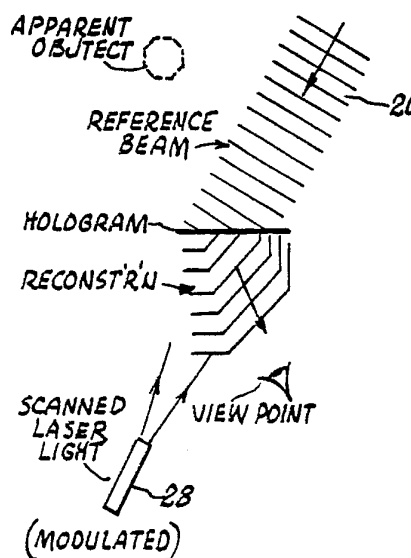




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁴ : G03H 1/08, H04N 13/00	A1	(11) International Publication Number: WO 87/ 07737 (43) International Publication Date: 17 December 1987 (17.12.87)
(21) International Application Number: PCT/US87/01369 (22) International Filing Date: 10 June 1987 (10.06.87) (31) Priority Application Number: 873,383 (32) Priority Date: 12 June 1986 (12.06.86) (33) Priority Country: US (71)(72) Applicant and Inventor: WAITS, Gregory, D. [US/US]; 203 S. Anaheim Blvd., Anaheim, CA 92805 (US). (74) Agent: BRANSCOMB, Ralph, S.; 1200 Third Avenue, Suite 1200, San Diego, CA 92101 (US). (81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent).		Published <i>With international search report.</i>

(54) Title: COMPUTER DRIVEN MOVING HOLOGRAM



(57) Abstract

A means and method for creating a moving hologram from a computer-driven scanning laser (28) which irradiates a photoactive surface on a transparent plate to create successive interference patterns corresponding to the successive frames of a holographic "movie". The plate is illuminated by a reconstruction beam (20) while the scanning beam creates the interference patterns so that a continuous holographic movie is created in real time.

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DescriptionComputer Driven Moving HologramBackground of the Invention

5 From its inception in the early 1960's,
holographic technology, utilizing developing laser
technology, has become more and more sophisticated. This
sophistication has led to the creation of clearer
holographic images, color holograms, and holographic
cylinders which permit the viewing of an imaginary object
10 in the center of the cylinder from 360 degrees. Some types
of holographic cylinders also cause the imagined image to
change color as one moves vertically above and below the
imaginary image.

15 According to present holographic techniques, the
holographic plate, or hologram, is created by an
interference pattern impacting a photographic plate. High
quality photographic plates of various high resolution are
required because the interference fringes created in the
hologram will only be separated by spaces on the order of
20 one-half to one wavelength of the light that will be used
from the reconstruction beam to create the holographic
image, when the hologram is being viewed.

25 The direct analog creation of the hologram has
been effected to create still images. As the technology
developed in holography in the 1960's to the late 1970's,
the incorporation of computer technology with holographic
creation was not practical because the speed, mass memory,
and random access memory capabilities of computers had not

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snowballed in their development as they have in the few years since about 1978.

5 However, with the enormous processing speed now possible in microcomputers, and with random access memories in excess of a megabyte and mass storage available in increments of 10 megabytes, the situation has substantially changed.

Disclosure of Invention

10 The instant invention takes advantage of the extremely high speed and enormous memory and processing capabilities of microcomputers and larger computers to create a moving hologram which is either generated from software, or which is derived from mass storage from pre-entered data, to continuously create an interference
15 pattern, which changes frame by frame sequentially, to produce a "moving picture" hologram in real time as the computer drives a laser:

20 At the heart of the invention is a sheet of material over a plate glass or other transparent plate, or over a reflective surface, which is photoactive to darken upon being illuminated by radiation, much as from a laser, at a particular point upon the sheet.

25 The computer data base, or the data from the software, which is operating the computer, scans the laser across the photoactive sheet or surface coating, modulating it as it is scanned, so that an interference pattern is created. The properties of the photoactive sheet are such that the pattern will maintain for a period of time, and then will fade away. This period is synchronized with the

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scanning time of the laser, so that new frames of the interference pattern, corresponding to new frames of the holographically reconstructed image, are repeatedly scanned on the photoactive sheet.

5 Although it is possible that the scanning could be at the same speed as a motion picture, which is a minimum of 16 times per second, a much slower scanning speed would still give the impression of movement, albeit somewhat jerky.

10 The computer which drives the scanning laser may operate on software which generates the data necessary for the scanning of the interference pattern based on some other kind of human input. Alternatively, the computer may interface with a digitizer which inputs the interference
15 pattern in analog fashion by having the digitizer image plate positioned where the photographic plate is ordinarily positioned in a conventional hologram-producing set-up. The object subject to the input into the computer data base could be successively moved into different positions, with
20 successive digitized inputs being made into the computer data base with each change in position. In this fashion, of course, the movement through which the object of the hologram is made would be re-created when the computer "plays back" its data base to produce the interference
25 fringes which in turn produce the moving holographic image as the apparatus plays.

Brief Description of Drawings

Figure 1 is a diagram illustrating the creation of a conventional hologram;

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Figure 2 illustrates the creation of the holographic image with a reference beam using the hologram created in Figure 1;

5 Figure 3 illustrates the plate with the photoactive coating which is the heart of the instant invention, with a holographic image being created on its surface with a computer-driven scanned laser beam;

10 Figure 4 illustrates the viewing of the moving holographic image when the scanned beam and the reference beam operate simultaneously;

Figure 5 illustrates an analog input utilizing a digitizer, as an alternative to a software-driven interference pattern creation; and,

15 Figure 6 is a diagrammatic illustration of a computer with its mass storage and optional digitizer being used to drive the scanned laser beam.

Best Mode for Carrying Out the Invention

20 The creation of a conventional hologram and its use to reconstruct the holographic image is shown in Figures 1 and 2. A photographic plate 10 is used, which will become the hologram when the process is finished. The photographic plate is darkened, and illuminated only by the reflected light from an illuminating beam 12, which is coherent with the light from the reference beam 14 and the
25 reference beam itself. The illuminating beam reflects off of the object 16 of which the hologram is being made. The reflected beam 18 interferes with the coherent light from the reference beam 14 to create an interference pattern on the photographic plate 10. The photographic plate is

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exposed to the interference pattern, and then developed as is the conventional photographic plate, to permanently record the series of interference fringes as the hologram.

After the hologram is complete, it may be viewed
5 by illuminating it with a reconstruction beam 20. As shown in Figure 2, the reconstruction beam strikes the interference pattern of the hologram 10 and is diffracted at an angle on the other side of the hologram. The diffracted beam 22, when illuminating the eye of the observer 24, will
10 give the observer the visual impression that he is observing a three-dimensional object in the position illustrated in dotted line in Figure 2. As the observer moves back and forth, he is able to see "behind" or at least around the edges of, the object of the original
15 hologram.

The instant invention in essence replaces the photographic plate which produces the interference fringes of the hologram as discussed in conjunction with Figure 1. This plate is replaced by a sheet 24 of photoactive
20 material which responds to being illuminated by turning opaque at the point of illumination. The sheet would ordinarily be applied as a coating to a planar plate 26 of glass or other transparent material as shown in Figure 3.

The instant invention is discussed in conjunction
25 with the plate illustrated in Figure 3, which is the transmission hologram. Naturally, this is the equivalent of a reflective hologram. Whether the hologram is transmissive or reflective is a matter of choice of the creator.

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Additionally, for purposes of the discussion of the invention, the sheet 24 is said to become opaque upon being illuminated. It could also be opaque to start with, and become transparent upon being illuminated. This would be the effective counterpart to a film negative, and would of course work just as well upon the image being "negatived" in the computer software, as will become apparent hereinafter.

The sheet 24 in the preferred embodiment, has a characteristic by which it will return to its original, or neutral, configuration after a dwell time, much as the phosphor on the viewing surface of a cathode ray tube will glow upon being irradiated by the electron beam, and then fade out over a period of time to become ready for the next scanning by the electron beam. Different phosphors are available to produce an almost infinitely selectable number of fading times.

In much the same way as a CRT operates in principal, a beam of coherent light, which would in ordinary cases be a beam from a laser, indicated at 28 in Figure 4, scans the sheet planar coating 24 to create the interference fringes 30. In the same way as the electron beam creates the raster scan in a CRT, the laser is scanned over the entire surface of the sheet 24, with a scanning period being on the order of the fading or dwell time of the sheet 24 so that when the laser is ready for the subsequent scan, the interference fringes created by the last scan would be in the process of dying out or fading.

The laser 28 is driven in its scanning and modulating mode by the computer 32. The actual physical

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scanning of the beam could be done by the pie-shaped rotating diffraction gratings or "holograms" that are routinely used in laser printers for the lateral scan on the rotating drum which actually prints the paper in laser printers. The vertical indexing or scanning, which operates at a much slower frequency to move the lateral scan down across the entire surface of the screen, could be accomplished by a horizontally elongated prism or mirror rotated on the horizontal axis. Modulation of the laser would amount to turning the laser element off and on as is done with the laser printing equipment.

As the computer drives the scanning laser 28, it scans the entire surface of the sheet 24, creating the diffraction pattern 30 illustrated in Figure 3. Once the first scan is complete, the scanning laser begins again and re-scans the plate to create the second diffraction pattern, corresponding to the second "frame" of the holographic image of the movie. Analogous to a movie picture projector, the scanner is made to repeatedly scan the plate, creating subsequent interference patterns, which are established and then fade in synchronization with the subsequent scanning of the plate by the scanning laser.

As shown in Figure 4, at the same time that the interference patterns are being scanned by the scanning laser, the plate is being illuminated from the other side by the reconstruction beam 20, with the result that an observer may look into the diffracted beam 22 and see a moving hologram.

There are at least two ways in which the computer could input the enormous amount of data necessary to

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present the consecutive frames of interference fringes on the plate 26. First, it could operate from software which, based on the input of simple figures by recognized symbols, or by drawing a simple figure on a digitizer, could convert the inputted figure into the corresponding interference pattern that would produce a holographic image of the figure when the interference pattern is illuminated with a reconstruction beam.

To avoid the extreme complexity of the software required for this type of application, another means of generating the required data base for forming the consecutive interference patterns would be to put the digitizer into the conventional hologram creation apparatus illustrated in Figure 5. The digitizer, indicated at 34, would lie in the plane where the photographic plate of the hologram would lie as shown in Figure 1. The object 16, of which the moving hologram is being made, could then be moved incrementally, with a new digital input being made from the digitizer with each successful position of the object. For example, a dog could be moved incrementally from a sitting to a standing position, with the increments being subsequently recorded through the digitizer 34. The information of each frame could be stored in the mass storage of the computer, and then drawn upon to create the holographic movie, which is the object of the instant invention.

There are undoubtedly hundreds of variations of the disclosed and claimed apparatus which would fall within the intended scope of the claims appended hereto. The field of holography itself is somewhat embryonic, and the

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marriage between the parts of the field of holography, and the strident successes in memory capacity and operating speeds of microcomputers, will almost without a doubt create a whole new technology and a myriad of new
5 developments of which the instant invention is one of the first.

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Claims

1. An apparatus for creating a hologram comprising:
 - a) a planar sheet of photoactive material which becomes at least partially opaque at any point thereon upon being irradiated at that point;
 - b) a radiation source capable of being scanned and being modulated to irradiate selected points on said sheet to cause said sheet to exhibit an interference pattern of a desired hologram; and,
 - c) a computer for driving said radiation source, to modulate and scan same to create said interference pattern.
2. Structure according to Claim 1 wherein said sheet comprises a layer of photoactive material on a planar transparent plate.
3. Structure according to Claim 1 wherein said sheet of material becomes at least partially opaque on being irradiated, for a period of time only, this time being defined as the "dwell period," subsequent to which dwell period said sheet returns to its non-irradiated, non-opaque state.
4. Structure according to Claim 3 wherein said radiation source scans said sheet of material repeatedly, having a scanning period, during which said sheet is completely scanned, on the order of magnitude of said dwell period.

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5. Structure according to Claim 4 wherein said computer includes a data base defining data for consecutive "frames" of interference pattern which reconstruct to a moving holographic image.
- 5 6. Structure according to Claim 5 wherein said planar sheet is photoactive to a specific range of wavelengths, and said radiation source is a laser which produces light within said range.
- 10 7. A method of creating a moving holographic image utilizing a photoactive planar sheet, each point of which becomes temporarily opaque upon being irradiated for a known dwell period, a scannable and modulatable radiation source for irradiating said sheet, and a computer for driving said radiation source, said method comprising the following steps:
 - 15 a) with said computer, driving said radiation source to irradiate and scan said sheet completely within on the order of said dwell period, producing a holographic pattern on said sheet that will
20 interfere with a reconstruction beam to create a holographic image;
 - b) repeating Step (a) with a repetition frequency with on the order of said dwell period, with each successive scan creating a successive interference
25 pattern on said sheet corresponding with the next frame of a moving holographic image; and,
 - c) illuminating said sheet with a reference beam.

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8. A method according to Claim 7 wherein said computer creates said successive interference patterns from a software interference pattern generator.
- 5 9. A method according to Claim 7 wherein said computer creates said successive holographic patterns from previously recorded data in a mass storage.
- 10 10. A method according to Claim 9 and including this Step, prior to Step (a), of interfacing a digitizer at the interference pattern plane of a conventional hologram-creating apparatus and converting successive interference patterns created from said apparatus to successive data base segments in said mass storage corresponding to successive interference pattern frames.

FIG. 1 PRIOR ART
CREATION OF HOLOGRAPHIC PLATE

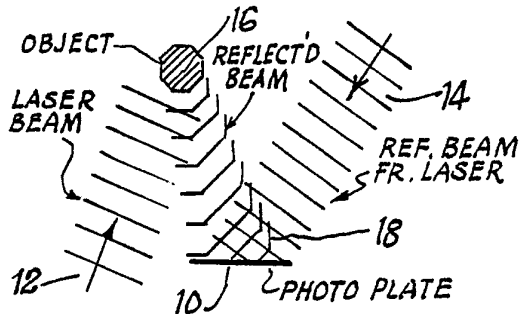
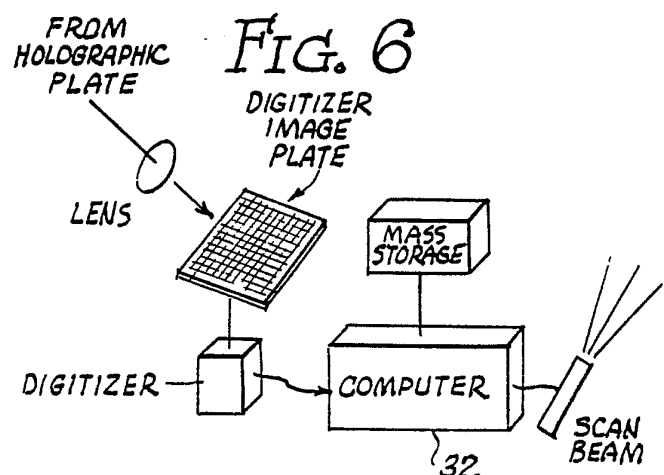
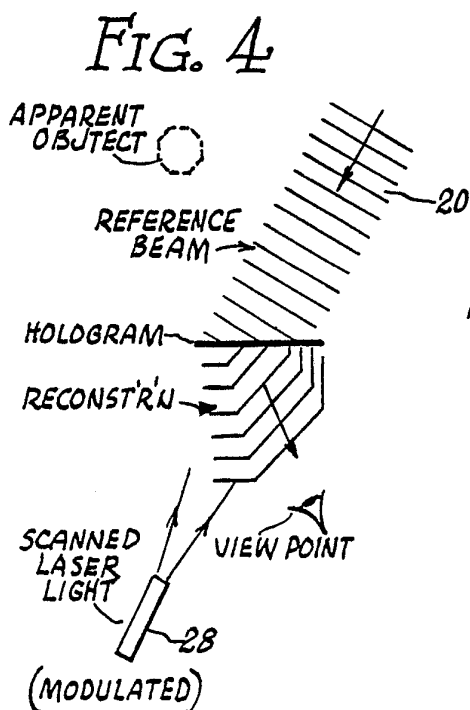
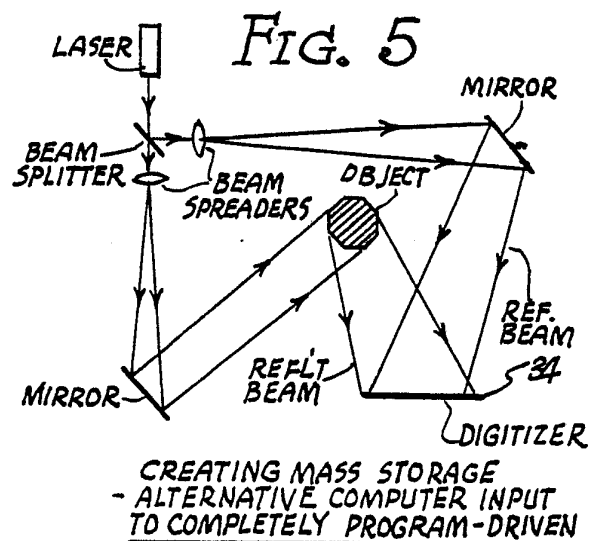
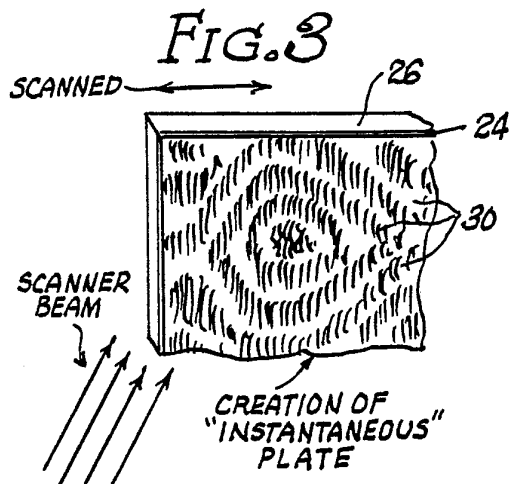
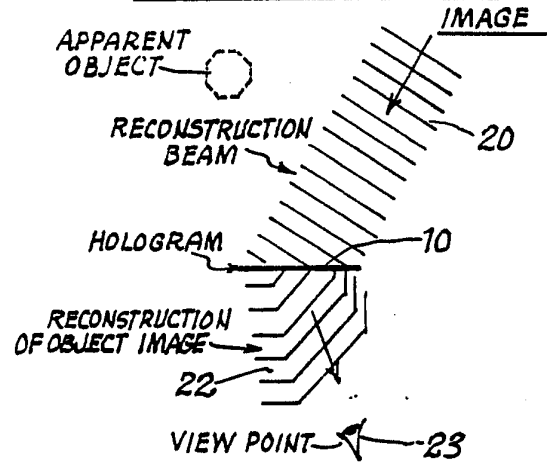


FIG. 2 PRIOR ART
RE-CREATION OF HOLOGRAPHIC



INTERNATIONAL SEARCH REPORT

International Application No PCT/US87/01369

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC. (4) G03H 1/08; H04N 13/00		
U.S. CL. 350/3.66; 358/90		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S.	350/3.64, 3.66; 358/90	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	US, A, 4,498,740 (CAULFIELD) 12 February 1985 See the entire document.	1, 2
Y	US, A, 3,518,367 (SMITH) 06 June 1970 See Fig. 2 col. 2 lines 55-58, and col. 6, line 70 to para. end.	3, 4
A	US, A, 3,548,093 (KOCK) 15 December 1970 See col. 1 lines 45-48.	5-10
[*] Special categories of cited documents: ¹⁵ "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 "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		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²		Date of Mailing of this International Search Report ³
19 August 1987		03 SEP 1987
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ISA/US		Bruce Y. Arnold Bruce Y. Arnold