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## DRAWINGS ATTACHED

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## (54) MULTIPLE IMAGE SYSTEM

(71) We TEXAS INSTRUMENTS INCORPORATED, a Corporation organised according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Multiple images for a micro-miniature circuit are usually produced on the semiconductor wafer by a system using a single image master. Each image in the pattern must be an accurate reproduction of the master image and precisely spaced with respect to the surrounding images. The two basic requirements for repetition of a circuit pattern are the achievement of high image quality and precise registration between each image.

Presently, the highest quality multiple image patterns are produced by using elaborate step-and-repeat cameras with lenses of high aperture to give the necessary resolving power. With the step-and-repeat camera, a multiple image mask is constructed, and the image pattern is transferred to a semiconductor wafer by the process of contact printing. To produce a 30-by-30 array on the mask, it is necessary to perform 900 exposures through the master image. For each of the 900 exposures, the master image must be positioned accurately within .0001 of an inch. Although the step-and-repeat camera produces the best results of previously available systems, it is a tedious, time-consuming, and expensive way to produce multiple images.

Another system for producing multiple images is the pinhole array camera. A pinhole array camera system consists of a mask having an array of precisely positioned, uniform diameter apertures. The resolution of the images formed by this system is controlled by the aperture size and the distance between the pinhole array and the light-sensitive surface on which the multiple images are formed. Since the effective lens quality of a pinhole opening is very poor, the images produced by this method are of a lower quality than the step-and-repeat camera system. However, the pinhole array camera system is relatively simple and inexpensive.

Another desirable feature in multiple reproduction is the ability to produce intermixed arrays of several master images. Also, it is often desirable to produce complex patterns of a master image. The pinhole array camera system lacks the ability to produce intermixed multiple images from several patterns.

The present invention provides apparatus for forming multiple images of a master image, including a multiple image generator in the form of an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images in the multiple image array to be formed, and a light-sensitive element so positioned with respect to the multiple image generator that multiple images of the master image are formed on the element in response to the impingement, on the multiple image generator, of the image of the master image when the latter is illuminated by monochromatic light.

The interference pattern hologram may be a hologram which is Fourier transform of the array of point sources at positions corresponding to the positions of the images of the multiple image array to be formed. A method of fabricating such a hologram is described and claimed in British Patent Application No. 35357/69 (Serial No. 1204170): that method includes the step of exposing a method of fabricating a hologram of the Fourier transform of an array of point sources of light, including the step of exposing a recording medium to a reference wave and an object wave of

monochromatic light simultaneously, once for each point source in the array of point sources, while varying the angles of incidence of the reference wave and the object wave for each exposure such that the relative difference between the angles of the incidence of the reference wave and the object wave for each exposure corresponds to the relative differences in location of the point sources in the array.

The present invention also provides a method of forming multiple images including the steps of illuminating a master image with monochromatic light, directing the light waves generated at the master image onto the surface of an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of the multiple image array to be formed, and forming multiple images of the master image upon a recording medium by directing the light output from the hologram onto the recording medium.

The invention also enables intermixed multiple images to be produced in that it provides apparatus for forming multiple images including a plurality of master images from which the multiple images are to be derived and a multiple image generator including a plurality of holograms on a single member, each hologram being for a respective master image, an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of that master image in the multiple array to be formed, and a light-sensitive element so positioned with respect to the multiple image generator that an intermixed composite multiple image array of the plurality of master images is formed on the element in response to the impingement, on the multiple image generator, of the images of the plurality of master images, when the latter are illuminated by monochromatic light. The apparatus may include means for masking all but one of the plurality of holograms; alternatively, the apparatus may include a plurality of monochromatic light sources corresponding to the plurality of master images and positioned to illuminate the plurality of master images simultaneously.

The invention further provides a method of forming multiple images, including the steps of illuminating a plurality of master images with monochromatic light, directing the light waves generated at each master image onto the surface of a respective one of a plurality of holograms, each hologram being an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of that master image in the multiple image array to be formed, and directing the light output from each hologram onto a recording medium to form an intermixed composite multiple image array of the plurality of master images.

By way of example, the invention will be described with reference to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic of a system for producing in a single step a multiple image pattern from a single image master;

FIGURE 2 is a schematic of a system for generating a Fourier transform hologram;

FIGURE 3 is a diagrammatic of a system for producing intermixed multiple images from several single image masters; and

FIGURE 4 is a plot of light intensity on a registration element from a hologram.

Referring to FIGURE 1, there is shown a system for producing multiple images from one single-image master. The single-image master 10 is illuminated from a source of monochromatic light 11, for example, a laser. Light waves from the source 11 passing through the master image 10 produce a diffraction pattern; the Fourier transform of this pattern is established at a hologram 12 by means of a double convex lens 13. The complex light pattern from the master image 10 passes through the hologram 12 thereby producing another complex diffraction pattern; the Fourier transform of this second pattern is established at the photosensitive surface of a body, such as a semiconductor wafer 14, by means of a double convex lens 16.

With the relatively simple system shown in Figure 1, it is possible to produce in a single step process, multiple images on the photosensitive surface of the semiconductor wafer 14 from the master image 10. The focal-length of the convex lenses 13 and 16 determines the spacing between the various elements. For example, the distance between the master image 10 and the convex lens 13, and the distance between the hologram 12 and the convex lens 13, are determined by the focal lengths of the convex lens 13. Similarly, the distance between the hologram 12 and the convex lens 16, and the distance between the semiconductor wafer 14 and the

convex lens 16 are determined by the focal lengths of the convex lens 16. The tolerances on the distances between the various elements are not critical.

In operation, consider that the master image 10 has a complex wave transmission function equal to  $f(x',y')$ , and that the master image is located on the focal plane  $x'y'$  of the convex lens 13. If the hologram 12 is also located on a focal plane of the convex lens 13, identified as plane  $uv$ , then the lens 13 establishes the Fourier transform of the function  $f(x',y')$  on the  $uv$  plane. From well known diffraction and Fourier transform theory, the amplitude of the light waves on the hologram will be:

$$F(u,v) = \mathcal{F}(f[x',y']) = \iint_{-\infty}^{\infty} f(x',y') e^{-\frac{i2\pi(ux'+vy')}{f_1\lambda}} dx'dy' \quad (1)$$

where  $f_1$  is the focal length of the lens 13 and  $\lambda$  is the wave-length of the light from the source 11. If the hologram 12, located in the  $uv$  plane, has a transmission function  $G(u,v)$  then the amplitude of the light wave passing through the hologram is equal to the product of  $F(u,v)$  and  $G(u,v)$ . Since the  $uv$  plane is also a focal plane of the convex lens 16, the Fourier transform of the product of  $F(u,v)$  and  $G(u,v)$  will be established on the semiconductor wafer 14. The plane of the semiconductor wafer 14 is identified as being the  $xy$  plane and is at a focal point of the convex lens 16. In mathematical terms, the light amplitude distribution on the  $xy$  plane is given by the equation:

$$h(x,y) = \iint_{-\infty}^{\infty} F(u,v) G(u,v) e^{-\frac{i2\pi}{f_2\lambda}(ux+vy)} du dv \quad (2)$$

where  $f_2$  is the focal length of the convex lens 16. According to the convolution theorem for Fourier transformation, the light amplitude distribution on the  $xy$  plane is given by the equation:

$$h(x,y) = \left[ \iint_{-\infty}^{\infty} F(u,v) e^{-\frac{i2\pi}{f_2\lambda}(ux+vy)} dudv \right]^* \left[ \iint_{-\infty}^{\infty} G(u,v) e^{-\frac{i2\pi}{f_2\lambda}(ux+vy)} dudv \right] \quad (3)$$

where the "\*" is the convolution integral. The first integral in equation (3) is the mathematical representation of the pattern of the master image 10 modified by a magnification factor  $f_1/f_2$ :

$$f(mx,my) = \iint_{-\infty}^{\infty} F(u,v) e^{-\frac{i2\pi}{f_2\lambda}(ux+vy)} dudv \quad (4)$$

where  $m = -f_1/f_2$ , the magnification factor.

Now if the function  $g(x,y)$  is chosen to represent the Fourier transformation of  $G(u,v)$  and  $f(mx,my)$  represents the Fourier transformation of  $F(u,v)$  from equation (1) then:

$$g(x, y) = \iint_{-\infty}^{\infty} G(u, v) e^{-\frac{i 2 \pi}{f_2 \lambda} (ux + vy)} du dv \quad (5)$$

and equation (3) can be written as:

$$h(x, y) = f^*(mx, my) g(x, y) - \iint_{-\infty}^{\infty} f^*(mx'', my'') g(x-x'', y-y'') dx'' dy'' \quad (6)$$

Assume the Fourier of the transformation of the function  $G(u, v)$  can be written as:

$$g(x, y) = \sum_{pq} \delta(x-a_p) \delta(y-b_q) \quad (7)$$

Then by substitution of equation (7) into equation (6) the function on the  $xy$  plane can be written as:

$$h(x, y) = \sum_{pq} f^*[m(x-a_p), m(y-b_q)] \quad (8)$$

where  $a_p$  is the distance along the  $x$  axis and  $b_q$  is the distance along the  $y$  axis. Equation (8) mathematically describes the original pattern on the master image 10 reduced and multiplied into an array by the hologram 12. The configuration of the array is described by the function  $G(u, v)$ ; by varying the  $a_p$  and  $b_q$  terms any array can be generated.

Referring to Figure 2, there is shown a system for producing the hologram 12 of Figure 1 of an array of the Fourier transform of points corresponding in position with the array of images to be formed from the master image 10. Holograms have frequently been described as modulated diffraction gratings. In the usual method of forming a hologram, a diffraction pattern is formed on a photographic plate by the interference of a secondary wave with a reference wave. The interference pattern on the photographic plate bears no resemblance to the original object but contains substantially more information than a photograph. To the unaided eye, the image embodied in a hologram cannot be detected since the visible structure is purely extraneous and is the result of a somewhat less than perfect light transmitting system. In the case of a hologram of an array of points, the object can be an array of pinholes arranged in the desired pattern. However, a hologram made by interference of light waves passing through a pinhole array with a reference wave, will not produce high quality images.

In Figure 2, the hologram is produced by multiple exposure of a photographic plate for each image position to be registered on the photosensitive surface of the semiconductor wafer 14. The system of Figure 2 includes a laser light source 17 generating a laser beam partially reflected by a reflective surface 18 to a reflective surface 19. The laser beam from the source 17, after reflection from the surface 19, is expanded by a beam expander 21 and collimated by a lens 22. The collimated light from the lens 22 is the reference wave required to generate an interference pattern on a photographic plate 23. Light passing through an aperture in the reflective surface 18 is transmitted to a reflective surface 24 and reflected therefrom to a wave expander 26. Light waves from the expander 26 are collimated by a lens 27 and reflected to the photographic plate 23 by means of an adjustable reflective surface 28.

In operation, the photographic plate 23 is exposed once for each image position desired on the semiconductor wafer 14. For each image position, the reference wave is maintained constant and the object wave varied by means of the adjustable

reflective surface 28. Thus, to create the desired multiple image pattern, the adjustable reflective surface 28 is positioned for each exposure. To insure equal intensity images on the photosensitive surface of the semiconductor wafer 14, the same exposure time is used for each image position. Remarkably good image resolution is possible by the system of Figure 1 when using a hologram produced by the system of Figure 2.

This technique of hologram production is known as optical image synthesis which can be shown mathematically; assume the reference wave is defined as:

$$R_w = A_0 e^{-i2\pi cu/f_2\lambda} \quad (9)$$

where  $A_0$  is the amplitude of the reference wave and  $cu$  is the position of the reference beam with respect to the  $uv$  plane. Also, assume that the object wave is given by the following equation:

$$O_w = A_1 e^{-i2\pi(a_p u + b_q v)/f_2\lambda} \quad (10)$$

where  $A_1$  is the amplitude of the object wave. The amplitude of the interference pattern recorded on the photographic plate 23, for each exposure, is equal to the sum of the equations 9 and 10, and is written as follows:

$$A_{pq} = A_0 e^{-i2\pi cu/f_2\lambda} + A_1 e^{-i2\pi(a_p u + b_q v)/f_2\lambda} \quad (11)$$

The amplitude transmission is given by the equation:

$$T(uv) = \alpha_1 + \alpha_2 \left[ \frac{\alpha}{pq} e^{-i2\pi cu/f_2\lambda} e^{-i2\pi(a_p u + b_q v)/f_2\lambda} + c.c. \right] \quad (12)$$

where  $\alpha_1$  and  $\alpha_2$  are constants, c.c. is the complex conjugate of  $e^{-i2\pi(a_p u + b_q v)/f_2\lambda}$

and all the remaining terms have been described previously. The direction of the object wave for each image positioned as it interferes on the photographic plate 23 is given by the terms  $a_p/f_2$  and  $b_q/f_2$  of equation 12; where  $a_p/f_2$  is an angle in the  $uw$  plane and  $b_q/f_2$  is an angle in the  $vw$  plane, as shown in Figure 2.

The hologram 12 can also be generated by a computer-guided plotter, also known as binary matched filters and low-information content holograms. A low-information content hologram is described by B. R. Brown and A. W. Lohmann in Applied Optics, Volume 5, pages 967-969. The computer generated hologram consists of a plurality of grating slits of varying width and position. Although the binary matched filter is suitable for multiple image production, there are some approximations involved in the process. To generate the desired pattern, the computer is programmed with the function  $G(u,v)$ .

Referring to Figure 3 there is shown a system for producing intermixed multiple images of two master images. A source of monochromatic light 29 illuminates the master image 31 thereby generating a diffraction light wave pattern; the Fourier transform of this pattern is established at the hologram 32 by means of a double convex lens 33. A source of monochromatic light 34 illuminates a master image 36 thereby generating a complex diffraction waveform; the Fourier transform of which is established at a hologram 37 by means of a double convex lens 38. The Fourier transform of the light wave patterns at the holograms 32 and 37 are established at the photosensitive surface of a body such as a semiconductor wafer 39 by means of a double convex lens 41.

In operation, the system shown in Figure 3 operates in substantially the same

15 manner as the system shown in Figure 1. The equations (1) through (8) would apply for the production of a multiple image pattern from the master image 31, and they would also apply to production of multiple images from the master image 36. Basically, the system of Figure 3 is merely a duplication of the system of Figure 1 combined to produce an intermixed multiple image pattern. However, the holograms 32 and 37 are generated on the same photographic plate and the convex lens 41 establishes the Fourier transform of both complex waves at the photosensitive surface of the semiconductor wafer 39.

10 The holograms 32 and 37 are separately generated on a photographic plate using, for example, the arrangement shown in Figure 2. Of course, more than two holograms can be generated on the same photographic plate if more than two master images are to be intermixed on the semiconductor wafer 39. Thus, if four master images are to be intermixed to form a multiple image pattern on the semiconductor wafer 39, four holograms would appear on the photographic plate.

15 Referring to Figure 4, there is shown a curve of the light amplitude on an element in the xy plane when a hologram is used between the convex lenses 13 and 16. The light pattern through a hologram produces distinct and separate irregular patterns at each desired image position. The wave pattern for each image is very narrow and appears only at the image position. Thus, the multiple images produced from one master would not interfere with the multiple images produced from another master, and the images of various masters can be intermixed.

20 With the system of Figure 3, the multiple images from the various masters can be produced either simultaneously or successively. For simultaneous operation, the master images 31 and 36 are illuminated at the same time and generate the complete intermixed multiple image pattern in one operation. In the alternative, either the master image 31 or 36 is illuminated separately, and the multiple images of the illuminated master produced on the photosensitive surface of the semiconductor wafer 39. After the first pattern has been registered on the semiconductor wafer 39, the second master image is illuminated and multiple images generated on the photosensitive surface of the semiconductor wafer.

30 It is also possible to produce intermixed multiple images by slight modification of the system shown in Figure 1. The hologram 12 is replaced by a photographic plate containing a plurality of holograms, one hologram for each master image. The convex lens 13 is made adjustable such that it establishes at the desired hologram, the Fourier transform of the light wave at the master image 10. To generate intermixed multiple images, the various master images are individually inserted in the x'y' plane and the convex lens 13 positioned to establish the Fourier transform at the desired hologram. The multiple image pattern for each master is separately recorded on the photosensitive surface of the semiconductor wafer 14. Thus, if three master images are to be intermixed into a multiple image pattern, three separate operations are required.

35 A still further modification of the system shown in Figure 1 to produce an intermixed multiple image pattern replaces the hologram 12 with a photographic plate containing a plurality of holograms, one for each master image. The convex lens 13 remains fixed and a mask is positioned over the photographic plate to block-out all but one hologram pattern. This is also a multiple step operation since each master would be individually placed in the x'y' plane and illuminated from the source 11.

40 Although the invention has been described with reference to forming images upon a semiconductor wafer coated with a photoresistive material, it should be understood that the invention is not limited thereto. For example, the semiconductor wafer in the xy plane can be replaced by any image recording medium, for example by a photographic plate. Either way, the operation of the system is identical; the master image is illuminated from a source of monochromatic light and the Fourier transform of the light waves at said master is generated on the surface of a hologram. A multiple image pattern is generated on the registration element as a result of the combining of the hologram pattern with the Fourier transform of the light waves at said master. To produce an intermixed multiple image pattern, the master images can be illuminated separately or simultaneously as described previously.

#### WHAT WE CLAIM IS:—

60 1. Apparatus for forming multiple images of a master image, including a multiple image generator in the form of an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images in the multiple image array to be formed, and a light-sensitive element so positioned with respect to the multiple image generator that multiple images of the master

manner as the system shown in Figure 1. The equations (1) through (8) would apply for the production of a multiple image pattern from the master image 31, and they would also apply to production of multiple images from the master image 36. Basically, the system of Figure 3 is merely a duplication of the system of Figure 1 combined to produce an intermixed multiple image pattern. However, the holograms 32 and 37 are generated on the same photographic plate and the convex lens 41 establishes the Fourier transform of both complex waves at the photosensitive surface of the semiconductor wafer 39.

The holograms 32 and 37 are separately generated on a photographic plate using, for example, the arrangement shown in Figure 2. Of course, more than two holograms can be generated on the same photographic plate if more than two master images are to be intermixed on the semiconductor wafer 39. Thus, if four master images are to be intermixed to form a multiple image pattern on the semiconductor wafer 39, four holograms would appear on the photographic plate.

Referring to Figure 4, there is shown a curve of the light amplitude on an element in the xy plane when a hologram is used between the convex lenses 13 and 16. The light pattern through a hologram produces distinct and separate irregular patterns at each desired image position. The wave pattern for each image is very narrow and appears only at the image position. Thus, the multiple images produced from one master would not interfere with the multiple images produced from another master, and the images of various masters can be intermixed.

With the system of Figure 3, the multiple images from the various masters can be produced either simultaneously or successively. For simultaneous operation, the master images 31 and 36 are illuminated at the same time and generate the complete intermixed multiple image pattern in one operation. In the alternative, either the master image 31 or 36 is illuminated separately, and the multiple images of the illuminated master produced on the photosensitive surface of the semiconductor wafer 39. After the first pattern has been registered on the semiconductor wafer 39, the second master image is illuminated and multiple images generated on the photosensitive surface of the semiconductor wafer.

It is also possible to produce intermixed multiple images by slight modification of the system shown in Figure 1. The hologram 12 is replaced by a photographic plate containing a plurality of holograms, one hologram for each master image. The convex lens 13 is made adjustable such that it establishes at the desired hologram, the Fourier transform of the light wave at the master image 10. To generate intermixed multiple images, the various master images are individually inserted in the x'y' plane and the convex lens 13 positioned to establish the Fourier transform at the desired hologram. The multiple image pattern for each master is separately recorded on the photosensitive surface of the semiconductor wafer 14. Thus, if three master images are to be intermixed into a multiple image pattern, three separate operations are required.

A still further modification of the system shown in Figure 1 to produce an intermixed multiple image pattern replaces the hologram 12 with a photographic plate containing a plurality of holograms, one for each master image. The convex lens 13 remains fixed and a mask is positioned over the photographic plate to block-out all but one hologram pattern. This is also a multiple step operation since each master would be individually placed in the x'y' plane and illuminated from the source 11.

Although the invention has been described with reference to forming images upon a semiconductor wafer coated with a photoresistive material, it should be understood that the invention is not limited thereto. For example, the semiconductor wafer in the xy plane can be replaced by any image recording medium, for example by a photographic plate. Either way, the operation of the system is identical; the master image is illuminated from a source of monochromatic light and the Fourier transform of the light waves at said master is generated on the surface of a hologram. A multiple image pattern is generated on the registration element as a result of the combining of the hologram pattern with the Fourier transform of the light waves at said master. To produce an intermixed multiple image pattern, the master images can be illuminated separately or simultaneously as described previously.

#### WHAT WE CLAIM IS:—

1. Apparatus for forming multiple images of a master image, including a multiple image generator in the form of an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images in the multiple image array to be formed, and a light-sensitive element so positioned with respect to the multiple image generator that multiple images of the master



image are formed on the element in response to the impingement, on the multiple image generator, of the image of the master image when the latter is illuminated by monochromatic light.

2. Apparatus as set forth in claim 1, wherein the interference pattern hologram is a Fourier transform of the array of point sources at positions corresponding to the positions of the images of the multiple image array to be formed.

3. Apparatus as set forth in Claim 1 or Claim 2, including optical means positioned to produce, upon the light-sensitive element, the Fourier transform of the light output from the hologram.

4. Apparatus as set forth in Claim 3, wherein said optical means includes a first lens positioned intermediate the master image and the hologram to establish the Fourier transform of the master image on the hologram, and a second lens positioned intermediate the hologram and the light-sensitive element to establish on the light-sensitive element the multiple image pattern of the master image.

5. Apparatus for forming multiple images, including a plurality of master images from which the multiple images are to be derived and a multiple image generator including a plurality of holograms on a single member, each hologram being for a respective master image, an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of that master image in the multiple array to be formed, and a light-sensitive element so positioned with respect to the multiple image generator that an intermixed composite multiple image array of the plurality of master images is formed on the element in response to the impingement, on the multiple image generator, of the images of the plurality of master images, when the latter are illuminated by monochromatic light.

6. Apparatus as set forth in claim 5, wherein each of the interference pattern holograms is a Fourier transform of the array of point sources for the respective master image, and further including a plurality of first lenses corresponding to the plurality of master images and individually interposed between a respective master image and the member on which the holograms are disposed to establish the Fourier transform of each of the master images on the respective hologram, and a second lens interposed between the member on which the holograms are disposed and the light-sensitive element.

7. Apparatus as set forth in claim 5 or claim 6, further including means for masking all but one of the plurality of holograms.

8. Apparatus as set forth in any preceding claim, including a monochromatic light source positioned to illuminate the master image(s):

9. Apparatus as set forth in claim 5 or claim 6, including a plurality of monochromatic light sources corresponding to the plurality of master images and positioned to illuminate the plurality of master images simultaneously.

10. Apparatus as set forth in claim 8 or claim 9 wherein the or each monochromatic light source is a laser.

11. Apparatus as set forth in any preceding claim, wherein the light-sensitive element is a semi-conductor wafer.

12. Apparatus as set forth in any one of claims 1 to 10, wherein the light-sensitive element is a photographic plate.

13. A method of forming multiple images, including the steps of illuminating a master image with monochromatic light, directing the light waves generated at the master image onto the surface of an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of the multiple image array to be formed, and forming multiple images of the master image upon a recording medium by directing the light output from the hologram onto the recording medium.

14. A method as set forth in any claim 13, wherein the light output from the hologram of the array of point sources is directed onto a surface of a semiconductor slice coated with a mask of photoresistive material to expose the photoresistive material to an array of images of the master image.

15. A method of forming multiple images, including the steps of illuminating a plurality of master images with monochromatic light, directing the light waves generated at each master image onto the surface of a respective one of a plurality of holograms, each hologram being an interference pattern hologram of an array of point sources at positions corresponding to the positions of the images of that master image in the multiple image array to be formed, and directing the light output from each hologram onto a recording medium to form an intermixed composite multiple image array of the plurality of master images.



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16. A method as set forth in claim 15, wherein the plurality of master images are simultaneously illuminated with monochromatic light.

17. Apparatus for forming multiple images substantially as described herein with reference to and as shown in Figures 1 or 3 of the accompanying drawings.

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18. A method of forming multiple images as set forth in claim 13, substantially as described herein with reference to Fig. 1 of the accompanying drawings.

19. A method of forming multiple images as set forth in claim 15, substantially as described herein with reference to Fig. 3 of the accompanying drawings.

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Applied Optics, Volume 5, pages 967—969. The computer generated hologram con-  
London, W.C.1.

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\* C L N S \*