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Geshwind et al.

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[54] **METHOD TO CONVERT TWO DIMENSIONAL MOTION PICTURES FOR THREE-DIMENSIONAL SYSTEMS**

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[51] **Int. Cl.**[5] **G03B 35/14**

[52] **U.S. Cl.** **352/57**; 352/86; 355/40

[58] **Field of Search** 355/40, 52, 77; 352/43, 352/57, 85, 86, 129; 358/88, 89, 22, 81, 160

[56] **References Cited**

U.S. PATENT DOCUMENTS

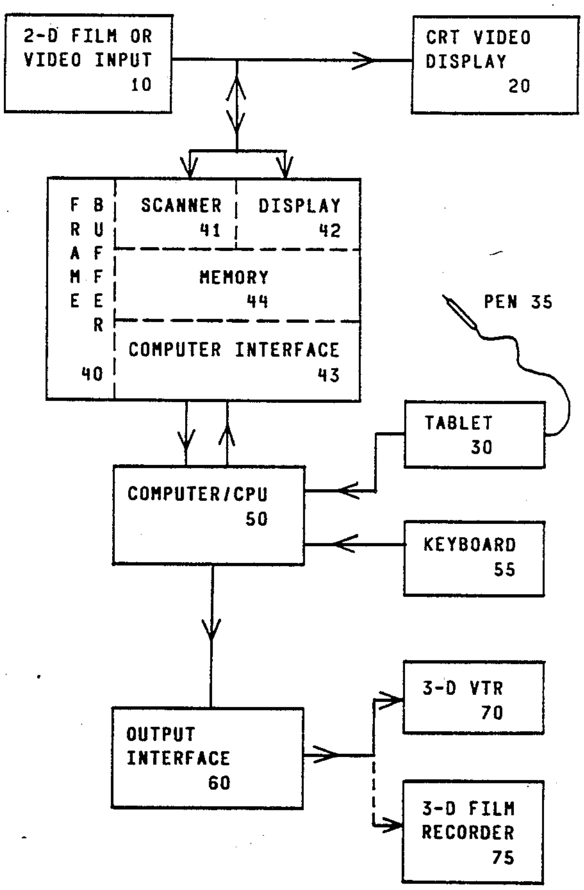
3,772,465	11/1973	Vlahos et al.	355/40
3,824,336	7/1974	Gould et al.	355/52
4,606,625	8/1986	Geswind	352/85 X
4,809,065	2/1989	Harris et al.	358/88

Primary Examiner—L. T. Hix
Assistant Examiner—D. Rutledge

[57] **ABSTRACT**

The present invention relates to the computer-assisted processing of standard two-dimensional motion pictures to generate processed image sequences which exhibit some three-dimensional depth effects when viewed under appropriate conditions.

44 Claims, 2 Drawing Sheets



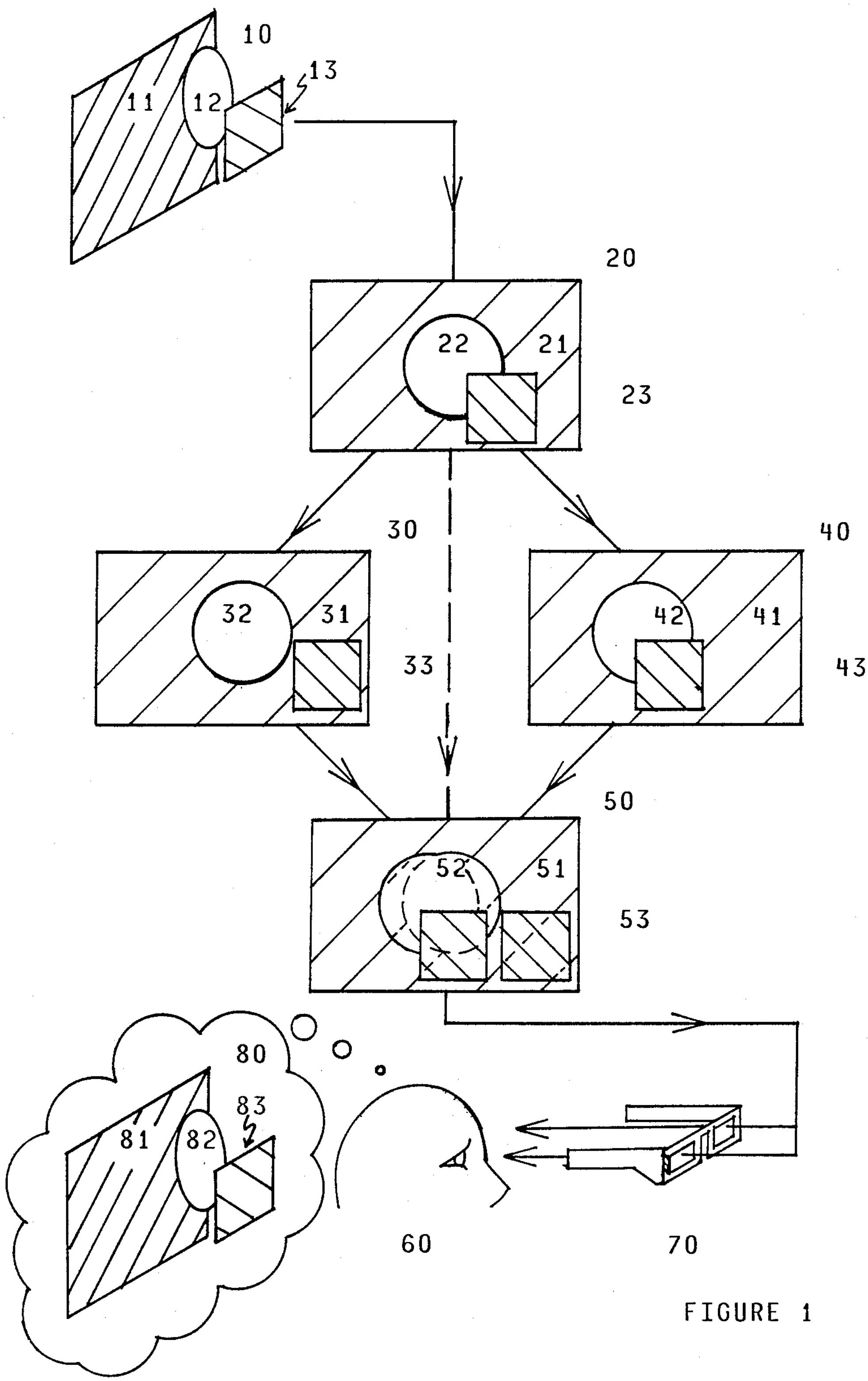

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FIGURE 1

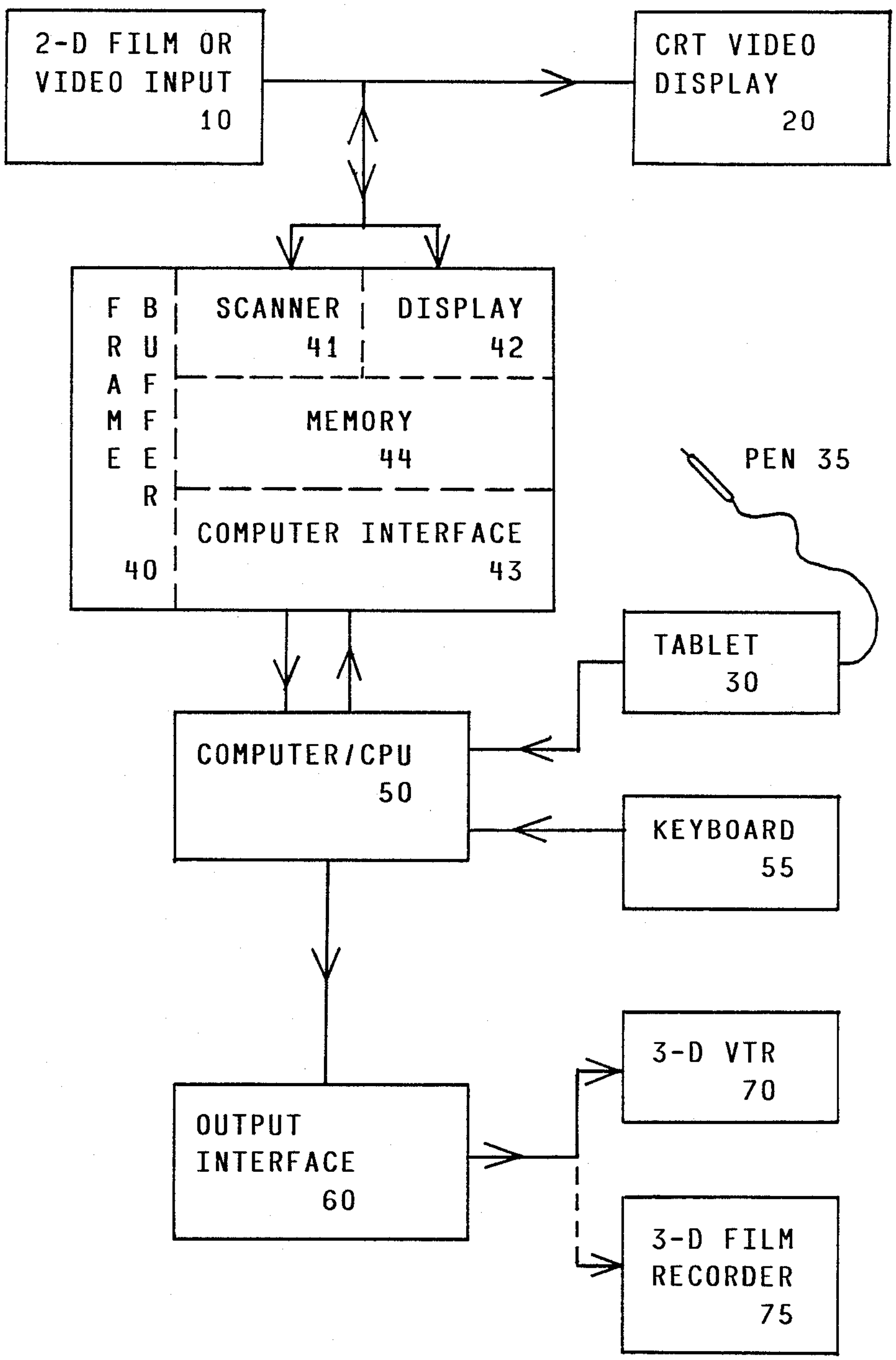
2-D FILM OR
VIDEO INPUT
10
CRT VIDEO
DISPLAY
20
FRAME BUFFER
40
SCANNER
41
DISPLAY
42
MEMORY
44
COMPUTER INTERFACE
43
PEN 35
TABLET
30
COMPUTER/CPU
50
KEYBOARD
55
OUTPUT
INTERFACE
60
3-D VTR
70
3-D FILM
RECORDER
75

FIGURE 2

METHOD TO CONVERT TWO DIMENSIONAL MOTION PICTURES FOR THREE-DIMENSIONAL SYSTEMS

TECHNICAL FIELD

The invention relates to a method for converting existing film or videotape motion pictures to a form that can be used with three-dimensional systems for broadcast or exhibition.

BACKGROUND ART

With the advent of stereophonic sound, various techniques were developed to convert or 're-process' existing monophonic programs for stereophonic broadcast or recording systems. These included modifying the equalization phase or tonal qualities of separate copies of the monophonic program for the left and right channels. While true stereophonic or binaural effects may not have been achieved, the effects were much improved over feeding the identical monophonic signal to both channels.

Similarly, with the almost universal use of color production, exhibition and broadcast systems for motion pictures and television, systems have been developed to convert existing monochrome or black and white materials to color programs. Such a systems is described in applicant Geshwind's Pat. No. 4,606,625, issued Aug. 19, 1986. The results of these colorized products, while not always identical to true color motion pictures, are more suitable than black and white for color systems.

There have been a number of systems for exhibition or display of left- and right-eye pairs of binocular motion pictures. Early systems required two completely redundant projection or display systems; e.g. two film projectors or CRT television displays, each routed to one eye via mirrors. Other systems require either complicated and expensive projection or display systems, or expensive 'glasses' to deliver two separate images. For example:

- red- and green-tinted monochrome images are both projected or displayed to be viewed through glasses with left and right lenses tinted either red or green;
- two full-color images are projected through mutually perpendicular polarized filters and viewed through glasses with lenses that are also polarized in the same manner;
- left and right images are displayed on alternate odd and even fields (or frames) of a standard (or high scan rate) television CRT and are viewed through 'glasses' with shutters (either rotating blades or flickering LCDs, for example) that alternate the view of left and right eyes in synchrony with the odd or even fields of the CRT.

Of the above systems, the second is not at all usable with standard home television receivers, the third requires very expensive 'glasses' and may flicker with standard home receivers, and the first produces only strangely tinted monochrome images. Further, none of the systems may be broadcast over standard television for unimpeded viewing without special glasses.

Thus, until now, compatible (i.e., viewable as two-dimensional, without glasses) home reception of b 3-D images was not possible. However, a new system, which takes advantage of differential processing of left- and right-eye images in the human perceptual system, delivers a composite image on a standard home television receiver that can be viewed as a normal 2-D picture without glasses. Very inexpensive glasses, with one light and one dark lens, accentuate the differential processing of the image, as viewed by each eye, to produce a 3-D depth effect.

Practical, inexpensive, compatible (with standard TV) 3-D television may now become widespread. In addition to materials specifically produced for the new system (or other 3-D systems) conversion of standard 2-D programs to 3-D format would provide additional product to broadcast using the new compatible system (or for other 3-D projection systems).

SUMMARY OF THE INVENTION

Applicant Handal's previous application, No. 479,679, filed Mar. 28, 1983 and now abandoned, relates a process and apparatus for deriving left- and right-eye pairs of binocular images, from certain types of two dimensional film materials. In particular, the materials must consist of separate foreground and background elements, such as cartoon animation cells and background art. By taking into account the parallax between scenes as viewed by the left and right eyes, two images are prepared where foreground elements are shifted with respect to background elements by an amount that indicates their depth in the third dimension. Two-dimensional motion pictures that consist of a series of single composite images could not be converted to three-dimensional format, by this technique, without first being separated into various background and foreground elements.

Once committed to two-dimensional motion pictures, the separation and depth information for various scene elements, in the third dimension, are lost. Thus, the separation of two-dimensional image sequences into individual image elements and the generation of three-dimensional depth information for each such image element are not simple or trivial tasks, and are the further subject of the instant invention.

In accordance with the invention, standard two-dimensional motion picture film or videotape may be converted or processed, for use with three-dimensional exhibition or transmission systems, so as to exhibit at least some three-dimensional or depth characteristics. Separation of a single 2-D image stream into diverse elements is accomplished by a computer assisted, human operated system. (If working from discrete 2-D film sub-components, such as animation elements, the separation step may be omitted.) Depth information is assigned to various elements by a combination of human decisions and/or computer analyses and resulting images of three-dimensional format are produced under computer control.

BRIEF DESCRIPTION OF DRAWINGS

A method for carrying out the invention is described in the accompanying drawings in which:

FIG. 1 is a diagram illustrating the relationship of a 2-D source film image, left and right image pairs, and a composite 3-D image frame.

FIG. 2 is a schematic diagram of a system for carrying out an implementation of the present invention.

DETAILED DESCRIPTION

An immense amount of standard, 2-D motion picture material exists in the form of film and videotape. In addition, certain materials exist in the form of discrete

2-D image sub-components, such as animated cell and background paintings. As the use of 3-D exhibition and broadcast systems becomes more widespread, the conversion of existing 2-D programs to a format that will exhibit at least some 3-D or depth effects, when used with 3-D systems, is desired.

Extracting individual image elements or 3-D depth information from a 2-D film frame, or synthesizing 3-D information for those elements, entirely by computer equipped with artificial intelligence, is not now practical. Therefore, the embodiment of the invention as described herein employs a high degree of human interaction with the computer. However, as artificial intelligence progresses, a predominantly or completely automated system may become practical and is within the intended scope of the invention.

FIG. **1** shows a frame **20** of a standard 2-D film of video motion picture, consisting of a cross-hatched background plane **21**, a large white circle **22** in the mid-ground, and a small black square **23** in the foreground. It is a 2-D representation of original 3-D scene **10** comprising elements **11**, **12** and **13**, which is not available for direct 3-D photography. After human identification of individual image elements and depth assignment, the computer generates, from frame **10**, a pair of coordinated left **30** and right **40** images with backgrounds **31** and **41**, circles **32** and **42**, and squares **33** and **43** respectively. Note that the relative positions of the square and circle are different in the left and right images; this situation is similar to the parallax that might result between left- and right-eye views if one were to have viewed the original scene **10** directly. Three-dimensional format frame **50** is generated by encoding the information in the left **30** and right **40** image pair, in a manner consistent with any one of a number of existing 3-D systems. The specific operation of these various 3-D systems is not the subject of the instant invention.

Alternately, the steps of generating and encoding 3-D information may be combined such that 3-D format frame **50** may be processed directly from 2-D frame **20** without generating left **30** and right **40** image pairs. In either case, 3-D format frame **50** when viewed by human **60** through 3-D glasses **70** is perceived as 3-D scene **80**, containing elements **81**, **82** and **83**, which has at least some of the 3-D characteristics of original 3-D scene **10**.

Various systems for the encoding, display, projection, recording, transmission or viewing of 3-D images exist, and new systems may be developed. Specifically, various techniques for specifying, encoding and viewing 3-D information may now, or come to, exist, which do not make use of parallax offset and/or left and right image pairs and/or viewing glasses, or which embody new techniques or changes and improvements to current systems. Further, such systems may integrate information from more than one 2-D source frame **20** into a single resultant 3-D frame **50**. The specifics of operation of such systems is not the subject of the instant invention, however, preparation of 2-D program material for such systems is.

The offsets shown for elements **31**, **32** and **33** in left frame **30** and elements **41**, **42** and **43** in right frame **40** are meant to be illustrative and do not necessarily follow the correct rules for image parallax. In fact, depending upon where viewer attention is meant to be centered, different rules may apply. For example, one technique is to give no parallax offset to far background elements and to give progressively more parallax offset to objects as they get closer. Alternately, attention may be centered in the mid-ground with no parallax offset to mid-range objects, some parallax offset to close-range objects and reverse parallax offset to far-range objects. The particular placement of objects and attention point in the 3-D scene is as much an art as a science and is critical to the enjoyment of 3-D programs and, in any event, is not meant to be the subject of this invention.

FIG. **2** shows a schematic of a system to implement the instant invention. A 2-D film or video image **10** is input to a video monitor **20** and to the scanning portion **41** of frame buffer **40**. Video monitor **20** is capable of displaying either the 2-D image being input **10** or the output from display portion **42** of frame buffer **40**.

Frame buffer **40** consists of an image scanner **41** which can convert the input image into digital form to be stored in a portion of frame buffer memory section **44**, a display section **42** which creates a video image from the contents of a portion of memory section **44**, and a computer interface section **43** which allows the computer CPU **50** to read from and write to the memory section **44**.

Graphic input tablet **30** and stylus **35** allow the human operator to input position information to the computer **50** which can indicate the outline of individual image elements, choice of a specific image element or part of an image element, depth specification, choice of one of a number of functions offered on a 'menu', or other information. An image cursor can be displayed on monitor **20** by frame buffer **40** to visually indicate the location or status of the input from the tablet **30** and pen **35**. Text and numeric information can also be input by the operator on keyboard **55**.

Computer CPU **50** is equipped with software which allows it to interpret the commands and input from the human operator, and to process the digitized 2-D information input from 2-D frame **10** into digital 3-D frame information, based on said human commands and input. Said digital 3-D frame information is then output by output interface **60** (which may be similar to frame buffer **40** or of some other design) to a videotape recorder **70** or to a film recorder **75**, capable of recording 3-D format frames.

The system as described above operates as follows. A frame of the 2-D program is displayed on the video monitor for viewing by the human operator. With the tablet and stylus the operator outlines various 2-D image areas to indicate to the computer the boundaries of various image elements to be separately processed. (For materials, such as animation components, that already exist as separate elements, the previous stage of the process may be skipped.) Depth position information, in the third dimension, is determined for each image element, by a combination of operator input and computer analysis. Left and right image pairs or a 3-D composite image is processed by the computer, from the 2-D input image, based on the computer software and operator instructions. Depending upon the particular 3-D system to be used, left- and right-image pairs may or may not be the final stage or an intermediate stage or bypassed entirely. Further, for some 3-D systems, information from more than one 2-D source frame may be combined into one 3-D frame (or frame pair). In any event, the final 3-D information is then collected on a videotape or film recorder. The process is then repeated for additional 2-D frames.

Each image element may be given a uniform depth designation which may cause the perception of 'card-

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