路計画の状態を経路計画状態テーブルに設定するのである。

【0200】まず、本システムにおいては実績走行所要時間のカウントが行われている。経路計画を選択する場合には、その経路計画を移動体が移動する所要時間が選択の際の大きなファクターとなる。経路計画情報テーブルには、その経路計画を移動体が移動する場合の標準走行所要時間が保持されている。この所要時間は、混雑状態によって変化してくる可能性がある。また、当該経路計画が割り当てられているターゲットが経路計画を完遂した時点で、ターゲット移動計画情報テーブルに保持するターゲットの経路移動開始時刻と、現在時刻との差分が実績走行所要時間として経路計画情報テーブルに設定される。この実績走行所要時間は、例えば管制官が手動にて経路計画を割り当てる場合には、目安とすることが可能である。このため、本システムにおいては管制官が手動で経路計画を割り当てるために、経路計画の候補を画面に表示した際に、合わせてこの実績走行所要時間を表示している。これによって、管制官がどの経路計画を移動体に割り当てるかについて、有効な情報を提供することが可能である。

【0201】本実施の形態に係る空港面移動体交通監視システムにおいては、その経路計画を使用しているターゲットの個数を管理している。経路計画情報テーブルの同時使用可能ターゲット数を越えるターゲットへの割当を禁止するために、現在その経路計画を使用しているターゲット数が計数されているのである。所定の経路計画があるターゲットに割り当てられた時点において、この現在使用中ターゲット数はカウントアップされ、ターゲットがこの経路計画を完遂した時点でカウントダウンが行われる。また、本システムにおいては、経路計画の使用可否をターゲットに割り当てる毎に、毎回チェックを行うことも考えられる。しかしながら、このようなチェックを毎回行うことは応答性能上好ましくはない。そのため、本システムにおいては、当該経路計画をターゲットに割り当てる直前に、使用可否最終チェック時刻と、設備状態最終変更時刻とを比較し、使用可否最終チェック時刻の方が古い場合には、この経路計画が使用する全ての設備について現在使用可能か否かをチェックし、使用が不可能な設備が（誘導路など）1個でも存在する場合には、当該経路計画の割当が不可能とし、さらに当該経路計画の使用可否状態を使用不可に設定するのである。そして、使用可否最終チェック時刻を現在時刻に更新するのである。

#### 【0202】経路計画利用設備監視

また、本システムにおいては、ターゲットに割り当てられた経路計画が使用する設備について、以下の監視を行って、現在の状態を設備混雑状態テーブルに設定している。これは、上記図38のフローチャートにおいても説

明している。

【0203】まず、割当時の通過予定ターゲット数の設定が行われている。すなわち、上述したように、経路計画があるターゲットに割り当てられた時点において、当該経路計画が使用する全ての誘導路について、設備混雑状態テーブルの検索が行われ、該当する全てのインスタンスの通過予定ターゲット数が全て1インクリメントされるのである。また、設備混雑状態テーブルを検索し、該当する設備に対応するインスタンスが存在しない場合には、新たなインスタンスとして、設備混雑状態テーブルに登録が行われる。ここでインスタンスとは、係るテーブル中において該当する1つのエントリーを言う。

【0204】また、本システムにおいては通過予定ターゲット数の変更が自動的に行われる。これは、経路計画が割り当てられたターゲットが、新たな誘導路に進入する毎に、それまでに使用されていた誘導路の通過予定ターゲット数を1デクリメントするのである。また、移動途中において、経路計画が変更された場合には、それまでに割り当てられていた経路計画に含まれていた未使用設備（誘導路など）に設定されている通過予定ターゲット数を1デクリメントする。このような動作をすることによって、通過予定ターゲット数を常に正確な値に保持することが可能である。

【0205】また、経路計画がターゲットに割り当てられた時点において、この経路計画が使用する全ての誘導路について設備混雑状態テーブルを検索し、該当する全てのインスタンスの進入交通ノードを設定する。進入交通ノードは、ある誘導路について、当該誘導路の直前に使用される誘導路と、この誘導路についてそれぞれ交通ノード属性情報テーブルを検索し（これによって、各誘導路毎に2個のインスタンス、すなわち両端の交通ノードが抽出される）、一致する交差点を進入交通ノードとする。

【0206】既に当該インスタンスに進入交通ノードが設定されている場合には、今回評価した進入交通ノードと比較し、不一致の場合にはその旨の警報を管制官などに発行する。

#### 【0207】経路計画手動割当の変更・追加

本システムにおいては、1個のターゲットについて複数の経路計画を割り当てることが可能である。例えば、天候の急変により、移動中の出発機ターゲットの使用滑走路の変更が余儀なくされた場合には、現在履行中の経路計画の途中から、別の経路計画に変更する必要がある。このように、新たな経路計画を設定した場合には、その経路計画の開始設備、または使用設備にターゲットが到達した時点において自動的にその設備から新たな経路計画に切り替えられるのである。

【0208】さらに、1個の経路計画では表現できない経路で移動体が移動する場合には、複数の経路計画をいわゆるチェーンすることを可能とする。この場合も、新

たな経路計画を設定した場合には、その経路計画の開始設備、または使用設備にターゲットが到着した時点で自動的に新たな経路計画に切り替えられる。

【0209】あるターゲットに現在履行中の経路計画以外に、履行前の経路計画が割り当てられている場合は、ターゲットが以前に使用していた設備から新たな設備に移動した場合に、履行前の経路計画の使用設備を開始から終了方向に探索し、いずれかと一致する場合に、この当該設備において新たな経路計画に移管を行い、新たな経路計画における当該設備からの経路計画に沿って履行を監視するのである。

【0210】例えば、このような経路計画の移管の様子が図39に示されている。この図39に示されているように、まずあるターゲットについて当初経路計画Aが割り当てられていたものとする。この経路計画Aは、設備A1、A2、A3、A4を使用するものである。これらの各設備が誘導路であったり例えばエプロンであったりする。そして、ターゲットがこの経路計画Aに従い設備A1、A2と移動していった場合に、天候の急変などにより急遽経路計画Bを履行する必要がある。すると、本システムにおいては、この経路計画Aと経路計画Bとの共通設備を検索し、その共通設備から経路計画Bに計画が移管するのである。図39に示されている例においては、例えば経路計画Aと経路計画Bとの共通設備はA3であり、ターゲットが経路計画Aの履行を行って途中の設備であるA3に到達した後、その設備から新たに経路計画Bを履行するのである。この結果、そのターゲットは経路計画Bの残りの部分すなわち、設備A3、B3、B4の順に移動を行う。このように、管制官の指示により新たな経路計画が割り当てられた場合には、本システムはこの新たな経路計画と、現在履行中の経路計画とを組み合わせることにより、内部的に新たな計画を実質的に構成しているのである。

#### 【0211】経路計画I/F

本システムにおいては、経路計画の割当及びその履行の監視を行うために管制官との種々のインターフェースを有している。

【0212】まず、空港面管制表示システムに対して、経路計画のターゲットへの始動割当を支援するために、経路計画のリスト表示を行うことが可能である。この経路計画のリスト表示は、移動開始地点、移動終了地点により抽出され、優先順位に従ってリスト表示が行われる。このリスト表示の内容は、個々の経路計画について経路計画識別子、標準走行時間、実績走行時間、現在履行中のターゲット数、及び使用禁止可否の状態を表示する。このように、管制官は開始地点と終了地点を入力することにより、それに対応する経路計画のリスト表示を行わせることができ、複数の候補の中から所望の経路計画を選択することが可能となり、円滑な経路計画の割当をすることができる。

【0213】また、本システムにおいては、経路計画リスト表示上の所望の経路計画を管制官が選択することにより、空港面のデジタルマップ上に選択された経路を表示することが可能である。この対応する経路の表示は当該経路が使用する誘導路の中心線を指示が行われた後一定時間特定の色（経路表示色）に変更することにより管制官に対し視覚的に把握し易くするものである。このように、経路計画を空港面の地図の上で具体的に示すことにより、経路計画の割当を迅速に行うことが可能である。

【0214】さらに、本システムにおいては、デジタルマップ上で誘導路の混雑状態を表示することが可能である。この混雑状態を表示するにはデジタルマップ上でその誘導路を使用しているターゲット数や混雑状態を表す数字などを表示することも好適であるが、本システムにおいては誘導路の中心線の線幅を変更することによって表示が行われている。本システムにおいて用いられているデジタルマップは誘導路としてその中心線と誘導路の幅をデジタルマップのデータとして保持している。そこで、この誘導路の混雑状態として、設備混雑状態情報テーブルの通過予定ターゲット数に基づきこのターゲット数に比例した線幅として上記中心線を表示することにより、各誘導路の混雑具合をデジタルマップ上で表示することが可能である。

【0215】例えば、このように中心線の太さを変更して表示した例が図40に示されている。図において黒で塗り潰されている部分が経路表示色であり、混雑している誘導路ほど太く表示がなされていることが理解されよう。このように、各誘導路の混雑具合を視覚的に把握することが可能となるため、適切な経路計画をターゲットに割り当てる際の目安として活用することが可能となる。

【0216】さらに、本システムにおいては、管制官の指示に基づき、選択されたターゲットについて、このターゲットが割り当てられている経路計画の利用する誘導路の中心線をデジタルマップ上で表示することが可能である。このような表示は、例えば図41に示されている。図41において、黒線で示されているのが選択されたターゲットが履行している経路計画の利用する誘導路を表す。このような表示を行うことにより、管制官はそのターゲットが今後どのような誘導路を進むのかを容易に把握することが可能である。

【0217】このように、本システムにおいては経路計画リストを管制官に指示することにより、経路計画の自動割当の他に管制官が手動で経路計画をターゲットに割り当てることも可能である。また、上述した経路計画自動割当の機能を選択するかあるいは禁止することも管制官の操作により指定することが可能である。

【0218】C. 移動体交通監視システムの監視の内容以上述べたように、本実施の形態に係る空港面移動体交

通監視システムにおいては、航空面のデジタルマップを表示すると共に、それに重畳して現在空港面上を移動している移動体を表示することにより、空港面内の交通監視を行うことが可能である。以下、本システムにおいて提供される各種管理・監視の機能について説明する。

#### 【0219】経路計画の履行監視

上述したように、本システムにおいては管理対象である各ターゲットに対し、経路計画をそれぞれ割り当てる。ターゲットに割り当てた経路計画は、そのターゲットが移動中は、割り当てられた経路計画が履行されているか否かの監視を行い、割り当てられた経路計画より外れた場合は、その旨の警報を画面に表示する。

【0220】この経路計画履行監視においては、ターゲット情報テーブルの現在使用中設備と現在履行中経路計画移動順序番号に対応する設備とを比較し、異なっている場合には経路計画移動順序が次の誘導路などに移動したものと判断し、ターゲット情報テーブルの現在履行中の経路計画移動順序番号をカウントアップする。そして、この移動順序番号と、現在使用中の設備とを比較することにより割り当てられた経路計画が正確に履行されているか否かの監視を行う。この監視を行うことにより、上記移動順序番号と現在使用中設備とが一致しない場合には経路計画が履行されていないものと判断し、所定の警報発行を行う。

#### 【0221】誘導路縦方向衝突監視(1)

本誘導路縦方向衝突監視(1)は、ある誘導路を使用中の移動体が既に存在する場合には、その移動体の縦方向の間隔が安全上問題が生じないように一定量確保するための監視である。

【0222】具体的には、本監視においては、当該誘導路の設備属性情報テーブル202に保持されている共用可能移動体数と、現在その誘導路を使用している使用中ターゲット数に基づいて、現在使用中のターゲット数が多い場合にはその誘導路への進入を制限するものである。

【0223】ある移動体が所定の交差点交通監視レンジ内にあり、かつ当該交差点における交通監視を選択する場合には当該移動体が次に進入する誘導路を判定する。この交差点交通監視レンジは、各交差点に設定されているレンジである。そして、この交差点交通監視レンジは、その交差点に対する進入を制限するため、交差点であるとして取扱われる領域より広い領域のレンジである。また、当該移動体が次に進入する誘導路を判定は、当該移動体に経路計画が設定されている場合は、この経路計画に基づき次に利用する設備を検索することにより実行される。また、経路計画が未設定である場合には進入可否の評価は本システムにおいては行わない。

【0224】進入可否の評価は、次に利用する誘導路に関する設備属性情報テーブル202に保持されている共用可能ターゲット数（移動体数）と、現在使用中移動体

数との比較に基づいて行われる。具体的には共用可能移動体数>現在使用中移動体数である場合には、当該移動体が当該誘導路に進入することを許可するのである。このような条件を満たさない場合には、当該移動体のデジタルターゲット表示において、停止指示表示が行われる。

【0225】現在使用中移動体数は、ある移動体が新たな誘導路に進入した場合に、設備属性情報テーブル202に保持されている現在使用中移動体数が1インクリメントすることにより計数する。

【0226】また、ある移動体の使用中の設備が変更されて、かつ前回使用されていた設備が誘導路である場合は、前回使用中の設備であったその誘導路の設備属性情報テーブル202に保持されている現在使用中移動体数を1デクリメントする。これは、その誘導路から移動体が離脱したことを意味する。このようなインクリメント及びデクリメントによる現在使用中移動体数の計数は、交通監視を行う行わないに関わらず実施される。

【0227】ある移動体が新たな誘導路に進入した場合に、設備属性情報テーブル202に保持されている現在使用中ターゲット数を1インクリメントした結果、当該誘導路の設備属性情報テーブル202に保持する共用可能移動体数を越える場合には、当該移動体のデジタルターゲット表示において警報表示が行われる。この表示は、交通監視を行う場合や行わない場合もいずれにも表示が行われる。

【0228】以上述べた誘導路縦方向衝突監視(1)においては、移動体のサイズの考慮は特に説明しなかった。すなわち、小さな車両もまた大きな旅客機も同等のスペースを占有すると仮定している。しかし、移動体のサイズは、移動計画情報114や、各種センサー100からの入力情報により把握することが可能である。そのため、移動体のサイズを考慮した誘導路縦方向衝突監視を行うことは容易である。このような衝突監視を行う場合には、移動体のサイズをクラス化し、このクラス毎に所定の計数を定義することにより、移動体のサイズを考慮した衝突監視を行うことが可能である。具体的には、ある誘導路を使用中の移動体 $M_i$ のサイズに対応した係数を $S_i$ とし、当該誘導路に $n$ 個の移動体が存在する場合には、単に上に述べた縦方向衝突監視における移動体数は $n$ であるが、移動体のサイズを考慮する場合にはこれを $\Sigma B_i$ とすることにより、移動体のサイズを考慮した縦方向衝突監視を行うことが可能である。ここで、 $B_i = M_i \times S_i$ である。

【0229】この誘導路縦方向衝突監視(1)の具体的な衝突監視の例が図42に示されている。図42に示されているように、誘導路Nの共用可能ターゲット数が例えば3機である場合には、これから誘導路Nに進入しようとしているターゲットDは誘導路Nへの進入が許可されない。

【0230】なお、移動体のサイズを考慮する場合にも同様の原理により進入の許可及び禁止が行われる。

【0231】なお、航空機の場合には単純にその移動体のサイズのみを考慮したのでは足りない。すなわち、大きな旅客機の後に小型機が位置する場合には、大型の旅客機のエンジンからの強い風により、後の小型機の運行に支障が生じることがある。そのため、単なる大きさではなくいわゆるブラストを考慮した各ターゲット間の距離を判断する必要がある。このように、機種別のブラストを考慮する場合にも、フライトプランからその機種を求め、上記移動体のサイズの考慮と同様に一定の重み付けをすることにより円滑な運行管理が行える。

【0232】誘導路縦方向衝突監視(2)  
空港面における誘導路などは全て一方通行である。この一方通行とは特にその通行方向が決まっているわけではなく、ある移動体がその誘導路に進入した場合にはその移動体と逆方向の移動体の進入ができないという意味であり、その瞬間瞬間に応じて方向が定まる一方通行と言えよう。

【0233】本誘導路縦方向衝突監視(2)は、ある誘導路上を使用中の移動体が既に存在する場合には、当該移動体が進行する方向の交差点から新たな移動体が進入してくることを監視している。また当該誘導路が保全などの理由により使用不可能状態である場合には、当該誘導路への誤進入を監視する。このような誘導路縦方向衝突監視(2)の説明図が図43に示されている。図43に示されているように、誘導路NをターゲットAが走行中の場合には、ターゲットAの進行方向にある交通ノードからの新たな進入をしようとしているターゲットDはその進入が禁止されるのである。

【0234】この誘導路縦方向衝突監視(2)は具体的には当該誘導路の交通ノードに対応する交通ノード属性情報テーブルに保持されている現在状態に基づいて以下のように行われる。

【0235】まず、ある移動体が交差点交通監視レンジ内にあり、かつ当該交差点における交通監視が選択されている場合には当該移動体が次に進入する誘導路を判定する。この誘導路の判定は、上記誘導路縦方向衝突監視(1)において述べたように、経路計画において次に利用する設備を検索することにより行われる。経路計画が未設定である場合には、進入可否の評価は行われない。このようにして、次に利用する誘導路、現在の交差点とをキーにして交通ノード属性情報テーブルを検索し、交通ノードの現在の状態を評価する。そして、現在の状態が進入許可状態である場合には当該ターゲットが当該誘導路に進入することを許可する。一方、上記条件を満たさない場合には当該移動体のデジタルターゲット表示において停止指示表示が行われる。

【0236】移動体が進入した誘導路の、その進入した交通ノードとは反対側の交通ノード、すなわち行先側の

交通ノードについて、交通ノード属性情報テーブルの現在状態を評価する。この評価の結果、進入許可状態である場合には、進入禁止状態に設定する。このような処理は、交通監視が選択されている場合や禁止されている場合に限らずいずれの場合も実施される。

【0237】移動体がある誘導路を離脱する場合には、現在使用中の誘導路の現在使用中移動体数を1デクリメントした結果、当該誘導路の現在使用中移動体数が0となった場合には、この移動体が離脱した側の交通ノードの現在状態を進入許可状態に設定する。すなわち、その移動体が誘導路に存在した場合にはその交通ノードは進入禁止にされていたわけであるが、その移動体が交通ノードから離脱したことにより、誘導路の移動体数が0になった場合にはその交通ノードからの進入があらためて許可される状態となるのである。このような処理は、交通監視が選択されている場合や禁止されている場合に限らず実施される。

【0238】移動体が進入した誘導路の、その進入した交通ノードとは反対側の交通ノード、すなわち移動体が向かっている方向の交通ノードについて、交通ノード属性情報テーブルの現在状態を評価し、もし進入禁止状態である場合には、当該移動体のデジタルターゲット表示において警報表示が行われる。この処理は交通監視が選択されている場合か禁止されている場合かに限らず実施される。

#### 【0239】誘導路横方向衝突監視

本誘導路横方向衝突監視は、ある誘導路上を移動中の移動体が既に存在する場合に、その誘導路に隣接し、かつ移動体の横方向の離隔距離が確保できない誘導路に移動体が進入することを監視するものである。

【0240】この誘導路横方向衝突監視の説明図が図44に示されている。図44(a)に示されているように、誘導路T1と誘導路T2が平行して位置している場合に、航空機AC1と航空機AC2とが互いに反対方向から移動してきた場合にその横方向の離隔距離を確保できない場合が生じる。このような場合に、誘導路T1に航空機AC1が移動している場合にその隣接する誘導路T2に航空機AC2に反対方向から進入してくるのを禁止することにより、横方向の衝突を防止するものである。

【0241】一方、図44(b)に示されているように、航空機AC1と、航空機AC2とが同じ向きに進行する場合には、図44(a)とは異なり横方向の離隔距離は確保可能である。

【0242】このように、ある誘導路に航空機が存在する場合には、その誘導路と近接している誘導路に対し、上記航空機と逆方向に進むような航空機の進入を禁止するものである。

【0243】このような衝突監視を行うために、本システムにおいては交通ノードのグループ化を行っている。

交通ノードをグループ化することにより上記横方向の衝突監視を行うことが可能である。具体的には、図44

(b)に示されているように交通ノードを以下のようにグループ化する。

$$\begin{aligned} & \{ (T1 * N1) + (T2 * N3) \} \\ & \{ (T1 * N2) + (T2 * N4) \} \\ & \{ (T2 * N3) + (T3 * N5) \} \\ & \{ (T2 * N4) + (T3 * N6) \} \end{aligned}$$

ここで、T1～T3は各誘導路を表す(図44(b)参照)。N1～N6は交通ノードを表す(図44参照)。このようにグループ化を行うことにより、例えば交通ノードN1から進入し誘導路T1を走行中の航空機が存在する場合には、N2から誘導路T1への進入を禁止すると同時に交通ノードN4から誘導路T2への進入についても禁止する交通制御が可能である。すなわち交通ノードN1から航空機が進入する場合に縦方向の衝突を回避するためまずその対面に存在する中間ノードN2の進入禁止が行われる。これと同時に、この交通ノードN2とグループ化されている他の交通ノードについても進入禁止が行われるのである。この結果、交通ノードN4からの進入が禁止されることにより、図44(a)に示されるように隣接する誘導路において逆方向に航空機が進入するという事態を未然に防止することが可能である。

【0245】この時、図44(b)に示されるように、T2\*N4と、T3\*N6とがさらにグループ化されているが、これについては交通制御の範囲外とする(グループ化による交通制御は1グループのみに限定している)。なお、このようなグループ化は、人間が予め設備データとして登録しておく。

【0246】図44に示されている例においては、ある誘導路の交通ノードのグループ化は2つの交通ノードに対してそれぞれグループ化が行われている。しかし、このグループ化は3つの交通ノードに対して1つのグループ化が行われる場合もある。例えば、図45に示されているように3本の誘導路が互いに近接しており、いずれの誘導路に航空機が存在する場合にも他の2つの誘導路が影響を受ける場合には、3つの交通ノードにこのように1つのグループが割り当てられる。

【0247】具体的な監視の方法を以下に説明する。

【0248】まず、当該誘導路の交通ノードに対応する交通ノードグループ属性情報テーブル218に保持されている交通ノードグループ現在状態に基づき、進入可否の評価がまず行われる。

【0249】ある移動体が交差点交通監視レンジ内にあり、かつ当該交差点における交通監視を選択する場合には、当該移動体が次に進入する誘導路を判定する。この誘導路の判定は、上記縦方向衝突監視において述べたように、当該移動体に経路計画が設定されている場合にはこの経路計画において次に利用する設備を検索することにより行われる。一方、経路計画が未設定である場合に

は進入可否の評価は行わない。次に、利用する誘導路と現在の交差点をキーにして交通ノード属性情報テーブルを検索し、交通ノードが交通ノードグループに所属している場合には、この交通ノードグループの交通ノードグループ属性テーブルの現在状態を評価する。この評価の結果、現在状態が進入許可状態である場合には、当該移動体は誘導路に進入することを許可される。一方、この条件を満たさない場合には、当該移動体のデジタルターゲット表示において停止指示表示が行われる。

【0250】一方、当該グループに対して進入禁止状態の設定は、以下のように行われる。まず、移動体が進入した誘導路の、その移動体が進む方向の交通ノード、すなわち進入した交通ノードとは反対側の交通ノードについて、交通ノード属性情報テーブルの現在状態が評価され、この評価の結果進入許可状態である場合には進入禁止状態に設定する。この動作は、上記縦方向衝突監視と同様である。さらに、当該交通ノードが一定の交通ノードグループに所属している場合には、この所属している交通ノードグループ属性情報テーブルの交通ノードグループ状態に、当該交通ノードの状態として進入禁止状態を設定する。この設定は、具体的には当該交通ノードの交通ノードグループ状態設定マスク値に対し、論理和設定することにより行われ、他の設定値の値を変更しないようにして設定が行われる。このような処理は、交通監視の選択/禁止状態のいずれに関わらず実施が行われる。

【0251】すなわち進入した交通ノードとは反対側の交通ノードについて、交通ノードグループ属性情報テーブルの現在状態を評価し、この評価の結果進入禁止状態が設定されている場合には、当該移動体のデジタルターゲット表示において警報表示が行われる。この警報表示は交通監視の選択/禁止状態に関わらず実施される。

#### 【0252】滑走路誤進入監視

本滑走路誤進入監視は、ターゲットの滑走路への進入可否を監視する。

【0253】従来から、滑走路への誤進入を防止する方法として種々の方法が知られている。

【0254】例えば、移動体（航空機、車両）の現在位置とその移動ベクトルより、移動体毎のセパレーション（通常は移動体のベクトル方向に広がる扇形）を計算し、そのセパレーション内に他の移動体が存在する場合に警報を発行する。

【0255】このように、ある一定距離、あるいは移動体の速度に応じたセパレーションによる移動体同士の間隔により衝突の検知を行う方法は、広域管制、ターミナル管制の分野で実用化されており、この方法を空港面における警報に適用することも考えられる。このようなセパレーションによる方法の説明図が図46に示されている。

【0256】但し、空港面の地形が非常に複雑であるた

め、セパレーション間隔を一意に決定することは困難であり、又、図47に示されている例においては誤警報が生じる可能性がある。

【0257】本実施の形態に係る空港面移動体交通監視システムにおいては、滑走路の使用に関し、排他制御に基づき滑走路誤進入警報の検知を行っている。まず、図48に示されているように、滑走路及び滑走路のアプローチを含めた滑走路占有エリア300を定義している。そして、この滑走路占有エリア300に進入した移動体は、その滑走路を占有することになる。この占有状態が図49に示されている。図49において、粗いハッチングで示された部分が滑走路302でありこの滑走路302が進入してきた進入機304に対して占有されるのである。このように、所定の進入機304が滑走路占有エリア300に進入したことにより、滑走路302がその進入機304に対し占有することにしたため、空港面の複雑な地形にも対応することが可能である。この方法は、これからこの滑走路を利用し離陸を行う出発機306（図50参照）にも、地上面を走行する地上面走行機308（図51参照）にも適用可能である。例えば、図50においては進入機304が滑走路占有エリア300に入る前に、出発機306が滑走路占有エリアに進入しているため、この出発機306に対し滑走路300が占有されている。また、図51においてはこの滑走路を利用する航空機ではないがこの滑走路を横切る地上面走行機308が滑走路占有エリア300に進入することによりその滑走路302が地上面走行機308に占有されている。

【0258】また、この滑走路占有エリア300に対して交差する経路を飛行する航空機に対しては、その航空機のヘディングにより適用除外とすることが可能である（図52参照）。すなわち、通過機310はこの滑走路占有エリア300の上空を単に通過するだけであるため、その通過機を監視の対象外としているのである（図52参照）。

【0259】また、滑走路占有エリア300としては以下に述べるように2種類のエリアとして定義することが好適である。本システムに係る滑走路占有エリア300は以下に示す滑走路監視レベルエリア300aと、滑走路警報レベルエリア300bとの2種類のエリアとして定義されている。まず、滑走路監視レベルエリア300aは、このエリアに進入した移動体は、当該エリアに対応する滑走路を占有中の移動体が他に存在しなければ、当該エリアに対応する滑走路を占有する。すなわち、この滑走路監視レベルエリア300aに新たに移動体が進入する場合には、その移動体が滑走路302を占有するのである。一方、滑走路警報レベルエリア300bは、この滑走路警報レベルエリア300bのエリアに進入した移動体が、当該エリアに対応する滑走路を占有している移動体ではない場合に、滑走路誤進入警報を発する。

【0260】このように、滑走路監視レベルエリア300aは、滑走路302に対する誤進入の監視を開始するためのエリアである。また、このエリアに移動体が進入した場合に、他に滑走路302を占有する移動体がない場合には、その進入された移動体が滑走路302を占有するのである。この滑走路監視レベルエリア300aの範囲は、図53に示されているように滑走路警報レベルエリア300bの外側、具体的には滑走路警報レベルエリア300bより広く設定する必要がある。一方、滑走路警報レベルエリア300bは、アプローチにおいては進入復行が可能な限界点を含めた範囲とする必要がある。さらに進入復行可能な限界点に到達するまでに管制官からの指示を行って、それに対するパイロットのアクションを起すことが可能なだけの時間的な余裕を含めておく必要がある。また、空港面に鑑みれば、この滑走路警報レベルエリア300bは滑走路302を十分に覆う範囲とする必要がある。

【0261】また、滑走路占有エリア300の属性としては、アプローチラインを横切る航空機を警報の対象外とするため、監視の対象とするベクトル方向の範囲を保持しておく必要がある。また、使用する滑走路（使用方向も含めて考える）、出発機/進入機毎の設定が可能である。

【0262】以上述べたように、本実施の形態に係る空港面移動体交通監視システムにおいては滑走路の誤進入を防止するために滑走路の周囲に警報を発行するための滑走路警報レベルエリア300bと、さらにそれより広い滑走路監視レベルエリア300aを設定した。そして、この滑走路監視レベルエリア300aに移動体が進入した場合には、警報は発行しないが滑走路をその進入した移動体に占有させることにより、他の移動体の進入を排除している。そして、このような排他制御により滑走路に対する誤進入を防止している。

【0263】滑走路の誤進入を防止するために、本システムにおいては誤進入に対し以下のような表示を管制官に対する表示部に行わせる。

【0264】まず、移動体が滑走路を占有した時点（移動体が滑走路監視レベルエリア300a内に進入した時点）において、滑走路302について占有中の表示を行う。滑走路が占有中である旨の表示は、デジタルマップ上の滑走路の表示の色を変更することにより行われる。なお、図49～図53においては色の代りに粗いハッチングにより滑走路302が占有状態であることを表している。

【0265】さらに、現在滑走路302を占有している移動体に対応するデジタルターゲットについてもその旨が判断できる表示がなされる。具体的には、その滑走路302が占有された対象であるデジタルターゲットについてもその色を変更したり、または近傍に滑走路を占有している旨の表示や記号を表すことなどが好適である。

【0266】このような表示をデジタルマップ、及び空港面上を移動する各移動体の表示と共に表示することにより、空港における管制の際、誤ったクリアランスの発行を防止することが可能である。さらに、既に占有中の移動体が存在する滑走路302に対し、別の移動体が誤進入した場合には、誤進入した移動体に対応するデジタルターゲットについてその旨が判断できるような表示がなされる。例えば、その誤進入による移動体を表すデジタルターゲットの色が変更されたり、または管制官の注意を促すべく点滅表示などを行うのが好適である。

【0267】又、空港面においては、滑走路近傍に移動体が存在することを許すため、管制官が介入するだけの余裕もなく、滑走路への誤進入が発生する可能性が十分考えられる。このため、滑走路への進入誘導路に踏切などの視覚援助施設を接地するとともに、さらに個々の視覚援助施設との連携オートメーションを実現することにより、安全性が向上するものと考えられる。このような例が図54に示されている。

【0268】尚、衝突警報を発出するエリア範囲は警報発生から、回避開始までの所要時間に移動体が進む距離と、回避のための最低必要距離の合計距離が必要であると考えられる。

【0269】警報発生から回避開始までの所要時間には、計算機の処理時間、管制官の指示、パイロットのアクションなどの時間が含まれますが、このうち計算機の処理時間については、他の時間に比較した場合に、ほとんど無視することが可能である。

【0270】又、回避のための最低必要距離は、例えば進入機で在れば進入腹腔の限界点になると考えられる。図55に警報発生から、回避開始までの所要時間を10秒/20秒/30秒/40秒とした場合の各々について、移動体の現在速度に対する警報発生から、回避開始までの移動体の進む距離を示す。

#### 【0271】交差点誤進入監視

滑走路302に対する誤進入を監視すると同様な目的により、交差点の誤進入を防止する必要もある。これは、ある交差点を使用中のターゲットが既に存在する場合には、新たなターゲットが交差点に進入しないように監視を行うものである。そして、新たなターゲットが交差点に進入しようとする場合に、ターゲットは既に交差点中に存在する場合にはその進入を制限するものである。

【0272】図56には、空港面における交差点の監視を行う交通監視レンジの説明図が示されている。図56に示されているように、交差点というものは、具体的にはある点を中心とする円で表される。この円をその交差点の範囲レンジと呼ぶ。また、同じく点（交差点）を中心とする範囲レンジより広い円を交通監視レンジと読んでいる。このように、交差点は、設備属性情報テーブル202内部に、交通監視レンジと範囲レンジとを保持しているのである。交通監視レンジ、及び範囲レンジは、



上述したように交差点を中心にする円で表され交通監視レンジはターゲットがその円内に進入した時点で、当該交差点に関する交差点誤進入監視の対象とするレンジである。一方、範囲レンジは、当該交差点の範囲を表し、範囲レンジ内に進入するターゲットは当該交差点を占有する。

【0273】そして、図56に示されているように範囲レンジに入る前に各誘導路に対しSTOPパー（Stop Bar）が設けられており、移動体が範囲レンジに入る前にその進入を阻止し得るように構成されている。

【0274】誘導路を走行中のターゲットが交差点の交通監視レンジに進入した場合には、当該交差点を占有するものとする。これは、上述した滑走路誤進入監視と同様である。このように、交差点の内部にターゲットが存在しない場合には、新たに交通監視レンジに進入したターゲットが当該交差点を占有するため、設備属性情報テーブル202の内部の占有中ターゲットの項目に当該ターゲットが設定され、現在状態を占有中に設定するのである。

【0275】次に、当該ターゲットがこの交差点を通過し、交通監視レンジで示される円内から脱出した場合には、設備属性情報テーブル202の占有中ターゲットを解除し、現在状態を使用可能に設定する。これによって、この交差点は新たにこの交差点に進入する別の移動体に使用されることが可能となる。

【0276】逆に、移動体が交通監視レンジに進入した場合に、既にこの交差点を占有するターゲットが存在する場合にはストップバーが閉じられ、この交差点が使用可能状態に復帰するまで移動体は範囲レンジに進入することはできない。このように、移動体を制御することにより交差点に対する誤進入を防止することが可能である。

【0277】

【発明の効果】第1の本発明によれば、所定のしきい値より高いか否かで警報の発行、非発行を制御しうるので、しきい値を変化させることにより、効率的に警報の抑止が行える空港面移動体交通監視装置が得られる。

【0278】第2の本発明によれば、各移動体に経路計画が割り当てられるので、管制官お負担を減少しうる空港面移動体交通監視装置が得られる。

【0279】第3の本発明によれば、各移動体の移動開始地点、及び終了地点に基づき経路計画が検索されるので、迅速な処理が可能な空港面移動体交通監視装置が得られる。

【0280】第4の本発明によれば、各経路計画の同時利用可能な移動体数を記憶保持しているため、特定の経路計画のみに割り当てが集中することを防止し、円滑な空港の運用が可能な空港面移動体交通監視装置が得られる。

【0281】第5の本発明によれば、各経路計画に含まれる誘導路毎に、その利用可能な移動体数を記憶、保持

し、その誘導路に対する利用移動体数がこの値より大きくならないように、割り当てを行った。そのため、誘導路ごとに特に混雑してしまうことを防止し、円滑な空港の運用が可能となる。

【0282】第6の本発明によれば、割り当てられた経路計画が変更された場合でも、変更の前後の経路計画に基づき、新たな経路計画が作成されるので、円滑な経路計画の切替が行える。

【0283】第7の本発明によれば、割り当てられた経路計画が正確に履行されているか否かを効率的に監視しうる空港面移動体交通監視装置が得られる。

【0284】第8の本発明によれば、誘導路の共用可能移動体数を超える移動体数がその誘導路に進入しようとした場合に警報を発行するため、衝突を未然に防止可能である。

【0285】第9の本発明によれば、誘導路が利用されている場合に、その移動体の移動方向とは反対側からの交通ノードからの進入を制限することにより、衝突を未然に防止可能である。

【0286】第10の本発明によれば、近傍に隣接して並ぶ誘導路を、同時にそれぞれ移動体を使用した場合に、これらの移動体が側面において衝突してしまうことを防止すべく、交通ノードのグループ化により、一定の交通ノードを進入禁止とする。そのため、横方向の衝突を未然に防止することが可能である。

【0287】第11の本発明によれば、滑走路を排他使用することにより衝突を回避する監視装置において、監視エリアと、警報エリアの2種類の領域を設けたので円滑な排他使用が可能となる。

【0288】第12の本発明によれば、上記第11の本発明と同様の効果が奏される。

【0289】第13の本発明によれば、誘導路の混雑状況が肉眼で容易に把握できるため、管制官の負担の軽減を図ることが可能な空港面移動体交通監視装置が得られる。

【図面の簡単な説明】

【図1】 本発明の好適な実施の形態である空港面移動体交通監視システムの主要な構成を表す構成ブロック図である。

【図2】 本実施の形態に係るデータの関係を表す説明図である。

【図3】 本システムにおいて、誘導路と交差点との関係を表す説明図である。

【図4】 図3と同じく誘導路と交差点との関係を表すとともに、交通ノードの関係をも表す説明図である。

【図5】 設備種別情報テーブルの内容を表す説明図である。

【図6】 設備属性情報テーブルの内容を表す説明図である。

【図7】 交差点情報テーブルの内容を表す説明図であ

る。

【図 8】 誘導路情報テーブルの内容を表す説明図である。

【図 9】 エリア種別情報テーブルの内容を表す説明図である。

【図 10】 エリア／設備形状情報の内容を表す説明図である。

【図 11】 デジタルターゲット表示制御情報テーブルの内容を表す説明図である。

【図 12】 交通ノード状態情報テーブルの内容を表す説明図である。

【図 13】 交通ノード所属交通ノードグループ情報テーブルの内容を表す説明図である。

【図 14】 交通ノードグループ属性情報テーブルの内容を表す説明図である。

【図 15】 メッシュデータの内容を表す説明図である。

【図 16】 移動体属性情報テーブルの内容を表す説明図である。

【図 17】 航跡情報テーブルの内容を表す説明図である。

【図 18】 経路計画割当状態情報テーブルの内容を表す説明図である。

【図 19】 移動計画情報テーブルの内容を表す説明図である。

【図 20】 空港運用情報テーブルの内容を表す説明図である。

【図 21】 経路計画情報テーブルの内容を表す説明図である。

【図 22】 経路計画使用設備情報テーブルの内容を表す説明図である。

【図 23】 経路計画状態テーブルの内容を表す説明図である。

【図 24】 設備混雑状態情報テーブルの内容を表す説明図である。

【図 25】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 26】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 27】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 28】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 29】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 30】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 31】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 32】 本実施の形態に係る空港面移動体交通監視

システムの画面表示の例を表す説明図である。

【図 33】 本実施の形態に係る空港面移動体交通監視システムの画面表示の例を表す説明図である。

【図 34】 現在の移動体数を把握する動作を表すフローチャートである。

【図 35】 交通密度を監視する際の動作を表すフローチャートである。

【図 36】 交通監視を行うか否かが自動的に切り替えられる場合の切替の動作を表すフローチャートである。

【図 37】 経路 A があるターゲットに割り当てられている場合、経路 B を別のターゲットに割り当てることはできないことを表す説明図である。

【図 38】 経路計画の自動割当の具体的な動作を表すフローチャートである。

【図 39】 経路計画の移管の様子を示す説明図である。

【図 40】 各誘導路の混雑具合に応じて各誘導路の中心線の太さを変更して表示したデジタルマップを表す説明図である。

【図 41】 ターゲットが履行している経路計画に含まれる誘導路が黒線で表示される様子を表す説明図である。

【図 42】 誘導路縦方向衝突監視（1）の具体的な衝突監視の例が示されている説明図である。

【図 43】 誘導路縦方向衝突監視（2）の具体的な衝突監視の例が示されている説明図である。

【図 44】 誘導路横方向衝突監視の具体的な衝突監視の例が示されている説明図である。

【図 45】 誘導路横方向衝突監視において、3 個のノードに対し 1 グループかなされている場合の例を表す説明図である。

【図 46】 セパレーションによる移動体同士の間隔により衝突の検知を行う方法の説明図である。

【図 47】 セパレーションによる移動体同士の間隔により衝突の検知を行う方法において誤警報が発生する可能性のある場合の説明図である。

【図 48】 滑走路誤進入監視の動作の説明図である。

【図 49】 滑走路誤進入監視の動作の説明図である。

【図 50】 滑走路誤進入監視の動作の説明図である。

【図 51】 滑走路誤進入監視の動作の説明図である。

【図 52】 滑走路誤進入監視の動作の説明図である。

【図 53】 滑走路誤進入監視の動作の説明図である。

【図 54】 滑走路誤進入監視の動作の説明図である。

【図 55】 警報発生から回避開始までの所要時間を 10 秒～40 秒とした場合の移動体の進む距離を表す表の説明図である。

【図 56】 交差点における交通監視レンジの説明図である。

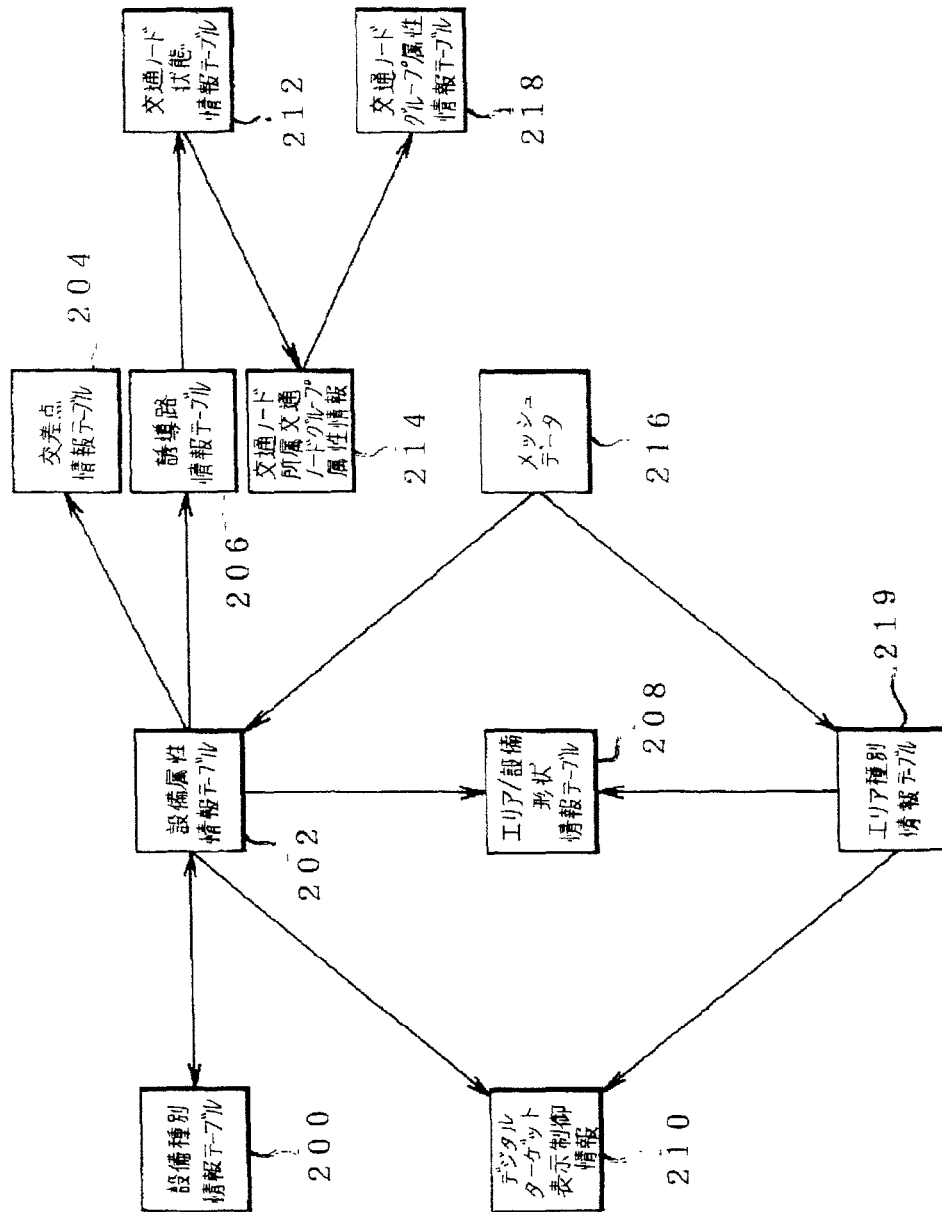
【図 57】 経路計画の選択において航空機型式により経路が変化する様子を表す説明図である。

【符号の説明】

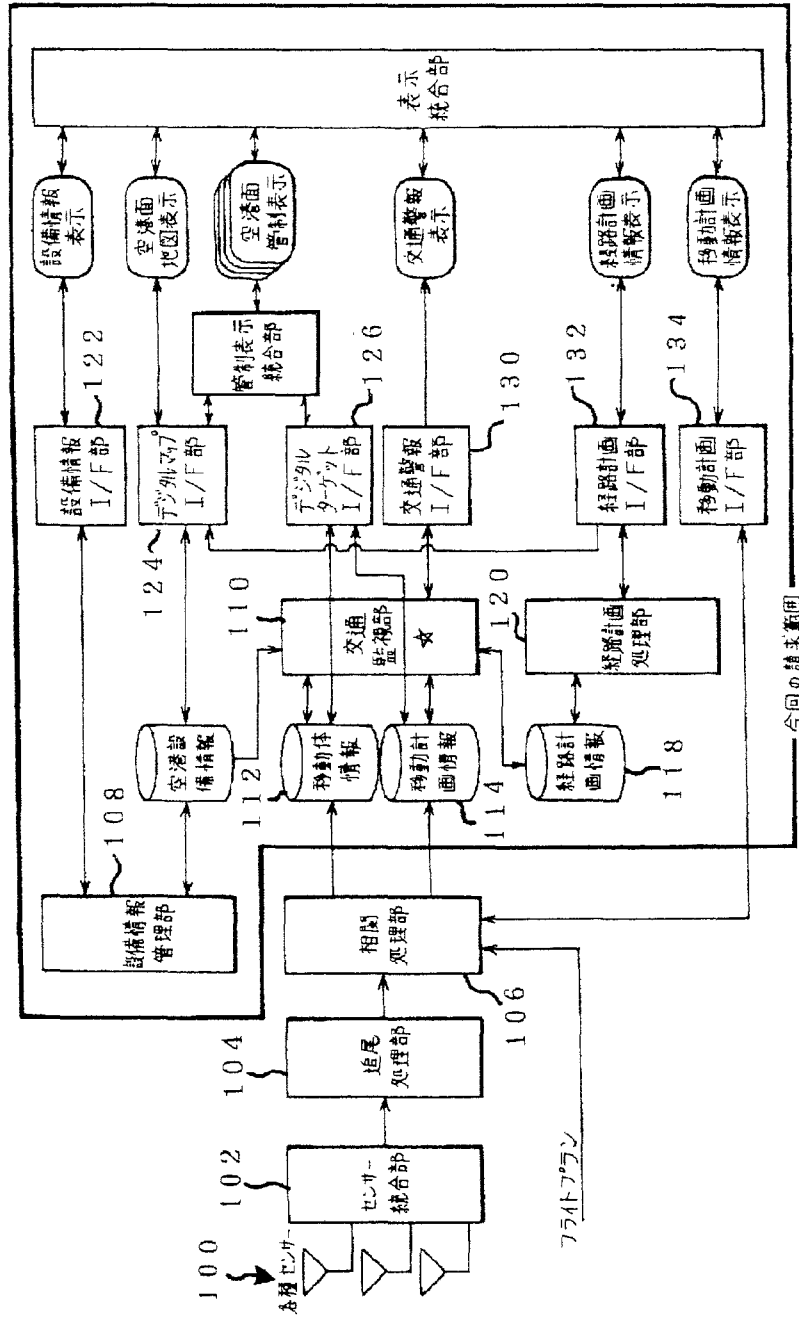
100 各種センサー、102 センサー統合部、104 追尾処理部、106 相関処理部、108 設備情報管理部、110 交通監視部、112 移動体情報、114 移動計画情報、116 空港設備情報、118 経路計画情報、120 経路計画処理部、122 設備情報I/F部、124 デジタルマップI/F部、128 管制表示統合部、130 交通警報I/F部、132 経路計画I/F部、134 移動計画I/F部、200 設備種別情報テーブル、202 設備属性情報

テーブル、204 交差点情報テーブル、206 誘導路情報テーブル、208 エリア/設備形状情報テーブル、210 デジタルターゲット表示制御情報、212 交通ノード状態情報テーブル、214 交通ノード所属交通ノードグループ属性情報、216 メッシュデータ、218 交通ノードグループ属性情報テーブル、219 エリア種別情報テーブル、300 滑走路占有エリア、300a 滑走路監視レベルエリア、300b 滑走路警報レベルエリア、302 滑走路、304 進入機、306 出発機、308 地上面走行。

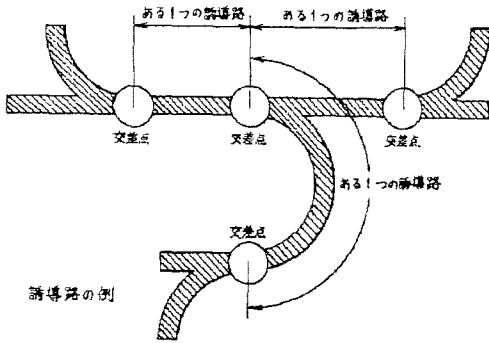
【図2】



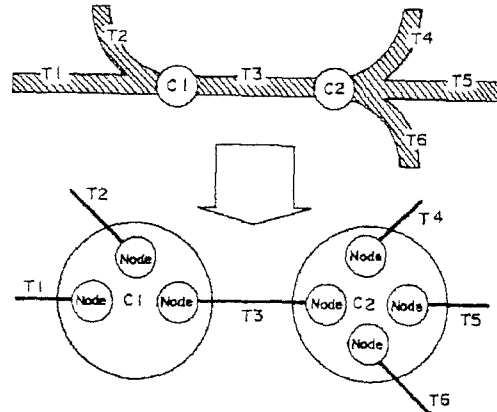
【図一】



【図3】



【図4】



【図5】

空港設備情報	
設備種別情報テーブル	
	設備種別情報テーブルは、設備種別毎の主にデジタルマップ表示に関する各種属性情報を保持し、1個の設備種別が1個のインスタンスに対応する。
* エリア/設備種別	設備/エリアの種別をユニークに判定するための識別子である。
+ 最小表示倍率	当該設備種別をデジタルマップに描画する場合のデジタルマップの最低の表示倍率を示す。デジタルマップの表示倍率を縮小した場合に、視認できる限界値であり、これ以下の倍率では、当該設備種別の表示を行わない。
+ 最大表示倍率	当該設備種別をデジタルマップに描画する場合のデジタルマップの最大の表示倍率を示す。デジタルマップの表示倍率を拡大した場合に、視認できる限界値であり、これ以上の倍率では、当該設備種別の表示を行わない。
+ デジタルマップ表示色	デジタルマップに表示する際の表示色を示す。
+ デジタルマップ塗りつぶし区分	デジタルマップに表示する際に輪郭のみ表示するか塗りつぶすかの区分を示す。
+ 表示デジタルマップ区分	表示するデジタルマップを示す。デジタルマップには、基本/セレクト/エリアマップの区分があり、どのデジタルマップに描画するかの情報を示す。

【図6】

設備属性情報テーブル	
	設備属性情報テーブルは、個々の設備毎の属性情報を示し、1個の設備が1個のインスタンスに対応し、存在する全ての設備に関する情報を保持する。
* エリア/設備種別	設備/エリアの種別をユニークに判定するための識別子である。
* 設備識別子	個々の設備をユニークに識別するための識別子である。
+ 設備名称	設備の名称であり、インスタンス生成時に運用者により名前付けされる。設備名称は、運用者、地上管制官、パイロット等により共通に認識できる名前である。
+ 交通監視を行なう最低交通密度レベル	当該設備を使用中の移動体に対する交通監視を行なう最低交通密度レベルを示す。空港の交通密度レベルが本値以上となった場合に、交通監視を実施する。
+ 交通監視を行なう最低視程条件レベル	当該設備を使用中の移動体に対する交通監視を行なう最低視程条件レベルを示す。空港の視程条件レベルが本値以上となった場合に、交通監視を実施する。
+ 共用可能ターゲット数	共用資源を同時に使用することが可能なターゲット数を示す。
+ 現在状態	当該設備の現在の状態を以下の区分で示す。 # 占有状態 # 使用可能状態 # 使用不可能状態 (交通監視に基づく) # 使用不可能状態 (クローズに基づく) 000
+ 現在使用中ターゲット数	当該設備が現在使用中のターゲット数を示す。
+ 経路計画自動割当て実施最大交通密度レベル	交通密度が当該レベル以上である場合は、経路計画自動割当てを行わない。
+ 経路計画自動割当て実施最大視程条件レベル	視程条件が当該レベル以上である場合は、経路計画自動割当てを行わない。
+ デジタルターゲット表示制御情報識別子	当該設備のデジタルターゲット表示制御情報の識別子を示す。

【図7】

交差点情報テーブル	
	設備種別が交差点である設備について、設備属性情報テーブルに加えて以下の付加情報を保持する。
* 設備識別子	個々の設備をユニークに識別するための識別子である。
+ 交差点位置情報	交差点の位置を基本座標系におけるXY座標で示す。
+ 交差点範囲レンジ	交差点の範囲を示す。交差点位置を中心とし、交差点範囲レンジを半径とする円内を当該交差点の範囲とする。交差点範囲内に存在する移動体は、その交差点を占有していなければならない。また、交差点の範囲は当該交差点に対するストップバーの内側になければならない。
+ 交差点交通監視レンジ	交差点の交通監視を行う範囲を示す。当該交差点を使用する移動体が、交差点位置を中心とした交差点交通監視レンジを半径とする円内に進入した場合に、その移動体について当該交差点の交通監視を行う。交差点交通監視レンジは、交差点範囲レンジ以上の領域である必要がある。
+ 占有中移動体識別子	現在当該交差点を占有しているターゲットの識別子を示す。

【図8】

誘導路情報テーブル	
	設備種別が誘導路である設備について、以下の付加情報を保持する。
	設備種別が誘導路である設備について、設備属性情報テーブルに加えて以下の付加情報を保持する。
* 設備識別子	個々の設備をユニークに識別するための識別子である。
+ 交通ノード(1) 識別子	当該誘導路に対応する交通ノードを示す。
+ 交通ノード(2) 識別子	当該誘導路に対応する交通ノードを示す。

【図9】

エリア種別情報テーブル	
	エリア種別に関する情報を保持する。
* エリア/設備種別	設備/エリアの種別をユニークに判定するための識別子である。
+ エリア判定キー	当該エリアに対するIN/OUTの判定を行なうためのキー情報である。エリア判定キーは、メッシュデータテーブルのエリア判定情報の当該エリアのIN/OUT情報格納位置を示す。
+ デジタルターゲット表示制御情報識別子	当該設備のデジタルターゲット表示制御情報の識別子を示す。

[図10]

エリア/設備形状情報	
	エリア/設備の形状に関する情報は、以下に示すエリア/設備形状情報テーブルにより表現する。エリア/設備の形状は、1個以上の図形により表現し、1個のエリアや設備の形状を、複数の図形の組み合わせで構成することを可能とする。
* エリア/設備種別	設備/エリアの種類をユニークに判定するための識別子である。
* 設備識別子	個々の設備、エリアをユニークに識別するための識別子である。
* 図形識別子	図形をユニークに識別するための識別子である。図形識別子は、エリア/設備種別識別子、及び設備識別子によりユニークに識別される1個のエリア、又は設備を構成する1個以上の図形に対してシーケンシャルな番号を付与することにより表現する。
+ 図形形状区分	図形形状の区分を(1)点、(2)線分、(3)ポリライン、(4)ポリゴン、(5)矩形、(6)2レンジ2アジマス(極座標系)の別で示す。
+ 図形座標情報	図形形状区分が点の場合は1点のXY座標、線分の場合は両端2点のXY座標、ポリライン/ポリゴンの場合は各端点のXY座標、矩形の場合は対角2点のXY座標、2レンジ2アジマスの場合は、中心のXY座標値、及び2個のレンジ値と2個のアジマス値により表現する。
+ 有効高度上限値	エリアのインスタンスである場合に、当該エリアによる制御が有効となる移動体の高度に対する条件である。
+ 有効高度下限値	エリアのインスタンスである場合に、当該エリア種別による制御が有効となる移動体の高度に対する条件である。
+ 有効ヘディング	エリアのインスタンスである場合に、当該エリア種別による制御が有効となる移動体のヘディングに対する条件である。移動体のヘディングが体積から有効ヘディング誤差範囲内にある場合に、その移動体に対する当該エリアの制御が有効となる。
+ 有効ヘディング誤差	エリアのインスタンスである場合に、有効ヘディングからの誤差の許容範囲値である。

[図12]

交通ノード状態情報テーブル	
	交通ノードは、交差点において、当該交差点に接続する各誘導路に対応して自動生成する。誘導路は2つの交差点を結ぶ線分であり、ある交差点は複数の誘導路の端点となっている。誘導路から見たこの端点を交通ノードと呼ぶ。
* 対応誘導路の設備識別子	当該交通ノードに対応する誘導路を、設備識別子により示す。
* 対応交差点の設備識別子	当該交通ノードに対応する交差点を、設備識別子により示す。
@ 交通ノード識別子	交通ノードをユニークに識別するための識別子であり、代替キー情報である。
+ 現在状態	当該交通ノードに対応する交差点から、当該交通ノードに対応する誘導路への進入の許可/禁止状態を示す。
+ 所属交通ノードグループ数	当該交通ノードが所属する交通ノードグループの個数を示す。

[図13]

交通ノード所属交通ノードグループ情報テーブル	
	当該交通ノードが、他の交通ノードと交通ノードグループを構成する場合に、当該交通ノードが所属する交通ノードグループに関する属性情報を示す。1個の交通ノードは、複数の交通ノードグループに所属可能とする。
* 交通ノード識別子	交通ノードをユニークに識別するための識別子である。
* 所属交通ノードグループ識別子	当該交通ノードが所属する交通ノードグループをユニークに識別するための識別子である。
+ 交通ノードグループ状態設定マスク値	交通ノードの現在状態変更に伴い、交通ノードグループ属性情報テーブルの交通ノードグループ状態を設定するマスク値を示す。進入許可状態から禁止状態に変更した場合に、本値を論理和設定し、進入禁止状態から許可状態に変更した場合に、本値の補数設定する。

【図11】

デジタルターゲット表示制御情報テーブル	
	設備やエリア内に存在するターゲットのデジタルターゲット表示を制御する情報である。これは、管制室に誤解を招くような表示を補正すると共に、必要とする情報のみをフィルタリングすることにより、管制のオーバロードを抑えることを目的とする。
* デジタルターゲット表示制御情報識別子	デジタルターゲット表示制御情報をユニークに識別するための識別子である。
+ 有効レンジスケール上限値	表示制御を行なう設備、エリアにおいて当該エリアによる制御が有効になる、デジタルマップのレンジスケール上限値である。
+ 有効レンジスケール下限値	表示制御を行なう設備、エリアにおいて当該エリアによる制御が有効になる、デジタルマップのレンジスケール下限値である。
+ リーダ方向	当該設備、エリア上にある移動体のデジタルターゲット表示のリーダ方向を指定する。これにより他のデジタルターゲットのタグとの重なりを防止する。本値が無効値の場合は、既定のリーダ方向を採用する。
+ 進入機タグ表示形式	当該設備、エリア内に存在する進入機移動体のデジタルターゲットタグ形式を規定する情報である。
+ 出発機タグ表示形式	当該設備、エリア内に存在する出発機移動体のデジタルターゲットタグ形式を規定する情報である。
+ 通過機タグ表示形式	当該設備、エリア内に存在する通過機移動体のデジタルターゲットタグ形式を規定する情報である。
+ 地上移動体タグ表示形式	当該設備、エリア内に存在する地上移動体のデジタルターゲットタグ形式を規定する情報である。
+ 進入機サブレス情報	当該エリア内にある進入機移動体のデジタルターゲット表示サブレスを指定する。サブレスは、シンボル、タグの各々について指定可能とする。
+ 出発機サブレス情報	当該エリア内にある出発機移動体のデジタルターゲット表示サブレスを指定する。サブレスは、シンボル、タグの各々について指定可能とする。
+ 通過機サブレス情報	当該エリア内にある通過機移動体のデジタルターゲット表示サブレスを指定する。サブレスは、シンボル、タグの各々について指定可能とする。
+ 地上移動体サブレス情報	当該エリア内にある地上移動体のデジタルターゲット表示サブレスを指定する。サブレスは、シンボル、タグの各々について指定可能とする。
+ 予測位置採用要否	当該設備、エリア内にある移動体について予測位置を採用した表示を行なうか否かを示す。予測位置採用要否が必要である場合は、当該設備上にある移動体が以下に示す最低速度条件、及びヘディング条件を満たす場合に、現在位置ではなく予測位置を使用した表示を行なう。
+ ヘディング補正採用要否	当該設備、エリア内にある移動体についてヘディング補正値を採用した表示を行なうか否かを示す。本データが必要である場合は、当該設備、エリア内にある移動体が以下に示すヘディング条件を満たす場合に、過去位置から算出したヘディングではなくヘディング補正値を採用する。
+ 予測位置採用最低速度条件	予測位置採用要否が必要である設備上で、予測位置表示を行なうためのターゲットの最低速度を示す。本速度以下の速度で移動するターゲットについては、現在位置で表示を行う。
+ 予測位置採用ヘディング条件基準値	予測位置採用要否が必要である設備上で、予測位置表示を行なうためのターゲットのヘディング条件を示す。ターゲットのヘディングが本値、または本値+180°から次に示す予測位置採用ヘディング条件誤差範囲内に無い場合は、現在位置で表示を行う。
+ 予測位置採用ヘディング条件誤差範囲	予測位置採用要否が必要である設備上で、予測位置表示を行なうための予測位置採用ヘディング条件基準値に対する誤差範囲を示す。

【図14】

交通ノードグループ属性情報テーブル	
	交通ノードグループ属性情報テーブルは、交通ノードグループの属性を示す情報であり、1個の交通ノードグループが1個のインスタンスに対応する。
* 交通ノードグループ識別子	交通ノードグループをユニークに識別するための識別子である。
+ 交通ノードグループ状態	交通ノードグループの状態を示す。本データは、少ない演算で交通ノードグループの状態を設定、参照するために、所属する交通ノード毎のビットマップフラグとして実装し、グループ中の進入禁止状態の交通ノードに対するビットがONとなる。



【図15】

メッシュデータ	
	メッシュデータは、空海面、及びその周辺の座標毎にインスタンスを保持し、個々の座標毎に当該座標に存在する設備識別子、及びエリアIN/OUT情報を保持する。メッシュデータは、ターゲットの現在位置における設備、エリアIN/OUT状態を知るために用いる。
* 位置座標	空海面上の位置を示す。
+ 設備識別子	位置座標に対応する設備を示す。
+ エリアIN/OUT状態	位置座標に対応するエリアIN/OUT状態を保持する。

【図16】

移動体情報	
移動体属性情報テーブル	
	移動体属性情報テーブルは、移動体の現在の属性情報を示し、現在存在する移動体に対応してインスタンスを保持する。
* 移動体識別子	移動体をユニークに識別するための識別子である。
+ 現在位置座標	移動体の現在位置座標を示す。
+ 現在速度	移動体の現在の速度を示す。
+ 現在高度	移動体の現在の高度を示す。
+ ヘディング	移動体の現在の進行方向を示す。
+ 予測位置座標	移動体の一定時間後の予測位置を示す。
+ 応答レーコンコード	移動体を識別するためのコード情報を示す。
+ 移動計画識別子	移動体と現在相関が取られている移動計画識別子を示す。
+ 割当て経路計画数	移動計画に現在割り当てられている経路計画数を示す。
+ 経路計画識別子	移動体が現在履行中の経路計画の履行順序番号を示す。
+ 現在履行中経路計画移動順序番号	移動体が現在履行中の経路計画中の移動順序番号を示す。
+ 現在使用中設備	移動体が現在使用中の設備の設備識別子を示す。
+ エリアIN/OUT状態	移動体の現在のエリアIN/OUT状態を示す。
+ 交通監視警報状態	移動体の現在の警報状態を示す。
+ 交通監視ホールド指示状態	移動体が交通監視に基づくホールド指示を受けている場合は、ホールド指示状態となる。
+ 交通監視ホールド指示開始時刻	移動体が交通監視に基づくホールド指示を受けた時刻を示す。

【図17】

航跡情報テーブル	
	航跡情報テーブルは、移動体の過去一定時間分の位置とヘディングに関する情報を示し、移動体毎に複数インスタンス保持する。本情報は、移動体の位置情報を受ける毎に追加し、更に定周期で監視して不要インスタンスをガベージする。
* 移動体識別子	移動体をユニークに識別するための識別子である。
+ 過去時刻	過去の時点の時刻を示す。
+ 位置座標	当該移動体の過去時刻における位置座標を示す。
+ ヘディング	当該移動体の過去時刻におけるヘディングを示す。

【図18】

経路計画割当て状態情報テーブル	
	経路計画割当て状態情報テーブルは、移動体に対して割り当てられている経路計画を示す。1個の移動体には複数の経路計画を割り当てることが可能であり、経路計画を割り当てられている移動体毎に複数インスタンスを保持する。
* 移動体識別子	移動体をユニークに識別するための識別子である。
* 経路計画履行順序番号	経路計画の履行の順序を示すシリアル番号である。
+ 経路計画識別子	経路計画履行順序番号に対応する担当経路計画識別子を示す。

【図19】

移動計画情報	
移動計画情報テーブル	
	移動計画情報テーブルは、移動計画の属性情報を示し、移動計画に対してインスタンスを保持する。
* 移動計画識別子	移動計画をユニークに識別するための識別子である。
+ フライトプラン情報	当該移動計画がフライトプラン由来である場合に、元となるフライトプラン情報を保持する。
+ スポット情報	当該移動計画（フライトプラン）に対応するスポット情報（スポット管理システムより受け取る）が存在する場合にそのスポット情報を保持する。
+ 空海面移動開始時刻	当該移動計画における空海面移動の開始予定時刻を示す。当該移動計画に対応するフライトプラン、スポット情報が存在する場合は、それらの情報より自動算出も可能である。
+ 空海面移動終了時刻	当該移動計画における空海面移動の終了予定時刻を示す。当該移動計画に対応するフライトプラン、スポット情報が存在する場合は、それらの情報より自動算出も可能である。
+ 空海面移動開始地点	当該移動計画における空海面移動の開始地点の設備識別子を示す。当該移動計画に対応するフライトプラン、スポット情報が存在する場合は、それらの情報より自動決定も可能である。
+ 空海面移動終了地点	当該移動計画における空海面移動の終了地点の設備識別子を示す。当該移動計画に対応するフライトプラン、スポット情報が存在する場合は、それらの情報より自動決定も可能である。

【図20】

空港運用情報	
空港運用情報テーブル	
	空港運用情報テーブルは、交通監視に関する現在の空港運用の状況に関する情報を保持する。
+ 交通密度レベル	現在の交通密度レベルを3段階（レベル1からレベル3、レベル値が高いほど交通密度が高い）で示す。
+ 視程条件レベル	現在の視程条件レベルを3段階（レベル1からレベル3、レベル値が高いほど視程条件が悪い）で示す。
+ 現在移動体数	現在空海面に存在する移動体の数を示す。
+ 交通密度レベル2移動体数	交通密度レベル2における最低の移動体数を示す。現在移動体数が本値を越えた場合は、レベル2状態とする。
+ 交通密度レベル3移動体数	交通密度レベル3における最低の移動体数を示す。現在移動体数が本値を越えた場合は、レベル3状態とする。
+ 現在選択中経路計画グループ	現在の空港運用（使用滑走路等）に基づき選択されている経路計画グループを示す。

【図 2 1】

経路計画情報	
経路計画情報テーブル	経路計画候補の属性を示し、経路計画候補毎にインスタンスを保持する。
* 経路計画識別子	経路計画候補をユニークに識別するための識別子である。
+ 経路計画名称	管制官、パイロット等が経路計画候補を認識するための名称を示す。
+ 移動開始地点	経路計画候補の移動開始地点の設備識別子を示す。
+ 移動終了地点	経路計画候補の移動終了地点の設備識別子を示す。
+ 選択優先順位	同一移動開始地点、移動終了地点を保持する経路計画候補群中の自動選択優先順位を示す。
+ 同時利用可能移動体数	当該経路計画候補を同時に割り当てることが可能な移動体の個数を示す。
+ 標準走行所用時間	当該経路計画により移動開始地点から移動終了地点に移動するのにかかる標準的な走行所要時間を示す。
+ 経路計画グループ識別子	当該経路計画候補が所属する経路計画グループ識別子を示す。経路計画の選択を容易にするため、その時点の空港運用状態（使用滑走路、視程条件、混雑状態等）によりグルーピングし、その時点で使用可能な経路計画候補を絞り込むことを可能とする。
+ 自動割当て選択/禁止	当該経路計画が自動割当ての対象となっているかを示す。経路計画には、管制官の許可無しに割り当てられる計画と管制官の許可が必要となる計画があることが想定され、管制官の許可が必要となる計画については自動割当て禁止となる。
+ 自動割当て可能移動形態	自動割当て時に当該経路計画を使用可能なターゲットの移動形態（進入/出発/空滑面移動等）の区分である。
+ 使用可能航空機クラス上限/下限	航空機クラスはクラス1〜クラス3の3道類程度を持ちフライトプランの航空機形式または後方乱気流区分（ヘビー/ミディアム/ライト）から導出可能

【図 2 2】

経路計画使用設備情報テーブル	
経路計画使用設備情報テーブル	経路計画候補毎に経路計画候補中で使用する滑走路設備の情報を示す。
* 経路計画識別子	経路計画候補をユニークに識別するための識別子である。
* 移動順序番号	経路計画候補を示すシリアル番号である。移動順序番号は当該経路計画で使用する各種滑走路設備に対して、使用する順番に番号付けする。
+ 使用設備識別子	当該経路計画の移動順序番号に対応する設備識別子（滑走路）を示す。
+ 進入交通ノード	当該滑走路に対する進入側の交通ノードを示す。使用設備（滑走路）設定時に内部的に自動設定する。

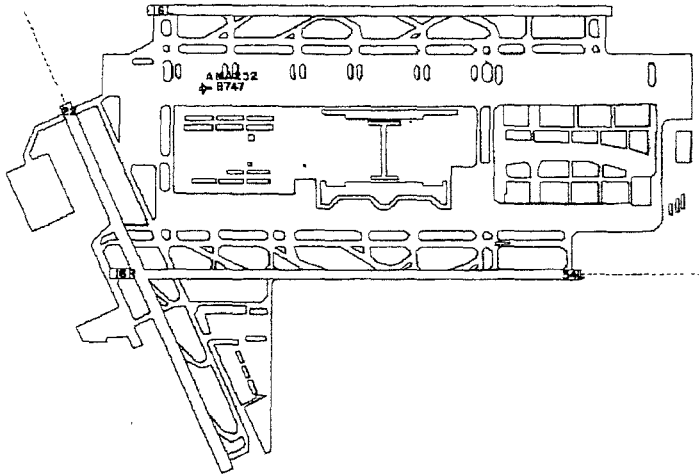
【図 2 3】

経路計画状態テーブル	
経路計画状態テーブル	経路計画候補毎に、経路計画候補の移動体への現在の割当て状態の情報を保持する。
* 経路計画識別子	経路計画候補をユニークに識別するための識別子である。
+ 現在使用中移動体数	当該経路計画を現在割り当てられている移動体の個数を示す。
+ 標準走行所用時間	当該経路計画の現在の標準走行所要時間を示す。
+ 使用可否状態	当該経路計画が使用する設備の中で、現在使用禁止状態の設備が含まれている場合には、使用不可とする。
+ 使用可否最終チェック時刻	当該経路計画について使用可否状態を最後にチェックした時刻を示す。

【図24】

設備混雑状況情報テーブル	
	設備混雑状況情報テーブルは、経路計画が使用する設備について設備毎の使用状況に関する情報を保持する。
* 設備識別子	個々の設備をユニークに識別するための識別子である。
+ 通過予定移動体数	当該経路を通過する予定のターゲット数を示す。
+ 進入交通ノード	当該経路の現在進入側として使用中の交通ノードを示す。移動体に割り当てられた複数の経路計画は同一経路を使用可能であるが、進入交通ノードが異なると安全性、移動効率上好ましくない。経路計画自動割当てでは、このような状態が発生しないようにチェックする。

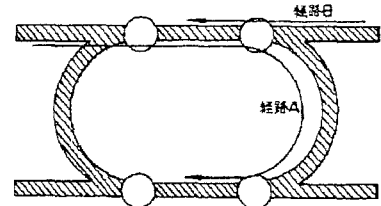
【図25】



【図39】

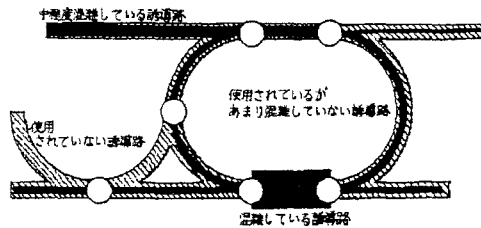


【図37】

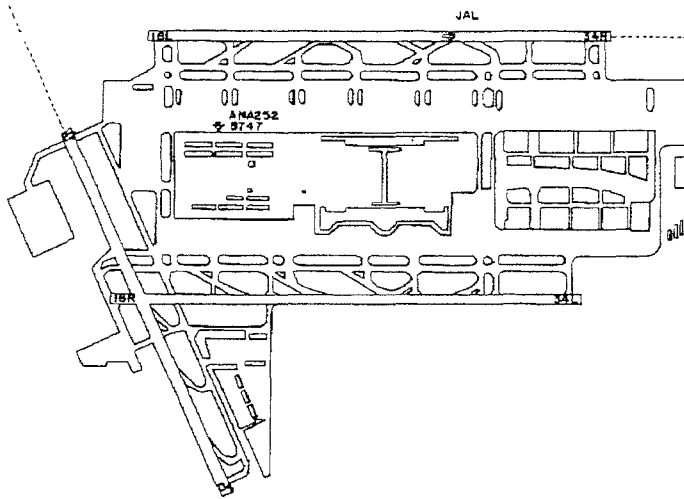


経路Aが既にいずれかのターゲットに割り当てられている場合に、経路Bを別のターゲットに割り当てることは出来ないように制御する。

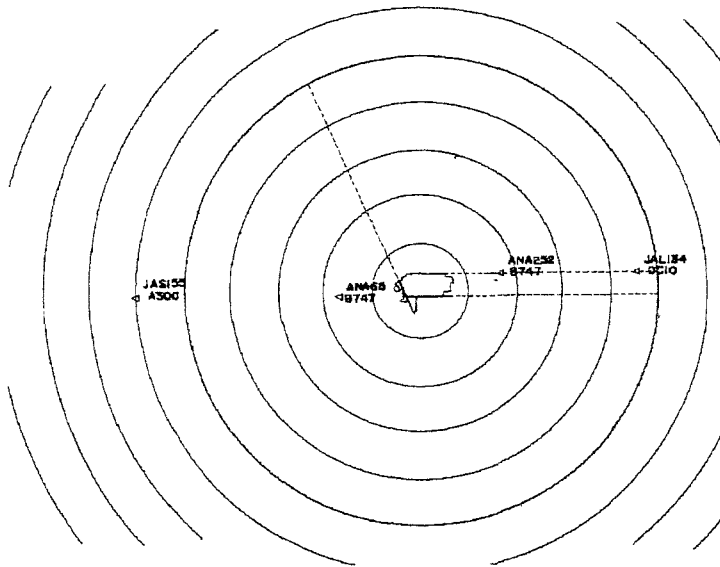
【図40】



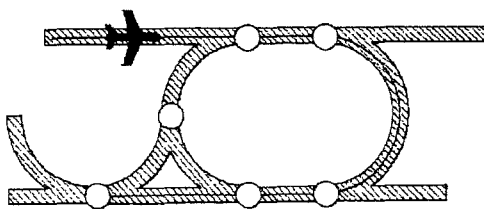
【図26】



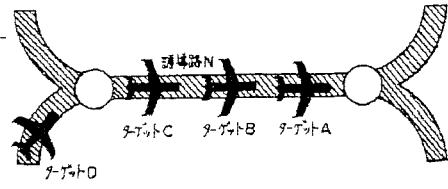
【図27】



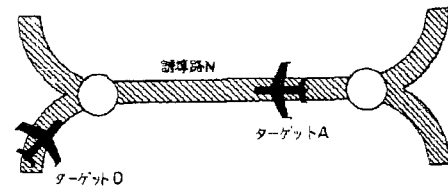
【図41】



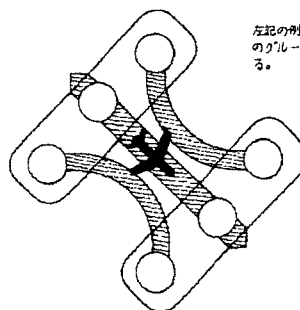
【図42】



【図43】

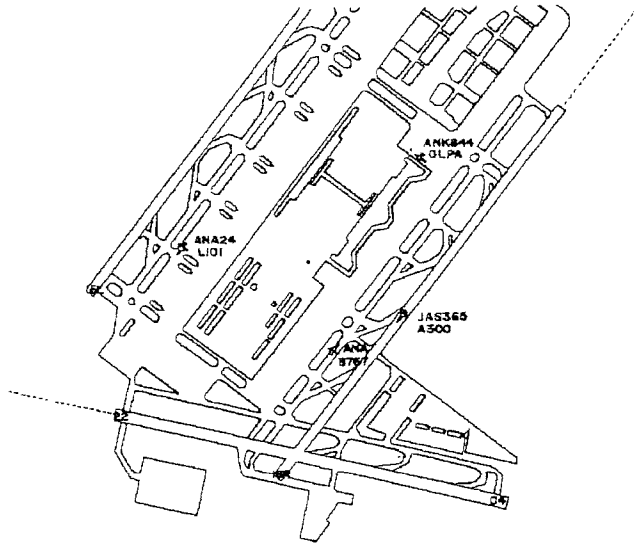


【図45】

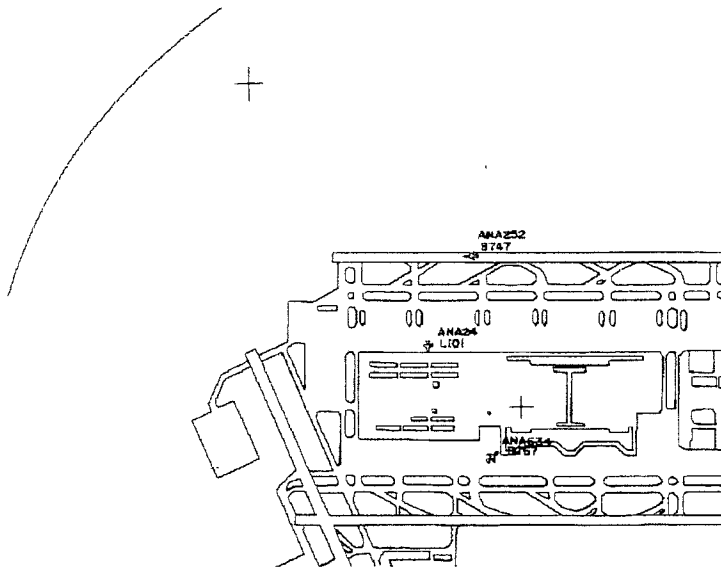


左記の例では、3つの変遷ノードを1つのグループにグループ化することになる。

【図28】

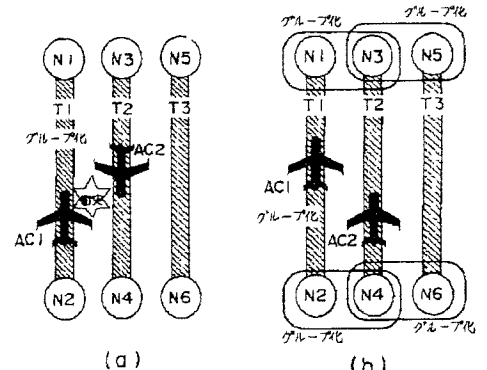


【図31】

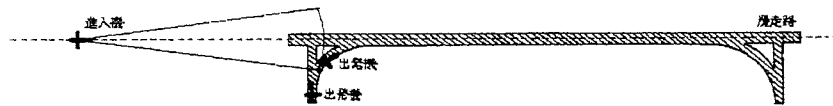


【図47】

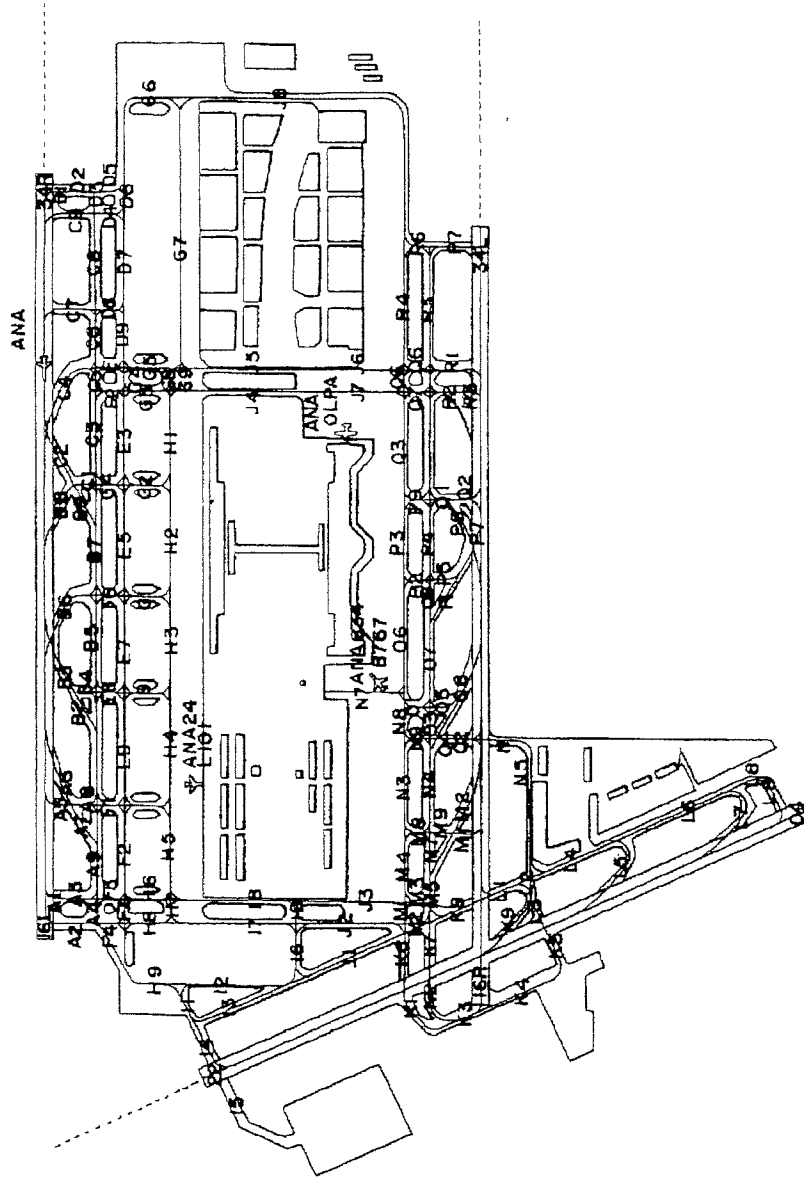
【図44】



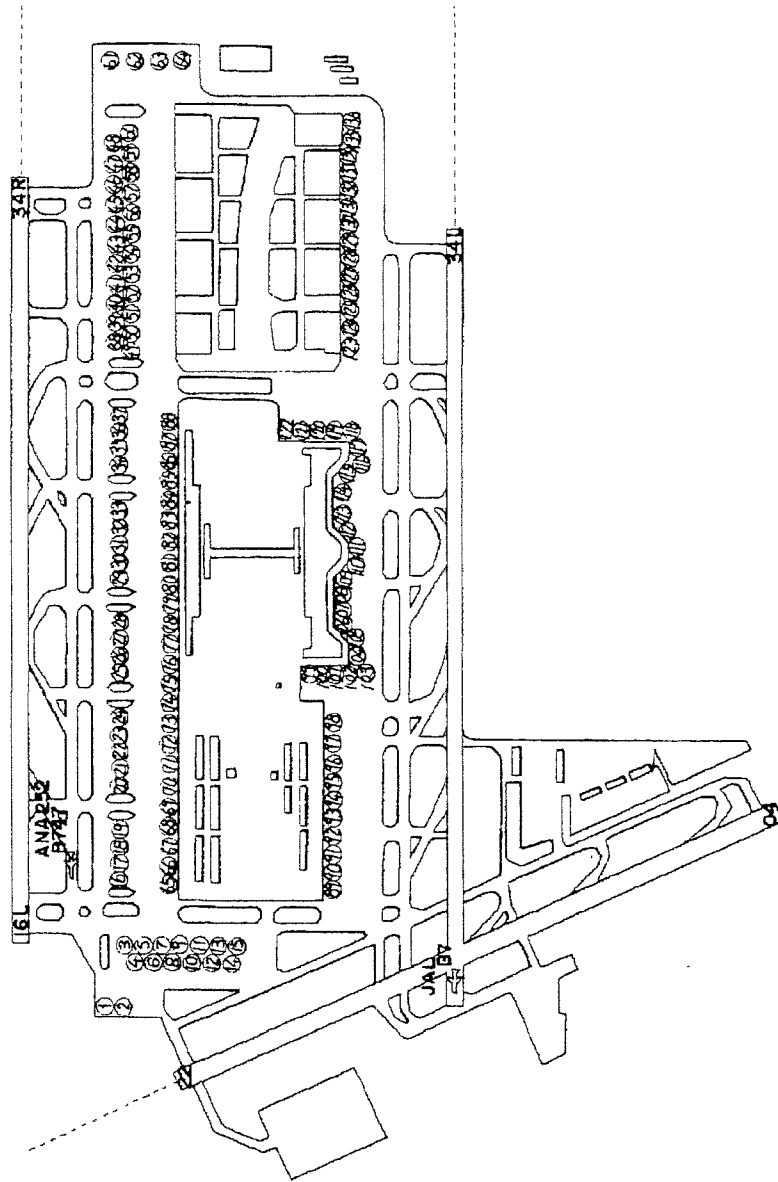
(a) 図の例では、AC1とAC2は、横方向の離隔距離を確保出来ない。  
 (b) 図の例では、AC1とAC2は、横方向の離隔距離を確保出来る。



【图 29】

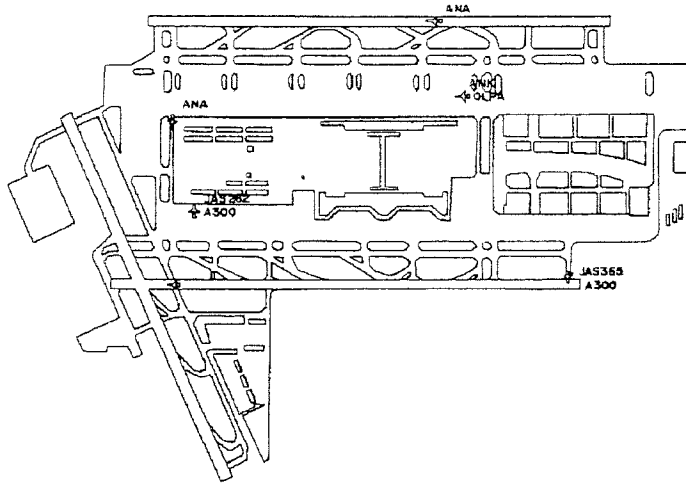


【图 30】

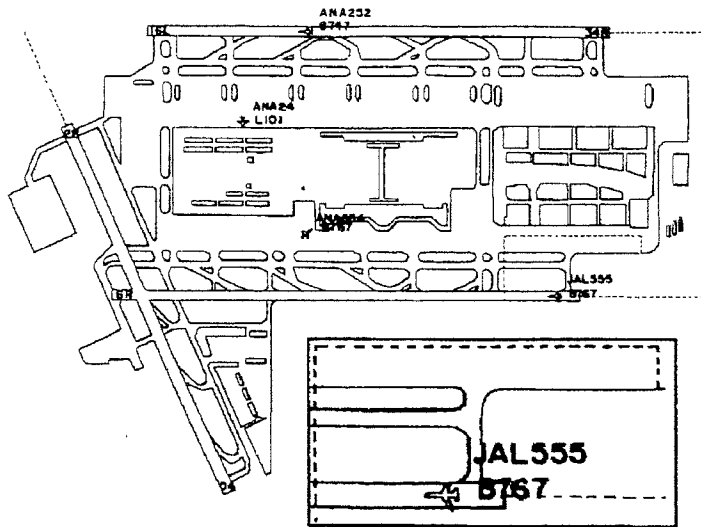




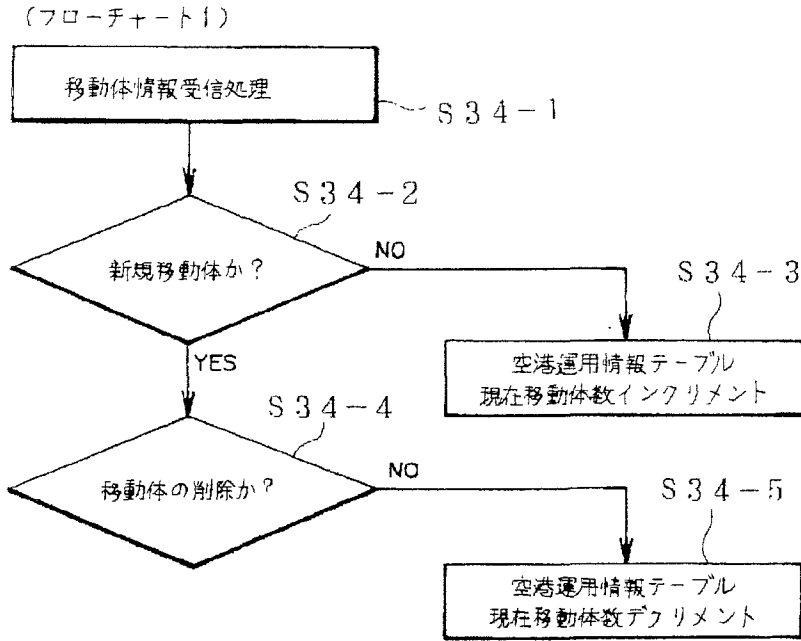
【図 3 2】



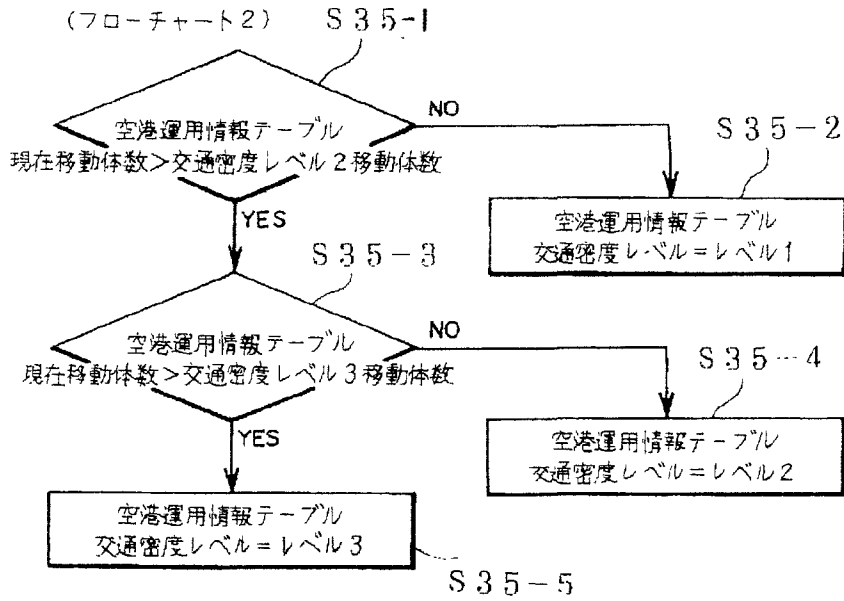
【図 3 3】



【図34】

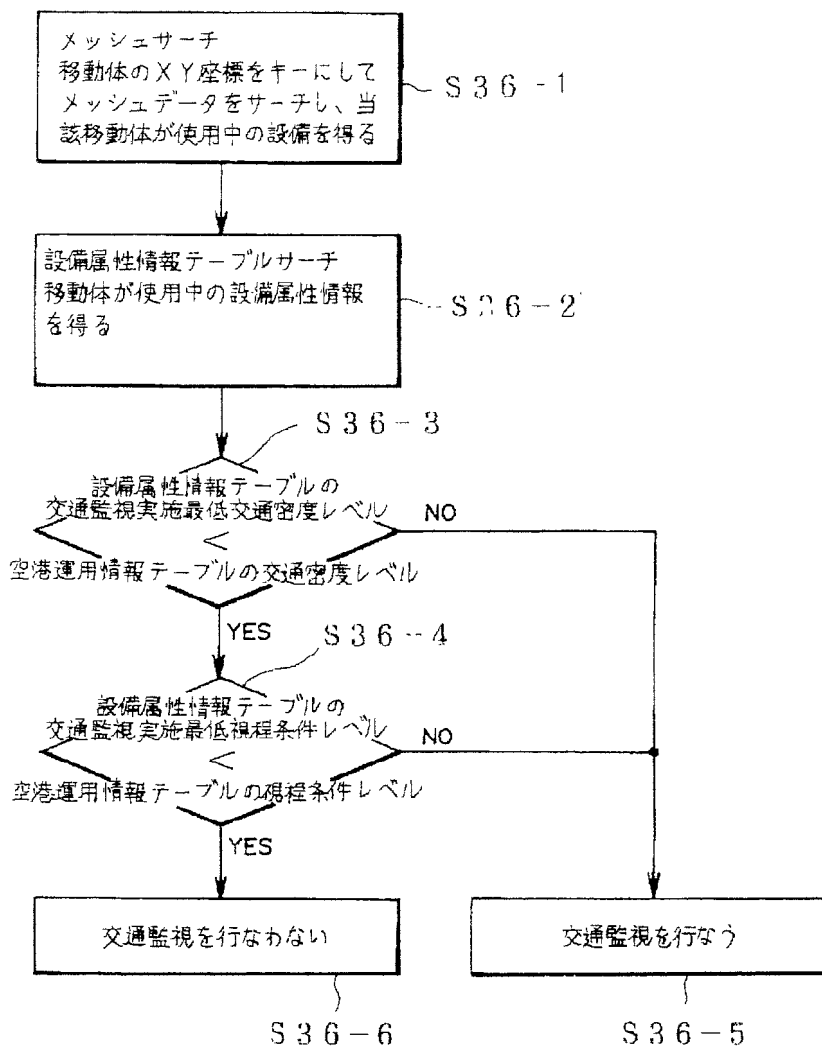


【図35】

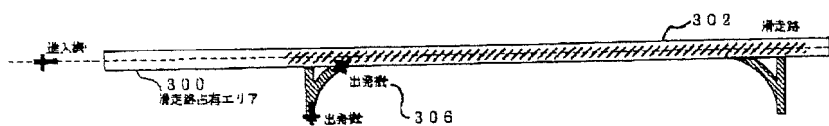


【図36】

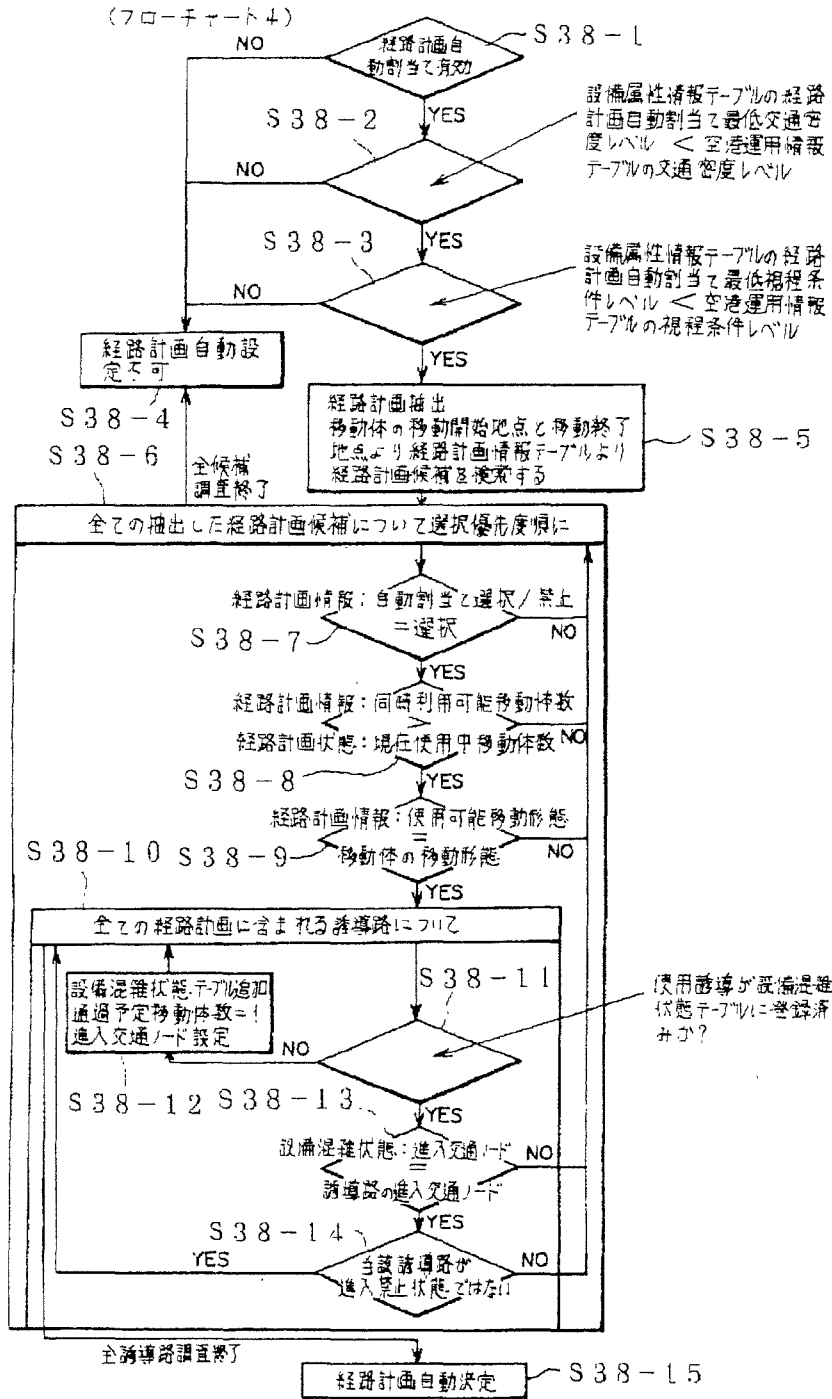
(フローチャート3)



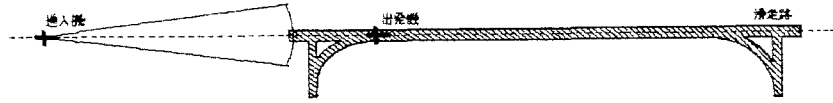
【図50】



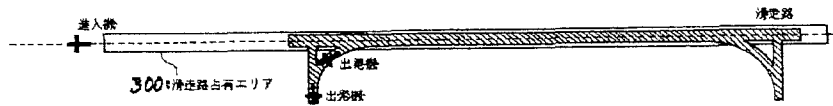
【図38】



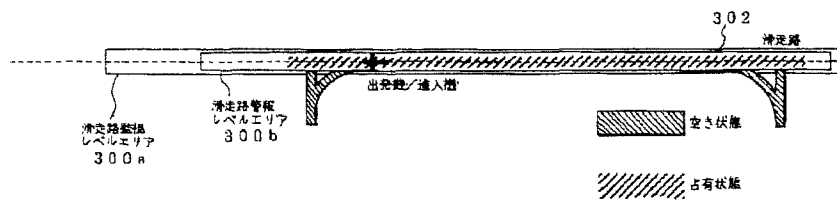
【図 46】



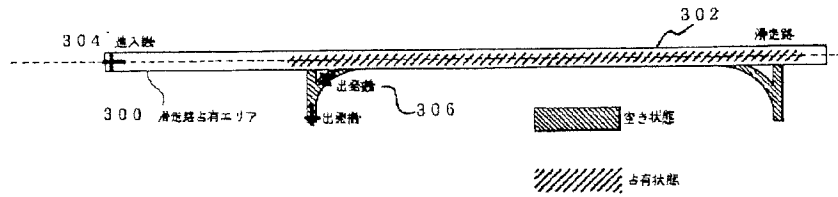
【図 48】



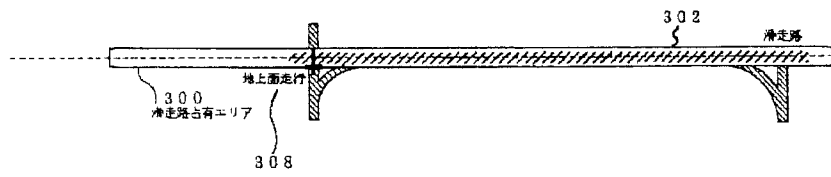
【図 53】



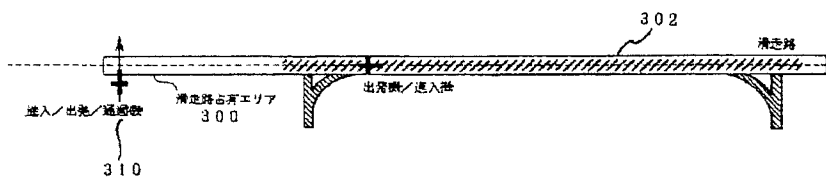
【図49】



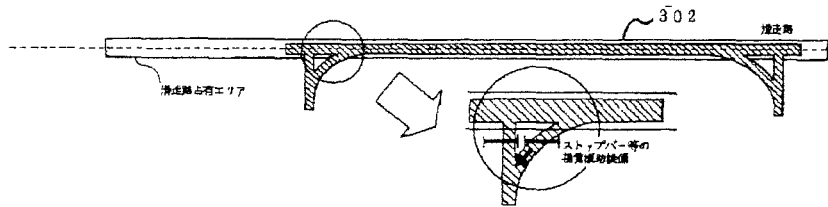
【図51】



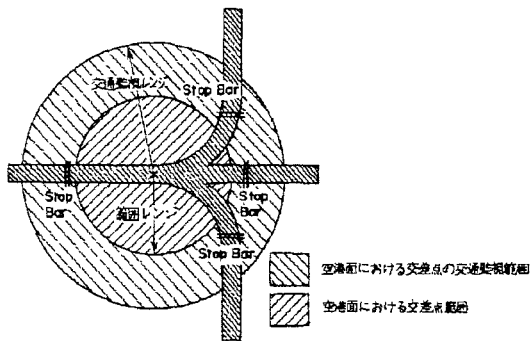
【図52】



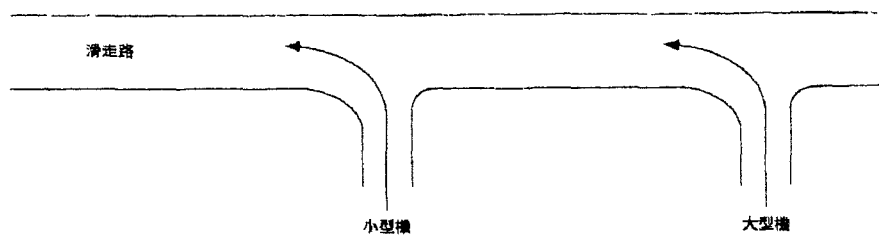
【図54】



【図56】



【図57】



【図 5 5】

現在速度 (k m/h)	警報発生から回避開始までに進む距離 (m)				備考
	10秒後	20秒後	30秒後	40秒後	
400	1111	2222	3333	4444	
390	1083	2167	3250	4333	
380	1056	2111	3167	4222	
370	1028	2056	3083	4111	
360	1000	2000	3000	4000	
350	972	1944	2917	3889	
340	944	1889	2833	3778	
330	917	1833	2750	3667	
320	889	1778	2667	3556	
310	861	1722	2583	3444	
300	833	1667	2500	3333	
290	806	1611	2417	3222	
280	778	1556	2333	3111	
270	750	1500	2250	3000	
260	722	1444	2167	2889	
250	694	1389	2083	2778	進入時の最終進入速度
240	667	1333	2000	2667	
230	639	1278	1917	2556	
220	611	1222	1833	2444	
210	583	1167	1750	2333	
200	556	1111	1667	2222	
190	528	1056	1583	2111	
180	500	1000	1500	2000	
170	472	944	1417	1889	
160	444	889	1333	1778	
150	417	833	1250	1667	
140	389	778	1167	1556	
130	361	722	1083	1444	
120	333	667	1000	1333	
110	306	611	917	1222	
100	278	556	833	1111	
90	250	500	750	1000	
80	222	444	667	889	
70	194	389	583	778	
60	167	333	500	667	
50	139	278	417	556	
40	111	222	333	444	
30	83	167	250	333	
20	56	111	167	222	
10	28	56	83	111	
0	0	0	0	0	



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11

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## Description

The present invention relates to an automatic surveillance, guidance and fire-fighting system or installation, and concerns a system or installation whose primary purpose is to prevent accidents and, in the event that they do occur due for example to aircraft fault or pilot error, to bring about the extinction of any fires which occur, in the shortest possible time, by means of the functional integration of surface telemetry and automated fire-fighting.

In the same way that other airport systems were designed and implemented in their time (such as VASIS, ILS, CALVERT, etc.), all of which satisfactorily met the established requirements for achieving air safety, so also the present, newly designed system (RUSTEM), meets other requirements in the same field, but within the airport precincts.

In order to explain what the system comprises as well as the grounds which justify it, it is useful to set out the current state of affairs and accordingly introduce the necessary conceptual innovation in specific important aspects, being those which epitomize the characteristics of RUSTEM ("Runway Security and Taxiway Escort System").

In effect, wherever there is an aircraft in operation, the concept of air safety and the necessary means of attaining this must be present, whether the aircraft is in the air or on the ground. Thus the concept of air safety covers the whole range of air-air, air-ground, ground-ground and ground-air circumstances.

Likewise, if this approach is not taken, a gap in safety will occur in this relationship which may result in an accident, whilst the aircraft is in operation in any of the four circumstances mentioned above, transporting people, goods and fuel.

It is well-known in the air industry that from time to time serious accidents occur, although their prevention, and where necessary fire-fighting operations, have been a priority effort of the aeronautical profession. The present system is part of this effort, though in this instance it is related to the airport environment, that is the ground-ground situation.

In this context it is appropriate to recall the accident which occurred in 1983 at the airport of Barajas (Madrid), in which two aircraft collided on the ground. On this occasion, one aircraft was on its take-off run, whilst the other aircraft in taxiing and trying to head for the start of the runway to take-off in its turn, took a wrong turning and moving across a fast exit slipped into the middle of the flight path, where the collision occurred.

At this time the airport was not under minimums, but visibility was poor so that the aircraft

which was taking off did not see the intruding aircraft, neither did the latter see the aircraft taking off, nor did the tower at that time see either of the aircraft, all due to the length of the runways. This occurs in certain circumstances where the airport is operative but there is not clear visibility over the full distances.

These situations, and many others, indicate conditions of a lack of air safety which require analysis and a complete solution of the problems to which they give rise.

Furthermore, an aircraft in flight is not close to the ground, whilst in take-offs, landings and taxiing, it is in contact with it and therefore is in a higher risk situation, in which safety conditions must be maximized.

Since it is possible to set up ground installations in airports which could not be set up throughout a country, and since aircraft must operate in airports, it is clearly desirable to provide a safety system on runways and taxiways capable of guaranteeing this safety. The RUSTEM system is intended to meet this requirement.

Also, the increase in modern air traffic, which leads at times to saturation in the number of operations per hour on an operative runway, has led to an increase in the risk of accidents, taking into account the poor visibility conditions which often occur. This expansion in traffic makes a built-in airport safety system increasingly urgent and necessary, as the accidents in different airports of the world confirm. The same problem occurs in military air bases, where there is the additional problem that combat aircraft may enter the base in emergency conditions, for which reason telemetric monitoring and automated fire-fighting thus become necessary. The RUSTEM system can be applied to both civil and military airport ground situations.

Two damaging effects occur in an accident: ruptures and fire.

In accidents en route, the most important factor is usually ruptures, whilst generally in airport accidents fire is the cause of the greatest damage.

This is due to the different velocity of the aircraft en route and in the airport, so that the dynamic impact is usually much greater in an accident in the air.

On the other hand, once an accident has taken place in an airport, it is obvious that there is not the least remedy in the case of ruptures, causing damage to the aircraft and the passengers. However, the fire factor develops according to a specific process, and, fire being the determining factor in causing the greatest damage in airport accidents, it may be combatted because it is a process, provided of course that there are the necessary means for this, both in extinguishing capacity and in speed of activation, since without the latter condition the

fire itself will put paid to the matter.

From what has been said it emerges that the sole means of combatting the rupture factor is by avoiding the accident, as far as possible in the airport, within the present margin of possible aircraft faults or pilot error, for which reason prevention in this case lies in the area of telemetric monitoring, guidance and signalling on the ground. If, despite the measures taken, an accident occurs due to the aircraft or the pilot, the airport infrastructure must then have available an automatic fire-fighting system for eliminating fires extremely rapidly, since fire is generally the most damaging factor in airport accidents.

The research carried out in the quest for an efficient airport system which will meet these requirements, emphasized the necessity for integrating the surveillance and fire-fighting functions into one single system.

In fact, given the great speed required in fire-fighting, this had to be of an automatic nature. Since an aircraft which has had an accident may become immobilized (or its hot sections) at any point of the surface in question, it was obviously necessary to have available the x,y coordinates of the aircraft or its sections. Hence it was necessary to integrate telemetric surveillance with automated fire-fighting. Furthermore, if surface telemetry provides the x, y position of a damaged aircraft, or of its sections in the case of it being ruptured, this surface telemetry could also be used to obtain the position of normal aircraft, that is not in a state of emergency, in normal operation.

With this, the conclusion was reached that a telemetric method had to be used in our system, both for the monitoring of normal aircraft and for establishing emergencies according to the various forms and circumstances in which these could occur in each instance, as for example fuel which has leaked and is on fire. As aforementioned, the fire-fighting method has to be automatic due to the great speed demanded, since it is not just dealing with a simple fire, but with an aircraft carrying people, and loaded with highly inflammable fuel. Hence the designer's thinking has to be governed by the time-scale, taking the second as the unit.

Nevertheless, it is essential to point out that, regarding air traffic, two very different areas or environments must be considered in airports: on the one hand the flight strips (which contain the flight runways, one runway for each strip), and on the other hand the taxiways in their entirety, and the aircraft parking areas.

The vast majority of airport accidents occur in the first mentioned area, where aircraft are running at great speed. In the second area, in the taxiways, aircraft are travelling slowly in procession and able to brake quickly where necessary, as is the case in

the parking areas.

This qualitative and quantitative distinction is taken into account in the present system, supplying the appropriate solution for the characteristics of each of the indicated environments.

As will be seen, the current situation is analysed and, as a result of the limitations of tanker trucks (as currently used in fire-fighting), as well as the limitations of surface radar (as used in surveillance in some airports), research into a new system which could completely solve these limitations, gave rise to the RUSTEM system, in which surveillance and fire-fighting are functionally integrated in a single operational system, constituting an innovation in the airport field.

An automatic aircraft taxi route selecting and traffic control system is disclosed in US 3706969, and may use an array of infrared sensors to detect position and/or movement of aircraft. However the system appears to be dedicated to such a function insofar as the sensors are all located adjacent runway and taxiway intersections and in areas between the intersections there seems to be no surveillance.

Furthermore EP 0117162 discloses an infra-red surveillance system for detecting fires in a forest, in which each of an array of sensors is scanned over a field of view; however in this case there appears to be no provision for tracking a moving heat source as it moves past the sensors.

In the present system, which is set out in the appended claims, an array of thermal sensors under computer control is provided which is adapted to provide both the function of tracking a moving aircraft as it passes the sensors and the function wherein each sensor scans its locality so that the position of any heat source within a locality may be determined from the outputs of adjacent detectors. Thus the present invention has the advantage that a single sensor array may be operated and used in two ways for two different and necessary purposes.

In broad outline, which will be explained in greater detail in the following pages, and taking into account the fact that statistically airport accidents occur on the flight strips in the vast majority of cases, a RUSTEM system can include the following elements:

- a) Two parallel, buried lines of hydrants, one on each side of the runway. These lines, being a fixed system, extend beyond both thresholds at the heads of the runways. The hydrants only emerge in case of accidents, and have elevation, rotation and to-and-fro movement. So that when their valve is triggered they can take care of any accident occurring within the flight strip as rapidly as possible. The automatic action of the hydrants is computer-controlled. The pipes feeding them are kept filled constantly. Thus,

activation of the system from the airport tower leads to their entry into operation in a matter of a few seconds.

b) As far as surveillance is concerned, there are two different zones as described earlier. The main surveillance is over the flight strips with additional surveillance over the taxiways and parking areas, by means of aircraft control and guidance.

b.1) Two parallel lines of infra-red, telemetric sensors are installed along the flight strips, capable not only of tracking the trajectory of the aircraft, but also of detecting heat sources in case of emergency, feeding this data to the automatic fire-fighting operations. Similarly, several anemometers obtain wind data. The whole flight strip is in the form of a rectangle, and the aforementioned telemetric sensors are located along the longest sides of this rectangle, monitoring the strip.

b.2) In the taxiways and parking areas the interest is in the aircraft control and guidance system, according to OACI SMGC requirements, simultaneously maintaining and monitoring minimum separation between aircraft. Thus continuous detectors are installed, as well as directional beacons along the axis, and, where necessary, directional beacons along the edges, and some airport traffic lights. Both the detectors and traffic lights are interconnected with a computer which processes taxiing and parking throughout the airport.

b.3) Aircraft movements in the taxiways and parking areas are automatically guided, each aircraft having in front of it a specific number of lit axial beacons, according to the aircraft's route. The number of beacons is always fixed, about 100 metres apart. Thus, as the aircraft moves forward it is detected by the taxiing beacons, which send signals to the computer, and the latter lights up new axial beacons in front of the aircraft according to the route it has to take, and switches off the beacons which the aircraft has left behind. The computer establishes rights of way at crossroads, where the aircraft which has to wait will see its axial beacons flashing on and off and the crossroad traffic light on red. Once the first aircraft having right of way has passed across the crossroad, the second aircraft which had to wait will have its axial beacons lit continuously to enable it to continue on its way.

Any intermittence in the guidance beacons signals the pilot to brake.

The aforementioned taxiing detectors are neutral and without electrical current through-

out the airport, with the exception of those corresponding to the sensing of each aircraft. These detectors only pick up the aircraft, but purposely do not pick up other objects such as service vehicles or people. Hence cars or people, purposely not being picked up, do not distort the detection signals which correspond only to aircraft, and therefore the computer continuously guides each aircraft from an initial point to a final point, according to a route which has been laid out by the control tower. The activated detectors go on activating others in the direction of travel of the aircraft, picking it up and deactivating the previous detectors along the aircraft's taxiway.

c) A set of elements is installed in the airport tower, which amongst others consist of the following:

c.1) A main panel on which the runway computer displays the aircraft's reference both in its flight path and as it comes to a halt. In the event of an emergency, this computer on the one hand produces several alarms and on the other hand draws some emergency circles corresponding to a damaged aircraft, or its hot sections and fire sources. In the event of aircraft collision the same thing happens. Similarly, in the event that an intruding aircraft penetrates into the rectangular area of the air-strip, the alarm is automatically activated.

Likewise, the computer which controls taxiing also displays the position of the identification references corresponding to the aircraft situated in the taxiways and parking areas. In the event that an aircraft goes below its minimum distance on the taxiway with respect to the aircraft preceding it or takes a wrong route, an alarm is also provided, and at the same time the reference on the panel relating to the offending aircraft blinks intermittently.

c.2) A control console from which the whole system is controlled, both for surveillance and guidance as well as for fire-fighting, with simple and extremely sparing operations for the controllers, since the system's data processor carries out the work.

Similarly, the taxiway traffic lights are automatically activated, the internal routes for taxiing being indicated "in situ", and activated locally for each aircraft, according to whether it is on its landing run, or "en route" from the parking area to the runway and the head of its take-off exit; also indicated are the routes from the runway to the parking area, taking into account the corresponding runway

head. In addition, routes from the parking area to the hangars and vice versa are shown; or from hangars to runway, and vice versa.

c.3) Computers and automatic connections.

d) Lastly, there is the installation of piping, for water and extinguishing substances, their storage tanks, pumps, dispensers, drums, auto-protection devices, connections, and other appropriate and necessary elements for the hydrant system. Also the general piping for the supply of the hydrants from one and the same line may be unique, the dispensing then being carried out at the start of the general piping. Also there is a power plant with electrical connection to the airport's supply network, and from this plant the various elements of the RUSTEM system are supplied. It is taken for granted that the whole airport has to have general emergency generating units. Furthermore, the system is adaptable to any civil airport or air base. And in the event that once installed it is decided to increase the length of a runway, the lines of hydrants and telemetric sensors of this flight lane can be extended, so that the previous installation remains operative and valid.

Statistically, 99% of airport accidents, including situations where aircraft have previously announced their emergency status, occur within flight lanes. Therefore it is both logical and necessary for automatic hydrants to be installed within the said lanes, hydrants which due to their range and their three degrees of freedom, are capable of covering any emergency, being able to act both in treating the whole runway, as well as on specific points on the damaged aircraft, colliding aircraft, or their dispersed sections, eliminating heat sources, acting globally and simultaneously on all of them.

The hydrants referred to are always without pressure and without electrical current. Thus, there is double protection against their being activated spontaneously. That is to say, if and only if, the tower activates the fire-fighting system, do the telemetric sensors along the flight lane send the position and extent of the heat sources to the computer, and the anemometers send the wind force and direction; with this data the computer system rapidly calculates the fire-fighting parameters, i.e. selects the specific hydrants which will be activated and supplies them with the operating parameters corresponding to each of them, and it is then that the selected hydrants enter into operation, in a very few seconds, launching a large discharge of extinguishing fluid and rapidly suppressing the heat sources.

While there is an aircraft in motion within the flight lane, whether in normal or emergency status, the system is locked and cannot operate. The fire-

fighting operation only occurs with a motionless aircraft.

However, the hydrants can prepare the runway on the announcement of a damaged aircraft approaching the airport.

Lastly, it was evident that an installation in accordance with the invention allows the possibility that the analogue type signals originating from the surface radar installed in an airport may be processed by the computer equipment of the said installation and incorporated as an additional element with regard to airport safety. The surface radar would act as one more sensor for the installation, its signals being used as additional data for the overall safety system. To this end, the aforementioned installation can be improved in the following manner: j) for airports operating in very low visibilities, some flight lane sensors, in addition to infra-red sensing, incorporate an emitter and detector of electro-magnetic pulses, or an ultrasonic active element, capable of detecting objects within the flight lane relating to aircraft or vehicles; k) for airports with normal or average visibility, the standard sensors not only pick up the aircraft located in the flight lane, but also vehicles penetrating it; l) there is the option of installing an interface capable of processing the signals originating from the surface radar which has been installed in an airport, and introducing such signals into the computer controlling the surveillance, and with this data making an addition to the functions of the system; m) there is the option that the installation's taxiing detectors may be generally activated simultaneously, and the sensing of aircraft and other objects may be carried out simultaneously, in this case means can be incorporated for discriminating aircraft from other objects, and maintaining the logical sequence in the guidance of each aircraft in the zone of movement and parking of aircraft; and n) there is the option that the piping and pressure storage tanks for water and extinguishing agents for the flight lane are divided up into independent modules, and their discharge is attained by means of the pressure of a compressed gas connected by regulating valves to the water and extinguishing agent storage tanks.

The invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure (1) is a representation of a "standard protected zone" (SPZ), i.e. a flight lane fitted with automated hydrants and telemetric sensors (ST) for surveillance, able to be integrated with automatic fire-fighting in emergencies. The hydrants can both treat the complete runway before the arrival of an aircraft arriving in an emergency situation, and also act in precision fire-fighting, either on one or more aircraft, or on

their hot sections and other burning surfaces caused by the accident.

Figure (2) illustrates the protection of two or more crossing runways and their corresponding flight lanes (SPZ).

Figure (3) shows diagrammatically the three degrees of freedom of an extinguishing unit (hydrant), according to its three perpendicular projections.

The dispensing of the extinguishing fluid may be carried out at the foot of the hydrant, or at the start of the supply pipe (in which case it could be single).

References in this figure include:

VL	- Side view	15
P	- Plan	
V	- View through A-A	
Tr	- Trap	
La	- Cannon jet	
Ag	- Rubber shock absorber	20
Tm	- Elevating motor supply trolley	
Ae	- Extinguishing agent	
Ag	- Water	
Mg	- Mobile base turning motor	
Ro	- Bearings	25
Tg	- Main cover	
To	- Trolley	
En	- Gear	
Bf	- Fixed base	
Bm	- Mobile base	30
Me	- Elevating motor	
Jr	- Rotary joint	

Figure (4) graphically demonstrates the parallax error produced by standard surface radars. In the figure it is seen that as  $MA = MP$ ; and  $RA = RA'$ , so that  $OA = OA'$ , and P does not coincide with A'. This distorts the x, y coordinates of the object when the runway has inclines.

Figure (5) represents a plan (P) and elevation (E) of a flight lane in which the variation in slope of the runway axis is seen. Also the position of the telemetric sensors is shown (not to scale), forming successive rectangles or squares along the whole length of the flight lane, the successive rectangles thus being adapted both to the slopes and to the changes in gradient allowed by the OACI standard.

Figure (6) is an illustration of the detection procedure while tracking an aircraft by means of infra-red sensors along the flight lane, thanks to the position of the colliding beams and the corresponding signals for their processing by computer.

Figure (7) is similar to the previous one, although here one sees a dangerous situation in having two aircraft within the flight lane, which could collide. One can see also the rectangles formed by each set of four telemetric sensors (STI) - "infra-red sensed areas" (ISA).

Figure (8) represents the tracking of an aircraft during the sequence of its entrance onto the runway.

Figure (9) shows the sweep mode of the telemetric sensors (ST) along the flight lane (SPZ). The sources in this case are motionless, three heat sources being represented, as well as the detection carried out by the four sensors from the four corners of the infra-red sensed area (ISA) in question, allowing the surface dimensions of each heat source to be accurately defined. The sweep mode is that used in emergencies.

Figure (10) shows an airport layout in which can be seen both the flight lane (SPZ) and the taxiways equipped with detectors (D), guidance beacons (B) and traffic lights (S). Inside the SPZ's neither detectors (D) nor traffic lights (S) are installed. However, at those points of the SPZ perimeter where taxiways impinge, the first detectors and traffic lights are installed, so that an aircraft is detected on leaving the runway. Full continuity in airport surveillance is thus achieved, since although an aircraft which exits from the area of the SPZ leaves behind the telemetric sensors (ST) tracking it, it will be immediately detected by the first taxiway detector (D) on entering the corresponding section of taxiway. Thus, in both cases, where the aircraft is inside the SPZ and where it is on any taxiway, it is immediately displayed on the main panel (Pn) located in the airport tower. Detectors (D), beacons (B) and traffic lights (S) have been shown in the drawing. Moreover, although automated hydrants could be sited in other zones, other than in the flight lanes, this does not seem justified in view of accident statistics.

Figure (11) represents a view of the system equipment located in the tower; panel (Pn), console (Co), computers (Or) and connections (Cn), as well as the position of the officer on watch in front of the controls. The panel (Pn) is of large dimensions and almost vertical, its angle of inclination being adjustable, for ease of observation both by the operator and by other tower personnel. Since it is necessary that all the controllers can see the aforementioned panel, it will be located in the upper part of the tower's large window, and for this purpose a small building modification will have to be made locally in the roof of the tower, allowing the panel to be housed in front of the controllers, so that the latter can both observe the panel and see through the tower's window.

Also shown in this figure are:

Tr	- Adjustable support rod	55
Pa	- Wall	
Ca	- Cable	
Gz	- Hinge	

The RUSTEM system console controller directs taxiing and parking, and the remaining controllers

direct flight operations on the runways and flight lanes.

The installation of the RUSTEM system does not involve alterations to the current consoles and installations, nor does it interfere with their operation or the work of the tower's flight controllers.

Figure (12) represents the main panel located in the tower. Its dimensions are those which are appropriate and necessary to reflect the resolution and definition of sources of which the flight lane telemetric sensors (ST) are capable. The operation of both the flight lane computer and the computer dealing with taxiing is displayed on the panel (Pn). When there are emergencies the telemetric sensors go into sweep mode and the reference symbols which appear directly on the panel are emergency circles. In tracking mode, the aircraft reference is seen on the panel as well as a reference which changes according to the actual path of the aircraft.

Figure (13) illustrates an airport flight lane in which an aircraft and a motor vehicle appear.

Figure (14) represents an airport layout in which the surface radar (RS) and control tower (T) are shown.

Having planned the system under the conditions described above, it is now appropriate to take stock of the current situation in airports in general, since the problem is substantially the same in all countries.

To start with the aspect of fire-fighting.

In all civil airports and air bases there is a fire station, equipped with tankers, prepared "ad hoc". This originates from the early days of aviation, as an extension of the method used by municipal fire brigades and has been evolved by trying to adapt to requirements.

Little by little, and despite the efforts made to improve it, its poor performance with regard to the special case of an aeronautical accident has become increasingly clear, as seen in practical cases.

Protests by pilots' associations and the frank pessimism of the aeronautical authorities devoted to this matter, confirm this situation in the various different countries.

For various reasons, as aircraft have been developed they have increased in volume and weight, and therefore in engine power and size of fuel tanks, and can achieve much longer flights.

This has caused airports to increase the capacity of the tankers in which water and special extinguishing agents are transported. This has already led to cases of enormous tankers, some of which have had to incorporate two engines, one in front and one behind. This would suggest that a limit has been reached in the method used.

Also, given the volume which has to be transported, there have been actual instances where the

tankers have overturned, since, although smooth, there are unavoidable gradients in the airport terrain. There are thus some limitations and interactions between the load transported, speed of travel of the vehicle and stability.

Furthermore, if an accident occurs at the head of a runway, at the far end of the start of the runway, often muddy areas and other obstacles prevent or make difficult an approach close to the said accident.

On occasion, the aeroplane or colliding aircraft, are broken into sections which are dispersed, thus requiring the said tankers to be able to attend to all the fires simultaneously and involving an increase in the fleet of trucks necessary.

Moreover, the trucks cannot act on their own, but only when the airport tower so indicates. So that as in the majority of airports the surveillance function is deficient, as the tower first has to determine whether there is an emergency or not, a question which is often difficult and uncertain due to the lack of an instrument which can rapidly verify this, especially at night or in low visibilities.

All this causes a build-up of time which weighs heavily against a hypothetical fire and rescue operation, since first the tower has to determine whether or not there is an emergency, after that it has to notify the fire brigade and this has to be mobilized; then the journey has to be made from the fire station to the site of the accident, at times far away as in the case of the heads of runways. Once the fire brigade have arrived, they have to take charge of the disaster which has occurred different each time, which is complicated in the case of dispersed sections.

Thus, there is an excessive time lag which is inconsistent with the type of accident being considered. It is thus inevitable that performances have been low, losing human lives and increasing the damage to aircraft.

When in the past, aircraft were much smaller, less global inefficiency was observed with this procedure, but currently this is continually on the increase, since it is actually the method and procedure used which have to be changed globally, both in theory and in practice.

According to OACI publications extinction must be carried out in a period of five minutes, due to the fuel, its explosive capacity, and the toxic gases which may asphyxiate the passengers trapped in the accident.

Currently, the OACI specifies between two and three minutes for starting up fast fire trucks after the alarm has been given.

This clearly shows that between the five tragic minutes available and the two or three minutes for the mobilization of the high-speed trucks, there only remain two minutes for the work of extinction,

thus emphasizing the necessity for using a different method, like the RUSTEM system whose automated hydrants enter into operation in a few seconds after the fire rescue button has been pressed by the tower.

In addition to the problems and limitations described, there are other problems which also act negatively on the efficiency of fire rescue operations, this time related to the rescue personnel themselves. These may be summarized as follows:

- the fortunate rarity in the number of accidents paradoxically has a negative effect on the rescue personnel, because they become out of practice due to their enforced inactivity, leading to reduced performances when the critical time arrives of unavoidable emergencies.

Also, having arrived at the site of the accident, on the one hand they are tied to the fire tanker, and on the other the accident has managed to produce a number of fire sources. Thus, each accident being different, they have to improvise their action on the way, often leading to psychological blocks in the face of the urgency of the various sources to be extinguished and their dispersal.

- The airport fireman, moreover, in contrast to his city counterpart, in all cases without the least exception, has to deal with an aircraft which is liable to explode at any moment in its emergency state. So that the fireman's own survival instinct militates against the work he carries out, acting in a situation of fear and insecurity which logically leads to low performances.

The truth is that it is irrational and preposterous to completely, systematically and without exception, require heroism as an everyday norm for work. So that if the technician does not carry out his own self-criticism, he will continue to maintain an error of principle and with it foreseeable low performances, as demonstrated in practical instances.

It is absurd to deal with saving the life of the pilot by placing the lives of several firemen at risk in the attempt. As human beings their lives are as important as that of the pilot and to be respected equally with all others.

If this is not agreed upon, the pilot may not be saved since fear will tend to paralyse the actions of the firemen, with predictable low performances.

Thus, no matter what the quality of the fire-tankers may be at a given moment, they have to be operated by firemen, whose actions are unpredictable.

Faced with this set of problems, both in the method employed and those related to the rescue personnel, the conceptual modification intrinsic to

the present system is based on the following:

a) the setting up of a fixed, buried installation on both sides of the runway, extending it to both ends beyond the thresholds (Figure 1).

b) these two lines consist of hydrants, which in the position of rest are underground, covered by a steel cover flush with the surrounding area so that if an aircraft leaves the runway and runs over the said cover it will not damage the aircraft nor the hydrant hidden underneath (Figure 3).

c) each hydrant incorporates two cannons whose elevations are generally at different angles and appropriate to every fire-fighting operation (Figure 3).

d) each hydrant (Figure 3) has a rotary base, so that it can rapidly assume any angle of azimuth, and therefore line up on the aiming position.

e) the complete hydrant is capable of to-and-fro movement for covering the damaged area.

f) the hydrant has a main trigger valve, continuously adjustable by servo-motor.

g) the hydrant's range is such that it covers the whole width of the flight lane, i.e. each line of hydrants, being rotatory, covers at least two-thirds of the said width. Thus, the runway and its two adjacent areas are covered along the length of the runway and its two ends. For instrument runways, the OACI Standards establish the permitted runway widths as being between 45 and 60 metres, so that on these runways the width of the flight lane has to be not less than 300 metres (Figure 1).

h) it happens that airport accidents occur statistically in 99% of the cases within the area defined by the flight lane, for which reason the automated hydrants are suitably located to cover any emergency in the aforesaid flight lane. The computer software does not improvise, but rationally covers all cases.

i) as the pipes which supply the hydrants are always under load, and as the hydrants cover the whole width of the flight lane, the triggering of the hydrants is extremely rapid and they cover any emergency, whatever the topographical position of the accident and its separate focal points.

j) the automatic action of the hydrants is computer-controlled, and as the buttons are pressed on the control console located in the tower, they act together in preparing the whole runway on the prior announcement of the arrival of an aircraft in an emergency, being accurately trained on the stopped aircraft, or its sections, whatever the topographical dispersal they may have. The fire-fighting takes place globally and simultaneously over all the heat sources present.



k) the position of the aircraft or its sections, in x, y coordinates, is supplied by the telemetric surveillance of the present system, as will be explained later (Figure 12).

So, concentrating for a moment on the fire-fighting method described, the following advantages may be pointed out, amongst others:

1. The automated fire-fighting system requires only a few seconds to come into operation after the button is pressed in the airport tower, thus cutting out the excessive time lag which occurs with fire tankers.

2. As both the water and the extinguishing substances are supplied under pressure to the hydrant by means of underground pipes, no transport by truck is necessary, since now the extinguishing fluid is placed "in situ" via continuously full pipes.

3. Since the water and extinguishing agent storage tanks are also fixed, they can be as large as required, with reserves, whatever the size of the aircraft or the collision in question. The pump, the dispensers, valves, connections and auto-protection devices act in fast response, each line being fitted with the necessary service pressure regulation drum. The pressure is sufficient to guarantee the maximum range of the hydrants, the pump being automatically triggered and responding as soon as there is a slight reduction in the pressure of the regulating drum.

4. The computer which controls the hydrants selects these according to each accident, in accordance with the topographical position of the aircraft, or its sections, as well as according to the force and direction of the wind.

Furthermore, once the fire-fighting operation is initiated, this computer is updated with the possible variations in both the topographical and meteorological data relating to the accident, since new heat sources may have arisen and the wind data may have changed, so that the parameters of each hydrant are altered throughout the fire-fighting operation, the latter being self-adjusted automatically according to the possible variations in the mishap, as well as to those in the prevailing wind.

5. Each hydrant releases via its two cannons a large volume of extinguishing fluid, hitting the whole accident zone. If the aircraft in the emergency does not break up into sections, several hydrants will act together on the aircraft from different angles, hitting it rapidly with a large volume flow, leading to an extremely rapid extinction.

6. The hydrants do not suffer from psychological blocks, since they do not have to think about their actions in each accident, nor are they afraid of fire or explosions, instead when the fire

brigade arrives on the scene of the accident, the fire sources will already be under control and since the lives of the rescue team will remain protected, the latter will complete the operation with high success rates, in favour of both the injured and uninjured.

7. The same can be said for the runway ends, since the system is the same.

8. Due to the automation and its great speed and coverage, in the majority of the accidents there will be a high rescue success rate, both in terms of people and in preventing more damage to the aircraft, which can be salvaged.

This completes the explanation of the principal fire-fighting concepts in the present RUSTEM system.

Now consider the aspect of airport surveillance.

The current general situation can be described as follows:

Although seemingly it might be imagined that there is nothing to enquire into regarding the matter in question, the negative secondary effects which the introduction of the ILS has had on civil airports and air bases should be pointed out, negative effects which were not taken into account when the use of the ILS was introduced and extended into all airports.

This very beneficial instrument was introduced to try to maintain air traffic running in spite of poor visibility conditions on an aircraft's approach to the airport.

The ILS (instrument landing system) is, in fact, a landing instrument.

The said instrument consists of an aerial which is located on the threshold of the runway, emitting signals which are picked up by an instrument on board, indicating whether the aircraft is to the right or left of the runway axis, as well as whether the aircraft in its approach is flying above or below the correct approach path. Hence, although the pilot cannot see the runway due to cloud, he carries out the landing on instruments, gradually altering his course until he is finally on the runway, landing in the touchdown zone.

The runways which have ILS are called instrument runways, which on the ground have to meet the strictest OACI standards regarding widths, slopes...etc., with their respective flight lanes being wider (a minimum of 300 metres).

Thus, it may easily be appreciated that in the past, when there was no ILS, pilots did not land unless they had complete visibility regarding the runway. The tower also had this same visibility with respect to the aircraft trying to land. Put simply, both visibilities, that of the pilot and that of the tower were one and the same visibility.

But, if suddenly the aircraft is given some electronic eyes with which the pilot can carry out

the landing, without seeing the runway with his naked eye, there is a situation in which the operating minimums of this airport have been reduced, by which the aircraft is helped to land, but at the cost of leaving the tower blind if the tower has lost visibility over the complete airport environment.

Together with this there is a situation of general risk in all ground operations, which negative effect was not taken into account when the ILS was introduced and its installation extended into all civil airports and air bases.

In fact, although initially it would appear somewhat illogical, in reality the airport accident referred to previously at Madrid airport, in which two aircraft collided, was basically due to the existence of the ILS in the said airport, since although the ILS is a landing instrument, and in that accident there had been one aircraft landing and the other taxiing, both ground operations were being carried out in conditions of poor visibility, since the introduction of the ILS has lowered the operating minimums in all the world's airports. Neither aircraft saw the other, nor did the tower see either of the two by eye, nor did the tower see the collision, nor the place where both the colliding aircraft were to come to a halt in the flight lane. All the tower saw was fog and initially not knowing what had happened, lost time in calling the fire brigade who then had to look for the site of the accident, also in poor visibility.

On this occasion, the general risk mentioned above became a disaster, with a corresponding loss of human lives and damage to the aircraft. This airport accident is symptomatic of the risk situation which has been highlighted and which it is essential to correct, because from time to time it costs the lives of passengers and pilots.

Air safety embraces the whole environment, and it therefore also includes the ground-ground area.

The ILS comes under the air-ground heading, but an airport is an organic whole as with any object in reality, so that it is connected. Accordingly, if only one part is considered without taking into account the rest, as happened with the ILS (which was aimed exclusively at aiding landing), secondary effects may be, and, in fact, have been produced, such as that quoted of leaving airport towers blind.

Aircraft in an airport cannot move without the proper instructions from the control tower, but if the latter are blind with respect to incidents occurring on the runways, the tower personnel seem to be in a contradictory situation where they have to control and direct surface traffic and at the same time are left blind and without any instrument allowing them to view incidents in the airport. This contradiction from time to time costs people's lives and must be

corrected.

That is to say, this is not an attempt to eliminate the ILS, since it is very beneficial, rather an attempt to provide the tower with a suitable instrument for carrying out telemetric surveillance in the airport, despite there being poor meteorological conditions, or that it is operating at night, as is usual.

In fact, the day has arrived for so-called surface radar, which instead of directing its beam into open space directs it towards the ground, sweeping the airport.

However, this equipment is not suitable, nor is it included in the present RUSTEM system. Here the telemetric method will be something else. There are various reasons for this:

In the first place, surface radar emits its pulses from one point, the aerial.

Secondly, the runway is not flat, but has gradients, even though limited and standardized.

In addition, it should be taken into account that radar does not measure distances, but the time difference between the transmission of the pulse and the reception of its echo bounced back by the object, although since the pulse and its echo consist of electromagnetic radiation their velocity (c) is known, and since the time difference between the transmission and reception is known, the corresponding distance is obtained. But in this process, if the object located on a runway is such that this runway is horizontal, or else has gradients, the result will be that although the straight distance between both objects and the aerial is the same, nevertheless their respective coordinates with respect to runway axes will be different in x, y. This parallax effect is shown in Figure (4).

That is to say, standard surface radar falsifies the x, y coordinates of the object due to a parallax effect which appears when runways have gradients.

These gradients are smooth, but as the length of runways is relatively great, the result is that often there is a very significant difference in height (z) between one end of the runway and the other, so that, in fact, the radar falsifies the corresponding measurement of the x, y position of the objects.

These radars, which in themselves are not very economic due to their functional structure and the elements which they incorporate, would be even more expensive if an attempt were made to obtain the correct x, y coordinates, since in this case one would have to turn to a three-dimensional radar accompanied by a correcting computer. Then the output signal from the (3D) radar receiver would have to be corrected with the computer, which in turn would have to contain the topographical data of the different points of the airport. This would have to take place in real time so that this type of equipment would be more complex and more ex-

pensive, and therefore not very advisable.

There is yet another problem which is that when speaking in general of airport or in-flight surveillance, the concept persists that this telemetric surveillance will be with respect to normal aircraft, when in fact in the case of an airport, not only do the movements and stoppages of normal aircraft have to be monitored, but also the telemetric system has to supply data on emergencies and fires in case of accidents. In addition, it is vital to obtain via telemetry, the actual form of the fire sources which appear. Only in this way will the aiming and automated action of the fire-fighting operation be efficient and accurate. That is, the surveillance function and the fire-fighting function cannot be separated nor split off.

Thus, considering the case of a fuel lake in flames, the result of an accident, three (3) negative factors emerge with regard to surface radar:

a) as said earlier, if the runway has gradients (and it always has some), the x, y position of the source is displaced, and as the hydrants constitute a fixed system in which each hydrant has its respective x, y coordinates with respect to the runway axes, the position of the source would be in error with respect to the hydrants, and their action would be incorrect, due to having carried out the telemetry by means of standard surface radar.

b) but imagine a three-dimensional, computer-corrected radar, making the installation even more expensive. A second difficulty now appears, making the increased outlay practically useless. In actual fact, a burning fuel lake is seen from the radar aerial basically as a "wall" of flames and smoke. So that in any case the echo signal is going to give the position of this "wall", but is not going to give the surface dimensions of this burning lake, since the "wall" prevents the determination of the surface length of the lake, i.e. it is the straight section of the object which is used in the radar; in an airport the radar has an aerial raised at a point of proper height, and therefore the sweep carried out by the beam will come up against this "wall". Naturally if the surface extent of the source is not known, it will not be possible to operate the hydrants correctly.

c) lastly, there is another reason, which is that flames generally return a distorted radar echo and the measurement is still not reliable.

All these reasons make the use of surface radar inadvisable, since in the event of using it, these problems would distort the necessary telemetry. Furthermore, radar will give the sections of the aircraft, but in an airport accident these sections are of less interest since the rupture factor already has no remedy in this case, of greater

interest instead in the telemetry of emergencies is the position of the heat sources, which will sometimes coincide with the sections and at other times not. For example, an aircraft could have its undercarriage broken off in an accident, and this part could be detected by radar. But this part is of no interest as far as the hydrants are concerned, only the fire sources which are the sole item which must be eliminated as quickly as possible after the accident has occurred. Thus, if the telemetry gives mainly the metal sections and not the heat sources, this telemetry would be completely useless and detrimental in this instance, since it would oblige the hydrants to have to act on sections and not on sources, the hydrants being "thrown off track" by a bad choice of the telemetric method used.

Radar has been a great advance, but on every occasion the correct instrument has to be used which is consistent with the function demanding solution, without confusing the uses and functional possibilities of each instrument.

Moreover, although surface radar distorts x, y positions, it is used to give a screen display which is often sufficient for surveillance exclusively. But if an automated fire-fighting system is sought, those errors and difficulties which have been pointed out are disadvantageous, and another method of telemetry must be turned to, which naturally gives the correct x, y position of normal aircraft, but which also gives accurate data in cases of emergency, that is, with one and the same method, both functions must be brought about without duplicating the elements used.

Again, it is essential to understand that an airport is divided into two zones which are completely different in function:

- a) the flight lanes and the runways contained within them.
- b) the taxiways and parking areas.

In fact, when an aircraft is in operation, it does not, nor cannot have any intention in the airport other than to move in one of two directions:

- from the parking area to the runway (going via the taxiways).
- from the runway to the parking area (also going via the taxiways).

In a taxiway the aircraft travels very slowly and often in procession, where some aircraft follow others.

But in the flight lanes and runways the situation is completely different, since this is the ground-air or air-ground transition area. In a taxiway an aircraft can stop sharply if necessary, but this is completely impossible on the runways.

Thus, although the airport is an organic whole and its parts are interconnected, there are basic qualitative differences in these parts, and this differentiation therefore also has to be reflected ap-

appropriately in the telemetry system and its respective consequences and functional derivations.

For example, 99% of airport disasters occur in the flight lanes, so that it makes sense for the automated hydrants to be installed in the flight lanes, but not in other airport areas. That is, although they could of course be installed, it would not make sense comparing the function/cost relationship.

The same thing occurs with the analysis of surface radar, since there are many zones of little or no conflict in the airport, and for these surface radar surveillance gives a totally disproportionate function/cost relationship. Hence, this is another reason for the present RUSTEM system not using surface radar.

Also, as indicated by the OACI SMGC requirements, surface radar will not be regarded as the determining element. This is due, among other reasons, to the fact that although the tower can observe the said radar screen, the pilots in the taxiway cannot see this screen. It is specified that the pilots be guided "in situ", which requires detectors, guidance beacons and traffic lights at crossings, something which surface radar does not provide.

Because of guidance and emergencies, the RUSTEM system does not make use of surface radar.

As will be explained, two different methods will be used:

1) Two parallel lines of infra-red sensors for the flight lanes (Figure 11). Each of these lines located on the longest sides of the rectangle formed by the flight lane. As for instrument runways, the flight lane has to be at least 300 metres wide, this would be the minimum distance at which both parallel lines of sensors are installed.

2) Detectors and beacons (Figure 10) for control of aircraft in the taxiways and parking areas. Reference is made here to the generic detector, the following different types of detector being able to be used: weight pickup, ultrasonic pickup, heat pickup, pickup of the metallic nature of the aircraft (magnetic or electrical fields) and so on, since it is essential in the RUSTEM system that such detectors are neutral throughout the airport, with the exception of the detectors which pick up the aircraft along its run, as the said detectors are only activated exclusively for aircraft, due to the interconnecting mechanism between each of the successive detectors.

In order that a detector can perform the pickup and send its signal to the computer it has to be activated by electric current. This activation will be such that it will occur as the aircraft itself moves. The activated detectors will

"accompany" the aircraft's progress.

These detectors are installed in such a way that they allow the standard minimum distance between aircraft to be controlled. That is to say, if two aircraft on the taxiway are not closer to each other than a minimum specified distance, they are certain of not colliding.

3) A simple system of traffic lights (Figure 10) installed at the taxiway crossings. In this way the tower records for example aircraft movements on each of the internal taxiway routes in the airport, whether for aircraft going from the parking area to the operative flight lane, or for coming from the runway to the parking area, routes that are held in the memory of the computer which controls and guides each aircraft step by step.

In their turn, these traffic lights, which are seen by the pilots when taxiing, are connected to each other, with the detectors described above, and with the tower.

A general description of this aspect of the system is given below:

1) Flight lane telemetric sensors.

The flight lane is another element which is very distinct from an aircraft parking area, since it is a place of movement, so that within the flight lane all aircraft have their engines running, and thus are sources of heat.

In the case of accident, fire sources are also heat sources. Ruptures are already without remedy and what has to be extinguished are fires. Hence, the common denominator of all incidents within a flight lane is heat.

Therefore the special ingredient of the RUSTEM system's telemetric method for flight lanes is the infra-red telemetric sensors (Figures 1,6,7). These sensors are installed in rectangles, one sensor at each corner. So that each sensor in a line has its counterpart in the line opposite.

The flat area which is the flight lane, with no obstacle between the aircraft and the sensors, as well as having no obstacles between the aircraft and the hydrants, allows "sui generis" activation, difficult to repeat in other contexts, but which is totally serviceable in the case of flight lanes, the vast majority of airport accidents occur, either by sudden accident, or else through the arrival at the airport of an aircraft announcing its emergency condition.

The sensors run along the source-detector line, producing a signal which when duly converted from analogue to digital is able to be processed by computer.

As it occurs in two sensors at the same time, there are two lines of bearing whose intersection is calculated by the aforesaid computer, supplying in real time the x, y position of the

source with great simplicity and accuracy.

In turn, the rectangles or squares formed by four sensors, are such that they are successively adjusted to the whole length of the flight lane and its corresponding topography, so that each set of four sensors form (with small error) a plane. Thus the three-dimensional problem substantially disappears and the telemetry is exclusively surface telemetry in x, y. This is taking into account the fact that we are not now considering aircraft in flight, but on the ground, i.e. in their landing or take-off runs and in their taxiing movements within the confines of the flight lane. The latter not only contains the runway, but also covers the part corresponding to fast exits etc, i.e. the paved junctions connecting with the runway.

The telemetric sensors of the present system can operate in two different modes:

- a) Tracking.
- b) Sweep.

In the first case this is the normal functional mode, tracking the paths of normal aircraft in their operations within the flight lane. It is naturally assumed that there has to be only one single aircraft within the perimeter of the flight lane, since although this is often forgotten after airport construction, the flight lane is a standard obstacle-free zone. It does not make the least sense to put great effort at the time into planning and constructing an airport, strictly observing the standard of obstacle-free zones, then afterwards, once the airport has entered into operation, aircraft are placed within the flight lane, as happens many times with threshold waiting zones.

A waiting aircraft has to be outside the flight lane, not inside it, since an aircraft inside the flight lane whilst there is another one operating on it, represents a dangerous obstacle for the aircraft which is not waiting, as it is loaded with passengers and above all fuel, so that inside the perimeter of the flight lane there must be only one aircraft if the intention is to meet the OACI standard for obstacle-free zones, which is absolutely necessary for air safety.

A chimney or an aircraft may be such an obstacle, if they are situated where they ought not to be.

So flight lane sensors will now detect it there are one or more aircraft in it, since the telemetry will of course be tracking, and this will be displayed on the main RUSTEM panel located in the tower.

When there is an emergency, the sensors leave tracking mode and change to sweep mode by the pressing of an emergency button on the control console also located in the tower.

The sweep (Figure 9) takes place from the four corners formed by four sensors, so that the surface form of the heat sources is obtained. (Surface radar only transmits from a single point, the aerial).

At the computer level this gives rise to a circle being displayed, inside which the source is recorded. If there is more than one source, they would have corresponding emergency circles.

This data, together with the wind force and direction data, is passed on to the computer which controls the hydrants, which computes the selection of hydrants and the parameters of each of those selected, thus initiating the fire-fighting operation.

That is to say, the sensors receive the emergency data and the hydrants are triggered by the computer system, all this work being done very rapidly, considering the elements involved, with the functions of telemetric surveillance and automated fire-fighting being integrated.

By pressing a single button on the console located in the tower, the process described is set off, which is measured in seconds, the response time being very fast, as demanded by the extinction operations in question.

2) The detectors located in the taxiways are in their turn connected to the computer controlling all the airport taxiing.

This is a different environment from that of the flight lanes. Here the aircraft travel more slowly, following in procession. What is of interest now is maintaining the minimum distance between aircraft. That is, the position of the aircraft has to be monitored within a taxiway, and above all the maintenance of the said distance has to be controlled for safety purposes.

In order to do this the detectors are sited in the taxiways and the guidance beacons also guarantee this minimum distance. Where there are crossings traffic lights are located at their "entrances".

In other words, this involves only having one aircraft between each two taxiing detectors, being activated by the aircraft's own progress, and not detecting other objects.

This is a similar situation to the technique used in the airways while aircraft are in flight, maintaining the distances between them. In the present case this situation is controlled on the ground by means of one of the said detectors, the aircraft being able to be quite close to each other, but not too close, since although they are travelling slowly they still have some velocity.

With this type of detector the passage of the aircraft in front of the detector as well as its

direction of travel are detected.

For each new detector which picks up the aircraft's progress, the computer lights another axial beacon for this aircraft, every aircraft on the taxiway having a fixed number of axial beacons lit in front of the nose of the aircraft according to the specific route of each aircraft.

The sequence of successive activation of the detectors is produced by means of the inter-connecting mechanism between adjacent detectors. An activated detector on picking up the aircraft not only sends its signal to the computer, but also activates the next detector and deactivates the previous one.

Furthermore, if there is an aircraft in a section of taxiway, which is accounted for, and another aircraft enters this same section, the record shows two aircraft in this section and another signal appears on the main panel in this section; the second signal being arranged to flash and a small alarm sounds on the console at the same time. That is to say, an infraction has been detected and the tower personnel slow down the offending aircraft, thus avoiding damage. That is, the offending aircraft would be at a lesser distance than the standard minimum distance between aircraft, causing risk and possible collision. In such cases, the appropriate computer causes the axial beacons of the offending aircraft to flash.

3) The airport traffic lights of the present system are different from those in towns, although the three lights, green, amber, red, are also used.

The traffic light has two faces with the three lights on both its faces, like the faces of a coin. Although all of this is adapted to the airport context.

In actual fact, what at one moment is given as the valid direction on a taxiway, may become the prohibited direction in another moment. For example, the airport of Las Palmas de Gran Canaria is situated in a region of the world subject to trade winds which change direction twice a year. Thus the operative head of the runway changes according to the season of the year in question. Hence, on altering the runway head the internal routes for taxiing are changed accordingly.

On the control console (Figure 12) there is a diagram of the runways and a button panel with which the internal taxiing routes are recorded at each moment: start and end point.

If a second aircraft tries to enter a taxiway crossing occupied at that time by a preceding aircraft, the pilot of the second aircraft meets with an amber light which tells him that the route he is taking on the taxiway is correct, but the amber light indicates to him that there is an

aircraft in front on this section of taxiway, and therefore the second aircraft has to wait until the amber light disappears, since only then will he be able to enter this section of road. In addition, the fixed number of axial beacons flash on and off.

That is to say, not only is the taxiing control function on the part of the tower involved, as happens with surface radar, but also the pilots have clear instructions "in situ" corresponding to this control. The pilots can see the traffic lights activated "in situ", but cannot view the surface radar screen, since obviously this will only be seen by the tower personnel. For these reasons also surface radar is not suitable and is not used in the RUSTEM system.

It is a question of synchronizing the tower and the taxiing aircraft, with the dual function of instructing the pilots "in situ" and at the same time controlling taxiing from the tower, both in marking out the internal taxiing routes and in detecting infractions, thus achieving control over the minimum distance between aircraft, which is what is important for safety purposes, having an objective measurement available on all occasions.

It is as important that the tower has a display available of what is happening on the runways as it is that the pilots have the data available "in situ".

The signals corresponding to aircraft may be seen on a surface radar screen, but the pilots cannot see this "in situ", nor does it help them at all in maintaining the standard distance between aircraft.

On the main RUSTEM system panel, one can see both the aircraft in the flight lanes (due to the signals sent back by the telemetric sensors), as well as all the aircraft on the taxiways (due to the continuous detectors). Thus, radio should only be used where essential.

To summarize, where there is an ILS in operation, the operating minimums are lowered and telemetric surveillance is therefore essential. Moreover, there must be monitoring and certainty that there is only one aircraft inside the flight lane, since the obstacle-free zone standard must be met which basically affects the whole of the flight lane. Similarly, the minimum distance between aircraft in the taxiing sequence must be monitored, while at the same time all the aircraft are being guided along their taxiway.

Furthermore, telemetric surveillance must be functionally integrated with automated fire-fighting in the flight lanes.

It emerges from all this that, for the reasons explained, surface radar is not the appropriate instrument, but rather the installation of telemetric

sensors, detectors, axial beacons and traffic lights, as in the case of the described RUSTEM system, which to distinguish it from other airport systems has been called this for short, standing for "runway security and taxiway escort system", in which three functions are considered: surveillance, guidance and fire-fighting. With this the tower actually recovers its functions. One could then have smaller, faster and cheaper fire tankers for taking care of possible fires in other airport zones, but used as an auxiliary measure with respect to the automated hydrant installation, as a much more powerful and faster system, as demanded by the aeronautical accident, this being able to take care of any type of emergency in the flight lanes which is where airport accidents tend to occur.

This also reduces the general installation costs and those of maintenance, simultaneously achieving a high degree of reliability, speed, and simple and secure operation on the part of the tower personnel, who would thus have a working tool which they can use whatever the meteorological conditions, night-time situation or traffic density, the RUSTEM system being adaptable to any airport.

Lastly, as shown in Figures 13 and 14, especially in Figure 13, along the sides of the flight lane will be arranged a series of standard infra-red sensors, Si, as well as some special infra-red sensors, SiA, with an additional element for transmitting and receiving electromagnetic or ultrasonic pulses. The infra-red rays, if, which leave the aircraft are picked up by both types of infra-red sensors as the aircraft passes in front of them, and the data thus obtained is sent to the central computer of the installation fitted in the control tower, T (Figure 14). The two types of infra-red detectors can pick up not only the infra-red rays originating from the aircraft, but also the infra-red rays, if, originating from any vehicle, vh, which is travelling along the flight lane.

Also, as can be seen in Figure 14, the control tower, T, is linked in with the airport's surface radar, RS, Figure 14 also illustrating the normal infra-red sensors, Si, and the taxiing and guidance detectors and beacons, D-B.

As a result of the present invention, the automatic surveillance, guidance and fire-fighting installation for airport aircraft covers the whole spectrum of safety in an airport and is thus in the optimum position to meet the different safety emergencies which may arise in airport traffic.

#### Claims

1. An automatic surveillance and fire fighting system in an airport having a flight lane, comprising an array of heat sensors each directed towards the flight lane and disposed at laterally of the flight lane in spaced relation substan-

tially along its entire length, including positions between intersections of the flight lane with any other lane, and a computer operable in a first mode to receive signals from the sensors to provide an indication of movement of an aircraft as it moves along the flight lane past successive sensors, characterised in that the system further comprises an array of selectively operable hydrants arranged such that any position along the flight path may be reached by fluid from at least one of the hydrants, the computer and the sensors are adapted to operate in a second mode in response to a control signal applied to the computer in which sensors are caused to sweep their respective local areas, and the computer acts to combine the outputs of adjacent sensors to detect the position of any heat source within any such area, and to selectively activate hydrants capable of providing fire extinguishing fluid to the position of the heat source.

2. A system according to claim 1, in which the computer is also operable in a third mode to cause the hydrants to direct fire extinguishing fluid over the whole or selected areas of the flight lane.

3. A system according to claim 1 or 2 in which in the second mode the computer also derives information as to the area of each heat source from the sensor outputs.

4. A system according to any preceding claim, further comprising at least one wind speed detector arranged to provide a wind speed signal indicative of the wind velocity in the flight lane to an input of the computer, and the computer is arranged to process this wind speed information with the sensor output signals to control the direction of the fluid from the hydrants.

5. A system according to any preceding claim, in which the airport has taxiways and parking areas, further comprising position detectors for detecting the position of aircraft in the taxiways and parking areas as a function of travel and direction of travel to provide position output signals to said computer, and guidance beacons along the taxiways controlled by the computer in response to the position signals to indicate the path to be followed by an aircraft.

6. A system according to claim 5 and comprising traffic lights connected to the guidance beacons and situated at appropriate positions such

as taxiway crossings.

- 7. A system in accordance with any one of claims 1 to 6, in which the infra-red sensors are arranged in two parallel rows situated outside the or each runway, on both sides of the latter and at the perimeter of the flight lanes, along the latter and preferably for a suitable distance beyond the runway threshold. 5
- 8. A system in accordance with claim 7, in which the flight lane sensors are interconnected and determine the position of the aircraft situated within such a lane in an instantaneous and continuous manner, in such a way that in normal operation they supply the corresponding computer with the data from the heat sources present on the flight lane and enable the aforementioned computer to define the position of each heat source, whether at rest or in motion, in real time on the tower control panel. 10 15 20
- 9. A system in accordance with claim 7 or 8, in which the separation between each two consecutive flight lane sensors of each row is defined in such a way that it is sufficiently small for the distance between them to be approximately equal to its horizontal projection, and between each two pairs of opposing detectors a rectangle of detection is created, within which, in an emergency situation, the heat sources are accurately detected by the four corner sensors which operate in the said emergency situation in the form of a continuous sweep, in such a way that the electrical signal from the infra-red sensors contains the information relating to position and size of the different heat sources, and is passed via an analogue to digital converter for processing by the aforesaid computer, the sensors being adapted to the flight lane's own particular topography, allowing surface telemetry. 25 30 35 40
- 10. A system in accordance with any one of claims 5 to 9 characterised by the fact that the taxiing and parking detectors are all neutral throughout the airport, not picking up any object other than aircraft exclusively, so that other objects do not interfere with the computer which processes the monitoring and guidance of the aircraft in their respective continuous sequences of travel, between an initial point and final point, various types of detector being able to be used, such as weight sensing; pickup by ultrasonic transmission and reception; transmission and reception of light; infra-red; laser; or else of the electrical or magnetic field type, so that only the detector corresponding to the 45 50 55

aircraft's position sends back the corresponding signal to the computer, and in such a way that as each aircraft goes on taxiing, the activated detector deactivates the previous detector and activates the following detector, the latter remaining ready to pick up the aircraft when it passes in front of it, causing the detector signals arriving at the computer to trigger the latter into lighting and extinguishing the guidance beacons.

- 11. A system in accordance with claim 10, in which the said taxiing and parking detectors do not constitute an obstacle for aircraft or service vehicles, but only pick-up aircraft, and the computer on being fed with the signals originating from the detectors keeps account of each detector which sends its signal, the computer holding the route of each aircraft in memory, between its starting point and end point, which causes the computer to go on lighting the guidance beacons in front of each aircraft, according to a fixed number of beacons, and in such a way that each aircraft has in front of it a fixed number of lighted beacons, whether day or night, which beacons will go on changing according to the progress of the aircraft, the pilot being guided along the whole taxiing route, and in such a way that a minimum distance between aircraft is maintained, so that should two aircraft enter a crossing the computer causes the guidance beacons of one of the aircraft to flash on and off intermittently at the same time as the crossing traffic light remains lit at red, so that this aircraft has to brake its progress, and once the other aircraft has passed the crossing, the computer will cancel the aforesaid intermittent flashing, the red traffic light will be cancelled to allow the aircraft to continue on its way.
- 12. A system in accordance with any one of claims 5 to 11, in which the arrangement of the flight lane telemetric sensors and the taxiing detectors is such that once an aircraft has ceased being monitored by the former, it will start to be monitored by the latter and vice versa.
- 13. A system in accordance with any one of claims 6 to 12, in which the traffic lights are situated only at the crossings of taxiways, in a position related to that of the detectors and are connected to the said detectors, to the guidance beacons and to the control console, the traffic lights being activated in the event of opposing routes in aircraft taxiing and in such a way that in the event that a taxiing aircraft has to return to the parking area, in order to report any fault



for example, a controller can cancel the route which had been allocated to the said aircraft and input on a keyboard a new initial and final point for the said aircraft, which is guided back on its return.

14. A system in accordance with any one of claims 4 to 13, in which the information relating to wind force and direction generated by the anemometers, is sent continuously to the control console and to the hydrant computer, so that the latter may effect calculations for aiming the different hydrants in emergency situations.

15. A system in accordance with any one of the preceding claims, in which the hydrants are arranged in two or more parallel rows on the runways, one or more on each side of the latter, and within the flight lanes, in such a way that each of the hydrants is independent of the rest, is solely controlled by the hydrant computer and launches its jets of extinguishing liquid with a horizontal to-and-fro motion whose amplitude depends upon the heat source to be extinguished, and with a different elevation for each discharge outlet, the hydrants being deactivated, despite being automatic in operation, unless the fire rescue control button is pressed from the airport tower, being capable of acting to prepare the runway on the announcement of the arrival of an aircraft in emergency status, or going into operation once the aircraft in the emergency is motionless; the system remaining locked whilst the aircraft is in motion.

16. A system in accordance with claim 15, in which the hydrants are anchored and buried underground, being covered by a metal, such as steel, cover, flush with the surrounding terrain, not constituting any obstacle in the event that an aircraft on leaving the runway passes over the top of the said cover, and in the event of the hydrants being activated due to an aircraft emergency, the hydrant cannons are raised up, raising the steel cover; the hydrants having three degrees of freedom being capable of horizontally rotating through 360°, to take care of any emergency.

17. A system in accordance with any one of the preceding claims, in which the hydrants are mobile, of the previous type, as well of the fixed type with multiple pipes, according to the requirements of the airport, at certain points of the flight lane and its ends.

18. A system in accordance with claim 15, in which the hydrants are arranged in locations

suited to the form of the crossings of the different flight lanes.

19. A system in accordance with any one of claims 4 to 18, in which the hydrant computer only intervenes in the event that an emergency situation arises, being inactive under normal conditions, and carries out continuous calculations of the hydrant triggering parameters, by taking account of continuous information originating from the flight lane detectors and anemometers in cases of emergency and activation of the system from the tower.

20. A system in accordance with claim 19, in which at least one hydrant computer is provided for each flight lane, and the said computers are interconnected.

21. A system in accordance with claim 19 or 20, in which the hydrants can spray the complete runway on the prior announcement of an aircraft in an emergency situation or operate accurately on the halted aircraft or its sections.

22. A system in accordance with any one of claims 4 to 21, in which the flight lane computer receives data from all the sensors and anemometers, using this to carry out calculations of aircraft positions, and the position and size of the different fire zones which already exist or which develop subsequently, transmitting this last data to the hydrant computers, and stores information in memory relating to day-to-day hazards, as well as normal movements.

23. A system in accordance with any one of claims 5 to 22, in which contained in the tower is a main panel with the representation and identification of the aircraft in the flight lanes and in the taxiways, the said representation being in a special form for aircraft in a situation of infraction, with heat sources also appearing in an emergency situation, the computer equipment producing the corresponding alarm, either for infractions or for emergencies.

24. A system in accordance with claim 23, in which the control console is fitted with infraction and emergency alarm signals, a constant display of the data from the anemometers, selection controls for taxiway courses by means of a data input keyboard, controls for selecting flight lanes and take-off direction on the latter, and fire-fighting activation controls, in expectation of an emergency in all the flight lanes; similarly, it has controls for carrying out tests with the hydrants, using only water to

check the system's response at any given moment, including also the necessary measuring instruments, switches and protection devices.

25. A system in accordance with any one of the preceding claims, characterised by its operation at any time, whether in a day- or night-time situation, or with poor visibility, due to its characteristics being adaptable to any aircraft configuration, as well as to any expansion there might be at any given time, the previously fitted system being capable of being expanded according to any extension of the runways and taxiways which may be carried out.
26. A system in accordance with any one of claims 5 to 25, in which each beacon is fitted with a compressed air outlet for the removal of dust, snow or other grime which has been deposited, whose discharge is activated when the beacon is lit.
27. A system in accordance with any one of claims 5 to 26, characterised by the fact that: (j) for airports operating in very poor visibilities, in addition to infra-red sensing, some flight lane sensors incorporate a transmitter and detector of electromagnetic pulses, or else an ultrasonic active element, capable of detecting objects located inside the flight lane relating to aircraft or vehicles; (k) for airports with normal or average visibility, the normal sensors not only pick up the aircraft located in the flight lane, but also the vehicles entering it; (l) there is the option of installing an interface capable of processing the signals originating from the surface radar which an airport may have installed, and introducing such signals into the computer which controls the surveillance, and with this data making an addition to the functions of the system; (m) there is the option that the systems taxiing detectors may be simultaneously activated throughout, and the pick up of aircraft and other objects carried out simultaneously, although in this case incorporating means for discriminating aircraft from other objects, achieving the maintenance of the logical sequence in the guidance of each aircraft in the zone of movement and parking of aircraft; and (n) there is the option of the water and extinguishing agent pipes and pressurized storage tanks being divided up into independent modules, and their discharge being achieved by means of the pressure of a compressed gas connected by regulating valves to the water and extinguishing agent storage tanks.

#### Patentansprüche

1. Automatisches Überwachungs- und Brandbekämpfungssystem auf einem Flugplatz mit einer Start- und Landebahn, mit einer Anordnung von Wärmefühlern, die je zur Start- und Landebahn hin gerichtet und seitlich der Start- und Landebahn im wesentlichen entlang ihrer gesamten Länge mit Abstand voneinander angeordnet sind, einschließlich Orten zwischen Kreuzungen der Start- und Landebahn mit jeder anderen Bahn, und einem in einer ersten Betriebsart betreibbaren Rechner zum Empfangen von Signalen von den Fühlern, um eine Bewegungsanzeige eines Flugzeugs bereitzustellen, während es sich entlang der Start- und Landebahn an aufeinanderfolgenden Fühlern vorbeibewegt,
- dadurch gekennzeichnet,**
- daß das System weiterhin eine Anordnung wahlweise betreibbarer Hydranten aufweist, die so angeordnet sind, daß jede Stelle entlang der Start- und Landebahn von Flüssigkeit aus zumindest einem der Hydranten erreicht werden kann, der Rechner und die Fühler als Antwort auf ein dem Rechner zugeführtes Steuersignal in einer zweiten Betriebsart betreibbar sind, in der Fühler zum Überstreichen ihrer jeweiligen lokalen Bereiche veranlaßt werden, und der Rechner tätig ist, um die Ausgangssignale benachbarter Fühler zum Ermitteln der Lage einer Wärmequelle in irgendeinem solchen Bereich zu kombinieren, und um Hydranten wahlweise zu aktivieren, die Feuerlöschflüssigkeit am Ort der Wärmequelle bereitstellen können.
2. System nach Anspruch 1, bei dem der Rechner auch in einer dritten Betriebsart betreibbar ist, um die Hydranten zu veranlassen, Feuerlöschflüssigkeit auf die gesamte oder ausgewählte Bereiche der Start- und Landebahn zu richten.
3. System nach Anspruch 1 oder 2, bei dem der Rechner in der zweiten Betriebsart aus den Ausgangssignalen der Fühler auch Information über die Fläche jeder Wärmequelle gewinnt.
4. System nach einem der vorhergehenden Ansprüche, das ferner zumindest einen Windgeschwindigkeitsmesser aufweist, der zum Liefern eines die Windgeschwindigkeit in der Start- und Landebahn anzeigenden Windgeschwindigkeitssignals an einen Eingang des Rechners angeordnet ist, wobei der Rechner dafür eingerichtet ist, diese Windgeschwindigkeitsinformation mit den Fühlerausgangssigna-

- len zu verarbeiten, um die Richtung der Flüssigkeit aus den Hydranten zu steuern.
5. System nach einem der vorhergehenden Ansprüche, wobei der Flugplatz Rollbahnen und Parkflächen hat, das ferner Ortsanzeiger zum Feststellen der Position von Flugzeugen auf den Rollbahnen und Parkflächen als Funktion von Bewegung und Bewegungsrichtung aufweist, um dem genannten Rechner Positionsausgangssignale zu liefern, und Leitfeuer entlang der Rollbahnen aufweist, die in Abhängigkeit der Positionssignale vom Rechner angesteuert werden, um den von einem Flugzeug zu folgenden Weg anzuzeigen. 5
  6. System nach Anspruch 5 mit Verkehrsampeln, die mit den Leitfeuern verbunden und an geeigneten Stellen wie z. B. Rollbahnkreuzungen angeordnet sind. 10
  7. System nach einem der Ansprüche 1 bis 6, bei dem die Infrarotsensoren in zwei parallelen, beidseits und außerhalb der oder jeder Start- und Landebahn gelegenen Reihen, und am Rand der Anflugbahnen längs dieser und vorzugsweise eine angemessene Wegstrecke über die Start- und Landebahngrenze hinaus angeordnet sind. 15
  8. System nach Anspruch 7, bei dem die Flugbahn-Sensoren miteinander verbunden sind und die Position des sich in solch einer Bahn befindenden Flugzeugs augenblicklich und fortwährend derart ermitteln, daß sie im Normalbetrieb den entsprechenden Rechner mit den Daten von den in der Flugbahn vorhandenen Wärmequellen versorgen und den vorgenannten Rechner in die Lage versetzen, die Position jeder Wärmequelle, ob im Stillstand oder in Bewegung, in Echtzeit auf der Anzeigetafel im Kontrollturm anzugeben. 20
  9. System nach Anspruch 7 oder 8, bei dem der Abstand zwischen je zwei aufeinanderfolgenden Flugbahnsensoren jeder Reihe derart festgesetzt ist, daß er klein genug ist, um die Wegstrecke zwischen ihnen etwa gleich ihrer Horizontalprojektion sein zu lassen, und bei dem zwischen je zwei Paaren gegenüberliegender Fühleinrichtungen ein Erfassungsrechteck erzeugt ist, innerhalb dessen in einer Notfallsituation die Wärmequellen von den vier Ecksensoren genau erfaßt werden, die in der genannten Notfallsituation in Form einer fortlaufenden Abtastung arbeiten, derart, daß das elektrische Signal der Infrarotsensoren die Information bezüglich Position und Größe der 25
  - verschiedenen Wärmequellen enthält und durch einen Analog/Digital-Wandler zum Verarbeiten durch den vorgenannten Rechner geführt wird, wobei die Sensoren an die der Flugbahn eigene, besondere Topographie angepaßt sind und Oberflächentelemetrie ermöglichen. 30
  10. System nach einem der Ansprüche 5 bis 9, **dadurch gekennzeichnet**, daß die Rollbahn- und Parkflächen-Fühleinrichtungen auf dem gesamten Flugplatz alle indifferent sind und kein anderes Objekt als ausschließlich Flugzeuge erfassen, so daß andere Objekte den Rechner nicht stören, der die Überwachung und Leitung der Flugzeuge in ihren entsprechenden fortlaufenden Bewegungsabschnitten zwischen einem Anfangs- und Endpunkt bearbeitet, wobei unterschiedliche Arten von Fühleinrichtungen eingesetzt werden können, wie z. B. Gewichtserfassung; Erfassung durch Aussendung und Empfang von Ultraschall; Aussendung und Empfang von Licht; Infrarot; Laser; oder eine andere elektrische oder magnetische Feldart, so daß nur die der Position des Flugzeugs entsprechende Fühleinrichtung das entsprechende Signal zu dem Rechner zurücksendet, derart, daß beim Weiterrollen jedes Flugzeugs die aktivierte Fühleinrichtung die vorhergehende Fühleinrichtung deaktiviert und die nächstfolgende Fühleinrichtung aktiviert, wobei letztere bereit bleibt, das Flugzeug zu erfassen, wenn es vor ihr vorbeifliegt, und bewirkt, daß die am Rechner ankommenden Signale der Fühleinrichtung letztere erleuchten und die Leitfeuer erlöschen lassen. 35
  11. System nach Anspruch 10, bei dem die genannten Rollbahn- und Parkflächen Fühleinrichtungen kein Hindernis für Flugzeuge oder Servicefahrzeuge darstellen, sondern nur Flugzeuge erfassen, und bei dem der Rechner, während ihm die von den Fühleinrichtungen stammenden Signale zugeführt werden, Buch über jede Fühleinrichtung führt, die ihr Signal sendet, wobei der Rechner den Weg jedes Flugzeugs zwischen seinem Anfangs- und Endpunkt speichert, was den Rechner veranlaßt, eine feste Anzahl von Leitfeuern vor jedem Flugzeug aufleuchten zu lassen, derart, daß jedes Flugzeug vor sich bei Tag oder Nacht eine feste Anzahl erleuchteter Feuer hat, die entsprechend dem Vorrücken des Flugzeugs umschalten, so daß der Pilot entlang des gesamten Rollwegs geleitet wird, derart, daß ein Minimalabstand zwischen Flugzeugen eingehalten wird, so daß im Falle zweier in 40

eine Kreuzung einlaufender Flugzeuge der Rechner die Leitfeuer für eines der Flugzeuge während der Zeitdauer blinken läßt, in der die Kreuzungsampel rot leuchtet, so daß dieses Flugzeug sein Vorrücken bremsen muß, und der Rechner das genannte Blinken beendet und die rote Ampel ausgeschaltet wird, so bald das andere Flugzeug die Kreuzung passiert hat, um dem Flugzeug zu gestatten, seinen Weg fortzusetzen.

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12. System nach einem der Ansprüche 5 bis 11, bei dem die Anordnung der Flugbahn-Telemetriensensoren und der Rollbahn-Fühleinrichtungen so ist, daß ein Flugzeug, sobald es nicht mehr von den ersteren überwacht wird, es von den letzteren überwacht wird und umgekehrt.

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13. System nach einem der Ansprüche 6 bis 12, bei dem die Ampeln nur an den Kreuzungen von Rollbahnen in einer mit der Position der Fühleinrichtungen in Bezug stehenden Position angeordnet und mit den genannten Fühleinrichtungen, den Leitfeuern und dem Kontrollpult verbunden sind, wobei die Ampeln bei entgegengerichteten Rollwegen von Flugzeugen aktiviert werden, so daß bei einem rollenden Flugzeug, das zu der Parkfläche zurückkehren muß, beispielsweise um irgendeinen Fehler zu melden, ein Controller die dem genannten Flugzeug zugewiesene Wegstrecke löscht und auf einer Tastatur einen neuen Anfangs- und Endpunkt für das genannte Flugzeug eingeben kann, das bei seiner Rückkehr zurückgeleitet wird.

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14. System nach einem der Ansprüche 4 bis 13, bei dem die sich auf Windstärke und -richtung beziehende, von den Windgeschwindigkeitsmessern erzeugte Information fortwährend zum Kontrollpult und zu dem Rechner für die Hydranten gesendet wird, so daß letzterer Berechnungen zum Ausrichten der verschiedenen Hydranten in Notfallsituationen ausführen kann.

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15. System nach einem der vorhergehenden Ansprüche, bei dem die Hydranten in zwei oder mehr parallelen Reihen auf den Start- und Landebahnen in einer oder mehreren Reihen auf jeder Seite derselben, und innerhalb der Flugbahnen derart angeordnet sind, daß jeder der Hydranten von den übrigen unabhängig ist, nur durch den Rechner für die Hydranten gesteuert wird und seine Löschlüssigkeitsstrahlen in einer horizontalen Hin- und Herbewegung, deren Amplitude von der zu löschenden Wärmequelle abhängt, und mit einer für jede Auslaßöffnung verschiedenen Neigung ausstößt, wo-

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bei die Hydranten, trotz automatischen Betriebs, deaktiviert sind, bis der Feuerretterknopf vom Kontrollturm aus gedrückt wird, und in der Lage sind, die Start- und Landebahn bei Ankündigung der Ankunft eines sich in einer Notfallsituation befindenden Flugzeugs vorzubereiten oder in Betrieb zu treten, sobald das sich in Not befindende Flugzeug nicht mehr in Bewegung ist, wobei das System gesperrt bleibt, so lange das Flugzeug in Bewegung ist.

16. System nach Anspruch 15, bei dem die Hydranten unterirdisch verankert und versenkt sind und von einer Metallabdeckung, beispielsweise aus Stahl, in einer Ebene mit dem umgebenden Gelände abgedeckt sind und kein Hindernis darstellen, falls ein Flugzeug beim Verlassen der Start- und Landebahn über die Oberseite der genannten Abdeckung fährt, und bei aufgrund einer Flugzeugnotsituation aktivierter Hydranten die Hydrantenkanonen, die Stahlabdeckung anhebend, hochgefahren werden, wobei die Hydranten mit drei Freiheitsgraden in der Lage sind, horizontal um 360° zu drehen, um sich jedes Notfalls anzunehmen.

17. System nach einem der vorhergehenden Ansprüche, bei dem die Hydranten an bestimmten Punkten der Flugbahn und ihrer Enden entsprechend den Anforderungen des Flugplatzes sowohl gemäß der vorhergehenden Art bewegbar als auch vom feststehenden Typ mit Mehrfachrohren sind.

18. System nach Anspruch 15, bei dem die Hydranten an Stellen angeordnet sind, die der Kreuzungsform der verschiedenen Flugbahnen angepaßt sind.

19. System nach einem der Ansprüche 4 bis 18, bei dem der Rechner für die Hydranten nur eingreift, wenn eine Notfallsituation auftritt und unter normalen Bedingungen nicht aktiv ist, und bei Notfällen und einer Aktivierung des Systems vom Kontrollturm aus fortwährende Berechnungen der Hydranten-Auslöseparameter durch Verfolgen der von den Fühleinrichtungen der Flugbahn und den Windgeschwindigkeitsmessern stammenden kontinuierlichen Information durchführt.

20. System nach Anspruch 19, bei dem für jede Flugbahn zumindest ein Rechner für Hydranten vorgesehen ist und die genannten Rechner miteinander verbunden sind.

21. System nach Anspruch 19 oder 20, bei dem die Hydranten nach vorheriger Ankündigung

- eines sich in einer Notfallsituation befindenden Flugzeugs die gesamte Start- und Landebahn besprühen oder gezielt das gestoppte Flugzeug oder seine Abschnitte bearbeiten können.
22. System nach einem der Ansprüche 4 bis 21, bei dem der Rechner für die Flugbahn Daten von allen Fühleinrichtungen und Windgeschwindigkeitsmessern empfängt und diese benutzt, um Berechnungen von Flugzeugpositionen und der Lage und Größe der verschiedenen, bereits vorhandenen oder sich nach und nach entwickelnden Brandzonen durchzuführen, wobei diese letzten Daten an die Rechner für die Hydranten übertragen werden, und Informationen sowohl bezüglich tagtäglicher Gefahren als auch bezüglich normaler Bewegungen abspeichert.
23. System nach einem der Ansprüche 5 bis 22, bei dem im Kontrollturm eine Haupttafel mit der Darstellung und Kennung der Flugzeuge in den Flugbahnen und in den Rollbahnen vorhanden ist, wobei die genannte Darstellung eine besondere Form für beschädigte Flugzeuge aufweist, und wobei Wärmequellen in einer Notfallsituation ebenfalls erscheinen und die Rechneranlage den entsprechenden Alarm erzeugt, entweder für Beschädigungen oder für Notfälle.
24. System nach Anspruch 23, bei dem das Kontrollpult mit Beschädigungs- und Notfallalarmsignalen, einer dauernden Anzeige der Daten von den Windgeschwindigkeitsmessern, Wahlorganen für Rollbahnwege mittels einer Dateneingabetastatur, Organen zur Wahl von Flugbahnen und Startrichtung auf letzterer, und mit Brandbekämpfungsaktivierungsorganen versehen ist, in Erwartung eines Notfalls in allen Flugbahnen; gleichermaßen weist es Bedienungsorgane zum Durchführen von Hydrantentests und auch die notwendigen Meßinstrumente, Schalter und Schutzvorrichtungen auf, wobei zum Prüfen der Reaktion des Systems zu jedem beliebigen Zeitpunkt nur Wasser eingesetzt wird.
25. System nach einem der vorhergehenden Ansprüche, **gekennzeichnet durch** seinen Betrieb zu jeder Zeit, ob bei Tag oder bei Nacht oder bei schlechter Sicht, welches aufgrund seiner Eigenschaften sowohl an jede Flugzeugkonfiguration als auch an jede zu jedem gegebenen Zeitpunkt mögliche Erweiterung anpaßbar ist, wobei das vorher installierte System entsprechend jeder Verlängerung der Start- und Landebahnen und Rollbahnen, die möglicherweise ausgeführt wird, erweiterbar ist.
- 5 26. System nach einem der Ansprüche 5 bis 25, bei dem jedes Feuer mit einem Druckluftauslaß zur Entfernung von Staub, Schnee oder anderem Schmutz, der abgelagert worden ist, versehen ist, dessen Ausströmen aktiviert wird, wenn das Feuer aufleuchtet.
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- 15 27. System nach einem der Ansprüche 5 bis 26, **dadurch gekennzeichnet,** daß: (j) für Flugplätze, die bei sehr schlechter Sicht betrieben werden, einige Flugbahnfühleinrichtungen zusätzlich zu Infrarotsensoren einen Sender und Empfänger elektromagnetischer Impulse oder ein aktives Ultraschallelement zum Erfassen von innerhalb der Flugbahn befindlichen Gegenständen in Bezug auf Flugzeuge oder Fahrzeuge aufweisen; (k) bei Flugplätzen mit normaler oder durchschnittlicher Sicht die normalen Fühleinrichtungen nicht nur das sich in der Flugbahn befindende Flugzeug, sondern auch in diese einführende Fahrzeuge erfassen; (l) die Wahl besteht, ein Interface zu installieren, welches in der Lage ist, die von einem Oberflächenradar stammenden Signale zu verarbeiten, welches ein Flugplatz installiert haben kann, und diese Signale dem Rechner zuzuführen, der die Überwachung steuert, und mit diesen Daten eine Funktionserweiterung des Systems vorzunehmen; (m) die Wahl besteht, daß die Rollbahnfühleinrichtungen des Systems gleichzeitig insgesamt aktiviert werden können und das Erfassen von Flugzeugen und anderen Gegenständen gleichzeitig durchgeführt wird, in diesem Fall allerdings Mittel zur Unterscheidung von Flugzeugen gegenüber anderen Gegenständen einschließend, wodurch der Erhalt der logischen Reihenfolge beim Leiten jedes Flugzeugs im Park- und Bewegungsbereich von Flugzeugen erreicht wird; und (n) die Wahl besteht, die Wasser- und Löschmittelrohre und Druckspeichertanks in unabhängige Module aufzuteilen, wobei ihr Ausströmen mittels des Drucks eines komprimierten Gases erreicht wird, das über Regelventile mit den Wasser- und Löschmittelspeichertanks verbunden ist.
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- Revendications**
- 55 1. Dispositif automatique de surveillance et de lutte contre l'incendie dans un aéroport comportant une bande aménagée, constitué par un réseau de détecteurs de chaleur, dont chacun est orienté vers la bande aménagée, et placés

- de façon espacée sur les côtés de la bande aménagée sensiblement sur toute sa longueur, y compris en des emplacements entre les intersections de la bande aménagée avec une autre piste, et un ordinateur qui peut fonctionner dans un premier mode pour recevoir des signaux émis par les capteurs afin de fournir une indication du mouvement d'un avion qui se déplace le long de la bande aménagée en passant devant les capteurs successifs, **caractérisé** en ce que le dispositif comporte en outre un réseau de bouches d'incendie, qui peuvent fonctionner de façon sélective, disposées de telle sorte que l'on puisse atteindre n'importe quelle position le long de la bande aménagée avec du fluide en provenance de l'une des bouches au moins ; l'ordinateur et les capteurs sont aptes à fonctionner dans un deuxième mode en réponse à un signal de commande appliqué à l'ordinateur, mode dans lequel on fait balayer par les capteurs la région locale qui leur correspond, et l'ordinateur agit pour combiner les sorties des capteurs adjacents, afin de détecter la position de toute source de chaleur dans n'importe laquelle de ces régions, et activer de façon sélective les bouches capables d'envoyer un fluide extincteur d'incendie à l'emplacement de la source de chaleur.
2. Dispositif suivant la revendication 1, dans lequel l'ordinateur peut aussi fonctionner dans un troisième mode pour amener les bouches d'incendie à diriger le fluide extincteur d'incendie sur toute la bande aménagée ou sur des zones choisies de celle-ci.
  3. Dispositif suivant la revendication 1 ou 2, dans lequel, dans le deuxième mode, l'ordinateur déduit aussi des sorties des capteurs une information sur l'étendue de chaque source de chaleur.
  4. Dispositif suivant l'une quelconque des précédentes revendications, comportant en outre au moins un détecteur de la vitesse du vent placé pour fournir un signal de vitesse de vent indicateur de la vélocité du vent dans la bande aménagée à une borne d'entrée de l'ordinateur, et l'ordinateur est prévu pour traiter cette information de vitesse du vent avec les signaux de sortie des capteurs de façon à commander la direction du fluide émis par les bouches d'incendie.
  5. Dispositif suivant l'une quelconque des précédentes revendications, dans lequel l'aéroport comporte des voies de circulation et des aires

- de stationnement, qui a en outre des détecteurs de position pour détecter la position d'un avion sur les voies de circulation et sur les aires de stationnement en fonction du trajet et de la direction de trajet, pour fournir en sortie des signaux de position audit ordinateur, et des balises de guidage le long des voies de circulation commandées par l'ordinateur en réponse aux signaux de position afin d'indiquer à l'avion le trajet à suivre.
6. Dispositif suivant la revendication 5, comportant des signaux lumineux de circulation reliés aux balises de guidage et placés en des endroits appropriés tels que les intersections de voies de circulation.
  7. Dispositif suivant l'une quelconque des revendications 1 à 6, dans lequel des capteurs infrarouges sont agencés en deux rangées parallèles situées à l'extérieur de la piste, ou de chacune d'elle, sur les deux côtés de celle-ci, et au périmètre de la bande aménagée, le long de celle-ci et de préférence jusqu'à une distance appropriée au-delà du seuil de la piste.
  8. Dispositif suivant la revendication 7, dans lequel les capteurs de la bande aménagée sont inter-reliés et déterminent la position de l'avion placé sur une telle piste de façon instantanée et continue, de telle manière qu'en fonctionnement normal ils fournissent à l'ordinateur correspondant les données en provenance des sources de chaleur présentes sur la bande aménagée et permettent à l'ordinateur ci-dessus mentionné de définir la position de chaque source de chaleur, qu'elle soit au repos ou en mouvement, en temps réel au tableau de la tour de contrôle.
  9. Dispositif suivant la revendication 7 ou 8, dans lequel on définit l'espacement entre deux capteurs de la bande aménagée consécutifs sur chaque rangée suffisamment petit pour que la distance entre eux soit sensiblement égale à leur projection horizontale, et on définit un rectangle de détection entre chacune des deux paires de détecteurs se faisant face à l'intérieur duquel, dans une situation d'urgence, les sources de chaleur sont détectées avec précision par les quatre détecteurs d'angle qui fonctionnent dans ladite situation d'urgence sous forme d'un balayage continu, de telle sorte que le signal électrique émis par les détecteurs infrarouges contient l'information concernant la position et la taille des différentes sources de chaleur, et est envoyé via un convertisseur analogique/numérique à l'ordinateur précité

pour qu'il le traite, les capteurs étant adaptés à la topographie particulière propre à la bande aménagée concernée, permettant une télémétrie de surface.

10. Dispositif suivant l'une quelconque des revendications 5 à 9, **caractérisé** par le fait que les détecteurs pour les voies de circulation et les aires de stationnement sont tous neutres partout dans l'aéroport, ne sont sensibles à aucun autre objet qu'exclusivement un avion, de telle sorte que d'autres objets ne peuvent pas interférer avec l'ordinateur qui surveille et guide les avions en continu dans leurs séquences respectives de trajet entre un point initial et un point final, et l'on peut utiliser différents types de détecteurs, sensibles au poids, fonctionnant par transmission et réception d'ultrasons, transmission et réception de lumière, d'infrarouges, au laser, ou tout autre type à champ magnétique ou électrique, de telle sorte que seul le détecteur qui correspond à la position de l'avion renvoie un signal correspondant à l'ordinateur, et cela de telle façon que, lorsque l'avion se déplace sur la voie de circulation, le détecteur activé désactive le détecteur qui le précède et active celui qui le suit, ce dernier étant prêt à détecter l'avion lorsqu'il passera en face de lui, amenant les signaux de détecteurs qui arrivent à l'ordinateur à déclencher celui-ci pour éclairer et éteindre les balises de guidage.

11. Dispositif suivant la revendication 10, dans lequel lesdits détecteurs des voies de circulation et des aires de stationnement ne constituent pas un obstacle pour un avion ni pour les véhicules de service, mais servent seulement à suivre l'avion, et l'ordinateur, alimenté par les signaux émis par ces détecteurs, garde en compte chaque détecteur qui envoie un signal, mémorise la route de chaque avion entre son point de départ et son point d'arrivée, ce qui l'amène à allumer les balises de guidage en face de chaque avion suivant un nombre fixe de balises, de telle sorte que chaque avion a en face de lui un nombre fixe de balises allumées, qu'il fasse jour ou nuit, balises qui vont changer au fur et à mesure de la progression de l'avion, le pilote étant guidé sur tout le chemin de la voie de circulation, et de telle sorte que soit maintenue une distance minimale entre avions, si bien que si deux avions arrivent à une intersection, l'ordinateur fait clignoter de façon intermittente les balises de guidage de l'un des avions alors qu'en même temps le feu au niveau du croisement reste au rouge ce qui oblige cet avion à s'arrêter, et

après que l'autre avion a traversé l'intersection l'ordinateur annule le clignotement intermittent précité, annule le feu rouge au niveau de l'intersection, pour autoriser l'avion à poursuivre sa route.

12. Dispositif suivant l'une quelconque des revendications 5 à 11, dans lequel la disposition des capteurs télémétriques de la bande aménagée et des détecteurs de la voie de circulation est telle qu'après que l'avion a cessé d'être surveillé par les premiers, il va être surveillé par les seconds et vice versa.

13. Dispositif suivant l'une quelconque des revendications 6 à 12, dans lequel les feux de circulation sont situés uniquement aux intersections des voies de circulation, dans une position reliée à celle des détecteurs et sont reliés auxdits détecteurs, aux balises de guidage et à la console de commande, les feux de circulation étant actionnés dans le cas où il y a des routes opposées pour la circulation de l'avion, et de telle sorte que, si un avion dans les voies de circulation doit retourner sur l'aire de stationnement, par exemple pour reporter une quelconque défaillance, un contrôleur peut annuler la route qui avait été allouée audit avion et entrer dans un clavier de nouveaux points initial et final pour ledit avion qui sera guidé sur son trajet de retour.

14. Dispositif suivant l'une quelconque des revendications 4 à 13, dans lequel l'information émise par les anémomètres concernant la direction et la force du vent est envoyée en continu à la console de commande et à l'ordinateur des bouches d'incendie, de telle sorte que ce dernier peut effectuer les calculs pour diriger l'orientation des bouches différentes dans des situations d'urgence.

15. Dispositif suivant l'une quelconque des précédentes revendications, dans lequel les bouches d'incendie sont disposées en deux rangées parallèles aux pistes, ou davantage, une ou plus de chaque côté de celles-ci, et à l'intérieur des bandes aménagées, de telle sorte que chaque bouche soit indépendante des autres, uniquement commandée par l'ordinateur des bouches et envoie ses jets de liquide extincteur avec un mouvement horizontal de va-et-vient dont l'amplitude dépend de la source de chaleur à éteindre, et ce, avec une hauteur différente pour chaque émission, les bouches étant désactivées, bien qu'automatiques dans leur fonctionnement, à moins que le bouton de commande d'intervention contre le

feu ne soit pressé par la tour de contrôle de l'aéroport, étant capable d'agir pour préparer la piste à l'annonce de l'arrivée d'un avion en état de détresse ou entrant en fonctionnement une fois que l'avion en détresse est immobile, le dispositif étant verrouillé tant que l'avion se déplace.

16. Dispositif suivant la revendication 15, dans lequel les bouches d'incendie sont fixées au sol et enterrées, recouvertes d'un couvercle en métal tel que de l'acier, se fondent avec le terrain environnant sans constituer quelque obstacle que ce soit dans le cas où un avion passe sur le sommet dudit couvercle au moment de quitter la piste, et dans le cas où les bouches sont activées à cause d'un avion en détresse, le canon de la bouche est soulevé en soulevant le couvercle en acier ; les bouches ont trois degrés de liberté et peuvent tourner horizontalement suivant 360° pour parer à toute situation d'urgence. 10 15
17. Dispositif suivant l'une quelconque des précédentes revendications, dans lequel les bouches d'incendie sont mobiles, du type précédent, ainsi que du type fixe avec tuyaux multiples, suivant les exigences de l'aéroport, en certains points de la bande aménagée et en ses extrémités. 25 30
18. Dispositif suivant la revendication 15, dans lequel les bouches d'incendie sont situées en des endroits appropriés à la forme des inter-sections des différentes bandes aménagées. 35
19. Dispositif suivant l'une quelconque des revendications 4 à 18, dans lequel l'ordinateur des bouches intervient uniquement dans le cas où se déclare une situation d'urgence, étant inactif en conditions normales, et effectue des calculs en continu des paramètres de déclenchement des bouches, en prenant en compte l'information continue émise par les détecteurs des bandes aménagées et les anémomètres en prévision d'une urgence et d'une activation du dispositif par la tour de contrôle. 40 45
20. Dispositif suivant la revendication 19, dans lequel au moins un ordinateur de bouche est prévu pour chaque bande aménagée, et lesdits ordinateurs sont interconnectés. 50
21. Dispositif suivant les revendications 19 ou 20, dans lequel les bouches d'incendie peuvent arroser l'intégralité de la piste à l'annonce d'un avion en situation de détresse, ou opérer de façon précise sur l'avion arrêté ou sur des

parties de celui-ci.

22. Dispositif suivant l'une quelconque des revendications 4 à 21, dans lequel l'ordinateur de bandes aménagées reçoit des données de tous les détecteurs et anémomètres, en les utilisant pour mener à bien les calculs des positions d'avion, et la position et la taille des zones différentes de feu qui existent déjà ou qui peuvent se développer ensuite, transmettant ces dernières données aux ordinateurs de bouches, et mémorise une information se rapportant aux incidents jour après jour ainsi qu'aux mouvements normaux.
23. Dispositif suivant l'une quelconque des revendications 5 à 22, dans lequel la tour de contrôle dispose d'un panneau principal avec la représentation et l'identification des avions dans les bandes aménagées et dans les voies de circulation, ladite représentation prenant une forme spéciale pour un avion en situation d'infraction, les sources de chaleur apparaissant aussi dans une situation d'urgence, l'ordinateur produisant une alarme correspondante que ce soit pour les infractions ou pour les urgences.
24. Dispositif suivant la revendication 23, dans lequel la console de contrôle est munie de signaux d'alarme pour infraction et pour urgence, d'une visualisation constante des données en provenance des anémomètres, de commandes de sélection pour les voies de circulation au moyen d'un clavier d'entrées de données, de commandes pour le choix des pistes d'envol et de la direction de décollage sur celles-ci, et des commandes d'activation de la lutte contre l'incendie, en prévision d'une urgence dans toutes les bandes aménagées ; de même, elle a des commandes pour conduire des essais avec les bouches, utilisant seulement de l'eau pour vérifier la réponse du dispositif à tout moment, comportant aussi les instruments nécessaires aux mesures, des interrupteurs et des dispositifs de protection.
25. Dispositif suivant l'une quelconque des précédentes revendications, **caractérisé** par le fait qu'il fonctionne à tout moment, jour et nuit, en faible visibilité, qu'il est adaptable, dû à ses caractéristiques, à n'importe quelle configuration d'avion, et aussi à quelque extension qui puisse se produire à n'importe quel moment, le dispositif précédemment installé étant capable d'être agrandi en fonction de toute extension des pistes et des voies de circulation qui puisse être réalisées.



26. Dispositif suivant l'une quelconque des revendications 5 à 25, dans lequel chaque balise est munie d'une sortie d'air comprimé pour retirer la poussière, la neige ou toute autre salissure qui a été déposée, dont l'émission est activée lorsque la balise est allumée. 5
27. Dispositif suivant l'une quelconque des revendications 5 à 26, **caractérisé** par le fait que :
- j) dans le cas d'aéroports qui fonctionnent avec une visibilité très faible, certains détecteurs de la bande aménagée, outre la détection par infrarouge, comportent un émetteur-détecteur d'impulsions électromagnétiques, ou bien un élément sensible aux ultrasons, capable de détecter des objets placés sur la bande aménagée se rapportant à un avion ou à des véhicules, 10
  - k) pour des aéroports avec une visibilité moyenne ou normale, les détecteurs normaux repèrent non seulement l'avion situé dans la bande aménagée mais aussi les véhicules qui y pénètrent, 15
  - l) il y a la possibilité d'installer une interface capable de traiter les signaux en provenance du radar de surface que l'aéroport peut avoir installé, et d'introduire de tels signaux dans l'ordinateur qui commande la surveillance, et d'ajouter, avec ces données, aux fonctions du dispositif, 20
  - m) en option, il est possible que les détecteurs des voies de circulation du dispositif soient tous actionnés en même temps et que l'on effectue en même temps la détection d'un avion et d'autres objets, avec dans ce cas des moyens pour faire la distinction entre un avion et les autres objets, tout en maintenant la séquence logique dans le guidage de chaque avion dans sa zone de déplacement et de stationnement, 25
  - (n) en option, les tuyaux d'agent d'extinction et d'eau et les réservoirs de stockage pressurisés peuvent être séparés en modules indépendants, et on peut obtenir leur émission au moyen de la pression d'un gaz comprimé relié par des valves de régulation aux réservoirs de stockage d'eau et de liquide extincteur. 30

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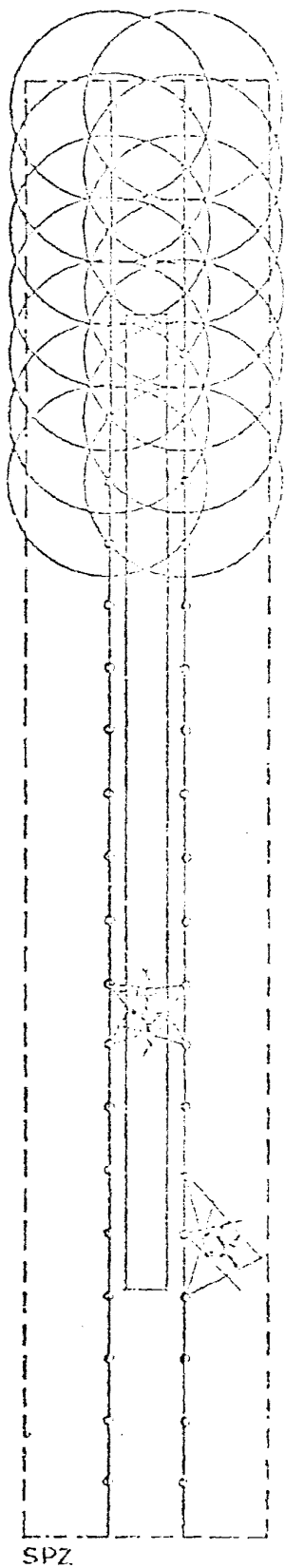
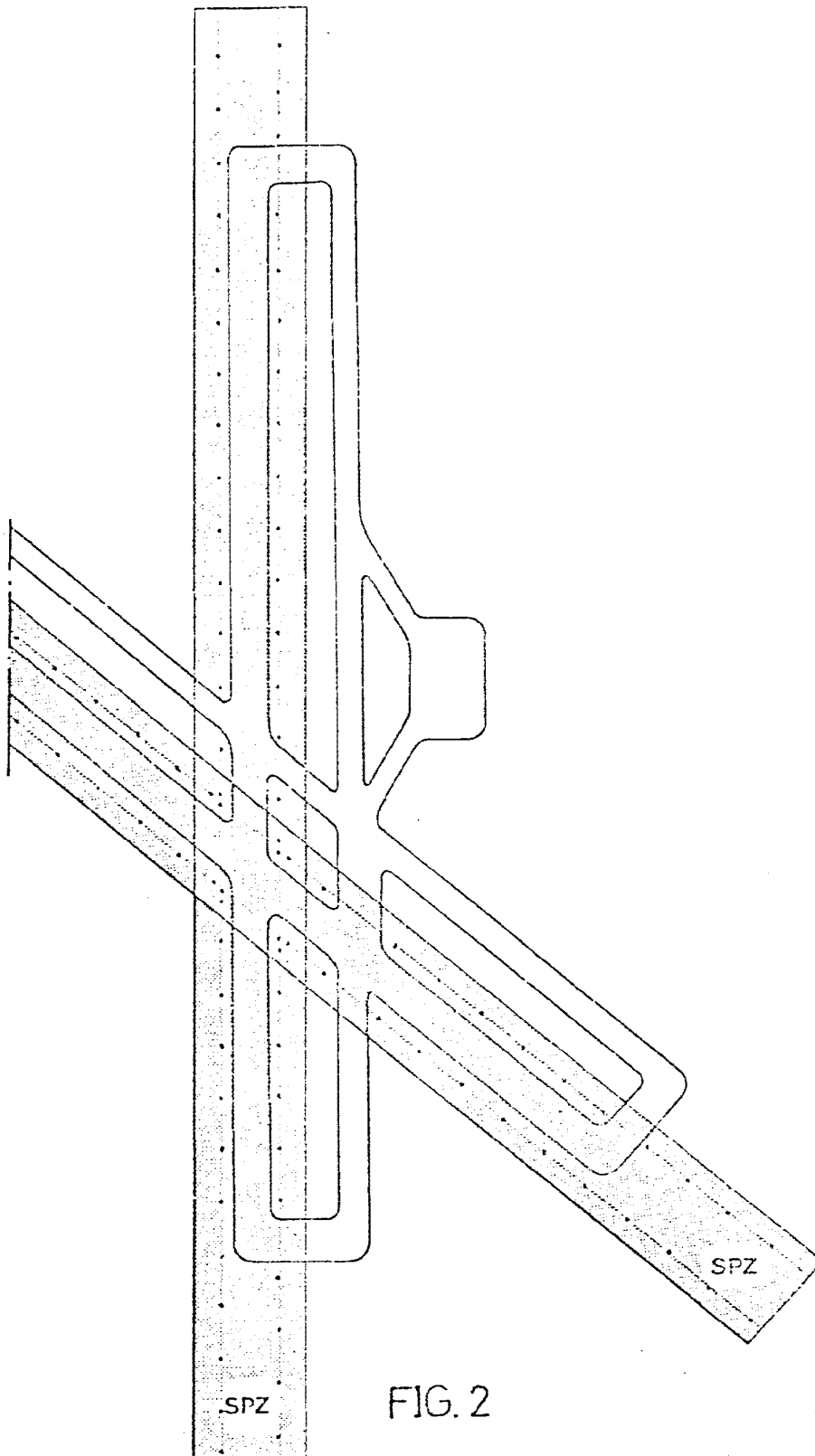


FIG. 1



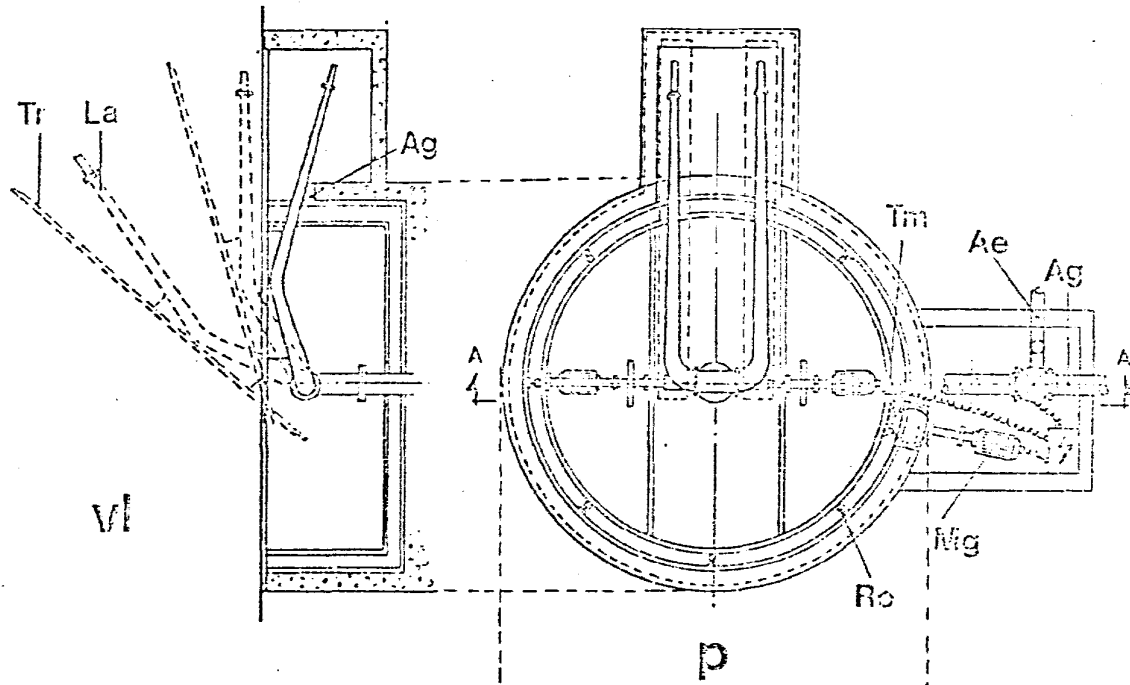
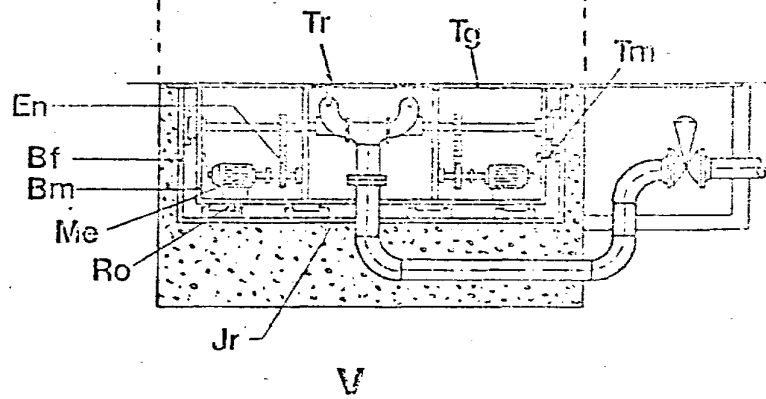


FIG.3



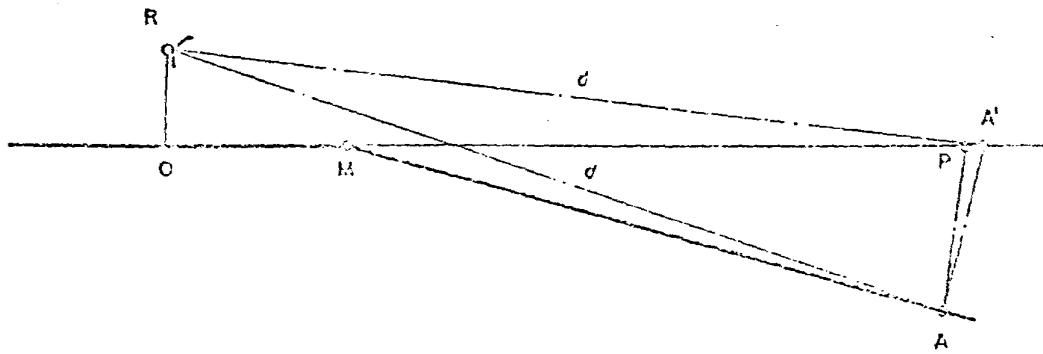


FIG.4

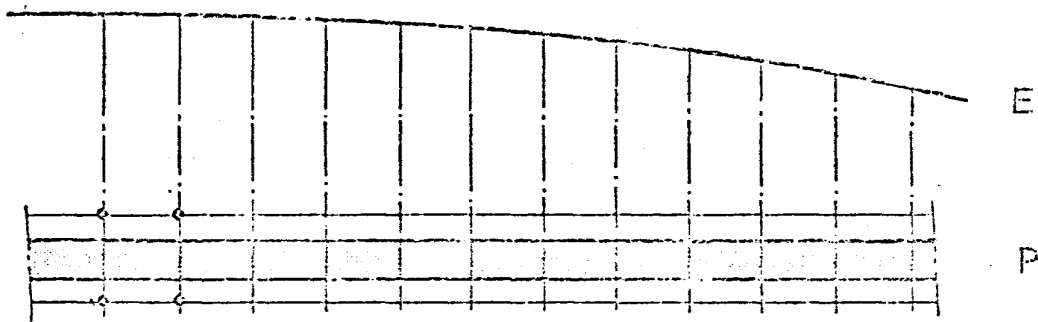


FIG.5

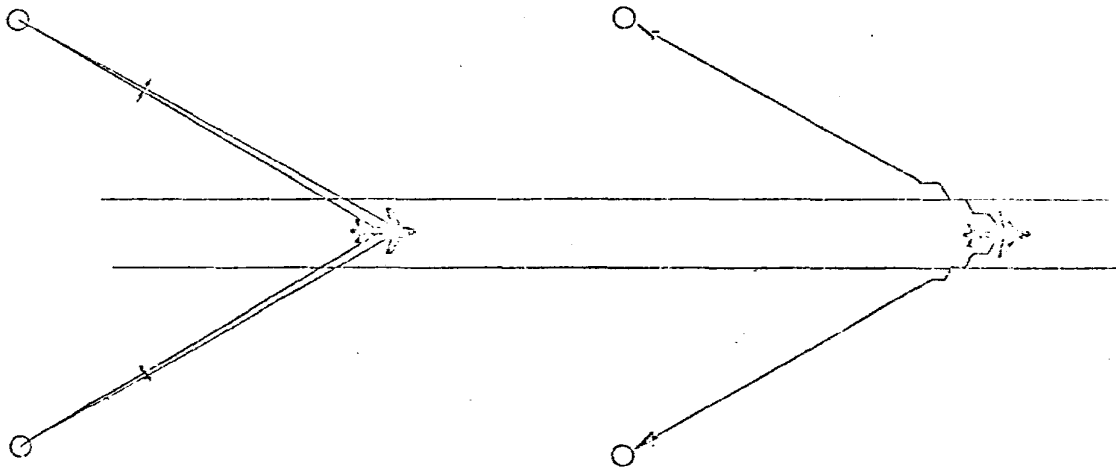


FIG. 6

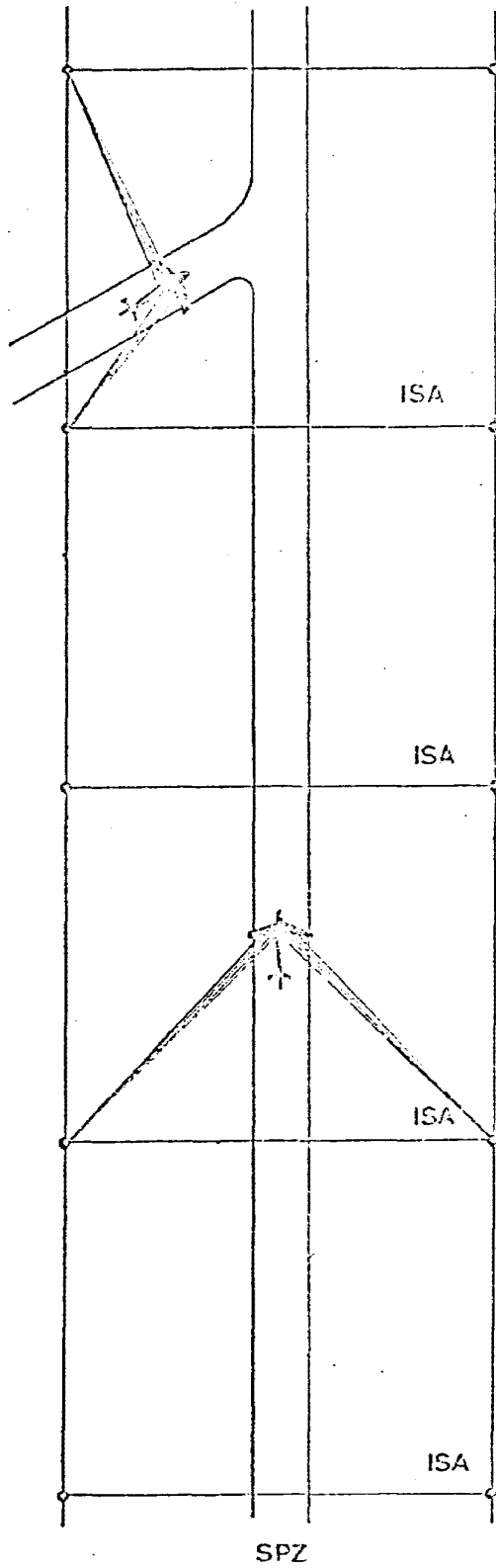


FIG.7



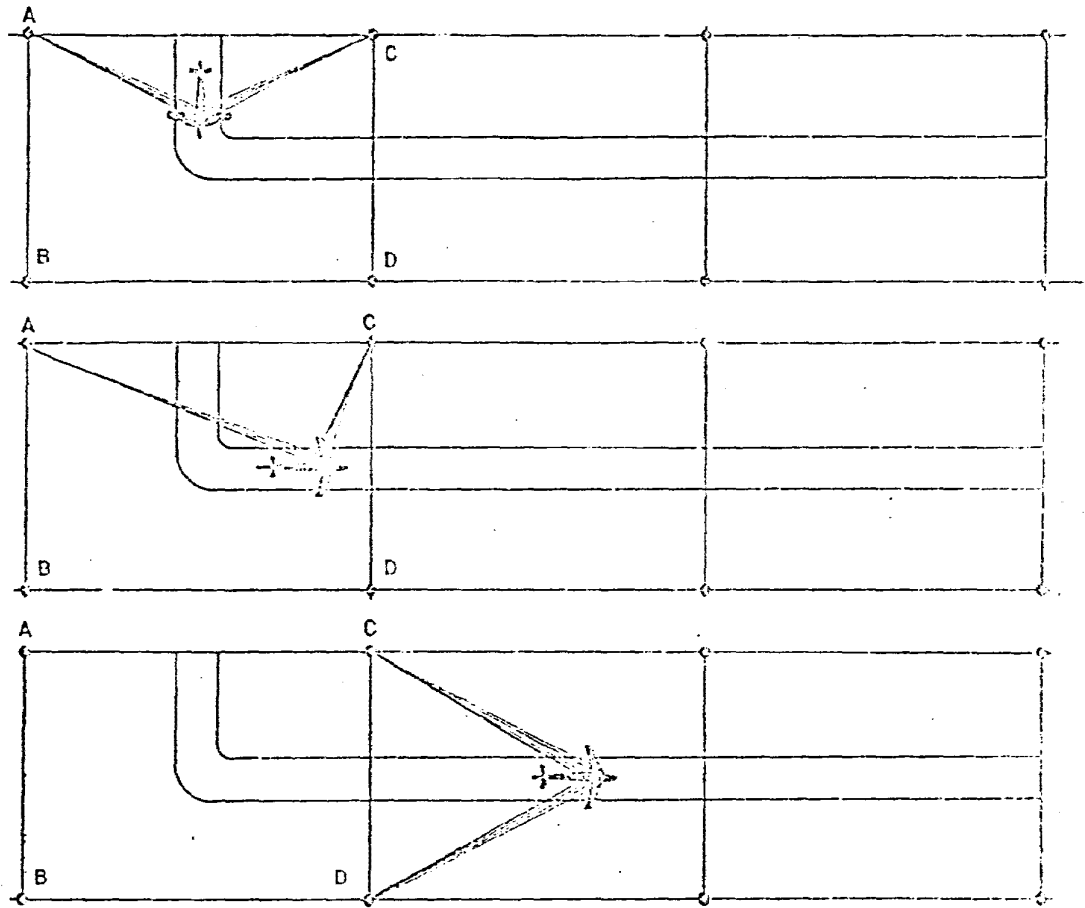
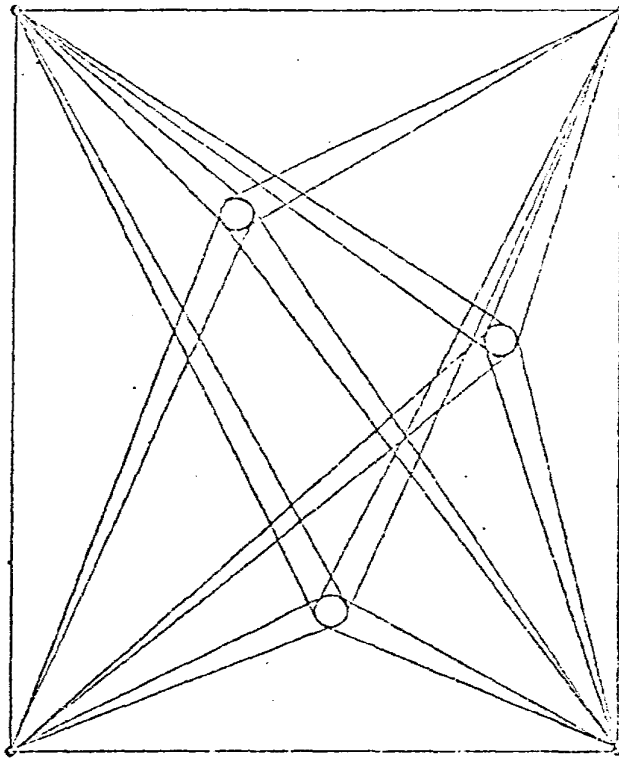


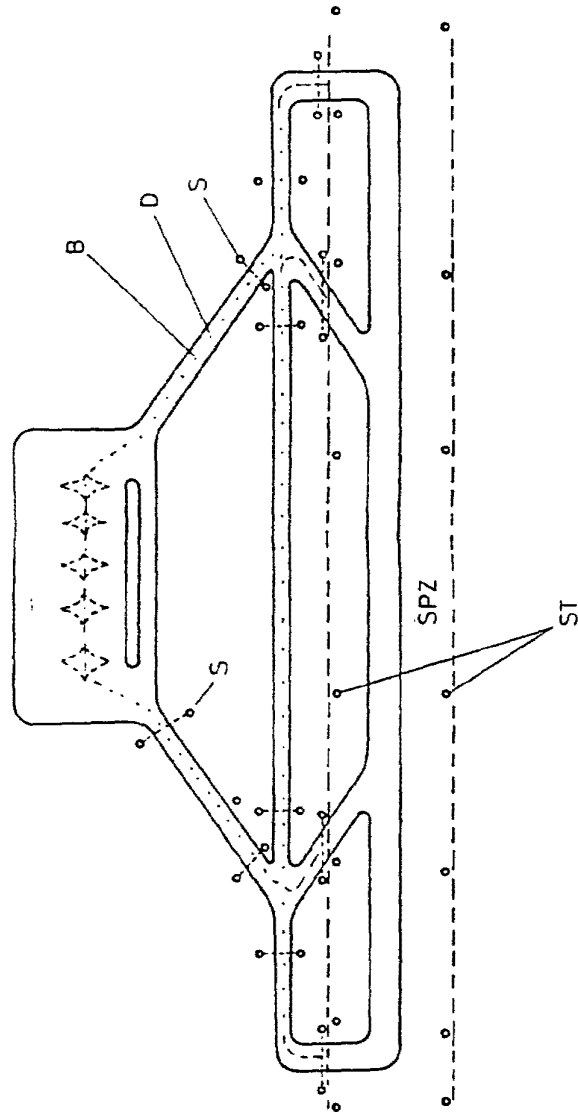
FIG.8



ISA

FIG.9

FIG. 10



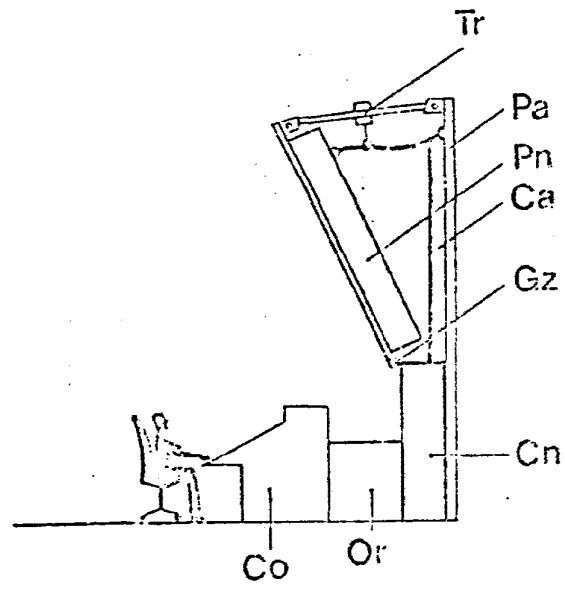


FIG.11

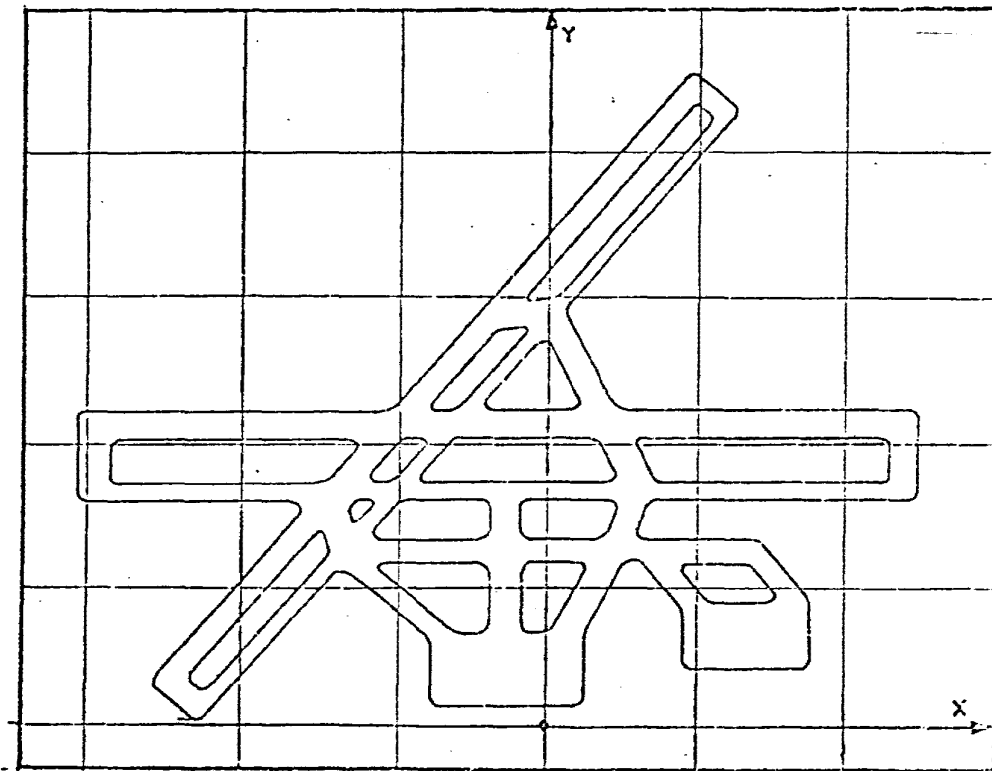


FIG.12

FIG. 13

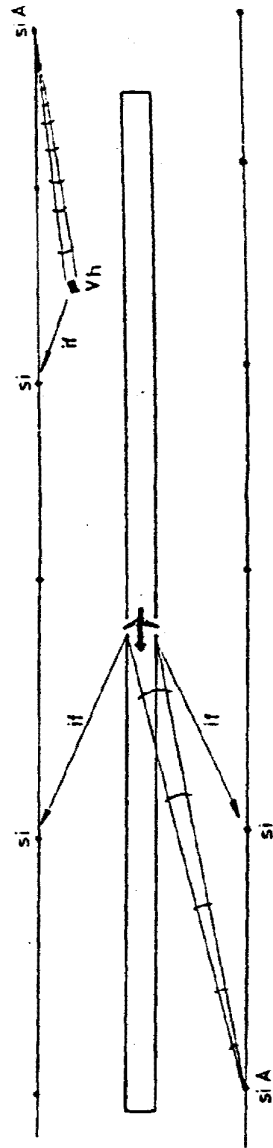
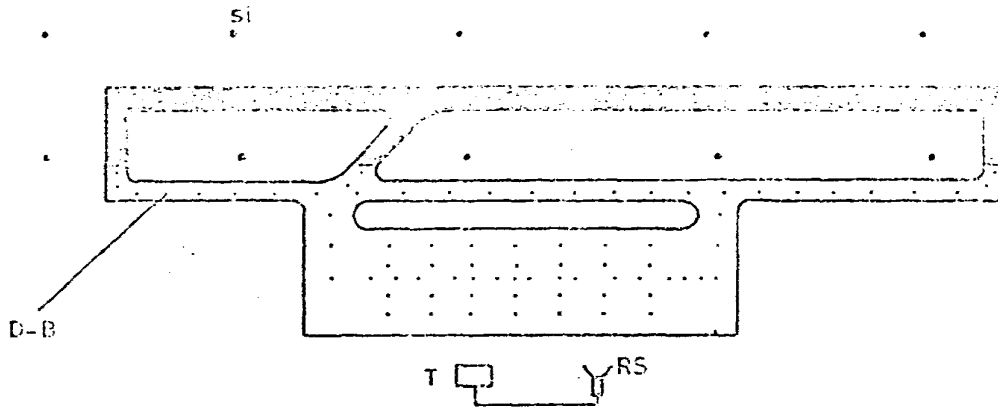


FIG. 14





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**Reference:** 683553.0038  
**Search scope:** EP-A EP-B  
**Years:** 1981-2006  
**Inventor(s):** Julin\_Michel

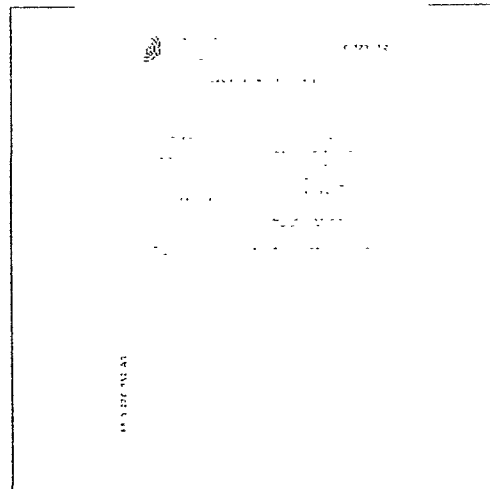
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**EP220752 A3**  
 D.R.I.M. LIMITED

### Abstract:

Ground control method, either at night or in poor visibility, or in good visibility when it is not possible to have a good view from the control tower of the whole of the aerodrome, of all the machines, aeroplanes and vehicles, such as service and security vehicles, parked or moving on the site of the aerodrome, in particular the take-off or landing runways as well as all the access routes to these runways, and arrangement for carrying out this method.



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**Inventor(s):**  
 Julin, Michel  
 Henderyckx, Hubert

**Application No.** EP1986201204A **Filed** 19860709 **Published** 19881102

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	<b>invention</b>	<b>additional</b>
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<b>Advanced</b>	G01S001391 20051008	G01S000700 20051008
	G08G000506 20051008	G01S000704 20051008
		G01S001386 20051008
		G01S001393 20051008
<b>Core</b>	<b>invention</b>	<b>additional</b>
	G01S001300 20051008	G01S000700 20051008
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**Priority:**

EP1986201204A 19860709  
BE215616A 19850920

**Designated States:**

AT CH DE FR GB IT LI LU NL SE

**Patents Citing This One** No US, EP, or WO patent/search reports have cited this patent.

**Agent(s):**

Thirion, Robert

**French Title:** Procédé pour le contrôle au sol des mobiles sur un aéroport et installation pour la mise en oeuvre de ce procédé

**French Abstract:**

Procédé pour le contrôle au sol, soit de nuit ou par mauvaise visibilité, soit par bonne visibilité lorsqu'il n'est pas possible d'avoir de la tour de contrôle une bonne vue d'ensemble de l'aéroport, de tous les engins, avions et véhicules, tels que véhicules de service et de sécurité, stationnant ou circulant sur le site de l'aéroport, en particulier les pistes d'envol ou d'atterrissage ainsi que toutes les voies d'accès à ces pistes, ledit procédé consistant à disposer, au moins le long des pistes et à leurs extrémités ainsi qu'aux intersections éventuelles de toutes les voies d'accès aux pistes, des systèmes de contrôle différents fournissant chacun des informations distinctes relatives au moins aux mobiles, à l'arrêt ou en mouvement, se trouvant sur le site, à analyser toutes les informations susdites par ordinateur dont les mémoires contiennent les caractéristiques des mobiles circulant sur le site, à activer, à partir de l'ordinateur, d'une part, des écrans cathodiques et/ou synoptiques permettant aux contrôleurs de visualiser les pistes et accès ainsi que tous les éléments, en particulier les mobiles, à l'arrêt ou en mouvement, présents sur ces pistes et accès avec des caractéristiques d'identification, et, d'autre part, des moyens de signalisation prévus sur le site et destinés à donner des indications quant aux libertés et interdictions de circuler et des moyens d'alarme associés aux écrans activés quand une interdiction n'est pas respectée.

**German Title:** Verfahren zur Steuerung beweglicher Koerper am Boden auf einem

Flughafen und Einrichtung zur Durchfuehrung dieses Verfahrens

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**DEMANDE DE BREVET EUROPEEN**

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54 **Procédé pour le contrôle au sol des mobiles sur un aéroport et installation pour la mise en oeuvre de ce procédé.**

57 Procédé pour le contrôle au sol, soit de nuit ou par mauvaise visibilité, soit par bonne visibilité lorsqu'il n'est pas possible d'avoir de la tour de contrôle une bonne vue d'ensemble de l'aéroport, de tous les engins, avions et véhicules, tels que véhicules de service et de sécurité, stationnant ou circulant sur le site de l'aéroport, en particulier les pistes d'envol ou d'atterrissage ainsi que toutes les voies d'accès à ces pistes, et installation pour la mise en oeuvre de ce procédé.

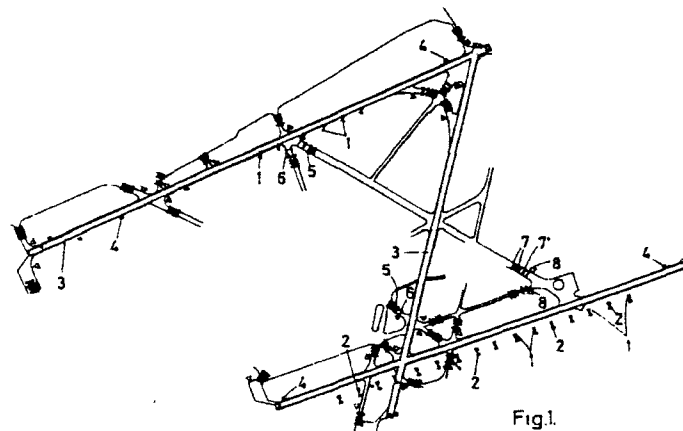


Fig.1.

Xerox Copy Centre

**EP 0 220 752 A2**

**"Procédé pour le contrôle au sol des mobiles sur un aéroport et installation pour la mise en oeuvre de ce procédé".**

La présente invention a pour objet un procédé pour le contrôle au sol, soit de nuit ou par mauvaise visibilité, soit par bonne visibilité lorsqu'il n'est pas possible d'avoir de la tour de contrôle une bonne vue d'ensemble de l'aéroport, de tous les engins, avions et véhicules, tels que véhicules de service et de sécurité, stationnant ou circulant sur le site de l'aéroport, en particulier les pistes d'envol ou d'atterrissage ainsi que toutes les voies d'accès à ces pistes. En général, lorsque la visibilité est bonne, le personnel de la tour de contrôle assure, à vue, le guidage au sol des avions et véhicules divers se déplaçant sur l'ensemble des pistes et voies d'accès de l'aérodrome, car il peut suivre et contrôler la circulation globale et donner, par liaison radio, les indications aux opérateurs des avions et véhicules pour le bon déroulement des opérations.

Il n'en est plus de même lorsque la visibilité à partir de la tour de contrôle est réduite et que le personnel de la tour n'a plus à sa disposition que les liaisons radio avec les avions et véhicules au sol alors que les informations fournies quant à la localisation précise de chacun des mobiles au sol peuvent être sujettes à caution. En effet, en ce qui concerne la position au sol des avions, qui est donnée par les pilotes, celle-ci ne peut être contrôlée de manière absolue par le personnel de la tour et un doute peut subsister quant à la position réelle des avions surtout lorsque les informations sont fournies par des pilotes peu familiarisés avec l'aéroport où ils font escale. Cette situation s'est encore aggravée depuis que les avions commerciaux décollent et atterrissent avec une visibilité de 100 à 150 mètres.

Par mauvaise visibilité, on dispose, sur un nombre réduit d'aéroports pour lesquels l'investissement très important a pu être consenti, de radars de sol et radars de veille qui, s'ils permettent d'améliorer la situation, présentent encore des inconvénients sérieux. En effet, les informations fournies par ces radars ne sont pas parfaitement fiables. Par exemple, lorsque le personnel de la tour autorise un avion à décoller et qu'il est dans l'impossibilité de suivre à vue cet avion, il ne pourra suivre sur les radars les diverses phases du décollage. Si l'avion autorisé à décoller ne prend pas son envol, le personnel de la tour restera dans l'incertitude tant qu'une liaison radio n'aura pas été établie avec le pilote de l'avion. Ces radars restent donc dans certains cas tributaires des liaisons radio, avec tous les aléas précités attachés à ces dernières. De plus, ces radars ne permettent pas d'identifier les mobiles en mouvement ou à l'arrêt

sur l'aéroport, ils ne peuvent que constater leur présence. En outre, ces radars font essentiellement appel à l'appréciation des informations fournies par le personnel de la tour, d'où possibilité de défaillance humaine et ce, d'autant plus qu'un individu ne peut contrôler qu'environ 50 points lumineux différents et que la permanence rétinienne peut encore entrer en jeu lors du passage d'un écran à un autre.

L'invention a pour but de remédier à ces inconvénients et de procurer un procédé et une installation pouvant renseigner le personnel de la tour de contrôle sur la situation des mobiles au sol, de manière fiable et précise, avec identification desdits mobiles, et ce, sans avoir recours aux liaisons radios.

A cet effet, suivant l'invention, le procédé consiste à disposer, au moins le long des pistes et à leurs extrémités ainsi qu'aux intersections éventuelles de toutes les voies d'accès aux pistes, des systèmes de contrôle différents fournissant chacun des informations distinctes relatives au moins aux mobiles, à l'arrêt ou en mouvement, se trouvant sur le site, à analyser toutes les informations susdites par ordinateur dont les mémoires contiennent les caractéristiques des mobiles circulant sur le site, à activer, à partir de l'ordinateur, d'une part, des écrans cathodiques et/ou synoptiques permettant aux contrôleurs de visualiser les pistes et accès ainsi que tous les éléments, en particulier les mobiles, à l'arrêt ou en mouvement, présents sur ces pistes et accès avec des caractéristiques d'identification, et, d'autre part, des moyens de signalisation prévus sur le site et destinés à donner des indications quant aux libertés et interdictions de circuler et des moyens d'alarme associés aux écrans activés quand une interdiction n'est pas respectée.

Suivant une forme avantageuse de l'invention, sur base des informations traitées par l'ordinateur et dès que le contrôleur autorise la circulation d'un avion sur une voie ou piste donnée, l'ordinateur crée le long de celle-ci une zone de protection.

L'installation suivant l'invention comprend au moins des moyens de contrôle associés aux pistes d'envol et d'atterrissage et agencés pour détecter tout élément situé sur ces pistes, en particulier les mobiles à l'arrêt ou en mouvement, des moyens de contrôle associés aux voies d'accès éventuelles et à toutes les intersections de ces dernières avec les pistes et agencés pour détecter tout mobile à l'arrêt ou en mouvement sur lesdites voies d'accès à proximité de ces intersections, des moyens pour transmettre les informations en provenance des

moyens de contrôle à un ordinateur agencé pour comparer les informations reçues des moyens de contrôle précités à des informations mises en mémoire et concernant les divers mobiles autorisés à se déplacer sur les pistes et voies d'accès, des écrans cathodiques et/ou synoptiques disposés au moins dans la tour de contrôle et activés par l'ordinateur pour visualiser, d'une part, les pistes et voies d'accès à celles-ci et, d'autre part, les éléments et en particulier les mobiles, à l'arrêt ou en mouvement sur ces voies et pistes munies de moyens de contrôle, avec leurs caractéristiques d'identification, des moyens de signalisation optiques et/ou sonores associés aux pistes et voies d'accès pour renseigner les opérateurs des mobiles au sujet des libertés et interdictions de circuler dans les zones protégées par les moyens de contrôle et des moyens d'alarme associés aux écrans précités et agencés pour être activés par l'ordinateur quand une interdiction de circuler n'est pas respectée.

D'autres détails et particularités de l'invention ressortiront de la description des dessins annexés au présent mémoire et qui représentent, à titre d'exemple non limitatif, une forme de réalisation particulière de l'installation et illustrent le procédé suivant l'invention.

La figure 1 est une vue schématique, en plan, d'un aéroport équipé de l'installation précitée.

La figure 2 est une vue analogue à la figure 1 montrant un détail de ladite installation.

Dans les différentes figures, les mêmes signes de référence désignent des éléments identiques.

Il est évident que le procédé et l'installation suivant l'invention devront être adoptés en fonction des caractéristiques propres de chacun des aéroports concernés et que la multiplicité des moyens de contrôle nécessaires pour assurer une sécurité automatique maximum, au sol, de la circulation des mobiles dépendra essentiellement du nombre de pistes à protéger et de l'interpénétration de ces pistes entre elles et avec un nombre plus ou moins élevé de voies d'accès aux pistes. Pour des aéroports qui ne posséderaient qu'une ou plusieurs pistes ne se croisant pas et n'étant pas recoupées par des voies d'accès, il suffirait, pour obtenir une excellente sécurité, de munir la ou chacune des pistes de moyens de contrôle constatant la présence ou l'absence d'éléments, en particulier mobiles, sur les pistes. Dans ce cas, la sécurité pourrait être accrue en contrôlant également l'accès en bout de chacune des pistes.

Pour les aéroports dont les pistes et les voies d'accès se croisent, il conviendra, pour atteindre le niveau de sécurité équivalent à celui obtenu ci-dessus, de créer à chaque point d'intersection, en plus des moyens de contrôle des pistes, une zone

protégée surveillée par un ou plusieurs moyens de contrôle propres à ces intersections.

Dans l'un et l'autre cas, la sécurité pourra être encore accrue en munissant au moins les véhicules de service de moyens optiques ou sonores renseignant automatiquement les opérateurs des dangers que peut présenter l'endroit où lesdits véhicules se trouvent ou vont aborder.

Il est également intéressant de pouvoir vérifier si les véhicules d'intervention, pompiers et ambulances, occupent leurs emplacements, qui sont bien déterminés sur l'aéroport. Dans ce but, des moyens sont prévus auxdits emplacements et dans les véhicules pour fournir les informations requises.

Dans tous les cas, les informations recueillies sont transmises à un ordinateur qui active des moyens audio-visuels situés au moins dans la tour de contrôle. De tels moyens peuvent en effet également être prévus à l'emplacement réservé aux véhicules d'intervention.

Dans tous les cas, l'ordinateur est agencé pour traiter les informations reçues des divers moyens et déclencher automatiquement tous les signaux optiques ou sonores assurant la sécurité de circulation. L'ordinateur est également agencé pour refuser une commande en conflit avec les informations provenant des différents moyens de contrôle.

Dans le cas où on ne surveille que la ou les pistes de l'aéroport, le scénario général consiste à acquérir des informations fournies par les moyens de contrôle, à traiter ces informations par ordinateur, à visualiser ces informations, à suivre l'atterrissage ou le décollage, à ramener en position d'attente après décollage ou atterrissage.

Pour obtenir un résultat valable, il est impératif d'incorporer dans le système, des moyens de contrôle alimentés par des réseaux indépendants pour des raisons tant électriques que techniques - (parasites, effets de réverbérations, radars).

Deux moyens de contrôle différents minimum sont nécessaires pour obtenir une sécurité totale.

Ces moyens de contrôle seront constitués par deux types de radars 1 et 2, des radars 1 à faisceau étroit le long des pistes 3 et des radars 2 à faisceau large répartis également à des distances variables le long desdites pistes 3. Les radars 1 seront installés tous les 150 m sur le bord de la piste à la hauteur prescrite et ce en un alignement parallèle aux lampes de balisage des pistes et à  $\pm 1$  m de celles-ci. Chacun des radars à faisceau étroit 1 fonction ne sur une fréquence de 9,9 GHz et est utilisé pour analyser le déplacement des avions sur la piste. L'effet doppler permet ce contrôle quel que soit le sens de déplacement de l'avion. Placés transversalement et de préférence perpendiculairement à l'axe de la piste 3 de façon à bénéficier au maximum de

l'effet doppler, le champ de vision avoisine les 9 degrés.

Les radars 2 à faisceau large seront répartis le long de la piste 3, un radar sera installé en début de piste afin de couvrir un large espace comprenant entre autres la zone d'attente des avions avant le décollage. Aux endroits de décollage ou d'atterrissage possibles et en fin de piste, les radars 2 seront dotés d'une inclinaison adéquate permettant de suivre l'avion en vol. Des caméras de télévision 4 seront également prévues pour compléter les informations fournies par les radars 1 et 2, elles fonctionneront avec des luminosités excessivement faibles (tubes infrarouges) et seront placées aux endroits stratégiques de façon que le contrôleur puisse visualiser différents paramètres (type d'avion ou d'autre mobile, arrêt ou mouvement de celui-ci). Les différents radars 1, à faisceau étroit, échelonnés à 150 le long de la piste 3, détectent le passage de l'avion et mesurent le temps que mettra celui-ci pour sortir du faisceau. Le radar 2, à faisceau large, en début de piste, vu la conception de sa cavité et de ses circuits, déterminera le début du processus de traitement. Au fur et à mesure de sa progression, l'avion coupera le faisceau des différents radars 1 et ce de plus en plus vite vu qu'il sera en accélération constante. Le radar 2 de fin de piste ou situé à l'endroit de décollage le détectera en altitude et ce pendant un laps de temps plus important. La non détection par les radars 2 permettra d'être certain que l'avion a bien décollé. L'ordinateur recevant les données ou informations des radars permettra par comparaison de suivre l'accélération, mais, comme les angles des faisceaux ne sont jamais rigoureusement identiques, il calculera la vitesse instantanée pour le passage à chaque radar et vérifiera ainsi les données de comparaison. Le programme est également prévu pour éliminer les détections parasites dues aux oiseaux et aux lièvres se déplaçant sur le site. Ce qui est énoncé pour le décollage est vrai pour l'atterrissage. Les caméras 4 permettront de visualiser l'avion en attente de décollage ainsi que lors de son trajet sur la piste 3. L'ordinateur numérise et mémorise les images reçues; il les compare aux modules de sa bibliothèque et identifie donc le mobile. Le module objet est intégré et positionné sur un écran cathodique et/ou synoptique pour que son déplacement soit pour le contrôleur une visualisation réelle de ce qui se passe sur la piste 3. Lorsque le contrôleur a autorisé le pilote à se mettre en bout de piste 3, il met en fonction par un commutateur le programme de gestion de la piste, ce qui active les caméras 4 et les systèmes radars 1 et 2. Sur les écrans grand format, le contrôleur voit apparaître la piste et le module objet de l'avion. Une fenêtre clignotante lui signale que le radar 2 en début de piste a

également pris en charge l'appareil. Le contrôleur peut ainsi donner l'ordre de décollage qui sera suivi par les caméras 4 jusqu'à la limite de leur champ d'action. Lors du passage de l'avion dans le champ d'un radar 1, la fenêtre correspondant à celui-ci s'illumine et la représentation de l'avion se déplace sur l'écran synoptique permettant de suivre sa progression sur la piste. La caméra de bout de piste ou d'endroit de décollage transmet les données à l'ordinateur qui analyse les images reçues et qui active l'affichage sur l'écran du module objet de l'avion décollé. Le radar 2 le plus proche de l'endroit de décollage détecte l'avion en vol et permet à l'ordinateur d'analyser l'état des radars 1 qui sont inactifs vu que l'avion est en vol. Soit après un temps préprogrammé, soit par une action du contrôleur, la mise au repos du système permet à l'ordinateur de passer en phase statistique, ce qui engendrera éventuellement une impulsion des informations compilées du décollage.

Lorsque les pistes sont recoupées par d'autres pistes ou par des voies d'accès, le contrôle des intersections se décompose en deux fonctions bien distinctes, à savoir :

-la signalisation donnée au pilote d'avion ou au conducteur d'un véhicule arrivant à une intersection,

-l'acquisition de la donnée, son traitement et le transfert vers le contrôleur des résultantes données par l'ordinateur.

La signalisation sera réalisée au moyen de deux bandeaux 5 à base de fibres optiques (figure 2) figurant le "STOP". Ces bandeaux forment une signalisation vraiment efficace vu la disposition particulière des fibres optiques et la puissance lumineuse rayonnée par celles-ci. Lorsque le système est en position d'attente, le contrôleur peut remplacer l'émission de lumière rouge correspondant toujours à cette position d'attente par un rayonnement vert lorsqu'il décide d'autoriser l'accès de la piste. Un troisième bandeau optique 6 situé environ à 5 m en aval de la zone de contrôle, constituée notamment par les bandeaux 5, se mettra à clignoter au rouge si un mobile franchit intempestivement lesdits bandeaux de sécurité 5.

L'acquisition des données se fera de deux façons:

-par boucles magnétiques 7 et

- par radar 8.

Deux boucles magnétiques 7 seront installées dans le sol et permettront de détecter le passage de tous les mobiles qui les franchissent ainsi que leur sens de circulation. Au-delà des bandeaux 5, une troisième boucle magnétique 7' permettra de

contrôler le respect des consignes fournies par ces bandeaux 5 et de donner une alerte à la tour de contrôle. Ces données seront affichées sur un synoptique par l'ordinateur qui tiendra compte des différents mouvements à l'approche des zones dangereuses.

Le radar 8 a pour but de contrôler par un autre canal les mesures effectuées par les boucles 7 et 7'. Il donnera les informations d'arrêt et de démarrage des mobiles. Ce radar 8 peut également être un élément générateur d'hyperfréquence qui influencerait des détecteurs prévus sur les mobiles et provoquerait l'émission de signaux optiques et/ou sonores pour avertir leur opérateur du danger.

Lorsqu'un avion a été autorisé à quitter son aire d'attente pour prendre place en bout de piste 3 en vue du décollage, le contrôleur fait passer la zone correspondant à cette piste au rouge ce qui a pour conséquence d'activer automatiquement tous les moyens de contrôle et de prévention. Il est évident que les actions prévues en cas de décollage s'appliquent également pour les atterrissages qui sont parfois imbriqués sur la même piste. Il est alors intéressant de créer une zone de sécurité automatique autour des points de conflit que sont les intersections de pistes avec les voies d'accès et les chemins utilisés par le personnel chargé d'éloigner les oiseaux des aires de décollage, etc.

Pour ce faire, on équipe d'un récepteur hyperfréquence un maximum de mobiles. Ce récepteur reçoit les informations émises par le dispositif zone rouge et donne une information auditive et visuelle à l'opérateur lorsqu'il pénètre dans la zone dangereuse.

Il faut considérer que les avions sur un aéroport sont prioritaires et que tout doit être fait pour ne pas déranger leurs évolutions.

Le but du système suivant l'invention est donc de prévenir toute circulation intempestive qui mettrait en danger les mobiles en présence.

Tous les véhicules de service sont équipés d'un récepteur hyperfréquence qui signalera immédiatement au conducteur qu'il s'engage dans une zone en activité ou qu'il va franchir une limite où

-une attention soutenue est de rigueur

-une autorisation de la tour est nécessaire.

Les véhicules étrangers à l'aéroport qui, pour des prestations, doivent circuler sur le site, recevront avantageusement un module portatif leur permettant ainsi d'avoir leur attention attirée à l'approche des zones dangereuses.

Sur les aéroports, les véhicules d'interventions occupent généralement un emplacement fixe et

dédiacé. Un émetteur miniature hyperfréquence monté sur les véhicules permet de contrôler instantanément la présence desdits véhicules sur leur aire de stationnement vu qu'un récepteur y est incorporé.

Dans la tour de contrôle et éventuellement à l'emplacement des véhicules d'intervention, le personnel aura à sa disposition une unité du type audiovisuel. Elle sera composée d'un pupitre de commande, d'un écran synoptique et de deux ou trois écrans cathodiques. Pour que la visualisation soit efficace et puisse se percevoir sans réflexion, les états représentés aux écrans apparaîtront comme une rupture dans l'affichage général.

La représentation réelle des pistes et de leurs accès sera donc visualisée sur l'écran synoptique suivant le système de pavé, système similaire à celui utilisé à la SNCV dans les gares de triage, et ce à une échelle efficace.

Les données acquises par les différents moyens de contrôle et les résultats de leur traitement par l'ordinateur seront visualisées sur les écrans synoptique et cathodique. L'écran synoptique permettra de positionner et de suivre avec grande précision le déplacement des mobiles, l'écran cathodique, de préférence couleur, reprendra chacune des pistes et informera le contrôleur des opérations en cours.

Afin de bien préciser l'ensemble des opérations, les différentes phases d'un décollage, la piste étant au repos, vont être décrites:

L'ensemble des signalisations est au rouge - (état de repos normal). Des véhicules circulent sur le site. Les véhicules de service sont sur leur aire de stationnement. L'écran synoptique est actif, car l'ordinateur tient en permanence compte des mobiles entrant et sortant des pistes, les écrans cathodiques passant automatiquement en position repos sont inactifs.

Lors d'une demande d'accès à la piste, un avion ayant quitté son terminal se dirige vers l'aire d'attente de la piste 3. Le contrôleur enclenche le processus de gestion du site. A ce moment, l'écran synoptique répercutera en clignotant la présence éventuelle d'un véhicule et émettra une signalisation optique et/ou sonore. La piste 3 passera en zone rouge et tous les véhicules se trouvant dans cette zone recevront sur leur récepteur hyperfréquence le signal optique et/ou sonore de zone dangereuse.

Lorsque le contrôleur le jugera utile, il donnera l'autorisation d'accès à la piste. Il sera informé à chaque instant de la situation vu que les données sont transmises en temps réel. De plus, afin de parer à une défaillance humaine et de manière à lui permettre de superviser le reste de l'aéroport, l'ordinateur l'avertira, en activant une alarme, si un conflit se présentait.

Le contrôleur, au moyen du module objet défini par la caméra, s'assure du type d'appareil qui est en instance de décollage et donne le feu vert. Au cas où il donne l'autorisation de décollage en présence d'un conflit, le système émet un signal d'avertissement et bloque les signalisations au rouge. Une commande de sécurité permet, après un laps de temps déterminé, de demander au système un nouvel essai.

L'avion se mettant en branle sur la piste 3 sera accompagné par une des caméras 4 et les radars de piste 1 et 2 qui permettront à l'ordinateur de suivre le décollage et de renseigner de façon continue le contrôleur sur l'accélération continue du mobile, grâce à l'écran synoptique. L'avion ayant décollé sera pris par le radar à large faisceau 2 susdit et l'ordinateur ne recevant aucune information des radars 1 affichera sur l'écran synoptique l'état décollé. La caméra de bout de piste confirmera la disparition de l'avion.

Le contrôleur au moyen de cette caméra pourra en cas de non décollage de l'avion suivre les évolutions de l'appareil en difficulté et déterminer de visu les interventions que la situation requiert car il sera averti par l'ordinateur dès que l'avion subira une décélération significative.

Le contrôleur, ayant constaté la bonne exécution de la manoeuvre, mettra le système en veilleuse ce qui déterminera pour le calculateur l'action statistique et l'impression des paramètres du décollage.

Il doit être entendu que l'invention n'est nullement limitée à la forme de réalisation décrite et que bien des modifications peuvent être apportées à cette dernière sans sortir du cadre du présent brevet.

C'est ainsi que l'on pourrait prévoir un rayon laser émis d'une extrémité de chaque piste 3 suivant l'axe de celle-ci et capté à l'autre extrémité pour que ce faisceau soit interrompu par un avion situé sur la piste. Ce dispositif pourrait compléter les radars 2 ou se substituer à ces derniers.

Pour parfaire l'identification d'un véhicule avec certitude, le véhicule qui se présente à une barrière de sécurité, on prévoit sur lui un émetteur, statique ou non, générateur d'une hyperfréquence codée qui permettra une identification infaillible pour le système du véhicule considéré. Une plaque magnétique codée propre à chaque véhicule remplacera, dans certains cas, le générateur avec un même résultat.

On pourrait encore prévoir, le long des pistes 3 et soit en combinaison avec les radars 1 à faisceau étroit, soit en remplacement de ces radars 1, une rangée d'émetteurs de rayon laser équidistants disposée, le long d'un des bords longitudinaux de la piste 3 et parallèlement à cette dernière, pour que les rayons soient sensiblement parallèles entre

eux, parallèles au sol et transversaux à l'axe de la piste et à une hauteur telle qu'ils soient interceptés par un véhicule ou avion à l'arrêt ou en mouvement sur la piste. Le long de l'autre bord longitudinal de la piste, on prévoit une rangée de récepteurs de rayon équidistants disposée parallèlement à la piste. Les récepteurs, dont le nombre est égal à celui des émetteurs et qui sont destinés chacun à recevoir le rayon émis par l'émetteur correspondant, sont alors connectés chacun à l'ordinateur pour fournir à celui-ci une information lorsqu'il n'est plus activé par le rayon laser. Les rayons laser émis par les émetteurs susdits sont avantageusement perpendiculaires à l'axe de la piste, la distance qui sépare deux de ces rayons voisins étant comprise entre 50 et 150 m, la distance des rayons du sol étant comprise entre 0,25 et 1 m et les rangées d'émetteurs et de récepteurs étant disposées à au moins 1 m en retrait des lampes de balisage de la piste.

## Revendications

1. Procédé pour le contrôle au sol, soit de nuit ou par mauvaise visibilité, soit par bonne visibilité lorsqu'il n'est pas possible d'avoir de la tour de contrôle une bonne vue d'ensemble de l'aéroport, de tous les engins, avions et véhicules, tels que véhicules de service et de sécurité, stationnant ou circulant sur le site de l'aéroport, en particulier les pistes d'envol ou d'atterrissage ainsi que toutes les voies d'accès à ces pistes, ledit procédé étant caractérisé en ce qu'il consiste à disposer, au moins le long des pistes et à leurs extrémités ainsi qu'aux intersections éventuelles de toutes les voies d'accès aux pistes, des systèmes de contrôle différents fournissant chacun des informations distinctes relatives au moins aux mobiles, à l'arrêt ou en mouvement, se trouvant sur le site, à analyser toutes les informations susdites par ordinateur dont les mémoires contiennent les caractéristiques des mobiles circulant sur le site, à activer, à partir de l'ordinateur, d'une part, des écrans cathodiques et/ou synoptiques permettant aux contrôleurs de visualiser les pistes et accès ainsi que tous les éléments, en particulier les mobiles, à l'arrêt ou en mouvement, présents sur ces pistes et accès avec des caractéristiques d'identification, et, d'autre part, des moyens de signalisation prévus sur le site et destinés à donner des indications quant aux libertés et interdictions de circuler et des moyens d'alarme associés aux écrans activés quand une interdiction n'est pas respectée.

2. Procédé suivant la revendication 1, caractérisé en ce qu'on équipe au moins une partie des mobiles, appelés à circuler sur le site de l'aéroport, de moyens d'avertissement pour les



opérateurs desdits mobiles les informant d'une interdiction ou d'un danger associé à la zone qu'ils occupent.

3. Procédé suivant l'une ou l'autre des revendications 1 et 2, caractérisé en ce que, sur base des informations traitées par l'ordinateur et dès que le contrôleur autorise la circulation d'un avion sur une voie ou piste donnée, l'ordinateur crée le long de celle-ci une zone de protection.

4. Procédé suivant la revendication 3, caractérisé en ce que l'ordinateur détermine toutes les intersections de la voie ou piste empruntée par l'avion avec les autres voies ou pistes de l'aéroport et crée à chacune de ces intersections une zone de protection.

5. Procédé suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que l'ordinateur analyse les informations provenant de moyens de contrôle disposés à intervalles réguliers le long des pistes d'envol ou d'atterrissage pour indiquer sur les écrans susdits la progression et la vitesse de circulation d'un avion se déplaçant sur ces pistes.

6. Procédé suivant l'une quelconque des revendications 1 à 5, caractérisé en ce que l'ordinateur analyse les informations provenant de moyens de contrôle associés aux pistes pour indiquer sur les écrans précités le moment où un avion circulant sur ces pistes quitte le sol.

7. Procédé suivant l'une quelconque des revendications 1 à 6, caractérisé en ce que l'ordinateur analyse conjointement les informations provenant des moyens de contrôle au sol et celles provenant du contrôle du trafic aérien pour indiquer toute éventuelle situation de conflit.

8. Installation pour la mise en oeuvre du procédé suivant l'une quelconque des revendications 1 à 7, caractérisée en ce qu'elle comprend au moins des moyens de contrôle associés aux pistes d'envol et d'atterrissage et agencés pour détecter tout élément situé sur ces pistes, en particulier les mobiles à l'arrêt ou en mouvement, des moyens de contrôle associés aux voies d'accès éventuelles et à toutes les intersections de ces dernières avec les pistes agencés pour détecter tout mobile à l'arrêt ou en mouvement sur lesdites voies d'accès à proximité de ces intersections, des moyens pour transmettre les informations en provenance des moyens de contrôle à un ordinateur agencé pour comparer les informations reçues des moyens de contrôle précités à des informations mises en mémoire et concernant les divers mobiles autorisés à se déplacer sur les pistes et voies d'accès, des écrans cathodiques et/ou synoptiques disposés au moins dans la tour de contrôle et activés par l'ordinateur pour visualiser, d'une part, les pistes et voies d'accès à celles-ci et, d'autre part, les éléments et en particulier les mobiles, à l'arrêt ou

en mouvement sur ces voies et pistes munies de moyens de contrôle, avec leurs caractéristiques d'identification, des moyens de signalisation optiques et/ou sonores associés aux pistes et voies d'accès pour renseigner les opérateurs des mobiles au sujet des libertés et interdictions de circuler dans les zones protégées par les moyens de contrôle et des moyens d'alarme associés aux écrans précités et agencés pour être activés par l'ordinateur quand une interdiction de circuler n'est pas respectée.

9. Installation suivant la revendication 8, caractérisée en ce que les moyens de contrôle associés à chacune des pistes surveillées sont constitués par une rangée de radars (1) équidistants à faisceau étroit disposée parallèlement à la piste - (3) pour que les faisceaux soient sensiblement parallèles et transversaux à l'axe de la piste, par un radar (2) à faisceau large installé en début de piste et couvrant la zone de stationnement des avions en instance de décollage, et par des radars à faisceau large échelonnés le long de la piste aux endroits de décollage ou d'atterrissage des différents types d'avions et dont les faisceaux sont orientés pour suivre un avion en mouvement.

10. Installation suivant la revendication 9, caractérisée en ce que les faisceaux de radars (1) à faisceau étroit sont perpendiculaires à l'axe de la piste (3), la distance qui sépare deux de ces radars (1) voisins est de l'ordre de 150 m, le champ de vision desdits radars, qui fonctionnent sur une fréquence de 9,9 gigaHz, est de l'ordre de 9°, la distance des radars du sol est fonction de leurs caractéristiques et la rangée desdits radars est disposée à environ 1 m en retrait des lampes de balisage de la piste.

11. Installation suivant l'une quelconque des revendications 8 à 10, caractérisée en ce que les moyens de contrôle associés à chacune des pistes surveillées comprennent, le long d'un des bords longitudinaux de la piste, une rangée d'émetteurs de rayon laser équidistants disposées parallèlement à la piste pour que les rayons soient sensiblement parallèles entre eux, parallèles au sol et transversaux à l'axe de la piste et à une hauteur qu'ils soient interceptés par un véhicule ou avion à l'arrêt ou en mouvement sur la piste et, le long de l'autre bord longitudinal de la piste, une rangée de récepteurs de rayon équidistants disposée parallèlement à la piste, les récepteurs, dont le nombre est égal à celui des émetteurs et qui sont destinés chacun à recevoir le rayon émis par l'émetteur correspondant, étant connectés chacun à l'ordinateur pour fournir à celui-ci une information lorsqu'il n'est plus activé par le rayon laser.

12. Installation suivant la revendication 11, caractérisée en ce que les rayons laser émis par les émetteurs susdits sont perpendiculaires à l'axe de

la piste, la distance qui sépare deux de ces rayons voisins étant comprise entre 50 et 150 m, la distance des rayons du sol étant comprise entre 0,25 et 1 m et les rangées d'émetteurs et de récepteurs étant disposées à au moins 1 m en retrait des lampes de balisage de la piste.

13. Installation suivant l'une quelconque des revendications 8 à 12, caractérisée en ce qu'elle comprend au moins deux caméras de télévision - (4) orientables, prévues pour fonctionner avec des luminosités extrêmement faibles, disposées en début et en fin de chacune des pistes (3), ces caméras (4) étant reliées à l'ordinateur qui numérise et mémorise les images reçues pour les comparer ensuite aux modules mis en mémoire et identifier le mobile filmé par les caméras, le module objet étant intégré et positionné sur les écrans cathodiques et/ou synoptiques précités.

14. Installation suivant l'une quelconque des revendications 8 à 13, caractérisée en ce qu'elle comprend, à une des extrémités de la piste (3), un émetteur de rayon laser agencé pour que ce rayon soit dans l'axe de la piste et à une hauteur telle qu'il soit intercepté par un avion à l'arrêt ou en mouvement sur la piste, un récepteur de ce rayon étant disposé à l'autre extrémité de la piste et connecté à l'ordinateur pour fournir à celui-ci une information lorsqu'il n'est plus activé par le rayon laser.

15. Installation suivant l'une quelconque des revendications 8 à 14, caractérisée en ce que les moyens de contrôle associés à chaque voie d'accès et à chacune des intersections de ces dernières avec les pistes (3) comprennent au moins deux boucles magnétiques (7) installées dans le revêtement des voies d'accès, en amont des pistes (3), et agencées pour détecter le passage d'un mobile et définir son sens de circulation, ces boucles magnétiques (7) étant associées à l'ordinateur pour que, suite aux informations fournies par ces boucles et par les moyens de contrôle de piste, ledit ordinateur active au moins un signal (5, 6) optique et/ou sonore autorisant ou interdisant l'accès à la piste.

16. Installation suivant la revendication 15, caractérisée en ce que les moyens de contrôle susdits associés à chaque voie d'accès aux pistes (3)

comprend, en aval du signal (5) optique et/ou sonore précité, une troisième boucle magnétique (7') noyée dans le revêtement, les informations transmises à l'ordinateur par cette troisième boucle (7') étant analysées conjointement avec l'état du signal (5) optique et/ou sonore, l'ordinateur étant agencé pour activer une alarme, au moins dans la tour de contrôle, si cette troisième boucle (7') est franchie alors que le signal (5) indique une interdiction de passage.

17. Installation suivant l'une ou l'autre des revendications 15 et 16, caractérisée en ce que les moyens de contrôle, associés à chacune des voies d'accès aux pistes, comprend un radar (8) dont le faisceau est orienté vers les boucles magnétiques - (7) et qui est connecté à l'ordinateur pour fournir à ce dernier des informations qu'il analyse conjointement aux informations fournies par les boucles magnétiques (7), ledit ordinateur activant, en cas de conflit, les moyens d'alarme précités.

18. Installation suivant l'une quelconque des revendications 8 à 17, caractérisée en ce qu'elle comprend, aux abords des intersections de pistes et de voies d'accès, des générateurs hyperfréquence, les mobiles circulant sur ces pistes et voies étant équipés de récepteurs hyperfréquence agencés pour activer un signal auditif et/ou lumineux renseignant l'opérateur à l'approche de la zone dans laquelle émettent ces générateurs.

19. Installation suivant l'une quelconque des revendications 8 à 18, caractérisée en ce que, à chacun des emplacements déterminés occupés par les véhicules d'intervention, tels que pompes et ambulances, elle comprend un récepteur hyperfréquence, chacun des véhicules d'intervention étant pourvu d'un émetteur hyperfréquence, les récepteurs susdits étant connectés à l'ordinateur qui, après analyse des informations, active les écrans cathodiques et/ou synoptiques pour que les véhicules d'intervention puissent être visualisés lorsqu'ils occupent leurs emplacements déterminés.

20. Installation suivant l'une quelconque des revendications 8 à 19, caractérisée en ce que la signalisation optique met en oeuvre des fibres optiques.

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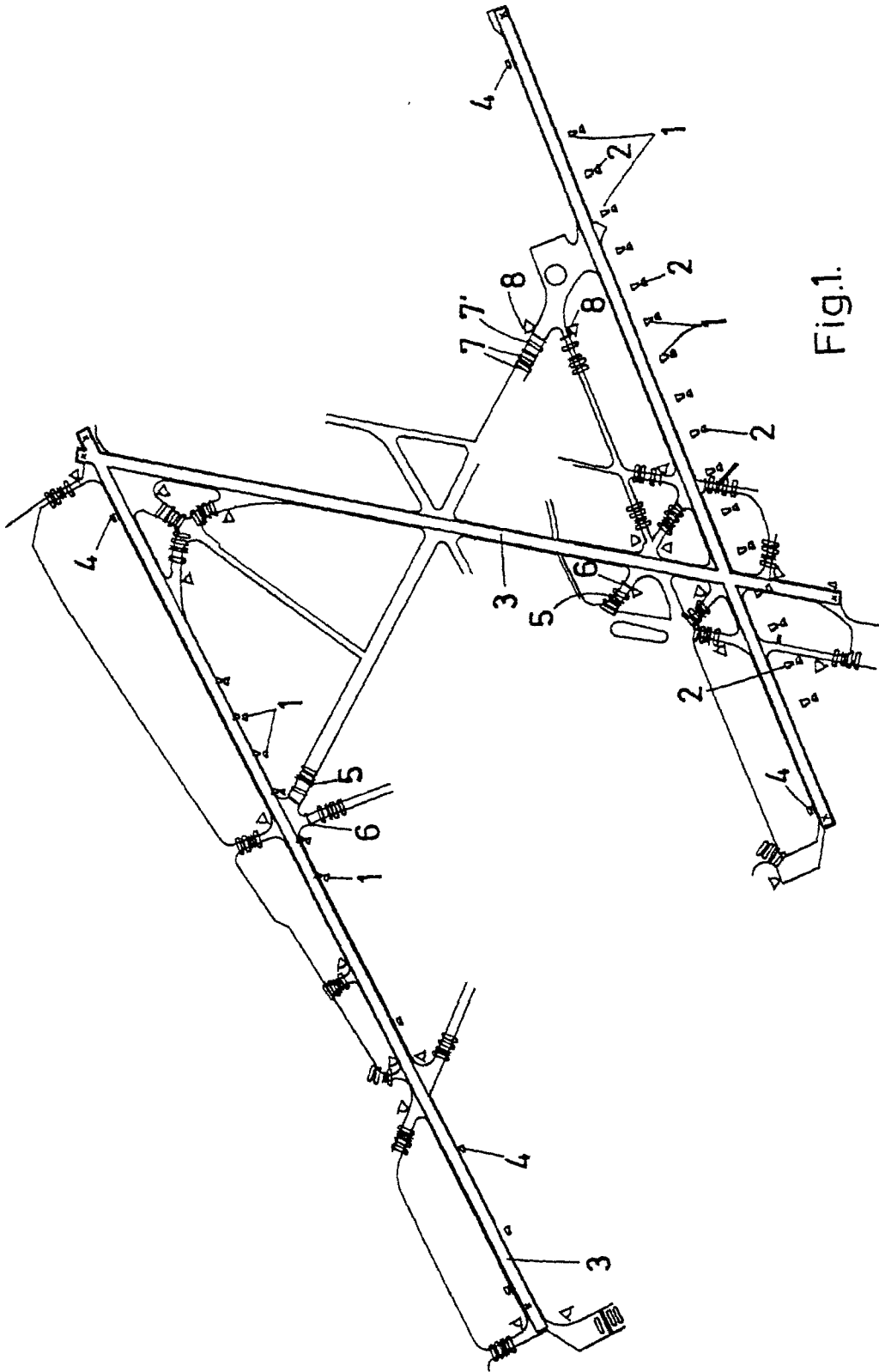
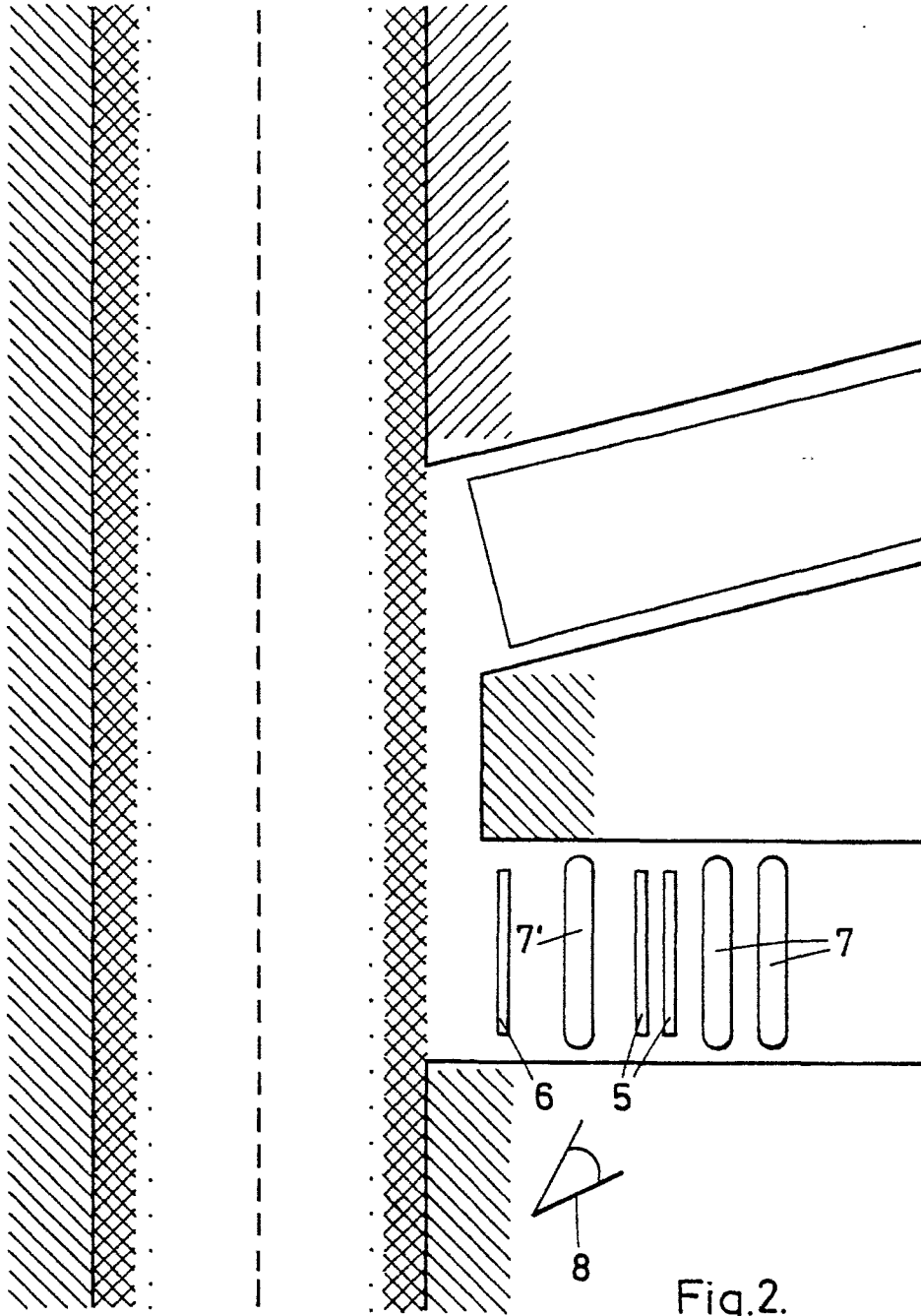


Fig.1.





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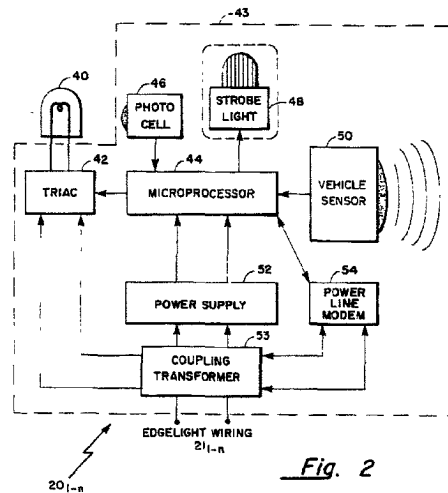
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**Airport incursion avoidance system.**

An airport incursion avoidance system for detection of aircraft and other vehicles utilizes edge lights [20] along taxiways and runways by having a sensor [50] co-located with each edge light, the sensor output being coupled to a central computer system [12] via the airport's edge light power lines [21]. The detection system comprises infrared sensors. The output of each sensor [50] is fed into a microprocessor [44] within an edge light assembly [20] and then to a power line modem [54] for transmission to the central computer system [12] which includes a display [30] at the airport tower for showing the airport and all traffic thereon. Data from each sensor [50] along taxiways and runways is received at the central computer system [12] and processed to provide vehicle tracking and control of all ground traffic on the airport taxiways and runways to avoid an airport incursion.



EP 0 613 110 A1

**Background of the Invention**

This invention relates to an airport ground collision avoidance system and in particular to an apparatus and method for monitoring, controlling and predicting aircraft or other vehicle movement primarily on airport taxiways and runways to avoid runway incursions.

Currently, ground control of aircraft at an airport is done visually by the air traffic controller in the tower. Low visibility conditions sometimes make it impossible for the controller to see all parts of the field. Ground surface radar can help in providing coverage during low visibility conditions; it plays an important part in the solution of the runway incursion problem but cannot solve the entire problem. A runway incursion is defined as "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing, or intending to land." The U.S. Federal Administration Agency (FAA) has estimated that it can only justify the cost of ground surface radar at 29 of the top 100 airports in the United States. However, such radar only provides location information; it cannot alert the controller to possible conflicts between aircraft.

In the prior art, an airport control and monitoring system has been used to sense when an airplane reaches a certain point on a taxiway and controls switching lights on and off to indicate to the pilot when he may proceed on to a runway. Such a system sends microwave sensor information to a computer in the control tower. The computer comprises software for controlling the airport lighting and for providing fault information on the airport lighting via displays or a control panel to an operator. Such a system is described in sales information provided on a Bidirectional Series 7 Transceiver (BRITEE) produced by ADB-ALNACO, Inc., A Siemens Company, of Columbus, Ohio. However, such a system does not show the location of all vehicles on an airfield and is not able to detect and avoid a possible vehicle incursion.

A well known approach to airport surface traffic control has been the use of scanning radars operating at high frequencies such as K-band in order to obtain adequate definition and resolution. An existing airport ground traffic control equipment of that type is known in the art as Airport Surface Detection Equipment (ASDE). However, such equipment provides surveillance only, no discrete identification of aircraft on the surface being available. Also there is a need for a relatively high antenna tower and a relatively large rotation antenna system thereon.

Another approach to airport ground surveillance is a system described in U. S. Patent No. 3,872,474, issued March 18, 1974, to Arnold M. Levine and assigned to International Telephone and Telegraph Corporation, New York, NY, referred to as LOCAR (Localized Cable Radar) which comprises a series of small, lower powered, narrow pulses, transmitting radars having limited range and time sequenced along opposite sides of a runway ramp or taxiway. In another U. S. Patent No. 4,197,536, issued on April 8, 1980, to Arnold M. Levine, an airport surface identification and control system is described for aircraft equipped with ATRCBS (Air Traffic Control Radio Beacon System) and ILS (Instrument Landing System). However, these approaches are expensive, require special cabling and for identification purposes require expensive equipment to be included on the aircraft and other vehicles.

Another approach to vehicle identification such as types of aircraft by identifying the unique characteristic of the "footprint" presented by the configuration of wheels unique to a particular type of vehicle is described in U.S. Patent No. 3,872,283, issued March 18, 1975, to Gerald R. Smith et al. and assigned to The Cadre Corporation of Atlanta Georgia.

An automatic system for surveillance, guidance and fire-fighting at airports using infrared sensors is described in U. S. Patent No. 4,845,629, issued July 4, 1989 to Maria V. Z. Murga. The infrared sensors are arranged along the flight lanes and their output signals are processed by a computer to provide information concerning the aircraft movements along the flight lanes. Position detectors are provided for detecting the position of aircraft in the taxiways and parking areas. However, such system does not teach the use of edge lights along the runways and taxiways along with their associated wiring and it is not able to detect and avoid a possible vehicle incursion.

The manner in which the invention deals with the disadvantages of the prior art to provide a low cost airport incursion avoidance system will be evident as the description proceeds.

**Summary of the Invention**

Accordingly, it is therefore an object of this invention to provide a system that detects a possible aircraft or vehicle incursion at an airport.

It is also an object of this invention to provide a low cost airport incursion avoidance system using edge light assemblies and associated wiring along runways and taxiways.

It is another object of this invention to provide an airport incursion avoidance system that generates a

graphic display of the airport showing the location of all ground traffic including direction and velocity data.

It is a further object of this invention to provide an airport incursion avoidance system that generates a verbal alert to an air traffic controller or an aircraft pilot.

The objects are further accomplished by providing an airport incursion avoidance system comprising a plurality of light circuits on an airport, each of the light circuits comprises a plurality of light assembly means, means for providing power to each of the plurality of light circuits and to each of the light assembly means, means in each of the light assembly means for sensing ground traffic on the airport, means for processing data received from each of the light assembly means, means for providing data communication between each of the light assembly means and the processing means, the processing means comprises means for providing a graphic display of the airport including symbols representing the ground traffic, each of the symbols having direction and velocity data displayed, the processing means further comprises means for predicting an occurrence of an airport incursion in accordance with the data received from the sensing means, and means for alerting an airport controller or aircraft pilot of the predicted airport incursion. Each of the light circuits are located along the edges of a taxiway or a runway on the airport. The sensing means comprises infrared detectors. The light assembly means comprises light means coupled to the lines of the power providing means for lighting the airport, the infrared detectors sensing means, microprocessor means coupled to the light means, the sensing means, and the data communication means for providing processing, communication and control for the light assembly means, the microprocessor controlling a plurality of lighting patterns of the light means on the airport, and the data communication means being coupled to the microprocessor means and the lines of the power providing means. The light assembly means further comprises a photocell means coupled to the microprocessor means for detecting the light intensity of the light means. The light assembly means further comprises a strobe light coupled to the microprocessor means. The processing means comprises redundant computers for fault tolerance operation. The symbols representing the ground traffic comprise icons having a shape indicating type of aircraft or vehicle. The processing means determines the locations of the symbols on the graphic display of the airport in accordance with the data receive from the light assembly means. The processing means further determines a future path of the ground traffic based on a ground clearance command, the future path being shown on the graphic display. The processing means for predicting an occurrence of an airport incursion comprises means for comparing position, direction and velocity of the ground traffic to predetermined separation minimums for the airport. The power providing means comprises constant current power means for providing a separate line to each of the plurality of light circuits, and network bridge means coupled to the constant current power means for providing a communication channel to the processing means for each line of the constant current power means. The alerting means comprises a speech synthesis unit connected to a speaker, and the alerting means also comprises a speech synthesis unit connected to a radio transmitter.

The objects are further accomplished by a method of providing an airport incursion avoidance system comprising the steps of providing a plurality of light circuits on the airport, each of the light circuits comprises a plurality of light assembly means, providing power to each of the plurality of light circuits, sensing ground traffic on the airport with means in each of the light assembly means, processing data received from each of the light assembly means in computer means, providing a graphic display of the airport comprising symbols representing the ground traffic, each of the symbols having direction and velocity data displayed, providing data communication between the computer means and each of the light assembly means, predicting an occurrence of an airport incursion in accordance with the data received from the sensing means, and alerting an airport controller or aircraft pilot of the predicted airport incursion. The step of sensing the ground traffic on the airport comprises the steps of lighting the airport with a light means coupled to the microprocessor means and the power lines, providing infrared detectors for sensing the ground traffic, performing processing, communication and control within the light assembly means with a microprocessor means coupled to the light means, the sensing means and data communication means, and coupling the data communication means between the microprocessor means and the power lines. The step of processing data comprises the step of operating redundant computers for fault tolerance. The step of providing power comprises the steps of providing a separate line to each of the plurality of light circuits with a constant current power means, and providing a communication channel to the computer means for each line of the constant current power means using a network bridge means. The step of providing a graphic display comprising symbols representing the ground traffic comprise the step of indicating a type of aircraft or vehicle with icons of various shapes. The step of processing the data from each of the light assembly means comprises the step of determining a location of the symbols on the graphic display of the airport in accordance with the data. The step of predicting an occurrence of an airport incursion comprises the step of determining a future path of the ground traffic in accordance with a ground clearance command and showing the future path on the graphic display.

**Brief Description of the Drawings**

Other and further features of the invention will become apparent in connection with the accompanying drawings wherein:

- 5 FIG. 1 is a block diagram of the invention of an airport vehicle incursion avoidance system;  
 FIG. 2 is a block diagram of an edge light assembly showing a sensor electronics unit coupled to an edge light of an airfield lighting system;  
 FIG. 3 is a pictorial diagram of the edge light assembly showing the edge light positioned above the sensor electronics unit;  
 10 FIG. 4 is a diagram of an airfield runway or taxiway having a plurality of edge light assemblies positioned along each side of the runway or taxiway for detecting various size aircraft as shown;  
 FIG. 5 is a block diagram of the central computer system shown in FIG. 1;  
 FIG. 6 shows eleven network variables used in programming the microprocessor of an edge light assembly to interface with a sensor, a light and a strobe light;  
 15 FIG. 7 is a block diagram showing an interconnection of network variables for a plurality of edge light assemblies located on both sides of a runway, each comprising a sensor electronics unit 10 positioned along a taxiway or runway;  
 FIG. 8 shows a graphic display of a typical taxiway/runway on a portion of an airport as seen by an operator in a control tower, the display showing the location of vehicles as they are detected by the sensors mounted  
 20 in the edge light assemblies located along taxiways and runways; and  
 FIG. 9 is a block diagram of the data flow within the system shown in FIG. 1 and FIG. 5.

**Description of the Preferred Embodiment**

25 Referring to FIG. 1 a block diagram of the invention of an airport vehicle incursion avoidance system 10 is shown comprising a plurality of light circuits 18<sub>1-n</sub>, each of said light circuits 18<sub>1-n</sub> comprises a plurality of edge light assemblies 20<sub>1-n</sub> connected via wiring 21<sub>1-n</sub> to a lighting vault 16 which is connected to a central computer system 12 via a wide area network 14. Each of the edge light assemblies 20<sub>1-n</sub> comprises an infrared (IR) detector vehicle sensor 50 (FIG. 2).

30 The edge light assemblies 20<sub>1-n</sub> are generally located along side the runways and taxiways of the airport with an average 100 foot spacing and are interconnected to the lighting vault 16 by single conductor series edge light wiring 21<sub>1-n</sub>. Each of the edge light circuits 18<sub>1-n</sub> is powered via the wiring 21<sub>1-n</sub> by a constant current supply 24<sub>1-n</sub> located in the lighting vault 16.

35 Referring now to FIG. 1 and FIG. 2, communication between the edge light assemblies 20<sub>1-n</sub> and the central computer system 12 is accomplished with LON Bridges 22<sub>1-n</sub> interconnecting the edge light wiring 21<sub>1-n</sub> with the Wide Area Network 14. Information from a microprocessor 44 located in edge light assembly 20<sub>1-n</sub> is coupled to the edge light wiring 21<sub>1-n</sub> via a power line modem 54. The LON bridges 22<sub>1-n</sub> transfers message information from the edge light circuits 18<sub>1-n</sub> via the wiring 21<sub>1-n</sub> to the wide area network 14. The wide area network 14 provides a transmission path to the central computer system 12. These circuit components also  
 40 provide the return path communications link from the central computer system 12 to the microprocessor 44 in each edge light assembly 20<sub>1-n</sub>. Other apparatus and methods, known to one of ordinary skill in the art, for data communication between the edge light assemblies 20<sub>1-n</sub> and the central computer system 12 may be employed, such as radio techniques, but the present embodiment of providing data communication on the edge light wiring 21<sub>1-n</sub> provides a low cost system for present airports. The LON Bridge 22 may be embodied by devices manufactured by Echelon Corporation of Palo Alto, California. The wide area network 14 may be implemented by one of ordinary skill in the art using standard Ethernet or Fiber Distributed Data Interface (FDDI)  
 45 components. The constant current supply 24 may be embodied by devices manufactured by Crouse-Hinds of Winslow, Connecticut.

50 Referring now to FIG. 2 and FIG. 3, FIG. 3 shows a pictorial diagram of the edge light assembly 20<sub>1-n</sub>. The edge light assembly 20<sub>1-n</sub> comprises a bezel including an incandescent lamp 40 and an optional strobe light assembly 48 (FIG. 2) which are mounted above an electronics enclosure 43 comprising the vehicle sensor 50. The electronics enclosure 43 sits on the top of a tubular shaft extending from a base support 56. The light assembly bezel with lamp 40 and base support 56 may be embodied by devices manufactured by Crouse-Hinds of Winslow, Connecticut.

55 A block diagram of the contents of the electronics enclosure 43 is shown in FIG. 2 which comprises a coupling transformer 53 connected to the edge light wiring 21<sub>1-n</sub>. The coupling transformer 53 provides power to both the incandescent lamp 40 via the lamp control triac 42 and the microprocessor power supply 52; in addition, the coupling transformer 53 provides a data communication path between the power line modem 54



and the LON Bridges 22<sub>1-n</sub> via the edge light wiring 21<sub>1-n</sub>. The microprocessor 44 provides the computational power to run the internal software program that controls the edge light assemblies 20<sub>1-n</sub>. The microprocessor 44 is powered by the microprocessor power supply 52. Also connected to the microprocessor 44 is the lamp control triac 42, a lamp monitoring photo cell 46, the optional strobe light assembly 48, the vehicle sensor 50, and the data communications modem 54. The microprocessor 44 is used to control the incandescent edge light 40 intensity and optional strobe light assembly 48. The use of the microprocessor 44 in each light assembly 20<sub>1-n</sub> allows complete addressable control over every light on the field. The microprocessor 44 may be embodied by a VLSI device manufactured by Echelon Corporation of Palo Alto, California 94304, called the Neuron® chip.

Still referring to FIG. 2, the sensor 50 in the present embodiment comprises an infrared (IR) detector and in other embodiments may comprise other devices such as proximity detectors, CCD cameras, microwave motion detectors, inductance loops, or laser beams. The program in the microprocessor 44 is responsible for the initial filtering of the sensor data received from the sensor 50 and responsible for the transmission of such data to the central computer system 12. The sensor 50 must perform the following functions: detect a stationary object, detect a moving object, have a range at least half the width of the runway or taxiway, be low power and be immune to false alarms. This system design does not rely on just one type of sensor. Since sensor fusion functions are performed within the central computer system 12, data inputs from all different types of sensors are acceptable. Each sensor relays a different view of what is happening on the airfield and the central computer system 12 combines them. There are a wide range of sensors that may be used in this system. As a new sensor type becomes available, it can be integrated into this system with a minimum of difficulty. The initial sensor used is an IR proximity detector based around a piezoelectric strip. These are the kind of sensors you use at home to turn on your flood lights when heat and/or movement is detected. When the sensor output provides an analog signal, an analog-to-digital converter readily known in the art may be used to interface with the microprocessor 44.

Another proximity detector that can be used is based around a microwave Gunn diode oscillator. These are currently in use in such applications as Intrusion Alarms, Door Openers, Distance Measurement, Collision Warning, Railroad Switching, etc. These types of sensors have a drawback because they are not passive devices and care needs to be taken to select frequencies that would not interfere with other airport equipment. Finally, in locations such as the hold position lines on taxiways, solid state laser and detector combinations could be used between adjacent taxiway lights. These sensor systems create a beam that when broken would identify the location of the front wheel of the airplane. This type of detector would be used in those locations where the absolute position of a vehicle was needed. The laser beam would be modulated by the microprocessor 44 to avoid the detector being fooled by any other stray radiation.

Referring to FIG. 2 and FIG. 4, a portion of an airport runway 64 or taxiway is shown having a plurality of edge light assemblies 20<sub>1-8</sub> positioned along each side of the runway or taxiway for detecting various size airplanes or vehicles 60, 62. The dashed lines represent the coverage area of the sensors 50 located in each edge light assembly 20<sub>1-8</sub> positioned along each side of the runway 64 or taxiway to insure detection of any airplane 60, 62 or other vehicles traveling on such runway 64 or taxiway. The edge light assemblies 20<sub>1-n</sub> comprising the sensor 50 are logically connected together in such a way that an entire airport is sensitized to the movement of vehicles. Node to node communication takes place to verify and identify the location of the vehicles. Once this is done a message is sent to the central computer system 12 reporting the vehicles location. Edge light assemblies (without a sensor electronics unit 43) and taxiway power wiring currently exist along taxiways, runways and open areas of airports, therefore, the sensor electronics unit 43 is readily added to existing edge lights and existing taxiway power wiring without the inconvenience and expense of closing down runways and taxiways while installing new cabling.

Referring now to FIG. 1, FIG. 5, FIG. 8 and FIG. 9, the central computer system 12 is generally located at a control tower or terminal area of an airport and is interconnected to the LON Bridges 22<sub>1-n</sub> located in the lighting vault 16 with a Wide Area Network 14. The central computer system 12 comprises two redundant computers, computer #1 26 and computer #2 28 for fault tolerance, the display 30, speech synthesis units 29 & 31, alert lights 34, keyboard 27 and a speech recognition unit 33, all of these elements being interconnected by the wide area network 14 for the transfer of information. The two computers 26 and 28 communicate with the microprocessors 44 located in the edge light assemblies 20<sub>1-n</sub>. Data received from the edge light assembly 20<sub>1-n</sub> microprocessors 44 are used as an input to a sensor fusion software module 101 (FIG. 9) run on the redundant computers 26 and 28. The output of the sensor fusion software module 101 operating in the computers 26, 28 is used to drive the CRT display 30 which displays the location of each vehicle on the airport taxiway and runways as shown in FIG. 8. The central computer system 12 may be embodied by devices manufactured by IBM Corporation of White Plains, New York. The Wide Area Network 14 may be embodied by

devices manufactured by 3Com Corporation of Santa Clara, California. The speech synthesis units 29, 31 and the speech recognition unit 33 may be embodied by devices manufactured by BBN of Cambridge, Massachusetts.

5 The speech synthesis unit 29 is coupled to a speaker 32. Limited information is sent to the speech synthesis unit 29 via the wide area network 14 to provide the capability to give an air traffic controller a verbal alert. The speech synthesis unit 31 is coupled to a radio 37 having an antenna 39 to provide the capability to give the pilots a verbal alert. The voice commands from the air traffic controller to the pilots are captured by microphone 35 and sent to the pilots via radio 36 and antenna 38. In the present embodiment a tap is made and the speech information is sent to both the radio 36 and the speech recognition unit 33 which is programmed to recognize  
10 the limited air traffic control vocabulary used by a controller. This includes airline names, aircraft type, the numbers 0-9, the name of the taxiways and runways and various short phrases such as "hold short", "expedite" and "give way to." The output of the speech recognition unit 33 is fed to the computers 26, 28.

Referring again to FIG. 2, the power line modem 54 provides a data communication path over the edge light wiring 21<sub>1-n</sub> for the microprocessor 44. This two way path is used for the passing of command and control  
15 information between the various edge light assemblies 20<sub>1-n</sub> and the central computer system 12. A power line transceiver module in the power line modem 54 is used to provide a data channel. These modules use a carrier current approach to create the data channel. Power line modems that operate at carrier frequencies in the 100 to 450 KHz band are available from many manufacturers. These modems provide digital communication paths at data rates of up to 10,000 bits per second utilizing direct sequence spread spectrum modulation. They conform to FCC power line carrier requirements for conducted emissions, and can work with up to 55 dB of power line attenuation. The power line modem 54 may be embodied by a device manufactured by Echelon Corporation of Palo Alto, California 94304, called the PLT-10 Power Line Transceiver Module.  
20

The data channel provides a transport layer or lowest layer of the open system interconnection (OSI) protocol used in the data network. The Neuron<sup>®</sup> chip which implements the microprocessor 44 contains all of the  
25 firmware required to implement a 7 layer OSI protocol. When interconnected via an appropriate medium the Neuron<sup>®</sup> chips automatically communicate with one another using a robust Collision Sense Multiple Access (CSMA) protocol with forward error corrections, error checking and automatic retransmission of missed messages (ARQ).

The command and control information is placed in data packets and sent over the network in accordance  
30 with the 7 Layer OSI protocol. All messages generated by the microprocessor 44 and destined for the central computer system 12 are received by the network bridge 22 via the power lines 21<sub>1-n</sub> and routed to the central computer system 12 over the wide area network 14.

The Neuron<sup>®</sup> chip of the microprocessor 44 comprises three processors (not shown) and the firmware required to support a full 6 layer open systems interconnection (OSI) protocol. The user is allocated one of the  
35 processors for the application code. The other two processors give the application program access to all of the other Neuron<sup>®</sup> chips in the network. This access creates a Local Operating Network or LON. A LON can be thought of as a high level local area network LAN. The use of the Neuron<sup>®</sup> chip for the implementation of this invention, reduces the amount of custom hardware and software that otherwise would have to be developed.

40 Data from the sensor electronic unit 43 of the edge light assemblies 20<sub>1-n</sub> is coupled to the central computer system 12 via the existing airport taxiway lighting power wiring 21. Using the existing edge light power line to transfer the sensor data into a LON network has many advantages. As previously pointed out, the reuse of the existing edge lights eliminates the inconvenience and expense of closing down runways and taxiways while running new cable and provides for a low cost system.

45 The Neuron<sup>®</sup> chip allows the edge light assemblies 20<sub>1-n</sub> to automatically communicate with each other at the applications level. This is accomplished through network variables which allow individual Neuron<sup>®</sup> chips to pass data between themselves. Each Neuron<sup>®</sup> 'C' program comprises both local and network variables. The local variables are used by the Neuron<sup>®</sup> program as a scratch pad memory. The network variables are used by the Neuron<sup>®</sup> program in one of two ways, either as a network output variables or a network input variables. Both kinds of variables can be initialized, evaluated and modified locally. The difference comes into  
50 play in that once a network output variable is modified, network messages are automatically sent to each network input variable that is linked to that output variable. This variable linking is done at installation time. As soon as a new value of a network input variable is received by a Neuron<sup>®</sup> chip, the code is vectored off to take appropriate action based upon the value of the network input variable. The advantage to the program is that this message passing scheme is entirely transparent since the message passing code is part of the embedded Neuron<sup>®</sup> operating system.  
55

Referring now to FIG. 6, eleven network variables have been identified for a sensor program in each microprocessor 44 of the edge light assemblies 20<sub>1-n</sub>. The sensor 50 function has two output variables: prelim\_de-

tect 70 and confirmed\_detect 72. The idea here is to have one output trigger whenever the sensor 50 detects movement. The other output does not trigger unless the local sensor and the sensor on the edge light across the runway both spot movement. Only when the detection is confirmed will the signal be fed back to the central computer system 12. This technique of confirmation helps to reduce false alarms in order to implement this technique the adjacent sensor 50 has an input variable called adj\_prelim\_detect 78 that is used to receive the other sensors prelim\_detect output 70. Other input variables are upstream\_detect 74 and downstream\_detect 76 which are used when chaining adjacent sensors together. Also needed is a detector\_sensitivity 80 input that is used by the central computer system 12 to control the detection ability of the sensor 50.

The incandescent light 40 requires two network variables, one input and the other an output variable. The input variable light\_level 84 would be used to control the light's brightness. The range would be OFF or 0% all the way to FULL ON or 100%. This range from 0% to 100% would be made in 0.5% steps. Since the edge light assembly 20<sub>1-n</sub> also contains the photocell 46, an output variable light\_failure 84 is created to signal that the lamp did not obtain the desired brightness.

The strobe light 48 requires three input variables. The strobe-mode 86 variable is used to select either the OFF, SEQUENTIAL, or ALTERNATE flash modes. Since the two flash modes require a distinct pattern to be created, two input variables active\_delay 88 and flash\_delay 90 are used to time align the strobe flashes. By setting these individual delay factors and then addressing the Neuron<sup>®</sup> chips as a group, allows the creation of a field strobe pattern with just one command.

Referring now to FIG. 7, a block diagram of an interconnection of network variables for a plurality of edge light assemblies 20<sub>1-n</sub> located on both sides of a runway is shown, each of the edge light assemblies 20<sub>1-n</sub> comprising a microprocessor 44. Each Neuron<sup>®</sup> program in the microprocessor 44 is designed with certain network input and output variables. The user writes the code for the Neuron<sup>®</sup> chips in the microprocessor 44 assuming that the inputs are supplied and that the outputs are used. To create an actual network the user has to "wire up" the network by interconnecting the individual nodes with a software linker. The resulting distributed process is best shown in schematic form, and a portion of the network interconnect matrix is shown in Figure 7. The prelim\_detect 70 output of a sensor node 44<sub>1</sub> is connected to the adj\_primary\_detect 92 input of the sensor node 44<sub>4</sub> across the taxiway. This is used as a means to verify actual detections and eliminate false reports. The communications link between these two nodes 44<sub>1</sub> and 44<sub>4</sub> is part of the distributed processing. The two nodes communicate among themselves without involving the central computer system 12. If in the automatic mode or if instructed by the controller, the system will also alert the pilots via audio and visual indications.

Referring again to FIG. 1 and FIG. 4, the central computer system 12 tracks the movement of vehicles as they pass from the sensor 50 to sensor 50 in each edge light assembly 20<sub>1-n</sub>. Using a variation of a radar automatic track algorithm, the system can track position, velocity and heading of all aircraft or vehicles based upon the sensor 50 readings. New vehicles are entered into the system either upon leaving a boarding gate or landing. Unknown vehicles are also tracked automatically. Since taxiway and runway lights are normally across from each other on the pavement (as shown in FIG. 4 and FIG. 7), the microprocessor 44 in each edge lights assembly 20<sub>1-n</sub> is programmed to combine their sensor 50 inputs and agree before reporting a contact. A further refinement is to have the microprocessor 44 check with the edge light assemblies 20<sub>1-n</sub> on either side of them to see if their sensors 50 had detected the vehicle. This allows a vehicle to be handed off from sensor electronic unit 43 to sensor electronic unit 43 of each edge light assembly 20<sub>1-n</sub> as it travels down the taxiway. This also assures that vehicle position reports remain consistent. Vehicle velocity may also be calculated by using the distance between sensors, the sensor pattern and the time between detections.

Referring to FIG. 5 and FIG. 8, the display 30 is a color monitor which provides a graphical display of the airport, a portion of which is shown in FIG. 8. This is accomplished by storing a map of the airport in the redundant computers 26 and 28 in a digital format. The display 30 shows the location of airplanes or vehicles as they are detected by the sensors 50 mounted in the edge light assemblies 20<sub>1-n</sub> along each taxiway and runway or other airport surface areas. All aircraft or vehicles on the airport surface are displayed as icons, with the shape of the icons being determined by the vehicle type. Vehicle position is shown by the location of the icon on the screen. Vehicle direction is shown by either the orientation of the icon or by an arrow emanating from the icon. Vehicle status is conveyed by the color of the icon. The future path of the vehicle as provided by the ground clearance command entered via the controllers microphone 35 is shown as a colored line on the display 30. The status of all field lights including each edge light 20<sub>1-n</sub> in each edge light circuit 18<sub>1-n</sub> is shown via color on the display 30.

Use of object orientated software provides the basis for building a model of an airport. The automatic inheritance feature allows a data structure to be defined once for each object and then replicated automatically for each instance of that object. Automatic flow down assures that elements of the data base are not corrupted due to typing errors. It also assures that the code is regular and structured. Rule based object oriented pro-

gramming makes it difficult to create unintelligible "spaghetti code." Object oriented programming allows the runways, taxiways, aircraft and sensors, to be decoded directly as objects. Each of these objects contains attributes. Some of these attributes are fixed like runway 22R or flight UA347, and some are variable like vehicle status and position.

5 In conventional programming we describe the attributes of an object in data structures and then describe the behaviors of the object as procedures that operate on those data structures. Object oriented programming shifts the emphasis and focuses first on the data structure and only secondarily on the procedures. More importantly, object oriented programming allows us to analyze and design programs in a natural manner. We can think in terms of runways and aircraft instead of focusing on either the behavior or the data structures of the  
10 runways and aircraft.

Table 1 shows a list of objects with corresponding attributes. Each physical object that is important to the runway incursion problem is modeled. The basic airplane or vehicle tracking algorithm is shown in Table 2 in a Program Design Language (PDL). The algorithm which handles sensor fusion, incursion avoidance and safety alerts is shown in a single program even though it is implemented as distributed system using both the central  
15 computer system 12 and the sensor microprocessors 44.

TABLE 1

<u>OBJECT</u>	<u>ATTRIBUTE</u>	<u>DESCRIPTION</u>
Sensor	Location	X & Y coordinates of sensor
	Circuit	AC wiring circuit name & number
	Unique_address	Net address for this sensor and its mate
	Lamp_intensity	0% to 100% in 0.5% steps
	Strobe_status	Blink rate/off
	Strobe-delay	From start signal
	Sensor_status	Detect/no detect
	Sensor_type	IR, laser, proximity, etc.
Runway	Name	22R, 27, 33L, etc.
	Location	X & Y coordinates of start of center line
	Length	In feet
	Width	In feet
	Direction	In degrees from north
	Status	Not_active, active_takeoff, active_landing, alarm
	Sensors (MV)	List of lights/sensors along this runway
40	Intersections (MV)	List of intersections
	Vehicles	List of vehicles on the runway
	Taxiway	Name of taxiway
45	Location	X & Y coordinates of start of center line
	Length	In feet
	Width	In feet
	Direction	In degrees from north
	Status	Not active, active, alarm
	Sensors (MV)	List of intersections
	50	Hold_Locations
	Vehicles (MV)	List of vehicles on the runway

55

	Intersection	Name	Intersection Name
		Location	Intersection of two center lines
5		Status	Vacant/Occupied
		Sensors (MV)	List of sensors creating intersection border
	Aircraft	Airline	United
10		Model	727-200
		Tail-number	N3274Z
		Empty_weight	9.5 tons
		Freight_weight	2.3 tons
15		Fuel_weight	3.2 tons
		Top_speed	598 mph
		V1_speed	100 mph
		V2_speed	140 mph
20		Acceleration	0.23 g's
		Deceleration	0.34 g's

MV = Multi-variable or array

25

Table 2

```

while (forever)
30   | if (edge light shows a detection)
   | | if (adjacent light also shows a detection sensor fusion)
   | | | /* CONFIRMED DETECTION */
35   | | | if (previous block showed a detection)
   | | | | /* ACCEPT HANDOFF */
   | | | | Update aircraft position and speed
40   | | | else
   | | | | /* MAY BE AN ANIMAL OR SERVICE TRUCK */
   | | | | Alert operator to possible incursion
45   | | | | /* MAY BE AN AIRCRAFT ENTERING THE SYSTEM */
   | | | | Start a new track
   | | else
   | | | Request status from adjacent light
50   | | | if (Adjacent light is OK)

```

55

```

| | | | /* NON CONFIRMED DETECTION */
| | | else
5 | | | | Flag adjacent light for repair
| | | endif
| | endif
10 | endif
| if (Edge light loses a detection AND status is OK)
| | if (Next block showed a detection)
| | | /* PROPER HANDOFF */
15 | | else
| | | if (vehicle speed > = takeoff)
| | | | Handoff to departure control
20 | | | else
| | | | /* MISSING HANDOFF */
| | | | Alert operator to possible incursion
25 | | | endif
| | endif
| endif
30 | /* CHECK FOR POSSIBLE COLLISIONS */
| for (all tracked aircraft)
| | Plot future position
35 | | if (position conflict)
| | | Alert operator to possible incursion
| | endif
40 | endif
| Update display
endwhile
45

```

Referring again to FIG. 1 and FIG. 2, the control of taxiway lighting intensity is usually done by placing all the lights on the same series circuit and then regulating the current in that circuit. In the present embodiment the intensity of the lamp 40 is controlled by sending a message with the light intensity value to the microprocessor 44 located within the light assembly 20<sub>i-n</sub>. The message allows for intensity settings in the range of 0 to 100% in 0.5% steps. The use of photocell 46 to check the light output allows a return message to be sent if the bulb does not respond. This in turn generates a maintenance report on the light. The strobe light 48 provides an additional optional capability under program control of the microprocessor 44. Each of the microprocessors 44 in the edge light assemblies 20 is individually addressable. This means every lamp on the field is controlled individually by the central computer system 12.

The system 10 can be programmed to provide an Active Runway Indicator by using the strobe lights 48 in those edge light assemblies 20<sub>i-n</sub> located on the runway 64 to continue the approach light "rabbit" strobe pattern all the way down the runway. This lighting pattern could be turned-on as a plane is cleared for landing

and then turned-off after the aircraft has touched down. A pilot approaching the runway along an intersecting taxiway would be alerted in a clear and unambiguous way that the runway was active and should not be crossed.

5 If an incursion was detected the main computers 26, 28 could switch the runway strobe lights 48 from the "rabbit" pattern to a pattern that alternatively flashes either side of the runway in a wig-wag fashion. A switch to this pattern would be interpreted by the pilot of an arriving aircraft as a wave off and a signal to go around. The abrupt switch in the pattern of the strobes would be instantaneously picked up by the air crew in time for them to initiate an aborted landing procedure.

10 During Category III weather conditions both runway and taxiway visibility are very low. Currently radio based landing systems are used to get the aircraft from final approach to the runway. Once on the runway it is not always obvious which taxiways are to be used to reach the airport terminal. In system 10 the main computers 26,28 can control the taxiway lamps 40 as the means for guiding aircraft on the ground during CAT III conditions. Since the intensity of the taxiway lamps 40 can be controlled remotely, the lamps just in front of an aircraft could be intensified or flashed as a means of guiding it to the terminal.

15 Alternatively, a short sequence of the "rabbit" pattern may be programmed into the taxiway strobes just in front of the aircraft. At intersections, either the unwanted paths may have their lamps turned off or the entrance to the proper section of taxiway may flash directing the pilot to head in that direction. Of course in a smart system only those lights directly in front of a plane would be controlled, all other lamps on the field would remain in their normal mode.

20 Referring now to FIG. 9, a block diagram is shown of the data flow within the system 10 (as shown in FIG. 1 and FIG. 5). The software modules are shown that are used to process the data within the computers 26, 28 of the central computer system 12. The tracking of aircraft and other vehicles on the airport operates under the control of a sensor fusion software module 101 which resides in the computers 26, 28. The sensor fusion software module 101 receives data from the plurality of sensors 50, a sensor 50 being located in each edge light assembly 20<sub>1-n</sub>, which reports the heat level detected, and this software module 101 combines this information through the use of rule based artificial intelligence to create a complete picture of all ground traffic at the airport on a display 30 of the central computer system 12.

25 The tracking algorithm starts a track upon the first report of a sensor 50 detecting a heat level that is above the ambient background level of radiation. This detection is then verified by checking the heat level reported by the sensor directly across the pavement from the first reporting sensor. This secondary reading is used to confirm the vehicle detected and to eliminate false alarms. After a vehicle has been confirmed the sensors adjacent to the first reporting sensor are queried for changes in their detected heat level. As soon as one of the adjacent sensors detects a rise in heat level a direction vector for the vehicle can be established. This process continues as the vehicle is handed off from sensor to sensor in a bucket brigade fashion as shown in FIG. 7. Vehicle speed can be roughly determined by calculating the time between vehicle detection by adjacent sensors. This information is combined with information from a system data base on the location of each sensor to calculate the velocity of the target. Due to hot exhaust or jet blast, the sensors behind the vehicle may not return to a background level immediately. Because of these condition, the algorithm only uses the first four sensors (two on either side of the taxiway) to calculate the vehicles position. The vehicle is always assumed to be on the centerline of the pavement and between the first four reporting sensors.

30 Vehicle identification can be added to the track either manually or automatically by an automated source that can identify a vehicle by its position. An example would be prior knowledge of the next aircraft to land on a particular runway. Tracks are ended when a vehicle leaves the detection system. This can occur in one of two ways. The first way is that the vehicle leaves the area covered by the sensors 50. This is determined by a vehicle track moving in the direction of a gateway sensor and then a lack of detection after the gateway sensor has lost contact. A second way to leave the detection system is for a track to be lost in the middle of a sensor array. This can occur when an aircraft departs or a vehicle runs onto the grass. Takeoff scenarios can be determined by calculating the speed of the vehicle just before detection was lost. If the vehicle speed was increasing and above rotation speed then the aircraft is assumed to have taken off. If not then the vehicle is assumed to have gone on to the grass and an alarm is sounded.

35 Referring to FIG. 5 and FIG. 9, the ground clearance routing function is performed by the speech recognition unit 33 along with the ground clearance compliance verifier software module 103 running on the computers 26, 28. This software module 103 comprises a vehicle identification routine, clearance path routing, clearance checking routine and a path checking routine.

40 The vehicle identification routine is used to receive the airline name and flight number (i.e. "Delta 374") from the speech recognition unit 33 and it highlights the icon of that aircraft on the graphic display of the airport on display 30.

The clearance path routine takes the remainder of the controller's phrase (i.e. "outer taxiway to echo, hold

short of runway 15 Left") and provides a graphical display of the clearance on the display 30 showing the airport.

The clearance checking routine checks the clearance path for possible conflict with other clearances and vehicles. If a conflict is found the portion of the path that would cause an incursion is highlighted in a blinking red and an audible indication is given to the controller via speaker 32.

5 The path checking routine checks the actual path of the vehicle as detected by the sensors 50 after the clearance path has been entered into the computers 26, 28 and it monitors the actual path for any deviation. If this routine detects that a vehicle has strayed from the assigned course, the vehicle icon on the graphic display of the airport flashes and an audible indicator is given to the controller via speaker 32 and optionally the vehicle operator via radio 37.

10 The airport vehicle incursion avoidance system 10 operates under the control of safety logic routines which reside in the collision detection software module 104 running on computers 26, 28. The safety logic routines receive data from the sensor fusion software module 101 via the tracker software module 102 location program and interpret this information through the use of rule based artificial intelligence to predict possible collisions or runway incursions. This information is then used by the central computer system 12 to alert tower controllers, aircraft pilots and truck operators to the possibility of a runway incursion. The tower controllers are alerted by the display 30 along with a computer synthesized voice message via speaker 32. Ground traffic is alerted by a combination of traffic lights, flashing lights, stop bars and other alert lights 34, lamps 40 and 48, and computer generated voice commands broadcast via radio 36.

20 Knowledge based problems are also called fuzzy problems and their solutions depend upon both program logic and an interface engine that can dynamically create a decision tree, selecting which heuristics are most appropriate for the specific case being considered. Rule based systems broaden the scope of possible applications. They allow designers to incorporate judgement and experience, and to take a consistent solution approach across an entire problem set.

25 The programming of the rule based incursion detections software is very straight forward. The rules are written in English allowing the experts, in this case the tower personnel and the pilots, to review the system at an understandable level. Another feature of the rule based system is that the rules stand alone. They can be added, deleted or modified without affecting the rest of the code. This is almost impossible to do with code that is created from scratch. An example of a rule we might use is:

```
If (Runway_Status = Active)
    then (Stop_Bar_Lights = RED).
```

30 This is a very simple and straight forward rule. It stands alone requiring no extra knowledge except how Runway\_Status is created. So let's make some rules affecting Runway\_Status.

```
If (Departure = APPROVED) or (Landing = IMMINENT),
    then (Runway_Status = ACTIVE).
```

35 For incursion detection, another rule is:

```
If (Runway_Status = ACTIVE) and (Intersection = OCCUPIED),
    then (Runway_Incursion = TRUE).
```

Next, detect that an intersection of a runway and taxiway are occupied by the rules:

```
If (Intersection_Sensors = DETECT),
    then (Intersection = OCCUPIED).
```

40 To predict that an aircraft will run a Hold Position stop, the following rule is created:

```
If (Aircraft_Stopping_Distance > Distance_to_Hold_Position),
    then (Intersection = OCCUPIED).
```

45 In order to show that rules can be added without affecting the reset of the program, assume that after a demonstration of the system 10 to tower controllers, they decided that they wanted a "Panic Button" in the tower to override the rule based software in case they spot a safety violation on the ground. Besides installing the button, the only other change would be to add this extra rule.

```
If (Panic_button = PRESSED),
    then (Runway_Incursion = TRUE).
```

50 It is readily seen that the central rule based computer program is very straight forward to create, understand and modify. As types of incursions are defined, the system 10 can be upgraded by adding more rules.

Referring again to FIG. 9, the block diagram shows the data flow between the functional elements within the system 10 (FIG. 1). Vehicles are detected by the sensor 50 in each of the edge light assemblies 20<sub>1-n</sub>. This information is passed over the local operating network (LON) via edge light wiring 21<sub>1-n</sub> to the LON bridges 22<sub>1-n</sub>. The individual message packets are then passed to the redundant computers 26 and 28 over the wide area network (WAN) 14 to the WAN interface 108. After arriving at the redundant computers 26 and 28, the message packet is checked and verified by a message parser software module 100. The contents of the message are then sent to the sensor fusion software module 101. The sensor fusion software module 101 is used



to keep track of the status of all the sensors 50 on the airport; it filters and verifies the data from the airport and stores a representative picture of the sensor array in a memory. This information is used directly by the display 30 to show which sensors 50 are responding and used by the tracker software module 102. The tracker software module 102 uses the sensor status information to determine which sensor 50 reports correspond to actual vehicles. In addition, as the sensor reports and status change, the tracker software module 102 identifies movement of the vehicles and produces a target location and direction output. This information is used by the display 30 in order to display the appropriate vehicle icon on the screen.

The location and direction of the vehicle is also used by the collision detection software module 104. This module checks all of the vehicles on the ground and plots their expected course. If any two targets are on intersecting paths, this software module generates operator alerts by using the display 30, the alert lights 34, the speech synthesis unit 29 coupled to the associated speaker 32, and the speech synthesis unit 31 coupled to radio 37 which is coupled to antenna 39.

Still referring to FIG. 9, another user of target location and position data is the ground clearance compliance verifier software module 103. This software module 103 receives the ground clearance commands from the controller's microphone 35 via the speech recognition unit 33. Once the cleared route has been determined, it is stored in the ground clearance compliance verifier software module 103 and used for comparison to the actual route taken by the vehicle. If the information received from the tracker software module 102 shows that the vehicle has deviated from its assigned course, this software module 103 generates operator alerts by using the display 30, the alert lights 34, the speech synthesis unit 29 coupled to speaker 32, and the speech synthesis unit 31 coupled to radio 37 which is coupled to antenna 39.

The keyboard 27 is connected to a keyboard parser software module 109. When a command has been verified by the keyboard parser software module 109, it is used to change display 30 options and to reconfigure the sensors and network parameters. A network configuration data base 106 is updated with these reconfiguration commands. This information is then turned into LON message packets by the command message generator 107 and sent to the edge light assemblies 20<sub>1-n</sub> via the WAN interface 108 and the LON bridges 22<sub>1-n</sub>.

This concludes the description of the preferred embodiment. However, many modifications and alterations will be obvious to one of ordinary skill in the art without departing from the spirit and scope of the inventive concept. Therefore, it is intended that the scope of this invention be limited only by the appended claims.

### Claims

1. An airport incursion avoidance system comprising:
  - a plurality of light circuits on an airport, each of said light circuits comprises a plurality of light assembly means;
    - means for providing power to each of said plurality of light circuits and to each of said light assembly means;
    - means in each of said light assembly means for sensing ground traffic on said airport;
    - means for processing data received from each of said light assembly means;
    - means for providing data communication between each of said light assembly means and said processing means;
    - said processing means comprises means for providing a graphic display of said airport comprising symbols representing said ground traffic, each of said symbols having direction and velocity data displayed;
    - said processing means comprises means for predicting an occurrence of an airport incursion in accordance with the data received from said sensing means; and
    - means for alerting an airport controller or aircraft pilot of said predicted airport incursion.
2. The airport incursion avoidance system as recited in Claim 1 wherein:
  - each of said light circuits being located along the edges of a taxiway or a runway on said airport.
3. The airport incursion avoidance system as recited in Claim 1 wherein:
  - said sensing means comprises infrared detectors.
4. The airport incursion avoidance system as recited in Claim 1 wherein said light assembly means comprises:
  - light means coupled to said lines of said power providing means for lighting said airport;

said sensing means;

microprocessor means coupled to said light means, said sensing means, and said data communication means for providing processing, communication and control for said light assembly means, said microprocessor controlling a plurality of lighting patterns of said light means on said airport; and

5       said data communication means being coupled to said microprocessor means and said lines of said power providing means.

5. The airport incursion avoidance system as recited in Claim 4 wherein:  
10       said light assembly means further comprises a photocell means coupled to said microprocessor means for detecting the light intensity of said light means.

6. The airport incursion avoidance system as recited in Claim 4 wherein:  
      said light assembly means further comprises a strobe light coupled to said microprocessor means.

7. The airport incursion avoidance system as recited in Claim 1 wherein:  
15       said processing means comprises redundant computers for fault tolerance operation.

8. The airport incursion avoidance system as recited in Claim 1 wherein:  
      said symbols representing said ground traffic comprise icons having a shape indicating type of aircraft or vehicle.  
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9. The airport incursion avoidance system as recited in Claim 1 wherein:  
      said processing means determines a location of said symbols on said graphic display of said airport in accordance with said data receive from said light assembly means.

10. The airport incursion avoidance system as recited in Claim 1 wherein:  
25       said processing means determines a future path of said ground traffic based on a ground clearance command, said future path being shown on said graphic display.

11. The airport incursion avoidance system as recited in Claim 1 wherein:  
30       said processing means for predicting an occurrence of an airport incursion comprises means for comparing position, direction and velocity of said ground traffic to predetermined separation minimums for said airport.

12. The airport incursion avoidance system as recited in Claim 1 wherein said power providing means comprises:  
35       constant current power means for providing a separate line to each of said plurality of light circuits; and  
      network bridge means coupled to said constant current power means for providing a communication channel to said processing means for each line of said constant current power means.  
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13. The airport incursion avoidance system as recited in Claim 1 wherein:  
      said alerting means comprises a speech synthesis unit connected to a speaker.

14. The airport incursion avoidance system as recited in Claim 1 wherein:  
45       said alerting means comprises a speech synthesis unit connected to a radio transmitter.

15. An airport incursion avoidance system comprising:  
      a plurality of light circuits on an airport, each of said light circuits comprises a plurality of light assembly means;  
50       constant current power means for providing a separate line to each of said plurality of light circuits; network bridge means coupled to said constant current power means for providing a communication channel to said processing means for each of said constant current power means;  
      infrared detector means in each of said light assembly means for sensing ground traffic on said airport;  
      means for processing ground traffic data received from each of said light assembly means;  
55       means for providing data communication on lines of said power providing means between each of said light assembly means and said processing means;  
      said processing means comprises means for providing a graphic display of said airport comprising

symbols representing said ground traffic located in accordance with said ground traffic data received from said light assembly means, each of said symbols having direction and velocity data displayed;

said processing means comprises means for predicting an occurrence of an airport incursion in accordance with said ground traffic data received from said sensing means including comparing position, direction and velocity of said ground traffic data to predetermined separation minimums for said airport; and

means for alerting an airport controller or aircraft pilot of said predicted airport incursion.

16. The airport incursion avoidance system as recited in Claim 15 wherein:  
each of said light circuits being located along the edges of a taxiway or a runway on said airport.
17. The airport incursion avoidance system as recited in Claim 15 wherein said light assembly means comprises:  
light means coupled to said lines of said power providing means for lighting said airport;  
said infrared detector sensing means;  
microprocessor means coupled to said light means, said sensing means, and said data communication means for providing processing, communication and control for said light assembly means, said microprocessor controlling a plurality of lighting patterns of said light means on said airport; and  
said data communication means being coupled to said microprocessor means and said lines of said constant current power providing means.
18. The airport incursion avoidance system as recited in Claim 17 wherein:  
said light assembly means further comprises a photocell means coupled to said microprocessor means for detecting the light intensity of said light means.
19. The airport incursion avoidance system as recited in Claim 17 wherein:  
said light assembly means further comprises a strobe light coupled to said microprocessor means.
20. The airport incursion avoidance system as recited in Claim 15 wherein:  
said processing means comprises redundant computers for fault tolerance operation.
21. The airport incursion avoidance system as recited in Claim 15 wherein:  
said symbols representing said ground traffic comprise icons having a shape indicating type of aircraft or vehicle.
22. The airport incursion avoidance system as recited in Claim 15 wherein:  
said processing means determines a future path of said ground traffic based on a ground clearance command, said future path being shown on said graphic display.
23. The airport incursion avoidance system as recited in Claim 15 wherein:  
said alerting means comprises a speech synthesis unit connected to a speaker.
24. The airport incursion avoidance system as recited in Claim 15 wherein:  
said alerting means comprises a speech synthesis unit connected to a radio transmitter.
25. A method of providing an airport incursion avoidance system comprising the steps of:  
providing a plurality of light circuits on said airport, each of said light circuits comprises a plurality of light assembly means;  
providing power to each of said plurality of light circuits;  
sensing ground traffic on said airport with means in each of said light assembly means;  
processing data received from each of said light assembly means in computer means;  
providing a graphic display of said airport comprising symbols representing said ground traffic, each of said symbols having direction and velocity data displayed;  
providing data communication between said computer means and each of said light assembly means;  
predicting an occurrence of an airport incursion in accordance with the data received from said sensing means; and  
alerting an airport controller or aircraft pilot of said predicted airport incursion.

26. The method as recited in Claim 25 wherein said step of sensing said ground traffic on said airport comprises the steps of:  
lighting said airport with a light means coupled to said microprocessor means and said power lines;  
providing a sensing means;  
5 performing processing, communication and control within said light assembly means with a microprocessor means coupled to said light means, said sensing means and data communication means; and  
coupling said data communication means between said microprocessor means and said power lines.
27. The method recited in Claim 25 wherein said step of processing data comprises the step of operating redundant computers for fault tolerance.
28. The method as recited in Claim 25 wherein said step of providing power comprises the steps of:  
providing a separate line to each of said plurality of light circuits with a constant current power means; and  
15 providing a communication channel to said computer means for each line of said constant current power means using a network bridge means.
29. The method as recited in Claim 25 wherein said step of providing a graphic display comprising symbols representing said ground traffic comprises the step of indicating a type of aircraft or vehicle with icons of various shapes.
30. The method as recited in Claim 25 wherein said step of processing said data from each of said light assembly means comprises the step of determining a location of said symbols on said graphic display of said airport in accordance with said data.
- 25 31. The method as recited in Claim 25 wherein said step of predicting an occurrence of an airport incursion comprises the step of determining a future path of said ground traffic in accordance with a ground clearance command and showing said future path on said graphic display.

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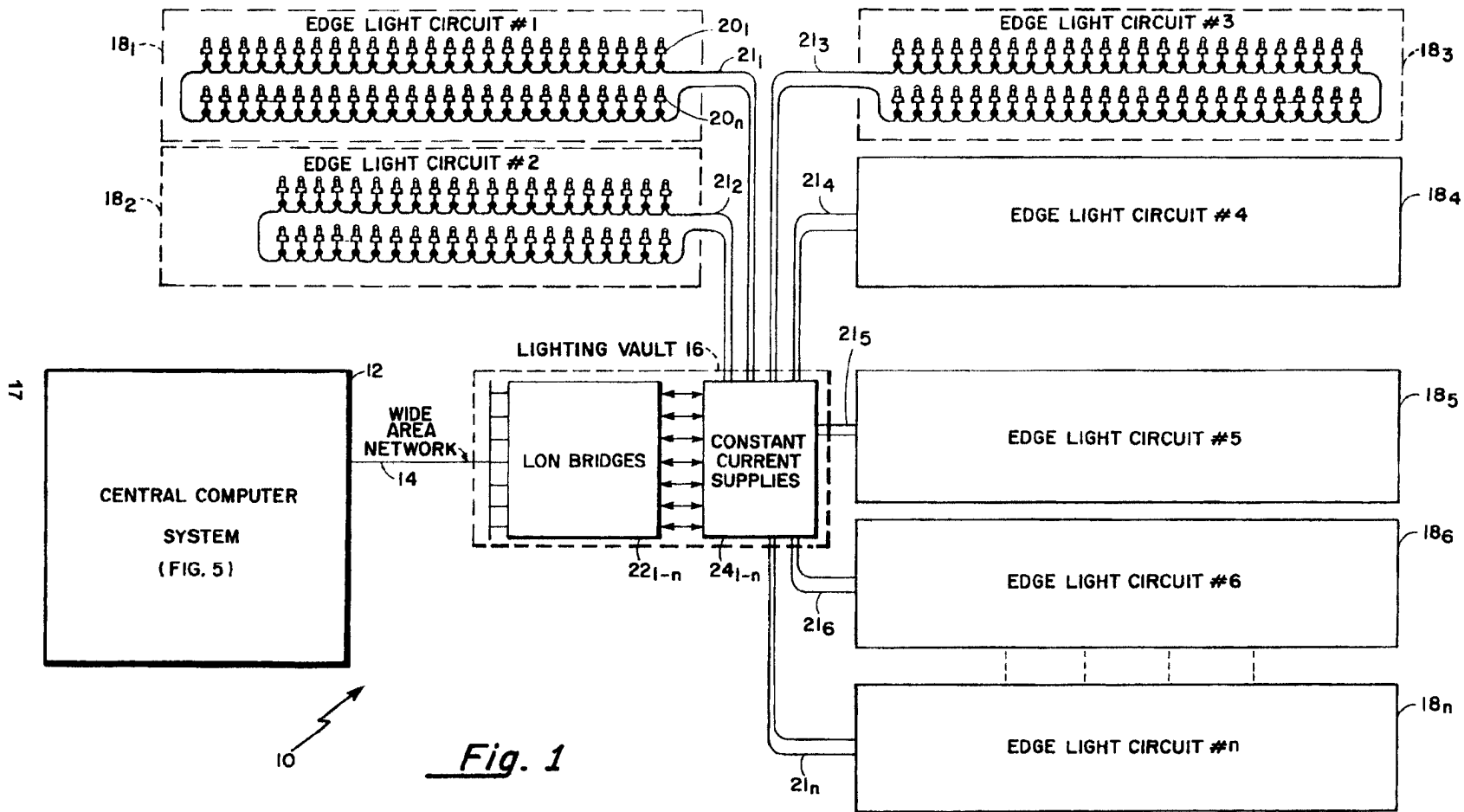
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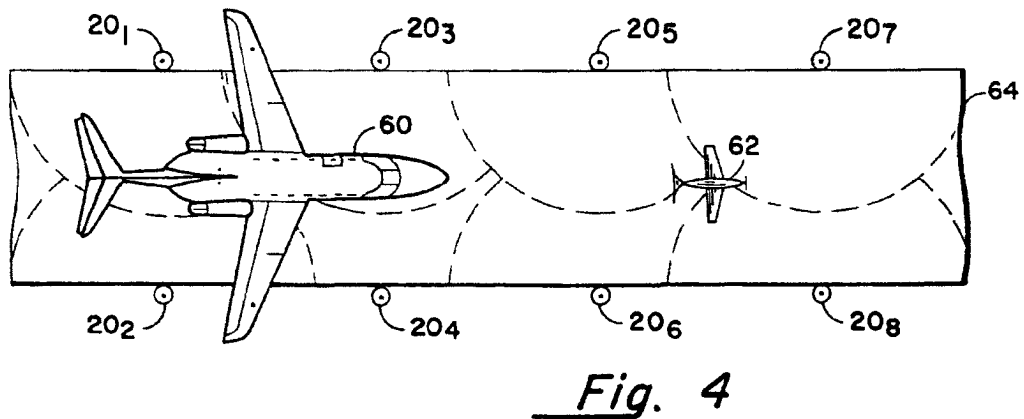
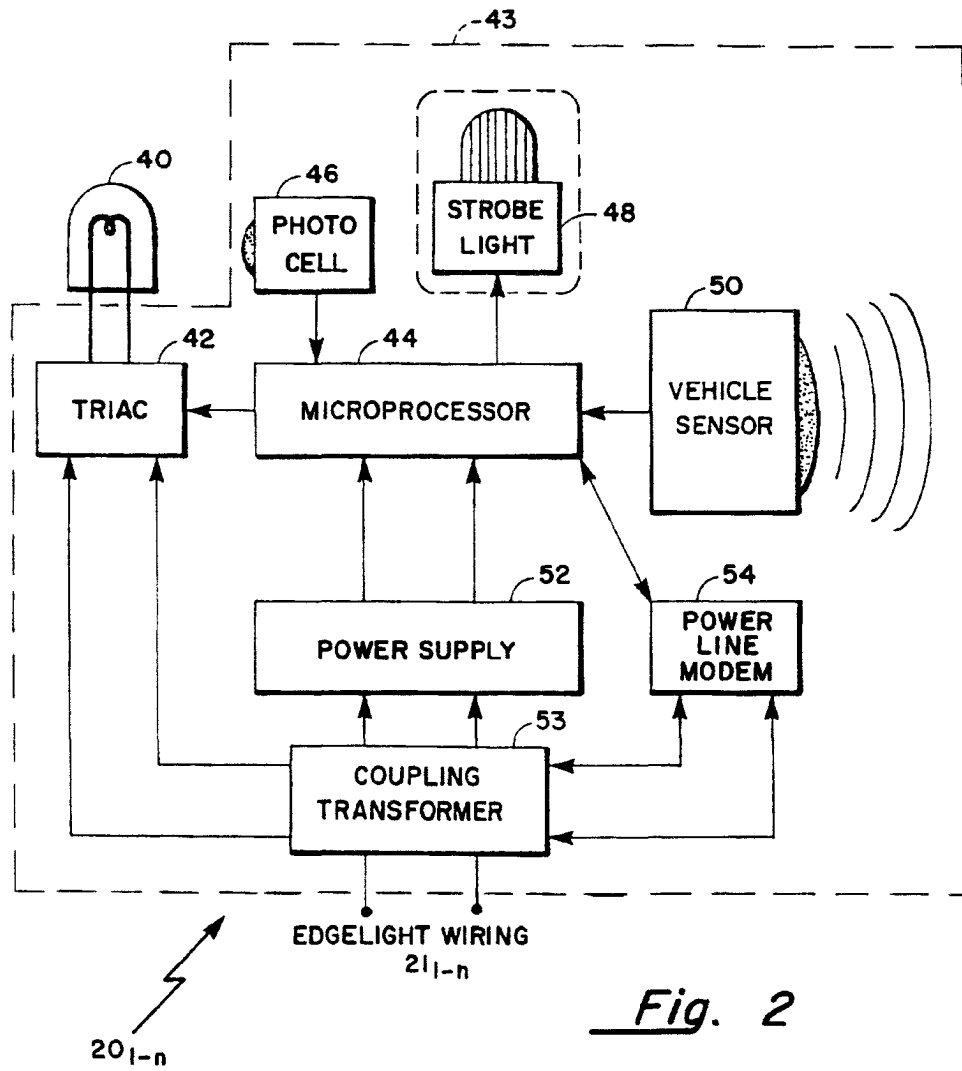
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*Fig. 1*



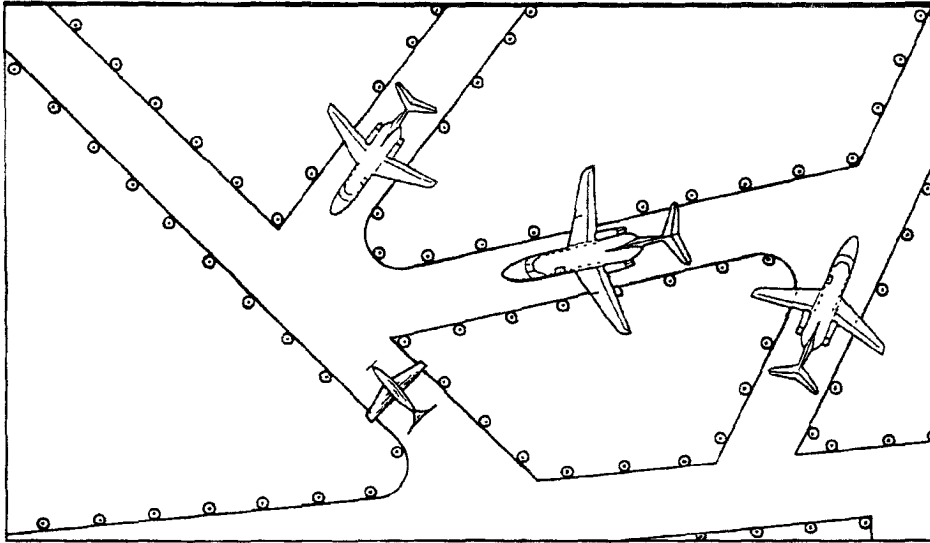


Fig. 8

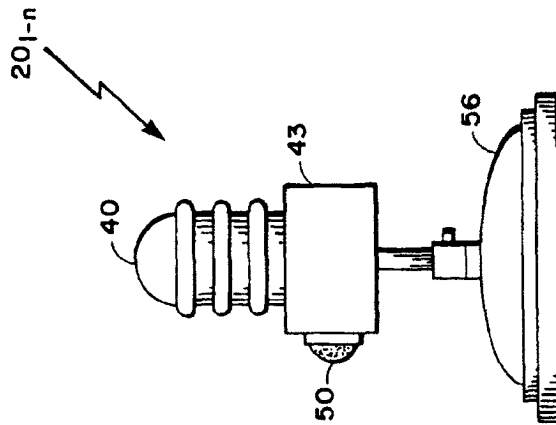


Fig. 3

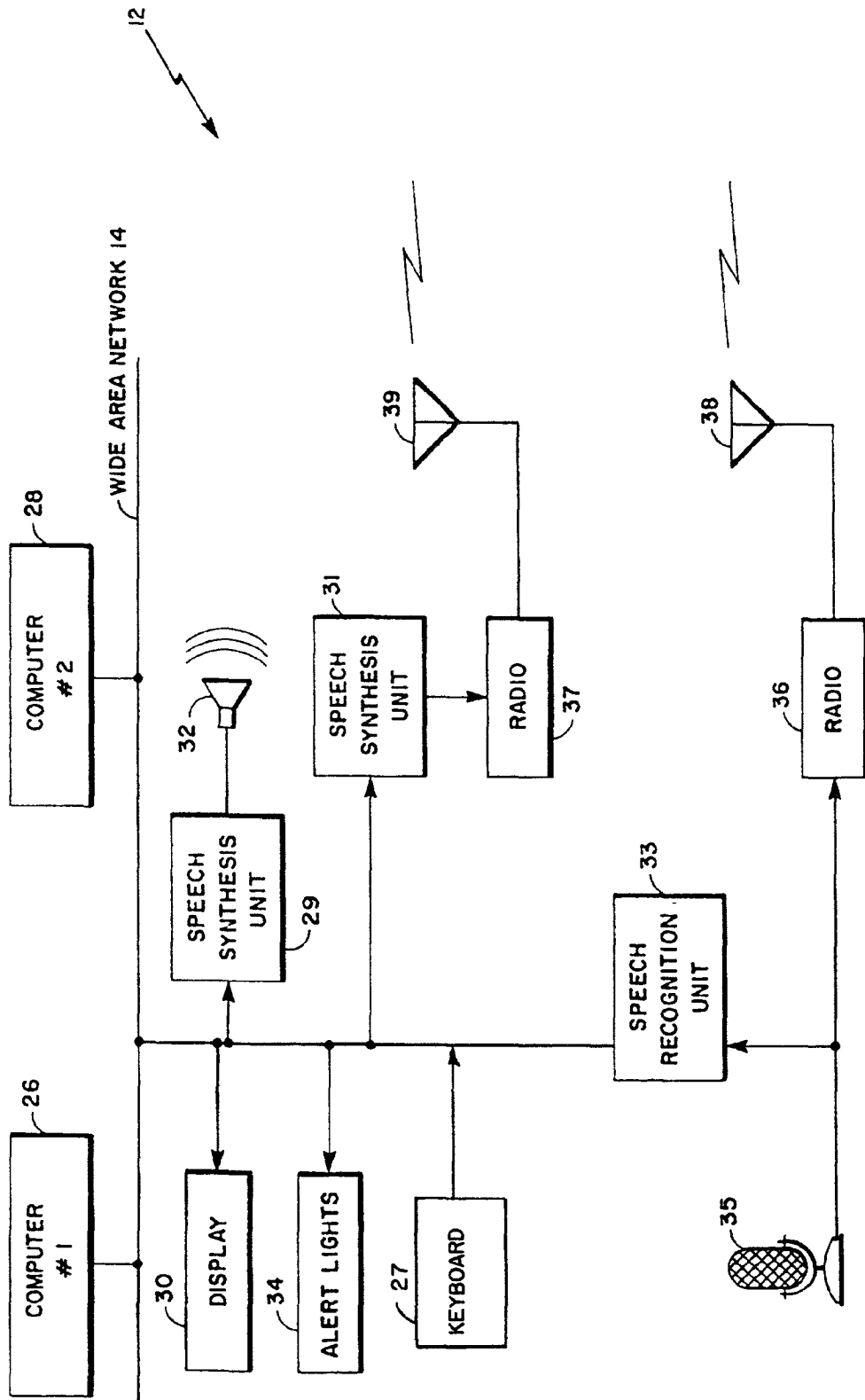


Fig. 5



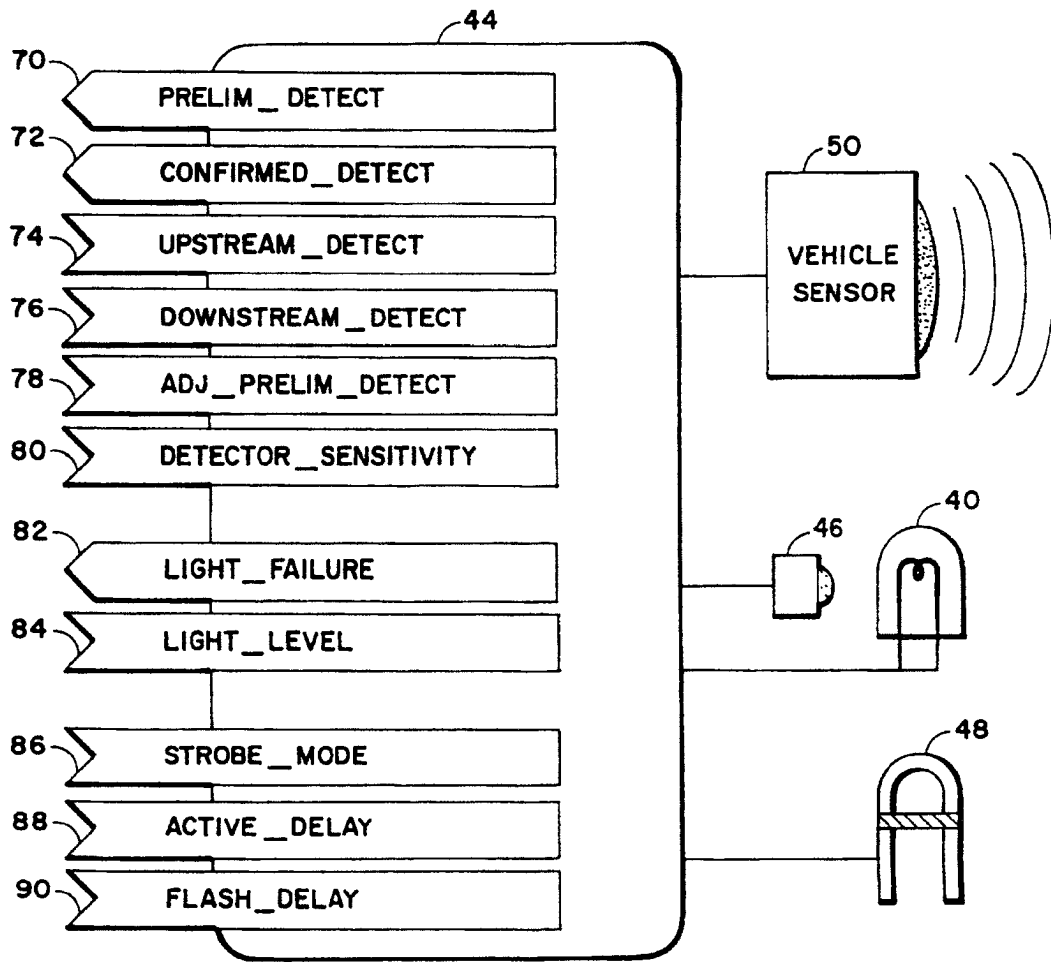


Fig. 6

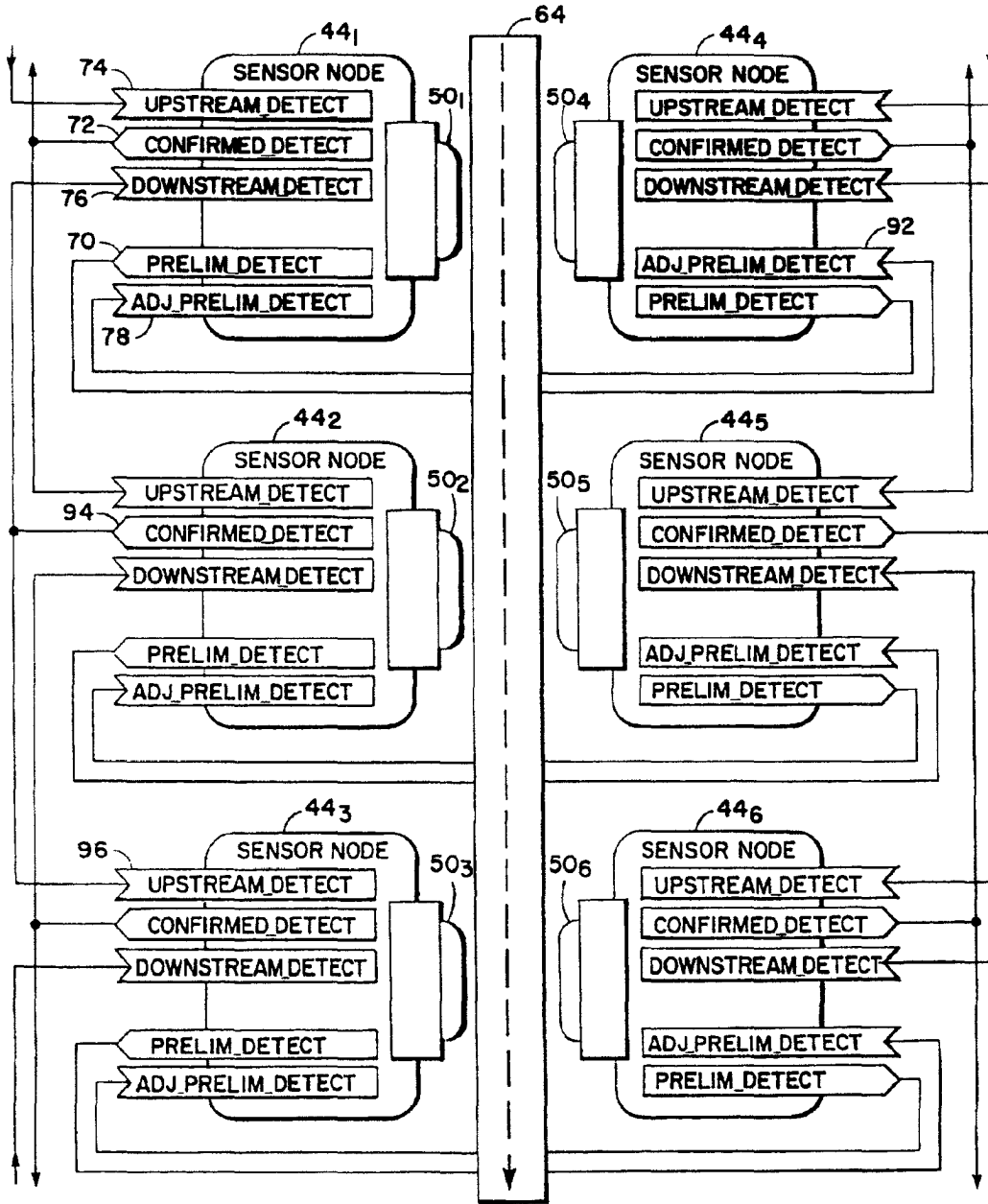


Fig. 7

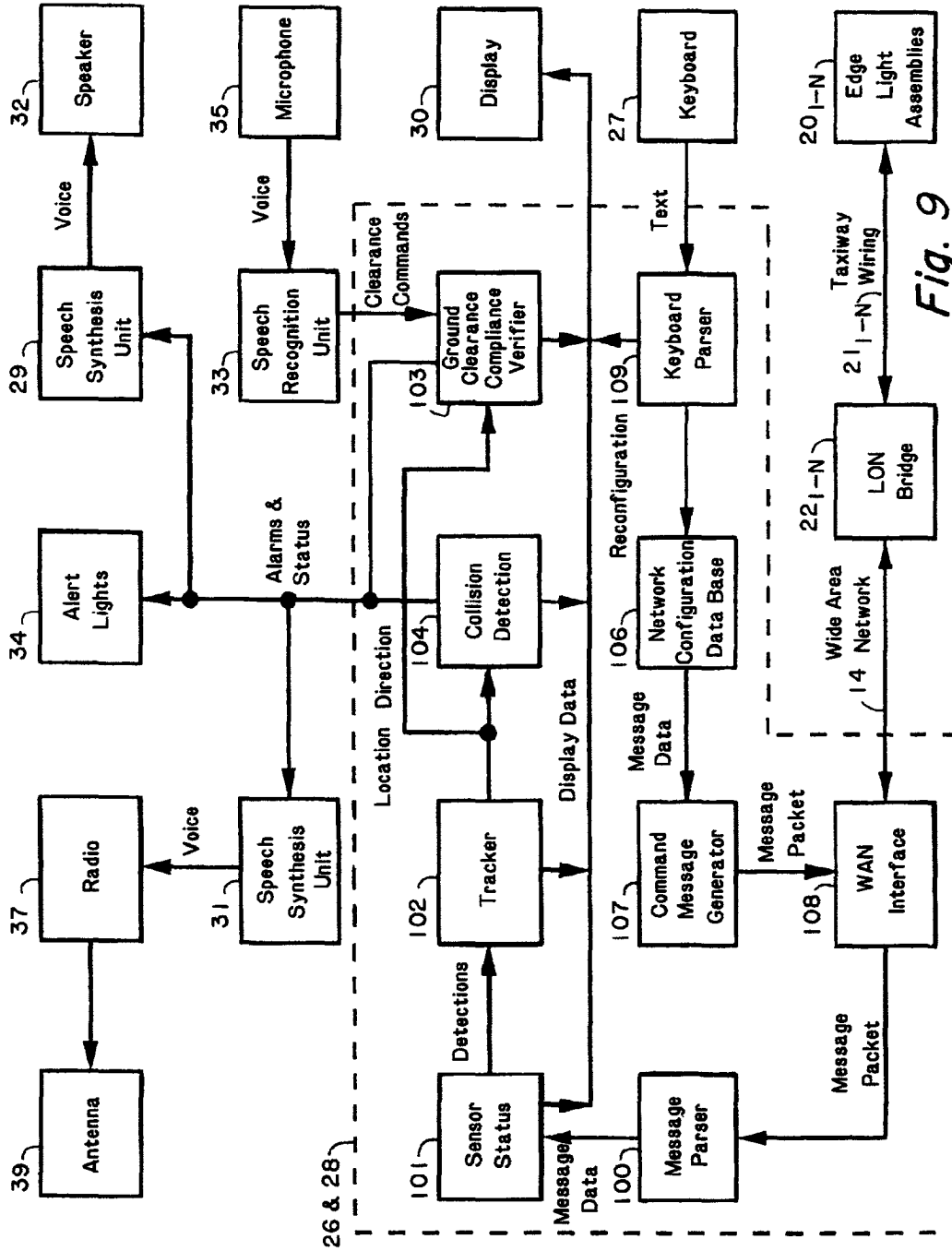


Fig. 9



European Patent  
Office

EUROPEAN SEARCH REPORT

Application Number  
EP 94 30 1262

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-3 706 969 (PAREDES) * the whole document * ---	1-31	G08G5/06
Y	WO-A-90 04242 (SWEDISH AIRPORT TECHNOLOGY HB)  * the whole document * ---	1-12, 15-22, 25-31	
Y	US-A-4 093 937 (HABINGER) * column 2, line 3 - line 33 * ---	6,19	
Y	US-A-4 455 551 (LEMELSON)  * abstract * ---	13,14, 23,24	
A	EP-A-0 209 397 (GENERAL INVESTIGACION Y DESARROLLO S.A.)  * claims 1,5-13,23,27 * & US-A-4 845 629 (MURGA ET AL.) ---	1-3, 8-11,15, 21,22, 25,26, 29-31	
A	EP-A-0 220 752 (D.R.I.M. LIMITED)  * claims * -----	1,10,11, 15,22, 25,26,31	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>20 June 1994</b>	Examiner <b>Reekmans, M</b>
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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**EUROPEAN PATENT APPLICATION**

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Int. Cl.<sup>5</sup> : **G08G 5/06**

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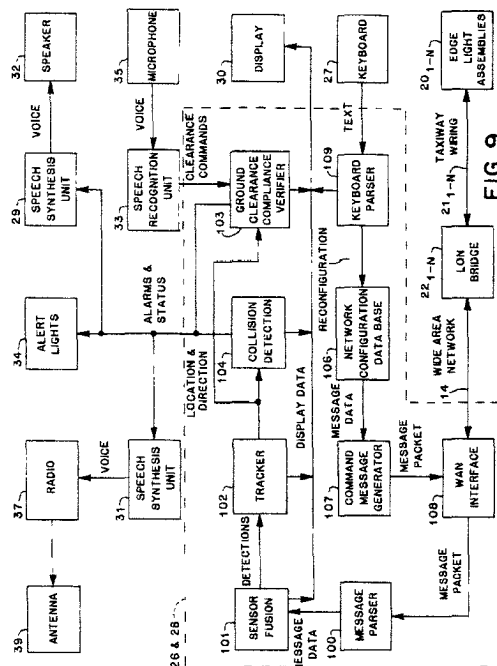
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Designated Contracting States :  
**DE ES FR GB IT NL SE**

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**54 Airport surveillance system.**

57 An airport surveillance system for detection of aircraft or other vehicles having a sensor co-located with edge lights (20<sub>1-N</sub>) along taxiways, runways and other surface areas, the sensor output being coupled to a central computer system (26,28) via the airport's edge light power lines (21<sub>1-N</sub>). The detection system comprises infrared sensors (50, Fig. 2). The output of each sensor (50) is fed into a microprocessor (44) within an edge light assembly (20) and then to a power line modem (54) for transmission to the central computer (26,28) which includes a display system (30) at the airport tower for displaying the airport and all traffic thereon. Data from each sensor (50) along taxiways and runways is received at the central computer system (26,8) and processed to provide comprehensive vehicle tracking and control of all ground traffic on the airport.



**Background of the Invention**

This invention relates to an airport ground surveillance system and in particular to an apparatus and method for monitoring and controlling aircraft or other vehicle movement primarily on airport taxiways, runways and other surface areas.

Currently, ground control of aircraft at an airport is done visually by the air traffic controller in the tower. Low visibility conditions sometimes make it impossible for the controller to see all parts of the field. Ground surface radar can help in providing coverage during low visibility conditions; it plays an important part in the solution of the runway incursion problem but cannot solve the entire problem. A runway incursion is defined as "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing, or intending to land." The U.S. Federal Administration Agency (FAA) has estimated that it can only justify the cost of ground surface radar at 29 of the top 100 airports in the United States. However, such radar only provides location information; it cannot alert the controller to possible conflicts between aircraft.

In the prior art, an airport control and monitoring system has been used to sense when an airplane reaches a certain point on a taxiway and controls switching lights on and off to indicate to the pilot when he may proceed on to a runway. Such a system sends microwave sensor information to a computer in the control tower. The computer comprises software for controlling the airport lighting and for providing fault information on the airport lighting via displays or a control panel to an operator. Such a system is described in sales information provided on a Bi-directional Series 7 Transceiver (BRITEE) produced by ADB-ALNACO, Inc., A Siemens Company, of Columbus, Ohio. However, such a system does not show the location of all vehicles on an airfield and is not able to detect and avoid a possible vehicle incursion.

A well known approach to airport surface traffic control has been the use of scanning radars operating at high frequencies such as K-band in order to obtain adequate definition and resolution. An existing airport ground traffic control equipment of that type is known in the art as Airport Surface Detection Equipment (ASDE). However, such equipment provides surveillance only, no discrete identification of aircraft on the surface being available. Also there is a need for a relatively high antenna tower and a relatively large rotation antenna system thereon.

Another approach to airport ground surveillance is a system described in U. S. Patent No. 3,872,474, issued March 18, 1974, to Arnold M. Levine and assigned to International Telephone and Telegraph Corporation, New York, NY, referred to as LOCAR (Localized Cable Radar) comprises a series of small, lower powered, narrow pulses, transmitting radars having limited range and time sequenced along opposite sides of a runway ramp or taxiway. In another U. S. Patent No. 4,197,536, issued on April 8, 1980, to Arnold M. Levine, an airport surface identification and control system is described for aircraft equipped with ATCRBS (Air Traffic Control Radio Beacon System) and ILS (Instrument Landing System). However, these approaches are expensive, require special cabling and for identification purposes require expensive equipment to be included on the aircraft and other vehicles.

Another approach to vehicle identification such as types of aircraft by identifying the unique characteristic of the "footprint" presented by the configuration of wheels unique to a particular type of vehicle is described in U.S. Patent No. 3,872,283, issued March 18, 1975, to Gerald R. Smith et al. and assigned to The Cadre Corporation of Atlanta Georgia.

An automatic system for surveillance, guidance and fire-fighting at airports using infrared sensors is described in U. S. Patent No. 4,845,629, issued July 4, 1989 to Maria V. Z. Murga. The infrared sensors are arranged along the flight lanes and their output signals are processed by a computer to provide information concerning the aircraft movements along the flight lanes. Position detectors are provided for detecting the position of aircraft in the taxiways and parking areas. However, such system does not teach the use of edge lights along the runways and taxiways along with their associated wiring and it is not able to detect and avoid a possible vehicle incursion.

The manner in which the invention deals with the disadvantages of the prior art to provide a low cost airport surveillance system, will be evident as the description proceeds.

**Summary of the Invention**

Accordingly, it is therefore an object of this invention to provide an airport surveillance system for detecting and monitoring all ground traffic on runways and taxiways and other surface areas.

It is also an object of this invention to provide a low cost airport surveillance system using edge light assemblies and associated wiring along runways and taxiways.

It is another object of this invention to provide a low cost airport surveillance system comprising infrared

detectors.

It is a further object of this invention to provide an airport surveillance system that generates a graphic display of the airport showing the location of all ground traffic including direction and velocity data.

The objects are further accomplished by providing an airport surveillance system comprising a plurality of light circuits on an airport, each of the light circuits comprises a plurality of light assembly means, means for providing power to each of the plurality of light circuits and to each of the light assembly means, means in each of the light assembly means for sensing ground traffic on the airport, means for processing data received from each of the light assembly means, means for providing data communication between each of the light assembly means and the processing means, and the processing means comprises means for providing a graphic display of the airport, the graphic display having symbols representing the ground traffic, each of the symbols having direction and velocity data displayed. Each of the light circuits are located along the edges of a taxiway or a runway on the airport. The light assembly means comprises light means coupled to the lines of the power providing means for lighting the airport, sensing means which comprises infrared detectors, micro-processor means coupled to the light means, the sensing means, and the data communication means for providing processing, communication and control for the light assembly means, the microprocessor controlling a plurality of lighting patterns of the light means on the airport, and the data communication means are coupled to the microprocessor means and the lines of the power providing means. The light assembly means further comprises a photocell means coupled to the microprocessor means for detecting the light intensity of the light means. The light assembly means further comprises a strobe light coupled to the microprocessor means. The processing means comprises redundant computers for fault tolerance operation. The symbols representing the ground traffic comprise icons having a shape indicating the type of airplane or vehicle. The processing means determines a location of the symbols on the graphic display of the airport in accordance with the data receive from the light assembly means. The processing means determines a future path of the ground traffic based on a ground clearance command, the future path being shown on the graphic display. The power providing means comprises constant current power means for providing a separate line to each of the plurality of light circuits, and network bridge means coupled to the constant current power means for providing a communication channel to the processing means for each line of the constant current power means.

The objects are further accomplished by a method of providing an airport surveillance system comprising the steps of providing a plurality of light circuits on the airport, each of the light circuits comprises a plurality of light assembly means, providing power to each of the plurality of light circuits, sensing ground traffic on the airport with means in each of the light assembly means, processing data received from each of the light assembly means in computer means, providing a graphic display of the airport comprising symbols representing the ground traffic, each of the symbols having direction and velocity data displayed, and providing data communication between the computer means and each of the light assembly means. The step of sensing the ground traffic on the airport comprises the steps of lighting the airport with a light means coupled to the power lines, providing infrared detectors for sensing ground traffic, performing processing, communication and control within the light assembly means with a microprocessor means coupled to the light means, the sensing means and data communication means, and coupling the data communication means between the microprocessor means and the power lines. The step of processing data comprises the steps of operating redundant computers for fault tolerance. The step of providing power comprises the steps of providing a separate line to each of the plurality of light circuits with a constant current power means, and providing a communication channel to the computer means for each line of the constant current power means using a network bridge means. The step of providing a graphic display comprising symbols representing the ground traffic comprises the step of indicating a type of aircraft or vehicle with icons of various shapes. The step of processing the data from each of the light assembly means comprises the step of determining a location of the symbols on the graphic display of the airport in accordance with the data.

### **Brief Description of the Drawings**

Other and further features of the invention will become apparent in connection with the accompanying drawings wherein:

FIG. 1 is a block diagram of the invention of an airport vehicle detection system;

FIG. 2 is a block diagram of an edge light assembly showing a sensor electronics unit coupled to an edge light of an airfield lighting system;

FIG. 3 is a pictorial diagram of the edge light assembly showing the edge light positioned above the sensor electronics unit;

FIG. 4 is a diagram of an airfield runway or taxiway having a plurality of edge light assemblies positioned along each side of the runway or taxiway for detecting various size aircraft as shown;

FIG. 5 is a block diagram of the central computer system shown in FIG. 1;

FIG. 6 shows eleven network variables used in programming the microprocessor of an edge light assembly to interface with a sensor, a light and a strobe light;

5 FIG. 7 is a block diagram showing an interconnection of network variables for a plurality of edge light assemblies located on both sides of a runway, each comprising a sensor electronics unit 10 positioned along a taxiway or runway;

FIG. 8 shows a graphic display of a typical taxiway/runway on a portion of an airport as seen by an operator in a control tower, the display showing the location of vehicles as they are detected by the sensors mounted in the edge light assemblies located along taxiways and runways; and

10 FIG. 9 is a block diagram of the data flow within the system shown in FIG. 1 and FIG. 5.

### **Description of the Preferred Embodiment**

Referring to FIG. 1 a block diagram of the invention of an airport vehicle detection system 10 is shown comprising a plurality of light circuits 18<sub>1-n</sub>, each of said light circuits 18<sub>1-n</sub> comprises a plurality of edge light assemblies 20<sub>1-n</sub> connected via wiring 21<sub>1-n</sub> to a lighting vault 16 which is connected to a central computer system 12 via a wide area network 14. Each of the edge light assemblies 20<sub>1-n</sub> comprises an infrared (IR) detector vehicle sensor 50 (FIG. 2).

20 The edge light assemblies 20<sub>1-n</sub> are generally located alongside the runways and taxiways of the airport with an average 100 foot spacing and are interconnected to the lighting vault 16 by single conductor series edge light wiring 21<sub>1-n</sub>. Each of the edge light circuits 18<sub>1-n</sub> is powered via the wiring 21<sub>1-n</sub> by a constant current supply 24<sub>1-n</sub> located in the lighting vault 16.

Referring now to FIG. 1 and FIG. 2, communication between the edge light assemblies 20<sub>1-n</sub> and the central computer system 12 is accomplished with LON Bridges 22<sub>1-n</sub> interconnecting the edge light wiring 21<sub>1-n</sub> with the Wide Area Network 14. Information from a microprocessor 44 located in each edge light assembly 20<sub>1-n</sub> is coupled to the edge light wiring 21<sub>1-n</sub> via a power line modem 54. The LON bridges 22<sub>1-n</sub> transfers message information from the edge light circuits 18<sub>1-n</sub> via the wiring 21<sub>1-n</sub> to the wide area network 14. The wide area network 14 provides a transmission path to the central computer system 12. These circuit components also provide the return path communications link from the central computer system 12 to the microprocessor 44 in each edge light assembly 20<sub>1-n</sub>. Other apparatus and methods, known to one of ordinary skill in the art, for data communication between the edge light assemblies 20<sub>1-n</sub> and the central computer system 12 may be employed, such as radio techniques, but the present embodiment of providing data communication on the edge light wiring 21<sub>1-n</sub> provides a low cost system for present airports. The LON Bridge 22 may be embodied by devices manufactured by Echelon Corporation of Palo Alto, California. The wide area network 14 may be implemented by one of ordinary skill in the art using standard Ethernet or Fiber Distributed Data Interface (FDDI) components. The constant current supply 24 may be embodied by devices manufactured by Crouse-Hinds of Winslow, Connecticut.

Referring now to FIG. 2 and FIG. 3, FIG. 3 shows a pictorial diagram of the edge light assembly 20<sub>1-n</sub>. The edge light assembly 20<sub>1-n</sub> comprises a bezel including an incandescent lamp 40 and an optional strobe light assembly 48 (FIG. 2) which are mounted above an electronics enclosure 43 comprising the vehicle sensor 50. The electronics enclosure 43 sits on the top of a tubular shaft extending from a base support 56. The light assembly bezel with lamp 40 and base support 56 may be embodied by devices manufactured by Crouse-Hinds of Winslow, Connecticut.

A block diagram of the contents of the electronics enclosure 43 is shown in FIG. 2 which comprises a coupling transformer 53 connected to the edge light wiring 21<sub>1-n</sub>. The coupling transformer 53 provides power to both the incandescent lamp 40 via the lamp control triac 42 and the microprocessor power supply 52; in addition, the coupling transformer 53 provides a data communication path between the power line modem 54 and the LON Bridges 22<sub>1-n</sub> via the edge light wiring 21<sub>1-n</sub>. The microprocessor 44 provides the computational power to run the internal software program that controls the edge light assemblies 20<sub>1-n</sub>. The microprocessor 44 is powered by the microprocessor power supply 52. Also connected to the microprocessor 44 is the lamp control triac 42, a lamp monitoring photo cell 46, the optional strobe light assembly 48, the vehicle sensor 50, and the data communications modem 54. The microprocessor 44 is used to control the incandescent edge light 40 intensity and optional strobe light assembly 48. The use of the microprocessor 44 in each light assembly 20<sub>1-n</sub> allows complete addressable control over every light on the field. The microprocessor 44 may be embodied by a VLSI device manufactured by Echelon Corporation of Palo Alto, California 94304, called the Neuron® chip.

Still referring to FIG. 2, the sensor 50 in the present embodiment comprises an infrared (IR) detector and in other embodiments may comprise other devices such as proximity detectors, CCD cameras, microwave mo-



tion detectors, inductance loops, or laser beams. The program in the microprocessor 44 is responsible for the initial filtering of the sensor data received from the sensor 50 and responsible for the transmission of such data to the central computer system 12. The sensor 50 must perform the following functions: detect a stationary object, detect a moving object, have a range at least half the width of the runway or taxiway, be low power and be immune to false alarms. This system design does not rely on just one type of sensor. Since sensor fusion functions are performed within the central computer system 12, data inputs from all different types of sensors are acceptable. Each sensor relays a different view of what is happening on the airfield and the central computer system 12 combines them. There are a wide range of sensors that may be used in this system. As a new sensor type becomes available, it can be integrated into this system with a minimum of difficulty. The initial sensor used is an IR proximity detector based around a piezoelectric strip. These are the kind of sensors you use at home to turn on your flood lights when heat and/or movement is detected. When the sensor output provides an analog signal, an analog-to-digital converter readily known in the art may be used to interface with the microprocessor 44.

Another proximity detector that can be used is based around a microwave Gunn diode oscillator. These are currently in use in such applications as Intrusion Alarms, Door Openers, Distance Measurement, Collision Warning, Railroad Switching, etc. These types of sensors have a drawback because they are not passive devices and care needs to be taken to select frequencies that would not interfere with other airport equipment. Finally, in locations such as the hold position lines on taxiways, solid state laser and detector combinations could be used between adjacent taxiway lights. These sensor systems create a beam that when broken would identify the location of the front wheel of the airplane. This type of detector would be used in those locations where the absolute position of a vehicle was needed. The laser beam would be modulated by the microprocessor 44 to avoid the detector being fooled by any other stray radiation.

Referring to FIG. 2 and FIG. 4, a portion of an airport runway 64 or taxiway is shown having a plurality of edge light assemblies  $20_{1-8}$  positioned along each side of the runway or taxiway for detecting various size airplanes or vehicles 60, 62. The dashed lines represent the coverage area of the sensors 50 located in each edge light assembly  $20_{1-8}$  positioned along each side of the runway 64 or taxiway to insure detection of any airplane 60, 62 or other vehicles traveling on such runway 64 or taxiway. The edge light assemblies  $20_{1-n}$  comprising the sensor 50 are logically connected together in such a way that an entire airport is sensitized to the movement of vehicles. Node to node communication takes place to verify and identify the location of the vehicles. Once this is done a message is sent to the central computer system 12 reporting the vehicles location. Edge light assemblies (without a sensor electronics unit 43) and taxiway power wiring currently exist along taxiways, runways and open areas of airports; therefore, the sensor electronics unit 43 is readily added to existing edge lights and existing taxiway power wiring without the inconvenience and expense of closing down runways and taxiways while installing new cabling.

Referring now to FIG. 1, FIG. 5, FIG. 8 and FIG. 9, the central computer system 12 is generally located at a control tower or terminal area of an airport and is interconnected to the LON Bridges  $22_{1-n}$  located in the lighting vault 16 with a Wide Area Network 14. The central computer system 12 comprises two redundant computers, computer #1 26 and computer #2 28 for fault tolerance, the display 30, speech synthesis units 29 & 31, alert lights 34, keyboard 27 and a speech recognition unit 33, all of these elements being interconnected by the wide area network 14 for the transfer of information. The two computers 26 and 28 communicate with the microprocessors 44 located in the edge light assemblies  $20_{1-n}$ . Data received from the edge light assembly  $20_{1-n}$  microprocessors 44 are used as an input to a sensor fusion software module 101 (FIG. 9) run on the redundant computers 26 and 28. The output of the sensor fusion software module 101 operating in the computers 26, 28 is used to drive the CRT display 30 which displays the location of each vehicle on the airport taxiway and runways as shown in FIG. 8. The central computer system 12 may be embodied by devices manufactured by IBM Corporation of White Plains, New York. The Wide Area Network 14 may be embodied by devices manufactured by 3Com Corporation of Santa Clara, California. The speech synthesis units 29, 31 and the speech recognition unit 33 may be embodied by devices manufactured by BBN of Cambridge, Massachusetts.

The speech synthesis unit 29 is coupled to a speaker 32. Limited information is sent to the speech synthesis unit 29 via the wide area network 14 to provide the capability to give an air traffic controller a verbal alert. The speech synthesis unit 31 is coupled to a radio 37 having an antenna 39 to provide the capability to give the pilots a verbal alert. The voice commands from the air traffic controller to the pilots are captured by microphone 35 and sent to the pilots via radio 36 and antenna 38. In the present embodiment a tap is made and the speech information is sent to both the radio 36 and the speech recognition unit 33 which is programmed to recognize the limited air traffic control vocabulary used by a controller. This includes airline names, aircraft type, the numbers 0-9, the name of the taxiways and runways and various short phrases such as "hold short", "expedite"

and "give way to." The output of the speech recognition unit 33 is fed to the computers 26, 28.

Referring again to FIG. 2, the power line modem 54 provides a data communication path over the edge light wiring 21<sub>1-n</sub> for the microprocessor 44. This two way path is used for the passing of command and control information between the various edge light assemblies 20<sub>1-n</sub> and the central computer system 12. A power line transceiver module in the power line modem 54 is used to provide a data channel. These modules use a carrier current approach to create the data channel. Power line modems that operate at carrier frequencies in the 100 to 450 Khz band are available from many manufacturers. These modems provide digital communication paths at data rates of up to 10,000 bits per second utilizing direct sequence spread spectrum modulation. They conform to FCC power line carrier requirements for conducted emissions, and can work with up to 55 dB of power line attenuation. The power line modem 54 may be embodied by a device manufactured by Echelon Corporation of Palo Alto, California 94304, called the PLT-10 Power Line Transceiver Module.

The data channel provides a transport layer or lowest layer of the open system interconnection (OSI) protocol used in the data network. The Neuron<sup>®</sup> chip which implements the microprocessor 44 contains all of the firmware required to implement a 7 layer OSI protocol. When interconnected via an appropriate medium the Neuron<sup>®</sup> chips automatically communicate with one another using a robust Collision Sense Multiple Access (CSMA) protocol with forward error corrections, error checking and automatic retransmission of missed messages (ARQ).

The command and control information is placed in data packets and sent over the network in accordance with the 7 Layer OSI protocol. All messages generated by the microprocessor 44 and destined for the central computer system 12 are received by the network bridge 22 via the power lines 21<sub>1-n</sub> and routed to the central computer system 12 over the wide area network 14.

The Neuron<sup>®</sup> chip of the microprocessor 44 comprises three processors (not shown) and the firmware required to support a full 6 layer open systems interconnection (OSI) protocol. The user is allocated one of the processors for the application code. The other two processors give the application program access to all of the other Neuron<sup>®</sup> chips in the network. This access creates a Local Operating Network or LON. A LON can be thought of as a high level local area network LAN. The use of the Neuron<sup>®</sup> chip for the implementation of this invention, reduces the amount of custom hardware and software that otherwise would have to be developed.

Data from the sensor electronic unit 43 of the edge light assemblies 20<sub>1-n</sub> is coupled to the central computer system 12 via the existing airport taxiway lighting power wiring 21. Using the existing edge light power line to transfer the sensor data into a LON network has many advantages. As previously pointed out, the reuse of the existing edge lights eliminates the inconvenience and expense of closing down runways and taxiways while running new cable and provides for a low cost system.

The Neuron<sup>®</sup> chip allows the edge light assemblies 20<sub>1-n</sub> to automatically communicate with each other at the applications level. This is accomplished through network variables which allow individual Neuron<sup>®</sup> chips to pass data between themselves. Each Neuron<sup>®</sup> 'C' program comprises both local and network variables. The local variables are used by the Neuron<sup>®</sup> program as a scratch pad memory. The network variables are used by the Neuron<sup>®</sup> program in one of two ways, either as a network output variables or a network input variables. Both kinds of variables can be initialized, evaluated and modified locally. The difference comes into play in that once a network output variable is modified, network messages are automatically sent to each network input variable that is linked to that output variable. This variable linking is done at installation time. As soon as a new value of a network input variable is received by a Neuron<sup>®</sup> chip, the code is vectored off to take appropriate action based upon the value of the network input variable. The advantage to the program is that this message passing scheme is entirely transparent since the message passing code is part of the embedded Neuron<sup>®</sup> operating system.

Referring now to FIG. 6, eleven network variables have been identified for a sensor program in each microprocessor 44 of the edge light assemblies 20<sub>1-n</sub>. The sensor 50 function has two output variables: prelim\_detect 70 and confirmed\_detect 72. The idea here is to have one output trigger whenever the sensor 50 detects movement. The other output does not trigger unless the local sensor and the sensor on the edge light across the runway both spot movement. Only when the detection is confirmed will the signal be fed back to the central computer system 12. This technique of confirmation helps to reduce false alarms in order to implement this technique the adjacent sensor 50 has an input variable called adj\_prelim\_detect 78 that is used to receive the other sensors prelim\_detect output 70. Other input variables are upstream\_detect 74 and downstream\_detect 76 which are used when chaining adjacent sensors together. Also needed is a detectQr\_sensitivity 80 input that is used by the central computer system 12 to control the detection ability of the sensor 50.

The incandescent light 40 requires two network variables, one input and the other an output variable. The input variable light\_level 84 would be used to control the light's brightness. The range would be OFF or 0% all the way to FULL ON or 100%. This range from 0% to 100% would be made in 0.5% steps. Since the edge light

assembly 20<sub>1-n</sub> also contains the photocell 46, an output variable light\_failure 84 is created to signal that the lamp did not obtain the desired brightness.

5 The strobe light 48 requires three input variables. The strobe-mode 86 variable is used to select either the OFF, SEQUENTIAL, or ALTERNATE flash modes. Since the two flash modes require a distinct pattern to be created, two input variables active\_delay 88 and flash\_delay 90 are used to time align the strobe flashes. By setting these individual delay factors and then addressing the Neuron® chips as a group, allows the creation of a field strobe pattern with just one command.

Referring now to FIG. 7, a block diagram of an interconnection of network variables for a plurality of edge light assemblies 20<sub>1-n</sub> located on both sides of a runway is shown, each of the edge light assemblies 20<sub>1-n</sub> comprising a microprocessor 44. Each Neuron® program in the microprocessor 44 is designed with certain network input and output variables. The user writes the code for the Neuron® chips in the microprocessor 44 assuming that the inputs are supplied and that the outputs are used. To create an actual network the user has to "wire up" the network by interconnecting the individual nodes with a software linker. The resulting distributed process is best shown in schematic form, and a portion of the network interconnect matrix is shown in Figure 7. The prelim\_detect 70 output of a sensor node 44<sub>1</sub> is connected to the adj\_primary\_detect 92 input of the sensor node 44<sub>4</sub> across the taxiway. This is used as a means to verify actual detections and eliminate false reports. The communications link between these two nodes 44<sub>1</sub> and 44<sub>4</sub> is part of the distributed processing. The two nodes communicate among themselves without involving the central computer system 12. If in the automatic mode or if instructed by the controller, the system will also alert the pilots via audio and visual indications.

Referring again to FIG. 1 and FIG. 4, the central computer system 12 tracks the movement of vehicles as they pass from the sensor 50 to sensor 50 in each edge light assembly 20<sub>1-n</sub>. Using a variation of a radar automatic track algorithm, the system can track position, velocity and heading of all aircraft or vehicles based upon the sensor 50 readings. New vehicles are entered into the system either upon leaving a boarding gate or landing. Unknown vehicles are also tracked automatically. Since taxiway and runway lights are normally across from each other on the pavement (as shown in FIG. 4 and FIG. 7), the microprocessor 44 in each edge lights assembly 20<sub>1-n</sub> is programmed to combine their sensor 50 inputs and agree before reporting a contact. A further refinement is to have the microprocessor 44 check with the edge light assemblies 20<sub>1-n</sub> on either side of them to see if their sensors 50 had detected the vehicle. This allows a vehicle to be handed off from sensor electronic unit 43 to sensor electronic unit 43 of each edge light assembly 20<sub>1-n</sub> as it travels down the taxiway. This also assures that vehicle position reports remain consistent. Vehicle velocity may also be calculated by using the distance between sensors, the sensor pattern and the time between detections.

Referring to FIG. 5 and FIG. 8, the display 30 is a color monitor which provides a graphical display of the airport, a portion of which is shown in FIG. 8. This is accomplished by storing a map of the airport in the redundant computers 26 and 28 in a digital format. The display 30 shows the location of airplanes or vehicles as they are detected by the sensors 50 mounted in the edge light assemblies 20<sub>1-n</sub> along each taxiway and runway or other airport surface areas. All aircraft or vehicles on the airport surface are displayed as icons, with the shape of the icons being determined by the vehicle type. Vehicle position is shown by the location of the icon on the screen. Vehicle direction is shown by either the orientation of the icon or by an arrow emanating from the icon. Vehicle status is conveyed by the color of the icon. The future path of the vehicle as provided by the ground clearance command entered via the controllers microphone 35 is shown as a colored line on the display 30. The status of all field lights including each edge light 20<sub>1-n</sub> in each edge light circuit 18<sub>1-n</sub> is shown via color on the display 30.

Use of object orientated software provides the basis for building a model of an airport. The automatic inheritance feature allows a data structure to be defined once for each object and then replicated automatically for each instance of that object. Automatic flow down assures that elements of the data base are not corrupted due to typing errors. It also assures that the code is regular and structured. Rule based object oriented programming makes it difficult to create unintelligible "spaghetti code." Object oriented programming allows the runways, taxiways, aircraft and sensors, to be decoded directly as objects. Each of these objects contains attributes. Some of these attributes are fixed like runway 22R or flight UA347, and some are variable like vehicle status and position.

In conventional programming we describe the attributes of an object in data structures and then describe the behaviors of the object as procedures that operate on those data structures. Object oriented programming shifts the emphasis and focuses first on the data structure and only secondarily on the procedures. More importantly, object oriented programming allows us to analyze and design programs in a natural manner. We can think in terms of runways and aircraft instead of focusing on either the behavior or the data structures of the runways and aircraft.

Table 1 shows a list of objects with corresponding attributes. Each physical object that is important to the

runway incursion problem is modeled. The basic airplane or vehicle tracking algorithm is shown in Table 2 in a Program Design Language (PDL). The algorithm which handles sensor fusion, incursion avoidance and safety alerts is shown in a single program even though it is implemented as distributed system using both the central computer system 12 and the sensor microprocessors 44.

5

**TABLE 1**

<u>OBJECT</u>	<u>ATTRIBUTE</u>	<u>DESCRIPTION</u>
Sensor	Location	X & Y coordinates of sensor
	Circuit	AC wiring circuit name & number
	Unique_address	Net address for this sensor and its mate
	Lamp_intensity	0% to 100% in 0.5% steps
	Strobe_status	Blink rate/off
	Strobe-delay	From start signal
	Sensor_status	Detect/no detect
Runway	Sensor_type	IR, laser, proximity, etc.
	Name	22R, 27, 33L, etc.
	Location	X & Y coordinates of start of center line
	Length	In feet
	Width	In feet
	Direction	In degrees from north
	Status	Not_active, active_takeoff, active_landing, alarm
	Sensors (MV)	List of lights/sensors along this runway
	Intersections (MV)	List of intersections
	Vehicles	List of vehicles on the runway
Taxiway	Name	Name of taxiway
	Location	X & Y coordinates of start of center line
	Length	In feet
	Width	In feet
	Direction	In degrees from north
	Status	Not active, active, alarm
	Sensors (MV)	List of intersections
	Hold_Locations	List of holding locations
	Vehicles (MV)	List of vehicles on the runway

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	Intersection	Name	Intersection Name
		Location	Intersection of two center lines
5		Status	Vacant/Occupied
		Sensors (MV)	List of sensors creating intersection border
	Aircraft	Airline	United
10		Model	727-200
		Tail-number	N3274Z
		Empty_weight	9.5 tons
		Freight_weight	2.3 tons
15		Fuel_weight	3.2 tons
		Top_speed	598 mph
		V1_speed	100 mph
		V2_speed	140 mph
20		Acceleration	0.23 g's
		Deceleration	0.34 g's

MV = Multi-variable or array

25

Table 2

```

while (forever)
30   | if (edge light shows a detection)
   | | if (adjacent light also shows a detection sensor fusion)
   | | | /* CONFIRMED DETECTION */
   | | | if (previous block showed a detection)
35   | | | | /* ACCEPT HANDOFF */
   | | | | Update aircraft position and speed
   | | | else
40   | | | | /* MAY BE AN ANIMAL OR SERVICE TRUCK */
   | | | | Alert operator to possible incursion
   | | | | /* MAY BE AN AIRCRAFT ENTERING THE SYSTEM */
45   | | | | Start a new track
   | | else
   | | | Request status from adjacent light

```

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```

| | | if (Adjacent light is OK)
| | | | /* NON CONFIRMED DETECTION */
5 | | | else
| | | | Flag adjacent light for repair
| | | endif
| | endif
10 | endif
| if (Edge light loses a detection AND status is OK)
| | if (Next block showed a detection)
15 | | | /* PROPER HANDOFF */
| | | else
| | | | if (vehicle speed > = takeoff)
20 | | | | Handoff to departure control
| | | | else
| | | | /* MISSING HANDOFF */
25 | | | | Alert operator to possible incursion
| | | | endif
| | | endif
| | endif
30 | endif
| /* CHECK FOR POSSIBLE COLLISIONS */
| for (all tracked aircraft)
35 | | Plot future position
| | if (position conflict)
| | | Alert operator to possible incursion
40 | | | endif
| | endif
| endif
45 | Update display
endwhile

```

Referring again to FIG. 1 and FIG. 2, the control of taxiway lighting intensity is usually done by placing all the lights on the same series circuit and then regulating the current in that circuit. In the present embodiment the intensity of the lamp 40 is controlled by sending a message with the light intensity value to the microprocessor 44 located within the light assembly 20<sub>1-n</sub>. The message allows for intensity settings in the range of 0 to 100% in 0.5% steps. The use of photocell 46 to check the light output allows a return message to be sent if the bulb does not respond. This in turn generates a maintenance report on the light. The strobe light 48 provides an additional optional capability under program control of the microprocessor 44. Each of the microprocessors 44 in the edge light assemblies 20 is individually addressable. This means every lamp on the field is controlled individually by the central computer system 12.

The system 10 can be programmed to provide an Active Runway Indicator by using the strobe lights 48 in those edge light assemblies 20<sub>1-n</sub> located on the runway 64 to continue the approach light "rabbit" strobe

pattern all the way down the runway. This lighting pattern could be turned-on as a plane is cleared for landing and then turned-off after the aircraft has touched down. A pilot approaching the runway along an intersecting taxiway would be alerted in a clear and unambiguous way that the runway was active and should not be crossed.

5 If an incursion was detected the main computers 26, 28 could switch the runway strobe lights 48 from the "rabbit" pattern to a pattern that alternatively flashes either side of the runway in a wig-wag fashion. A switch to this pattern would be interpreted by the pilot of an arriving aircraft as a wave off and a signal to go around. The abrupt switch in the pattern of the strobes would be instantaneously picked up by the air crew in time for them to initiate an aborted landing procedure.

10 During Category III weather conditions both runway and taxiway visibility are very low. Currently radio based landing systems are used to get the aircraft from final approach to the runway. Once on the runway it is not always obvious which taxiways are to be used to reach the airport terminal. In system 10 the main computers 26,28 can control the taxiway lamps 40 as the means for guiding aircraft on the ground during CAT III conditions. Since the intensity of the taxiway lamps 40 can be controlled remotely, the lamps just in front of an aircraft could be intensified or flashed as a means of guiding it to the terminal.

15 Alternatively, a short sequence of the "rabbit" pattern may be programmed into the taxiway strobes just in front of the aircraft. At intersections, either the unwanted paths may have their lamps turned off or the entrance to the proper section of taxiway may flash directing the pilot to head in that direction. Of course in a smart system only those lights directly in front of a plane would be controlled, all other lamps on the field would remain in their normal mode.

20 Referring now to FIG. 9, a block diagram is shown of the data flow within the system 10 (as shown in FIG. 1 and FIG. 5). The software modules are shown that are used to process the data within the computers 26, 28 of the central computer system 12. The tracking of aircraft and other vehicles on the airport operates under the control of a sensor fusion software module 101 which resides in the computers 26, 28. The sensor fusion software module 101 receives data from the plurality of sensors 50, a sensor 50 being located in each edge light assembly 20<sub>1-n</sub> which reports the heat level detected, and this software module 101 combines this information through the use of rule based artificial intelligence to create a complete picture of all ground traffic at the airport on a display 30 of the central computer system 12.

25 The tracking algorithm starts a track upon the first report of a sensor 50 detecting a heat level that is above the ambient background level of radiation. This detection is then verified by checking the heat level reported by the sensor directly across the pavement from the first reporting sensor. This secondary reading is used to confirm the vehicle detected and to eliminate false alarms. After a vehicle has been confirmed the sensors adjacent to the first reporting sensor are queried for changes in their detected heat level. As soon as one of the adjacent sensors detects a rise in heat level a direction vector for the vehicle can be established. This process continues as the vehicle is handed off from sensor to sensor in a bucket brigade fashion as shown in FIG. 7. Vehicle speed can be roughly determined by calculating the time between vehicle detection by adjacent sensors. This information is combined with information from a system data base on the location of each sensor to calculate the velocity of the target. Due to hot exhaust or jet blast, the sensors behind the vehicle may not return to a background level immediately. Because of these condition, the algorithm only uses the first four sensors (two on either side of the taxiway) to calculate the vehicles position. The vehicle is always assumed to be on the centerline of the pavement and between the first four reporting sensors.

30 Vehicle identification can be added to the track either manually or automatically by an automated source that can identify a vehicle by its position. An example would be prior knowledge of the next aircraft to land on a particular runway. Tracks are ended when a vehicle leaves the detection system. This can occur in one of two ways. The first way is that the vehicle leaves the area covered by the sensors 50. This is determined by a vehicle track moving in the direction of a gateway sensor and then a lack of detection after the gateway sensor has lost contact. A second way to leave the detection system is for a track to be lost in the middle of a sensor array. This can occur when an aircraft departs or a vehicle runs onto the grass. Takeoff scenarios can be determined by calculating the speed of the vehicle just before detection was lost. If the vehicle speed was increasing and above rotation speed then the aircraft is assumed to have taken off. If not then the vehicle is assumed to have gone on to the grass and an alarm is sounded.

35 Referring to FIG. 5 and FIG. 9, the ground clearance routing function is performed by the speech recognition unit 33 along with the ground clearance compliance verifier software module 103 running on the computers 26, 28. This software module 103 comprises a vehicle identification routine, clearance path routing, clearance checking routine and a path checking routine.

40 The vehicle identification routine is used to receive the airline name and flight number (i.e. "Delta 374") from the speech recognition unit 33 and it highlights the icon of that aircraft on the graphic display of the airport on display 30.

The clearance path routine takes the remainder of the controller's phrase (i.e. "outer taxiway to echo, hold short of runway 15 Left") and provides a graphical display of the clearance on the display 30 showing the airport.

The clearance checking routine checks the clearance path for possible conflict with other clearances and vehicles. If a conflict is found the portion of the path that would cause an incursion is highlighted in a blinking red and an audible indication is given to the controller via speaker 32.

The path checking routine checks the actual path of the vehicle as detected by the sensors 50 after the clearance path has been entered into the computers 26, 28 and it monitors the actual path for any deviation. If this routine detects that a vehicle has strayed from the assigned course, the vehicle icon on the graphic display of the airport flashes and an audible indicator is given to the controller via speaker 32 and optionally the vehicle operator via radio 37.

The airport system 10 operates in a vehicle detection mode under the control of safety logic routines which reside in the collision detection software module 104 running on computers 26, 28. The safety logic routines receive data from the sensor fusion software module 101 via the tracker software module 102 location program and interpret this information through the use of rule based artificial intelligence to predict possible collisions or runway incursions. This information is then used by the central computer system 12 to alert tower controllers, aircraft pilots and truck operators to the possibility of a runway incursion. The tower controllers are alerted by the display 30 along with a computer synthesized voice message via speaker 32. Ground traffic is alerted by a combination of traffic lights, flashing lights, stop bars and other alert lights 34, lamps 40 and 48, and computer generated voice commands broadcast via radio 36.

Knowledge based problems are also called fuzzy problems and their solutions depend upon both program logic and an interface engine that can dynamically create a decision tree, selecting which heuristics are most appropriate for the specific case being considered. Rule based systems broaden the scope of possible applications. They allow designers to incorporate judgement and experience, and to take a consistent solution approach across an entire problem set.

The programming of the rule based incursion detections software is very straight forward. The rules are written in English allowing the experts, in this case the tower personnel and the pilots, to review the system at an understandable level. Another feature of the rule based system is that the rules stand alone. They can be added, deleted or modified without affecting the rest of the code. This is almost impossible to do with code that is created from scratch. An example of a rule we might use is:

```
If (Runway_Status = Active)
    then (Stop_Bar_Lights = RED).
```

This is a very simple and straight forward rule. It stands alone requiring no extra knowledge except how Runway\_Status is created. So let's make some rules affecting Runway\_Status.

```
If (Departure = APPROVED) or (Landing = IMMINENT),
    then (Runway_Status = ACTIVE).
```

For incursion detection, another rule is:

```
If (Runway_Status = ACTIVE) and (Intersection = OCCUPIED),
    then (Runway_Incursion = TRUE).
```

Next, detect that an intersection of a runway and taxiway are occupied by the rules:

```
If (Intersection_Sensors = DETECT),
    then (Intersection = OCCUPIED).
```

To predict that an aircraft will run a Hold Position stop, the following rule is created:

```
If (Aircraft_Stopping_Distance > Distance_to_Hold_Position),
    then (Intersection = OCCUPIED).
```

In order to show that rules can be added without affecting the reset of the program, assume that after a demonstration of the system 10 to tower controllers, they decided that they wanted a "Panic Button" in the tower to override the rule based software in case they spot a safety violation on the ground. Besides installing the button, the only other change would be to add this extra rule.

```
If (Panic_button = PRESSED),
    then (Runway_Incursion = TRUE).
```

It is readily seen that the central rule based computer program is very straight forward to create, understand and modify. As types of incursions are defined, the system 10 can be upgraded by adding more rules.

Referring again to FIG. 9, the block diagram shows the data flow between the functional elements within the system 10 (FIG. 1). Vehicles are detected by the sensor 50 in each of the edge light assemblies 20<sub>1-n</sub>. This information is passed over the local operating network (LON) via edge light wiring 21<sub>1-n</sub> to the LON bridges 22<sub>1-n</sub>. The individual message packets are then passed to the redundant computers 26 and 28 over the wide area network (WAN) 14 to the WAN interface 108. After arriving at the redundant computers 26 and 28, the message packet is checked and verified by a message parser software module 100. The contents of the mes-



sage are then sent to the sensor fusion software module 101. The sensor fusion software module 101 is used to keep track of the status of all the sensors 50 on the airport; it filters and verifies the data from the airport and stores a representative picture of the sensor array in a memory. This information is used directly by the display 30 to show which sensors 50 are responding and used by the tracker software module 102. The tracker software module 102 uses the sensor status information to determine which sensor 50 reports correspond to actual vehicles. In addition, as the sensor reports and status change, the tracker software module 102 identifies movement of the vehicles and produces a target location and direction output. This information is used by the display 30 in order to display the appropriate vehicle icon on the screen.

The location and direction of the vehicle is also used by the collision detection software module 104. This module checks all of the vehicles on the ground and plots their expected course. If any two targets are on intersecting paths, this software module generates operator alerts by using the display 30, the alert lights 34, the speech synthesis unit 29 coupled to the associated speaker 32, and the speech synthesis unit 31 coupled to radio 37 which is coupled to antenna 39.

Still referring to FIG. 9, another user of target location and position data is the ground clearance compliance verifier software module 103. This software module 103 receives the ground clearance commands from the controller's microphone 35 via the speech recognition unit 33. Once the cleared route has been determined, it is stored in the ground clearance compliance verifier software module 103 and used for comparison to the actual route taken by the vehicle. If the information received from the tracker software module 102 shows that the vehicle has deviated from its assigned course, this software module 103 generates operator alerts by using the display 30, the alert lights 34, the speech synthesis unit 29 coupled to speaker 32, and the speech synthesis unit 31 coupled to radio 37 which is coupled to antenna 39.

The keyboard 27 is connected to a keyboard parser software module 109. When a command has been verified by the keyboard parser software module 109, it is used to change display 30 options and to reconfigure the sensors and network parameters. A network configuration data base 106 is updated with these reconfiguration commands. This information is then turned into LON message packets by the command message generator 107 and sent to the edge light assemblies 20<sub>1-n</sub> via the WAN interface 108 and the LON bridges 22<sub>1-n</sub>.

This concludes the description of the preferred embodiment. However, many modifications and alterations will be obvious to one of ordinary skill in the art without departing from the spirit and scope of the inventive concept. Therefore, it is intended that the scope of this invention be limited only by the appended claims.

## Claims

1. An airport surveillance system comprising:
  - a plurality of light circuits on an airport, each of said light circuits comprises a plurality of light assembly means;
  - means for providing power to each of said plurality of light circuits and to each of said light assembly means;
  - means in each of said light assembly means for sensing ground traffic on said airport;
  - means for processing data received from each of said light assembly means;
  - means for providing data communication between each of said light assembly means and said processing means; and
  - said processing means comprises means for providing a graphic display of said airport comprising symbols representing said ground traffic, each of said symbols having direction and velocity data displayed.
2. The airport surveillance system as recited in Claim 1 wherein:
  - each of said light circuits being located along the edges of a taxiway or a runway on said airport.
3. The airport surveillance system as recited in Claim 1 wherein said light assembly means comprises:
  - light means coupled to said lines of said power providing means for lighting said airport;
  - said sensing means;
  - microprocessor means coupled to said light means, said sensing means, and said data communication means for providing processing, communication and control for said light assembly means, said microprocessor controlling a plurality of lighting patterns of said light means on said airport; and
  - said data communication means being coupled to said microprocessor means and said lines of said power providing means.

4. The airport surveillance system as recited in Claim 3 wherein:  
said sensing means comprises an infrared detector.
- 5 5. The airport surveillance system as recited in Claim 3 wherein:  
said light assembly means further comprises a photocell means coupled to said microprocessor  
means for detecting the light intensity of said light means.
6. The airport surveillance system as recited in Claim 3 wherein:  
said light assembly means further comprises a strobe light coupled to said microprocessor means.
- 10 7. The airport surveillance system as recited in Claim 1 wherein:  
said processing means comprises redundant computers for fault tolerance operation.
8. The airport surveillance system as recited in Claim 1 wherein:  
said symbols representing said ground traffic comprise icons having a shape indicating type of air-  
15 plane or vehicle.
9. The airport surveillance system as recited in Claim 1 wherein:  
said processing means determines a location of said symbols on said graphic display of said airport  
in accordance with said data receive from said light assembly means.
- 20 10. The airport surveillance system as recited in Claim 1 wherein:  
said processing means determines a future path of said ground traffic based on a ground clearance  
command, said future path being shown on said graphic display.
- 25 11. The airport surveillance system as recited in Claim 1 wherein said power providing means comprises:  
constant current power means for providing a separate line to each of said plurality of light circuits;  
and  
network bridge means coupled to said constant current power means for providing a communica-  
tion channel to said processing means for each line of said constant current power means.
- 30 12. An airport surveillance system comprising:  
a plurality of light circuits on an airport, each of said light circuits comprises a plurality of light as-  
sembly means;  
means for providing power to each of said plurality of light circuits and to each of said light assembly  
35 means;  
means in each of said light assembly means for sensing ground traffic on said airport;  
means in each of said light assembly means coupled to said sensing means for providing commu-  
nication and control for said light assembly means;  
means for processing data received from each of said light assembly means;  
40 means for providing data communication between each of said light assembly means and said proc-  
essing means; and  
said processing means comprises means for providing a graphic display of said airport comprising  
symbols representing said ground traffic in accordance with said data received from each of said light  
assembly means, each of said symbols having direction and velocity data displayed.
- 45 13. The airport surveillance system as recited in Claim 12 wherein:  
said sensing means comprises an infrared detector.
14. The airport surveillance system as recited in Claim 12 wherein:  
50 each of said light circuits being located along the edges of a taxiway or a runway on said airport.
15. The airport surveillance system as recited in Claim 12 wherein:  
said light assembly means further comprises a photocell means coupled to said communication  
and control providing means for detecting a light intensity of said light assembly means.
- 55 16. The airport surveillance system as recited in Claim 12 wherein:  
said light assembly means further comprises a strobe light coupled to said communication and con-  
trol providing means.

17. The airport surveillance system as recited in Claim 12 wherein:  
said processing means comprises redundant computers for fault tolerance operation.
- 5 18. The airport surveillance system as recited in Claim 12 wherein:  
said symbols representing said ground traffic comprise icons having a shape indicating type of air-  
plane or vehicle.
- 10 19. The airport surveillance system as recited in Claim 12 wherein:  
said processing means determines a future path of said ground traffic based on a ground clearance  
command, said future path being shown on said graphic display.
- 15 20. The airport surveillance system as recited in Claim 12 wherein said power providing means comprises:  
constant current power means for providing a separate line to each of said plurality of light circuits;  
and  
network bridge means coupled to said constant current power means for providing a communica-  
tion channel to said processing means for each line of said constant current power means.
- 20 21. A method of providing an airport surveillance system comprising the steps of:  
providing a plurality of light circuits on said airport, each of said light circuits comprises a plurality  
of light assembly means;  
providing power to each of said plurality of light circuits;  
sensing ground traffic on said airport with means in each of said light assembly means;  
processing data received from each of said light assembly means in computer means;  
providing a graphic display of said airport comprising symbols representing said ground traffic,  
each of said symbols having direction and velocity data displayed; and  
25 providing data communication between said computer means and each of said light assembly  
means.
- 30 22. The method as recited in Claim 21 wherein said step of sensing said ground traffic on said airport com-  
prises the steps of:  
lighting said airport with a light means coupled to said power lines;  
providing infrared detectors for sensing ground traffic;  
performing processing, communication and control within said light assembly means with a micro-  
processor means coupled to said light means, said infrared detectors and data communication means;  
and  
35 coupling said data communication means between said microprocessor means and said power  
lines.
- 40 23. The method recited in Claim 21 wherein said step of processing data comprises the step of operating re-  
dundant computers for fault tolerance.
- 45 24. The method as recited in Claim 21 wherein said step of providing power comprises the steps of:  
providing a separate line to each of said plurality of light circuits with a constant current power  
means; and  
providing a communication channel to said computer means for each line of said constant current  
power means using a network bridge means.
- 50 25. The method as recited in Claim 21 wherein said step of providing a graphic display comprising symbols  
representing said ground traffic comprises the step of indicating a type of aircraft or vehicle with icons  
of various shapes.
- 55 26. The method as recited in Claim 21 wherein said step of processing said data from each of said light as-  
sembly means comprises the step of determining a location of said symbols on said graphic display of  
said airport in accordance with said data.

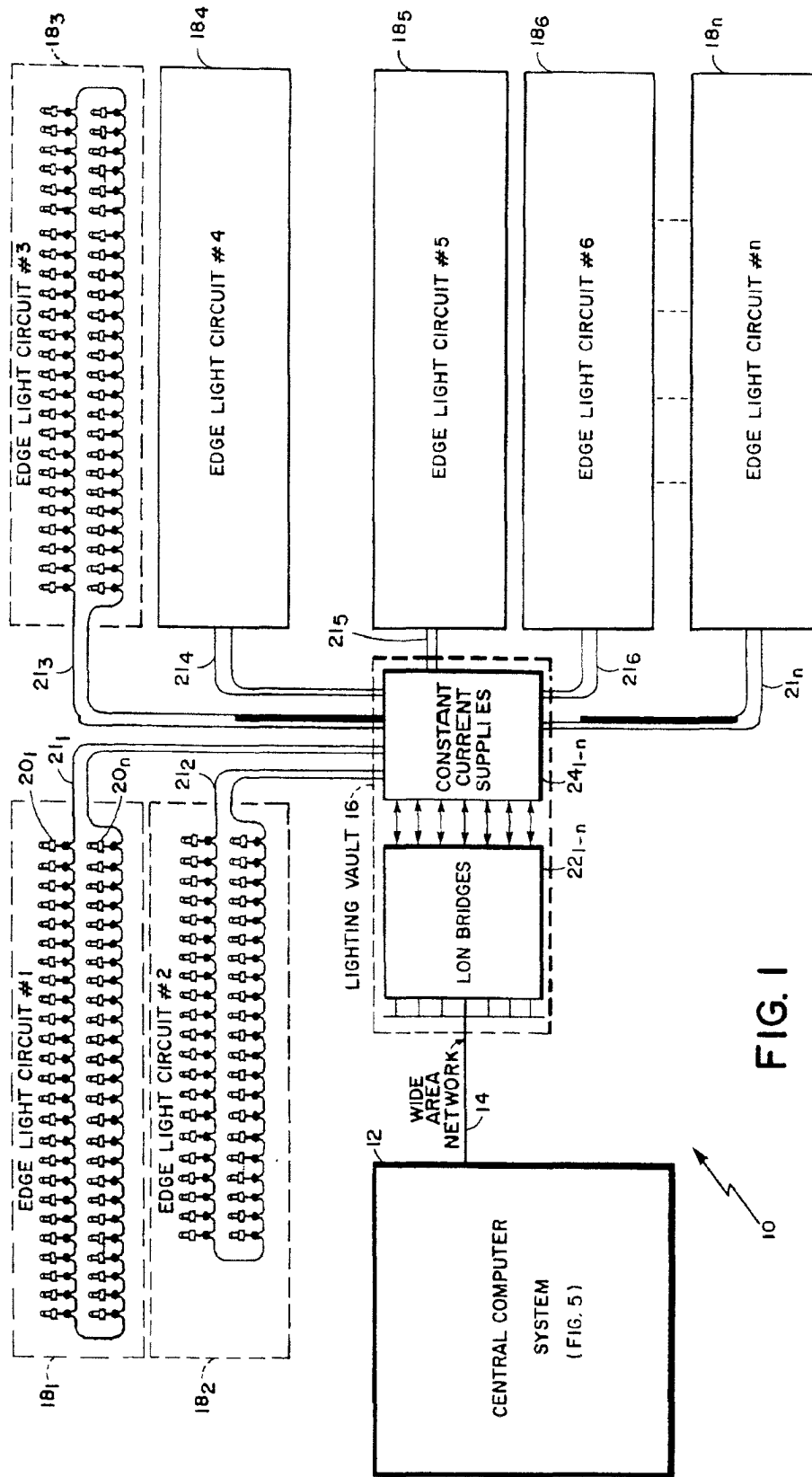
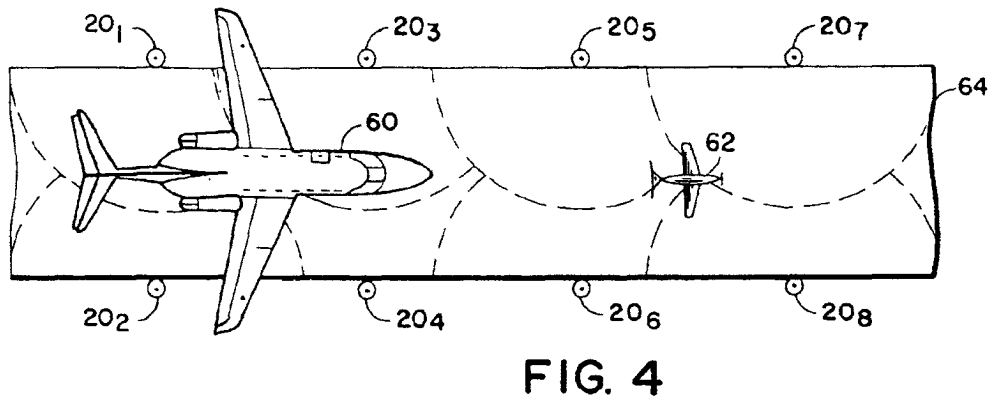
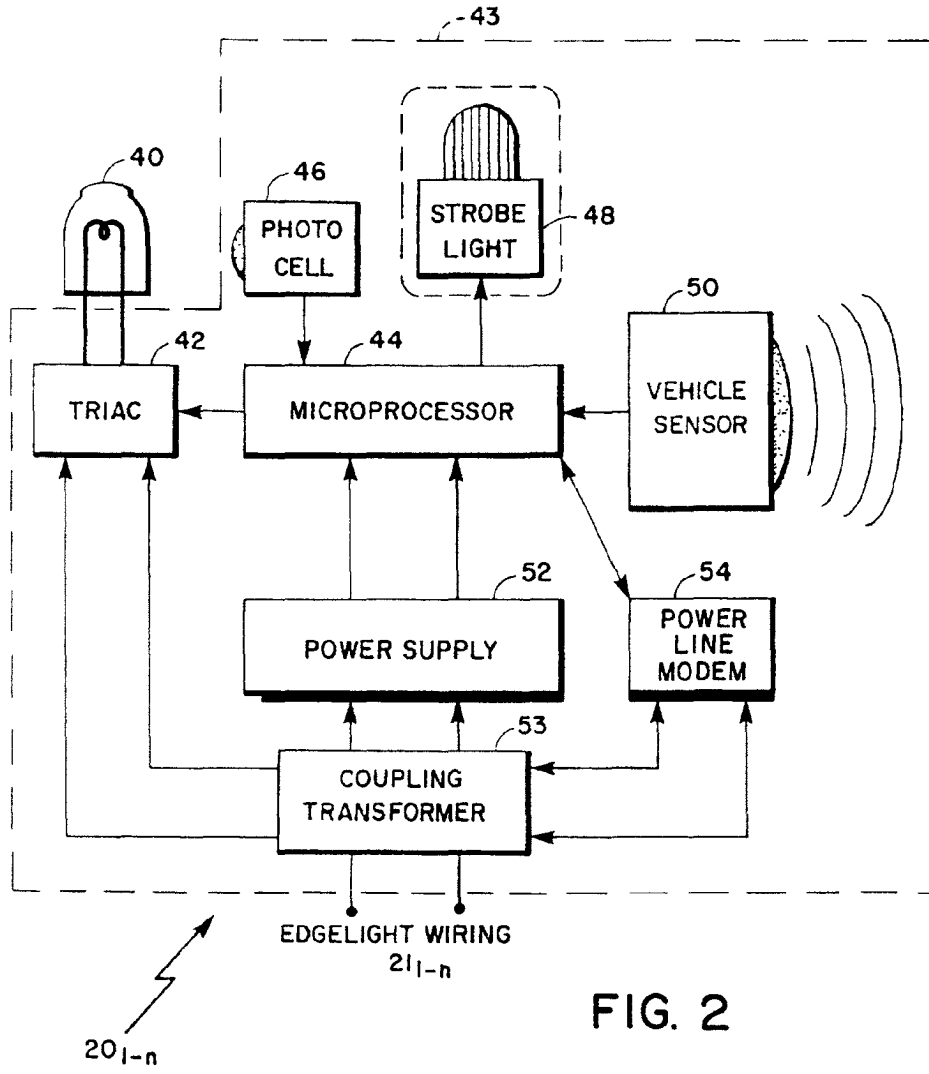


FIG. 1



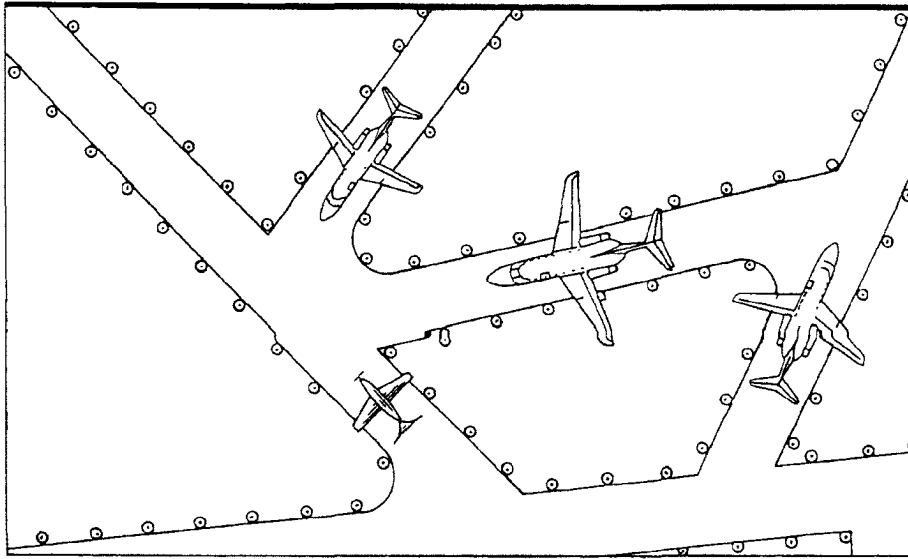


FIG. 8

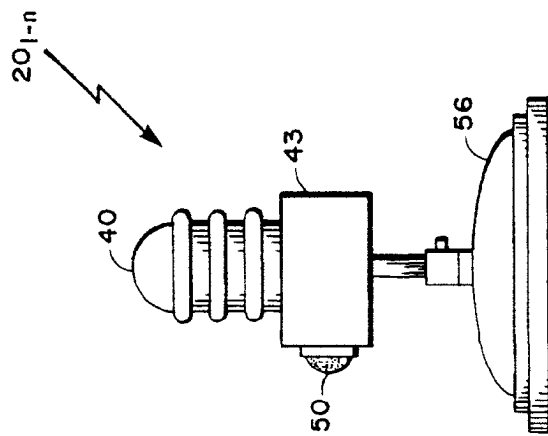


FIG. 3

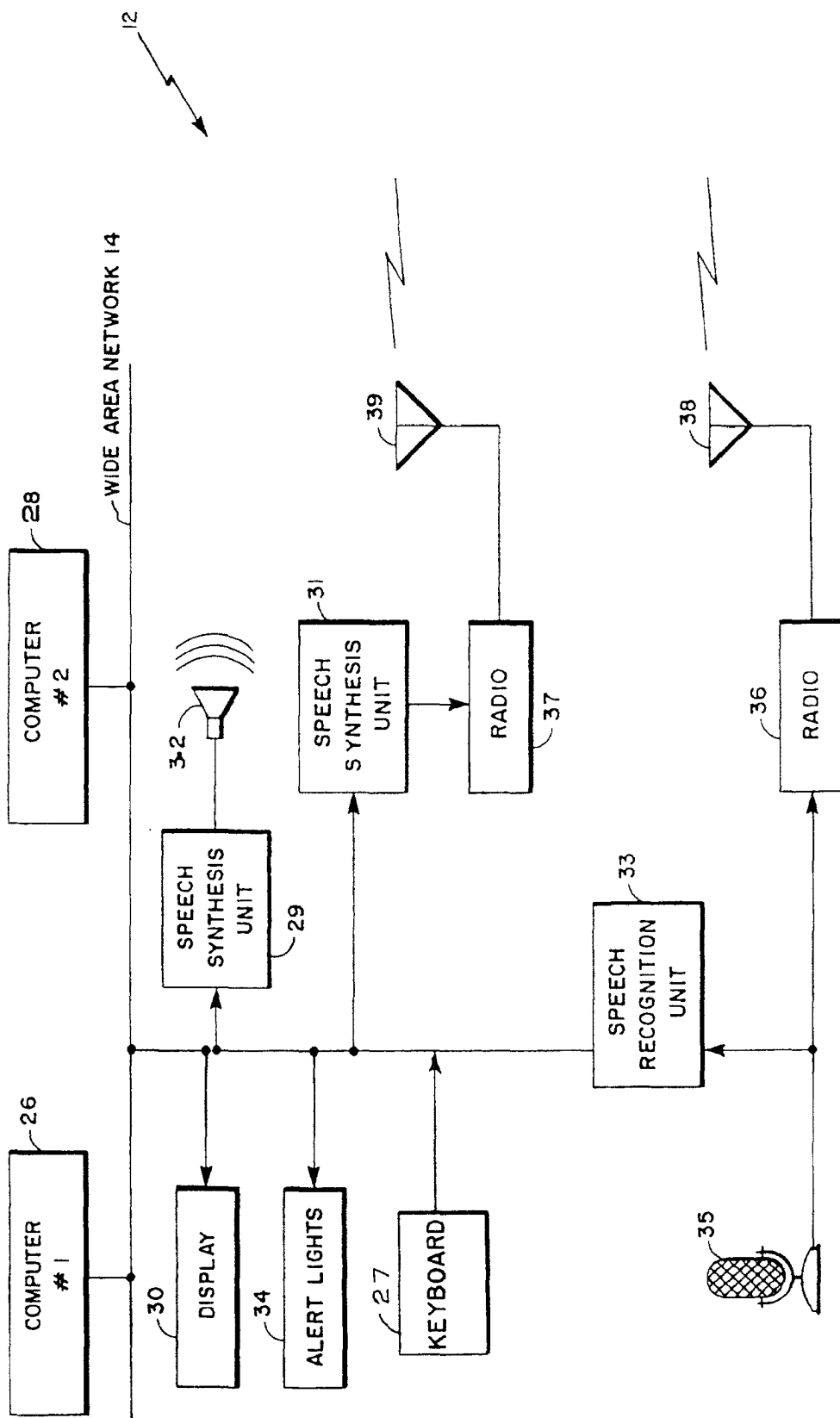


FIG. 5

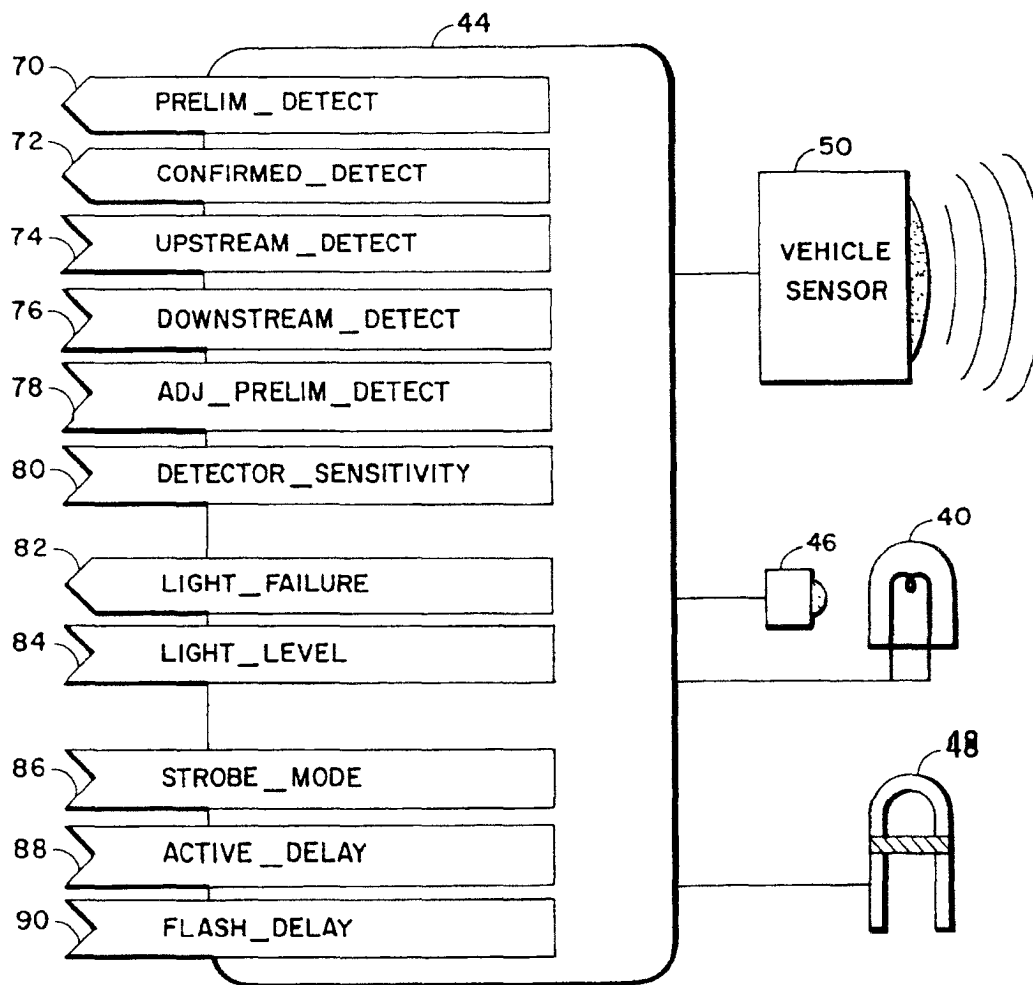


FIG. 6



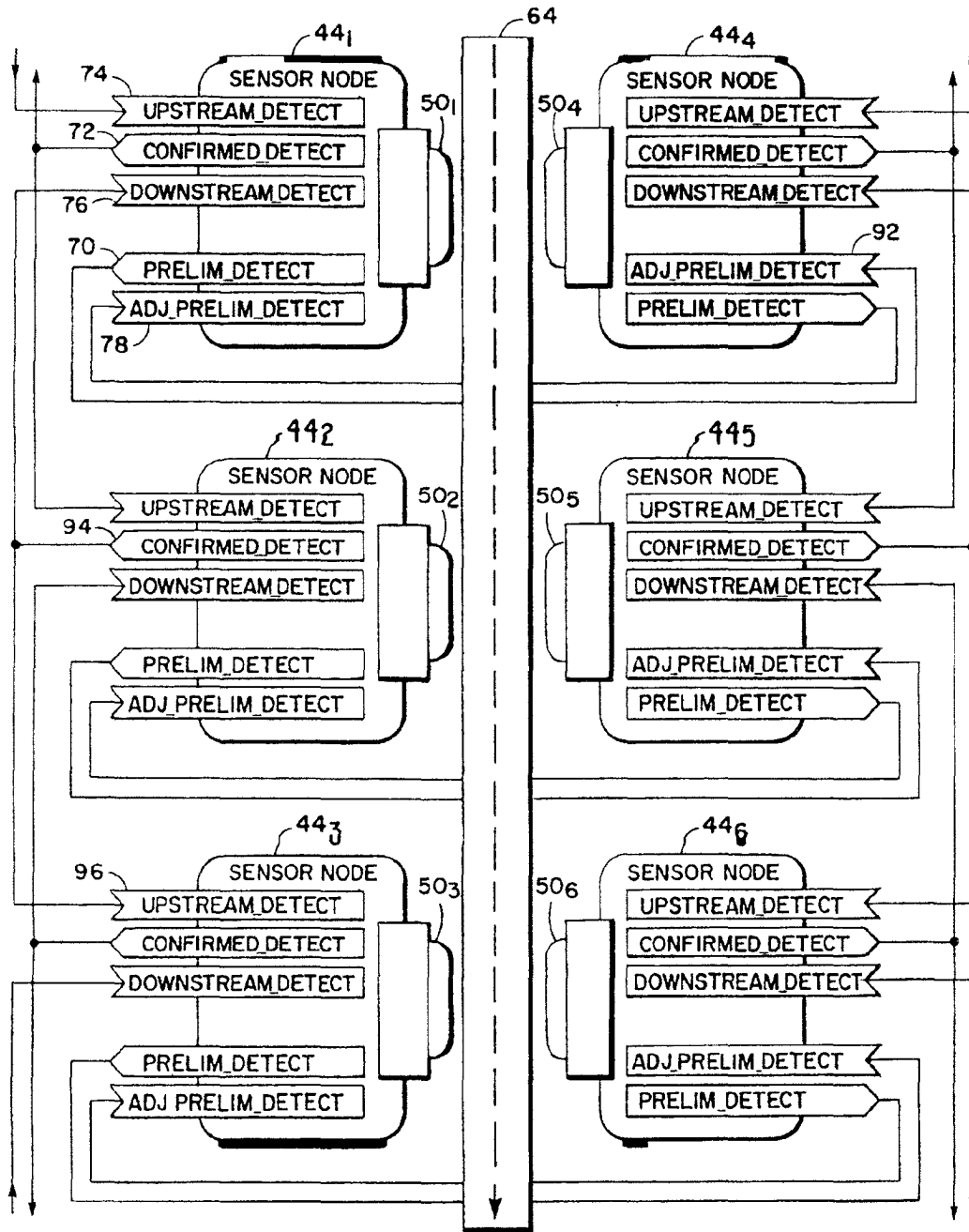


FIG. 7

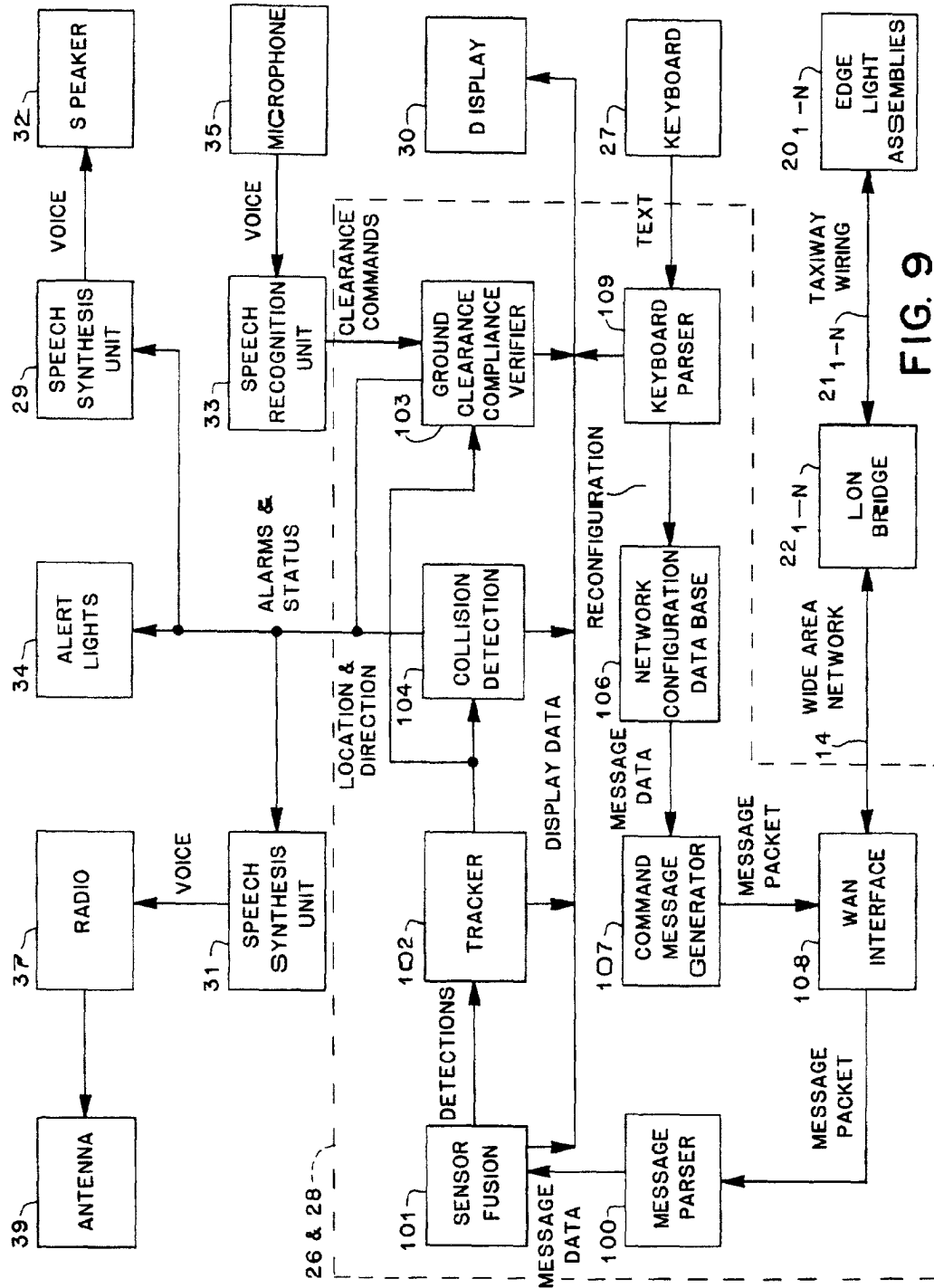


FIG. 9



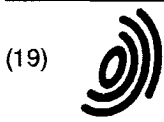
European Patent  
Office

EUROPEAN SEARCH REPORT

Application Number  
EP 94 30 1263

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	WO-A-90 04242 (SWEDISH AIRPORT TECHNOLOGY HB)	1-3, 5, 7, 11-15, 17, 20-24	G08G5/06
Y	* the whole document *	4, 6, 8-10, 16, 18, 19, 25, 26	
Y	US-A-3 706 969 (PAREDES) * column 6, line 53 - line 56 *	4	
Y	* column 3, line 18 - column 4, line 59 *	10, 19	
Y	EP-A-0 209 397 (GENERAL DE INVESTIGACION Y DESARROLLO S.A.) * claims 1, 5-13, 23, 27 *	8, 9, 18, 25, 26	
D	& US-A-4 845 629 (MURGA ET AL.)		
Y	US-A-4 093 937 (HABINGER) * column 2, line 3 - line 33 *	6, 16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			G08G
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		20 June 1994	Reekmans, M
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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(54) Airport surface monitoring and runway incursion warning system

(57) An airport runway incursion warning system (10) for monitoring air and ground traffic at an airport. The system (10) is optimally used with an aircraft (12) that has an electronic tag (21) or interrogation system (21) that stores identification information regarding the aircraft (12), and an RF transponder (22) for receiving interrogation signals and for transmitting the identification information in response thereto. A radar system (41, 20) comprises a plurality of radar sensor units (13) disposed at predetermined installation sites adjacent to a runway (11). Each radar sensor unit (13) typically has an interface processor (42, 14) and telemetry electronics (43, 14a) for communication, although hard-wired communication paths may be used. An RF/telemetry interface (43, 18) is provided for communicating with the radar sensor units (13) when the interface processor (42, 14) and telemetry electronics (43, 14a) are used. The RF/telemetry interface (43, 18) is also used to transmit the interrogation signals to the aircraft (12) and receive the identification information therefrom. A central processing unit (44, 16) is coupled to the radar sensor units (13) for receiving and integrating radar data produced by each the radar sensor units (13) to produce a map of the runway (11) that identifies authorization objects (26) and aircraft (12) that do not constitute intrusion threats, and intruding objects that do constitute intrusion threats to the runway (11). The central processing unit (44, 16) is optionally coupled to the RF/telemetry interface (43, 18) for transmitting signals to and from the aircraft (12), and in this case, the central processing unit (44, 16) processes identification information received from the aircraft (12) to integrate the identification information into to generate a displayed image. An operator display (45, 17) is coupled to the central processing unit (44, 16) for displaying the map

and identification information generated thereby for use by an operator.

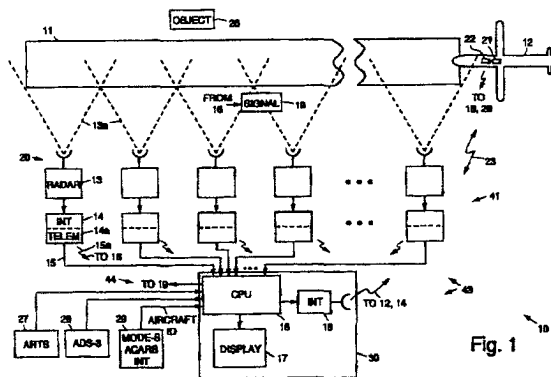


Fig. 1

## Description

### BACKGROUND

The present invention relates to radar systems, and more particularly, to a radar system that is used to provide surface monitoring and runway incursion for airports.

The prevention of runway incursions has been an issue of increasing concern and has resulted in the development of the Airport Surface Detection Equipment (ASDE-3), the Airport Movement Area System (AMASS), and the Airport Surface Traffic Automation Program (ASTA).

The most relevant prior art relating to the present invention, and airport surface monitoring and runway incursion systems in particular is the ASDE-3 radar system which is a single high power Ku-Band real aperture radar that is located on a tower adjacent to an airport. The ASDE-3 system experiences shadowing and multiple reflections that seriously affect its performance, which is a consequence of the fact that it is a single radar system. The ASDE-3 radar system does not have the ability to interrogate vehicles or aircraft monitored by the system. The ASDE-3 radar system is also relatively expensive.

Therefore, it is an objective of the present invention to provide for an improved radar system that may be used to monitor surface and runway incursion at airports, and the like, and which improves upon the currently-used ASDE-3 radar system.

### SUMMARY OF THE INVENTION

In order to meet the above and other objectives, the present invention is a runway incursion warning system for monitoring a runway of an airport and for displaying data indicative of unauthorized intrusion onto the runway to an operator. A radar system is provided that comprises a plurality of radar sensor units that are disposed at predetermined installation sites adjacent to selected runways of the airport. Each radar sensor unit associated with a particular runway generates a radar beam that typically overlaps the adjacent radar beam to provide complete coverage of a runway. Each radar sensor unit is coupled to a collocated interface processor and telemetry electronics that interface between the radar sensor unit and a central processing unit. Communication between each radar sensor unit and the central processing unit may be by physical electrical interconnection and/or RF communication using the telemetry electronics. The physical electrical interconnection may be provided by way of existing cabling normally for runway lights to provide power and the communication link for each of the radar sensor units.

The central processing unit is coupled to an operator display that processed data derived from each of the radar sensor units and displays the data on the operator display. The central processing unit is coupled to an

RF/telemetry interface that is used to communicate with the radar sensor units and to aircraft having an electronic tag or transponder system. The central processing unit also integrates and causes the display of data derived from other systems coupled to it, such as the ARTS, ASDE-3, MODE-S or ACARS systems, for example. The central processing unit also generates a display showing the airport runways along with moving and non-moving physical objects that are in the vicinity of the runway. Such objects include departing and arriving aircraft, buildings, and vehicles that are in the vicinity of the runway. Thus, the present system provides a complete display of the runway environment to an operator.

The system may be used with non-cooperative objects or vehicles, or with aircraft or vehicles that have the electronic tag or RF transponder (transmitter and receiver) system. The electronic tag or RF transponder system contains identification information regarding the aircraft, vehicle, or object. The tag or RF transponder receives interrogation signals and transmits the identification information, and other additional information, if desired, in response to the interrogation signals.

The interface processor and telemetry electronics at each radar sensor unit and the RF/telemetry interface provide a communication link between the radar sensor units and the central processing unit. The RF/telemetry interface transmits the interrogation signals and receives the identification information from the aircraft and other cooperative objects or vehicles. Alternatively, the identification information may be received by a central receiver at the airport while the RF/telemetry interface only transmits interrogation signals in conformance with existing aircraft equipment, such as MODE-S or ACARS systems, for example. Multiple interrogation signals sent by different sensor units are separated and identified on the basis of timing, for example, for reception of identifications signals or GPS position information contained in the identification signals themselves.

The telemetry electronics receives data produced by the radar sensor units and the central processing unit integrates the data derived from the radar sensor units and the electronic tag or transponder system in the aircraft. The central processing unit processes data derived from the radar system and identification information received from the electronic tag to produce a map of the airport that identifies authorization objects and aircraft that are not intrusion threats, and intruding objects that are intrusion threats. The operator display displays the map generated by the central processing unit.

The central processing unit generates warning signals in response to intrusion threats that are detected by the system and wherein the warning signals are transmitted to the aircraft by means of the RF/telemetry interface and the RF transponder system. The central processing unit generates an image of the runways that identifies objects, aircraft that are landing and taking off from the runways, and identifying information associ-

ated with interrogated aircraft derived from the electronic tag or transponder system. The central processing unit may also produce data that is displayed on the map that includes priority alert information indicating aircraft that may impose a possible runway incursion, a list of arriving and departing aircraft, and displays that show landing and take-off patterns of arriving and departing aircraft.

The system thus provides for a distributed system of relatively low-cost radars disposed adjacent the runways. Each radar has limited angular coverage and the complete system provides coverage of the entire airport runway area. The present system provides a surface map of aircraft and surface vehicles and point interrogation of aircraft for identification purposes using the electronic tags or transponder system.

The present runway incursion warning system is considerably less expensive than the ASDE-3 radar system, and does not suffer from the shadowing and multiple reflection problems experienced by the ASDE-3 system. The system is scalable to provide monitoring of different size airports. The system provides high range resolution and velocity information, and may be used to interrogate electronic tags or transponder systems disposed on vehicles and aircraft to provide identification information to aircraft traffic controllers that operate the system. The system provides a real-time display of airport surface traffic and warnings of runway incursion.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawing, wherein like reference numerals designate like structural elements, and in which:

Fig. 1 illustrates a system block diagram of a runway incursion warning system in accordance with the principles of the present invention; and

Fig. 2 illustrates a typical video display produced by the runway incursion warning system of Fig. 1.

#### DETAILED DESCRIPTION

Referring to the drawing figure, Fig. 1 illustrates a system block diagram of a runway incursion warning system 10 in accordance with the principles of the present invention. The system 10 includes a radar system 20 that is comprised of a plurality of radar sensor units 13, such as millimeter wave radar sensor units 13, for example, disposed at predetermined installation sites on the ground adjacent to a runway 11, or runways 11, of an airport. Each radar sensor unit 13 associated with a particular runway 11 generates a radar beam 13a that typically overlaps the adjacent radar beam 13a to provide complete coverage of a runway 11, although

this is not absolutely required. Each radar sensor unit 13 is coupled to an interface processor (INT) 14 and telemetry electronics (TELEM) 14a that permit communication with a processing center 30 located in an airport control tower, for example. Intelligent processing may be performed at each installation site in the interface processor 14 to reduce the data rate of telemetered data and perform confidence tests. Existing cabling 15 for airport lights provide power and a communication link for each of the plurality of radar sensor units 13, interface processor 14, and telemetry electronics 14a. Alternatively, a dedicated RF communications link 15a may be employed.

A central processing unit (CPU) 16 integrates the data received from the plurality of radar sensor units 13, and maintains a map of authorized targets 26, such as fixed objects 26 or buildings 26 that do not constitute intrusion threats. The central processing unit 16 may also collect input data from an ARTS or ASDE-3 system 27 and available identification reports derived therefrom. The ARTS and ASDE-3 systems provide information regarding aircraft approaching the airport. Data that is derived from an ASDE-3 radar 28, if available, may also be integrated by the central processing unit 16, and a dynamic real-time situation display 17 is provided to an aircraft controller, in graphic format, that is clear and easy to interpret. A sample image on the video display 17 that is presented to an operator of the system 10 is shown in Fig. 2.

The aircraft 12 includes an electronic tag or interrogation system 21 such as a MODE-S or ACARS transponder system 21, for example, that provides identification information regarding the aircraft, and an RF transponder system 22. Warning signals may be transmitted to the aircraft 12 by means of the RF/telemetry interface 18 and the RF transponder system 22 over an RF communications link 23. Warning signals may also be displayed to arriving and departing aircraft 12 using ground signals 19 such as lights or beacons disposed adjacent the runway 11. In addition, the electronic tag or interrogation system 21 may be interrogated by the system 10 using the RF/telemetry interface 18 and the RF transponder system 22. Interrogation signals are transmitted to the aircraft 12 by way of the communication link 23, and the electronic tag or interrogation system 21 on the aircraft 12 responds by outputting information stored therein that is returned to the central processing unit 16 by way of the RF communications link 23.

As shown in Fig. 1, the system 10 is comprised of five major subsystems 41-45. The first subsystem 41 comprises the radar system 20 including the plurality of radar sensor units 13 and electronic components installed at each installation site. The second subsystem 42 comprises the interface processor 14 that is coupled to the radar sensor units 13 and that is located at each remote installation site. The third subsystem 43 comprises a telemetry subsystem and includes the telemetry electronics 14a installed at the installation

sites and an RF/telemetry interface 18 that is coupled to the central processing unit 16 at the central processor site. The fourth subsystem 44 comprises the central processing unit 16. The fifth subsystem 45 comprises the operator display 17 that includes a conventional display and control terminal. Each of the subsystems 41-45 employed in the present invention are well-known and their interconnection and operation is routine to those skilled in the art.

The operator display 17 used in the runway incursion warning system 10 displays information for use by an airport traffic planner or aircraft traffic controller. The data presented on the operator display 17 optimizes the available data while minimizing the need for physical interaction with the system 10. Fig. 2 illustrates a typical video image displayed on the operator display 17 by the runway incursion warning system 10. Referring to Fig. 2, the display 17 shows an image of the runways 11 of the airport and identifies the locations of buildings 26 and other stationary objects 26, aircraft 12 that are landing and taking off from the runways 11, including data 47 from the transponders 21 from interrogated aircraft 12. Typically the data 47 from each transponder system 21 indicates the aircraft number or flight number, as is indicated by the alphanumeric identifiers in the boxes shown on the display 17. Additional data may be displayed including information provided in a system area 51 that provides data regarding the instrument landing system (ILS) system, the time and other relevant system parameters, priority alert information 52 indicating objects 26 or aircraft 12 that are determined to be runway incursions, a list 53 of arriving and departing aircraft 12, and displays 34 that provide real-time images showing the landing and take-off of arriving and departing aircraft 12.

A preliminary proof-of-concept demonstration model of the present system 10 was constructed and data collection was performed at Los Angeles International Airport (LAX) using a test version of a millimeter-wave radar (radar sensor units 13) developed by the assignee of the present invention. Test results show that the system 10 works as expected and provides superior performance over the ASDE-3 radar system.

In summary, there is disclosed an airport runway incursion warning system 10 for monitoring air and ground traffic at an airport. The system 10 is optimally used with an aircraft 12 that has an electronic tag 21 or interrogation system 21 that stores identification information regarding the aircraft 12, and an RF transponder 22 for receiving interrogation signals and for transmitting the identification information in response thereto. A radar system 41, 20 comprises a plurality of radar sensor units 13 disposed at predetermined installation sites adjacent to a runway 11. Each radar sensor unit 13 typically has an interface processor 42, 14 and telemetry electronics 43, 14a for communication, although hard-wired communication paths may be used. An RF/telemetry interface 43, 18 is provided for communicating with the radar sensor units 13 when the interface processor

42, 14 and telemetry electronics 43, 14a are used. The RF/telemetry interface 43, 18 is also used to transmit the interrogation signals to the aircraft 12 and receive the identification information therefrom. A central processing unit 44, 16 is coupled to the radar sensor units 13 for receiving and integrating radar data produced by each the radar sensor units 13 to produce a map of the runway 11 that identifies authorization objects 26 and aircraft 12 that do not constitute intrusion threats, and intruding objects that do constitute intrusion threats to the runway 11. The central processing unit 44, 16 is optionally coupled to the RF/telemetry interface 43, 18 for transmitting signals to and from the aircraft 12, and in this case, the central processing unit 44, 16 processes identification information received from the aircraft 12 to integrate the identification information into to generate a displayed image. An operator display 45, 17 is coupled to the central processing unit 44, 16 for displaying the map and identification information generated thereby for use by an operator.

Thus there has been described a new and improved radar system for providing surface monitoring and runway incursion for airports. It is to be understood that the above-described embodiments are merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention.

Clearly, numerous and other arrangements can be readily devised by those skilled in the art without departing from the scope of the invention.

#### Claims

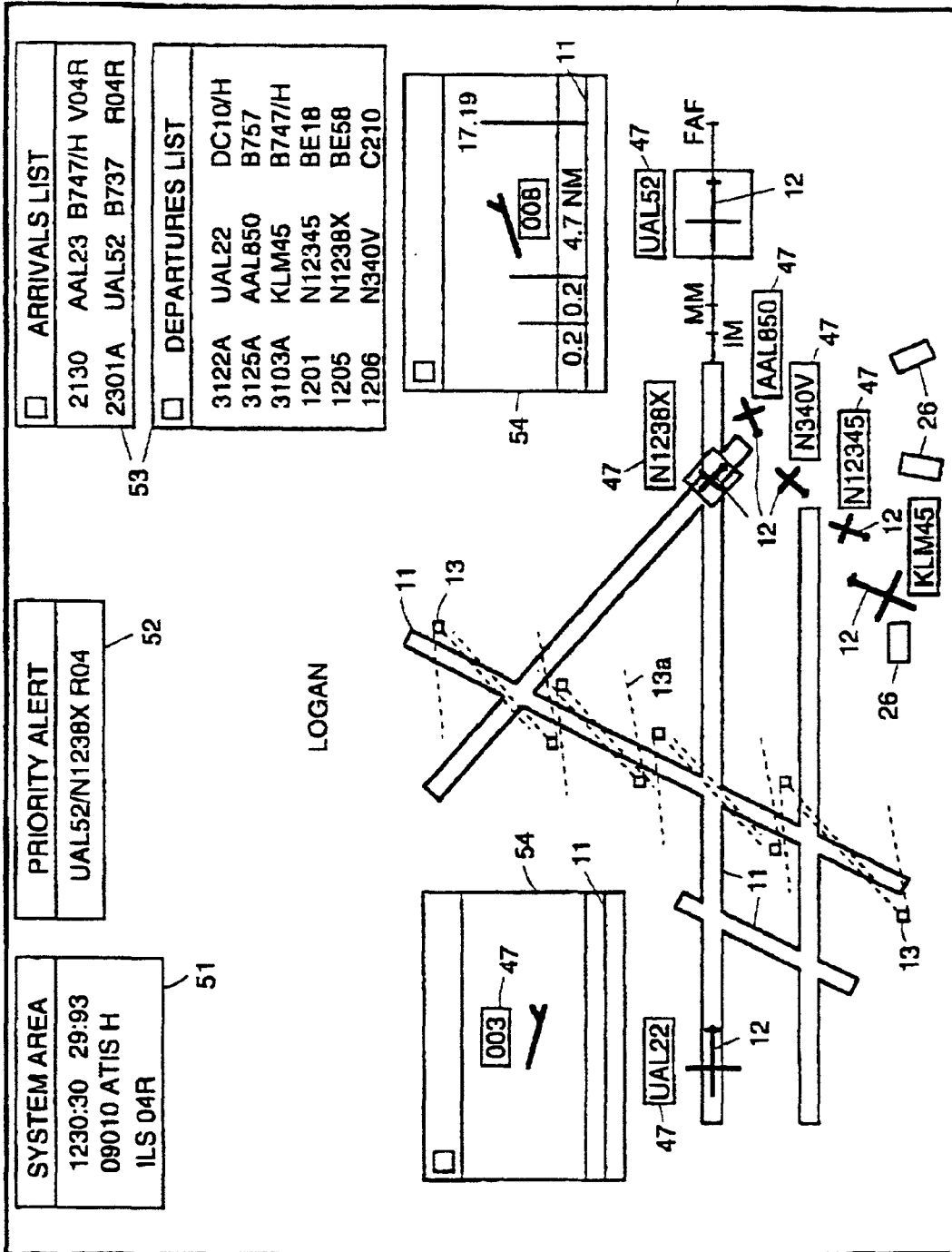
1. An airport runway incursion warning system (10) for monitoring air and ground traffic in the vicinity of a runway (11) of an airport, said system (10) characterized by:
  - a radar system (41, 20) comprising of a plurality of radar sensor units (13) disposed at predetermined installation sites adjacent to the runway (11) and wherein the plurality of radar sensor units (13) generate adjacent or substantially overlapping radar beams (13a) that illuminate the runway (11);
  - a central processing unit (44, 16) coupled to the plurality of radar sensor units (13), for receiving radar data produced by the plurality of radar sensor units (13), and for processing the radar data to produce a map of the runway (11) that identify objects (26) and aircraft (12) in the vicinity thereof;
  - an operator display (45, 17) coupled to the central processing unit (44, 16) for displaying the map of the runway (11), objects (26) and aircraft (12) generated by the central processing unit (44, 16)
2. The system (10) of Claim 1, characterized in that each radar sensor unit (13) is coupled to an interface processor (42, 14) for processing radar data generated by the radar sensor unit (13), wherein

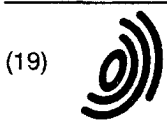
- each interface processor (42, 14) is coupled to RF telemetry electronics (43, 14a) for transmitting the radar data to the central processing unit (44, 16), and wherein the central processing unit (44, 16) is coupled to an RF/telemetry interface (43, 18) for receiving the radar data transmitted from the radar sensor unit (13) by the RF telemetry electronics (43, 14a).
3. The system (10) of Claim 2, characterized in that the aircraft (12) comprises an electronic tag (21) that stores identification information regarding the aircraft (12), and comprises an RF transponder (22) coupled to the electronic tag (21) for receiving interrogation signals generated by the central processing unit (44, 16) and for transmitting the identification information in response to the interrogation signals;  
and wherein the interrogation signals generated by the central processing unit (44, 16) are transmitted to the aircraft (12) by way of the RF/telemetry interface (43, 18), and the identification information is received from the RF transponder (22) by way of the RF/telemetry interface (43, 18) and wherein the central processing unit (44, 16) generates signals for display on the operator display (45, 17) that identifies the aircraft (12).
4. The system (10) of Claim 2 or 3, characterized in that the central processing unit (44, 16) is coupled to the plurality of radar sensor units (13) by way of a RF communications link (43, 15a) for communicating radar to the central processing unit (44, 16) by way of the RF/telemetry interface (43, 18).
5. The system (10) of any of Claims 1-4, characterized further by an ARTS system (27) coupled to the central processing unit (44, 16), and wherein the central processing unit (44, 16) processes data and identification reports derived from the ARTS system (27) and integrates them into the map that is displayed on the operator display (45, 17).
6. The system (10) of any of Claims 1-5, further characterized by an ASDE-3 radar (28) coupled to the central processing unit (44, 16) and wherein the central processing unit (44, 16) integrates data derived from the ASDE-3 radar (28) into the map that is displayed on the operator display (45, 17).
7. The system (10) of any of Claims 3-6, characterized in that the central processing unit (44, 16) generates an image of the runway (11) that identifies objects (26), aircraft (12) that are landing and taking off from the runway (11), and identifying information (47) associated with interrogated aircraft (12) derived from the transponder (21).
8. The system (10) of any of Claims 3-7, characterized in that the central processing unit (44, 16) produces data for display that includes priority alert information (51) indicating aircraft (12) that are runway incursions, a list (53) of arriving and departing aircraft (12), and displays (54) that show landing and take-off patterns of arriving and departing aircraft (12).
9. The system (10) of any of Claims 3-8, characterized in that the central processing unit (44, 16) generates warning signals (19) in response to intrusion threats that are detected and wherein the warning signals (19) are transmitted to the aircraft (12) by means of the RF/telemetry interface (43, 18) and the RF transponder (22).





Fig. 2





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(54) Airport surface monitoring and runway incursion warning system

(57) An airport runway incursion warning system (10) for monitoring air and ground traffic at an airport. The system (10) is optimally used with an aircraft (12) that has an electronic tag (21) or interrogation system (21) that stores identification information regarding the aircraft (12), and an RF transponder (22) for receiving interrogation signals and for transmitting the identification information in response thereto. A radar system (41, 20) comprises a plurality of radar sensor units (13) disposed at predetermined installation sites adjacent to a runway (11). Each radar sensor unit (13) typically has an interface processor (42, 14) and telemetry electronics (43, 14a) for communication, although hard-wired communication paths may be used. An RF/telemetry

interface (43, 18) is provided for communicating with the radar sensor units (13) when the interface processor (42, 14) and telemetry electronics (43, 14a) are used. The RF/telemetry interface (43, 18) is also used to transmit the interrogation signals to the aircraft (12) and receive the identification information therefrom. A central processing unit (44, 16) is coupled to the radar sensor units (13) for receiving and integrating radar data produced by each the radar sensor units (13) to produce a map of the runway (11) that identifies authorization objects (26) and aircraft (12) that do not constitute intrusion threats, and intruding objects that do constitute intrusion threats to the runway (11).

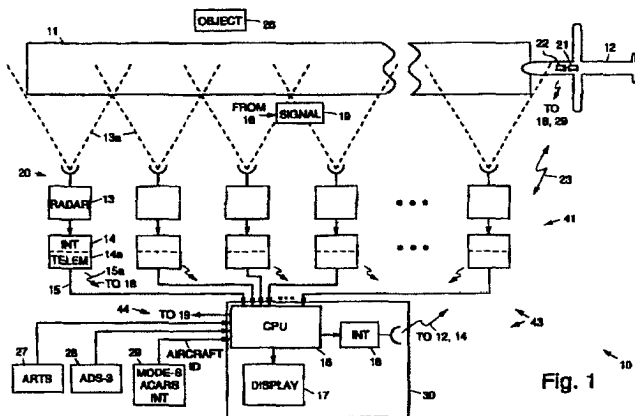


Fig. 1

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European Patent  
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EP 96 10 8293

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	ATUL JAIN: "APPLICATIONS OF MILLIMETER-WAVE RADARS TO AIRPORT SURFACE SURVEILLANCE" DIGITAL AVIONICS SYSTEMS CONFERENCE, PHOENIX, OCT. 30 - NOV. 3, 1994, no. CONF. 13, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 528-533, XP000512920	1-6	G01S13/91 G01S13/93 G01S7/06 G08G5/00 G08G5/06
Y	* page 528, left-hand column - page 531, left-hand column * * page 533, left-hand column - right-hand column; figures *	7-9	
Y	--- US 5 374 932 A (WYSCHOGROD DANIEL ET AL) 20 December 1994 * column 6 - column 7 * * column 10 - column 34 *	7,8	
Y	--- GO G ET AL: "ENHANCED AIRPORT SURFACE SURVEILLANCE RADAR" DIGITAL AVIONICS SYSTEMS CONFERENCE, PHOENIX, OCT. 30 - NOV. 3, 1994, no. CONF. 13, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 544-551, XP000512923 * page 550 *	9	
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			G01S G08G
A	--- EP 0 220 752 A (DRIM LTD) 6 May 1987 * column 4 - column 9; figures *	1-9	
A	--- DE 36 40 401 A (SIEMENS) 9 June 1988 * column 11, line 36 - line 51 * * column 2 - column 3 *	1	
A	--- US 3 872 474 A (LEVINE) 18 March 1975 * abstract; figures *	1	
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The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>15 October 1997</b>	Examiner <b>Devine, J</b>
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 466 239 A (HAAN FRANS HERMAN DE) 15 January 1992  -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
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<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone                      Y : particularly relevant if combined with another document of the same category                      A : technological background                      O : non-written disclosure                      P : intermediate document</p> <p>T : theory or principle underlying the invention                      E : earlier patent document, but published on, or after the filing date                      D : document cited in the application                      L : document cited for other reasons                      &amp; : member of the same patent family, corresponding document</p>			

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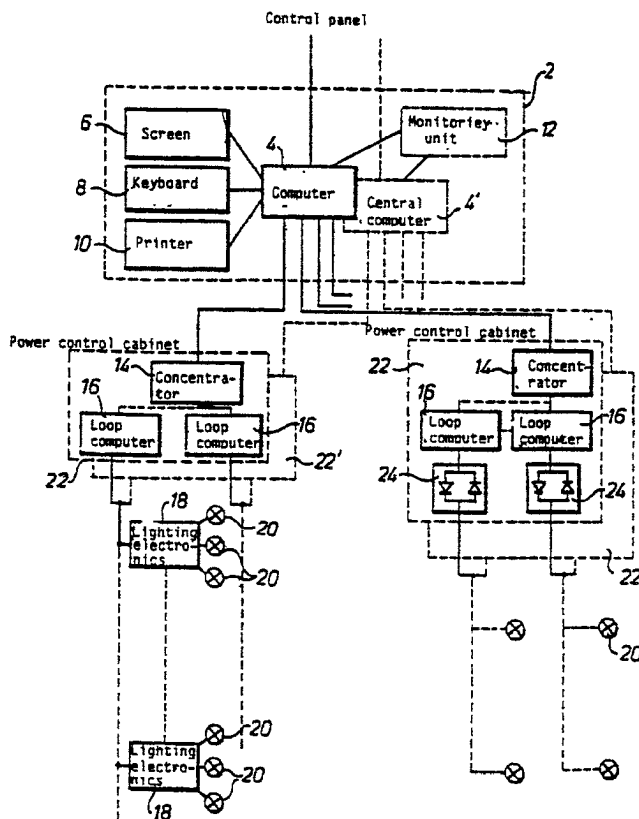
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<p>(21) International Application Number: PCT/SE89/00546 (22) International Filing Date: 9 October 1989 (09.10.89) (30) Priority data: 8803565-4 7 October 1988 (07.10.88) SE (71) Applicant (for all designated States except US): SWEDISH AIRPORT TECHNOLOGY HB [SE/SE]; Box 360, S-831 35 Östersund (SE). (72) Inventors; and (75) Inventors/Applicants (for US only) : NORMAN, Rolf [SE/SE]; Duvslaget 4, S-641 35 Katrineholm (SE). BÄCKSTRÖM, Göran [SE/SE]; Bagarvägen 10, S-831 52 Östersund (SE). MILLGÅRD, Lars [SE/SE]; Bagarvägen 3, S-831 52 Östersund (SE). (74) Agents: HOPFGARTEN, Nils et al.; Bergenstråhle &amp; Lindvall AB, Sankt Pualsgatan 1, S-116 47 Stockholm (SE).</p>		<p>(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  <b>Published</b> <i>With international search report. In English translation (filed in Swedish).</i></p>

(54) Title: SUPERVISION AND CONTROL OF AIRPORT LIGHTING AND GROUND MOVEMENTS

(57) Abstract

In a method and plant for supervising and controlling field lighting (20) at an airport, a regulator provided with a monitoring unit for power supply and monitoring the lighting fitting is arranged individually for each lighting (18, 20), such as to regulate the light intensity of the lighting and for receiving information as to its operational status. Each lighting in the plant is provided with a lighting electronic unit including a regulator, monitoring unit and modem for power supply to the light source and monitoring the operation of the lighting, each lighting being individually addressable from a control central for the airport. In the method and plant in accordance with the above, a ground traffic control system can be integrated in the field lighting system by connecting suitable presence detectors to the system.



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Supervision and Control of Airport Lighting and Ground Movements.

5       The present invention relates to a method and a plant for supervising and controlling field lighting at an airport, and which optionally include presence detectors.

      The traditional implementation of a system for field lights is as follows.

10       High-intensive and low-intensive lightings along approach paths, runways and taxiways are supplied from one or more supply points, so-called cabinets or stations situated in the airport field, usually two for a field with one runway. These supply points are fed with high voltage unregulated electricity which is transformed down to 380/320 V  
15 and the supply points contain regulator equipment, thyristor or transducer regulators or regulating transformers for converting the unregulated electricity into controlled, regulated electric power for supplying the light units, which takes place via several power supply loops. Supply takes place in two principally different ways, i.e. by  
20 series of parallel feed to the lightings. Each lighting is provided with a transformer for retransforming the electricity to a suitable low voltage for supplying the lighting with power, in addition, the supply points also contain a supervisory system which monitors the status of the field lighting plant, e.g. such as to ensure that a sufficiently large  
25 number of light units function, that the intensity of the light units is correct etc. The supply points, i.e. the cabinets, communicate via a communication link, inter alia with the traffic control tower supervising and operating panel, from which the regulating and supervisory systems are controlled, and at which information from the systems is received.  
30 This communication takes place via separate wire pairs for each function, or with time multiplex transmission on wires or optical fibres.

      The object of the present invention is to present a new method for supervising and controlling field lighting, and to provide a new field lighting plant, where each individual lighting is addressable and  
35 includes a communicating local regulator and a monitoring unit for supplying power to, and monitoring the lighting. Thus each lighting or subsystem of lightings can be controlled individually, irrespective of the sections into which the power cabling is divided.

      This object is achieved with a method according to claim 1 and a  
40 plant according to claim 9.



Furthermore, the invention enables a presence indication system for detecting vehicle and aircraft movements on the ground to be integrated in the field lighting system implemented in accordance with the present invention.

5       Communication between the traffic control tower supervision and operating panel takes place via a central computer to a so-called concentrator and loop computer. The communication signals can be in the form of time multiplexed electrical or optical signals on signal cables or optical fibre cables.

10       A plurality of advantages are achieved by the present invention compared with the already known state of the airport lighting art.

In the implementation of a traditional field lighting system, the different power supply loops are fed via a regulator centrally connected to each loop for regulating the intensity of the lightings connected to the loop. For reasons of safety, the different lighting configurations such as approach lighting, runway edge lighting, glidepath beacons, threshold lighting and taxiway lighting must be fed by several loops in case there should be a regulator or cable fault. A large number of centrally placed regulators are therefore required for controlling the field lighting system, and these occupy large spaces which must often be specially built. With the present invention, on the other hand, each lighting is provided with a local regulator which is placed at the light fitting or in a so-called fitting well associated therewith. At the supply point there will only be a so-called concentrator, sling computer, contactor and modem. This results in less voluminous equipment, which gives savings in space and cost compared with the implementation carried out in a conventional way. In addition, the necessary redundancy is obtained automatically with the method of implementation in accordance with the invention.

30       With a conventional method of implementation there is further required one or more lamp transformers at each lighting. These are heavy and take up considerable space. With the present invention, one or more of these transformers can be replaced by a small and light electronic unit on the fitting for intensity regulation and monitoring each individual lighting.

35       Since, in accordance with the present invention, each lighting can communicate and is addressable with the aid of its electronic unit, and is thus provided with local intelligence, a lighting with several

individual illumination points can control these separately in spite of the supply taking place merely over a single phase or a common cable. The necessary amount of power cable can thus be substantially reduced.

Field lighting plant for airports in accordance with the invention  
5 can advantageously be made up of certain modules, namely the lighting  
electronic unit (hereinafter denoted the AE unit), loop computer,  
concentrator and modem, where the concentrator and loop computer are  
realized with the same hardware but with different software, the plant  
being completed by a central computer and a supervising and operating  
10 unit in the traffic control tower (hereinafter denoted TWR). This simple,  
modular implementation method reduces the hardware costs for a given  
field lighting plant as well as design costs for a given lighting  
configuration. Since an ordinary-sized airport has several hundred  
lightings, the size of the AE unit manufacturing series will be  
15 considerable, which considerably reduces the manufacturing cost of each  
AE unit.

The modular method of implementation means that service and  
maintenance are facilitated. If an individual lighting does not light,  
this can either be due to the lamp or the corresponding AE unit failing,  
20 or both. In the great majority of cases, it is the lamp that fails, and  
therefore it is changed first. If a section coupled to a loop computer  
does not light, this can only be due to failing of the loop computer and  
modem, and this unit is then changed. Service and maintenance work will  
thus be extremely simplified, which is an advantage from the time, cost  
25 and personnel aspects.

With conventionally implemented field lighting systems, there must be  
an ocular inspection of the field lighting at least once a day to  
determine which light units are defect. For airports with heavy traffic  
this must take place at night, since the runway system is not available  
30 for inspection during daytime. This results in increased costs. With the  
present invention this inspection is eliminated, since each lighting is  
individually monitored and a presentation of the status of each one can  
be obtained via the sling computer, concentrator and central computer,  
either on a display or printed out on a printer. In addition, monitoring  
35 can take place without the field lighting being lit up, since the AE unit  
only needs to drive a minimum amount of current through the lamp in order  
to decide whether it is failing or not. This method saves energy. Each AE  
unit can furthermore be implemented to enable measuring of the operating

time of the light source to which it is connected. Since the average life (illumination time) of the lamps in question is well known, this individual information as to lamp status, namely illumination time and functioning/failing enables planned maintenance of the field lighting plant, which gives better status of the plant and more effective utilization of maintenance personnel. The total illumination time of each light source is suitably continuously registered at e.g. the central computer.

According to an advantageous embodiment of the plant in accordance with the invention, each lighting includes two separate light sources, the lighting configurations of which are identical. Only one light source is in service at a time, but should it fail the other light source is automatically connected, and information is sent that there is no reserve lamp for the lighting.

Since each lighting is addressable in accordance with the present invention, there is the possibility of guiding aircrafts, using parts of the field lighting system, for taxiing to and from runways, i.e., to arrange a so-called taxiway guidance system. This can be arranged by the lighting system along the central line of a taxiway being sectioned so that a given section is given a group address. This section can then either have its own operating button in a control tower panel where the section is lit when the appropriate button is pressed, or the central computer in the system can select a path with given input values for the taxiing path of the aircraft, taking into consideration any maintenance work on the taxiway, or to other aircraft movements etc. The decided path can either be lit up simultaneously in its entirety or successively in front of the aircraft. In existing plants this sectioning has been achieved by each section being provided with a separate power supply. With the present invention, the sectioning is performed, with the aid of the AE units' addresses, in the software, which drastically reduces the installation costs for a guidance system, and simplifies any future changes in the section configuration.

The invention can also be used for detecting vehicle and aircraft movements on the ground, i.e. it can form a so-called ground traffic detection system. In airports with heavy traffic, the collision risk between aircraft/aircraft and aircraft/vehicle is namely a great problem in poor visibility conditions. Since the inventive lighting system includes "intelligent" and addressable AE units at each point where there

is a lighting, every taxiway and runway can be divided into frequent identification blocks. This inventive implementation of the plant, supplemented with a presence detector allocated to each fitting the complete field lighting system or parts thereof enables detection and supervision of aircraft and vehicle movements along the rolling way system or parts thereof. The signals from the ground traffic detectors are taken up by the AE units and transmitted together with other lighting information via loop computer and concentrator to the central computer, which depicts the ground traffic on a display. The central computer, or a special supervisory computer, can give an alarm for situations where unpermitted ground traffic situations occur. This ground traffic detection system integrated with the field lighting system is very cost-effective compared with existing ground radar systems. The present invention moreover permits that only those parts of the rolling way system selectively chosen from the safety aspect are provided with ground traffic detection capacity, whereby further cost savings can be made.

In accordance with a further advantageous development of the invention, the guidance system is integrated with the ground traffic detection system such that the centre line lights included in the guidance system are lit up or extinguished or change lighting colour in front of and after the taxiing aircraft, respectively, lighting up and extinguishing the centre line lights taking place individually or in sections with the aid of control signals from the presence detection of the aircraft.

According to another embodiment of the plant, each lighting position where an AE unit is to be connected is provided with an unique address, which is automatically transferred to the AE unit when the unit is connected, such that this address is tied to its location and is not lost if an AE unit were to be changed.

An advantageous method of realizing an address which is not tied to the AE unit but to its position is to arrange a plurality of permanent magnets in the AE unit mounting such that these magnets have a unique combination of north and south pole orientation, giving the position in question an unique address which is automatically transferred to the AE unit by magnetic field-sensitive elements when the unit is connected. An eight bit address can be realized using eight magnets, for example.

According to a still further advantageous embodiment of the plant, and via the AE unit, the lightings are made for three-phase supply

enabling the supply to be dimensioned to cope with a phase failure up to a predetermined current or voltage level. Up to this level all lightings light with no change if there is a phase failure. The central computer can be programmed such as to increase the number of lightings which are  
5 extinguished with an increasing modulation in order that the maximum transmitted power for two phases is not exceeded.

Examples of the invention will now be described in more detail, with reference to the accompanying drawings, where Fig. 1 illustrates the two systems in use today for controlling field lighting at an airport, Fig. 2  
10 illustrates the principle implementation of an embodiment of the plant in accordance with the invention, Fig. 3 illustrates the principle system implementation of an embodiment of the plant in accordance with the invention, Fig. 4 illustrates an embodiment of the lighting electronics in the inventive plant, Fig. 5 illustrates an example of the realization  
15 of a unique address for each fitting, Fig. 6 illustrates the principle of ground traffic detection in the inventive plant, Fig. 7 illustrates an embodiment of the plant in accordance with the invention for microwave-based ground traffic detection, Fig. 8 illustrates a system with stop lights having automatic re-illumination for controlling ground traffic,  
20 Fig. 9 is an idealized depiction of vehicle and aircraft ground movements and Fig. 10 illustrates a guidance system in a conventional construction and a system which may be realized with the plant in accordance with the invention.

Fig. 1 illustrates the two different systems used today for  
25 controlling the field lighting at an airport. The internationally most usual form is the so-called series system. The power supply line is here fed with a constant current which can be set at different levels. The lightings 20 on the field are connected via a so-called series transformer 50 in series with each other. Two or more such loops are  
30 required for supplying each lighting system such as runway edge lighting, approach lighting, glidepath beacons, centre line lighting, taxiing lighting etc. Since the lightings 20 are in series there is most often required high secondary voltage at the main transformer 51. The regulator 24 is connected on the primary side. In fig. 1 it is illustrated as a  
35 thyristor regulator 46, 48 but it can also be a transductor regulator or a regulating transformer.

The power supply system most usual in Sweden is the so-called parallel system. In this case the lightings 20 are connected in parallel

to each other via their individual transformers 21 along the power supply loop. Transducer regulators or regulator transformers are used here as well, apart from thyristor regulators 24, 46, 48. The control and monitoring equipment, (the equipment to the left of the dashed line in 5 Fig. 1), is often placed in so-called cabinets or stations in the field for these systems. For a medium-sized airport there are usually about 10-15 such regulator units for supplying the different power supply loops included in the field lighting system.

Fig. 2 illustrates in principle the implementation of an embodiment 10 of a plant in accordance with the invention. The power supply loop is here formed of the ordinary power supply, and connected to each lighting 20 there is a so-called lighting electronic unit 18, denoted AE.

Fig. 3 illustrates the principle system implementation of a plant according to an embodiment of the invention.

15 Field lighting installations (existing and future) are controlled and monitored from an operating panel in the airport control tower (TWR). In the invention, a so-called central computer 4 senses the status of the different functions of the operating panel and sends control signals via its control program to one or more so-called concentrators 14. These are 20 most often placed in a so-called power control cabinet 22 at the power supply points for the field lighting. This communication between the central computer 4, most often placed in the apparatus room of the control tower, and the concentrator 14 may be by a time multiplexed signal on cable or optical fibre. Radio signalling can also be used. The 25 concentrator 14 sends its control signals further to one or more loop computers 16. Via a modem communication each loop computer 16 looks after the AE units 18 which are connected to the associated power supply loop. One loop computer can at present communicate with a maximum of 127 AE units, with retention of the necessary rapidity in the system. 30 Communication between the loop computer 16 and the respective AE units 18 along the loop can either take place with digital signals superposed on the power supply loop or via separate signal cable. The most advantageous embodiment appears to be communication via the power cables, no special signal cable thus being required.

35 Each AE unit 18 monitors the status of the lighting fitting 20 and sends this information to the loop computer 16 in question, for further transmission via the concentrator 14 to the central computer 4, which coordinates the information and gives an alarm when so required. As will be

seen from Fig. 3, the status of the plant can also be depicted on a screen 6 with associated keyboard 8 or a printer 10 in the so-called operational supervision centre. As is further apparent from Fig. 3, this embodiment of the plant in accordance with the invention, with supply to the lightings 20 via AE units 18, permits this new control and monitoring method to be mixed with the conventional technique using series of parallel supply by the power supply loops. The loop computer 16 thus provides a centrally placed regulator 24 with the necessary control signals (criterion values) and it also monitors the regulator 24 so that the right intensity is set and the right load connected to the loop. This possibility of combining conventional power supply methods with the new technique in accordance with the invention makes the system very flexible.

For meeting functional reliability requirements, the central computer 4 and the power control cabinets 22 can be doubled, as indicated in Fig. 3 by dashed lines. When the central computer 4, 4' and the power control cabinets 22, 22' are doubled, all the cables between the operating panel and the power control cabinets 22,22' are similarly doubled.

A monitoring unit 12, e.g. of the so-called watchdog type, is connected to both the central computers 4, 4' for monitoring the function of the plant.

Fig. 4 illustrates an embodiment of the AE unit in the plant in accordance with the invention. This comprises a modem 36 for receiving control signals which are either carried on separate signal cables or are digital signals superposed on the power cabling. The AE unit further includes a lamp control unit 35 with a microprocessor and associated interfaces 37 and power semiconductors 39 for regulating the power supply to the light sources 20. The microprocessor of the lamp control unit 35 also looks after monitoring of the operation so that if incorrect light intensity is set, or if a lamp 20 fails, the AE unit sends information on this to the loop computer 16, c.f. Fig. 3.

Power control in the AE unit can take place according to several different principle methods. Fig. 4 illustrates so-called primary switching, with which, while using high switching frequency, there is obtained extremely small lamp transformers and thereby a very compact construction. Ideally, the transformer decreases in size inversely proportional to the frequency. The frequency is determined here by the construction of the lamp control unit 35 and control can take place, e.g.

by pulse length modulation, i.e. the pulse length in the "on position" is greater for higher output effect, and for lower output effect this pulse length becomes shorter, the switching frequency being constant the whole time.

5 A voltage regulator 41 is illustrated in Fig. 4 for supplying the electronics. the fitting electronics also includes a rectifier bridge 43 and a filter 45 for preventing noise from the fittings and electronics to propagate to the network.

By each lighting having its individual regulator, at least certain  
10 lightings can advantageously be fitted with battery backup, so that for voltage failure the lamp in the lighting continues to light with predetermined intensity.

Each AE unit has its unique address, as mentioned above. There is thus obtained a possibility of individual control and monitoring of each  
15 lighting 20 or section of lightings. Fig. 5 illustrates an advantageous method of achieving this. Permanently situated on the lighting there is a magnetic strip 1 containing the necessary number of permanent magnets 3. The magnets 3 are made as reversible magnet plugs to enable pole reversing. The AE unit contains magnetosensitive elements 2, for sensing  
20 the orientation of the north and south poles of the magnets, this orientation enabling a binary address code to be obtained, at 4 in Fig. 5. When the AE unit is positioned it automatically obtains its address, which is permanently associated with the location. This means that each AE unit can be used anywhere in the field lighting system, as far as address-  
25 pressing is concerned, which is advantageous from the point of view of service and maintenance. The embodiment illustrated in Fig. 5 shows how the magnetic field 5 connects the address code from the permanently installed address code transmitter B to an address code decoder A in the lighting electronic unit without galvanic contacts, a signal converter  
30 and address transmission unit 6 being connected to the decoder.

It is obviously possible to implement this memory so that the input address is also retained when there is no current, the input taking place with the aid of a special command to start with.

With the technique in accordance with the invention for controlling  
35 and monitoring the field lighting using addressable local regulators there is obtained the field system divided into unique addressing blocks  $a_i$ , as is illustrated in Fig. 6. By providing the field system with the required number of presence detectors 72, c.f. Fig. 4, a system for



detecting vehicle and aircraft ground traffic can be achieved, integrated with the field lighting system. In such a case the presence detector can be placed on a lighting fitting, as illustrated in Fig. 7. Since each fitting has a unique address to which the presence detector signal is correlated, vehicle and aircraft movements on the field can be supervised with the aid of this procedure.

In the illustrated embodiment, the presence detector 72 comprises a microwave based detector. The microwave signals are transmitted and received via an antenna unit 71 and are evaluated at 74. However, the detector can be based on other physical measuring principles using such as supersonics, infrared rays, eddy current etc.

In order to control the ground traffic, above all in airports with heavy traffic, stop lights are required at the entrances to runways, and also at crossings between taxiways. Such an arrangement is illustrated in Fig. 8, the stoplights 11 are usually sunk lightings arranged across the taxiway 80, where it is suitable to stop the traffic. The stoplights 11 comprise a line of at least 5 light units sunk into the taxiway and providing directed, steady red lights solely for the traffic which is to be stopped. Light ramps included in the stop light system must be enabled for separate operation in the control tower, and the installation of the stop lights should be carried out so that not all light units in such a ramp are extinguished at the same time for failure in the supply system.

The stop lights 11 are controlled such that when an aircraft 82 approaches an illuminated ramp of stop lights, the pilot stops the aircraft and calls the control tower to obtain permission to pass the stoplights. The flying controller gives a clearance sign for passage by extinguishing the stop lights. When the aircraft 82 has passed the lights, they shall be illuminated once again with red light as soon as possible to prevent further aircrafts from unintentionally crossing them. This re-illumination takes place either manually or automatically. For configuring a stop light ramp with automatic re-illumination, and using the technique known up to now, there are required at least two centrally placed current regulators in order to obtain the separate operation required according to the above, and also to obtain the necessary redundancy.

In apparatus of this kind known up to now, the automatic re-illumination is controlled by a separate traffic signal system which, with separate current supply and with separate control signal cables, is

connected to the regulator units for the lighting in question. This is an expensive way of controlling and automatically re-illuminating only five light units, for example.

A configuration in accordance with the present invention is  
5 illustrated in Fig. 8. Each lighting in the stop lights 11 is provided with an electronic unit AE, which is controlled via the power cables from the loop computer/concentrator 13, 14. Supply can take place as  
illustrated in the figure, e.g. it can be three-phase supply to obtain great redundancy in the supply. The same power supply which is used, e.g.  
10 for surrounding illuminated signs, can be used for supplying the stop lights and thus considerably reducing cable costs. A presence detection system is integrated into the configuration for obtaining the automatic re-illumination. In fig. 8 there is illustrated a microwave-based presence detector 12 with a transmitter ND/S and a receiver ND/M. A  
15 fitting electronics unit 17 is connected to the receiver for looking after the signal from the receiver. The signal from the receiver is sent on the cable 18 to the associated loop computer 13, which in turn sends the re-illumination signal to the fitting electronic units of the stop lights. Also schematically illustrated in the figure are the necessary  
20 modem 15, way edge lighting 16, a power point 19 and signal cable 21 to an operating and display panel 10 in the control tower.

The described configuration for controlling and automatically re-illuminating the stop lights 11 for aircraft at an airport is  
substantially cheaper than the configuration according to previously  
25 known technique, with regard to hardware cost and cable cost. In addition there is automatically obtained great redundancy, which is important from the safety aspect, a possibility of being able to regulate the intensity of the stop lights being obtained as well.

The system permits vehicle and aircraft movements to be depicted on a  
30 monitor in the control tower or at another desired place, see Fig. 9. The described method of detecting ground traffic is very cost effective compared with today's ground radar systems. Such systems also have the disadvantage that in heavy rain and snowfall they cause high background noise, thus causing difficulties in effective supervision. Another  
35 advantage with the solution in accordance with this invention is that if the field movement supervision is only desired or required for a small part of the runway system, this can be advantageously achieved.

At airports with the most heavy traffic in the world today, so-called guidance systems have been built up to guide aircraft when taxiing to and from runways, see Fig. 10. The lower part of the figure illustrates how such a system is built up today. This is done by the power supply to the 5 lightings in question being sectioned so that each section can be lit up and extinguished individually. A large amount of cable is required for this, as well as many centrally placed regulators. With the present invention having addressable regulators the sectioning is done in the software. Different sections of lightings can thus be connected to the 10 same power supply cable, and merely by defining what lighting addresses are associated with a certain section the section in question can be lit up and extinguished individually. This configuration results in large cost savings, see the upper part of Fig. 10.

Claims

1. Method of supervising and controlling field lighting at an airport, characterized in that each lighting has a  
5 regulator with associated monitoring unit for power supply to and monitoring of said lighting, which is addressed individually for controlling the light intensity of the lighting and for receiving information as to the operational status of the lighting.
2. Method as claimed in claim 1, communication between a traffic  
10 control tower and the lightings taking place via a so-called loop computer and modem, characterized in that communication between the loop computer and lightings is expedited over existing power cables, and superposed on the existing power supply.
3. Method as claimed in claim 1, communication between a traffic  
15 control tower and the lightings taking place via a so-called loop computer and modem, characterized in that communication between loop computer and lightings is expedited via a special signal cable.
4. Method as claimed in either of claims 2 or 3,  
20 characterized in that the lightings along one or more power supply loops are addressed from a loop computer individually or in groups.
5. Method as claimed in any one of claims 1-4,  
characterized in that the central line lighting on a taxiway  
25 is lit up successively, individually or sectionally, in front of a taxiing aircraft for indicating the route of the aircraft when it is taxiing home or out, the necessary electric sectioning being determined in the software of a central computer via the addresses of the lighting electronic unit, and lighting being controlled by the taxiing route  
30 determined in the central computer.
6. Method as claimed in claim 5, characterized in that the extent of lighting up, extinguishing or changing colour of the light is controlled via a presence detecting system.
7. Method as claimed in any one of claims 1-6,  
35 characterized in that said output effect of each lighting for a given intensity level is changed by reprogramming via a centrally placed computer using the lighting electronics unit in situ.

8. Method as claimed in any one of claims 1-7,  
c h a r a c t e r i z e d in that the total illumination time of each  
light source is automatically and individually registered.

9. Plant for supervising and controlling field lighting at an  
5 airport, c h a r a c t e r i z e d in that each lighting is provided  
with an electronic unit controlling a regulator, monitoring unit and  
modem for power supply to the light source of the lighting, and for  
monitoring the operation of the lighting, each lighting being  
individually addressable from a control central for the airport.

10 10. Plant as claimed in claim 9, c h a r a c t e r i z e d in that  
a selected plurality of the electronic units of the lightings are each  
allotted a presence detector for forming a ground traffic detection  
system for detecting the ground movements of aircraft and vehicles, said  
detector including transducers based on supersonics, optics, magnetism,  
15 eddy currents, or microwaves.

11. Plant as claimed in claim 9 or 10,  
c h a r a c t e r i z e d in that each lighting electronic unit includes  
a unique address block, permanently mounted on the lighting, or its  
associated lighting well, such that when said unit is put in place the  
20 lighting is automatically given its unique address.

12. Plant as claimed in claim 11,  
c h a r a c t e r i z e d in that the address block includes permanent  
magnets, the north and south pole orientation of which gives a unique  
digital address, the lighting electronic unit containing magnetism-  
25 sensitive elements for sensing the north and south pole orientation of  
the magnets.

13. Plant as claimed in claim 10, c h a r a c t e r i z e d in that  
at least certain lightings are arranged to form so-called stop lights,  
each lighting of these stoplights including an individual electronic  
30 unit, and in that a presence detection system connected to said stop  
lights is arranged for automatically giving a re-illumination signal to  
the lightings of the stop lights as a reply to the passage of an aircraft  
or other vehicle past the stop lights.

14. Plant as claimed in any one of claims 9-13,  
35 c h a r a c t e r i z e d in that a given number of lightings are  
provided with battery backup, so that should there be a voltage failure  
the light intensity of the lamp is regulated to a previously determined  
value.

15. Plant as claimed in any one of claims 9-14,  
c h a r a c t e r i z e d in that the power supply to the lighting  
electronic unit is three-phase connected, and disposed such that should a  
phase fail, all the light units continue to light up with unaltered in-  
5 tensity unless the light intensity exceeds a predetermined value, at  
which a predetermined number of lightings are adapted such as to be  
extinguished.

16. Plant as claimed in any one of claims 9-15,  
c h a r a c t e r i z e d in that each lighting includes two separate  
10 light sources, the light configurations of these sources being identical,  
it only being intended that one light source is connected at a time, and  
in that the lighting electronic unit is adapted such that for a failure  
of one light source it automatically connects the other and gives an  
alarm for the failed light source.

Fig. 1

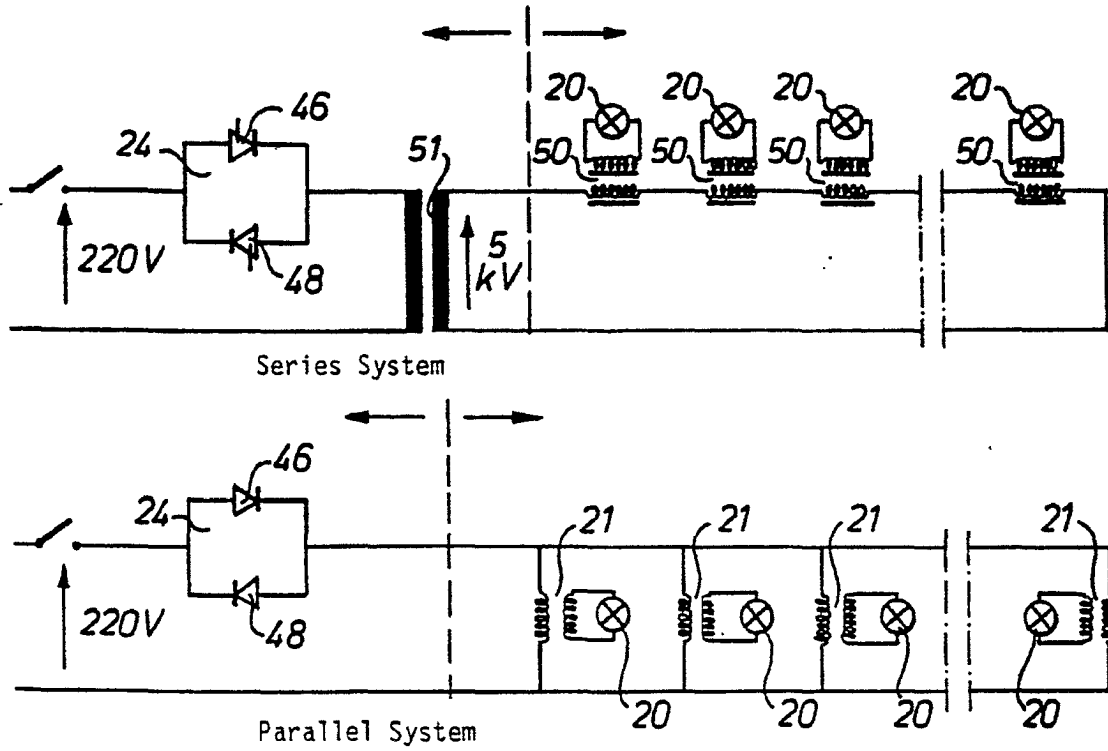


Fig. 2

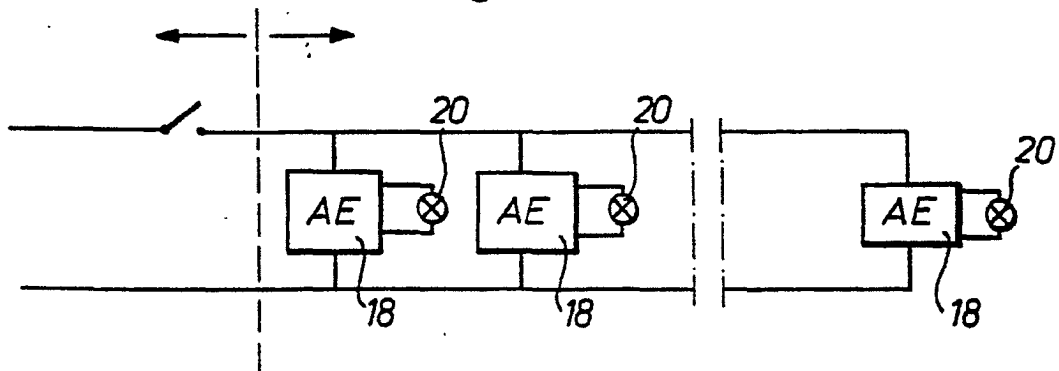


Fig.3

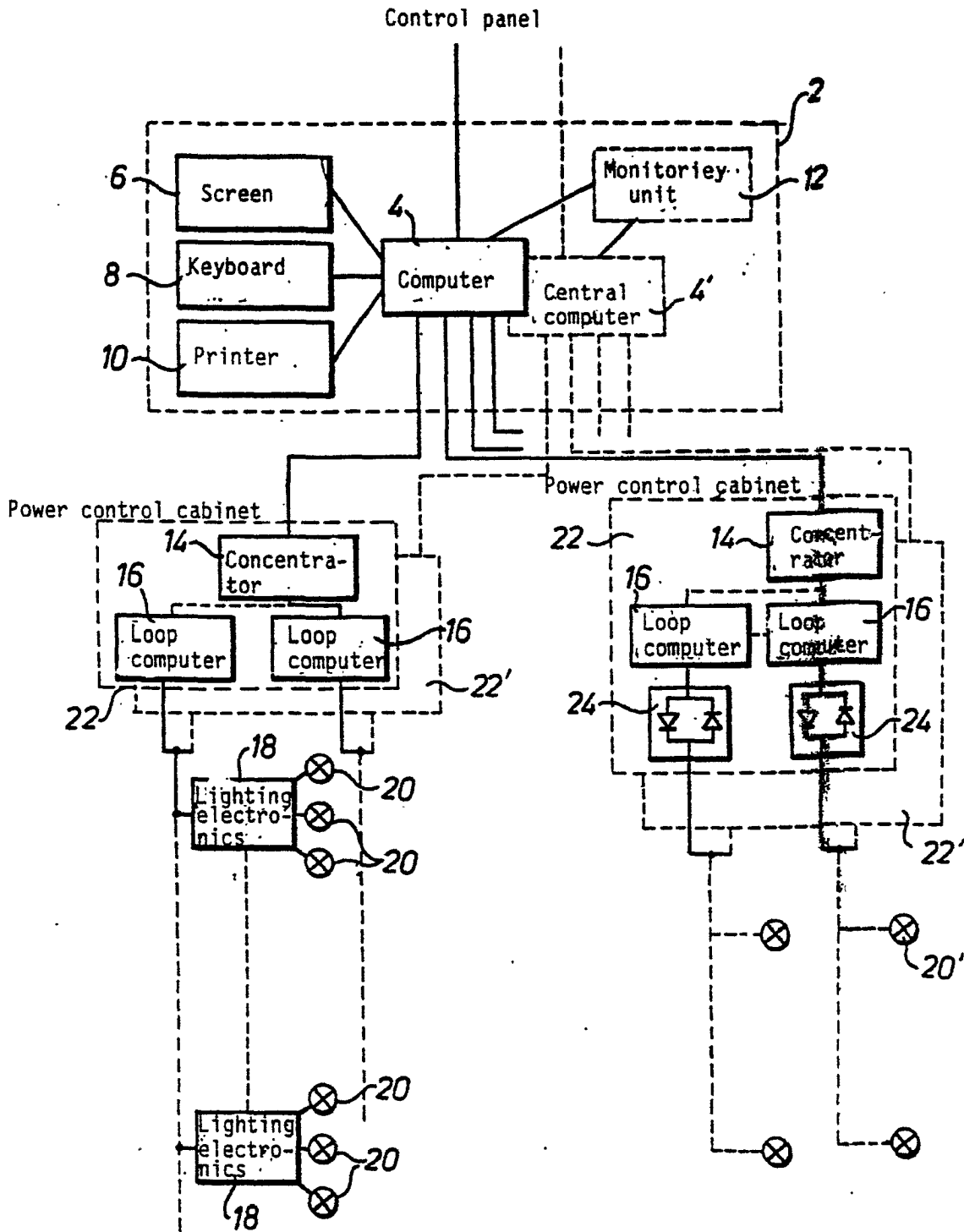
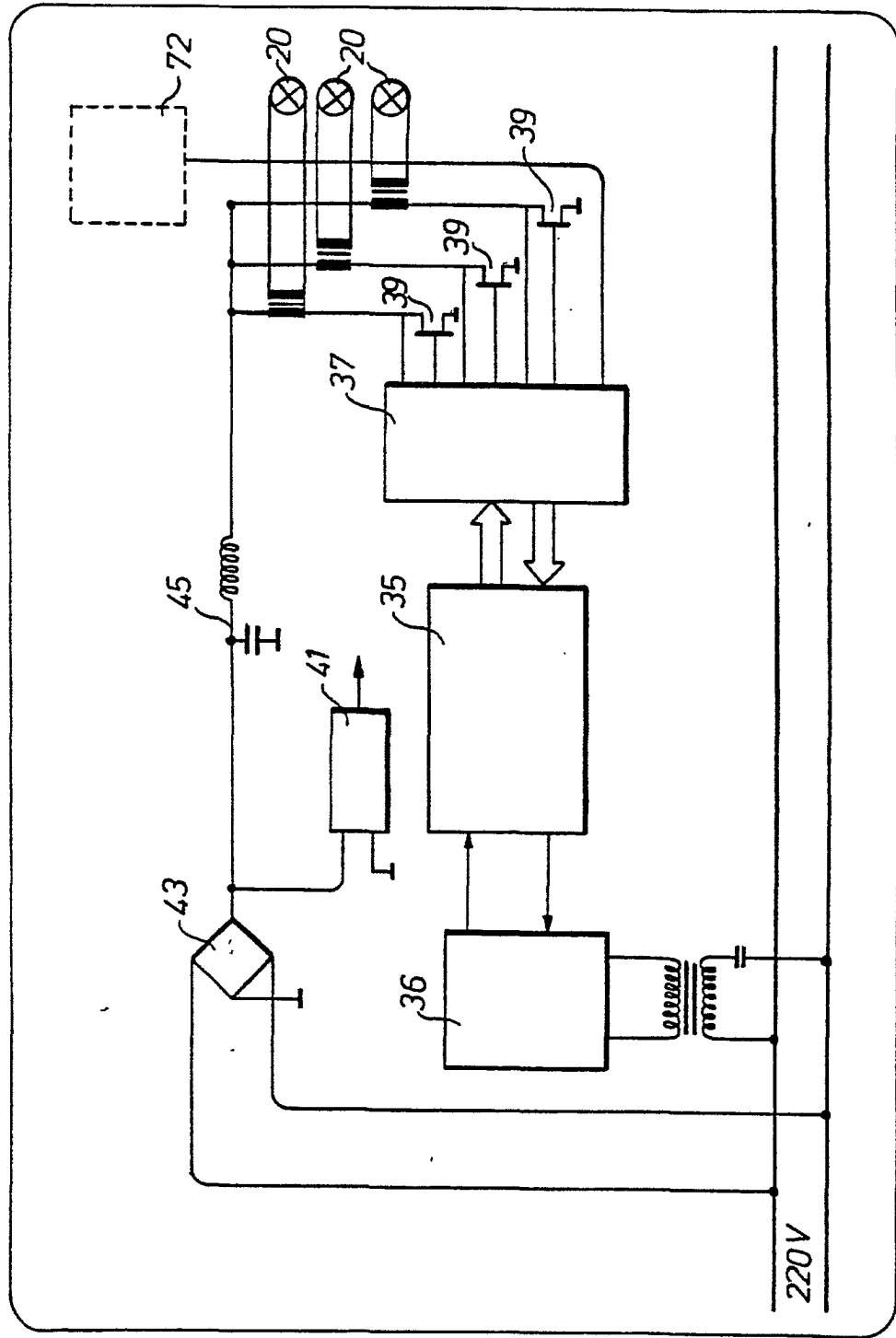




Fig. 4



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Fig. 5

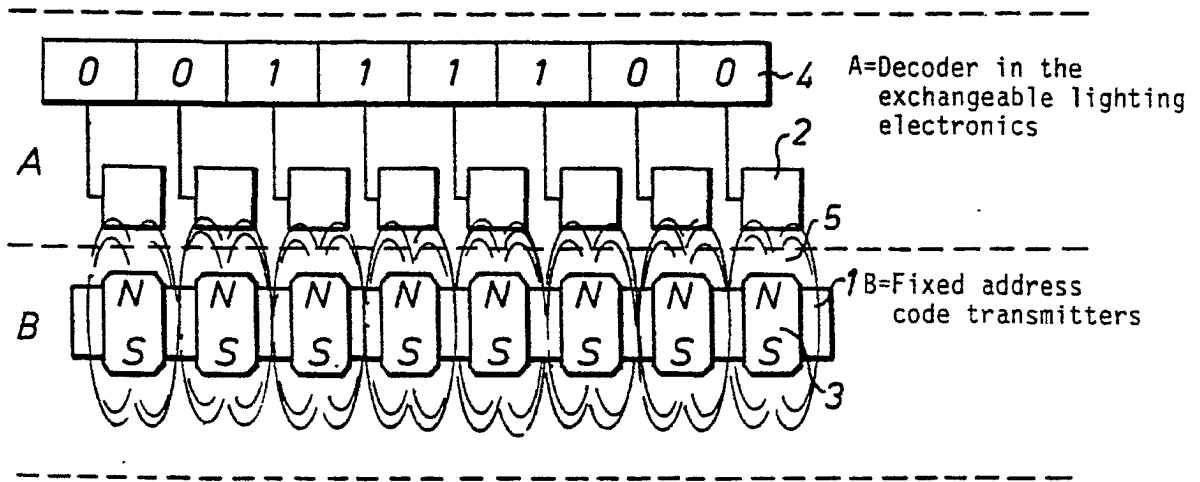
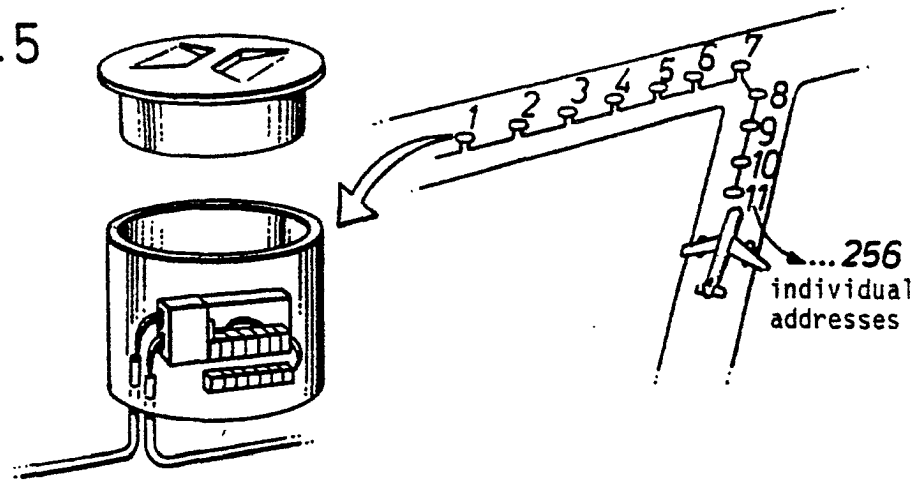


Fig. 6

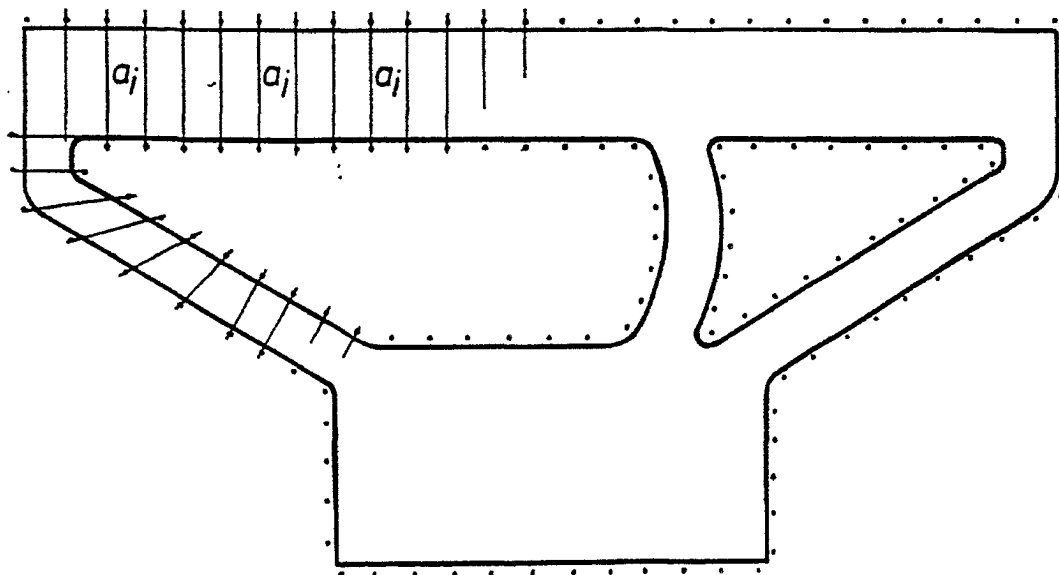


Fig. 7

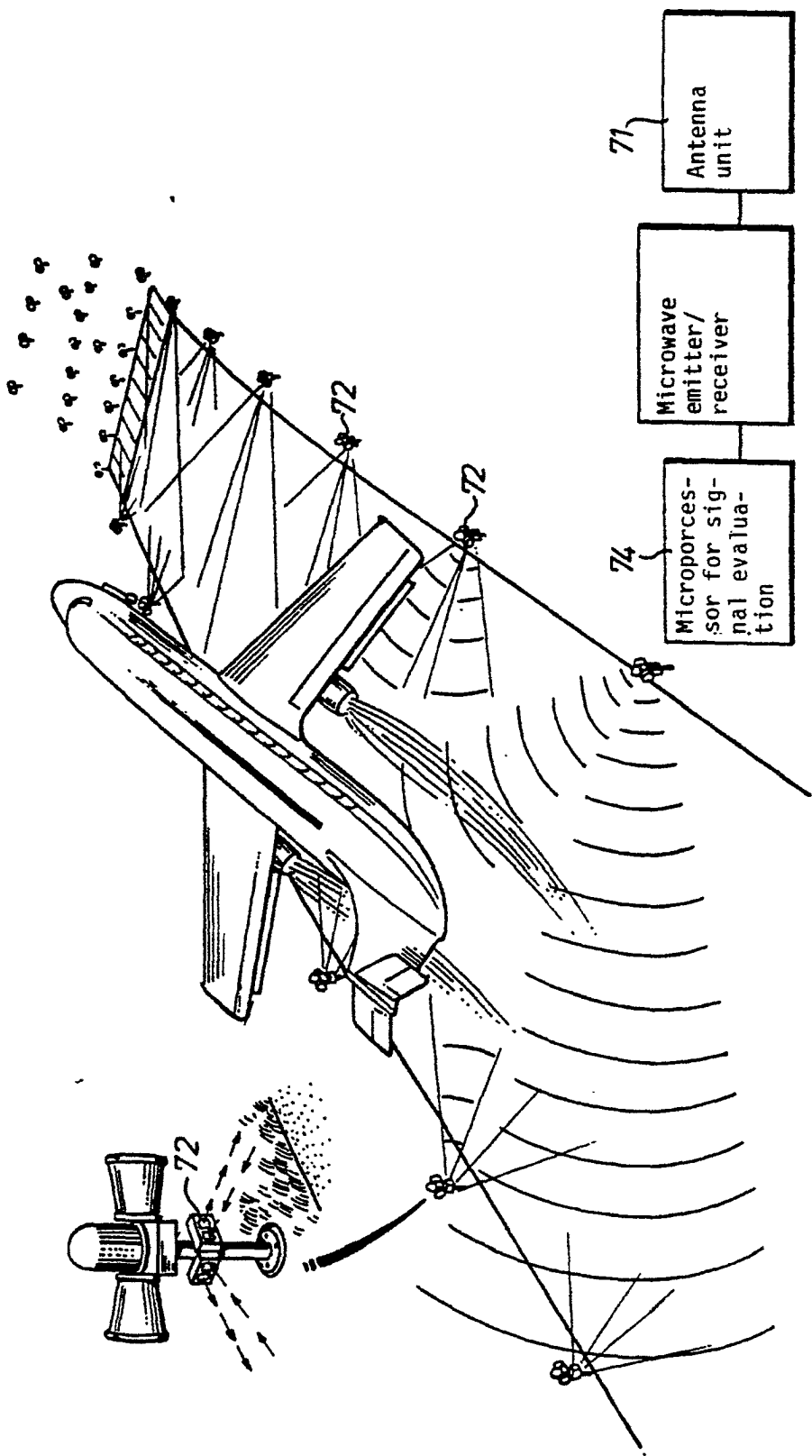
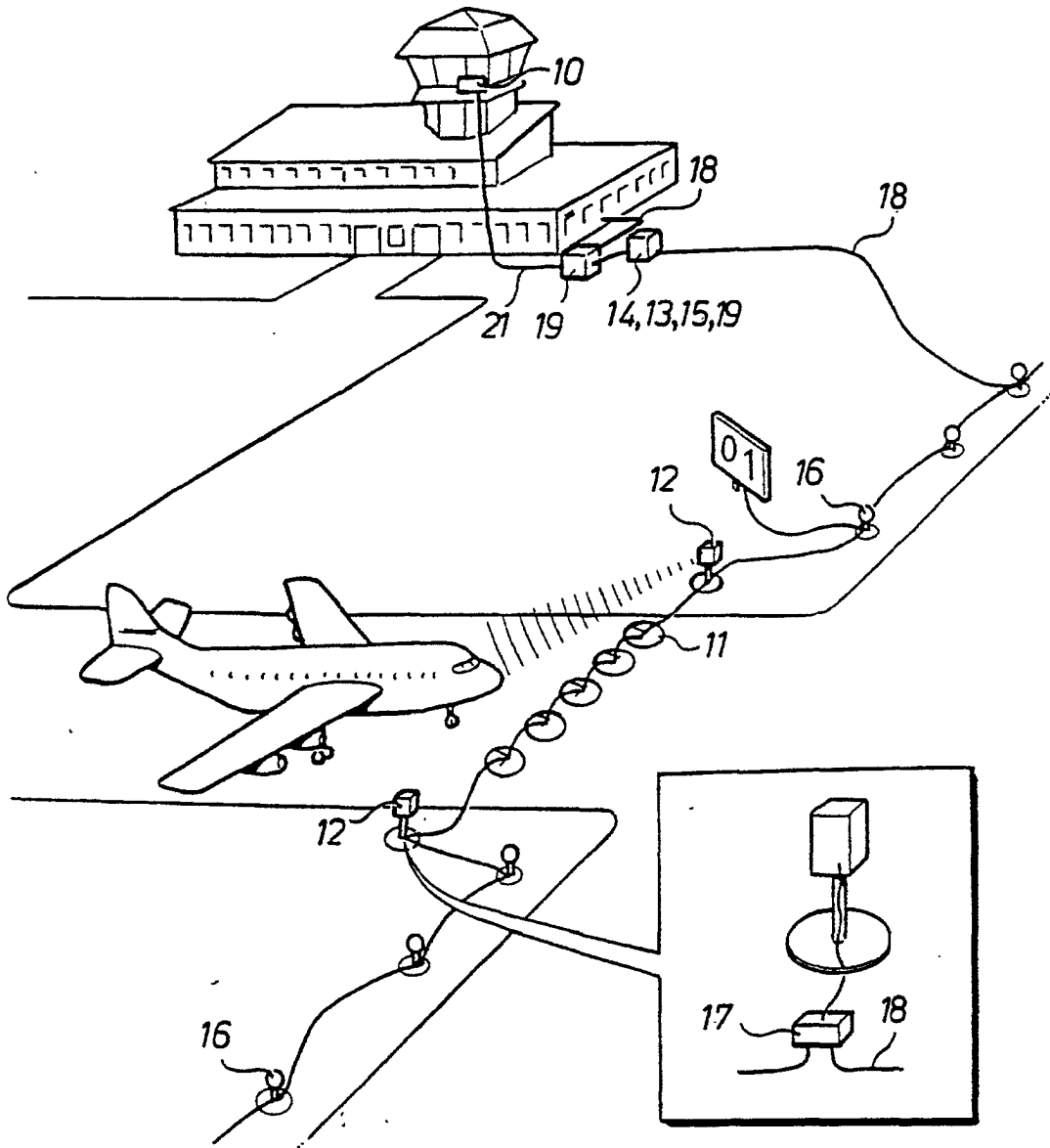
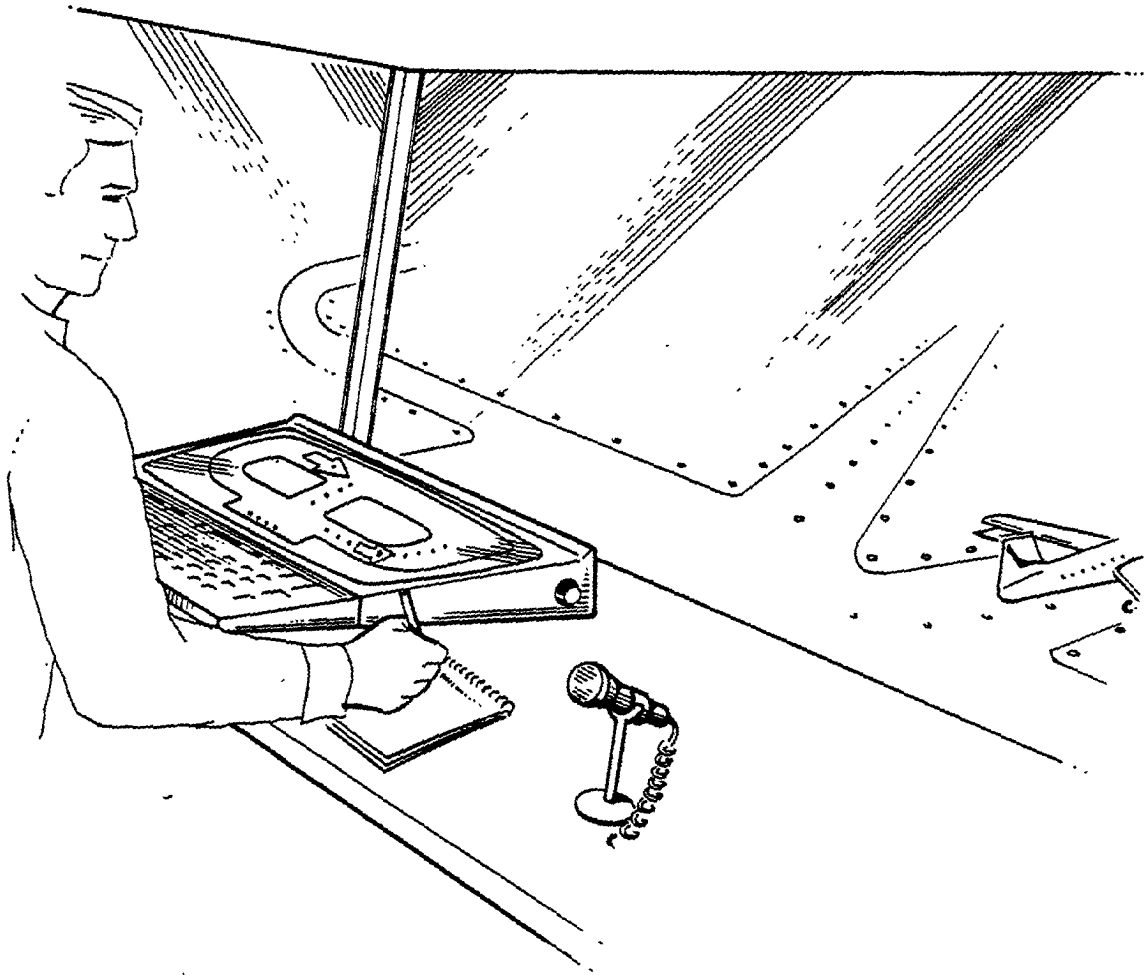


Fig.8



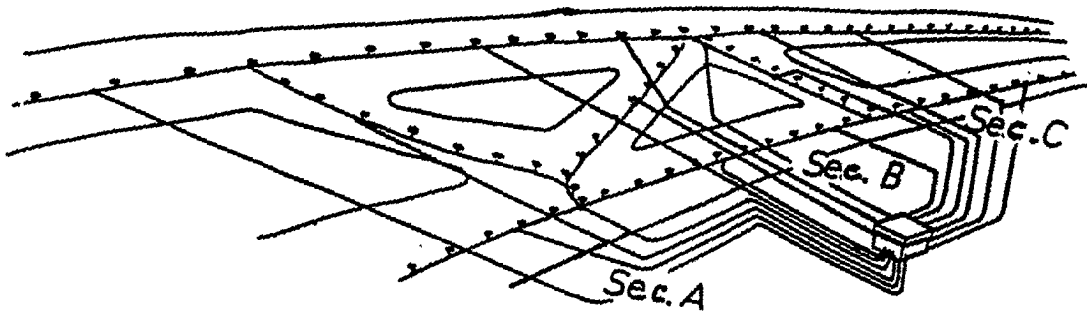
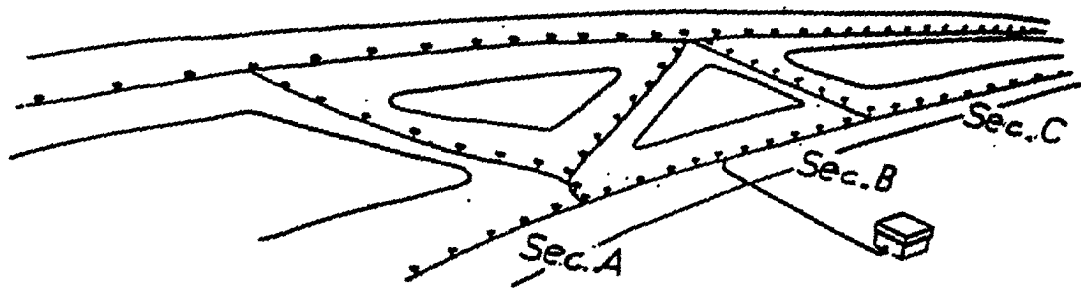
**SUBSTITUTE SHEET**

Fig. 9



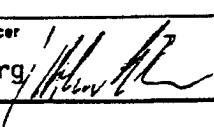
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Fig. 10



# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 89/00546

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC IPC4: G 08 G 5/00, H 05 B 37/00		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System <sup>1</sup>	Classification Symbols	
IPC4	B 64 F, F 21 P, G 05 D, G 08 G, H 05 B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
SE,DK,FI,NO classes as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>9</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	US, A, 4388567 (K. YAMAZAK ET AL) 6 June 1983, see the whole document --	1-7,9, 10,14, 16
Y	US, A, 4095139 (A.P. SYMONDS ET AL) 13 June 1978, see abstract --	1-7,9, 10,14,
Y	EP, A1, 0060068 (VARI-LITE) 15 September 1982, see abstract --	1-7,9, 10,14,
Y	EP, A1, 0069470 (PITWAY CORPORATION) 12 January 1983, see abstract --	1-7,9, 10,14,
Y	GB, A, 2174852 (TANN ELECTRONICS LTD) 12 November 1986, see the whole document --	1-7,9, 10,14, 16
<p><sup>9</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Δ" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search 14th December 1989	Date of Mailing of this International Search Report 1989 -12- 27	
International Searching Authority  SWEDISH PATENT OFFICE	Signature of Authorized Officer Bertil Nordenberg 	

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 3122721 (Y.J. LIU ET AL) 22 May 1964, see the whole document --	1-7,9, 10,14,
Y	US, A, 4590471 (C.S. PIEROWAY) 20 May 1986, see the whole document --	5
Y	GB, A, 2155226 (V.M. ARANZANA) 18 September 1985, see the whole document --	6,10
Y	US, A, 4481516 (P.E. MICHELOTTI) 6 November 1984, see the whole document --	6,10
Y	US, A, 3801794 (R.E. MAUCH ET AL) 2 April 1974, see the whole document --	14
Y	DE, A1, 3703830 (LICENTIA PATENT-VERWALTUNGS-GMBH) 18 August 1988, see the whole document --	16
A	US, A, 4313063 (J.I. MCHERRON) 26 January 1982, see the whole document --	1,9
A	US, A, 4449073 (M.A. MONGOVEN ET AL) 15 May 1984, see the whole document --	1,9
A	DE, A1, 3635682 (BBC BROWN BOVERI AG) 28 April 1988, see the whole document --	1,9
A	US, A, 3771120 (R.P. BONAZOLI ET AL) 6 November 1973, see the whole document --	1,9
A	US, A, 3531765 (W.D. CHRISTIANSON ET AL) 29 September 1970, see the whole document -----	1,9



ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 89/00546

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.

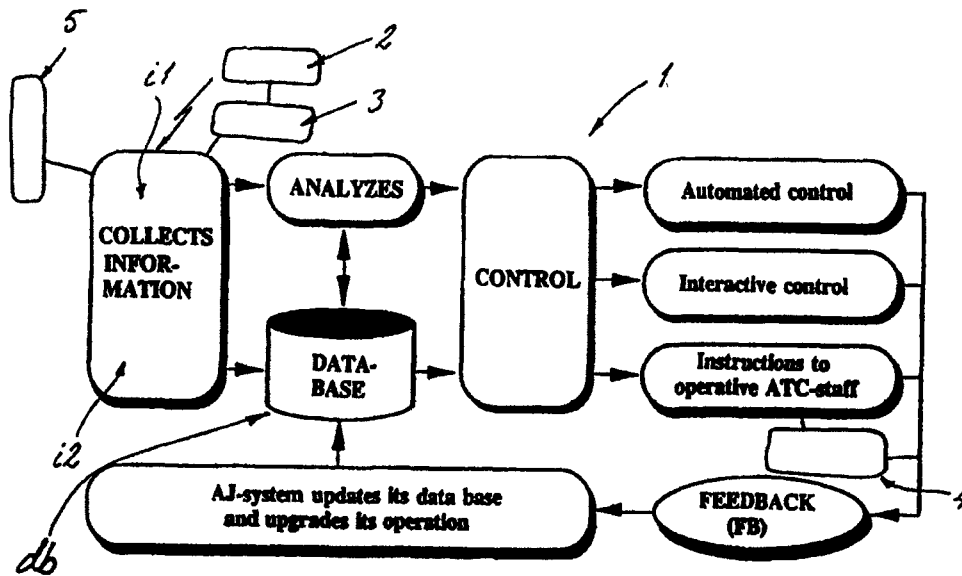
Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4388567	06/06/83	GB-A-B- 2070830 JP-A- 56118295	09/09/81 17/09/81
US-A- 4095139	13/06/78	NONE	
EP-A1- 0060068	15/09/82	JP-A- 57157491 AU-D- 79646/82 US-A- 4392187 CA-A- 1181795 EP-A-B- 0140994 JP-A- 60143502 AU-A- 546433 JP-A- 61173402	29/09/82 09/09/82 05/07/83 29/01/85 15/05/85 29/07/85 29/08/85 05/08/86
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GB-A- 2174852	12/11/86	NONE	
US-A- 3122721	22/05/64	NONE	
US-A- 4590471	20/05/86	NONE	
GB-A- 2155226	18/09/85	FR-A-B- 2560702	06/09/85
US-A- 4481516	06/11/84	NONE	
US-A- 3801794	02/04/74	NONE	
DE-A1- 3703830	18/08/88	NONE	
US-A- 4313963	26/01/82	NONE	
US-A- 4449073	15/05/84	NONE	
DE-A1- 3635682	28/04/88	NONE	
US-A- 3771120	06/11/73	NONE	
US-A- 3531765	29/09/70	NONE	



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>6</sup> : <b>G08G 5/06</b></p>	<p><b>A1</b></p>	<p>(11) International Publication Number: <b>WO 98/52174</b> (43) International Publication Date: 19 November 1998 (19.11.98)</p>
<p>(21) International Application Number: PCT/FI97/00281 (22) International Filing Date: 13 May 1997 (13.05.97) (71)(72) Applicant and Inventor: HATJASALO, Leo [FI/FI]; Särkiniementie 11 A 6, FIN-00210 Helsinki (FI). (74) Agent: KANGASMÄKI, Reijo; Finnish Patent Consulting FPC, Hermiankatu 14, FIN-33720 Tampere (FI).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. In English translation (filed in Finnish).</i></p>

(54) Title: METHOD AND CONTROL SYSTEM FOR OPERATIVE TRAFFIC



(57) Abstract

The invention relates to a method for operative traffic, said traffic, such as operative ground traffic associated with air traffic, being controlled by means of a real-time and preferably so-called self-learning expert system (1), at least substantially all operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, as well as preferably also persons and groups of persons, present in an operative traffic area, being at least in an information transmitting communication therewith at least for the identification and substantially continuous positioning of the latter. The invention relates also to a control system applying the method.

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## Method and control system for operative traffic

5 A method for operative traffic, said operative traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area, being  
10 at least in an information transmitting communication therewith at least for the identification and positioning of the latter.

15 It is possible to apply a method of the invention in a wide variety of applications, e.g. for safely controlling operative traffic occurring on the ground, in water and/or in the air. One of the key applications for a method of the invention is the control of operative ground traffic associated  
20 especially with air traffic.

25 It is prior known that the ground traffic, especially one associated with air traffic, is run by using quite traditional methods and arrangements, each airport being always provided with an air traffic control tower, which is the base for controlling all airport operations involving both ground and air traffic activities by using conventional radar and monitor systems. However, the traditional control methods are  
30 largely based on visual monitoring performed by air traffic controllers, whereby, especially in adverse weather conditions, such as in fog, snowfall, or the like, the conditions may cause major setbacks and interruptions for air traffic. A principal reason for  
35 this is that it is not possible in all circumstances to visually make sure in a sufficiently reliable fashion e.g. the condition of a required runway door the equipment possibly present in such runway.

Therefore, e.g. after a snowplowing operation, it is generally necessary to wait at least an hour before it is possible to re-commission a runway to its primary applications. Snowy conditions are particularly inconvenient for traditional air traffic control methods since, as a result of sufficiently long runway standstill required as a safety precaution, there is time for fresh snow to gather thereon prior to the next commissioning of the runway, and this necessitates another pawing operation very shortly, leading to a continuing delay in air traffic as snowfall continues.

In addition, the traditional control system is not capable of controlling and guiding e.g. a landed aircraft to a terminal best suited for a given situation but, in principle, it is necessary to always stick with operating plans decided a long time before. Thus, e.g. occasional malfunctions, equipment breakdowns etc. often cause lengthy downtimes, resulting in a confusion in terms of preplanned timetables and arrangements. Furthermore, so-called "last-minute tune-ups" in traditional inflexible control systems frequently cause danger situations since, with manual arrangements, it is not possible to account for a sufficient number of factors even in minor changes of operating plan.

The prior art is described in US Patent 4,827,418, relating to an expert system which relies on so-called artificially intelligence based data processing for controlling the altitude and heading of especially airborne aircraft in order to avoid collisions. Such solutions make use particularly of LISP-programming or the like which, however, from the viewpoint of a person skilled in the art, does not have any significant equivalence to the processing solutions of the present invention. Thus, the system disclosed in

the cited patent is indeed primarily intended for air traffic control, which can also be used as an air control simulator. Moreover, in the cited solution, e.g. the positioning is carried out conventionally by means of a radar. It should further be noted that the mere LISP-programming represents quite traditional processing in terms of technology and, hence, the (at present virtually "out-of-use") LISP-programming is not even close to being sufficiently powerful in terms of solving problems equivalent to those addressed by the present invention.

On the other hand, unlike both the above-cited and the present invention, the reference publication EP 613,109 encompasses infrared-radiation based transmitters and receivers for the identification and positioning of aircraft in a ground traffic area. In the cited solution, the positioning is largely based on monitoring the field temperature levels, whereby sensors mounted on the field detect a new aircraft on the basis of an increase in temperature. Thereafter, the heading of this particular aircraft is determined as soon as some other heat identification unit has detected the elevated temperature caused by this aeroplane. Then, it is possible to determine mathematically the heading/acceleration/speed etc. of the aircraft, e.g. by the application of vector mathematics or the like.

From the viewpoint of a person skilled in the art, the cited solution is also essentially different from the present invention since, first of all, it is based on IR radiation. On the other hand, the positioning of aircraft as well represents quite traditional technology, especially in light of the present invention, nor does it function with reliability that would be even nearly equal to that of the present invention. Neither is the cited type of arrangement by

any means such that it could be utilised, at least not with a sufficient reliability, for monitoring the movements of persons/groups of persons working within a ground traffic area.

5

Thus, the cited solution is only capable of performing a fraction of what can be done with the present invention. Moreover, especially the use of IR radiation in this connection is unfavourable particularly for the following reasons:

10

- restricted in terms of its range/power
- necessitates a physical contact
- a limited number of channels
- out-of-date technology

15

- few practical applications, and even those in not absolutely crucial circumstances.

20

Hence, what the cited solution has in common with the present invention is primarily that it is intended for monitoring the position of aircraft or the like currently within a ground traffic area for avoiding collisions or the like by means of computer-assisted processing.

25

30

35

An object of a method of the invention is to provide a decisive improvement in terms of the above problems and hence to raise substantially the available prior art. In order to achieve this object, a method of the invention is principally characterized in that an expert system is informed about each unit on commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system as well as by means of an antenna system enabling a substantially continuous-action positioning, the operative traffic being monitored and controlled by means of a comprehensive expert system, preferably making use of

so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

5

The most important benefits gained by a method of the invention include simplicity, reliability in operation, and a remarkable improvement in the safety of operative traffic, the method making it possible to safely control for example all operative traffic associated with aviation while eliminating safety hazards and risk factors in the ground traffic within an airfield perimeter all the way from the landing of an aircraft to its take-off. A method of the invention also improves the speed and reliability of decision-making especially in abnormal situations, the method making it possible to eliminate unnecessary operation stoppages as well as congestions. Thus, a method of the invention provides a substantial improvement in the flexibility of especially ground and air traffic control, thereby producing a significant increase in the capacity of airfield traffic and in the economy of the entire airport operation. One further advantage gained especially by so-called soft computing technology over the prior art-technology is that, first of all, e.g. the neuro-sum logic provides a system which is distinctly more inexpensive, speedier, and simpler than those described above and which requires significantly fewer rules. In addition, the deduction-making is significantly speedier, with possibly more than 1000-fold differences in favour of the present invention.

The non-independent claims directed to a method disclose preferred applications for a method of the invention.

35



The invention relates also to a control system operating in accordance with the method. The control system is defined in more detail in the preamble of an independent claim directed thereto. The principal  
5 characterizing features of the control system are set forth in the characterizing clause of the same claim.

When correctly implemented, the control system of the invention is trouble-free, operates in real time, and  
10 self-learning, in addition to which it can be coupled, e.g. in the afore-mentioned aviation, e.g. interactively with ground radar, surveillance, or e.g. meteorological systems or the like. Since it is also possible to connect the operative staff to an  
15 integral, intelligent coding and information system, controlled by an expert system and further secured preferably with arrangements based e.g. on biothermal identification for preventing e.g. the passage of unauthorized persons within operative areas, the  
20 control system of the invention is capable of providing a significant improvement especially in terms of the safety and efficiency of aviation by eliminating major safety hazards and risk factors associated with traditional aviation. Thus, the  
25 control system of the invention can be used for controlling all activities within the operative ground traffic area of an airport from the moment an aircraft has touched down on runway all the way to the moment said aircraft has safely taxied to its designated  
30 terminal lot or vice versa.

The non-independent claims directed to a control system disclose preferred embodiments for a control system of the invention. The invention will now be  
35 described in detail with reference made to the accompanying drawings, in which

fig. 1 shows basically a general operating principle for a control system applying a method of the invention,

5 fig. 2 shows further a method of the invention, applying a so-called diffuse spectrum-radio positioning system based on GSM-technology.

A method for operative traffic, said operative  
10 traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time, automated data processing system, at least some of the operative units present in an operative traffic area, such as aircraft, field,  
15 maintenance, and upkeep equipment, vehicles or the like, being at least in an information transmitting communication therewith at least for the identification and positioning of the latter. An expert system 1 is informed about each unit on  
20 commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system 2 as well as by means of an antenna system 3 enabling a  
25 substantially continuous-action positioning, the operative traffic being monitored and controlled by means of a comprehensive expert system 1, preferably making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum  
30 logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

In one preferred application of a method of the  
35 invention, the expert system 1 is supplied not only with collected real-time information i1, such as that regarding said operative units, but also with information i2 regarding the conditions of an

operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models  
5 db pre-programmed therein.

In reference to traditional solutions, it is naturally preferable to control operative traffic also by means of guide boards, one preferred application of a method  
10 of the invention comprising the use of luminous, such as optical fiber, LCD-, LED-matrix displays 4 and/or the like, which are controlled integrally by means of the expert system 1 especially for providing an active guidance optimally compatible with the situation of  
15 each controlled unit.

In a further preferred application of the method, each unit present in an operative traffic area is identified and/or positioned by means of a unit-specific and/or personal detector system 5, such as  
20 through the intermediary of remote identification and/or preferably the antenna system 3 or, respectively, by means of a transponder system (TIRIS) enabling the positioning, a fingertip, eyeground  
25 identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system 1.

In a particularly preferred application of the method, each unit present in an operative traffic area is identified and positioned most preferably by means of a cellular network principle, such as a mobile  
30 communicator system included in a mobile communication network consisting of cells containing a base station, the positioning being effected by using a diffuse spectrum-radio positioning system 2, 3, 5 based on so-called GSM-technology. Fig. 2 illustrates one  
35

particular lay-out example for setting up the  
afore-mentioned diffuse spectrum-radio positioning  
system. 3', 5' represents in fig. 2 a taxiway shoulder  
light and a positioning beacon connected therewith.  
5 Respectively, 3", 5" represents a runway shoulder  
light and a positioning beacon connected therewith. kx  
represents a runway mid-line light. In a type of  
solution depicted in the figure, each  
moving/stationary object, or in this example an  
10 aircraft fp, fitted with a diffuse-spectrum  
transmitter 2' emitting an identification code. At  
this juncture, the runway shoulder lights present in  
the runway area and the taxiway shoulder lights  
receive and identify various diffuse-spectral  
15 transmissions, operating in accordance with the  
above-described logic as so-called positioning  
beacons. In this context, the radio path is provided  
by a system 2400 - 2450 GHz operating on ISM  
(Industrial & Scientifical & Medical) frequencies,  
20 having a frequency band of 50 MHz and a transmission  
capacity of < 10 mW. In this type of solution, at the  
object speed of 0 - 100 m/s, the coordinates are  
obtained at the accuracy of 0,1 - 10 meters. The scope  
of surveillance provides a possibility of monitoring  
25 all aircraft, vehicles moving in the area, maintenance  
people walking within the field area etc. In addition,  
the number of objects within the operating range of a  
single positioning analyzer may always be as high as  
15 objects, whose activated identifications are  
30 included in the system data base.

For example, the above-mentioned TIRIS-system is based  
on an identifier (transponder), which is identifiable  
and preferably also attachable to an object to be  
35 positioned, and on a reader, which in this case is  
arranged in communication with the position-defining  
antenna system 2. In terms of technology, the  
TIRIS-system is constructed in such a way that the

identifier is provided with an antenna element, a micro-circuit containing an identification code, and a capacitor. When subjected to a magnetic field from the reader, the passive identifier is charged and transmits the message contained in the identifier. The identifications are either previously encoded or to be updated in the field of a reader. The identifier receives its necessary operating energy preferably from an electromagnetic field (radio waves) and, thus, it needs no battery or other source of energy.

Referring particularly to the preferred operating principle depicted in the drawing, the control system of the invention comprises a transmitter system 2, operating on radio frequencies and informing an expert system 1 about each unit operating within an operative traffic area, including preferably also persons and groups of persons present in the operative traffic area, as well as an antenna system 3 enabling a substantially continuous-action positioning, the surveillance and control of operative traffic in the control system being effected by means of the expert system 1, making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, a chaos theory, genetic algorithms and/or the like, enabling its adaptive or self-learning operation.

The control system is further preferably based on a self-learning expert system 1, whose information and control channels are preferably constituted by apparatus-specifically encoded high-frequency transmitters 2, and further on an antenna system 3, required for positioning and detecting a set of coordinates to be positioned, and on an active and luminous display board arrangement 4, controlling an operative field area preferably through the intermediary of a so-called intelligent optical

network and based e.g. on an optical fiber/LCD-, LED-matrix.

5 In a further preferred application, the operative units/persons are linked to the system also by means of a unit-specific/personal detector system 5, such as a transponder system (TIRIS) enabling remote identification and the positioning preferably through the intermediary of the antenna system 3, a fingertip, 10 eyeground identification system based on biometric identification, and/or the like. This enables making use of unit-specific clearances, restrictions, priorities and/or the like programmed especially in the expert system 1.

15 In a preferred application, the control system includes a diffuse spectrum-radio positioning system 2,3,5, which is preferably based on GSM-technology and whereby each unit present in an operative traffic area is identified and positioned preferably on a cellular 20 network principle, such as a mobile communicator system included in a mobile communicator network consisting of cells that contain a base station.

25 In an intended application as described above, the control system monitors and controls automatically as well as transmits information independently about all operative traffic action within a field area and, by virtue of this, provides air traffic control and 30 aviators with significantly improved possibilities of taking correct decisions and measures required by a given situation. In addition, the above type of control system increases substantially the capacity of operative field action (landing, take-off, surface 35 traffic, flight maintenance) especially in foul weather conditions, as it is capable of composing an overall picture of all surveillance and sensor points simultaneously. The accuracy is further enhanced, as

the control system is capable of determining and deciding continuously and in real-time all situations and by constantly simulating both mathematically and empirically such situations before they are likely to occur. Thus, an expert system included in the control system is capable of identifying also completely unpredictable events e.g. by alarming the operative staff automatically and by describing the problem as well as by also presenting preferably e.g. graphic and safe, i.e. previously simulated and tested model solutions.

One further advantage offered by the control system of the invention in this context is that it relieves the air traffic control of all control measures regarding aircraft present on the ground and in a normal condition as well as other surface traffic. Hence, the control system concentrates the decision-making especially in a crisis situation on the air traffic control, the expert system, as well as on other monitoring systems associated preferably interactively with the control system, e.g. as depicted in the chart of the drawing. Hence, an expert system of the invention operates as part of the control system by delivering continuous, real-time, graphic information, solution models and suggestions, while leaving, whenever necessary, the actual decision-making to the air traffic control. According to the chart depicted in the drawing, the control system thus collects the real-time information, compares it to a safe decision compatible with the condition of the expert system 1, and produces an alarm about immediate or anticipated discrepancies. The analyzed surveillance information is stored automatically in the data base db.

In certain type of cases, the expert system 1 included in the control system operates automatically by deciding and performing all conventional and non-

hazardous control duties. In addition, it is possible to monitor thereby that the air traffic control performs correctly the ground traffic control operations assigned thereto.

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The method and control system of the invention can be further exploited in such a manner that all relevant travelling paths within an operative area are also provided with guiding tapes or the like, controlled in real time by the expert system, whereby e.g. an advancing light or sound effect is used to guide each controlled unit to its proper destination.

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It is naturally obvious that a method of the invention can be applied not only in the above-mentioned and -described applications but in the most diverse of contexts, i.e. in addition to ground traffic application, e.g. in a harbour area for controlling and monitoring the passage of boats/ships. Naturally, the operating chart depicted by way of example only represents generally the operating principle for a method of the invention, as it is of course possible to link directly therewith, in addition to the above-mentioned supplementary functions, e.g. an air traffic control radar and monitor info, air traffic control preference decisions, weather observations, etc. Also naturally, e.g. the above-described TIRIS-system can be active as well, whereby, when fitted with a current supply, it will be capable of independently communicating with the expert system, e.g. for the continuous positioning of a moving vehicle.

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Claims:

1. A method for operative traffic, said operative traffic, especially operative ground traffic associated with air traffic, being controlled by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area, being at least in an information transmitting communication therewith at least for the identification and positioning of the latter, characterized in that an expert system (1) is informed about each unit on commission within an operative traffic area, preferably including also persons or groups of persons within the operative traffic area, by means of a radio-frequency operated transmitter system (2) as well as by means of an antenna system (3) enabling a substantially continuous-action positioning, the operative traffic being monitored and controlled by means of the comprehensive expert system (1), preferably making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, chaos theory, genetic algorithms and/or the like for enabling its adaptive or self-learning operation.

2. A method as set forth in claim 1, characterized in, that the expert system (1) is supplied not only with collected real-time information (i1), such as that regarding said operative units, but also with information (i2) regarding the conditions of an operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models (db) pre-programmed therein.

3. A method as set forth in claim 1 or 2, wherein the operative traffic is controlled by means of guide boards present at least in an operative traffic area, characterized in that said guidance is effected by using luminous, such as optical fiber, LCD-, LED-matrix displays (4) and/or the like, which are controlled integrally by means of the expert system (1) especially for providing an active guidance optimally compatible with the situation of each controlled unit.

4. A method as set forth in any of the preceding claims 1-3, characterized in that each unit present in an operative traffic area is identified and/or positioned by means of a unit-specific and/or personal detector system (5), such as through the intermediary of remote identification and/or preferably the antenna system (3) or, respectively, by means of a transponder system (TIRIS) enabling the positioning, a fingertip, eyeground identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system (1).

5. A method as set forth in any of the preceding claims 1-4, characterized in that each unit present in an operative traffic area is identified and positioned most preferably by means of a cellular network principle, such as a mobile communicator system included in a mobile communication network consisting of cells containing a base station, the positioning being effected by using a diffuse spectrum-radio positioning system (2,3,5), most preferably based on GSM-technology.

6. A control system for operative traffic, said control system intended for controlling operative traffic, especially operative ground traffic

associated with air traffic, being implemented by means of a real-time and automated data processing unit, at least some of the operative units, such as aircraft, field, maintenance, and upkeep equipment, vehicles or the like, present in an operative traffic area being at least in an information transmitting communication therewith at least for the identification and positioning of the latter, characterized in that the control system comprises a transmitter system (2), operating on radio frequencies and informing an expert system (1) about each unit operating within an operative traffic area, including preferably also persons and groups of persons present in the operative traffic area, as well as an antenna system (3) enabling a substantially continuous-action positioning, the surveillance and control of operative traffic in the control system being effected by means of the expert system (1), making use of so-called soft computing technology, such as a sum logic, a neural network, a neuro-sum logic, a chaos theory, genetic algorithms and/or the like, enabling its adaptive or self-learning operation.

7. A control system as set forth in claim 6, characterized in that the expert system (1) is adapted to process not only real-time information (i1) collected therein and regarding said operative units, but also information (i2) regarding the conditions of an operative traffic area, such as wind, ice, snow, water, temperature and/or the like factors, for anticipating hazardous situations, such as collision situations or the like, by means of operating models (db) pre-programmed therein.

8. A control system as set forth in claim 6 or 7, including guide boards present at least in an operative traffic area for guiding said operative traffic, characterized in that said guidance is

provided by means of luminous, such as optical fiber, LCD-, LED-matrix displays (4) and/or the like, which are adapted to be integrally controlled by means of the expert system (1) especially for providing an active guidance optimally compatible with the situation of each controlled unit.

9. A control system as set forth in any of the preceding claims 6-8, characterized in that, for identifying and/or positioning each unit present in an operative traffic area, said control system includes a unit-specific and/or personal detector system (5), such as a transponder system (TIRIS) enabling the positioning through the intermediary of remote identification and/or preferably the antenna system (3) or, respectively, a fingertip, eyeground identification system and/or the like, based on biometric identification, especially for making use of unit-specific clearances, restrictions, priorities and/or the like programmed in the expert system (1).

10. A control system as set forth in any of the preceding claims 6-9, characterized in that it includes a diffuse spectrum-radio positioning system (2,3,5), most preferably based on GSM-technology, for identifying and positioning each unit present in an operative traffic area most preferably on a cellular network principle, such as by means of a mobile communicator system included in a mobile communication network consisting of cells containing a base station.

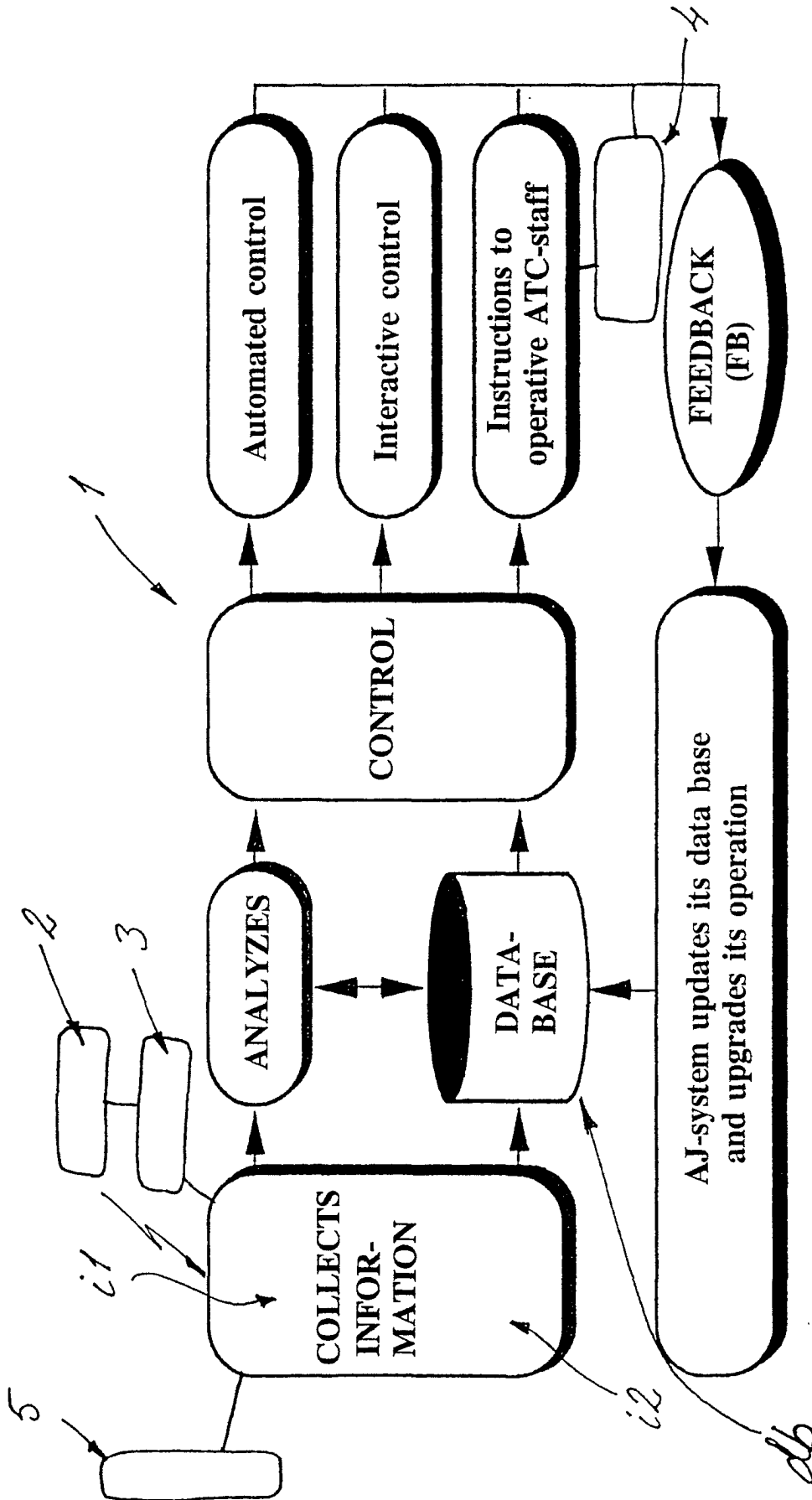
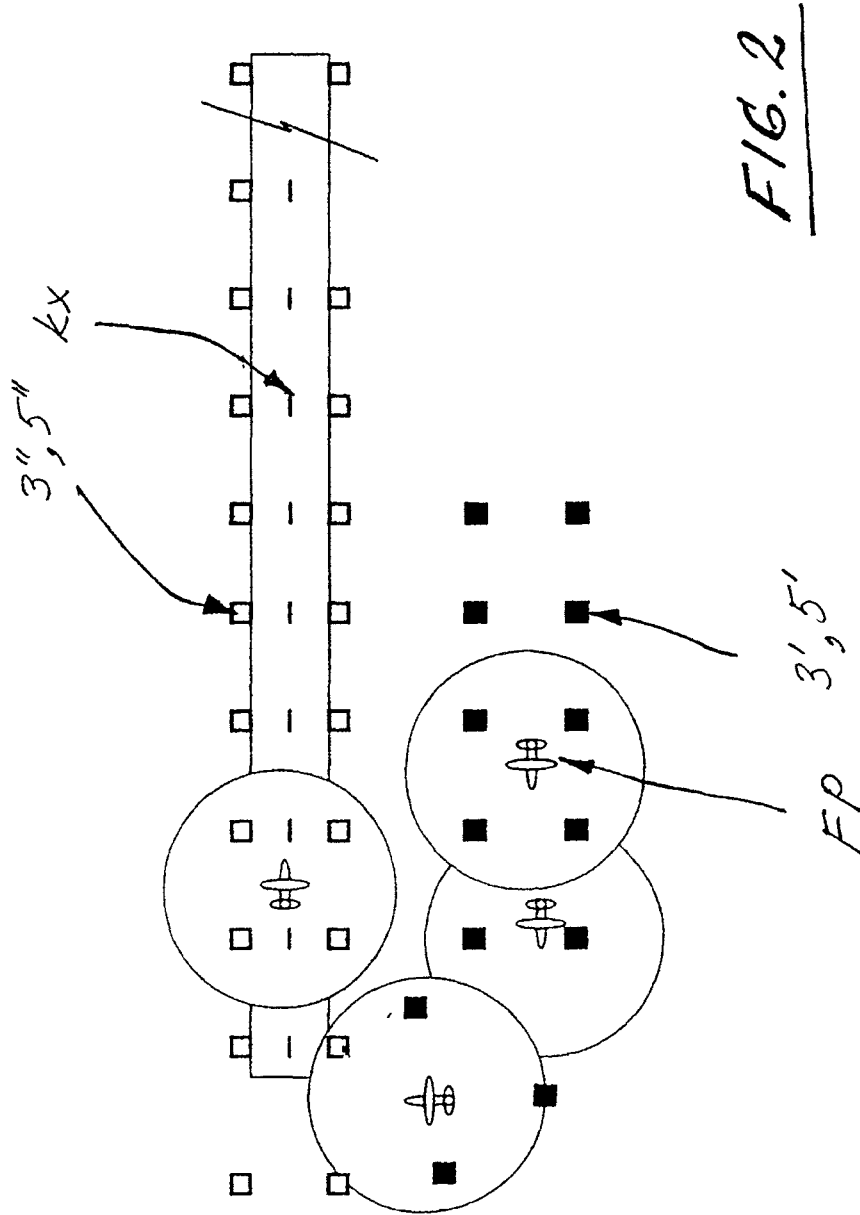


FIG. 1



## INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: G08G 5/06 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: G08G		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Electrical Communication, Volume, January 1993, Monzel F.-G. et al, "Surface Movement Guidance and Control System", page 51 - page 59, see the whole document  --	1-10
A	US 4827418 A (ARTHUR GERSTENFELD), 2 May 1989 (02.05.89), abstract  --	1,6
A	EP 0613109 A1 (RAYTHEON COMPANY), 31 August 1994 (31.08.94)  -- -----	4,9
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "B" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
13 February 1998		16 -02- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer  Göran Magnusson Telephone No. +46 8 782 25 00

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 Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP 0613109 A1	31/08/94	CA 2114482 A	27/08/94
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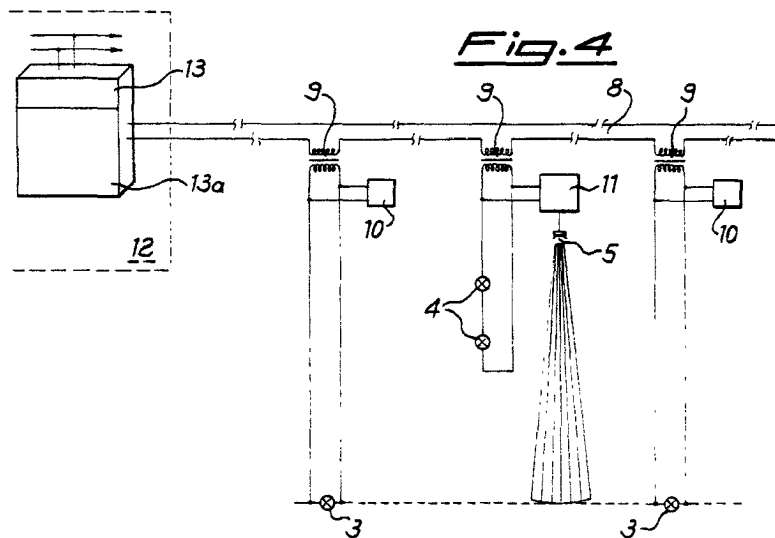
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54 **Automatic equipment for controlling and guiding the movement of aircraft travelling on the ground.**

57 Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b), comprising illumination devices (3) disposed at predetermined intervals along the longitudinal axis of the taxi strips (1b); light signalling devices (4) spaced equally apart in such a way that each successive pair of signalling devices (4) defines, in the longitudinal direction, consecutive seg-

ments (2) of the taxi strip (1b); devices (5) for detecting the passage of aircraft (6) capable of sending a signal to corresponding means of controlling (10, 13, 14) and displaying (15) the actuation of the sequence of lighting and extinguishing of the illumination and guiding (3) devices and of the light signalling devices (4) of the various segments (2, 102) of the taxi strip (1b).



EP 0 532 110 A2

The present invention relates to equipment for controlling and guiding the movement of aircraft travelling on the ground on taxi strips for access to and exit from the runway and parking and standing areas of airports.

It is known that one of the principal problems relating to the operational management of airports is constituted by the necessity of moving aircraft as rapidly as possible, but in conditions of complete safety, in their transit from the parking area to the take-off runway and from the landing runway to the parking area.

Among the known methods of providing the aircraft pilot with signals permitting proceeding and guiding on predetermined routes of exit from and/or entry to the runways, particular mention may be made of those based on direct visual observation by the pilot of signs located on the ground, manually operated on sight by the control tower operator, and those based on surface radar devices installed at predetermined points at the airport; such devices, however, have numerous disadvantages, including the total lack of control of ground traffic in case of failure or disabling of the device for maintenance operations, or incorrect signalling and/or interpretation of the signalling due to high reflection levels caused by irregularities of the ground, the presence of obstacles, driving rain and the like, image splitting and the like.

Such problems are also significantly increased in critical operating conditions such as those arising with high traffic flows, adverse meteorological conditions and poor visibility.

Consequently there is a technical problem of providing automatic equipment which is capable of signalling to and guiding aircraft during their transit on the ground on sections of taxi and connecting strips, and which is able to ensure a specified safe distance between the aircraft, permitting or refusing their access to sections of taxi strip, and operating reliably in any weather and traffic density conditions, and with a signalling speed proportional to the actual requirements related to the real traffic density in such a way as to cause no significant decrease of the operating capacity of the airport.

The equipment must also be such that correct operation is ensured even in case of failure and/or during ordinary maintenance operations, and such that it may be applied both at new airports and at airports already in operation, by making use, in the latter case, of auxiliary services and transmission lines which may already be in existence.

These results are achieved by the present invention, which provides automatic equipment for controlling and guiding the movement of aircraft travelling on the ground on taxi strips to and from the runways and to and from the standing and parking areas, this equipment comprising in com-

bination illumination devices disposed at predetermined intervals along the longitudinal axis of the taxi strips; light signalling devices spaced equally apart in such a way that each successive pair of signalling devices defines, in the longitudinal direction, consecutive segments of the taxi strip; devices for detecting the transit of aircraft and capable of sending a signal to corresponding means of controlling and displaying the actuation of the sequence of lighting and extinguishing of the illumination and guiding devices and of the light signalling devices of the various segments of the taxi strip, for corresponding permission for or prohibition of the advance of the aircraft along successive segments.

More particularly, it is specified that the said light signalling devices consist of pairs of lights disposed at the lateral edges of the taxi strip on the transverse axes of the segments and that the said detection devices preferably consist of sensors of the microwave and infrared type and consequently that the said sensors illuminate the respective signalling devices when any detection of the passage of the aircraft has ceased.

A further characteristic of the invention consists in the fact that the said control units comprise local control units disposed next to the segments, substation control units disposed inside electrical equipment substations, and central control units disposed in the control tower; in particular, the said substation control units are capable of receiving signals from a central unit and of operating local control units to light and extinguish the axial illumination devices and to extinguish the signalling devices, while the local control units are capable of receiving signals confirming the passage of an aircraft from the sensors and of autonomously causing the lighting of the signalling devices.

In particular, each unilluminated segment is delimited by illuminated red light signals to prevent the access of an aircraft to the said segment.

According to the invention, the automatic equipment may also be used with illumination devices each of which comprises a signalling light and a sensor, each illumination device being capable of operating in this mode, and also as a segment end light, in which case each segment has a minimum length which may be varied as required, and is determined by the lighting of the illumination device with a red light.

For the better use of the equipment it is also specified that the central control unit only controls the intersections delimiting sections of taxi strip and that the local and substation control units directly control the segments into which each of the said taxi strip sections, delimited by consecutive nodes, is divided.

Further details may be obtained from the following description, with reference to the attached drawings, which show:

in Fig. 1:

a partial schematic plan of an airport;

in Fig. 2:

a plan view of a section of taxi strip equipped with signalling devices according to the invention;

in Fig. 3:

a schematic diagram of the local electrical power supply and control circuit of the signalling equipment;

in Fig. 4:

a schematic diagram of the circuit connecting the taxi strip equipment to the substation control unit;

in Fig. 5:

a block diagram of the system of connection of the substation control unit to the central control unit;

in Figs. 6a, 6b, 6c:

the operating sequence of the control and signalling equipment according to the invention;

in Fig. 7:

a view of the device displaying the current state of the ground traffic situation;

in Fig. 8:

an alternative division of the taxi strips into sections delimited by intersections.

As shown in Fig. 1, the map of an airport 1 is normally divided into landing and take-off runways 1a, taxi strips 1b comprising links and intersections 1c, and standing and parking areas 1d.

In order for the aircraft to be guided automatically from the moment at which they leave the landing runway 1a until they stop in the parking area 1d, and vice versa, the taxi strips 1b are, according to the invention, ideally divided into segments 2 adjacent to each other and physically delimited by lighting elements whose lighting and extinguishing are monitored and controlled by programmed control units which receive signals from sensors associated with the lighting elements and send lighting or extinguishing commands to local control units which are in communication with a central unit installed in the control tower.

In greater detail, each segment 2 (Fig. 2) is provided with illuminating elements 3 disposed at predetermined intervals, as will be more clearly specified subsequently, along the longitudinal axis of the segment 2 which is delimited by two opposite theoretical transverse lines 2a constituting the axis of alignment of stop lights 4 associated with sensors 5 capable of detecting the passage of an aircraft 6 and of lighting the stop lights 4 through the local control unit 11, which in turn sends a confirmation signal to a substation control

unit 13 located near the taxi strip in corresponding substations 12 (Fig. 4).

The minimum length of a segment 2 is determined on the basis of certain parameters which affect the whole design of the equipment and include the photometric properties of the illuminating elements 3, the characteristic category of authorization for landing, the geometry of the electrical circuits of the light fittings and the dimensions of the aircraft; the power of the lamps and their spacing along the segment, together with the length of the segment itself, will be calculated from these parameters.

As is more clearly shown in Fig. 3, the axial illuminating elements 3 are connected to the series power supply circuits 8 disposed along the taxi strip 1b at its edges, each pair of illuminating elements 3 formed in this way being connected to isolation transformers 9 in parallel to which are connected local control units 10 in order to implement the lighting and extinguishing commands received from the substation control unit 13.

As has been stated, two pairs of stop lights 4 are also installed at each transverse axis of the start and end of a segment 2 near the edge of the taxi strip, these lights also being supplied from the mains 8 through transformers 9, in parallel with which are connected sensors 5 to detect the passage of the aircraft, these sensors also being supplied from the mains 8 through isolation transformers 9.

According to the invention (Fig. 4), the terminals of the electrical circuits are connected to constant current regulators 13a housed in the electrical substations 12, which in turn are connected to substation control units 13 for connection (Fig. 5) to the central control unit 14 which is located in the control tower and substantially consists of a pair of electronic computers 14a arranged in parallel, a monitoring unit 14b capable of determining the priority of operation between the two computers, a data compression unit 14c and an intermediate register 14d for the temporary storage of signals from and to the substation control units 13, installed in the individual substations 12, which operate at a different rate from the central unit 14.

The operating sequence of the equipment is as follows (Fig. 6a): when an aircraft 6a passes through a given segment 2a, all the axial lights 3a of the segment 2a are illuminated to guide the aeroplane and at the same time the red stop lights 4'a, defining the start of segment 2a, are illuminated to prevent any access to the same segment by another aeroplane. During such a phase the axial lights 3b of segment 2b, behind and adjacent to the occupied segment 2a, are extinguished, since the presence of an aeroplane 6, which would be too close to the one in front, is not permitted in

this segment.

If the two segments 2c, 2d following segment 2a are free, the stop lights 4''a disposed next to the transverse end axis of segment 2a permit free passage, being extinguished, and allow the aeroplane 6a to proceed on its way, guided by the corresponding axial lights 3c which will be lighted.

At the same time, a second aeroplane 6b travelling along the same taxi strip behind the aeroplane 6a would find the axial lights 3e of its segment 2e illuminated and the rear stop lights 4'e and forward stop lights 4''e illuminated with red lights to prevent the advance of the aeroplane 6b to the following segment 2b, which would be immediately adjacent to the segment 2a already occupied by the aeroplane 6a and which, in turn, has axial lights 3b extinguished as stated previously.

When the first aeroplane 6a passes the sensor 5a (Fig 6b), the latter, detecting the interruption of the beam, changes state and sends a signal to the substation control unit 13 which, by a dialogue with the central control unit 14, enables the latter to send signals to the local control unit 10 to modify the situation as follows: illumination of the axial lights 3d of segment 2d to allow aeroplane 6a to proceed on its way, on completion of the passage of which in front of the sensors 5'a the situation is further changed as follows (Fig. 6c): axial lights 3c, 3d of the adjacent segments 2c, 2d illuminated and stop lights 4''c extinguished to allow aeroplane 6a to proceed on its way; axial lights 3a of segment 2a to the rear and adjacent extinguished and stop lights 4'a, 4''a illuminated with a red light to prevent access of a second aeroplane to segment 2a, stop lights 4'e extinguished and axial lights 3b of segment 2b illuminated to permit the advance of aeroplane 6b to segment 2b following that being passed through.

Consequently the control of the illumination of consecutive adjacent segments as described above enables the advance of a number of aeroplanes to be guided, while simultaneously ensuring the maintenance of the desired safety distance between one aeroplane and the other, this distance always being measured in multiples of segments 2 of a minimum predetermined length as described above.

The equipment according to the invention is completed by a device for the display of the complete ground traffic situation of the airport, which enables the operators to identify on a video screen 15 (Fig. 7) fixed areas 15a for identification of particular aeroplanes, distinguished for example by their own flight numbers, such fixed areas being associated with a broken line 15b or the like to graphically link the identification area 15a with the segment 2 of taxi strip occupied by the aeroplane and represented on the screen within the map of the airport; as the aeroplane moves along the taxi

strip to take off or, in the opposite direction, to the parking area 1d, the identification number will occupy successive fixed areas and change its position on the screen.

Many constructional and dimensional modifications may be introduced into the embodiment of the various components of the equipment without thereby departing from the scope of the invention in its general characteristics; in particular, it is possible to specify the connection of stop light 4 and of the sensor 5 inside each axial illuminating element 3, which in this case will be designed to emit either a green light or a red light, providing, by means of appropriate processing of the data carried out by the corresponding units, continuous control of the whole airport area with the further important possibility of freely modifying the minimum length of segment 2 according to necessity and/or convenience, for example as a result of a decrease in visibility which necessitates a greater safety distance.

It is also possible (Fig. 8) to theoretically divide the map of the airport into sections 102 located between two consecutive intersections, known as nodes, 101c, additionally dividing the tasks of the various control units in such a way that the substation control units 13 have the task of guiding the aeroplane in the individual segments 102 until the final sensor 105 indicates that the aeroplane is entering a node 101c, at which point control passes to the central control unit 14, which is informed of the presence or absence of the other segments leading to this particular intersection, and which may establish the order of precedence of access to the intersection or may divert a machine to other segments; with such a configuration it would be possible to make considerable savings of transmission time, since the data traffic relating to the control of the advance of the aircraft 6 in segments 102 would be limited to the substation control units situated near the taxi strips, while only the data concerning the actual position of each aeroplane would be sent to the central control unit (14).

#### Claims

1. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) from and to the runways (1a) and to and from the standing and parking areas (1d), characterized in that it comprises in combination illumination devices (3) disposed at predetermined intervals along the longitudinal axis of the taxi strips (1b); light signalling devices (4) spaced equally apart, in such a way that each pair of successive signalling devices (4) defines, in the longitudinal direction, consecutive segments (2) of taxi strip

- (1b); devices (5) for detecting the transit of aircraft (6), capable of sending a signal to corresponding means of control (10, 13, 14) and display (15) of the actuation of the illumination and extinguishing sequence of the illumination and guiding devices (3) and of the light signalling devices (4) of the various segments (2, 102) of the taxi strip (1b), for the corresponding permission for or prohibition of the advance of the aircraft through successive segments (2).
2. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) according to claim 1, characterized in that the said light signalling devices (4) consist of pairs of lights disposed at the lateral edges of the taxi strip (1b) next to the transverse axes (2a) of the segments (2) delimiting the length of the segments.
  3. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) according to claim 1, characterized in that the said detection devices preferably consist of sensors (5) of the microwave and infrared type, and in that the said sensors illuminate the corresponding signalling devices (4) when any detection of the passage of the aircraft (6) has ceased.
  4. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said control units comprise local control units (10, 11) disposed next to the segments (2), substation control units (13) disposed inside electrical equipment substations (12), and central control units (14) disposed in the control tower.
  5. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said substation control units (13) are capable of receiving signals from a central unit (14) and of actuating local control units (10, 11) to illuminate and extinguish the axial illumination devices (3) and to extinguish the signalling devices (4), and in that the said local control units (11) are capable of receiving signals confirming the passage of an aircraft (6) from sensors (5) and of autonomously causing the illumination of the signalling devices (4).
  6. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said central control unit (14) controls the illumination and extinguishing of the first pair of signalling lights (4) disposed near the accesses to the taxi strip (1b), thus specifying the taxi strip along which the aeroplane has to travel.
  7. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that each of the said illumination devices (3) comprises a signalling light (4) and a sensor (5), each illumination device (5) being capable of operating in this mode, and also as a segment end light (2).
  8. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claims 1 and 7, characterized in that each segment (2) has a minimum length which may be varied as necessary and is determined by the illumination with red light of the illumination device (3).
  9. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that each unilluminated segment is delimited by illuminated red signal lights (4) to prevent the access of an aircraft to this segment.
  10. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the central control unit (14) controls only the intersections (101c) delimiting sections of the taxi strip (1b), and in that the local control units (10) and substation control units (11) directly control the segments (102) into which each of the said sections of taxi strip delimited by consecutive nodes (101c) is divided.

Fig.1

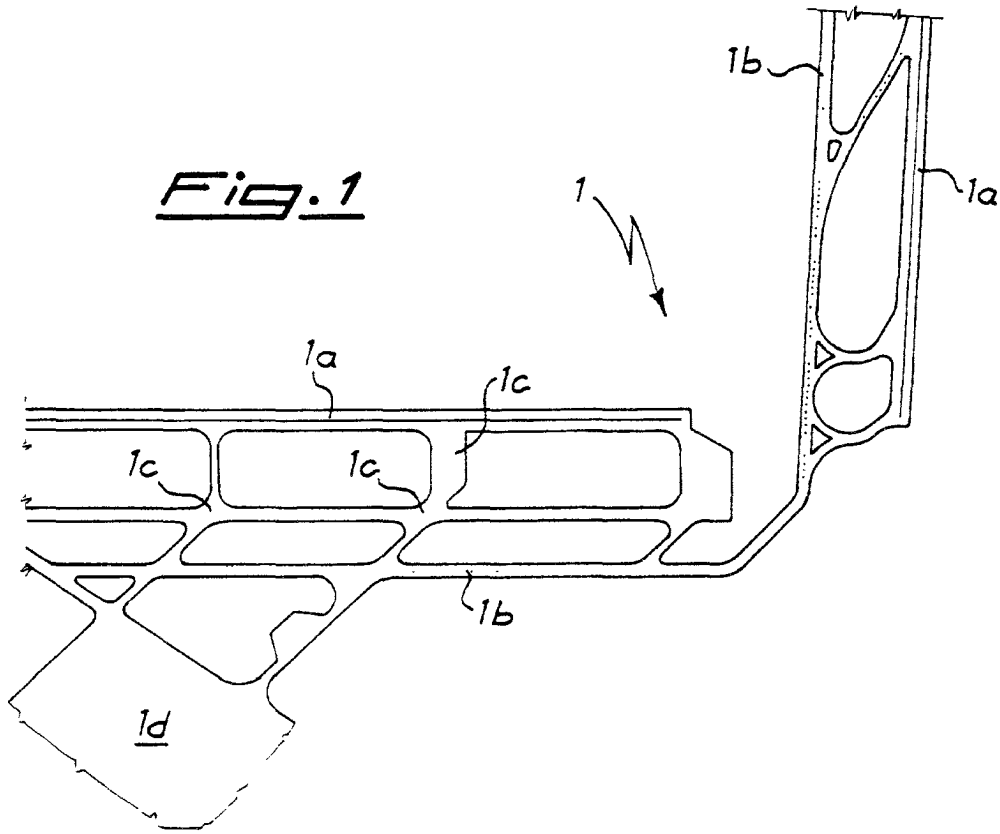


Fig.2

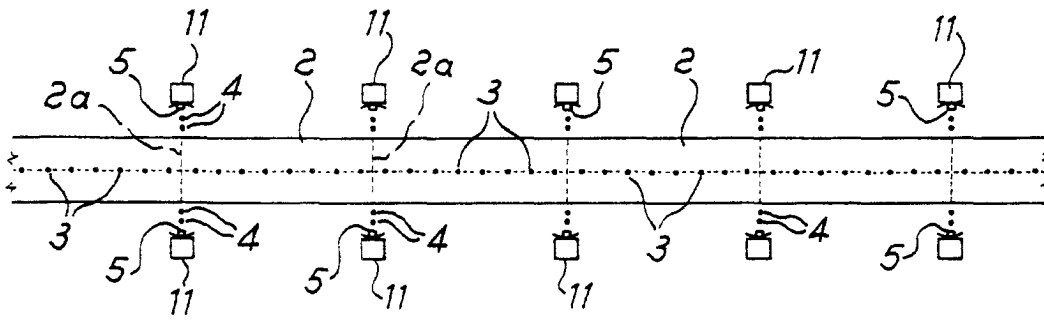
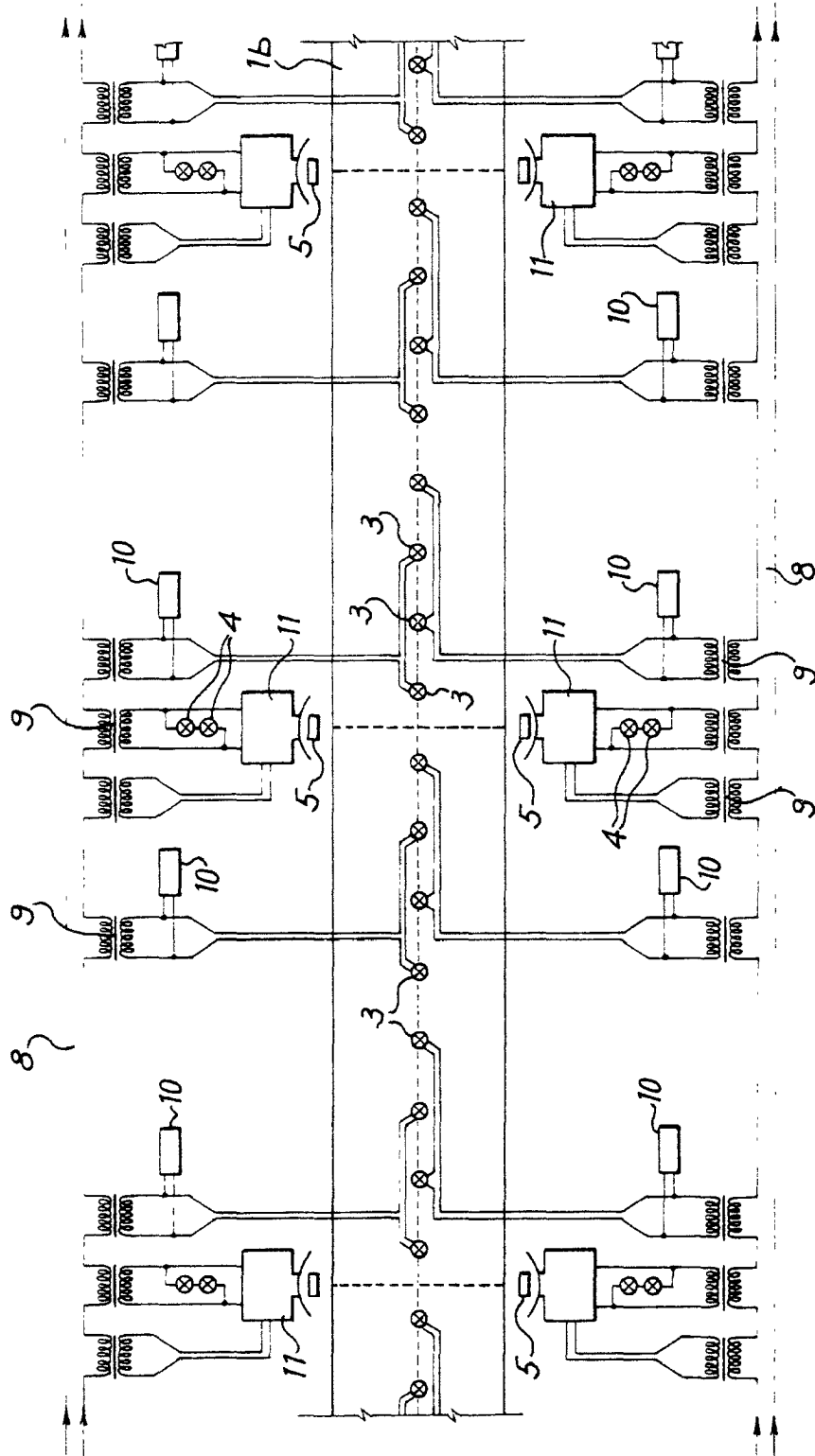
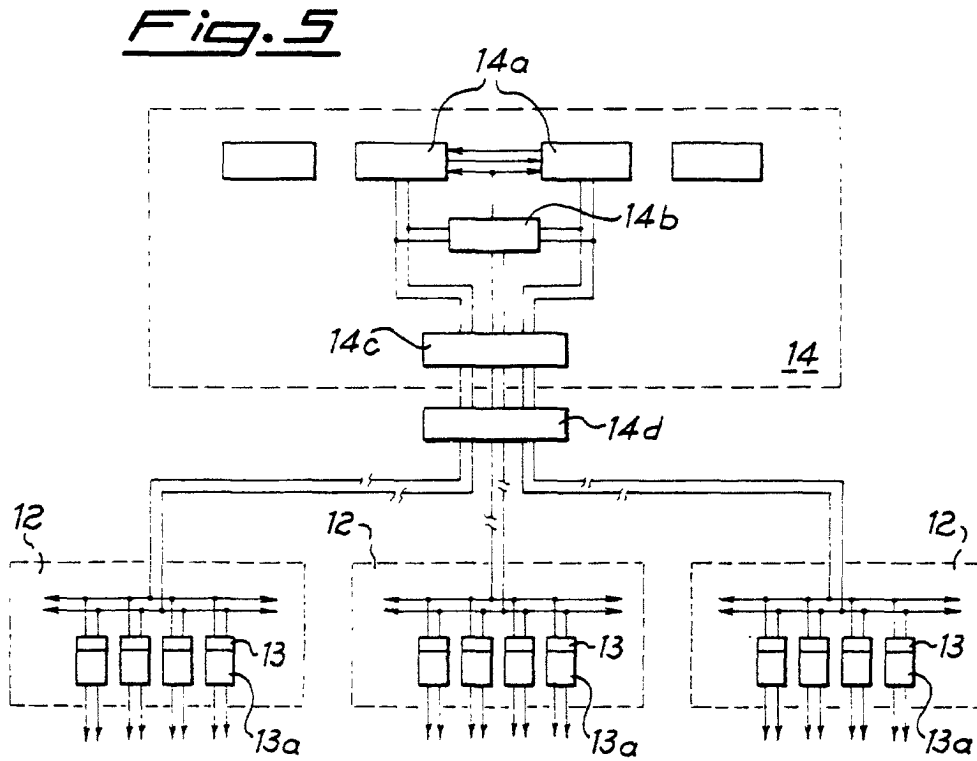
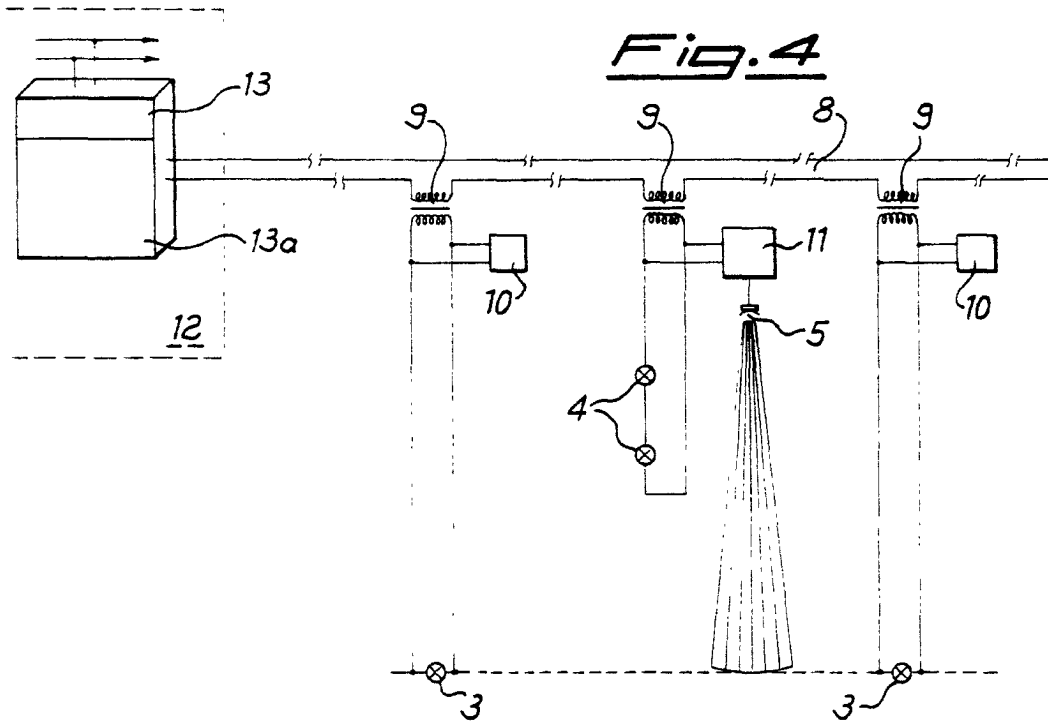


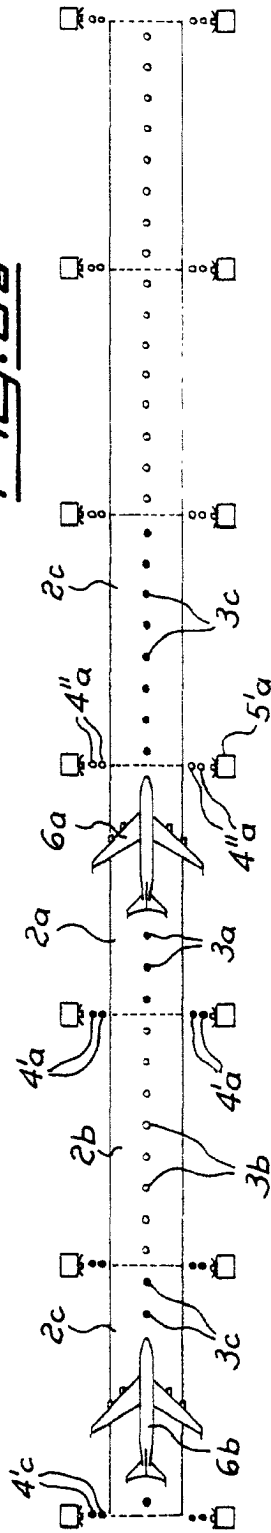
Fig. 3



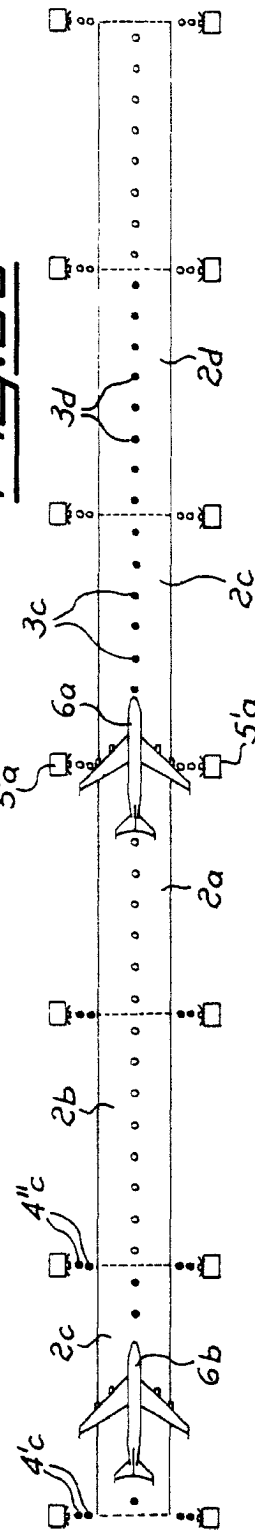




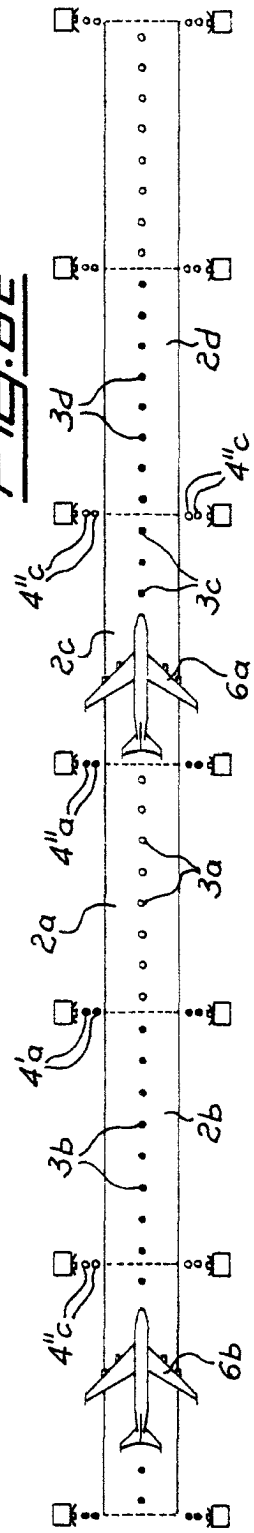
**Fig. 6a**



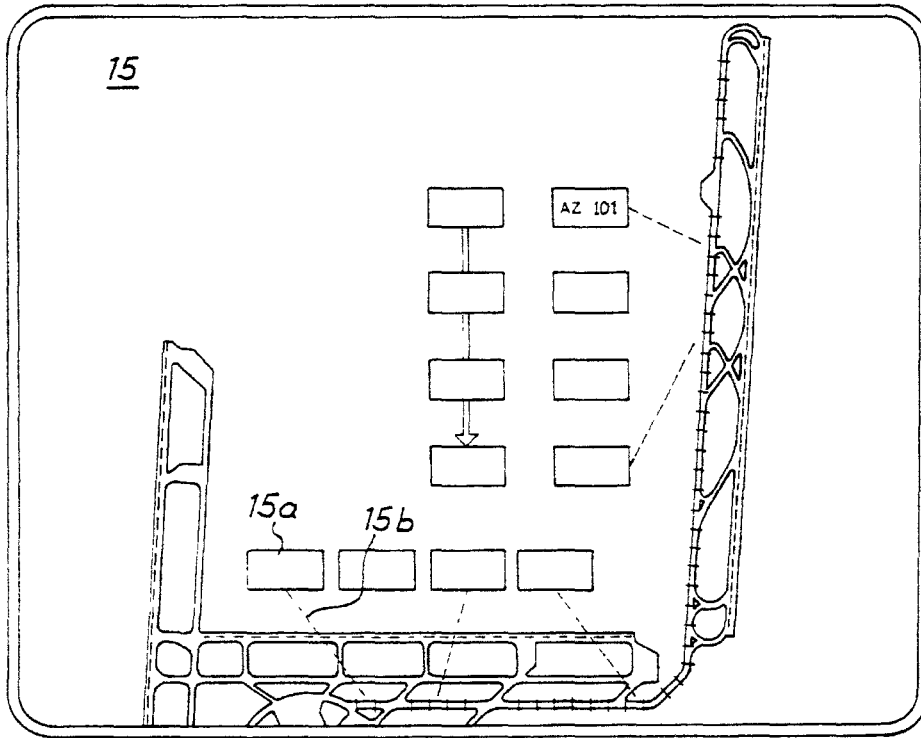
**Fig. 6b**



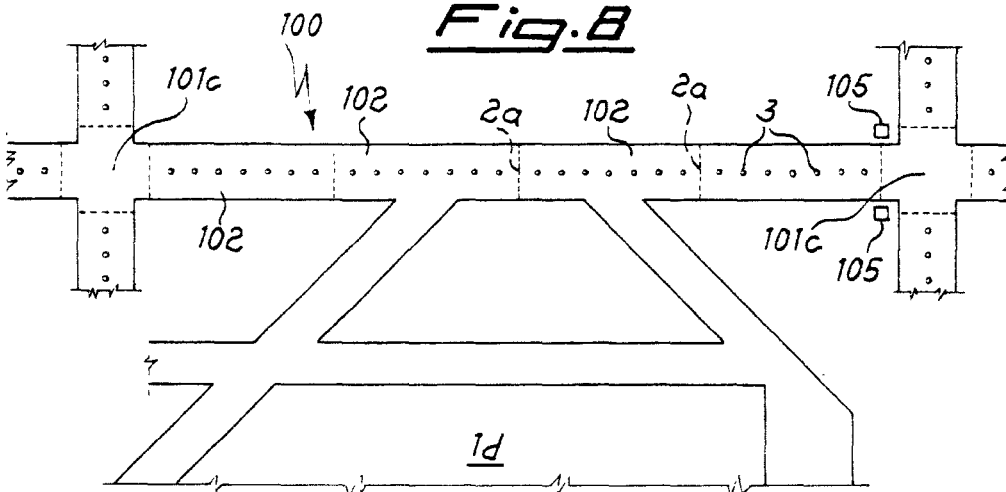
**Fig. 6c**



*Fig. 7*



*Fig. 8*





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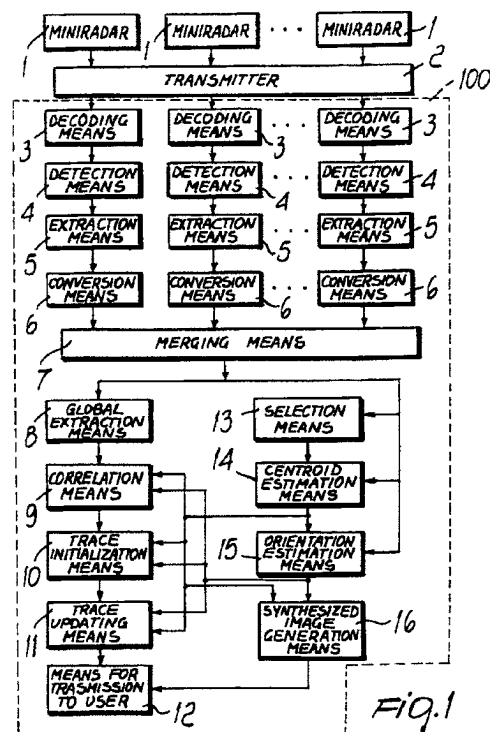
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(54) **Airport surface traffic monitoring system**

(57) An airport surface traffic monitoring system includes a plurality of sensors suitable to detect signals from the airport surface. The signals are sent to a signal and sensor image processing unit suitable to provide in output the exact location of aircraft, moving or stationary vehicles, and of obstacles for controlling traffic on the airport surface.



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## Description

The present invention relates to an airport surface traffic monitoring system.

In particular, the invention relates to airport surface movement guidance and control systems, for the safety and efficiency of airport ground traffic. More particularly, the invention is in the field of the monitoring function.

Airports worldwide are currently affected by an amount of air traffic which is often close to the maximum limit of their capacity and is further increased by the corresponding traffic flow of all the support vehicles which are indispensable in order to ensure the operation of the airport. Accordingly, ground traffic management is becoming increasingly difficult and subject to a considerable risk of accidents.

In most airports, monitoring is currently performed substantially by means of direct visual observation carried out by the controllers from the control tower, complemented by the position reports sent by the pilots and by the drivers of the various vehicles which are present on the airport surface.

In poor visibility conditions, typically at nighttime or in bad weather, in some airports the controller is assisted by a radar sensor for surface movement control, known as SMR (Surface Movement Radar) or ASDE (Airport Surface Detection Equipment) which operates at frequencies below 40 GHz.

The information provided by this kind of radar, which has a relatively long range capable of covering the entire surface involved but is not able to identify the detected objects, must be interpreted by the controller.

Especially in poor visibility conditions, the controller must mentally visualize a "picture" of the situation of the traffic on the airport surface in addition of course to planning the flow of the traffic. Obviously, such a task is extremely demanding due to the large number of trucks, vehicles, and the like which are present on the airport surface in addition to the aircraft.

Current radar monitoring systems are heavily hindered by the poor resolution and poor precision of the radar sensor, by masking effects caused by the inevitable presence of obstacles in the area of interest, and by difficulties in promptly identifying the targets for safety purposes, particularly as regards the danger of collisions between vehicles or between vehicles and obstacles.

Furthermore, the position and movement information dictated by controllers to the individual aircraft and trucks that move on the airport surface are currently sent by radio, using channels which are already overloaded.

The document "Sistema di guida e controllo del movimento a terra", F.G. Monzel, A. Bories, Prospettive di telecomunicazioni - 1st quarter 1993 describes a control system which should partly solve these problems; however, even this system has insufficient resolution in addition to being complicated and expensive.

The aim of the present invention is to provide an air-

port surface traffic monitoring system which is capable of ensuring safe, orderly and efficient traffic flow even in poor visibility conditions and in bad weather.

Within the scope of this aim, an object of the invention is to provide an airport surface traffic monitoring system which allows to locate the aircraft and the other vehicles and occasional obstacles, eliminating the effects of interference.

A further object of the present invention is to provide an airport surface traffic monitoring system which allows to cover the airport surface with a better resolution than conventional systems.

A further object of the invention is to provide an airport surface traffic monitoring system which is capable of using radar images to clearly locate and identify the various aircraft and vehicles.

A further object of the present invention is to provide an airport surface traffic monitoring system which is simple to manufacture and highly reliable and has a competitive cost.

This aim, these objects, and others which will become apparent hereinafter are achieved by an airport surface traffic monitoring system, characterized in that it comprises a plurality of sensors which are suitable to detect signals from the airport surface, the signals being sent to devices for processing signals and images of the sensors, which are suitable to provide in output the exact location of aircraft, moving or stationary vehicles and of obstacles in order to control the traffic on the airport surface.

Further characteristics and advantages will become apparent from the description of a preferred but not exclusive embodiment of the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a block diagram of the system according to the present invention; and

Figure 2 is a block diagram of one of the miniradars used in the block diagram of Figure 1.

With reference to the above figures, the system according to the invention includes a plurality of sensors which are connected to a subsystem for processing the signals and data of the sensors over high-capacity communications channels, advantageously provided by means of optical fibers.

The sensors that are used are small radars 1 (miniradars), which are characterized by small dimensions with respect to the state of the art and by low weight and cost, which can be achieved by using millimeter waves with higher frequencies than those used by existing systems (<40 GHz). These miniradars 1 are placed in elevated locations (buildings, pylons) in the airport area or in the immediate vicinity. The number of these miniradars typically varies from 1 to 5, depending on the structure of the particular airport in which they are used.

By way of example and for the sake of greater clarity, Figure 1 illustrates the block diagram of the system according to the invention in the case in which there are three miniradars 1.

The miniradars 1 have a range which is shorter than the dimensions of the airport surface and are organized like a network so as to ensure optimum coverage of the airport surface.

The miniradars 1 use millimeter frequencies both during reception and during transmission in order to have small antennas.

The use of these millimeter frequencies prevents electromagnetic compatibility problems in the operating environment and minimizes the effects caused by ground reflections.

Frequencies around 95 GHz are used in a preferred embodiment.

The miniradars 1 are connected to the processing subsystem by means of a transmission means 2, which is advantageously constituted by optical fibers.

The transmission means 2 connects each miniradar 1 to a means 100 for processing the signals and the data of the miniradars.

In particular, the transmission means 2 connects each miniradar 1 to a corresponding demodulation and decoding means conveniently constituted by a demodulator decoder 3 which is suitable to convert the signal into a numeric representation.

The signal in output from each demodulator decoder 3 enters a signal processing and detection means 4 suitable to eliminate the effects of the interference caused by unwanted echoes and by noise.

A local radar data extraction means 5 is cascade-connected to the signal processing and detection means and is suitable to provide, in output, data in polar-coordinate form, which are sent to a converter means 6 suitable to convert the polar representation into an X-Y representation.

The outputs of the various conversion means 6, one for each miniradar 1, are sent to a radar data merging means 7.

A global radar data extraction means 8 is cascade-connected to the merging means 7 and is suitable to generate numeric messages which indicate the presence and the position of the objects of interest.

The output of the global extraction means 8 is sent to a correlation means 9, suitable to correlate the numeric messages that indicate the presence and position of objects of interest with summary indications of moving vehicles with their corresponding path and, if available, their identification (hereinafter termed "traces").

The output of the correlation means 9 is sent to a trace initialization means 10, which initializes a new trace if the comparison performed by the correlation means 9 does not yield a match between the numeric message (hereinafter referenced as "plot") and an existing trace.

The output of the initialization means 10 is sent to a

trace updating means 11, which sends its output to a transmission means 12 suitable to display the result to the controller assigned to airport surface traffic monitoring.

The output signal from the merging means 7 is sent not only to the global extraction means but also to an image processing means. The image processing means includes an area selection means 13, a centroid estimation means 14, an orientation estimation means 15, and a synthesized image generation means 16.

The area selection means 13 is suitable to select a specific area which includes a single target of interest for transfer to a subsequent means 14 for estimating the centroid of the target and its extension.

The output of the centroid estimation means 14 is sent to the correlation means 9, to the trace initialization means 10, and to the trace updating means 11.

The same output of the merging means 7 and the output of the centroid estimation means 14 are sent to a target orientation estimation means 15, whose output is sent on the one hand to a synthesized image generation means 16 and on the other hand to the correlation means 9, to the trace initialization means 10, and to the trace updating means 11.

The synthesized image generation means then sends its output to the means 12 for transmission to the user.

In detail, as shown in Figure 2, each miniradar 1 includes a transmission and reception means constituted by a solid-state transceiver, an antenna, and a circuit for encoding and modulating the raw signals produced by the miniradar to transmit them to the processing subsystem.

The entire miniradar revolves about a vertical axis at a typical rate of one revolution per second.

More particularly, each miniradar 1 includes a reflector-type antenna 22 which provides the optimum radiation pattern for the applications being considered, particularly a lobe that is very narrow in the azimuth plane so as to achieve the necessary high angular discrimination, and is shaped in the vertical plane so as to receive, for a set target, an echo power that is independent of the distance of the object of interest in the range of the radar.

The antenna 22, in addition to having a linear polarization, has a circular polarization in order to increase the signal ratio between the useful signal and rain echo.

A duplexer 21 provides the connection between the antenna 22 on one side and the receiver and transmitter on the other side, according to techniques which are well-known to the persons skilled in the art and are described for example in the book by M. I. Skonlik "Introduction to the radar system", McGraw-Hill, 2nd edition, chapter 9, pages 359-366.

The transmitter is of the solid-state type, which can be used in this case by virtue of the low power that is required, but it might also be of the amplifier-tube or oscillator type without altering the subject of the present invention.

In a preferred embodiment, described hereinafter, it is essentially composed of a stable millimeter-band oscillator 17 whose radio-frequency signal, before being transmitted to the antenna 22 through the duplexer 21, passes through a first up-converter 18 so as to vary the transmitted frequency from pulse to pulse or from one group of pulses to the next, and then through a second up-converter 19, to allow medium-frequency conversion, and through a millimeter-band power amplifier with solid-state technology 20, where the transmitted pulse is generated; the pulse has a very short duration so as to allow high distance discrimination.

In order to achieve the two up-conversions of the transmitted frequency, by means of the two converters 18 and 19, and still ensure the stability of the millimeter-band oscillator 17, an intermediate reference frequency generator 29 is used for the unequivocal synchronization of all the frequencies of the miniradar 1.

The receiver of the miniradar 1 is of the superheterodyne type (a type which is well-known to the persons skilled in the art) and is composed of a first down-converter 23, which is required in order to take into account the variation of the transmitted frequency from one pulse or group of pulses to the next, of an intermediate-frequency signal amplifier 24, of a second down-converter 25 to obtain the video signal, and finally of a detector stage 26 to obtain the amplitude information of the received echo signal.

The final part of the receiver is constituted by a stage 27 for converting the received echo amplitude signal from the analog format to the digital one, and finally by an encoding and modulation stage 28 to adapt the signal to the transmission thereof over the communications channel 2 towards the central processing system, which is provided by virtue of optical fibers in the preferred embodiment.

With reference to the above figures, the operation of the system according to the invention is as follows.

The raw signals that arrive from the miniradars 1 represent the amplitude of the radar echo by means of an appropriate representation scale; they are sent to the processing subsystem over the transmission means 2, which in the preferred embodiment is constituted by optical fibers and can also be constituted by radio links of adequate capacity.

At the processing subsystem, the signal that arrives from each miniradar 1 is input to the demodulator decoder 3, where it is converted to the numeric representation that is most suited to the subsequent processing operations, according to methods that are well-known to the persons skilled in the art.

The signal then enters the signal processing and detection means 4, which has the purpose of eliminating the effects of the interference produced by unwanted echoes and noise and of providing in output the indications of the presence of echoes originating from targets of interest (aircraft, vehicles, obstacles).

In particular, the signal processing and detection means 4 internally include a detection threshold of the

"time integration" type, which provides an estimate of the average interference level for each resolving cell of the radar.

This estimate, multiplied by a suitable parameter, provides the detection threshold used for the particular resolving cell.

In the present invention, the multiplying parameter takes on two separate values: the first one, which is higher, is used before echo detection occurs, whereas the second one, which is lower, is used after detection of an echo, so as to avoid compromising the detection of slow and/or large targets.

For the same reason, the time constant of time integration is provided so that it can vary between two separate values, the first one to be applied before detection of the target and the second one to be applied after detection of the target.

Detection indications are transferred to the local radar data extraction means 5, which correlates these indications with the current distance and azimuth indications, providing in output data in polar-coordinate form, which are sent to the subsequent coordinate conversion means 6 which, by using algorithms that are well-known to the persons skilled in the art, performs real-time conversion from polar coordinates to X-Y coordinates, according to an X-Y reference system which is rigidly linked to the monitoring area and is therefore common to all the miniradars 1.

The outputs of the various coordinate conversion means 6, one for each miniradar, are sent to the radar data merging means 7, which in the above mentioned common reference system merges the information from the various miniradars, generating unique detections by virtue of elementary logic operations that are well-known to the persons skilled in the art.

The resulting detections are transferred to the global radar data extraction means 8 which, by virtue of techniques that are well-known to the persons skilled in the art, generates numeric messages, known as "plots", which indicate the presence and position of the objects of interest (aircraft, vehicles, occasional obstacles).

The plots are sent to the subsequent radar tracking subsystem, which is constituted by the following functions:

-- correlation between the plot and the trace (provided by the correlation means 9), in which a check whether each plot can be ascribed or not to an existing trace is performed by comparing the position of the plots and the summary indications of moving vehicles with their corresponding path and, if available, their identification, that is to say, the so-called "traces";

-- initialization of a trace (provided by the initialization means 10), by virtue of which the plots that do not correlate with existing traces produce new traces by means of appropriate logic systems;

-- updating of the trace (11), by virtue of which, as a function of the localization of the plot that correlates with the trace and of the extrapolated trace with the current trace, the optimum estimate of the position, orientation, and speed of the object of interest is produced.

These functions, in a preferred embodiment of the present invention, are made more accurate and effective by virtue of information which originates from the image processing subsystem, whose functions are described hereafter

The outputs of the radar data merging means 7 are transferred to the area selection means 13, which on command from an operator or from the general airport traffic management system extract the outputs of the merging means that belong to a rectangular window within the above mentioned reference system rigidly linked to the surface of interest.

The dimensions and position of the window are such as to include a single target of interest for transfer to the subsequent centroid estimation means 14, wherein, by means of weighted-average algorithms, the centroid of the radar image of the target and its size are estimated.

The same output of the merging means 7 and the output of the centroid estimation means 14 are sent to the orientation estimation means 15, in which the orientation angle of the target, that is to say, the direction of its front end with respect to the north, is estimated.

The outputs of the centroid estimation means 14 and of the orientation estimation means 15 are sent to the correlation means 9, to the trace initialization means 10, and to the trace updating means 11 in order to produce significant improvements in the correlation between the plot and the trace, in trace initialization, and in trace updating, by virtue of the considerable increase in the amount of information on the target provided by the image processing performed in the centroid estimation means 14 and in the orientation estimation means 15.

The information obtained by the radar image processing performed by the means 14 and 15 is used in the tracking process, performed by the trace correlation means 9, the trace initialization means 10, and the trace updating means 11 by means of an optimum non-linear filtering or by means of a linearized filtering (Kalman filter techniques).

Finally, the outputs of the centroid estimation means 14 and of the orientation estimation means 15 are sent to the synthesized image generation means 16 which, by means of techniques well-known to the persons skilled in the art, prepares the radar information for display by virtue of a commercial-type display system.

The means 12 for transmission to the user receives the outputs of the trace updating means 11 and of the synthesized image generation means 16 and transmits them to the user for the traffic monitoring purposes of the present invention.

In practice it has been observed that the system according to the invention achieves the intended aim and objects, since it allows to monitor the entire airport surface by virtue of a network of small, low-cost radars 1 and of a subsystem for processing the data produced by the radars 1 which has a high resolution and is capable of identifying the various targets which are present in the area of interest

In this manner, the controller assigned to monitoring the traffic on the airport surface has a system which is capable of locating the aircraft and the other vehicles, as well as occasional obstacles, eliminating the effects of various kinds of interference.

Furthermore, the system according to the invention also uses the radar images of the aircraft provided by virtue of the high spatial resolution of each one of the miniradars 1.

The airport surface traffic monitoring system can be used by modern control, monitoring, and guidance systems known to airport traffic control experts as SMGCS (Surface Movement Guidance and Control System) with new functions for processing and displaying the radar images with high resolution in order to provide more effective automatic or controller-dependent solving of possible conflicts between vehicles and occasional obstacles.

The system according to the invention can also be applied to the radar monitoring of sea and river ports or of traffic in other confined spaces.

The system according to the invention is susceptible of numerous modifications and variations, all of which are within the scope of the claims; all the details may be replaced with other technically equivalent elements.

The materials employed, as well as the dimensions, may of course be any according to the requirements and the state of the art.

## Claims

1. Airport surface traffic monitoring system, characterized in that it comprises a plurality of sensors (1) adapted to detect signals from the airport surface, said signals being sent to a means (100) for processing the signals of said sensors which provides in output the exact location of aircraft, stationary or moving vehicles, and obstacles in order to control traffic on the airport surface.
2. System according to claim 1, characterized in that said sensors comprise mini radars (1).
3. System according to claim 2, characterized in that each of said mini radars has a range that is shorter than the airport surface to be covered.
4. System according to claim 2, characterized in that said mini radars are arranged so as to cover the entire airport surface together.

5. System according to claim 2, characterized in that said mini radars use millimeter frequencies for both transmission and reception.
6. System according to claim 2, characterized in that each of said radars (1) comprises a transmission and reception means, an antenna (22), and a means for encoding and modulating the raw signals produced by said radars for transmission to the signal processing means.
7. System according to claim 2, characterized in that said radars are connected to said signal processing means by optical fibers.
8. System according to claim 2, characterized in that said radars are connected to said signal processing means by high-capacity radio channels.
9. System according to claim 6, characterized in that said antenna is a millimeter-band reflector antenna.
10. System according to claim 6, characterized in that said transmission and reception means of said radars comprises a solid-state transmitter and a superheterodyne receiver.
11. System according to claim 6, characterized in that said transmitter of said radars is an amplifier-tube transmitter.
12. System according to claim 6, characterized in that said transmitter of said radars is an oscillator-type transmitter.
13. System according to claim 10, characterized in that said transmission and reception means of said radars is connected to said antenna by a duplexer.
14. System according to claim 10, characterized in that said transmission means of said radars comprises a stable oscillator in the millimeter band, said oscillator being adapted to generate a radio-frequency signal, a first up-converter adapted to vary the transmitted frequency from pulse to pulse or from one group of pulses to the next, a second up-converter adapted to perform medium-frequency conversion, and a power amplifier.
15. System according to claim 14, characterized in that it comprises an intermediate-frequency generator having an output connected to said first and second up-converters, said intermediate-frequency generator being adapted to maintain the stability of said oscillator.
16. System according to claim 10, characterized in that said reception means of said radars comprises a first down-converter, an intermediate-frequency signal amplifier, a second down-converter, and a detection stage adapted to detect the amplitude of the echo signal received by said reception means.
17. System according to claim 16, characterized in that it comprises a conversion means connected to the output of said detection stage, said conversion means being adapted to convert said received echo amplitude signal into a digital signal.
18. System according to claim 17, characterized in that said encoding and modulation means is connected to the output of said conversion means and is adapted to prepare said received echo amplitude signal for transmission to said signal processing means.
19. System according to claim 2, characterized in that said signal and radar data processing means comprises, for each one of said radars, a demodulation and decoding means adapted to demodulate and decode the input signal into a numeric representation; a processing and detection means adapted to provide in output a detection threshold; a local extraction means adapted to provide position data in polar-coordinate form; and a conversion means adapted to convert said position data from polar coordinates to X-Y coordinates according to a single reference which is common to all of said radars.
20. System according to claim 19, characterized in that said signal and radar data processing means furthermore comprises a merging means adapted to merge the signals that originate from said radars, in order to obtain a single position data item for each target detected by said radars together.
21. System according to claim 19, characterized in that said processing and detection means is of the time integration type and is adapted to provide an estimate of the average level of the interference for each resolving cell of said radars, said estimate, multiplied by a parameter, providing the detection threshold used for the particular resolving cell.
22. System according to claim 21, characterized in that said multiplying parameter assumes a first value and a second value in two separate moments, said first value being used before the detection of an echo, said second value being used after the detection of said echo, said first value being higher than said second value.
23. System according to claim 21, characterized in that the time constant of the time integration of said processing and detection means can vary between a first value and a second value, said first value being applied before the detection of an echo, said second value being applied after the detection of



said echo.

24. System according to claim 2, characterized in that said signal and radar data processing means furthermore comprises a global extraction means adapted to generate numeric messages which indicate the position of targets of interest, a correlation means adapted to perform a position comparison between said numeric messages and existing paths of moving targets, a path initialization means adapted to initialize a new path following a failed comparison in said correlation means, a path updating means, and a means for transmission to the user.
25. System according to one or more of the preceding claims, characterized in that the output of said merging means is sent to said image processing means.
26. System according to claim 25, characterized in that said image processing means comprises an area selection means adapted to select an area of the airport surface which contains a single target of interest, a means for estimating the centroid of the radar image adapted to estimate the centroid of said target of interest, and an orientation estimation means adapted to estimate the orientation angle of the target with respect to the magnetic north.
27. System according to claim 26, characterized in that it furthermore comprises a means for generating synthesized images which are cascade-connected to said orientation estimation means and is adapted to prepare the resulting radar images for display.
28. System according to claim 26, characterized in that the output of said centroid estimation means and the output of said orientation estimation means are sent to the correlation means, to the path initialization means, and to the path updating means.

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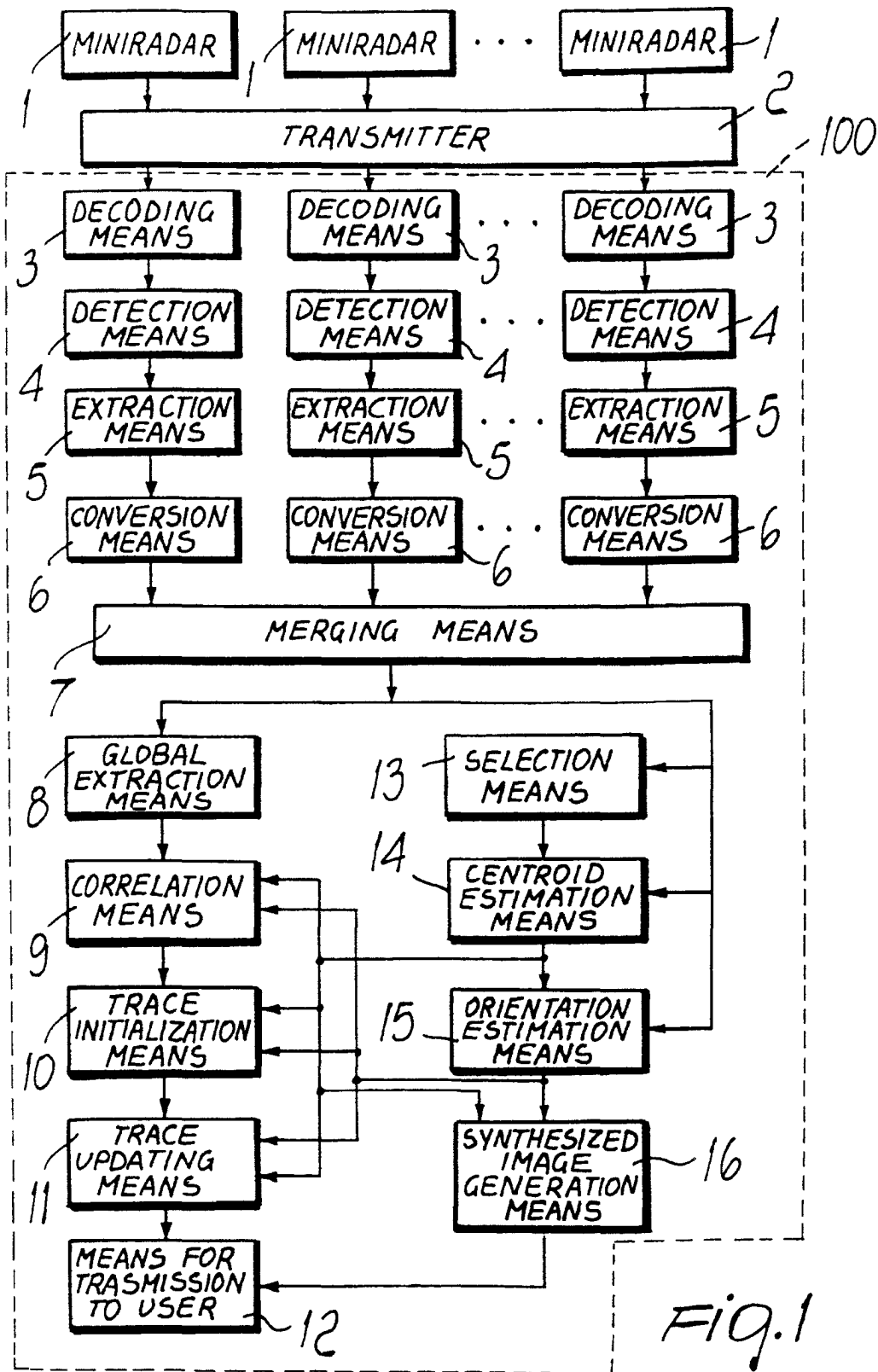
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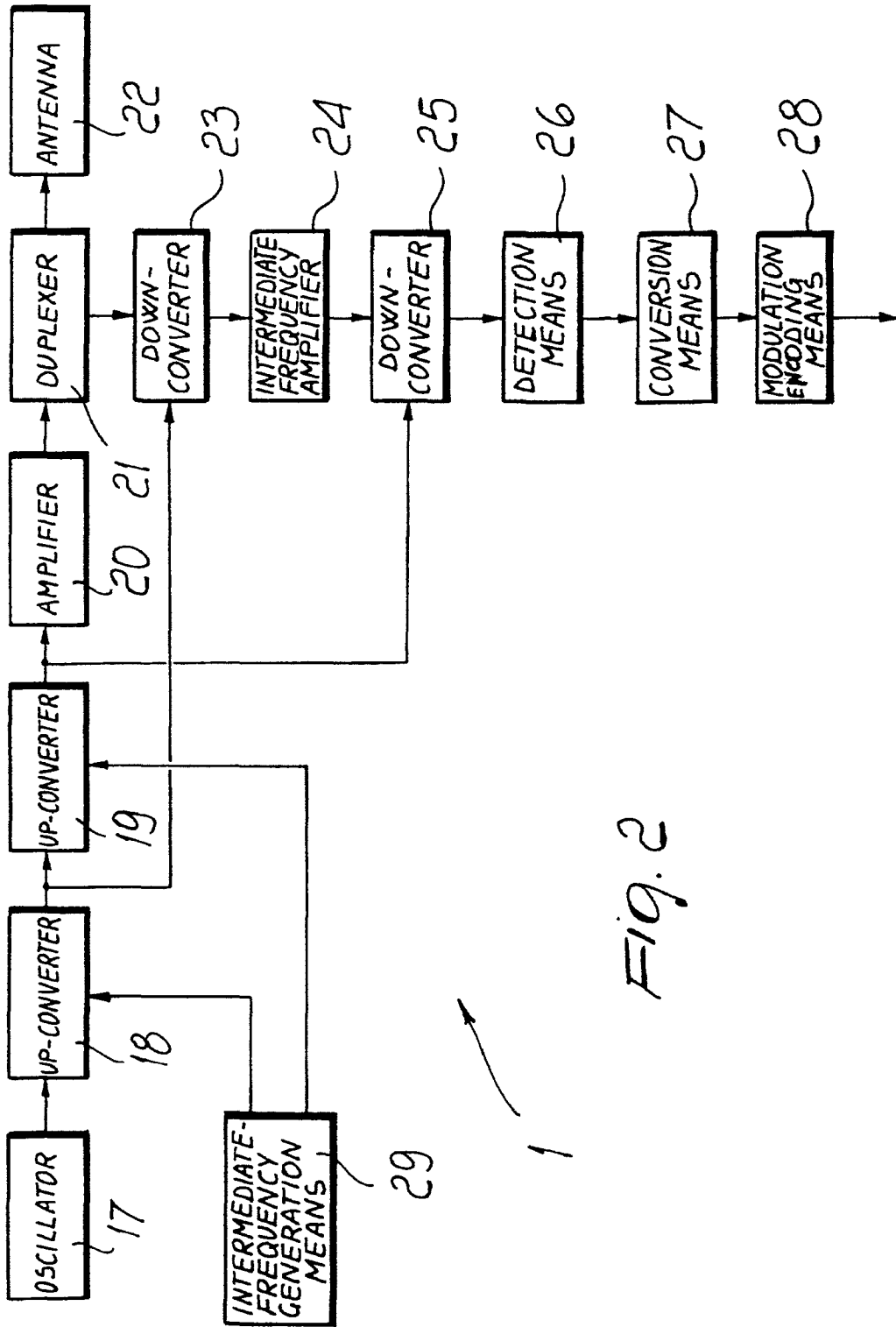


Fig. 2



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Application Number  
EP 97 10 0509

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	INTERNATIONAL RADAR CONFERENCE, ALEXANDRIA, MAY 8 - 11, 1995, 8 May 1995, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 505-510, XP000529139 SCHROTH A ET AL: "THE DLR NEAR-RANGE EXPERIMENTAL RADAR SYSTEM FOR AIRPORT SURFACE MOVEMENT GUIDANCE AND CONTROL" * the whole document *	1-3	G08G5/06
A	---	4-28	
Y	PROCEEDINGS OF THE DIGITAL AVIONICS SYSTEMS CONFERENCE, SEATTLE, OCT. 5 - 8, 1992, no. CONF. 11, 5 October 1992, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 549-552, XP000366735 WATNICK M ET AL: "AIRPORT MOVEMENT AREA SAFETY SYSTEM" * figures 2-4 *	1-3	
A	---	4-28	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
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A	US 5 400 031 A (FITTS RICHARD A) 21 March 1995 * column 2, line 1 - column 3, line 13 * -----	1-28	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 April 1997	Examiner Crechet, P
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	
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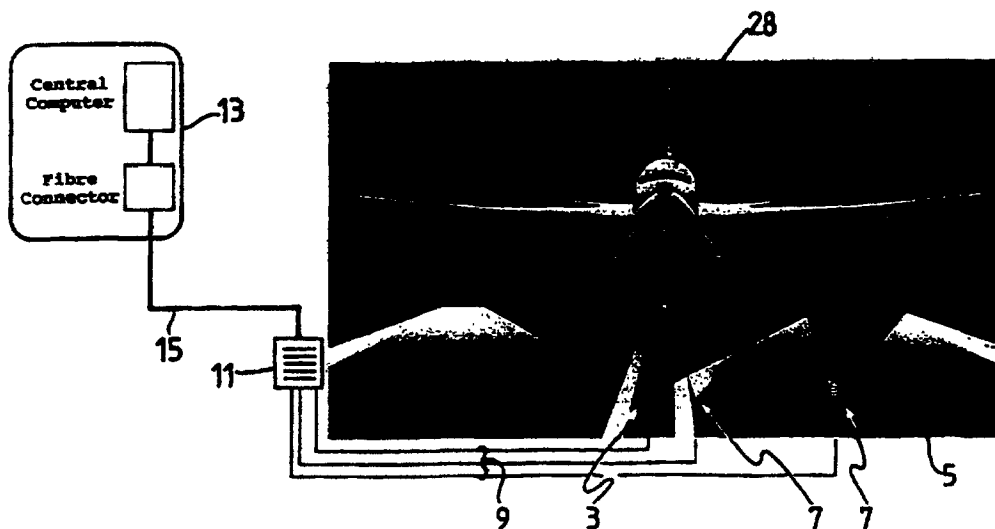
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<p>(51) International Patent Classification <sup>6</sup> : G08G 5/00, G01P 3/38, G06T 7/20, G06K 9/78, 9/46</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 97/37336</b> (43) International Publication Date: 9 October 1997 (09.10.97)</p>
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(54) Title: AN AIRCRAFT DETECTION SYSTEM



(57) Abstract

An object detection system including passive sensors (3) for receiving electromagnetic radiation from a moving object (28) and generating intensity signals representative of the received radiation, and a processing system for subtracting the intensity signals to obtain a differential signature representative of the position of the moving object. An image acquisition system including at least one camera (7) for acquiring an image of at least part of a moving object, in response to a trigger signal, and an analysis system for processing the image to locate a region in the image including markings identifying the object and processing the region to extract the markings for optical recognition.

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5 **AN AIRCRAFT DETECTION SYSTEM**

The present invention relates to an object detection system and, in particular to an aircraft detection system.

10 The International Civil Aviation Organisation (ICAO) has established regulations which require all civil aircraft to have registration markings beneath the port wing to identify an aircraft. The markings denote the nationality of an aircraft and its registration code granted by the ICAO. In some countries, airline operators do not follow the regulations and the markings appear on an aircraft's fuselage. Owners of  
15 aircraft are charged for airport use, but a satisfactory system has not been developed to automatically detect aircraft and then, if necessary, administer a charge to the owner. Microwave signals for detecting an aircraft can interfere with microwave frequencies used for airport communications and, similarly, radar signals can interfere with those used for aircraft guidance systems. A system which can be used to detect  
20 an aircraft using unobtrusive passive technology is desired.

In accordance with the present invention there is provided an object detection system including:

passive sensing means for receiving electromagnetic radiation from a moving  
25 object and generating intensity signals representative of the received radiation; and  
processing means for subtracting said intensity signals to obtain a differential signature representative of the position of said moving object.

The present invention also provides an image acquisition system including:  
30 at least one camera for acquiring an image of at least part of a moving object, in response to a trigger signal, and

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analysis means for processing said image to locate a region in said image including markings identifying said object and processing said region to extract said markings for a recognition process.

5       The present invention also provides an object detection method including: passively sensing electromagnetic radiation received from a moving object; generating intensity signals representative of the received radiation; and subtracting said intensity signals to obtain a differential signature representative of the position of said moving object.

10

          The present invention also provides an image acquisition method including: acquiring an image of at least part of a moving object, in response to a trigger signal, using at least one camera, and  
          processing said image to locate a region in said image including markings  
15 identifying said object and processing said region to extract said markings for a recognition process.

Preferred embodiments of the present invention are hereinafter described, by way of example only, with reference to the accompanying drawings, wherein:

20       Figure 1 is a block diagram of a preferred embodiment of an aircraft detection system;

          Figure 2 is a schematic diagram of a preferred embodiment of the aircraft detection system;

25       Figure 3 is a block diagram of a connection arrangement for components of the aircraft detection system;

          Figure 4 is a more detailed block diagram of a proximity detector and a tracking system for the aircraft detection system;

          Figure 5 is a coordinate system used for the proximity detector;

30       Figures 6(a) and 6(b) are underneath views of discs of sensors of the tracking system;

          Figure 7 is a schematic diagram of an image obtained by the tracking system;

          Figures 8 and 9 are images obtained from a first embodiment of the tracking



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system;

Figure 10 is a graph of a pixel row sum profile for an image obtained by the tracking system;

Figure 11 is a graph of a difference profile obtained by subtracting successive  
5 row sum profiles;

Figure 12 is a diagram of a coordinate system for images obtained by the tracking system;

Figure 13 is a diagram of a coordinate system for the aircraft used for geometric correction of the images obtained by the tracking system;

10 Figure 14 is a diagram of a coordinate system used for predicting a time to generate an acquisition signal;

Figure 15 is a graph of aircraft position in images obtained by the tracking system over successive frames;

Figure 16 is a graph of predicted trigger frame number over successive image  
15 frames obtained by the tracking system;

Figure 17 is a schematic diagram of a pyroelectric sensor used in a second embodiment of the tracking system;

Figure 18 is graphs of differential signatures obtained using the second embodiment of the tracking system;

20 Figures 19 and 20 are images obtained of an aircraft by high resolution cameras of an acquisition system of the aircraft detection system;

Figure 21 is a schematic diagram of an optical sensor system used for exposure control of the acquisition cameras;

Figure 22 is a flow diagram of a preferred character location process executed  
25 on image data obtained by the high resolution cameras;

Figure 23 is a diagram of images produced during the character location process; and

Figure 24 is a flow diagram of a character recognition process executed on a binary image of the characters extracted from an image obtained by one of the high  
30 resolution cameras.

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An aircraft detection system 2, as shown in Figure 1, includes a proximity detector 4, a tracking sensor system 6, an image processing system 8, an image acquisition system 10 and an analysis system 12. A control system 14 can be included to control the image acquisition system 10 on the basis of signals provided by the image processing system 8, and also control an illumination unit 16.

The proximity detector 4 and the tracking sensor system 6 includes sensors 3 which may be placed on or near an aircraft runway 5 to detect the presence of an aircraft 28 using visual or thermal imaging or aural sensing techniques. Also located on or near the runway 5 is at least one high resolution camera 7 of the image acquisition system 10. The sensors 3 and the acquisition camera 7 are connected by data and power lines 9 to an instrument rack 11, as shown in Figure 2, which may be located adjacent or near the runway 5. The instrument rack 11 may alternatively be powered by its own independent supply which may be charged by solar power. The instrument rack 11 includes control circuitry and image processing circuitry which is able to control activation of the sensors 3 and the camera 7 and perform image processing, as required. The instrument rack 11, the data and power lines 9, the sensors 3 and the acquisition camera 7 can be considered to form a runway module which may be located at the end of each runway of an airport. A runway module can be connected back to a central control system 13 using an optical fibre or other data link 15. Images provided by the sensors 3 may be processed and passed to the central system 13 for further processing, and the central system 13 would control triggering of the acquisition cameras 7. Alternatively image processing for determining triggering of the acquisition camera 7 may be performed by each instrument rack 11. The central control system 13 includes the analysis system 12. One method of configuring connection of the instrument racks 11 to the central control system 13 is illustrated in Figure 3. The optical fibre link 15 may include dedicated optical fibres 17 for transmitting video signals to the central control system 13 and other optical fibres 19 dedicated to transmitting data to and receiving data from the central control system 13 using the Ethernet protocol or direct serial data communication. A number of different alternatives can be used for connecting the runway modules to the central control

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system 13. For example, the runway modules and the control system 13 may be connected as a Wide Area Network (WAN) using Asynchronous Transfer Mode (ATM) or Synchronous Digital Hierarchy (SDH) links. The runway modules and the central control system 13 may also be connected as a Local Area Network (LAN) using a LAN protocol, such as Ethernet. Physical connections may be made between the runway modules and the central control system 13 or alternatively wireless transmission techniques may be used, such as using infrared or microwave signals for communication.

10           The proximity detector 4 determines when an aircraft is within a predetermined region, and then on detecting the presence of an aircraft activates the tracking sensor system 6. The proximity detector 4, as shown in Figure 4, may include one or more pyroelectric devices 21, judiciously located at an airport, and a signal processing unit 23 and trigger unit 25 connected thereto in order to generate an activation signal to  
15 the tracking sensor system 6 when the thermal emission of an approaching aircraft exceeds a predetermined threshold. The proximity detector 4 may use one or more pyroelectric point sensors that detect the infrared radiation emitted from the aircraft 28. A mirror system can be employed with a point sensor 70 to enhance its sensitivity to the motion of the aircraft 28. The point sensor 70 may consist of two or more  
20 pyroelectric sensors configured in a geometry and with appropriate electrical connections so as to be insensitive to the background infrared radiation and slowly moving objects. With these sensors the rate of motion of the image of the aircraft 28 across the sensor 70 is important. The focal length of the mirror 72 is chosen to optimise the motion of the image across the sensor 70 at the time of detection. As an  
25 example, if the aircraft at altitude  $H$  with glide slope angle  $\theta_{GS}$  moves with velocity  $V$  and passes overhead at time  $t_0$ , as shown in Figure 5, then the position  $h$  of the image of the aircraft 28 on the sensor 70 is

$$h = f \left( \frac{H}{V(t_0 - t)} + \tan\theta_{GS} \right) \quad (1)$$

where  $f$  is the focal length of a cylindrical mirror.

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If the rate of motion of the image  $dh/dt$  is required to have a known value, then the focal length of the mirror 72 should be chosen to satisfy

$$f = v \frac{(t_0 - t)^2}{H} \frac{dh}{dt} \quad (2)$$

where  $t_0 - t$  is the time difference between the time  $t_0$  at which the aircraft is overhead and the time  $t$  at which it is to be detected. Alternatively, the proximity  
 5 detector 4 may include different angled point sensors to determine when an aircraft enters the monitored region and is about to land or take-off. In response to the activation signal, the tracking sensor system 6 exposes the sensor 3 to track the aircraft. Use of the proximity detector 4 allows the sensor 3 to be sealed in a housing when not in use and protected from damaging environmental conditions, such as  
 10 hailstorms and blizzards or fuel. The sensor 3 is only exposed to the environment for a short duration whilst an aircraft is in the vicinity of the sensor 3. If the tracking system 6 is used in conditions where the sensor 3 can be permanently exposed to the environment or the sensor 3 can resist the operating conditions, then the proximity detector 4 may not be required. The activation signal generated by the proximity  
 15 detector 4 can also be used to cause the instrument rack 11 and the central control system 13 to adjust the bandwidth allocated on the link 15 so as to provide an adequate data transfer rate for transmission of video signals from the runway module to the central system 13. If the bandwidth is fixed at an acceptable rate or the system 2 only uses local area network communications and only requires a reduced  
 20 bandwidth, then again the proximity detector 4 may not be required.

The tracking sensor system 6 includes one or more tracking or detection cameras 3 which obtain images of an aircraft as it approaches or leaves a runway. From a simple image of the aircraft, aspect ratios, such as the ratio of the wingspan  
 25 to the fuselage length can be obtained. The tracking camera 3 used is a thermal camera which monitors thermal radiation received in the 10 to 14  $\mu\text{m}$  wavelength range and is not dependent on lighting conditions for satisfactory operation. Use of the thermal cameras is also advantageous as distribution of temperatures over the

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observed surfaces of an aircraft can be obtained, together with signatures of engine exhaust emissions and features in the fuselage or engines. The tracking camera 3 can obtain an instantaneous two-dimensional image  $I_n$  using all of the sensors in a CCD array of the camera, or alternatively one row of the array perpendicular to the direction  
5 of motion of the aircraft can be used to obtain a linear image at each scan and the linear image is then used to build up a two-dimensional image  $I_n$  for subsequent processing.

To allow operation of the tracking and acquisition cameras 3 and 7 in rain, a  
10 rotating disc system is employed. The use of a rotating disc for removing water drops from windows is used on marine vessels. A reflective or transparent disc is rotated at high speed in front of the window that is to be kept clear. Water droplets falling on the disk experience a large shear force related to the rotation velocity. The shear force is sufficient to atomise the water drop, thereby removing it from the surface of the disc.  
15 A transparent disc of approximate diameter 200 mm is mounted to an electric motor and rotated to a frequency of 60 Hz. A camera with a 4.8 mm focal length lens was placed below a glass window which in turn was beneath the rotating disc. The results of inserting the rotating disc are illustrated in Figure 6(a), which shows the surface of a camera housing without the rotating disc, and in Figure 6(b), which shows the  
20 surface of a camera housing with the rotating disc activated and in rain conditions.

The image processing system 8 processes the digital images provided by the tracking sensor system 6 so as to extract in real-time information concerning the features and movement of the aircraft. The images provided to the image processing  
25 system, depending on the tracking cameras employed, provide an underneath view of the aircraft, as shown in Figure 7. The tips of the wings or wingspan points 18 of the aircraft are tracked by the image processor system 8 to determine when the image acquisition system 10 should be activated so as to obtain the best image of the registration markings on the port wing 20 of the aircraft. The image processing system  
30 8 generates an acquisition signal using a trigger logic circuit 39 to trigger the camera of the image acquisition system 10. The image processing system 8 also determines

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and stores data concerning the wingspan 22 of the aircraft and other details concerning the size, shape and ICAO category (A to G) of the aircraft. The image processing system 8 classifies the aircraft on the basis of the size which can be used subsequently when determining the registration markings on the port wing 20. The data obtained can also be used for evaluation of the aircraft during landing and/or take-off.

Alternatively a pyroelectric sensor 27 can be used with a signal processing wing detection unit 29 to provide a tracking system 1 which also generates the acquisition signal using the trigger logic circuit 39, as shown in Figure 4 and described later.

Detecting moving aircraft in the field of view of the sensor 3 or 27 is based on forming a profile or signature of the aircraft,  $P(y,t)$ , that depends on a spatial coordinate  $y$  and time  $t$ . To eliminate features in the field of view that are secondary or slowly moving, a difference profile  $\Delta P(y,t)$  is formed. The profile or signature can be differenced in time or in space because these differences are equivalent for moving objects. If the intensity of the light or thermal radiation from the object is not changing then the time derivative of the profile obtained from this radiation is zero. A time derivative of a moving field can be written as a convective derivative involving partial derivatives, which gives the equation

$$\frac{dP(y,t)}{dt} = \frac{\partial P(y,t)}{\partial t} + v \frac{\partial P(y,t)}{\partial y} = 0 \quad (3)$$

where  $v$  is the speed of the object as observed in the profile. After rearranging equation (3), gives

$$\frac{\partial P(y,t)}{\partial t} = -v \frac{\partial P(y,t)}{\partial y} \quad (4)$$

which shows that the difference in the profile in time is equivalent to the difference in the profile in space. This only holds for moving objects, when  $v \neq 0$ . Equation (4) also follows from the simple fact that if the profile has a given value  $P(y_0, t_0)$  at the

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coordinate  $(y_0, t_0)$ , then it will have this same value along the line

$$y = y_0 + v(t - t_0) \quad (5)$$

To detect and locate a moving feature that forms an extremum in the profile, such as an aircraft wing, the profile can be differenced in space  $\Delta_y P(y, t)$ . Then an extremum in the profile  $P(y, t)$  will correspond to a point where the difference profile  $\Delta_y P(y, t)$  crosses zero.

In one method for detecting a feature on the aircraft, a profile  $P(y, t)$  is formed and a difference profile  $\Delta_y P(y, t)$  is obtained by differencing in time, as described below. According to equation (4) this is equivalent to a profile of a moving object that is differenced in space. Therefore the position  $y_p$  of the zero crossing point of  $\Delta_y P(y, t)$  at time  $t$  is also the position of the zero crossing point of  $\Delta_y P(y, t)$  which locates an extremum in  $P(y, t)$ .

In another method for detecting a feature on the aircraft, the difference between the radiation received by a sensor 27 from two points in space is obtained as a function of time,  $\Delta_y S(t)$ , as described below. If there are no moving features in the field of view, then the difference is constant. If any object in the field of view is moving, then the position of a point on the object is related to time using equation (5). This allows a profile or signature differenced in space to be constructed

$$\Delta_y P(y(t), t) = \Delta_y S(t) \quad (6)$$

and, as described above, allows an extremum corresponding to an aircraft wing to be located in the profile from the zero crossing point in the differential signature.

The image acquisition system 10 includes at least one high resolution camera 7 to obtain images of the aircraft when triggered. The images are of sufficient resolution to enable automatic character recognition of the registration code on the port wing 20 or elsewhere. The illumination unit 16 is also triggered simultaneously to provide illumination of the aircraft during adverse lighting conditions, such as at night

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or during inclement weather.

The acquired images are passed to the analysis system 12 which performs Optical Character Recognition (OCR) on the images to obtain the registration code. 5 The registration code corresponds to aircraft type and therefore the aircraft classification determined by the image processing system 8 can be used to assist to the recognition process, particularly when characters of the code are obscured in an acquired image. The registration code extracted and any other information concerning the aircraft can be then passed to other systems via a network connection 24.

10

Once signals received from the pyroelectric sensors 21 indicate the aircraft 28 is within the field of view of the sensors 3 of the tracking sensor system 6, the tracking system 1 is activated by the proximity detector 4. The proximity detector 4 is usually the first stage detection system to determine when the aircraft is in the proximity of the more precise tracking system 1. The tracking system 1 includes the tracking sensor system 6 and the image processing system 8 and according to one embodiment the images from the detection cameras 3 of the sensor system 6 are used by the image processing system 8 to provide a trigger for the image acquisition system when some point in the image of the aircraft reaches a predetermined pixel position. One or more 15 detection cameras 3 are placed in appropriate locations near the airport runway such that the aircraft passes within the field of view of the cameras 3. A tracking camera 3 provides a sequence of images,  $\{I_n\}$ . The image processing system 8 subtracts a background image from each image  $I_n$  of the sequence. The background image represents an average of a number of preceding images. This yields an image  $\Delta I_n$  that 20 contains only those objects that have moved during the time interval between images. The image  $\Delta I_n$  is thresholded at appropriate values to yield a binary image, i.e. one that contains only two levels of brightness, such that the pixels comprising the edges of the aircraft are clearly distinguishable. The pixels at the extremes of the aircraft in the direction perpendicular to the motion of the aircraft will correspond to the edges 25 18 of the wings of the aircraft. After further processing, described below, when it is determined the pixels comprising the port edge pass a certain position in the image 30



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corresponding to the acquisition point, the acquisition system 10 is triggered, thereby obtaining an image of the registration code beneath the wing 20 of the aircraft.

Imaging the aircraft using thermal infrared wavelengths and detecting the  
5 aircraft by its thermal radiation renders the aircraft self-luminous so that it can be imaged both during the day and night primarily without supplementary illumination. Infrared (IR) detectors are classified as either photon detectors (termed cooled sensors herein), or thermal detectors (termed uncooled sensors herein). Photon detectors (photoconductors or photodiodes) produce an electrical response directly  
10 as the result of absorbing IR radiation. These detectors are very sensitive, but are subject to noise due to ambient operating temperatures. It is usually necessary to cryogenically cool (80°K) these detectors to maintain high sensitivity. Thermal detectors experience a temperature change when they absorb IR radiation, and an electrical response results from temperature dependence of the material property.  
15 Thermal detectors are not generally as sensitive as photon detectors, but perform well at room temperature.

Typically, the cooled sensing devices are formed from Mercury Cadmium Telluride offer far greater sensitivity than uncooled devices, which may be formed from  
20 Barium Strontium Titanate. Their Net Equivalent Temperature Difference (NETD) is also superior. However, with the uncooled sensor a chopper can be used to provide temporal modulation of the scene. This permits AC coupling of the output of each pixel to remove the average background. This minimises the dynamic range requirements for the processing electronics and amplifies only the temperature differences. This is  
25 an advantage for resolving differences between cloud, the sun, the aircraft and the background. The advantage of differentiation between objects is that it reduced the load on subsequent image processing tasks for segmenting the aircraft from the background and other moving objects such as the clouds.

30 Both a cooled and uncooled thermal infrared imaging system 6 has been used during day, night and foggy conditions. The system 6 produced consistent images of

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the aircraft in all these conditions, as shown in Figures 8 and 9. In particular, the sun in the field of view produced no saturation artefacts or flaring in the lens. At night, the entire aircraft was observable, not just the lights.

5           The image processing system 8 uses a background subtraction method in an attempt to eliminate slowly moving or stationary objects from the image, leaving only the fast moving objects. This is achieved by maintaining a background image that is updated after a certain time interval elapses. The update is an incremental one based on the difference between the current image and the background. The incremental  
10 change is such that the background image can adapt to small intensity variations in the scene but takes some time to respond to large variations. The background image is subtracted from the current image, a modulus is taken and a threshold applied. The result is a binary image containing only those differences from the background that exceed the threshold.

15

One problem with this method is that some slow moving features, such as clouds, still appear in the binary image. The reason for this is that the method does not select on velocity but on a combination of velocity and intensity gradients. If the intensity in the image is represented by  $I(x,y,t)$ , where  $x$  and  $y$  represent the position  
20 in rows and columns, respectively, and  $t$  represents the image frame number (time) and if the variation in the intensity due to ambient conditions is very small then it can be shown that the time variation of the intensity in the image due to a feature moving with velocity  $v$  is given by

$$\frac{\partial I(x,y,t)}{\partial t} = -v \cdot \nabla I(x,y,t) \quad (7)$$

In practice, the time derivative in equation (7) is performed by taking the  
25 difference between the intensity at  $(x,y)$  at different times. Equation (7) shows that the value of this difference depends on the velocity  $v$  of the feature at  $(x,y)$  and the intensity gradient. Thus a fast moving feature with low contrast relative to the background is identical to a slow moving feature with a large contrast. This is the

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situation with slowly moving clouds that often have very bright edges and therefore large intensity gradients there, and are not eliminated by this method. Since features in a binary image have the same intensity gradients, better velocity selection is obtained using the same method but applied to the binary image. In this sense, the background-subtraction method is applied twice, once to the original grey-scale image to produce a binary image as described above, and again to the subsequent binary image, as described below.

The output from the initial image processing hardware is a binary image  $B(x,y,t)$  where  $B(x,y,t) = 1$  if a feature is located at  $(x,y)$  at time  $t$ , and  $B(x,y,t) = 0$  represents the background. Within this image the fast moving features belong to the aircraft. To deduce the aircraft wing position the two-dimensional binary image can be compressed into one dimension by summing along each pixel row of the binary image,

$$P(y,t) = \int B(x,y,t) dx \quad (8)$$

where the aircraft image moves in the direction of the image columns. This row-sum profile is easily analysed in real time to determine the location of the aircraft. An example of a profile is shown in Figure 10 where the two peaks 30 and 31 of the aircraft profile correspond to the main wings (large peak 30) and the tail wings (smaller peak 31).

In general, there are other features present, such as clouds, that must be identified or filtered from the profile. To do this, differences between profiles from successive frames are taken, which is equivalent to a time derivative of the profile. Letting  $A(x,y,t)$  be the aircraft where  $A(x,y,t) = 1$  if  $(x,y)$  lies within the aircraft and 0 otherwise and letting  $C(x,y,t)$  represent clouds or other slowly moving objects, then it can be shown that the time derivative of the profile is given by

$$\begin{aligned} \frac{\partial P(y,t)}{\partial t} &= \int \frac{\partial A(x,y,t)}{\partial t} dx + \int \frac{\partial C(x,y,t)}{\partial t} dx - \int \frac{\partial}{\partial t} [A(x,y,t)C(x,y,t)] dx \\ &= \int \frac{\partial A(x,y,t)}{\partial t} [1 - C(x,y,t)] dx + \varepsilon(C) \end{aligned} \quad (9)$$

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where  $\varepsilon(C) \approx 0$  is a small error term due to the small velocity of the clouds. Equation (9) demonstrates an obvious fact that the time derivative of a profile gives information on the changes (such as motion) of feature  $A$  only when the changes in  $A$  do not overlap features  $C$ . In order to obtain the best measure of the location of a feature, the  
5 overlap between features must be minimised. This means that  $C(x,y,t)$  must cover as small an area as possible. If the clouds are present but do not overlap the aircraft, then apart from a small error term, the time difference between profiles gives the motion of the aircraft. The difference profile corresponding to Figure 10 is shown in Figure 11 where the slow moving clouds have been eliminated. The wing positions  
10 occur at the zero-crossing points 33 and 34. Note that the clouds have been removed, apart from small error terms.

The method is implemented using a programmable logic circuit of the image processing system 8 which is programmed to perform the row sums on the binary  
15 image and to output these as a set of integers after each video field. When taking the difference between successive profiles the best results were obtained using differences between like fields of the video image, i.e. even-even and odd-odd fields.

The difference profile is analysed to locate valid zero crossing points  
20 corresponding to the aircraft wing positions. A valid zero crossing is one in which the difference profile initially rises above a threshold  $l_T$  for a minimum distance  $y_T$  and falls through zero to below  $-l_T$  for a minimum distance  $y_T$ . The magnitude of the threshold  $l_T$  is chosen to be greater than the error term  $\varepsilon(C)$  which is done to discount the affect produced by slow moving features, such as clouds.

25

In addition, the peak value of the profile, corresponding to the aircraft wing, can be obtained by summing the difference values when they are valid up to the zero crossing point. This method removes the contributions to the peak from the non-overlapping clouds. It can be used as a guide to the wing span of the aircraft.

30

The changes in position of the aircraft in the row-sum profile are used to

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determine a velocity for the aircraft that can be used for determining the image acquisition or trigger time, even if the aircraft is not in view. This situation may occur if the aircraft image moves into a region on the sensor that is saturated, or if the trigger point is not in the field of view of the camera 3. However, to obtain a reliable estimate  
5 of the velocity, geometric corrections to the aircraft position are required to account for the distortions in the image introduced by the camera lens. These are described below using the coordinate systems  $(x,y,z)$  for the image and  $(X,Y,Z)$  for the aircraft as shown in Figures 12 and 13, respectively.

- 10 For an aircraft at distance  $Z$  and at a constant altitude  $Y_0$ , the angle from the horizontal to the aircraft in the vertical plane is

$$\tan\theta_y = \frac{Y_0}{Z} \quad (10)$$

Since  $Y_0$  is approximately constant, a normalised variable  $Z_N = Z/Y_0$  can be used. If  $y_0$  is the coordinate of the centre of the images,  $f$  is the focal length of the lens and  $\theta_c$  is the angle of the camera from the horizontal in the vertical plane, then

$$\frac{y_0 - y}{f} = \tan(\theta_y - \theta_c) = \frac{\tan\theta_y - \tan\theta_c}{1 + \tan\theta_y \tan\theta_c} \quad (11)$$

- 15 where the tangent has been expanded using a standard trigonometric identity. Using (10) and (11) an expression for the normalised distance  $Z_N$  is obtained

$$Z_N(y) = \frac{1 + \beta(y - y_0)\tan\theta_c}{\tan\theta_c - \beta(y - y_0)} \quad (12)$$

where  $\beta = 1/f$ . This equation allows a point in the image at  $y$  to be mapped onto a true distance scale,  $Z_N$ . Since the aircraft altitude is unknown, the actual distance cannot be determined. Instead, all points in the image profile are scaled to be  
20 equivalent to a specific point,  $y_1$ , in the profile. This point is chosen to be the trigger line or image acquisition line. The change in the normalised distance  $Z_N(y_1)$  at  $y_1$  due to an increment in pixel value  $\Delta y_1$  is  $\Delta Z_N(y_1) = Z_N(y_1 + \Delta y_1) - Z_N(y_1)$ . The number

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of such increments over a distance  $Z_N(y_2) - Z_N(y_1)$  is  $M = (Z_N(y_2) - Z_N(y_1))/\Delta Z_N(y_1)$ . Thus the geometrically corrected pixel position at  $y_2$  is

$$y_{c2} = y_1 + M\Delta y_1 = y_1 + \frac{Z_N(y_2) - Z_N(y_1)}{\Delta Z_N(y_1)} \Delta y_1 \quad (13)$$

For an aircraft at distance  $Z$  and at altitude  $Y_0$ , a length  $X$  on it in the  $X$  direction subtends an angle in the horizontal plane of

$$\tan\theta_x = \frac{X}{\sqrt{Y_0^2 + Z^2}} = \frac{X_N}{\sqrt{1 + Z_N^2}} \quad (14)$$

5 where normalised values have been used. If  $x_0$  is the location of the centre of the image and  $f$  is the focal length of the lens, then

$$\frac{x - x_0}{f} = \tan\theta_x \quad (15)$$

Using (12), (14) and (15), the normalised distance  $X_N$  can be obtained in terms of  $x$  and  $y$

$$X_N = \frac{(x - x_0)}{f} \sqrt{1 + Z_N^2(y)} \quad (16)$$

As with the  $y$  coordinate, the  $x$  coordinate is corrected to a value at  $y_1$ . Since  $X_N$  10 should be independent of position, then a length  $x_2 - x_0$  at  $y_2$  has a geometrically corrected length of

$$\begin{aligned} x_{c2} - x_0 &= (x_2 - x_0) \frac{\sqrt{1 + Z_N^2(y_2)}}{\sqrt{1 + Z_N^2(y_1)}} \\ &= (x_2 - x_0) \frac{\sqrt{1 + \beta^2(y_2 - y_0)^2} \sin\theta_c - \beta(y_1 - y_0)\cos\theta_c}{\sin\theta_c - \beta(y_2 - y_0)\cos\theta_c \sqrt{1 + \beta^2(y_1 - y_0)^2}} \end{aligned} \quad (17)$$

The parameter  $\beta = 1/f$  is chosen so that  $x$  and  $y$  are measured in terms of pixel numbers. If  $y_0$  is the centre of the camera centre and it is equal to half the total number of pixels, and if  $\theta_{FOV}$  is the vertical field of view of the camera, then

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$$\beta = \frac{\tan(\theta_{FOV}/2)}{y_0} \quad (18)$$

This relation allows  $\beta$  to be calculated without knowing the lens focal length and the dimensions of the sensor pixels.

The velocity of a feature is expressed in terms of the number of pixels moved between image fields (or frames). Then if the position of the feature in frame  $n$  is  $y_n$ , the velocity is given by  $v_n = y_n - y_{n-1}$ . Over  $N$  frames, the average velocity is then

$$\langle v \rangle = \frac{1}{N} \sum_{n=1}^N v_n = \frac{1}{N} \sum_{n=1}^N (y_n - y_{n-1}) = \frac{1}{N} (y_N - y_0) \quad (19)$$

which depends only on the start and finish points of the data. This is sensitive to errors in the first and last values and takes no account of the positions in between. The error in the velocity due to an error  $\delta y_N$  in the value  $y_N$  is

$$\varepsilon(\langle v \rangle) = \frac{\delta y_N}{N} \quad (20)$$

10 A better method of velocity estimation uses all the position data obtained between these values. A time  $t$  is maintained which represents the current frame number. Then the current position is given by

$$y = y_0 - vt \quad (21)$$

where  $y_0$  is the unknown starting point and  $v$  is the unknown velocity. The number  $n$  of valid positions  $y_n$  measured from the feature are each measured at time  $t_n$ .

15 Minimising the mean square error

$$\chi^2 = \frac{1}{N} \sum_{n=1}^N (y_n - y_0 + vt_n)^2 \quad (22)$$

with respect to  $v$  and  $y_0$  gives two equations for the unknown quantities  $y_0$  and  $v$ . Solving for  $v$  yields

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$$v = \frac{\sum_{n=1}^N y_n \sum_{n=1}^N t_n - N \sum_{n=1}^N y_n t_n}{N \sum_{n=1}^N t_n^2 - \sum_{n=1}^N t_n \sum_{n=1}^N t_n} \quad (23)$$

This solution is more robust in the sense that it takes account of all the motions of the feature, rather than the positions at the beginning and at the end of the observations. If the time is sequential, so that  $t_n = n\Delta t$  where  $t_n = 1$  is the time interval between image frames, then the error in the velocity due to an error  $\delta y_n$  in the value  $y_n$  is

$$\varepsilon(\langle v \rangle) = \frac{\delta y_n \{ 6(N+1-2n) \}}{N \{ (N+1)(N-1) \}} \quad (24)$$

5 which, for the same error  $\delta y_N$  in (19), gives a smaller error than (21) for  $N > 5$ . In general, the error in (24) varies as  $1/N^2$  which is less sensitive to uncertainties in position than (19).

If the aircraft is not in view, then the measurement of the velocity  $v$  can be used  
10 to estimate the trigger time. If  $y_l$  is the position of a feature on the aircraft that was last seen at a time  $t_l$ , then the position at any time  $t$  is estimated from

$$y = y_l - v(t - t_l) \quad (25)$$

Based on this estimate of position, the aircraft will cross the trigger point located  
at  $y_T$  at a time  $t_T$  estimated by

$$t_T = t_l - \frac{y_T - y_l}{v} \quad (26)$$

An alternative method of processing the images obtained by the camera 3 to  
15 determine the aircraft position, which also automatically accounts for geometric  
corrections, is described below. The method is able to predict the time for triggering  
the acquisition system 10 based on observations of the position of the aircraft 28.



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To describe the location of an aircraft 28 and its position, a set of coordinates are defined such that the  $\hat{x}$  axis points vertically upwards, the  $\hat{z}$  axis points horizontally along the runway towards the approaching aircraft, and  $\hat{y}$  is horizontal and perpendicular to the runway. The image 66 of the aircraft is located in the digitised  
 5 image by pixel values  $(x_p, y_p)$ , where  $x_p$  is defined to be the vertical pixel value and  $y_p$  the horizontal value. The lens on the camera inverts the image so that a light ray from the aircraft strikes the sensor at position  $(-x_p, -y_p, 0)$ , where the sensor is located at the coordinate origin. Figure 14 shows a ray 68 from an object, such as a point on the aircraft, passing through a lens of a focal length  $f$ , and striking the imaging sensor at  
 10 a point  $(-x_p, -y_p)$ , where  $x_p$  and  $y_p$  are the pixel values. The equation locating a point on the ray is given by

$$r = x_p(z/f - 1)\hat{x}_c + y_p(z/f - 1)\hat{y}_c + z\hat{z}_c \quad (27)$$

where  $z$  is the horizontal distance along the ray, and the subscript  $c$  refers to the camera coordinates. The camera axis  $\hat{z}_c$  is collinear with the lens optical axis. It will be assumed that  $z/f \gg 1$ , which is usually the case.

15

Assuming the camera is aligned so that  $\hat{y}_c = \hat{y}$  is aligned with the runway coordinate, but the camera is tilted from the horizontal by angle  $\theta$ . Then

$$\begin{aligned} \hat{x}_c &= \hat{x} \cos\theta - \hat{z} \sin\theta \\ \hat{z}_c &= \hat{x} \sin\theta + \hat{z} \cos\theta \end{aligned} \quad (28)$$

and a point on the ray from the aircraft to its image is given by

$$r = z[(x_p \cos\theta / f + \sin\theta) \hat{x} + (y_p / f) \hat{y} + (\cos\theta - x_p \sin\theta / f) \hat{z}] \quad (29)$$

Letting the aircraft trajectory be given by

$$r(t) = (z(t) \tan\theta_{GS} + x_0) \hat{x} + y_0 \hat{y} + z(t) \hat{z} \quad (30)$$

20 where  $z(t)$  is the horizontal position of the aircraft at time  $t$ ,  $\theta_{GS}$  is the glide-slope angle, and the aircraft is at altitude  $x_0$  and has a lateral displacement  $y_0$  at  $z(t_0) = 0$ . Here,  $t = t_0$  is the time at which the image acquisition system 10 is triggered, i.e. when

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the aircraft is overhead with respect to the cameras 7.

Comparing equations (29) and (30) allows  $z$  to be written in terms of  $z(t)$  and gives the pixel positions as

$$x_p(t) = f \left( \frac{z(t)[\cos\theta \tan\theta_{GS} - \sin\theta] + x_0 \cos\theta}{z(t)[\sin\theta \tan\theta_{GS} + \cos\theta] + x_0 \sin\theta} \right) \quad (31)$$

5 and

$$y_p(t) = \frac{fy_0}{z(t)[\sin\theta \tan\theta_{GS} + \cos\theta] + x_0 \sin\theta} \quad (32)$$

Since  $z_p(t)$  is the vertical coordinate and its value controls the acquisition trigger, the following discussion will be centred on equation (31). The aircraft position is given by

$$z(t) = v(t_0 - t) \quad (33)$$

where  $v$  is the speed of the aircraft along the  $\hat{z}$  axis.

10

The aim is to determine  $t_0$  from a series of values of  $z_p(t)$  at  $t$  determined from the image of the aircraft. For this purpose, it is useful to rearrange (31) into the following form

$$c - t + ax_p - bt_x = 0 \quad (34)$$

where

$$a = \frac{vt_0(\tan\theta_{GS} + \cot\theta) + x_0}{f(1 - \tan\theta_{GS} \cot\theta)} \quad (35)$$

$$b = \frac{\tan\theta_{GS} + \cot\theta}{f(1 - \tan\theta_{GS} \cot\theta)} \quad (36)$$

15 and



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Then the values of  $a$ ,  $b$  and  $c$  that minimise equation (39) are given by

$$a = \frac{(NP - XT)(P^2 - NS) - (NR - PT)(PX - NQ)}{(NY - X^2)(P^2 - NS) + (PX - NQ)^2} \quad (41)$$

$$b = \frac{(NP - XT)(PX - NQ) + (NR - PT)(NY - X^2)}{(NY - X^2)(P^2 - NS) + (PX - NQ)^2} \quad (42)$$

and

$$c = \frac{T + bP - aX}{N} \quad (43)$$

On obtaining  $a$ ,  $b$  and  $c$  from equations (41) to (43), then  $t_0$  can be obtained from equation (38).

5

Using data obtained from video images of an aircraft landing at Melbourne airport, a graph of aircraft image position as a function of image frame number is shown in Figure 15. The data was processed using equations (41) to (43) and (38) to yield the predicted value for the trigger frame number  $t_0 = 66$  corresponding to trigger point 70. The predicted point 70 is shown in Figure 16 as a function of frame number. The predicted value is  $t_0 = 66 \pm 0.5$  after 34 frames. In this example, the aircraft can be out of the view of the camera 3 for up to 1.4 seconds and the system 2 can still trigger the acquisition camera 7 to within 40 milliseconds of the correct time. For an aircraft travelling at 62.5 m/s, the system 2 captures the aircraft to within 2.5 metres  
15 of the required position.

The tracking system 6, 8 may also use an Area-Parameter Accelerator (APA) digital processing unit, as discussed in International Publication No. WO 93/19441, to extract additional information, such as the aspect ratio of the wing span to the  
20 fuselage length of the aircraft and the location of the centre of the aircraft.

The tracking system 1 can also be implemented using one or more pyroelectric sensors 27 with a signal processing wing detection unit 29. Each sensor 27 has two

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adjacent pyroelectric sensing elements 40 and 42, as shown in Figure 17, which are electrically connected so as to cancel identical signals generated by each element. A plate 44 with a slit 46 is placed above the sensing elements 40 and 42 so as to provide the elements 40 and 42 with different fields of view 48 and 50. The fields of view 48 and 50 are significantly narrower than the field of view of a detection camera discussed previously. If aircraft move above the runway in the direction indicated by the arrow 48, the first element 40 has a front field of view 48 and the second element 42 has a rear field of view 50. As an aircraft 28 passes over the sensor 27 the first element 40 detects the thermal radiation of the aircraft before the second element 42, 5 the aircraft 28 will then be momentarily in both fields of view 48 and 50, and then only detectable by the second element 42. An example of the difference signals generated by two sensors 27 is illustrated in Figure 18 where the graph 52 is for a sensor 27 which has a field of view that is directed at 90° to the horizontal and a sensor 27 which is directed at 75° to the horizontal. Graph 54 is an expanded view of the centre of 15 graph 52. The zero crossing points of peaks 56 in the graphs 52 and 54 correspond to the point at which the aircraft 28 passes the sensor 27. Using the known position of the sensor 27 the time at which the aircraft passes, and the speed of the aircraft 28, a time can be determined for generating an acquisition signal to trigger the high resolution acquisition cameras 7. The speed can be determined from movement of the 20 zero crossing points over time, in a similar manner to that described previously.

The image acquisition system 10, as mentioned previously, acquires an image of the aircraft with sufficient resolution for the aircraft registration characters to be obtained using optical character recognition. According to one embodiment of the 25 acquisition system 10, the system 10 includes two high resolution cameras 7 each comprising a lens and a CCD detector array. Respective images obtained by the two cameras 7 are shown in Figures 19 and 20.

The minimum pixel dimension and the focal length of the lens determine the 30 spatial resolution in the image. If the dimension of a pixel is  $L_p$ , the focal length  $f$  and the altitude of the aircraft is  $h$ , then the dimension of a feature  $W_{\min}$  on the aircraft that

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is mapped onto a pixel is

$$W_{\min} = \frac{L_p h}{f} \quad \text{or} \quad f = \frac{L_p h}{W_{\min}} \quad (44)$$

The character recognition process used requires each character stroke to be mapped onto at least four pixels with contrast levels having at least 10% difference from the background. The width of a character stroke in the aircraft registration is regulated by the ICAO. According to the ICAO Report, Annex 7, sections 4.2.1 and 5.3, the character height beneath the port wing must be at least 50 centimetres and the character stroke must be 1/6<sup>th</sup> the character height. Therefore, to satisfy the character recognition criterion, the dimension of the feature on the aircraft that is mapped onto a pixel should be  $W_{\min} = 2$  centimetres, or less. Once the CCD detector is chosen,  $L_p$  is fixed and the focal length of the system is determined by the maximum altitude of the aircraft at which the spatial resolution  $W_{\min} = 2$  centimetres is required.

The field of view of the system at altitude  $h$  is determined by the spatial resolution  $W_{\min}$  chosen at altitude  $h_{\max}$  and the number of pixels  $N_{pl}$  along the length of the CCD,

$$W_{FOV} = \frac{N_{pl} W_{\min} h}{h_{\max}} \quad (45)$$

For  $h = h_{\max}$  and  $N_{pl} = 1552$  the field of view is  $W_{FOV} = 31.04$  metres.

To avoid blurring due to motion of the aircraft, the image moves a distance less than the size of a pixel during the exposure. If the aircraft velocity is  $v$ , then the time to move a distance equal to the required spatial resolution  $W_{\min}$  is

$$t = \frac{W_{\min}}{v} \quad (46)$$

The maximum aircraft velocity that is likely to be encountered on landing or

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take-off is  $v = 160 \text{ knots} = 82 \text{ ms}^{-1}$ . With  $W_{\min} = 0.02 \text{ m}$ , the exposure time to avoid excessive blurring is  $t < 240 \text{ } \mu\text{s}$ .

The focal length of the lens in the system 10 can be chosen to obtain the 5 required spatial resolution at the maximum altitude. This fixes the field of view. Alternatively, the field of view may be varied by altering the focal length according to the altitude of the aircraft. The range of focal lengths required can be calculated from equation (44)

10 The aircraft registration, during daylight conditions, is illuminated by sunlight or scattered light reflected from the ground. The aircraft scatters the light that is incident, some of which is captured by the lens of the imaging system. The considerable amount of light reflected from aluminium fuselages of an aircraft can affect the image obtained, and is taken into account. The light power falling onto a 15 pixel of the CCD is given by

$$P_p = L_\lambda \Delta\lambda \Omega_{\text{sun}} \frac{R_{\text{gnd}} R_A A_p}{8f\#^2} \quad (47)$$

where  $L_\lambda$  is the solar spectral radiance,  $\Delta\lambda$  is the wavelength bandpass of the entire configuration,  $\Omega_{\text{sun}}$  is the solid angle subtended by the sun,  $R_{\text{gnd}}$  is the reflectivity of the ground,  $R_A$  is the reflectivity of the aircraft,  $A_p$  is the area of a pixel in the CCD detector and  $f\#$  is the lens f-number.

20

The solar spectral radiance  $L_\lambda$  varies markedly with wavelength  $\lambda$ . The power falling on a pixel will therefore vary over a large range. This can be limited by restricting the wavelength range  $\Delta\lambda$  passing to the sensor and optimally choosing the centre wavelength of this range. The optimum range and centre wavelength are 25 chosen to match the characteristics of the imaging sensor.

In one embodiment, the optimum wavelength range and centre wavelength are chosen in the near infrared waveband, 0.69 to 2.0 microns. This limits the variation in

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light power on a pixel in the sensor to within the useable limits of the sensor. A KODAK™ KAF-1600L imaging sensor (a monolithic silicon sensor with lateral overflow anti-blooming) was chosen that incorporated a mechanism to accommodate a thousandfold saturation of each pixel, giving a total acceptable range of light powers 5 in each pixel of  $10^5$ . This enables the sensor to produce a useful image of an aircraft when very bright light sources, for example the sun, are in its field of view.

The correct choice of sensor and the correct choice of wavelength range and centre wavelength enables an image to be obtained within a time interval that arrests 10 the motion of the aircraft and that provides an image with sufficient contrast on the aircraft registration to enable digital image processing and recognition of the registration characters.

In choosing the wavelength range and centre wavelength, it was important to 15 avoid dazzling light from the supplementary illumination of the illumination unit 16. The optimum wavelength range was therefore set to between  $0.69 \mu\text{m}$  and  $2.0 \mu\text{m}$ .

The power of sunlight falling onto a pixel directly from the sun is

$$P_{p\text{-sun}} = L_{\lambda} \Delta\lambda \frac{A_p \pi}{4f\#^2} \quad (48)$$

The relative light powers from the sun and from the aircraft registration falling 20 onto a single pixel is

$$\frac{P_{p\text{-sun}}}{P_p} = \frac{2\pi}{\Omega_{\text{sun}} R_{\text{gnd}} R_A} \quad (49)$$

With  $\Omega_{\text{sun}} = 6.8 \times 10^{-5}$  steradians,  $R_{\text{gnd}} \approx 0.2$  and  $R_A = 1$ , the ratio is  $P_{p\text{-sun}}/P_p = 4.6 \times 10^5$ . This provides an estimate of the relative contrast between the image of the sun and the image of the underneath of the aircraft on a CCD pixel. The CCD sensor and system electronics are chosen to accommodate this range of light 25 powers.



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In poor lighting conditions, the aircraft registration requires additional illumination from the illumination unit 16. The light source of the unit 16 needs to be sufficient to illuminate the aircraft at its maximum altitude. If the source is designed to emit light into a solid angle that just covers the field of view of the imaging system then  
 5 the light power incident onto a pixel of the imaging system 10 due to light emitted from the source and reflected from the aircraft is given by

$$P_p = P_s \frac{R_A}{8A_A} \frac{A_p}{N_{\text{ptot}} \#^2} \quad (50)$$

where  $A_A$  is the area on the aircraft imaged onto a pixel of area  $A_p$ ,  $P_s$  is the light power of the source,  $R_A$  is the aircraft reflectivity,  $N_{\text{ptot}}$  is the total number of pixels in the CCD sensor and  $\#$  is the f-number of the lens. The power of the source required  
 10 to match the daytime reflected illumination is estimated by setting  $P_p = 7.3 \times 10^{-11}$  W,  $R_A = 1$ ,  $A_p = 81 \mu\text{m}^2$ ,  $N_{\text{ptot}} = 1552 \times 1032$ ,  $\# = 1.8$  and noting that  $A_A = W_{\text{min}}^2$  where  $W_{\text{min}} = 0.02$  m. Then  $P_s = 1.50 \times 10^4$  W. For a Xenon flash lamp, the flash time is typically  $t = 300 \mu\text{s}$  which compares favourably with the exposure time to minimise motion blurring. Then the source must deliver an energy of  
 15  $E_s = P_s t = 4.5$  J. This is the light energy in a wavelength band  $\Delta\lambda = 0.1 \mu\text{m}$ . Xenon flash lamps typically have 10% of their light energy within this bandpass centred around  $\lambda = 0.8 \mu\text{m}$ . Furthermore, the flash lamp may only be 50% efficient. Thus the electrical energy required is approximately 90 J. Flash lamps that deliver energies of 1500 J in 300  $\mu\text{s}$  are readily available. Illumination with such a flash lamp during the  
 20 day reduces the contrast between the direct sun and the aircraft registration, thereby relaxing the requirement for over-exposure tolerance of the CCD sensor. This result depends on the flash lamp directing all of its energy into the field of view only and that the lens focal length is optimally chosen to image the region of dimension  $W_{\text{min}} = 0.02$  m onto a single pixel.

25

In one embodiment, the aperture of the lens on the acquisition camera 7 is automatically adjusted to control the amount of light on the imaging sensor in order to optimise the image quality for digital processing. In the image obtained, the intensity

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level of the registration characters relative to the underside of the aircraft needs to be maintained to provide good contrast between the two for OCR. The power  $P_s$  of the flash 16 is automatically adjusted in accordance with the aperture setting  $f\#$  of the acquisition camera 7 to optimise the image quality and maintain the relative contrast  
5 between the registration characters and the underside of the aircraft, in accordance with the relationship expressed in equation (50). For example, during the day the aperture of the lens may be very small and the power of the flash may be increased to provide additional illumination of the underside, whereas during night conditions, the aperture may be fully opened and the power of the flash reduced considerably as  
10 additional illumination is not required. As an alternative, or in addition, the electrical gain of the electronic circuits connected to an acquisition camera 7 is adjusted automatically to optimise the image quality.

To appropriately set the camera aperture and/or gain one or more point optical  
15 sensors 60, 62, as shown in Figure 21, are used to measure the ambient lighting conditions. The electrical output signals of the sensors 60, 62 are processed by the acquisition system 10 to produce the information required to control the camera aperture and/or gain. Two point sensors 60, 62 sensitive to the same optical spectrum as the acquisition cameras 7 can be used. One sensor 60 receives light from the sky  
20 that passes through a diffusing plate 64 onto the sensor 60. The diffusing plate 64 collects light from many different directions and allows it to reach the sensor 60. The second sensor 62 is directed towards the ground to measure the reflected light from the ground.

25 The high resolution images obtained of the aircraft by the acquisition system 10 are submitted, as described previously, to the analysis system 12 which performs optical character recognition on the images to extract the registration codes of the aircraft.

30 The analysis system 12 processes the aircraft images obtained by a high resolution camera 7 according to an image processing procedure 100, as shown in

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Figure 22, which is divided into two parts 102 and 104. The first part 102 operates on a sub-sampled image 105, as shown in Figure 23, to locate regions that contain features that may be registration characters, whereas the second part 104 executes a similar procedure but is done using the full resolution of the original image and is  
5 executed only on the regions identified by the first part 102. The sub-sampled image 105 is the original image with one pixel in four removed in both row and column directions, resulting in a one in sixteen sampling ratio. Use of the sub-sampled image improves processing time sixteen-fold.

10       The first part 102 receives the sub-sampled image at step 106 and filters the image to remove features which are larger than the expected size of the registration characters (b) at step 108. Step 108 executes a morphological operation of linear closings applied to a set of lines angled between 0 and 180°. The operation passes a kernel or window across the image 105 to extract lines which exceed a  
15 predetermined length and are at a predetermined angle. The kernel or window is passed over the image a number of times and each time the predetermined angle is varied. The lines extracted from all of the passes are then subtracted from the image 105 to provide a filtered difference image 109. The filtered difference image 109 is then thresholded or binarised at step 110 to convert it from a grey scale image to a  
20 binary scale image 111. This is done by setting to 1 all image values that are greater than a threshold and setting to 0 all other image values. The threshold at a given point in the image is determined from a specified multiple of standard deviations from the mean calculated from the pixel values within a window centred on the given point. The binarised image 111 is then filtered at step 112 to remove all features that have pixel  
25 densities in a bounding box that are smaller or larger than the expected pixel density for a bounded registration character. The image 111 is then processed at step 114 to remove all features which are not clustered together like registration characters. Step 114 achieves this by grouping together features that have similar sizes and that are close to one another. Groups of features that are smaller than a specified size are  
30 removed from the image to obtain a cleaned image 113. The cleaned image 113 is then used at step 116 to locate regions of interest. Regions of interest are obtained

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in step 116 from the location and extents of the groups remaining after step 114. Step 116 produces regions of interest which include the registration characters and areas of the regions are bounded above and below, as for the region 115 shown in Figure 23.

5

The regions of interest obtained by the first part 102 of the procedure 100 are further processed individually using the full resolution of the original image and the second part 104 of the procedure. The second part 104 takes a region of interest 115 from the original image at step 120 and for that region filters out features larger than  
10 the expected character sizes at step 122, using the same morphological operation of linear closings applied to a set of lines angled between 0 and 180°, followed by image subtraction, as described above, to obtain image 117. The filtered image 117 is then binarised at step 124 by selecting a filter threshold that is representative of the pixel values at the edges of features. To distinguish the registration characters from the  
15 aircraft wing or body the filter threshold needs to be set correctly. A mask image of significant edges in image 117 is created by calculating edge-strengths at each point in image 117 and setting to 1 all points that have edge-strengths greater than a mask threshold and setting to 0 all other points. An edge-strength is determined by taking at each point pixel gradients in two directions,  $\Delta x$  and  $\Delta y$ , and calculating  
20  $\sqrt{\Delta x^2 + \Delta y^2}$  to give the edge-strength at that point. The mask threshold at a given point is determined from a specified multiple of standard deviations from the mean calculated from the edge-strengths within a window centred on the given point. The filter threshold for each point in image 117 is then determined from a specified multiple of standard deviations from the mean calculated from the pixel values at all points  
25 within a window centred on the given point that correspond to non-zero values in the mask image. The binarised image 118 is then filtered at step 126 to remove features that are smaller than the expected character sizes. Features are clustered together at step 128 that have similar sizes, that are near to one another and that are associated with similar image values in image 117. At step 130 the correctly clustered features  
30 that have sizes, orientations and relative positions that deviate too much from the averages for the clusters are filtered out to leave features that form linear chains. Then

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at step 132, if the number of features remaining in the image produced by step 130 is greater than 3, then a final image is created by rotating image 118 to align the linear chain of features with the image rows and by masking out features not belonging to the linear chain. The final image is passed to a character recognition process 200 to  
5 determine whether the features are registration characters and, if so, which characters.

The final image undergoes a standard optical character recognition process 200, as shown in Figure 24, to generate character string data which represents the  
10 ICAO characters on the port wing. The process 200 includes receiving the final image at step 202, which is produced by step 132 of the image processing procedure 100, and separating the characters of the image at step 204. The size of the characters are normalised at step 206 and at step 208 correction for the alignment of the characters is made and further normalisation occurs. Character features are extracted at step 210  
15 and an attempt made to classify the features of the characters extracted at step 212. Character rules are applied to the classified features at step 214 so as to produce a binary string representative of the registration characters at step 216.

Although the system 2 has been described above as being one which is  
20 particularly suitable for detecting an aircraft, it should be noted that many features of the system can be used for detecting and identifying other moving objects. For example, the embodiments of the tracking system 1 may be used for tracking land vehicles. The system 2 may be employed to acquire images of and identify automobiles at tollway points on a roadway.

25

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention as hereinbefore described with reference to the accompanying drawings.

30

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CLAIMS:

1. An object detection system including:  
passive sensing means for receiving electromagnetic radiation from a moving  
5 object and generating intensity signals representative of the received radiation; and  
processing means for subtracting said intensity signals to obtain a differential  
signature representative of the position of said moving object.
2. An object detection system as claimed in claim 1, wherein said processing  
10 means generates an image acquisition signal on the basis of said differential  
signature.
3. An object detection system as claimed in claim 2, including acquisition means,  
responsive to said acquisition signal, for acquiring an image of at least part of said  
15 moving object; and  
analysis means for processing said image to identify said moving object.
4. An object detection system as claimed in claim 3, wherein said analysis system  
processes said acquired image to extract markings to identify said moving object  
20
5. An object detection system as claimed in claim 1, 2, 3 or 4, wherein said moving  
object is an aircraft.
6. An object detection system as claimed in claim 5, wherein said aircraft is in  
25 flight.
7. An object detection system as claimed in claim 5, wherein said electromagnetic  
radiation is thermal radiation.

30

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8. An object detection system as claimed in claim 5, including proximity detecting means for detecting the presence of said aircraft within a predetermined region and, in response thereto, generating an activation signal for said passive sensing means.
- 5 9. An object detection system as claimed in claim 1, wherein said passive sensing means includes imaging means for obtaining images of said radiation at successive periods of time, and  
said processing means generates respective profiles of pixel values for said images and a difference profile, generated from the difference between successive  
10 profiles, which includes said differential signature.
10. An object detection system as claimed in claim 9, wherein said position corresponds to a zero crossing point in said difference profile where said difference profile has risen above a first predetermined threshold for at least a first predetermined  
15 distance and then falls to below a second predetermined threshold for a second predetermined distance.
11. An object detection system as claimed in claim 10, wherein said processing means monitors the movement of said position in successive ones of said difference  
20 profile and determines the time for generation of an image acquisition signal.
12. An object detection system as claimed in claim 11, wherein said processing means generates a background image from successive images obtained by said imaging means and subtracts said background image from images of said radiation  
25 before generating said profiles.
13. An object detection system as claimed in claim 1, wherein said passive sensing means includes pyroelectric sensors with different fields of view and said intensity signals include at least first and second signals representative of the thermal radiation  
30 present in said views, respectively, and

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said processing means subtracts said first and second signals to obtain a differential signal including said differential signature.

14. An object detection system as claimed in claim 13, wherein said processing  
5 means determines a time for generation of an image acquisition signal on the basis of the position of said passive sensing means, the time of generation of said differential signature and the speed of said moving object.

15. An object detection system as claimed in claim 14, wherein said time of  
10 generation and said speed are determined from a zero crossing point of said differential signature.

16. An image acquisition system including:  
at least one camera for acquiring an image of at least part of a moving object,  
15 in response to a trigger signal, and  
analysis means for processing said image to locate a region in said image including markings identifying said object and processing said region to extract said markings for a recognition process.

20 17. An image acquisition system as claimed in claim 16, wherein said camera images received radiation between 0.69 to 2.0  $\mu\text{m}$ .

18. An image acquisition system as claimed in claim 17, wherein said camera has an exposure time of < 240  $\mu\text{s}$ .

25

19. An image acquisition system as claimed in claim 17, including an infrared flash having its power adjusted on the basis of the aperture setting of said camera.

20. An image acquisition system as claimed in claim 17, including optical sensor  
30 means positioned to obtain measurements of ambient direct light and reflected light for the field of view of said camera and adjust settings of said camera on the basis of said measurements.



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21. An image acquisition system as claimed in claim 16, wherein said analysis means sub-samples said image, extracts lines exceeding a predetermined length and at predetermined angles, binarises the image, removes features smaller or larger than said markings, removes features not clustered as said markings, and locates said  
5 region using the remaining features.

22. An image acquisition system as claimed in claim 21, wherein said analysis means extracts said region from said image and processes said region by removing features larger than expected marking sizes, binarising said region, removing features  
10 smaller than expected marking sizes, removing features not clustered as identifying markings, and passing the remaining image for optical recognition if including more than a predetermined number of markings.

23. An image acquisition system as claimed in claim 17, wherein said moving object  
15 is an aircraft.

24. An image acquisition system as claimed in claim 23, wherein said aircraft is in flight.

20 25. An object detection system as claimed in claim 2, including an image acquisition system as claimed in any one of claims 16 to 24, wherein said trigger signal is said image acquisition signal.

26. An object detection method including:  
25 passively sensing electromagnetic radiation received from a moving object;  
generating intensity signals representative of the received radiation; and  
subtracting said intensity signals to obtain a differential signature representative of the position of said moving object.

30 27. An object detection method as claimed in claim 26, including generating an image acquisition signal on the basis of said differential signature.

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28. An object detection method as claimed in claim 27, including acquiring an image of at least part of said moving object in response to said acquisition signal; and processing said image to identify said moving object.

5 29. An object detection method as claimed in claim 28, including processing said acquired image to extract markings identifying said moving object.

30. An object detection method as claimed in claim 26, 27, 28 or 29, wherein said moving object is an aircraft.

10

31. An object detection method as claimed in claim 30, wherein said aircraft is in flight.

32. An object detection method as claimed in claim 30, wherein said  
15 electromagnetic radiation is thermal radiation.

33. An object detection method as claimed in claim 30, including detecting the presence of said aircraft within a predetermined region and, in response thereto, generating an activation signal to execute said passive sensing step.

20

34. An object detection method as claimed in claim 26, wherein said passive sensing includes imaging said radiation at successive periods of time, and said subtracting includes generating respective profiles of pixel values for images of said radiation and generating a difference profile, from the difference  
25 between successive profiles, which includes said differential signature.

35. An object detection method as claimed in claim 34, wherein said position corresponds to a zero crossing point in said difference profile where said difference profile has risen above a first predetermined threshold for at least a first predetermined  
30 distance and then falls to below a second predetermined threshold for a second predetermined distance.

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36. An object detection method as claimed in claim 35, including monitoring the movement of said position in successive ones of said difference profile and determining the time for generation of an image acquisition signal.
- 5 37. An object detection method as claimed in claim 36, wherein said subtracting includes generating a background image from successive images of said radiation imaging means and subtracting said background image from images of said radiation before generating said profiles.
- 10 38. An object detection method as claimed in claim 26, wherein said passive sensing includes pyroelectric sensing with different fields of view and said intensity signals include at least first and second signals representative of the thermal radiation present in said views, respectively, and  
said subtracting includes subtracting said first and second signals to obtain a  
15 differential signal including said differential signature.
39. An object detection method as claimed in claim 38, including determining a time for generation of an image acquisition signal on the basis of the position of passive sensors, the time of generation of said differential signature and the speed of said  
20 moving object.
40. An object detection method as claimed in claim 39, wherein said time of generation and speed are determined from a zero crossing point of said differential signature.  
25
41. An image acquisition method including:  
acquiring an image of at least part of a moving object, in response to a trigger signal, using at least one camera, and  
processing said image to locate a region in said image including markings  
30 identifying said object and processing said region to extract said markings for a recognition process.

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42. An image acquisition method as claimed in claim 41, wherein said camera images received radiation between 0.69 to 2.0  $\mu\text{m}$ .

43. An image acquisition method as claimed in claim 42, wherein said camera has  
5 an exposure time of  $< 240 \mu\text{s}$ .

44. An image acquisition method as claimed in claim 42, including adjusting the power of an infrared flash for said camera on the basis of the aperture setting of said camera.

10

45. An image acquisition method as claimed in claim 42, including obtaining automatic measurements of ambient direct light and reflected light for the field of view of said camera and adjusting settings of said camera on the basis of said measurements.

15

46. An image acquisition method as claimed in claim 41, wherein said image processing includes sub-sampling said image, extracting lines exceeding a predetermined length and at predetermined angles, binarising the image, removing features smaller or larger than said markings, removing features not clustered as said  
20 markings, and locating said region using the remaining features.

47. An image acquisition method as claimed in claim 46, wherein said region processing includes extracting said region from said image, removing features larger than expected marking sizes, binarising said region, removing features with areas  
25 smaller or larger than expected marking areas, removing features not clustered as identifying markings, and passing the remaining image for optical recognition if including more than a predetermined number of markings.

48. An image acquisition method as claimed in claim 42, wherein said moving  
30 object is an aircraft.

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49. An image acquisition method as claimed in claim 48, wherein said aircraft is in flight.

50. An object detection method as claimed in claim 27, including an image acquisition method as claimed in any one of claims 41 to 49, wherein said trigger signal is said image acquisition signal.

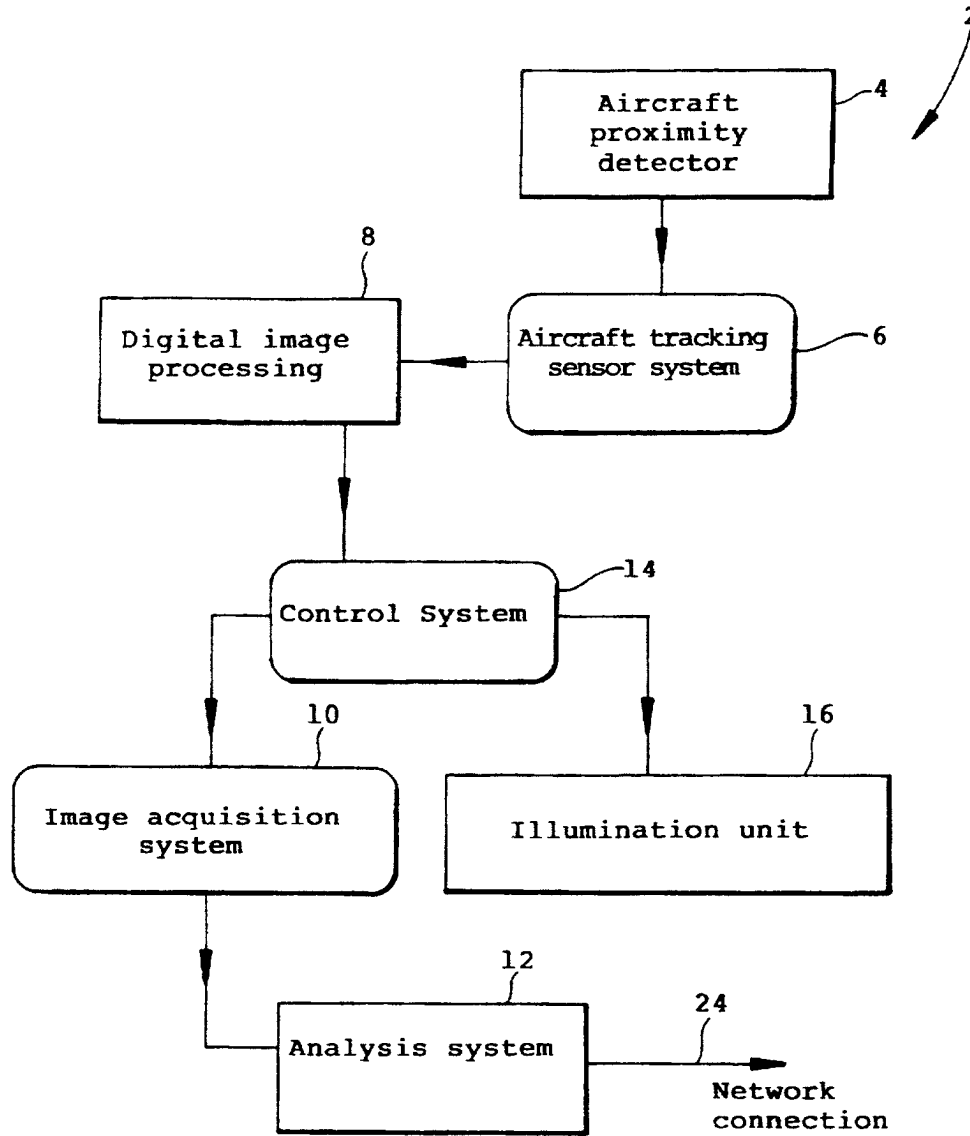


FIGURE 1

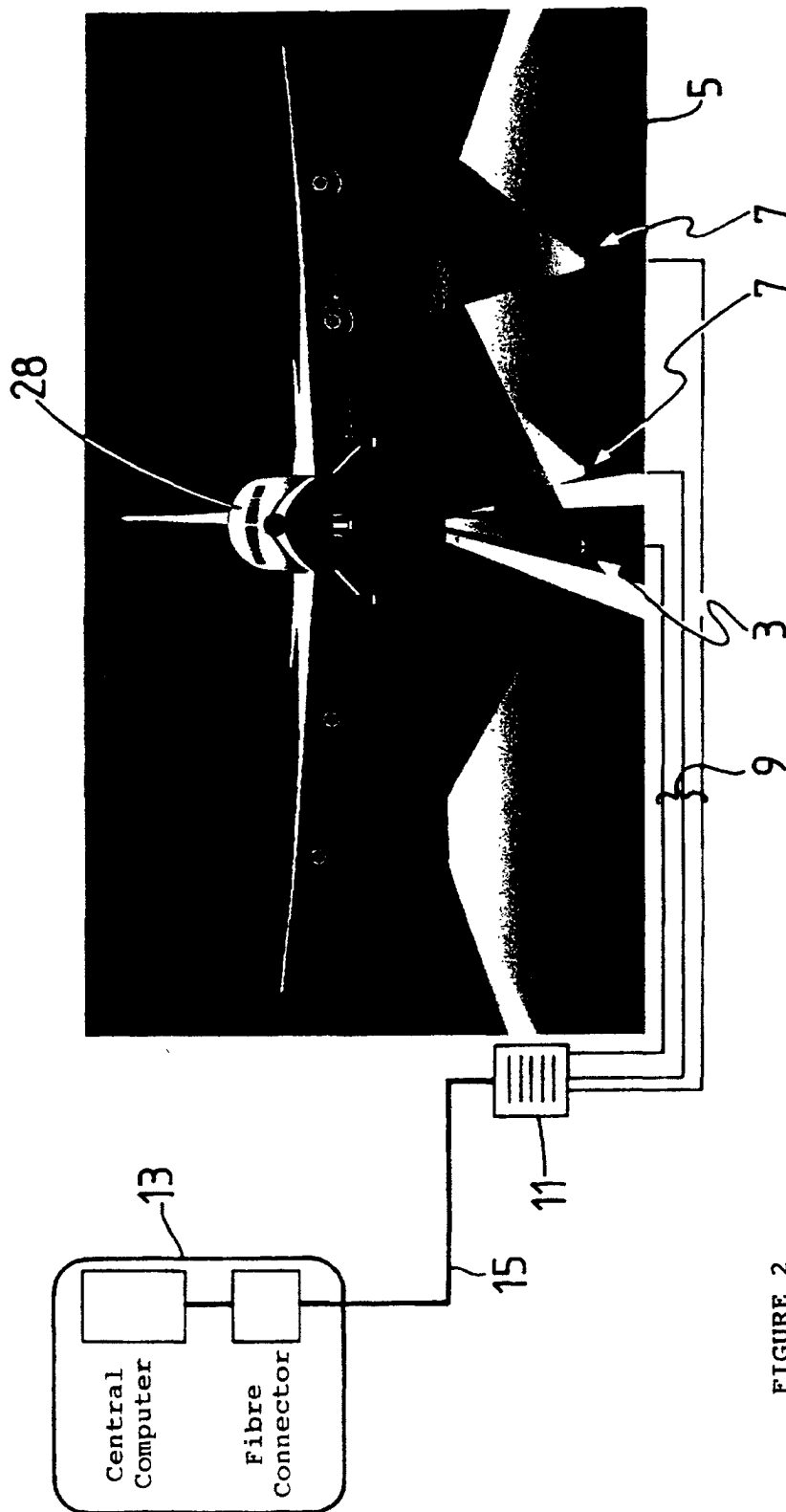
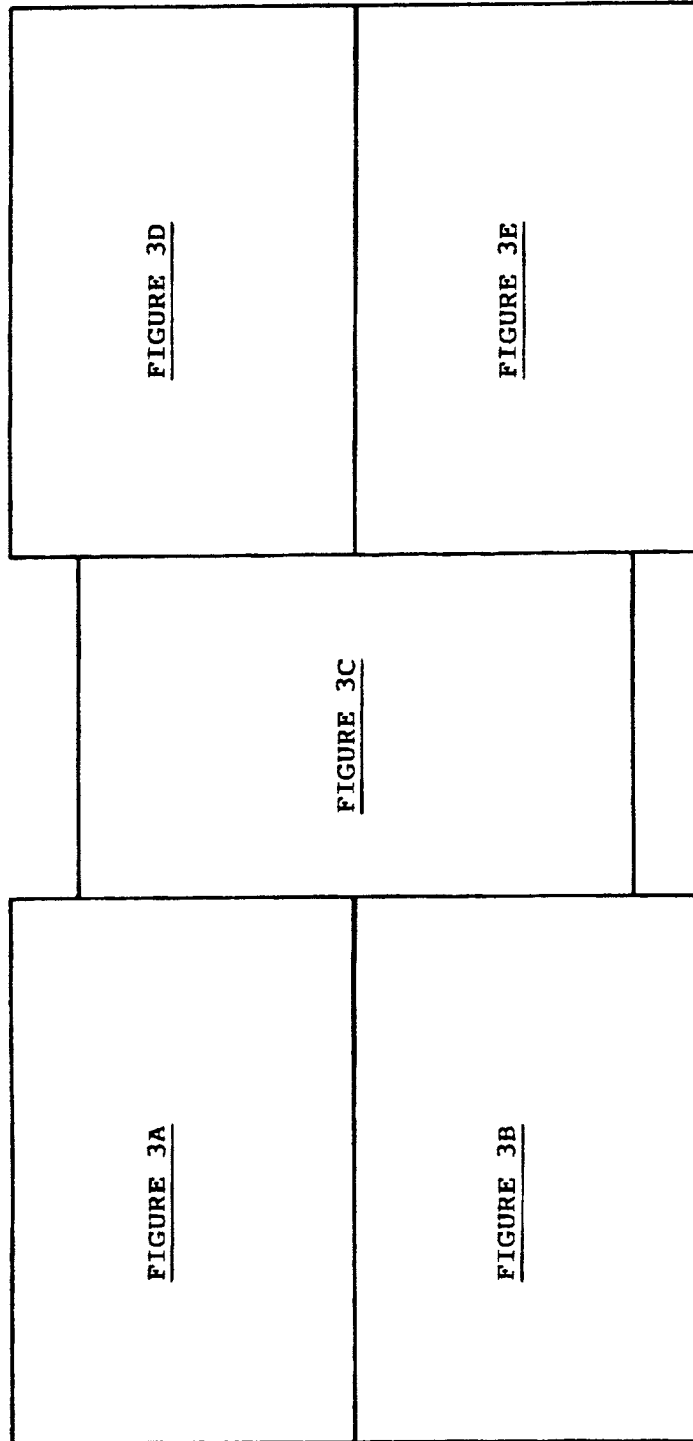


FIGURE 2

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SUBSTITUTE SHEET (RULE 26)



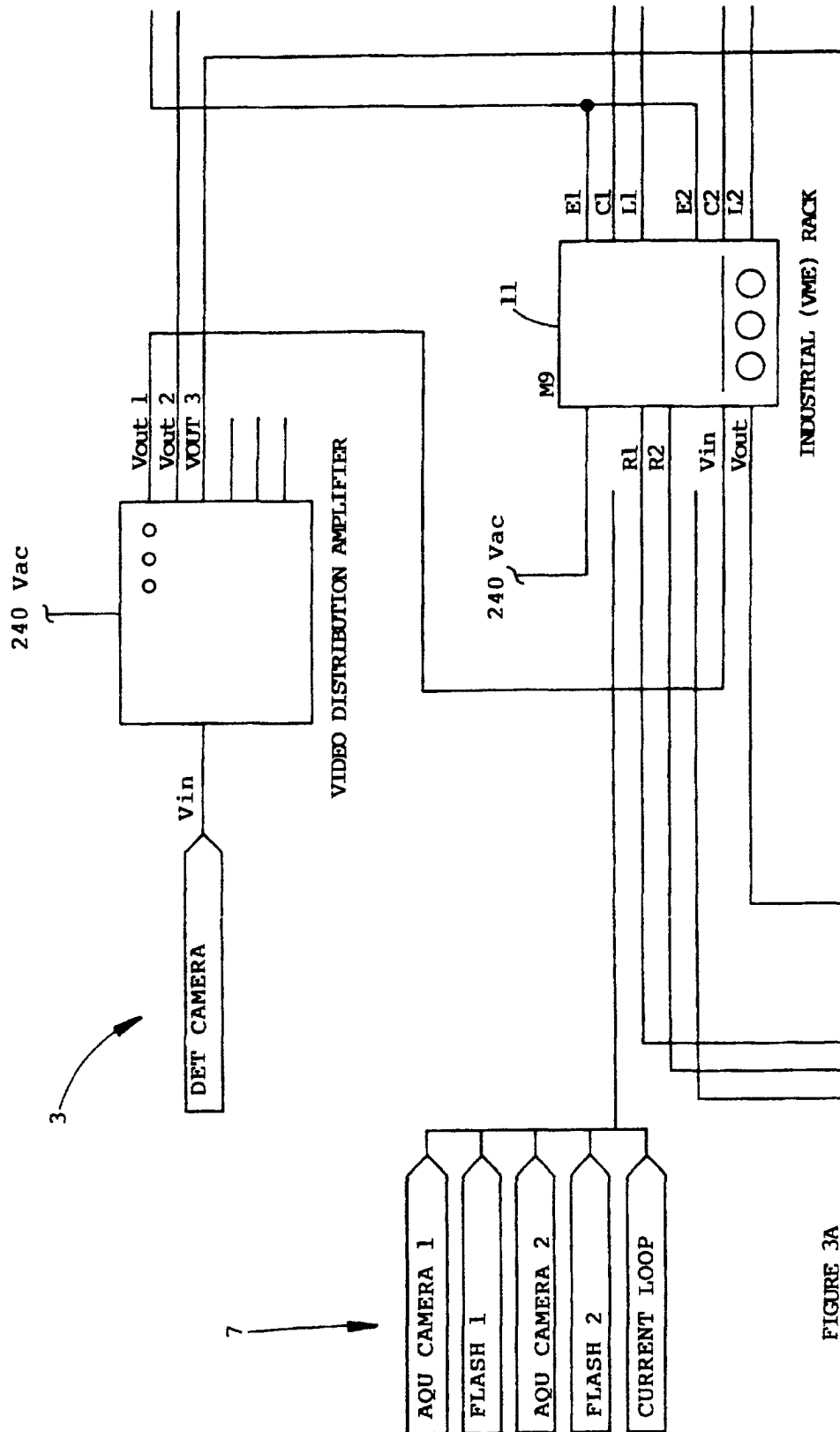


FIGURE 3A

SUBSTITUTE SHEET (RULE 26)

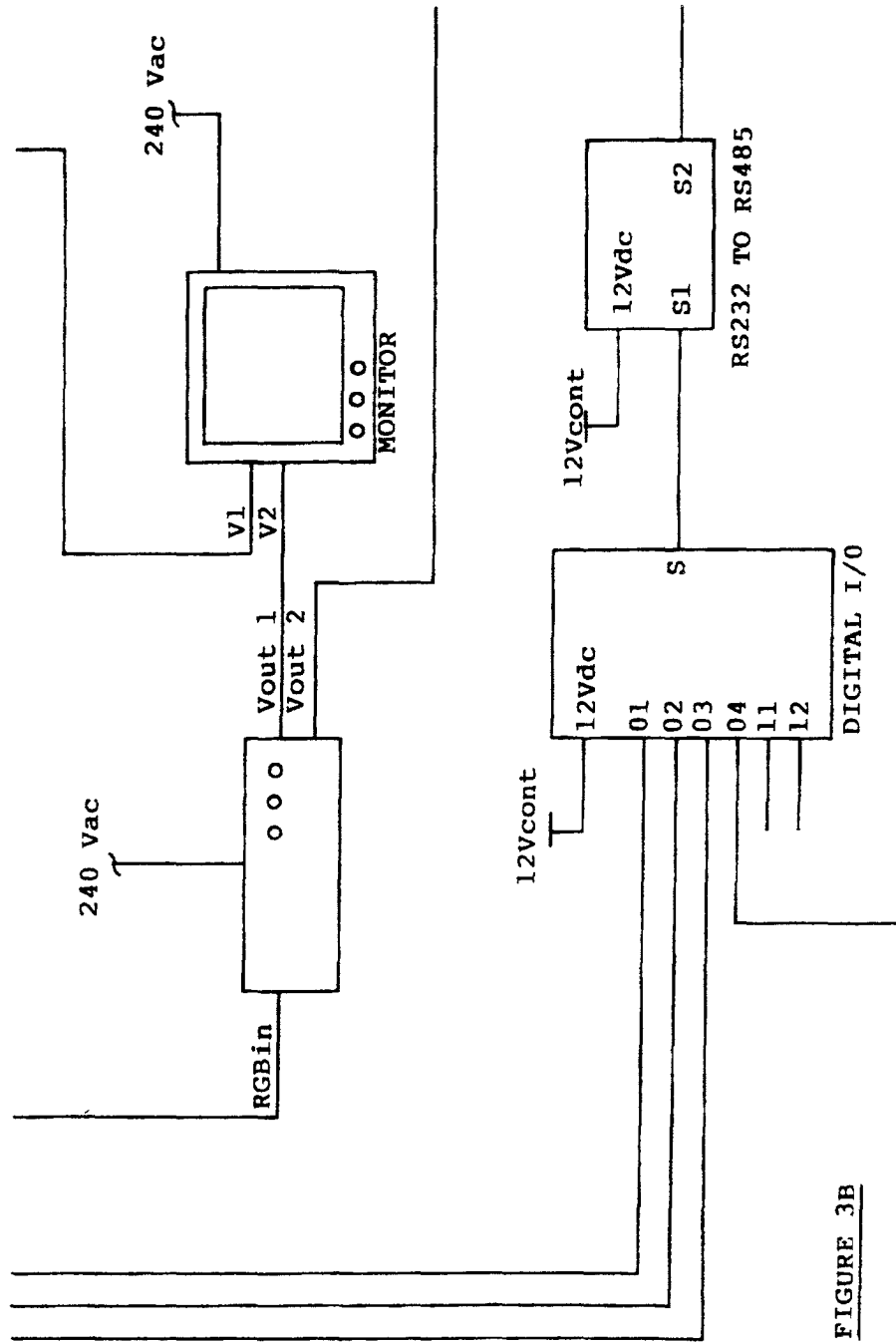
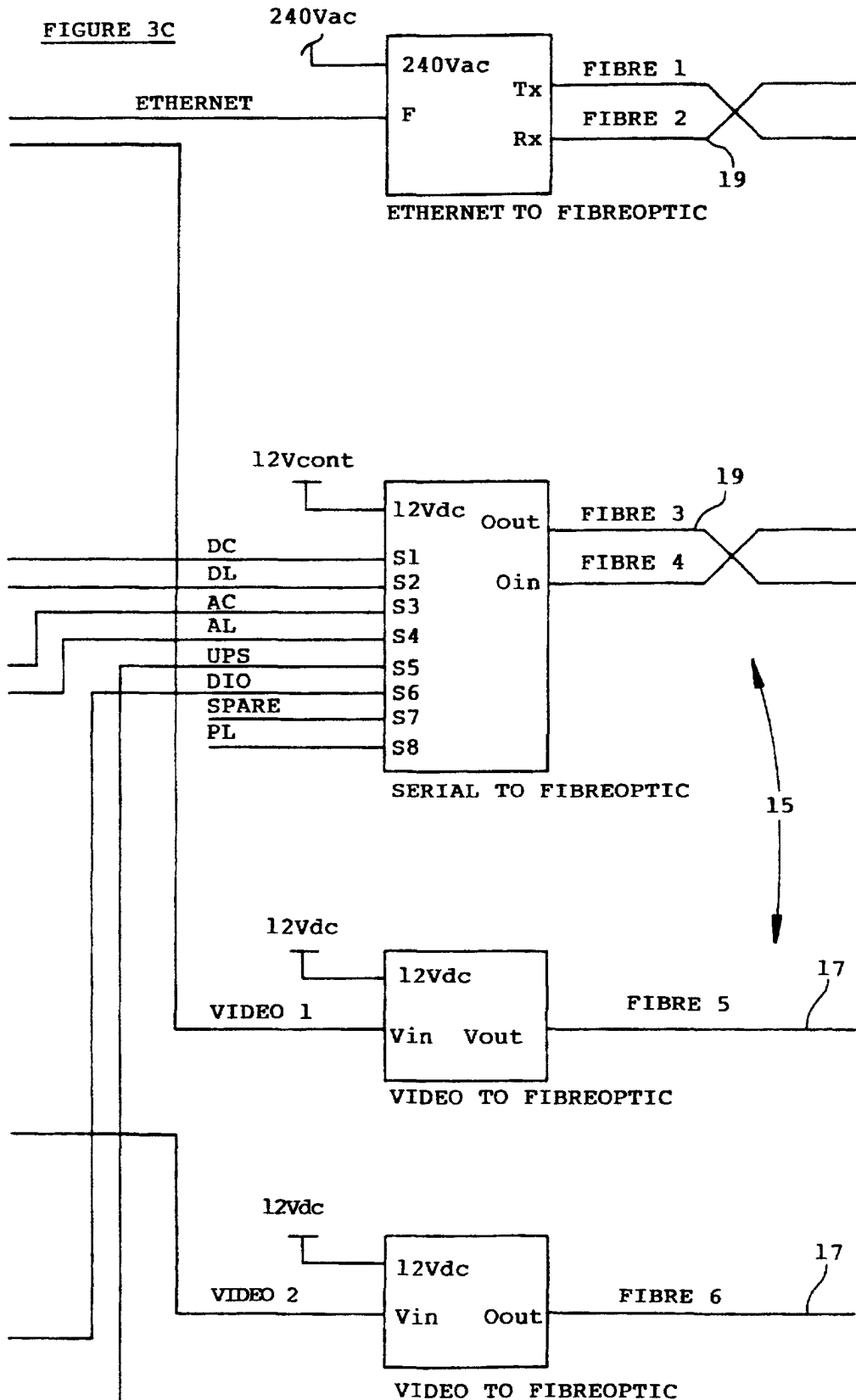


FIGURE 3B

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FIGURE 3C



SUBSTITUTE SHEET (RULE 26)

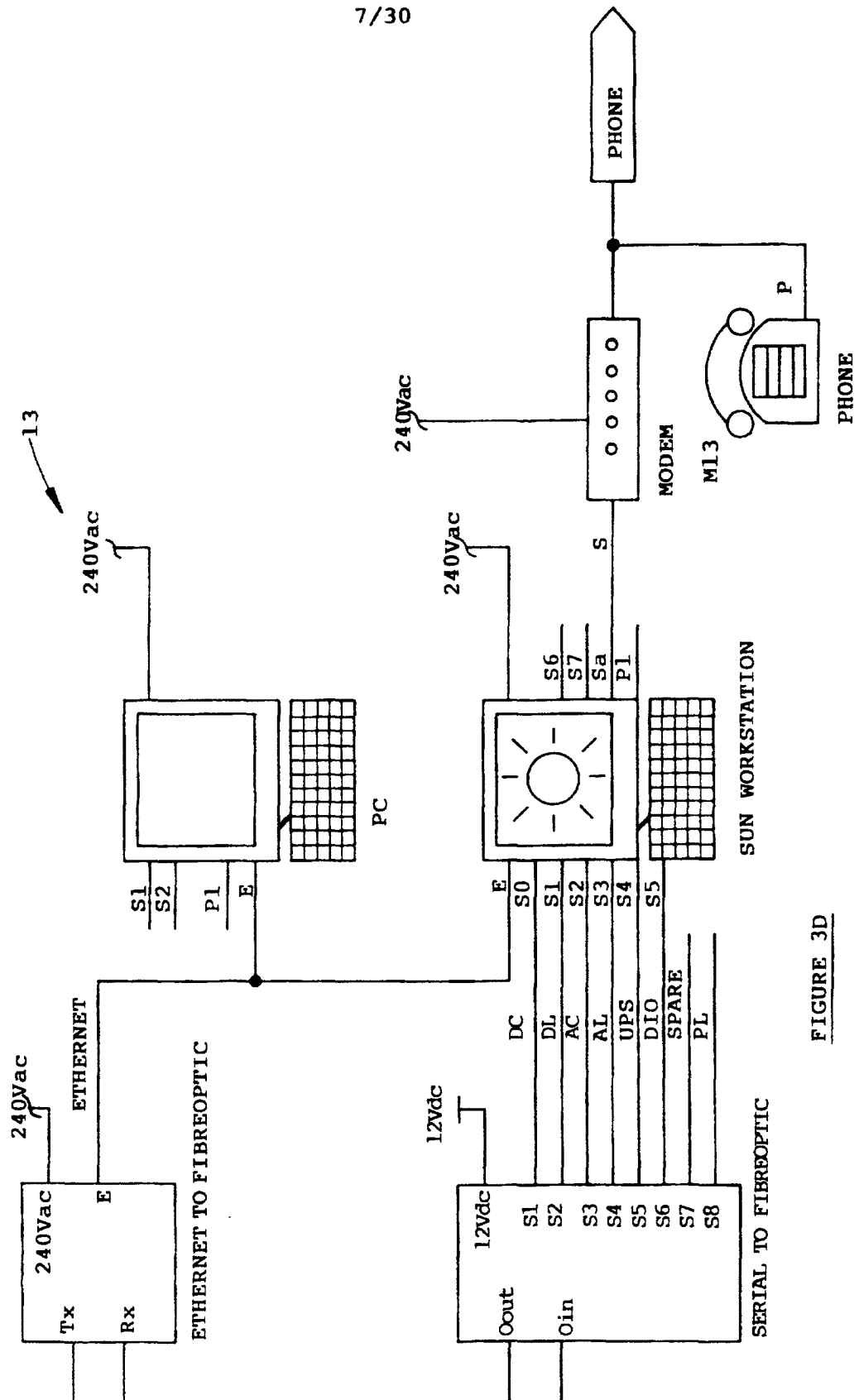


FIGURE 3D

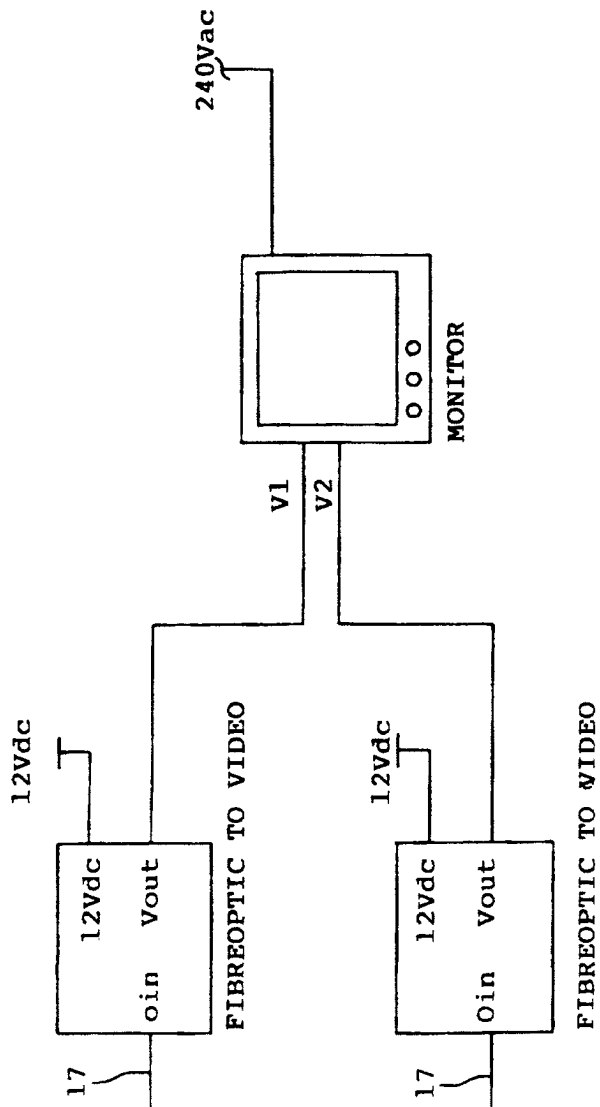


FIGURE 3E

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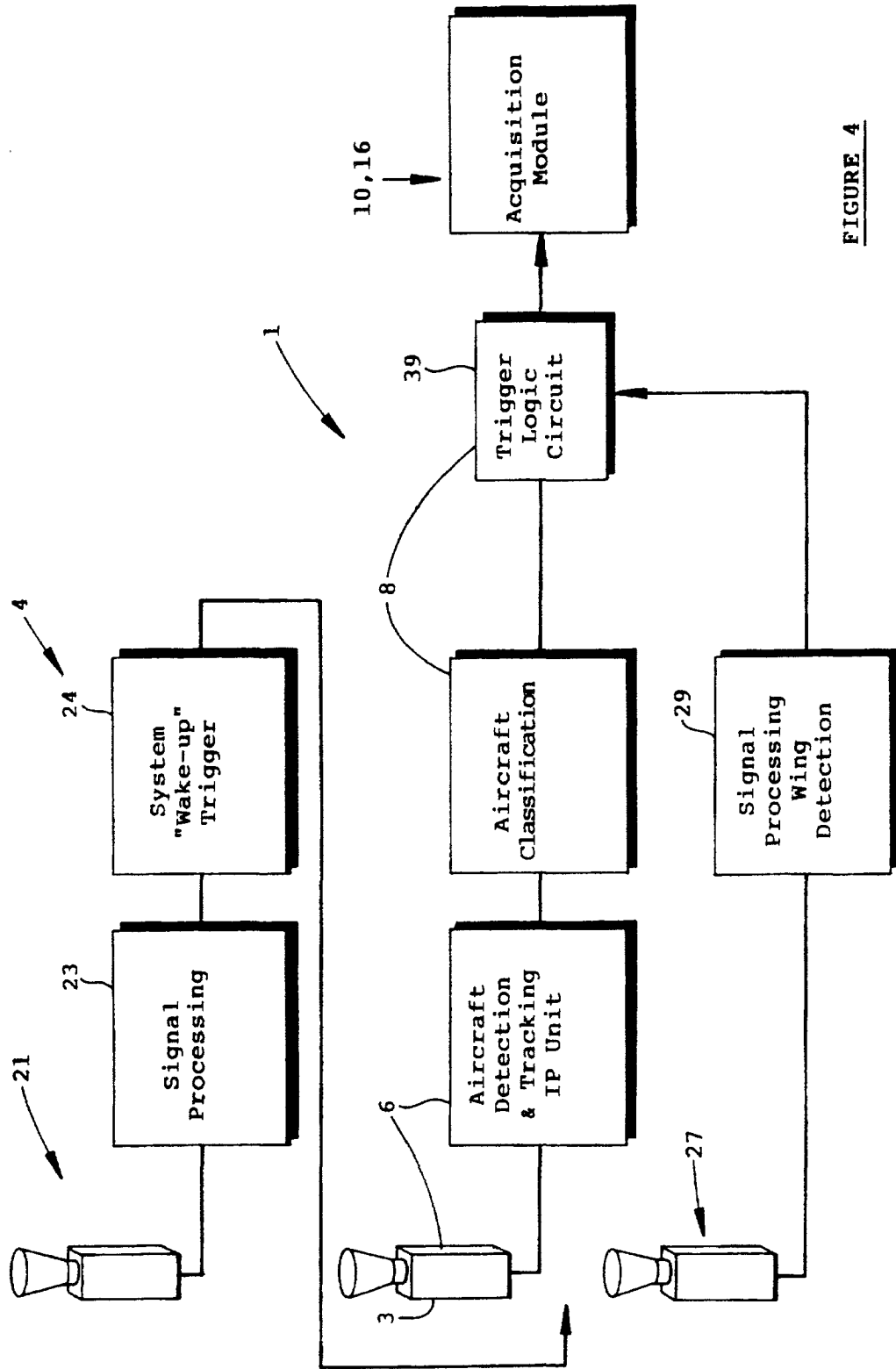


FIGURE 4

10/30

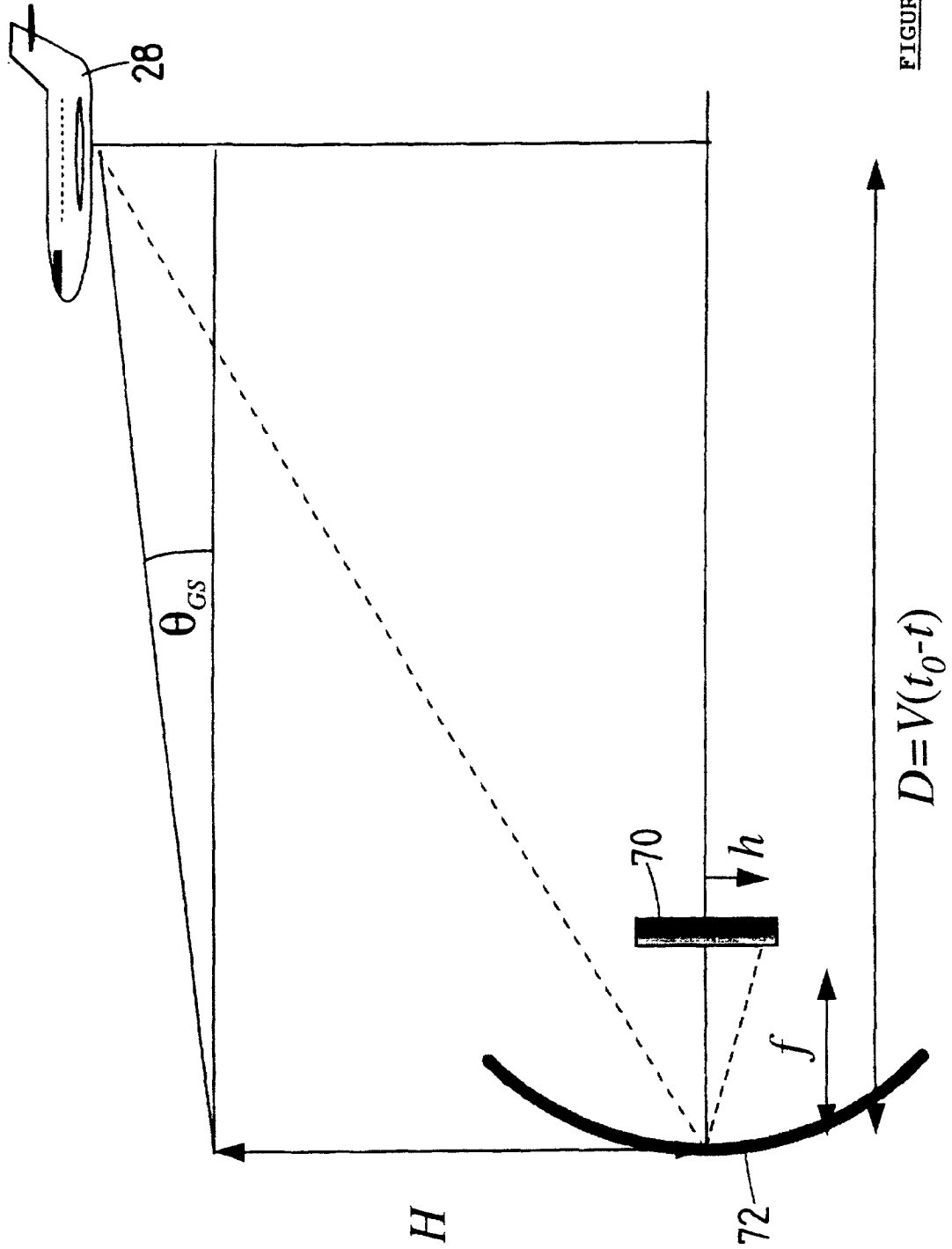
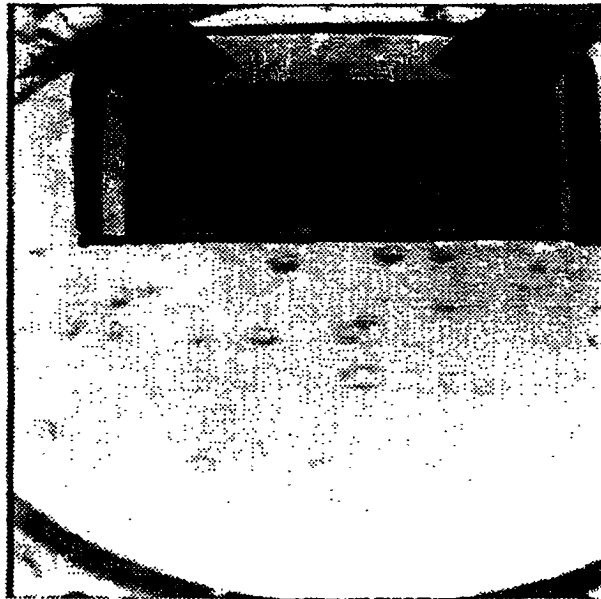
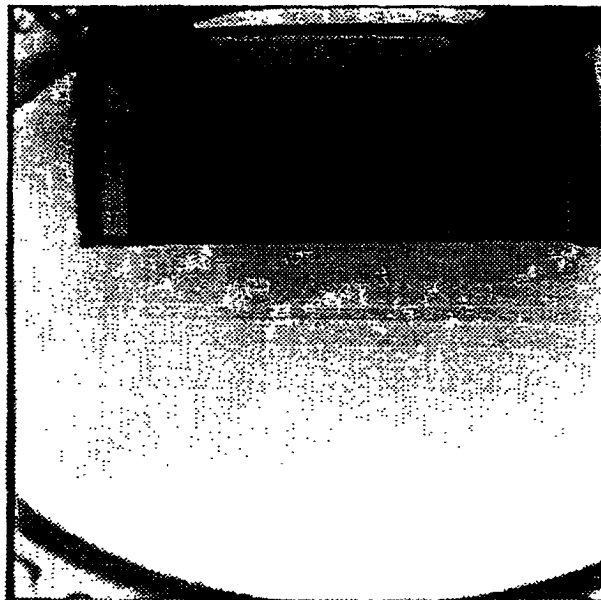


FIGURE 5



**Figure 6a**





**Figure 6b**

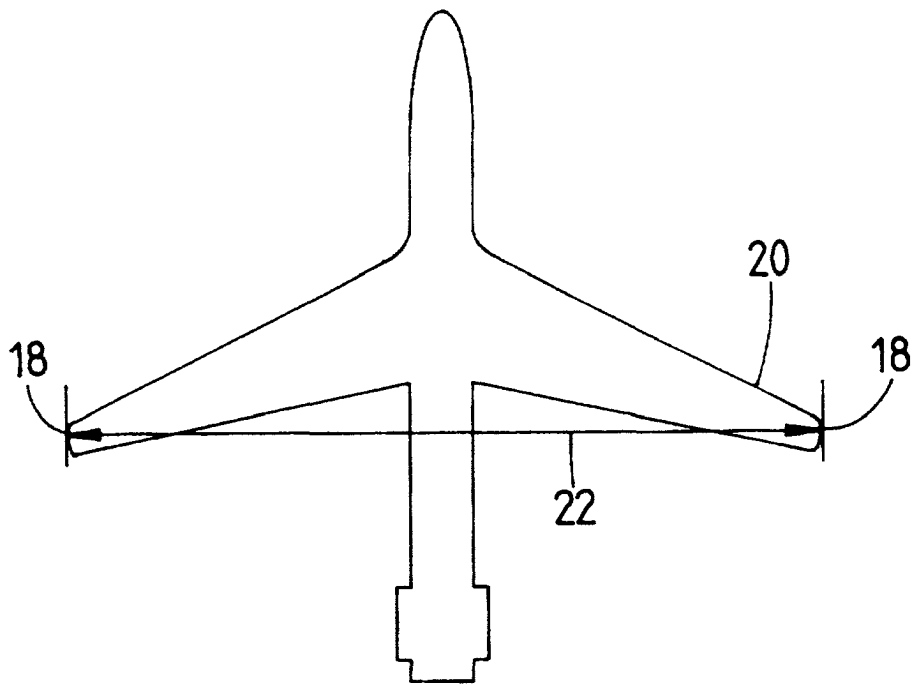
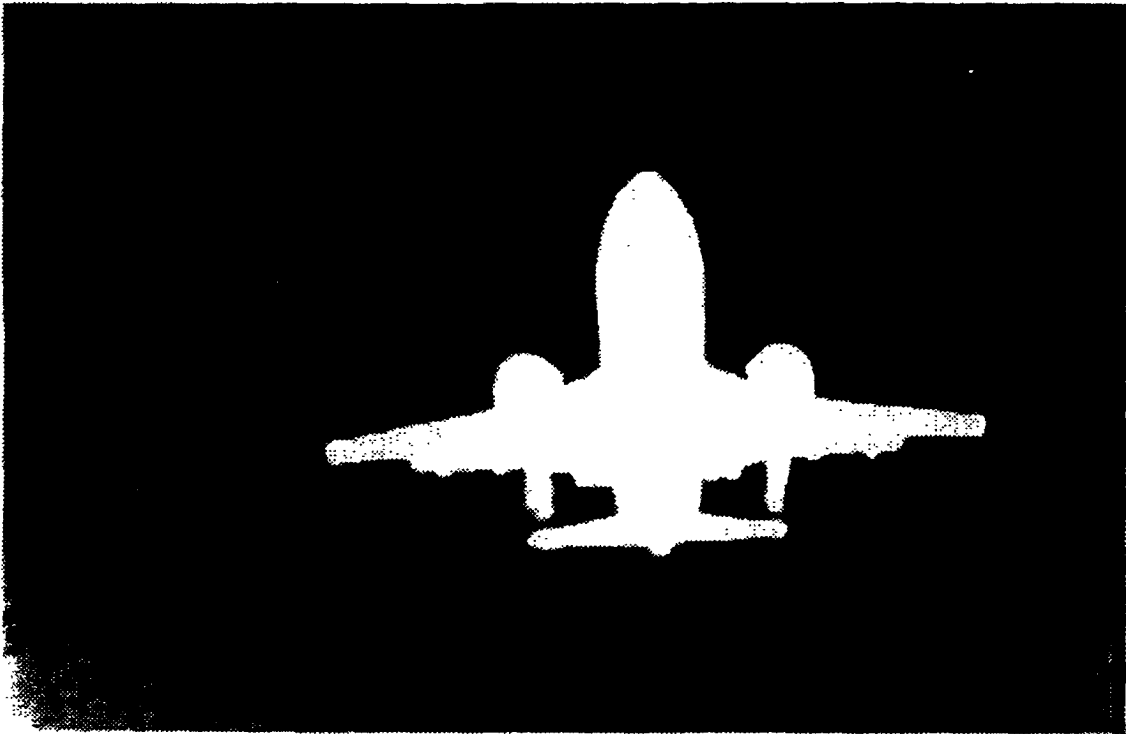


FIGURE 7

SUBSTITUTE SHEET (RULE 26)



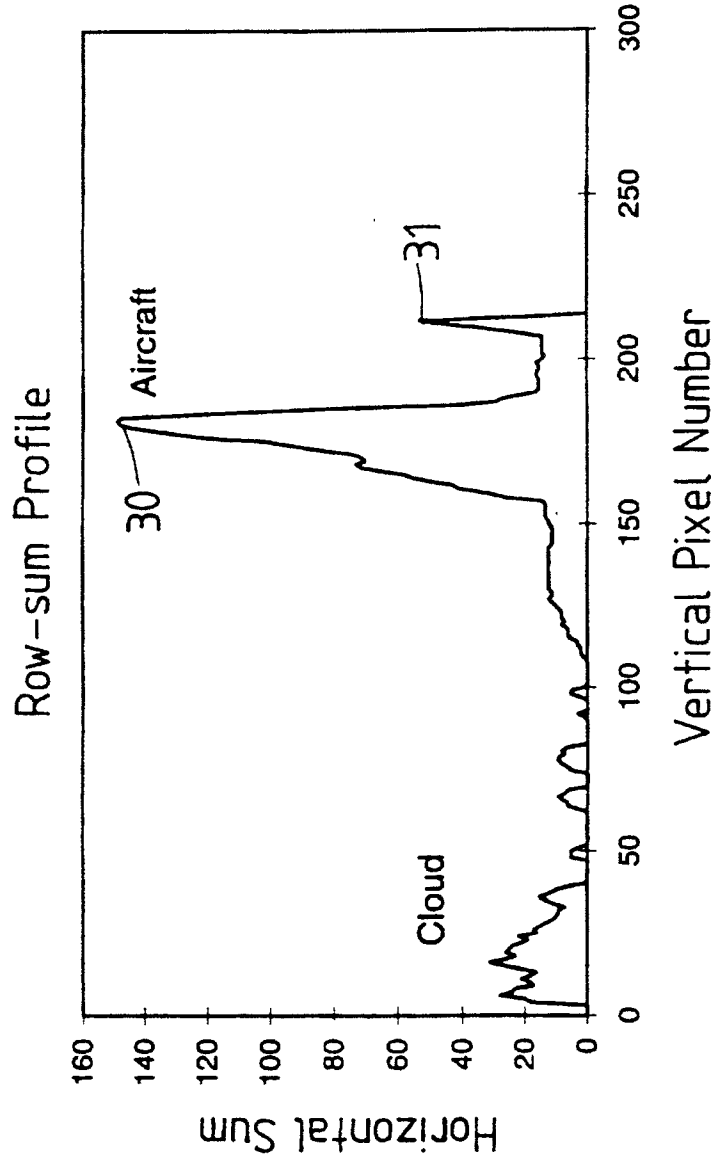
**Figure 8**

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**Figure 9**

FIGURE 10



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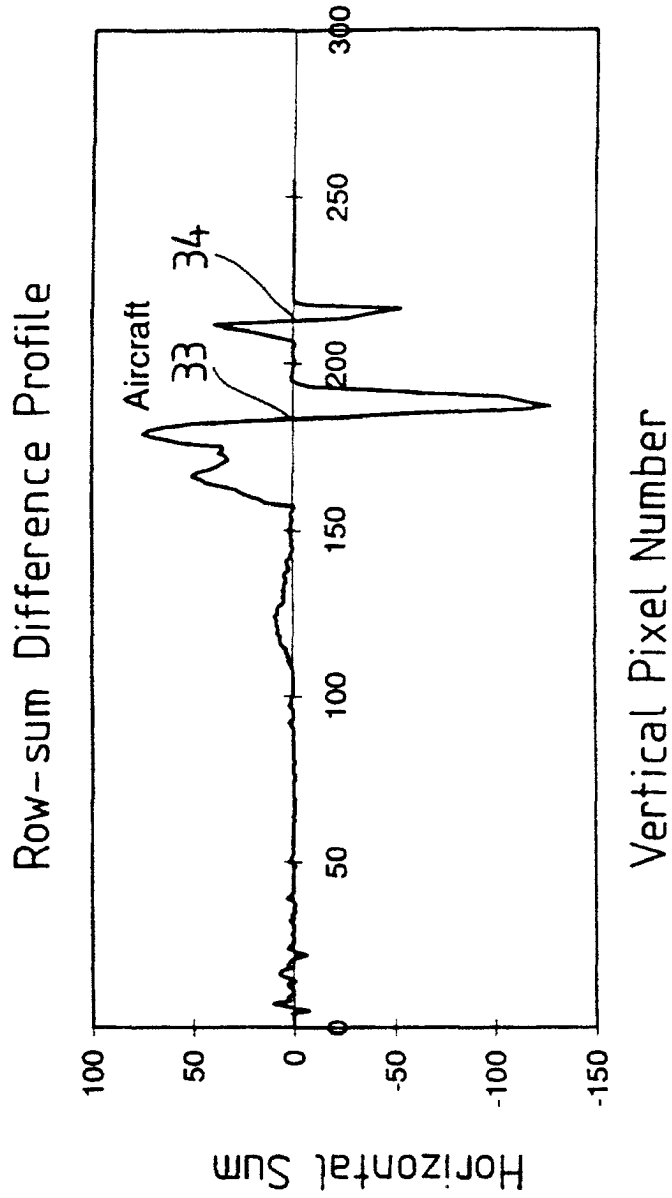


FIGURE 11

$(x, y, z)$

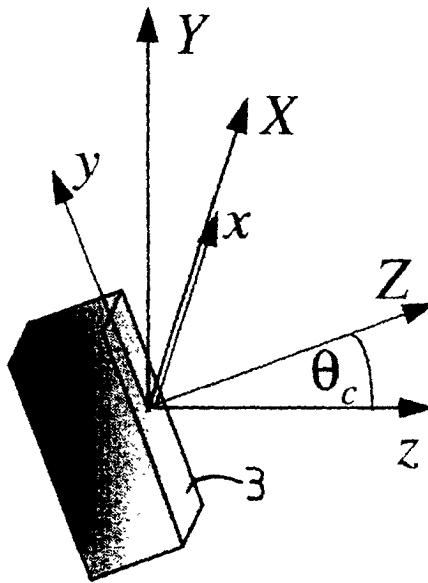


FIGURE 12

SUBSTITUTE SHEET (RULE 26)

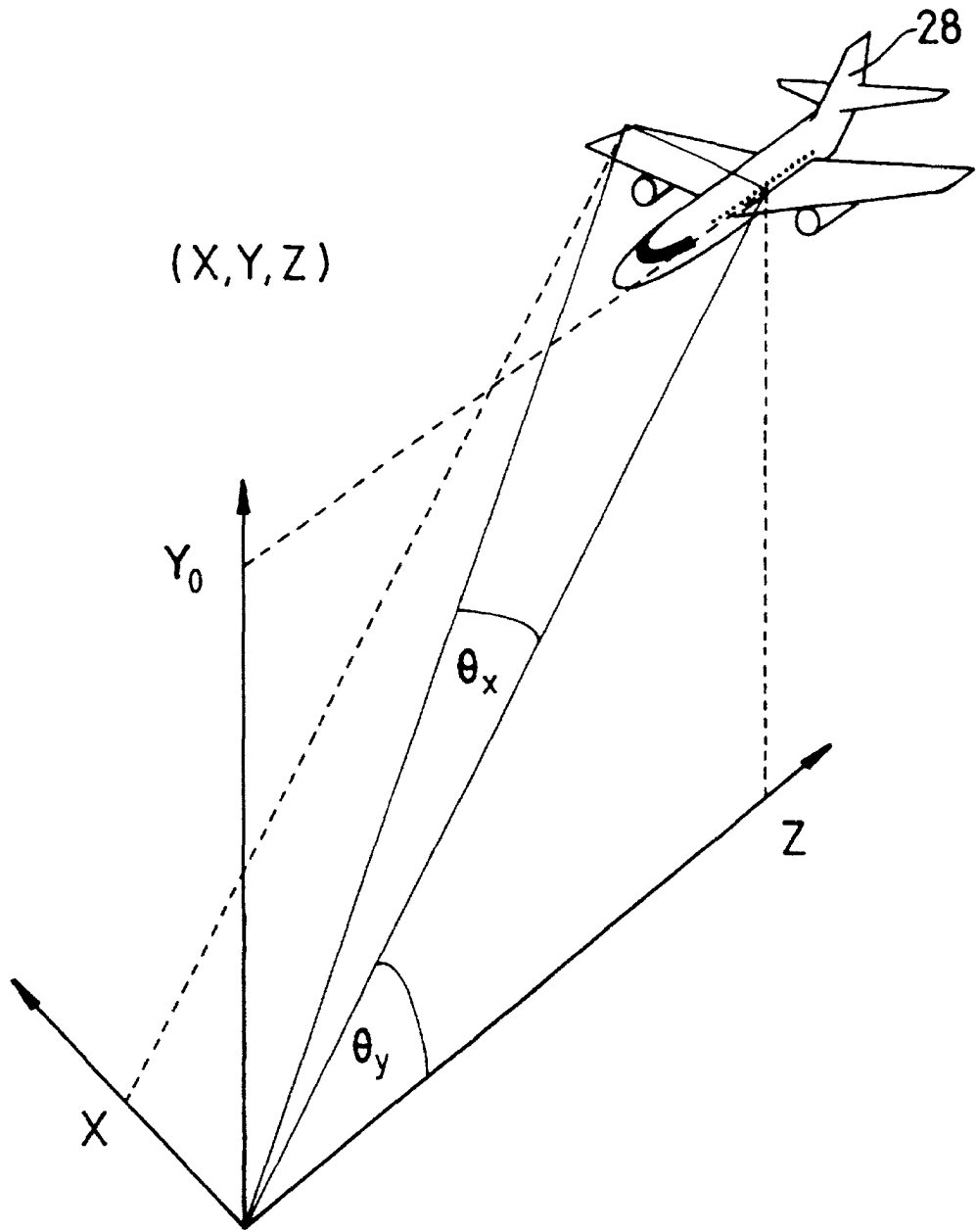


FIGURE 13

SUBSTITUTE SHEET (RULE 26)



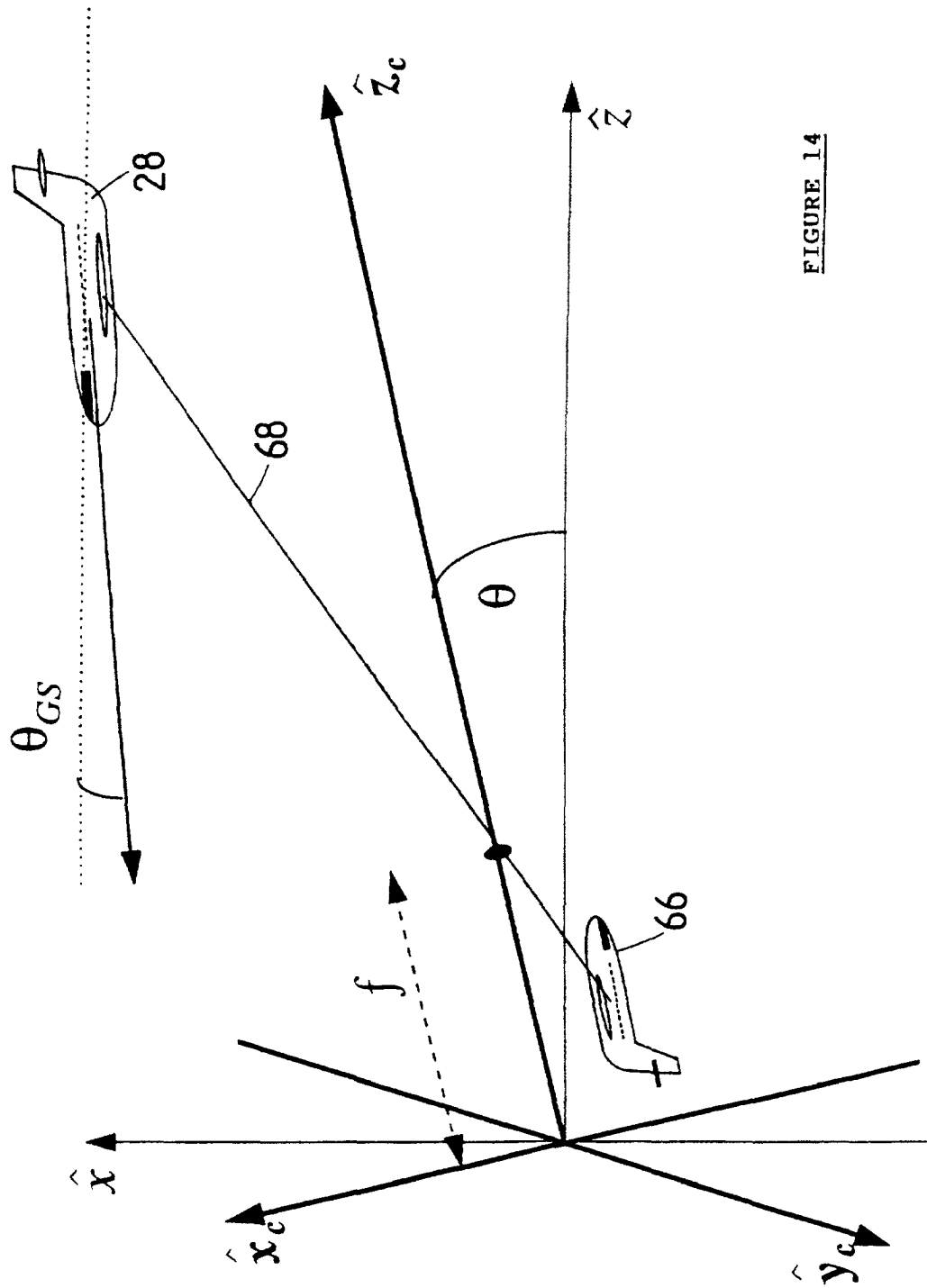
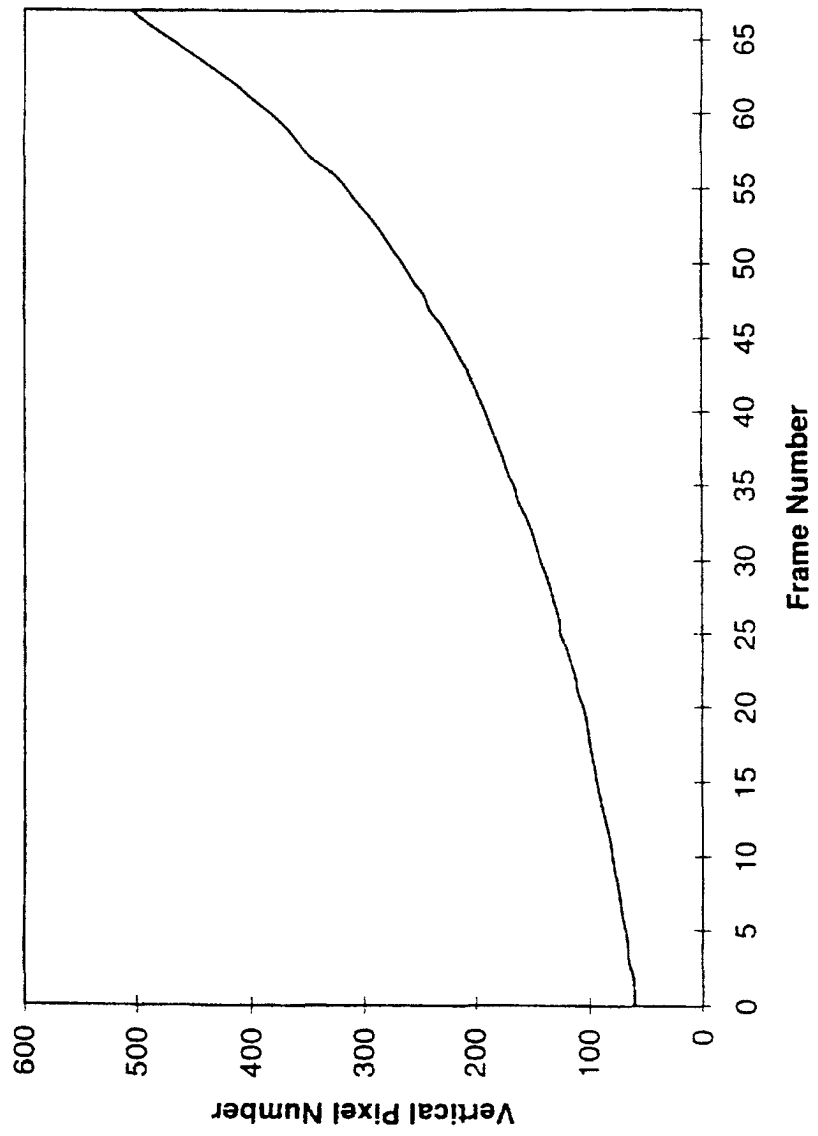


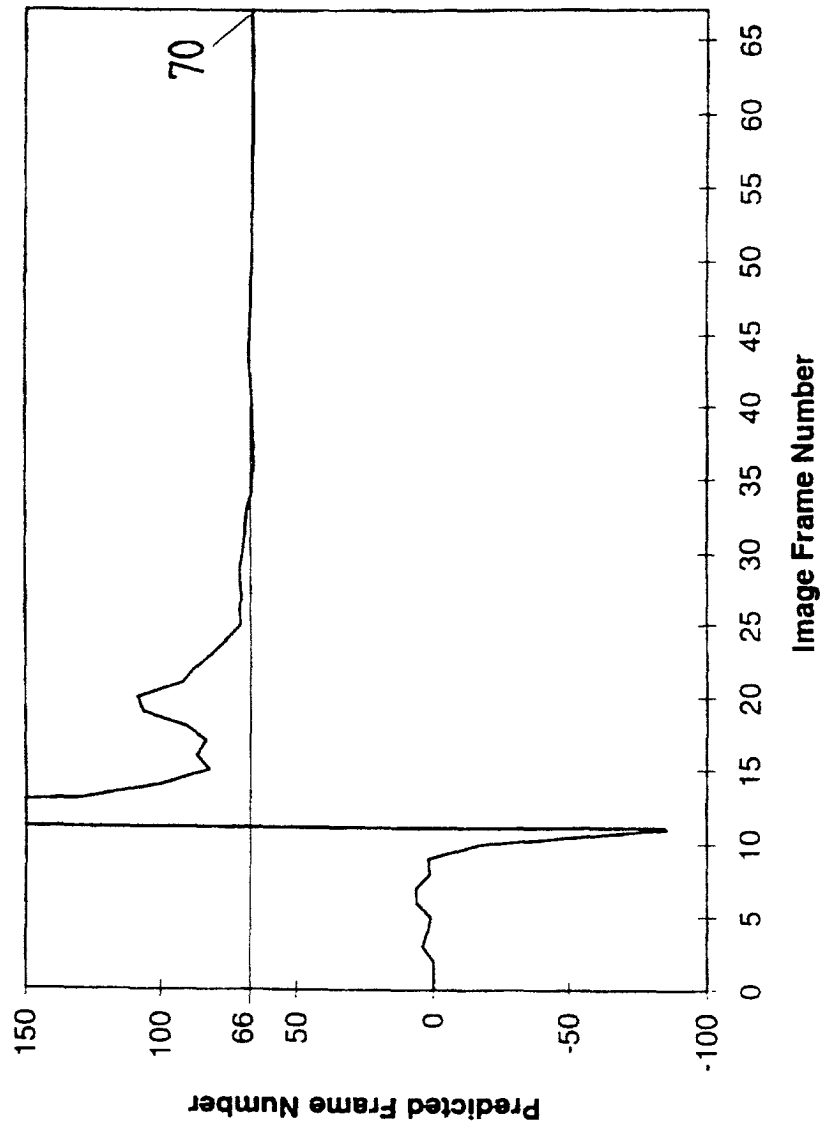
FIGURE 14

**Aircraft Image Position**



**FIGURE 15**

**Aircraft Location Prediction**



**FIGURE 16**

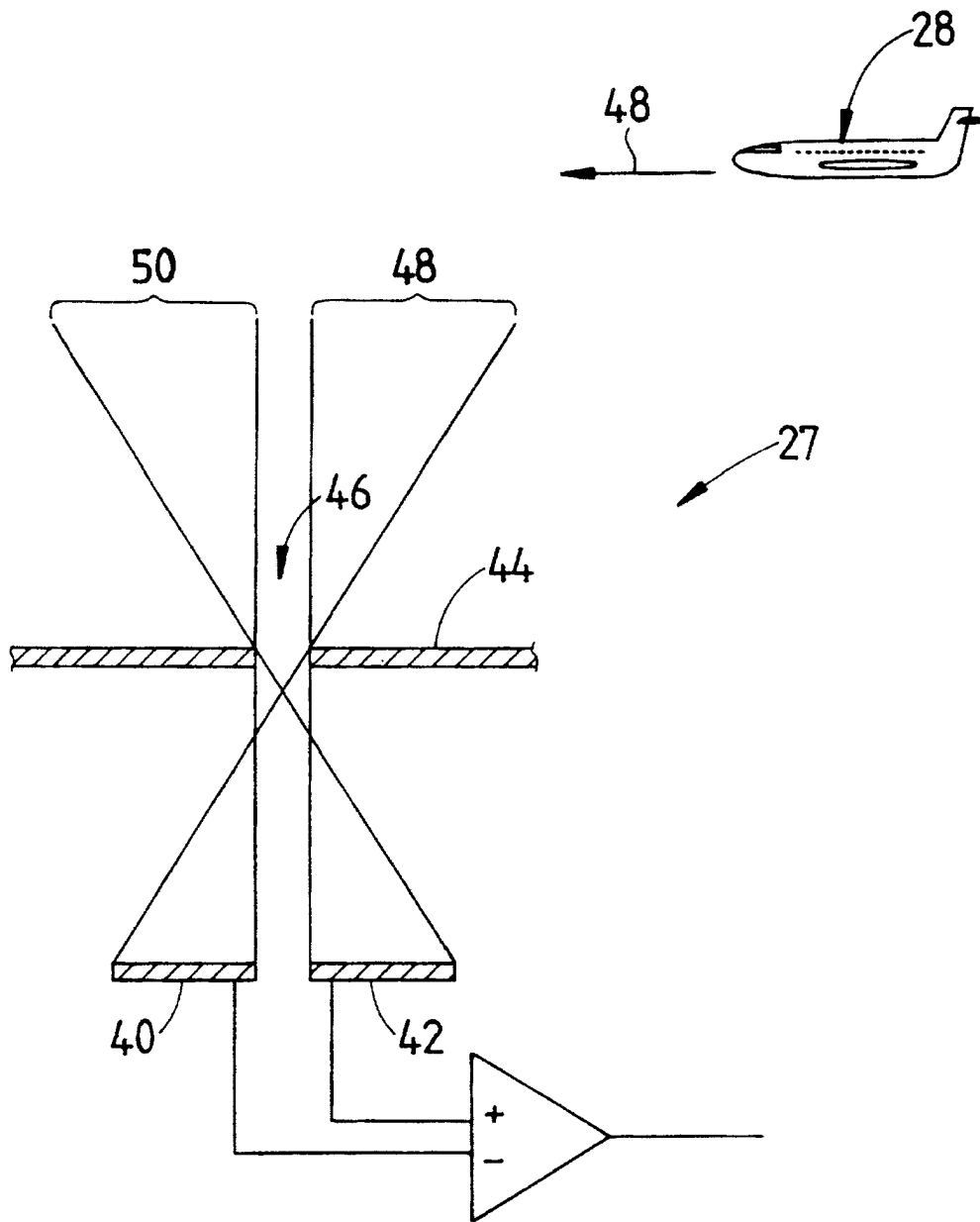


FIGURE 17

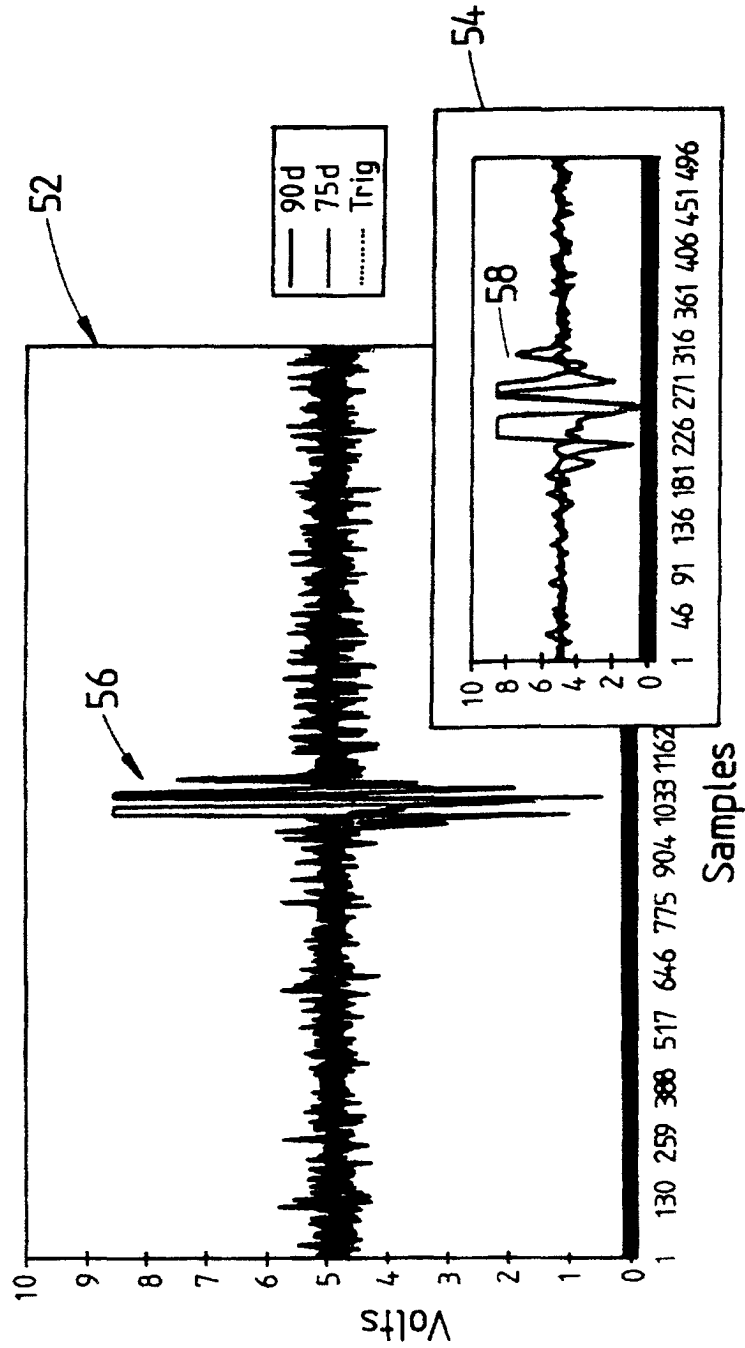
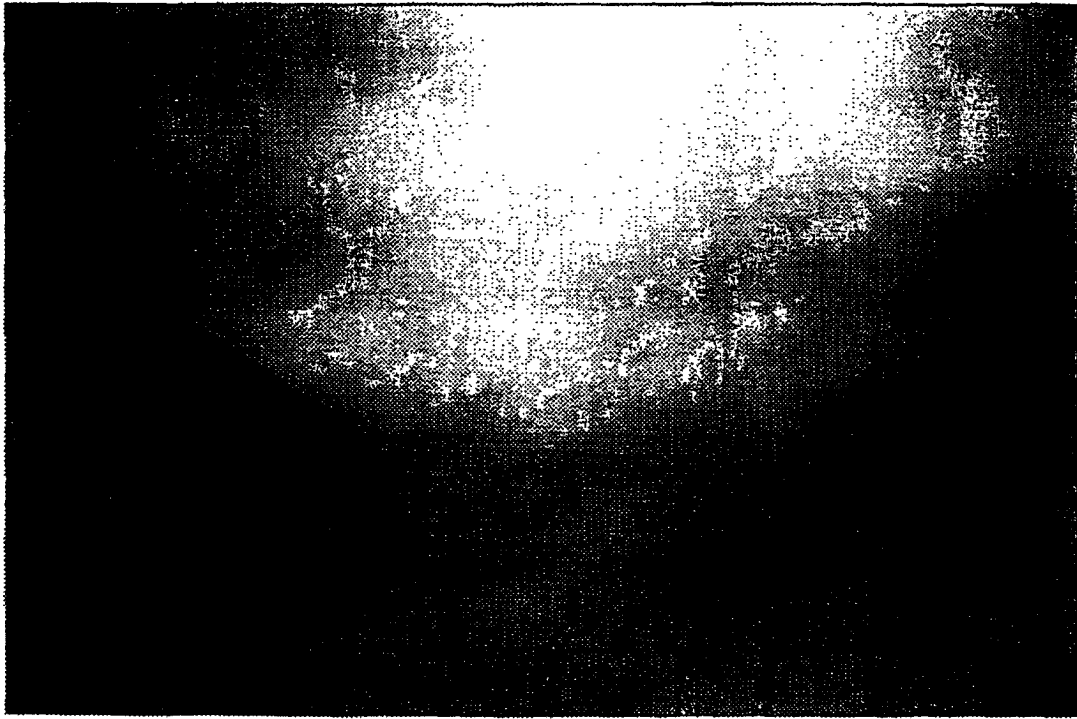


FIGURE 18



**Figure 19**

**SUBSTITUTE SHEET (RULE 26)**



**Figure 20**

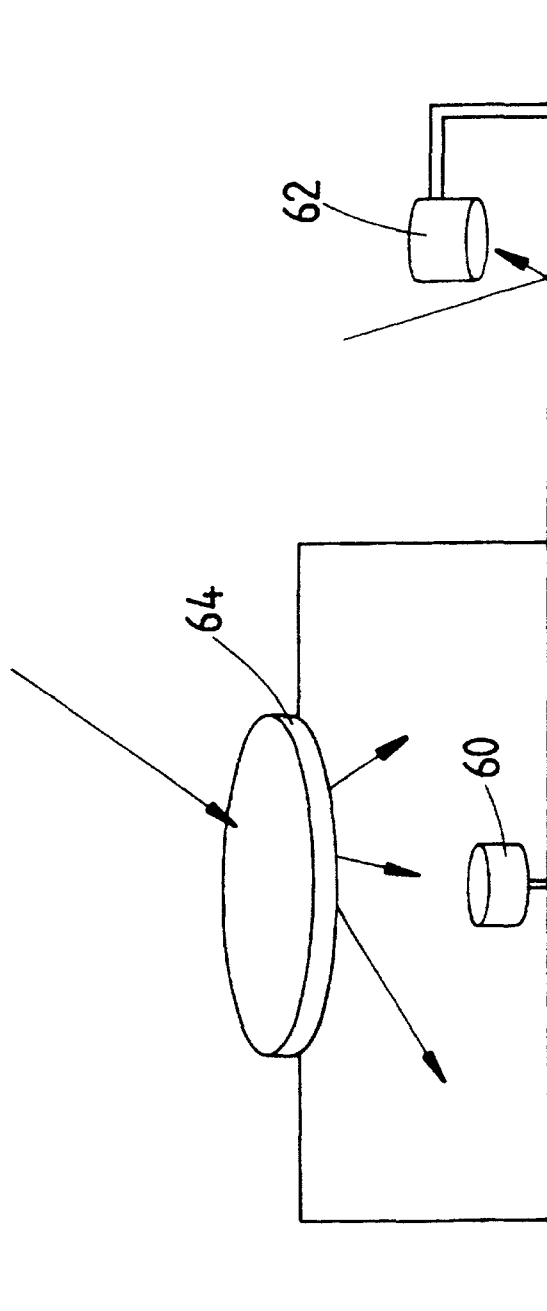


FIGURE 21



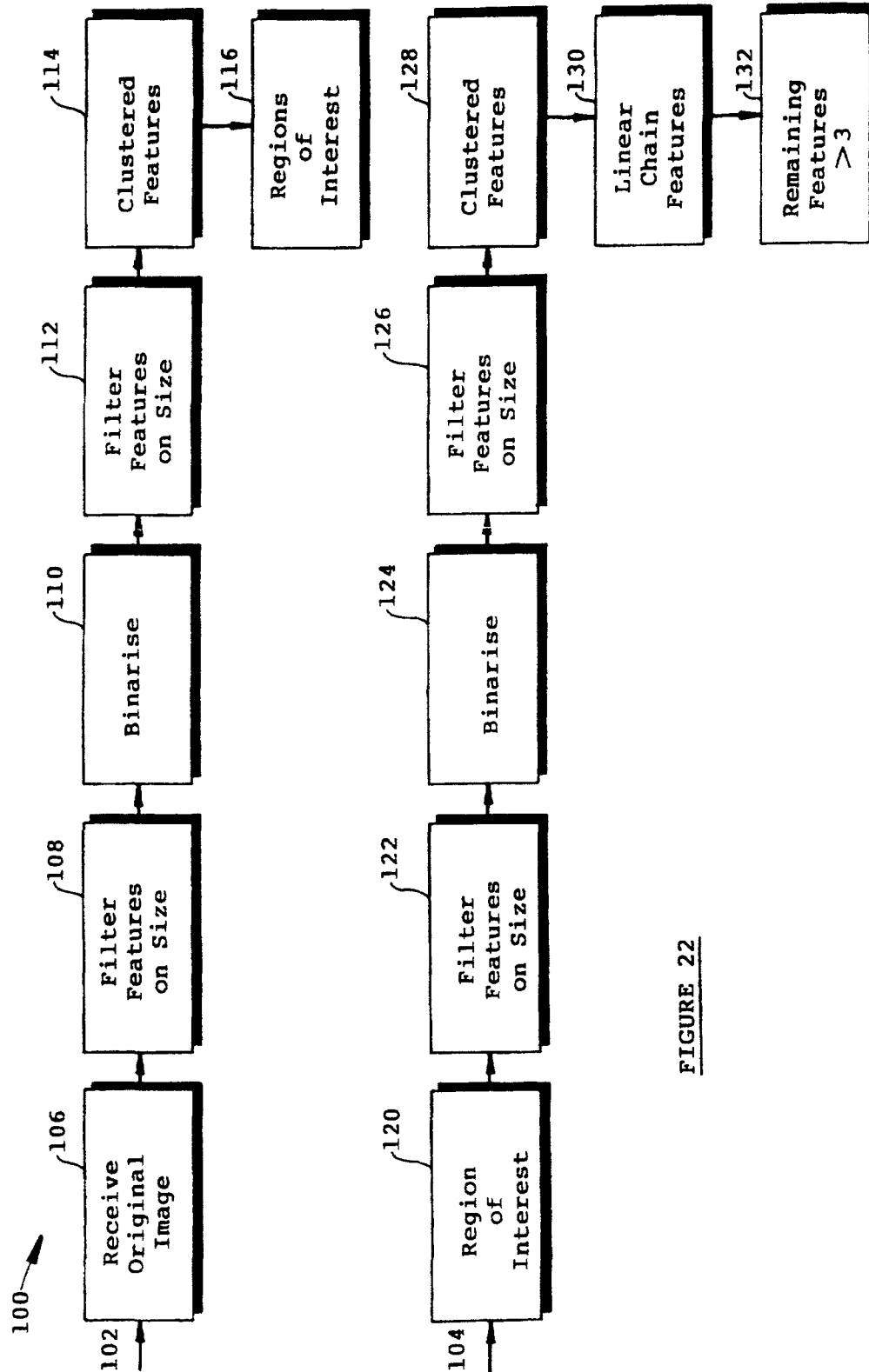
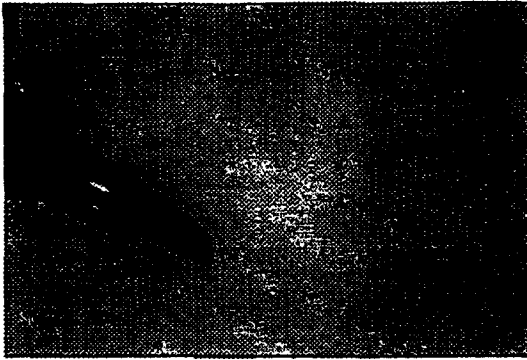


FIGURE 22

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105



109



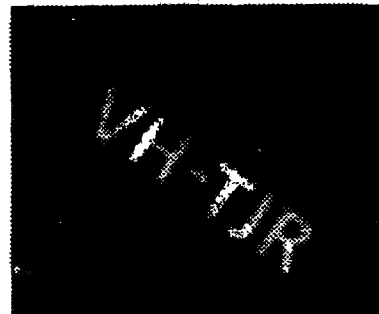
111



113



115



117



118



Figure 23

SUBSTITUTE SHEET (RULE 26)

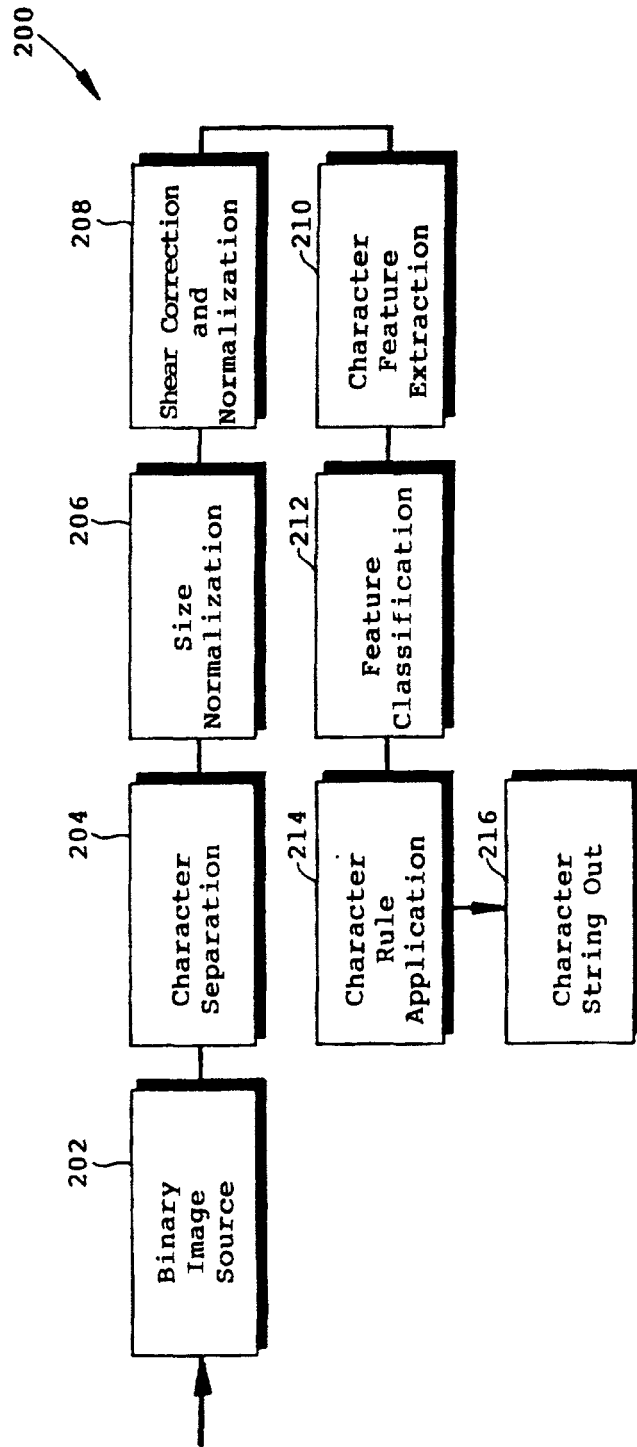


FIGURE 24

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int Cl <sup>6</sup> : G08G 5/00, G01P 3/38, G06T 7/20, G06K 9/78, 9/46		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC as above		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: IPC as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT, INSC (IMAG.; OBJECT.; DETECT.; POSITION.; MARK, ID:)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 686943- A2 (Matsushita Electric Industrial Co. Ltd.) 13 December 1995, whole document	1, 26, 9, 34
X	US 5,406,501 (U.S. Philips Corp.) 11 April 1995, whole document	1, 7, 9, 32, 34
X	WO 93/19441 (Commonwealth Scientific and Industrial Research Organisation) 30 September 1993 whole document	1-4, 16, 17, 19, 20 26-29, 41, 42, 44, 45
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 9 May 1997		Date of mailing of the international search report <b>21 MAY 1997</b>
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. (06) 285 3929		Authorized officer  Dale Siver Telephone No.: (06) 283 2196

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X Y	US 5,243,418 (K.K. Toshiba, Kawasaki) 7 September 1993, whole document	1, 26, 9, 34 10, 35
X Y	AU-35311/93-B (Iconix Pty Ltd) 8 July 1993, whole document especially page 21, lines 11-26	16, 41 21, 46
X	US 5, 134, 472 (K.K. Toshiba) 28 July 1992, whole document	1, 9, 26, 34
X Y	GB 2,227,589 A (Image Recognition Equipment Corp.) 1 August 1990 Abstract, Summary pages 1-4, Figures	16, 41 21, 46
X	WO 90/01706 (Hughes Aircraft Co.) 22 February 1990, whole document	1, 5, 6, 9, 10, 26, 30, 31, 34, 35
Y	WO 93/21617 (Traffic Technology Ltd.) 28 October 1993, whole document	1, 2, 26, 27
A	WO 96/12265 (Airport Technology in Scandinavia) 25 April 1996, Abstract Figures	5, 23, 26, 48

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos. .  
because they relate to subject matter not required to be searched by this Authority, namely
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. An object detection system using passive sensor to obtain a differential signature representative of the position of moving object. (No image acquisition or analysis ) Claims 1, 5-10, 26, 34, 35, 38.
  2. An image acquisition system and analysis system to locate a region in an image including markings identifying said object and processing said region to extract said markings for recognition. (No position or movement detection.) Claims 16-22, 41-47.
1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
  2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
  4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No.

**PCT/AU 97/00198**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
EP	686943	CA	2151079	JP	7336694	US	5606376
US	5406501	EP	492724	FR	2670978	JP	4307681
WO	9319441	AU	37402/93	EP	631683	JP	7505966
		NZ	249799				
US	5243418	JP	4192781	JP	5046771		
AU	35311/93	AU	37398/93	WO	9319429		
US	5134472	JP	2207381	JP	2214989		
GB	2227589	FR	2642542	JP	2282881	US	4958064
WO	9001706	AU	44005/89	CA	1313704	DE	68910498
		EP	380658	ES	2016049	IL	90898
		JP	3502018	NO	901560	TR	25266
		US	4937878				
WO	9321617	AU	39599/93	GB	2266398		
WO	9612265	AU	11251/95				

END OF ANNEX

12

**EUROPEAN PATENT APPLICATION**

21 Application number: 87300392.5

51 Int. Cl. 4: **G 08 B 13/18**

22 Date of filing: 16.01.87

30 Priority: 03.02.86 GB 8602575

43 Date of publication of application:  
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84 Designated Contracting States:  
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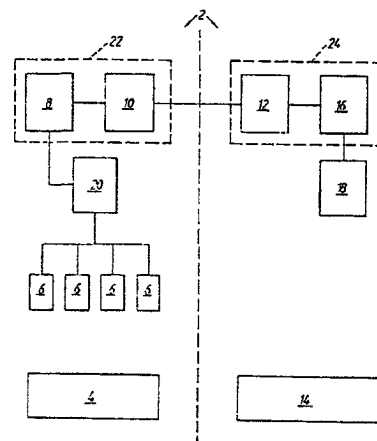
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54 **An aircraft surveillance system.**

57 An aircraft surveillance system (2) comprising an aircraft (4), at least one closed circuit slow scan television camera (6) which is positioned in the aircraft (4) and which is for surveying a predetermined area, first transducer means (8) which is positioned in the aircraft (4) and which is for converting video signals from the camera (6) into audio signals, first transceiver means (10) which is positioned in the aircraft (4) and which is for transmitting the audio signals from the first transducer means (8) and for receiving command signals, second transceiver means (12) which is positioned in a command base (14) remote from the aircraft (4) and which is for receiving the audio signals from the first transceiver means (10) and for sending the command signals, second transducer means (16) which is positioned in the command base (14) and which is for converting the audio signals received from the second transceiver means (12) into video signals, and at least one television monitor (18) for providing a visual display consequent upon receiving the video signals from the second transducer means (16).



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