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Sheridon

[11] **3,842,406**

[45] **Oct. 15, 1974**

[54] **CYCLIC RECORDING SYSTEM BY THE USE OF AN ELASTOMER IN AN ELECTRIC FIELD**

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[73] Assignee: **Xerox Corporation,** Stamford, Conn.

[22] Filed: **Nov. 24, 1972**

[21] Appl. No.: **309,379**

Related U.S. Application Data

[60] Division of Ser. No. 101,729, Dec. 28, 1970, Pat. No. 3,716,359, which is a continuation of Ser. No. 23,649, March 30, 1970, abandoned.

[52] **U.S. Cl.** ..... **340/173 R,** 96/1.1

[51] **Int. Cl.** **G03g 13/22**

[58] **Field of Search**..... 340/173 R, 173 LM; 96/1.1, 96/1.5, 27 H

[56] **References Cited**

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2,896,507	7/1959	Mast	88/61
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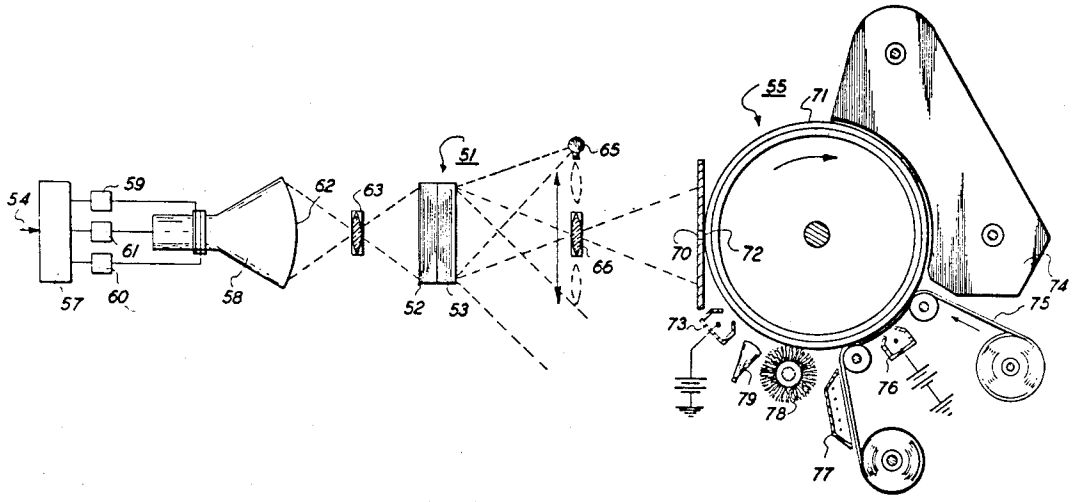
Primary Examiner—Terrell W. Fears

Attorney, Agent, or Firm—James J. Ralabate; David C. Petre; Gaetano Maccarone

[57] **ABSTRACT**

The applications of elastomers to various imaging techniques are described which may be used for the cyclic recording, storage and subsequent erasure of optical information. Several embodiments of the invention are described, all of which form images by the elastic deformation of a thin elastomer layer. The pattern of the surface deformation, in general, follows the light distribution of the optical image being recorded. This image is formed on a photoconductive layer which is adjacent to, or integral with, the elastomer layer. An electric field is placed across the elastomer and the photoconductor layers, the field being modulated by the action of the image light on the conductivity of the photoconductor and provides the mechanical force necessary to deform the elastomer. Once the elastomer surface has deformed, it will in general remain deformed as long as the field across it is maintained; the image recorded, accordingly, being stored. Removing the electric field allows the elastomer to relax and the image is consequently erased. Reversing the field increases the rate at which the image is erased. A new image may now be formed, and the cycle started over again. Such an elastomer material is capable of a great many recording/storage/erasure cycles.

50 Claims, 13 Drawing Figures



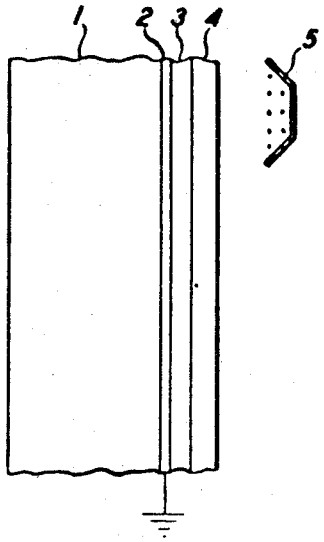


FIG. 1

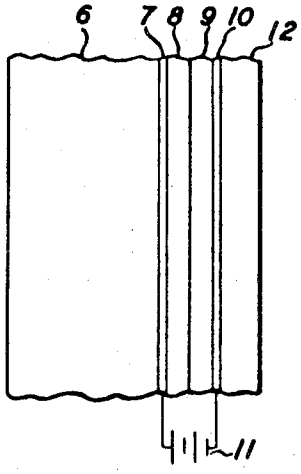


FIG. 2

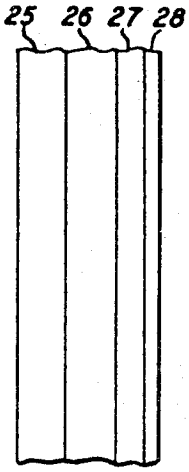


FIG. 5

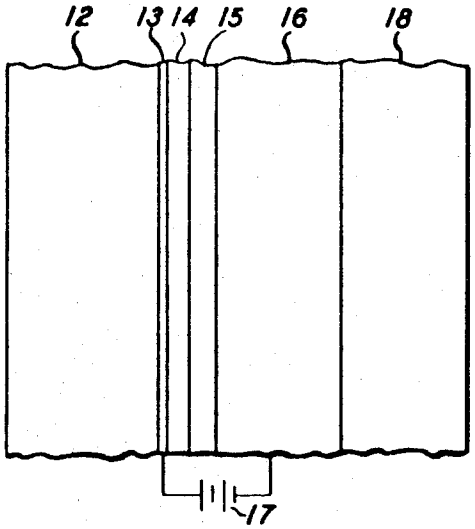


FIG. 3

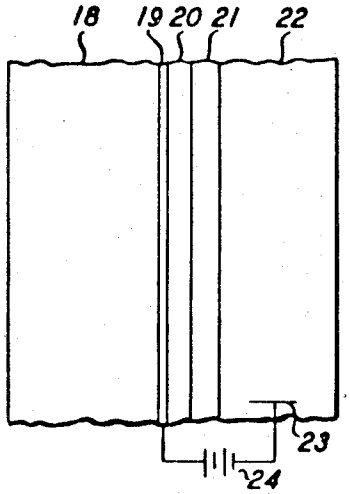


FIG. 4

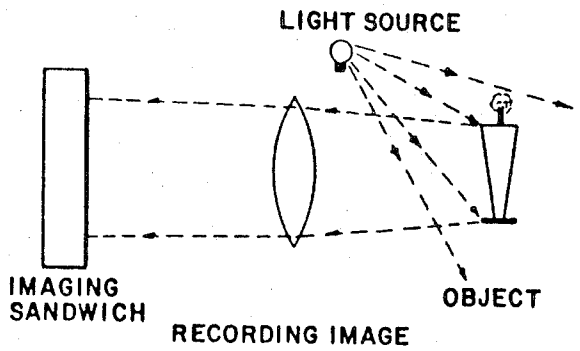


FIG. 6a

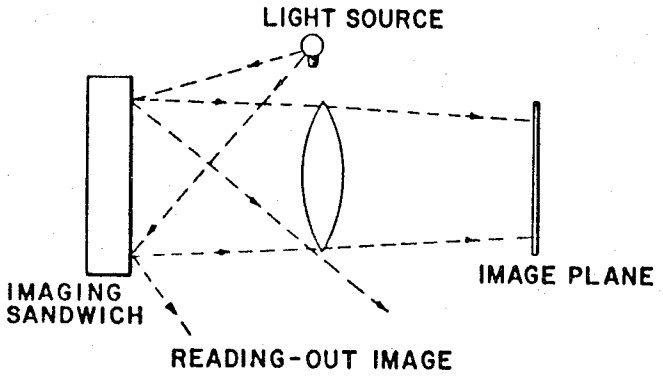


FIG. 6b

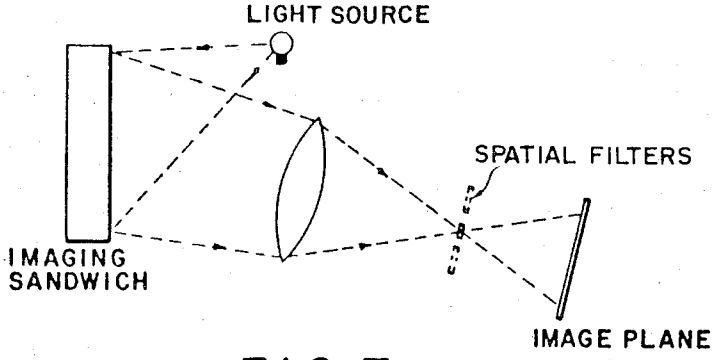


FIG. 7

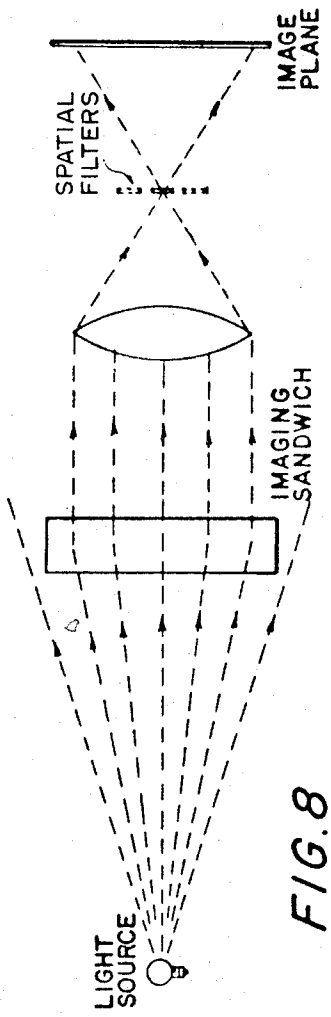

IMAGE PLANE
SPATIAL FILTERS
IMAGING SANDWICH
LIGHT SOURCE

FIG. 8

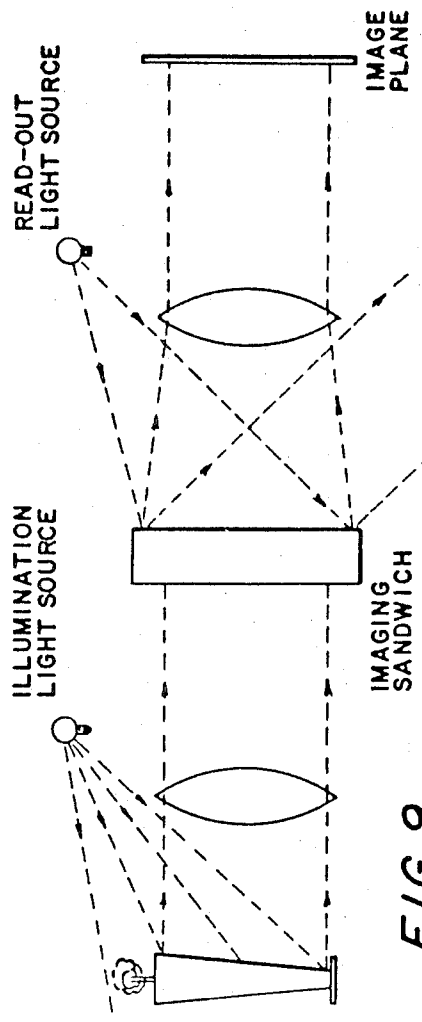

IMAGE PLANE
READ-OUT LIGHT SOURCE
ILLUMINATION LIGHT SOURCE
IMAGING SANDWICH

FIG. 9

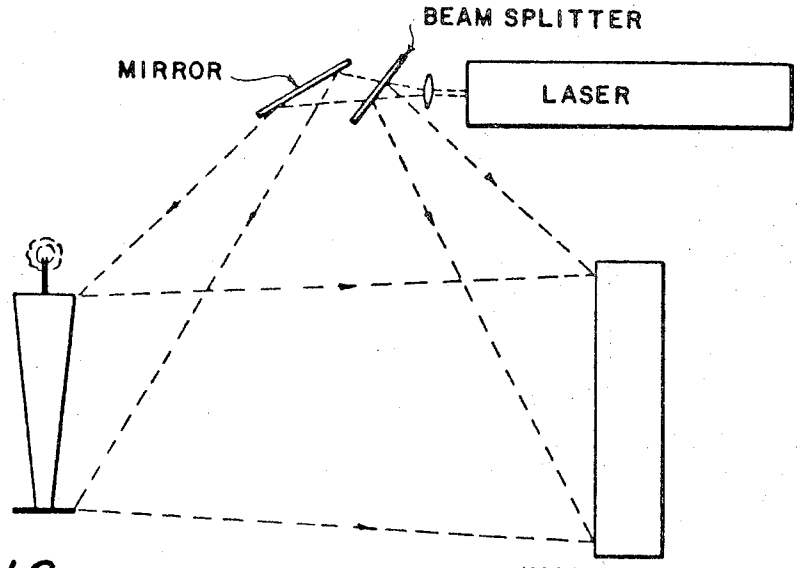


FIG. 10a

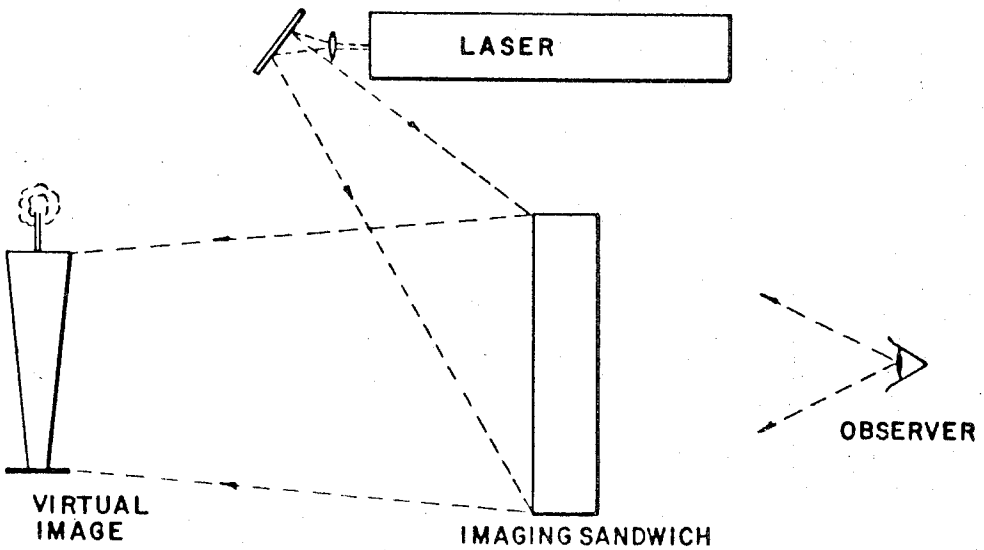


FIG. 10b

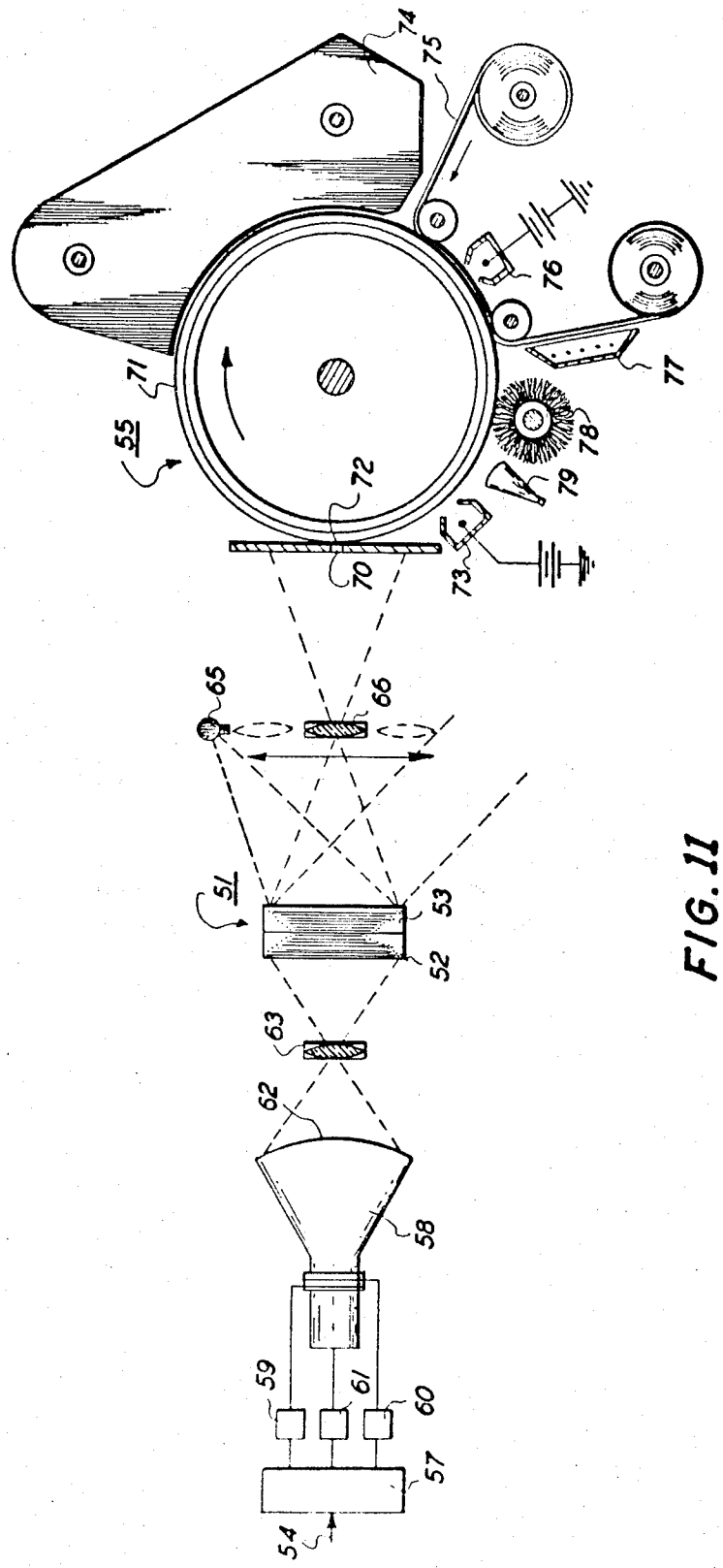


FIG. 11

CYCLIC RECORDING SYSTEM BY THE USE OF AN ELASTOMER IN AN ELECTRIC FIELD

CROSS REFERENCE

This application is a division of copending application Ser. No. 101,729, filed Dec. 28, 1970, now U.S. Pat. No. 3,716,359 which is a continuing application of my copending application under the same title filed Mar. 30, 1970, Ser. No. 23,649 now abandoned.

BACKGROUND OF THE INVENTION

Prior art thermoplastic surface relief imaging taught the recording of images by means of deformations in an otherwise smooth thermoplastic surface. The image information is recorded as a hill and valley structure on this surface. Light reflected or transmitted through this surface may be used to make the recorded image visible because such light will be scattered or diffracted by this structure. Three basic types of thermoplastic surface relief imaging may be distinguished.

Historically, the first of these is "frost imaging" which may be seen in U.S. Pat. Nos. 3,196,009, 3,196,011, 3,258,336 and 3,196,008 as a few of many examples. Frost imaging has been practiced in the past by creating a voltage pattern across a thin layer of insulating thermoplastic. This voltage pattern is usually established by means of an adjacent layer of photoconductor material although the thermoplastic itself may be made photoconductive. In use, the electric field is placed across the thermoplastic/photoconductor sandwich or across the photoconductive thermoplastic. The light intensity pattern of the image formed on the photoconductor now creates a varying electrostatic field.

It has been observed by this inventor and others that a thin liquid layer, across which a high electric field has been placed, will preferentially deform in a pattern exactly matching the spatial frequency variations in this field; provided these variations are predominately composed of spatial frequencies in the neighborhood of the characteristic or resonant frequency of the layer. For moderate values of the electric field this resonant frequency commonly has the value ½T, where T is the thickness of the liquid layer. Where the field pattern varies much more slowly than this, the surface will tend to wrinkle or randomly deform; such wrinkles having characteristic spatial frequencies in the neighborhood of ½T and being referred to as frost. Hence, images having spatial frequencies within the region of the resonant frequency of the deformable surface will be faithfully reproduced by deformations of this surface. Images, on the other hand, having spatial frequencies much lower than this resonant frequency will tend to form frost in the regions of greater illumination. In conjunction with a Schlieren optical or other suitable system, good quality images may be reconstructed from frost deformations. However, the inherent noise structure of the frost image is objectionable for some applications.

The second type of surface relief imaging was taught by Urbach and is commonly called "screened frost." See U.S. Pat. Nos. 3,196,012 and 3,436,216. This imaging technique is capable of recording surface deformation images of spatial frequency much lower than the resonant frequency of the deformable layer. Urbach has shown that by interposing an absorption type

line grating of spatial frequency close to the resonant spatial frequency of the deformable surface between the image being projected on the photoconductor and the photoconductor itself, the surface will deform without frost in those regions where the photoconductor is illuminated. The solid areas, i.e., low spatial frequency areas, of this screened frost image are now filled, not with frost, but with remnants of the screen. If these screen remnants are objectionable, they can be removed by subsequent spatial filtering or by techniques further taught by Urbach.

The third type of surface relief imaging is actually a variant of the first two, but because of its importance deserves to be treated separately. This relates to the recording of holograms on a deformable surface structure and has been taught by Cathey, for bleached gelatin emulsions and later by Urbach for thermoplastic/photoconductor sandwich structures. See U.S. Pat. No. 3,560,205, Imaging System, Ser. No. 521,982, filed on Jan. 20, 1966. A hologram is a recording of the interference pattern between two coherent light beams. One light beam usually contains information about an object and the other is a reference beam, generally of simple structure. The interference pattern generally resembles a somewhat garbled image of a screen. If the spatial frequency of the screen approximates the resonant frequency of the thin liquid layer, the surface would deform along the structure of the interference pattern and little noise would be generated.

All of the above imaging techniques involve the deformation of a thin heat or solvent vapor softenable plastic layer to record image deformation. They may, in principle, be recycled by applying heat or solvent vapors to soften the plastic and allow the recorded image to erase. Ordinarily, the surface would be allowed to solidify again by cooling or vapor ventilation and another image could be formed on it as before. However, these systems cannot be cycled very rapidly or very conveniently. Moreover, cycling requires the expenditure of solvents, or large amounts of power. Further, it has been repeatedly observed that state of the art plastics do not erase completely, due to chemical changes associated with the development process; and, hence, only a limited number of imaging cycles can be obtained with these materials. Accordingly, there is a continuing need for surface deformation imaging systems that will store information and can be repeatedly cycled rapidly and conveniently, with low power consumption.

OBJECTS OF THE INVENTION

It is, therefore, an object of the present invention to provide an optical imaging system which overcomes the above noted deficiencies and satisfies the above-noted wants.

It is another object of the present invention to provide an optical imaging system that will record optical information, store it, erase it and do these things many times.

It is another object of this invention to provide an optical imaging system capable of recording the high spatial frequency optical interference patterns characteristic of holograms, as well as the lower spatial frequency images commonly characteristic of non-coherent light images.

It is another object of this invention to provide an optical imaging system which records a surface relief

image with light incident from one side of the imaging member and to simultaneously allow light of the same or different wave length or the same or different intensity incident from the opposite side of the member to form a similar optical image for purposes of wavelength change, image projection, image intensification and other optical transformations.

It is another object of this invention to provide an optical imaging system which records a surface relief image on an essentially transparent imaging member, such that images may be recorded and reformed by transillumination.

It is another object of this invention to provide an optical imaging system which will be capable of recording images most efficiently within a narrow range of spatial frequencies, or within several narrow ranges of spatial frequencies.

BRIEF SUMMARY OF THE INVENTION

In accomplishing the above and other desired aspects of the present invention, Applicant has invented improved apparatus and methods for a fully cyclycable imaging device on which images may be recorded, stored for short periods of time and erased at will. The inventor provides an imaging member which comprises a substrate that is conductive or has a conductive surface. Coated on this surface is a photoconductive layer whose conductivity is dependent upon illumination, and coated above this is an elastomer layer. In another embodiment a separate photoconductor layer is not used, but rather the elastomer layer is photoconductive. A deformable conductive layer including either a flexible conductive member, a conductive liquid, a conductive gas or a layer of elastrostatic charge is placed contiguous to the surface of the elastomer. An electric field established between the deformable conductive layer and the conductive substrate increases in those regions where the photoconductive layer is exposed to electromagnetic radiation (hereafter referred to as light) causing the elastomer to deform in those regions. Two types of imaging behavior have been observed. In the case of very compliant elastomers and large electric fields the elastomer remains deformed while the electric field is maintained. This deformation is not substantially affected by subsequent illumination of the photoconductor, and thus may be said to be electrically locked. The recorded image information may now be read out at leisure with any brightness illumination. The deformation is removed by removing the field, allowing the elastomer to relax. By reversing the field across the elastomer instead of removing the field, the image may be erased much more quickly. A new image may now be formed. It is to be noted, however, that the electrical locking property of the elastomer exists only above a certain value of the electric field. Below this field threshold value the image erases slowly especially upon exposure of the photoconductor to light. This constitutes the second type of imaging behavior. Here again the image may be rapidly erased by removing or reversing the field across the elastomer.

Because thin layers of elastomers behave in a manner similar to thin layers of viscous liquids for small deformations, an elastomer imaging device, much like a thermoplastic imaging device, is capable of forming three types of image: frost images, screened frost images and limited spatial frequency or holographic images. However, because an elastomer is, in general, essentially an incompressible material and because the extent of its possible deformation is limited by internal elastic forces as well as surface forces, a thin elastomer layer can exhibit an appreciable response to surface force patterns lying only within a limited spatial frequency bandwidth. The greatest response is in the neighborhood of the resonant frequency, usually equal to approximately ½T as in the case of thermoplastics. When an elastomer is exposed to an image having the bulk of its information within the spatial frequency response of the elastomer, the elastomer will record that image very well. Such images are of great interest primarily for holography and for recording printed, written or numeric information of high contrast. When such an elastomer layer is exposed to an image composed of spatial frequencies lower than the recording band of the elastomer, the brightly illuminated areas of the elastomer will deform into a random deformation pattern similar to the frost of the thermoplastic recording. The spatial frequency of the frost deformation lies within the recording bandwidth of the elastomer, and the frost will randomly scatter incident light. Less brightly illuminated areas will not frost and hence will not scatter. Such an image is called a frost image and, as in the thermoplastic case, is sometimes objectionable for some applications because of its inherently noisy structure.

The third type of surface relief image called screened frost is suitable for recording images having spatial frequencies substantially lower than the resonant deformation frequency of the elastomer layer. This is formed by placing an absorption type line grating between the projected image light and the photoconductor upon which it is imaged. The elastomer will now deform along the pattern of this high spatial frequency screen in those areas where it is illuminated and, therefore, will not form frost. The screened surface relief image will then consist of segments of the shadow of the screen. The image obtained by illuminating the elastomer will, thus, have a fine structure of lines superimposed upon the original image that was recorded. If this line structure is objectionable, it may be removed by suitable optical filtering techniques well known in the art.

For the imaging structures described herein, the preferred location of the screen, e.g. a line grating, is immediately adjacent to a photoconductive layer in the imaging structure. Other types of screens that may be similarly located are described in two copending applications, both titled "Methods of Organized Thermoplastic Xerography and Photoreceptor Structure Therefor," one in the name of Lloyd F. Bean and the other in the name of John C. Heurtley, filed Sept. 18, 1970, and Sept. 18, 1970, Ser. No.'s 73,406 and 73,317, respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a side sectional view of the elastomer imaging apparatus of a first embodiment of the present invention;

FIG. 2 is a side sectional view of the elastomer imaging apparatus of a second embodiment of the present invention;

FIG. 3 is a side sectional view of the elastomer imaging apparatus of a third embodiment of the present invention;

FIG. 4 is a side sectional view of the elastomer imaging apparatus of a fourth embodiment of the present invention;

FIG. 5 is a side sectional view of a multilayered elastomer in accordance with the principles of the present invention;

FIGS. 6 to 10 are partly schematic, partly side sectional view of various physical applications of the principles of the present invention;

FIG. 11 is a schematic, perspective view of a computer print-out systems using the imaging structures and methods of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The term "elastomer" in the various forms used herein is defined as a usually amorphous material which exhibits a restoring force in response to a deformation; that is, an amorphous material which deforms under a force, and, because of volume and surface forces, tends to return to the form it had before the force was applied.

The first embodiment of the present application shown in FIG. 1 is an elastomeric imaging device in which charges are placed on the surface of the elastomer by means of a corona discharge. Modified forms of a corona discharge device are well known in the art as coratrons or scoratrons. With such a device, positive or negative ions are produced by a high voltage field in a gas and deposited upon the surface.

The apparatus of FIG. 1 includes a substrate 1 which is either conductive or is conductive on one surface thereof. It will most generally be a transparent substrate although, in those cases where light is to be reflected from the elastomer to reconstruct an image, it may be opaque. Substrate 1 may also have a highly reflective mirror finish so that reconstruction light will pass through the elastomer, reflect from it and pass through the elastomer once again; thereby obtaining twice the modulation that a transmissive device will impart. If the substrate is to be transparent, commonly available NESA glass could be used. This is a tin oxide coated glass conductive on the surface corresponding to layer 2 in FIG. 1. Alternatively, it could be a piece of transparent glass with a metallic conductive layer on the surface, a layer thin enough to be transparent. If transparency of the substrate is not important, a metallic substrate may be used. The substrate could be a plastic material such as Mylar or acetate, if flexibility were desired. If substrate 1 is not conductive, layer 2 which is a conductive layer must be added. This is normally a transparent, or partially transparent layer.

The photoconductive layer 3 is a material which will allow the passage of more electric charge in those regions which are exposed to light. This definition of a photoconductor may be extended to any materials in which the conductivity is inhibited by the presence of light. Such a photoconductor is often a mixture of poly-n-vinyl carbazole and a sensitizing dye. The thickness of the photoconductor will probably range from 0.1 microns to 200 microns, depending largely upon the spatial frequency of the information to be recorded.

The elastomer layer 4 may be of a class of elastomeric soft solid materials for use in this application including both natural, such as natural rubbers and synthetic polymers which have rubber like characteristics, i.e., are elastic and include materials such as styrene-butadiene, poly-butadiene, neoprene, butyl, polyisoprene, nitrile and ehtylene propylene rubbers. Preferred elastomers for use in this application include: water based gelatin gels and dimethylpolysiloxane based silicone gels. These materials may be coated on the photoconductor as monomers and polymerized in place or they may be coated on the surface from solutions in volatile solvents which will evaporate and leave a thin uniform layer. In general, these materials should be resonably good insulators, having volume resistivities in excess of 10^4ohm-centimeters.

The preferred elastomer is a transparent composition comprising an elastomeric dimethylpolysiloxane silicone gel made by steps including combining about one part of Dow Corning No. 182, silicone resin potting compound and anywhere from about zero to about thirty parts of Dow Corning No. 200 dimethylpolysiloxane silicone oil. Suitable resins include transparent flexible organosilonane resins of the type described in U.S. Pat. No. 3,284,406 in which a major portion of the organic groups attached to silicon are methyl radicals.

The thickness of the elastomer layer will range from approximately 0.1 microns to approximately 2,000 microns, depending upon the spatial frequency of the information required. Various optical properties of the device may be enhanced by a suitable selection of the elastic modulus of the material used. For example, a stiffer elastomer will recover more rapidly from an image when the electric field is removed, that is, may be erased more quickly. On the other hand, a material having a low elastic modulus will be capable of greater deformations and hence greater optical modulation for a given value of electric field.

The corona charging apparatus 5 may be a stationary charging unit provided such a unit provides enough uniformity of charge deposition, or it may be a scanning system. This device places positive or negative charges on the surface of the elastomer. The voltage drop across the elastomer photoconductive sandwich will lie in the range of 1 to 25,000 volts depending on the modulus of elasticity of the elastomer and its thickness, as well as certain properties of the photoconductor. Particular types of scoratron devices which have been found useful in corona charging are disclosed in the Vyverberg U.S. Pat. No. 2,836,725 and the Walkup U.S. Pat. No. 2,777,957 and assigned to the same assignee as herein. The device should be placed in such a way that will cause minimal interference with light reaching the photoconductor and light used to reconstruct the image. It may be appreciated that substrate 1 or layer 2 in FIG. 1 need not be conductive in the corona charging mode since double sided corona charging may be used to charge a surface of both layer 1 and the elastomer 4, the two charging devices, one on each side of the imaging member, are oppositely charged and are traversed more or less in register. In other words, a second corona charging device may be used to obviate the need for a conductive layer 2 or substrate 1.

In operation, the corona charging apparatus 5 lays charges down on the elastomer layer 4. The sandwich

in FIG. 1 is then exposed, either simultaneously or subsequently to the charging step depending upon the ability of the elastomer to hold charge on its surface, to a light field which must come from the right if substrate 1 is opaque. If substrate 1 is transparent, the light may propagate from either the right or the left. Substrate 1, or the alternate layer 2, are grounded thereby creating an electric field across the photoconductor and elastomer combination. This electric field induces a flow of charge in those regions of teh photoconductor which are exposed to light, varying the electric field across the elastomer. The mechanical force of the electric field across the elastomer causes it to deform. This deformation will proceed until the forces of the electric field are balanced by the surface tension and elastic forces of the elastomer. At this point, the deformation stops and becomes stable as long as the electric fields across the elastomer are maintained. This deformation is different from that occurring in thermoplastic materials in that the elastomer deformations are independent of any developing step such as heat and/or solvent softening steps employed with thermoplastic materials. Another difference between elastomer and thermoplastics is that the elastomer deformations assume a definite limit for a given electric field because elastic forces oppose the deformation. The thermoplastic deformations do not encounter such a definite limit for a given field as long as the thermoplastic is maintained in a softened condition. To erase this image, the field across the elastomer is removed; to erase more quickly the field across the elastomer is reversed. Now the device is ready to accept another image.

In FIG. 2 is a second embodiment wherein an electric field is created across the elastomer 9 and photoconductor layer 8 by means of a thin continuous conductive layer 10 on the surface of the elastomer, which layer is flexible enough to follow the deformations of the elastomer. In the case where this layer is highly reflective, this apparatus will utilize the readout light with great efficiency. If the layer is opaque, light propagating from the left may be used to form the surface deformation image, while simultaneously light propagating from the right may be used to reconstruct the image. The light sources used may be of different wavelengths and/or intensities and/or one light source may be coherent and the other noncoherent. Hence, this device may be used to convert an image formed in one wavelength into an equivalent image formed in a different wavelength. Also, if the readout light incident from the right is very much more intense than the imaging light incident from the left, the apparatus shown in FIG. 2 will provide great amplification of an input image, such amplified light being used, for example, for large panel displays. Furthermore, the reconstruction light may be coherent, e.g., that produced by a laser, so that image processing steps may be performed on the surface deformation image which is formed with non-coherent light propagating from the left. On the other hand, the light giving rise to the surface deformation image may be coherent light while the reconstruction light may be non-coherent. This latter case is desirable because non-coherent light is more pleasing to the human eye and current coherent light generators are limited to production of light within narrow wavelength bands, i.e. one color such as red. A reason for having coherent light for forming the surface deformation image arises when it is the reconstruction light for forming images with holograms. Therefore, the present device may have a holographically reconstructed image projected onto it forming a surface deformation image that is viewed with non-coherent light of substantially greater intensity as suited for large panel displays.

In FIG. 2, as it was for the embodiment shown in FIG. 1, substrate 6 may be transparent or opaque depending upon use. Conductive layer 7 is optional and is used if substrate 6 is not conductive. If substrate 6 is transparent then the conductive layer 7 would generally also be transparent. Over the conductive layer 7 is coated the photoconductive layer 8. Over the photoconductive layer 8 is the elastomer layer 9. The thin conductive layer 10 must be flexible enough to follow the deformations of the elastomer layer 9. If the conductive layer 10 is opaque, for example, a thin metal film, the substrate 6 and conductive layer 7 must be transparent to allow image information to reach the photoconductive layer 8. In this case, image information can be read out continuously if the readout light is incident from the right. If the conductive layer 10 is transparent, light may be reflected from its surface or the device may be used in transillumination, provided substrate 6 and layer 7 are transparent.

Conductive layer 10 may be a thin layer of gold, or a thin layer of indium, or a combination of the two, or other suitable metal layers. The thickness of the metallic layers would normally be between approximately 50 angstroms to several thousand angstroms thick, depending on the desired flexibility, and the necessary conductivity. A transparent conductive layer 10 could also be used, such as Dow Corning resin ECR 34 may be coated on the surface of the elastomer 9. Other conductive layers, such as may occur to one skilled in the art, may also be used within the principles of the present invention. To form and lock the deformation image, the values of voltage between substrate 6 and conductive layer 10 would be approximately between 1 and 25,000 volts, depending on the thickness, and other characteristics, of elastomer 9.

The requirements for conductive layer 10 include: sufficient conductivity to become an equipotental surface when connected to an electrical energy source; sufficient flexibility to follow the deformations of the elastomer; sufficient fatigue resistance to withstand numerous and rapid formations and erasures of surface deformations; and, in some cases, high opacity and reflectivity as when being read out by a high intensity light source to which the photoconductive layer is sensitive.

The preferred materials for conductive layer 10 include gold and indium. The layer is formed by steps including vapor depositing the materials onto the elastomer which involves heating a material to or above its melting point and condensing the vapors on the desired surface. This technique is well understood in the art and conventional practices are followed in evaporating and condensing the materials. However, a problem associated with shrinkage of a condensed metal layer is overcome by novel techniques in order to fabricate a conductive layer 10 meeting the above requirements. Vapor deposited metals tend to shrink, i.e. contract, as they cool and at some thermo-energy state the metal layer tends to break up or crack making the layer discontinuous. This break up of a metal layer is referred to herein as "mud-cracking" since mud cracks are broadly descriptive of the appearance of the layer after

shrinkage. The instant novel technique includes vapor depositing a second metal over the first before the first has mudcracked. The two materials may be vapor deposited simultaneously. The second metal is selected so as to have a lower melting point than the first deposited metal. The final product is a continuous layer meeting the above requirements which yet does not experience mud cracking over a wide range of temperatures. The described layer may include portions where the two metals (or other suitable materials) are coated one over the other, portions where the two metals are intermixed macroscopically as well as microscopically (e.g., to form an alloy) and portions where they reside side by side. Naturally, additional materials may be added to the layer to enhance or suppress particular characteristics.

One theory, to which this invention is not limited, that explains why mud cracking is suppressed in the above multiple component layer, is connected with the relative mobility of atoms at the surfaces of the different materials. The atoms of high melting point materials normally exhibit low surface mobility which gives rise to the mud cracking when the metals are coated over an elastomer. The atoms of lower melting point materials exhibit by comparison much greater surface mobility and their presence enables the stresses developed in the high melting point material to be relieved.

The preferred materials of gold and indium have high and low melting points respectively. Mud cracking is usually observed in vapor deposited gold layers within minutes after cooling to room temperatures. This usually provides ample time to vapor deposit the indium onto the gold layer. An example of a highly successful coating is one formed by depositing from 50 to several thousand angstroms of gold followed by depositing onto this gold layer from 50 to several thousand angstroms of indium. The resultant layer is continuous and exhibits no mud cracking over a wide range of temperatures. The indium is particularly advantageous because it increases the opacity of the resultant layer and, because of its silver appearance, enhances the reflectivity of the layer.

It is noted that indium by itself is not a highly efficient material for layer **10** because of poor conductivity. The poor conductivity is peculiar to low melting point materials because they tend to form islands during condensation which do not join together into a continuous layer of a reasonable thickness. Accordingly, it is observed that vapor deposition of single materials (or alloys thereof), whether high or low melting point materials, yields layers that are less satisfactory than the layer comprised of high and low melting point materials.

Other suitable high melting point materials besides gold include aluminum, silver, magnesium, copper, cobalt, iron, chromium, nickel and others. Aluminum has the further desirable property of being highly corrosion resistant. Other suitable low melting point materials besides indium include gallium, cadmium, mercury, lead and others. Cadmium by itself exhibits a low tendency to mud cracking.

Of course, the foregoing problems of mud cracking and island forming may not arise if the conductive layer **10** is formed by chemical reaction, precipitation out of a solution, electrophoresis, electrolysis and/or other techniques.

Over the conductive layer **10** in FIG. **2** may also be an optional transparent insulating layer of oil. Its purpose is to make less stringent the fabrication requirements for this apparatus. The presence of pin holes in the elastomer layer **9** may cause the apparatus in FIG. **2** to short circuit, possibly destroying its performance. The addition of the layer **12** prevents such short circuits from disrupting the performance of the device by allowing insulating oil to flow into such pin holes.

Layer **12** serves another important function when it has an index of refraction different than air. The presence of oil **12** over the conductive layer **10** means light propagating from the right will be modulated more than it would be if only air was present. The reason being is that for the same magnitude of surface deformation the optical path changes are proportional to the refraction index of the medium adjacent to the surface.

Power supply **11** of FIG. **2** provides DC voltage of one polarity to form a deformation image on the surface of the elastomer. The polarity required depends upon the nature of the photoconductor. Power supply **11** must be capable of being turned off to erase the image, or, undergo a shift in polarity to more rapidly erase the image. For a television type of picture wherein approximately 30 images per second are formed, stored and erased, the power supply must be capable of undergoing such cycles with appropriate speed. The extent of the deformation and the rapidity with which information may be erased is dependent upon the voltages supplied by the power supply. The stability of the voltage output of the power supply must be great enough to prevent unwanted erasure of the image. An alternate scheme for erasing the surface deformation image is to position a strobe light at the left in FIG. **2** to flood the photoconductive layer **8** with light thereby erasing the modulated field pattern across the structure set up by the imagewise light. This operation is appropriate as long as the fields across the elastomer layer **9** are below a level causing the surface deformations to be locked.

The embodiment in FIG. **3** employs a very thick conductive liquid **16** in contact with elastomer **15** to provide the necessary electric field across the elastomer/photoconductor sandwich. The other components of the apparatus of FIG. **3** are similar to those in FIGS. **1** and **2**. That is, substrate **12** may be transparent or opaque and in turn may or may not be conductive. Conductive layer **13** must be present if substrate layer **12** is not conductive. If substrate **12** is transparent then conductive layer **13** will normally also be transparent. Coated on the conductive layer **13** are the photoconductor layer **14** and the elastomer layer **15**.

The thick conductive liquid **16** in FIG. **3** may or may not be transparent. Non-transparent conductive fluids include mercury, room-temperature molten gallium-indium alloys, etc. Transparent fluids include water to which conductive impurities have been added. If transparent, the fluid **16** should have a substantially different refractive index than the elastomer **15** in order that deformations of the elastomer surface will phase modulate the illuminating light. A transparent fluid may also be used for reflection, which may be enhanced by placing a thin flexible transparent layer on the elastomer **15** having a substantially different refractive index than either the elastomer or the transparent conducting fluid. Window layer **18** could be of normal optical

property glass which contains the conductive fluid against the elastomer layer **15.** Power supply **17** supplies the necessary operating potential to the apparatus in FIG. **3.** It is noted that most conducting transparent fluids will undergo electrolysis in a DC electric field. This is undesirable because it leads to a deterioration of the operating components of the apparatus, as well as the evolution of gas. Thus, operation with conductive transparent fluids would normally require the use of an AC field across the elastomer/photoconductor sandwich.

The fourth embodiment is illustrated in FIG. **4.** This embodiment is essentially identical to the embodiment illustrated in FIG. **3,** except that the thick conductive layer **16** in FIG. **3** is replaced by a conductive gas **22** and requires an electrode **23** which may be a transparent conducting window. The conductive gas in cavity **22** may be obtained by means of a glow discharge through a low pressure gas of a few millimeters of mercury pressure, or by means of a low pressure arc discharge which commonly takes place at a few microns of mercury pressure. The gas may also be ionized by means of intense radioacitvity in or near a low pressure gas **22** or radio frequency excitation of the gas in cavity **22** or other techniques for producing a conductive gaseous plasma well known in the art. Charging of the elastomer surface **21** may also take place if gas **22** is at a sufficiently high vacuum and contains a source of thermally excited electrons, such as a heated tungsten filament, which is directed against the elastomer surface. This may be a scanned beam as from an electron gun, or an unscanned beam, or from a multiplicity of electron emitting sources. A reflective layer may also be placed over layer **21** on the surface interface between layers **21** and **22.**

Apart from the conductive gas **22** in FIG. **4,** the components thereof are similar to that as shown in FIG. **3.** That is, substrate **18** would have a conducting layer **19** thereon with transparency or not as set forth above. Photoconductive layer **20** and elastomer layer **21** are placed over the conductive layer **19.** Here, however, the conductive gas **22** may be between **0.1** microns thick to an indefinite thickness. As set forth above, electrode **23** may be a separate electrode or may be coupled to a transparent conducting window to contain the conductive gas against the elastomer layer **21.** The container for withholding the conductive gas **22** from escaping would, of course, have to be airtight to contain the gas at the necessary level of vacuum.

The embodiment of FIG. **4** is particularly suited for holographic interferometry because the input light can be transmitted through it to form a composite image with the output light. Therefore, a holographically reconstructed image of an object may be superimposed upon the actual image of the object to obtain interference fringes as a result of dimensional changes.

Apart from comprising a novel imaging technique for imaging on an elastomer layer, the embodiment in FIG. **4** teaches a novel technique for charging a surface without the use of the prior art corona discharging devices such as a corotron or a scorotron. The limitations of the corotron and the scorotron are that the power requirement is high in relation to the density of charge placed on the receptive layer. Further, corotrons and scorotrons being corona discharge devices must normally have a relative motion between the corona discharge device and the receptive layer. In prior art devices such as normally utilized in xerographic machines, an electrophotographic drum such as an aluminum drum overcoated with selenium, is rotated about a central axis past a corona discharge device such as the corotron or scorotron hereinabove set forth. Additionally, the corona discharge device could be advanced past a receptive layer, for example, in a situation where the receptive layer is flat with respect to the path of movement of the corona discharge device. Further, the fact that the prior art corona discharge devices operate in a normal room environment, that is, with normal air of varying humidities, the charge laid upon a receptive layer is not as accurate as could be desired. The embodiment set forth in FIG. **4,** however, overcomes these disadvantages by utilizing the conductive gas in a predetermined vacuum, the level of charge placed upon a receptive layer can be precisely determined. If the conductive gas is coupled to a vacuum pump, the evacuated pressure and/or the potential applied to the electrode **23** may be controlled to specifically predetermine the charge generated on the receiving layer.

A number of variations of the various elements may be substituted for those used in the imaging devices set forth above in the embodiments disclosed in FIGS. **1** to **4.** Thus, any one of any combination of the elements hereinafter described may be substituted for a corresponding element hereinabove described.

With respect to the photoconductive layers hereinabove described, in addition to the brilliant green dye produced by the J. T. Baker Chemical Co. which is added to the poly-n-vinyl carbazole photoconductor to sensitize it for red light, other dyes may also be used for sensitization, such as trinitro-9-fluorene for blue light sensitivity. Finely ground pigments such as phthalocyanine may also be added to the poly-n-vinyl carbazole to obtain visible light sensitivity. Other organic photoconductors known in the art may also be utilized effectively. In addition, non-organic photoconductors, such as selenium and selenium alloys, may also be used.

Adjacent photoconductor and elastomer layers may be replaced by a single layer of a photoconductive elastomer under some circumstances, in all embodiments hereinabove set forth. For example, the elastomer made by combining sylgard **184** with dimethylpolysiloxane oils may be made photoconductive for blue or ultraviolet light by adding p-phenylenediamine, indoform and Calco oil orange dye manufactured by the American Cyanamid Company prior to the curing thereof.

With respect to the elastomer layers, a thin elastomer layer is capable of undergoing appreciable elastic deformation for only a limited bandwidth of spatial frequencies. Its response outside this bandwidth is quite limited. The spatial frequency response of the elastomer may be broadened or made multiply peaked by replacing the single elastomer layer with a multiply layered apparatus as illustrated in FIG. **5.** Each of these layers **25, 26, 27** and **28** will have a different limited spatial frequency response, but the combination of layers will have a broad or multiply peaked spatial frequency response. In general, it will be noted that the thickest layer **25** will be placed closest to the photoconductor and the thinnest layer **28** will have the deformable surface. Two or more of such layers may be used as desired. As described previously, each of these layers may also be photoconductive, eliminating the need

for a separate photoconductor and in some instances enhancing the resolution of the device.

It should also be noted that in addition to controlling the thickness of the elastomer layer to peak its spatial frequency response for a given spatial frequency bandwidth, its elastic modulus will also be controlled to obtain deformations commensurate with that spatial frequency bandwidth. Materials of lower elastic modulus are capable of greater elastic deformations. On the other hand, materials of higher elastic modulus may be more quickly erased. Such factors must be taken into account when designing the apparatus for speed or greater deformation.

In several of the above embodiments, there is described the reflection of light from the elastomer surface. Numerous methods known in the art are available fo enhancing such reflection. In addition to these, the previously mentioned thin layers of gold or indium, and/or other suitable metals, vacuum deposited on the surface of the elastomer provide a highly reflective surface that is sufficiently smooth to cause little optical noise. These metal depositions do not appear to appreciably change the elastic behavior or the electrical insulating properties of the elastomer surface, but it greatly enhances the reflective power of such surfaces.

It has hereinabove been set forth that the elastomer surfaces as described herein may be used for the recording, storage and erasure of image information over a great many cycles, provided that the electric fields across the elastomer are not allowed to become excessively great. When these fields do become great enough that the deformations of the elastomer surface exceed the elastic limit of the elastomer, it has been observed that the image is permanently recorded on the elastomer. The upper limit on the electric field applied to the previously mentioned dimethylpolysiloxane silicone gel is observed to be about 100 volts per micron. While for many systems this is regarded as undesirable, there are those in which it is also desired to record a permanent image. Thus, the cyclic properties of the elastomer may be used in an attempt to obtain a satisfactory image, which is then permanently recorded by an over voltage application.

FIGS. **6** through **10** show actual physical embodiments of imaging systems which could utilize the inventive principles of the present invention. FIG. **6***a*, for example, shows a frost or screened frost imaging technique with the elastomer sandwich. A light source would impinge upon an object, the reflected light from which would be focused onto the imaging sandwich. The elastomer surface would record the image as set forth in the embodiments of FIGS. **1** to **4.** Readout of the imaging sandwich is effected in FIG. **6***b*. The light source would illuminate the elastomer surface of the sandwich, the reflected light from which would be reflected away from the elastomer surface in the unfrosted areas, while the light impinging thereon would be scattered when reflected by the frosted area of the image. Such scattered light from the frosted areas would enter the lens and would form an image at the image plane. For this image, frosted areas would appear right, unfrosted areas dark, yielding a positive image having bright and dark areas corresponding to those of the original object.

If the light source were a coherent light source as from a laser, the system set forth in FIG. **6** could be utilized to record a hologram. That is, the light source in FIG. **6***a* would be extended to impinge directly upon the imaging sandwich as a reference beam to coact with the object modulated beam from the object to form a holographic image at the imaging sandwich. Upon reconstruction, the light source would be a similar light source which would impinge upon the imaging sandwich as indicated in FIG. **6***b*. In FIG. **6***b*, however, the lens would be unnecessary to form the reconstructed image.

The apparatus in FIGS. **6***a* and **6***b* are pertinent to the embodiments shown in FIGS. **1** to **4.** With regard to the embodiemnt shown in FIG. **2,** if conductor **10** is transparent, the readout light may be incident from either the left or the right. If the layer **10** is opaque, the readout light may be incident from the left. In this latter case, the image may be readout at the same time the image is being recorded. With regard to the embodiment shown in FIG. **3,** if fluid **16** is transparent, the readout light may be incident from either the right or the left. If the fluid is opaque, the readout light must be incident from the left.

FIG. **7** of the present application shows another structure which utilizes the principles of the present invention. In a manner similar to that for FIG. **6***a*, the light source impinges upon the object, the reflection from which is imaged by the lens onto the imaging device. With the technique utilized in FIGS. **1** to **4,** the elastomer in the presence of the electrical field records the image impinged thereon. Upon reconstruction, in FIG. **7,** the light source now illuminates the recorded image on the elastomer layer. The reflection from the elastomer layer is gathered by the lens which images the reflected image onto a plane. Between the plane and the lens is a focus point for the lens which, by the use of a spatial filter, causes a positive or negative image to be generated at the image plane. That is, a frost image reflects high frequency spatial frequencies while the unfrosted areas reflect very low frequency spatial frequencies. Thus, a solid spatial frequency filter placed at the focal point for the lens filters the low frequency spatial signals while allowing the high frequency spatial signals to be passed and imaged on the image plane as a positive image. For a negative image, an annular spatial filter is utilzied which filters the high frequency spatial signals while passing the low frequency spatial frequency signals. The embodiments shown in FIG. **7** are applicable to the embodiments set forth in FIGS. **1** to **4** and are additionally applicable in the production of a hologram as set forth above.

FIG. **8** shows an additional embodiment utilizing the principles of the present invention, the image thereof being recorded in a manner similar to that set forth in FIG. **6***a*. Upon reconstruction, however, the light source would be transmitted through the elastomer layer rather than reflecting from it as set forth in FIGS. **6** and **7.** Again, for either a positive or negative image, the particular spatial filter is required. This embodiment is pertinent to FIGS. **1** through **4** as were the embodiments in FIGS. **6** and **7.** With respect to FIG. **2,** the embodiment therein is to be utilized only if the conductive layer **10** is transparent. With respect to the embodiment in FIG. **3,** the embodiment therein can be utilized only if the conductive fluid **16** is transparent.

FIG. **9** shows apparatus utilizing the principles of the present invention wherein the construction and reconstruction steps occur simultaneously with similar or different light sources. That is, light from an object illumi-

nated with light of a given wavelength and intensity is focused on the photoconductor of the imaging sandwich. Simultaneously, light of a possibly different wavelength and/or intensity is reflected from the coated surface of the elastomer. This image is converted to an intensity image at the image plane as was set forth above in conjunction with FIG. **6.** The apparatus of FIG. **9** can be extended as was the apparatus of FIGS. **6** and **7** for the construction of a hologram. That is, in FIG. **9** the illumination light source would not only be impinged upon the object to generate an object modulated wavefront, but would be impinged upon the imaging sandwich as a reference beam. Then, at the surface of the elastomer, a hologram would be constructed in accordance with the object and reference wavefronts. Of course, the illumination light source must now be coherent as from a laser source, for example. Upon readout, a coherent light source would impinge upon the other side of the imaging sandwich, the light diffracted therefrom forming the reconstructed image. Here, of course, the lens system would not be necessary. FIG. **9** is pertinent to the embodiment set forth in FIG. **2** for simultaneous image recording and readout primarily if a reasonably opaque metal is used for layer **10,** or if the readout wavelength is non-actinic for the photoconductor. That is, the photoconductive layer of the imaging sandwich cannot be sensitive to the readout light source or else the readout light source will affect the generation of the image on the elastomer surface. If these conditions do not hold, FIG. **9** is pertinent to the embodiment set forth in FIG. **2** primarily if the image is first formed and subsequently read out. That is, readout light would not be present during image forming in sufficient intensity to interfere with image forming. FIG. **9** is also pertinent to the embodiments shown in FIGS. **1, 3** and **4** for simultaneous image recording and readout. It is also pertinent to the use of high and low pass spatial filters, depending upon the generation of a positive or negative image.

FIG. **10** utilizes the imaging sandwich for holographic recording. In FIG. **10***a*, a laser source would impinge upon the object by means of reflection from a mirror, for example, while an unobstructed reference beam would impinge upon the imaging sandwich. The modulated beam from the object would coact with the reference beam within the photoconductor layer forming a holographic image therein. By deleting the mirror and the object itself, the laser source can be used to reconstruct the image for an observer as shown in FIG. **10***b*. Thus, FIG. **10** shows the use of the imaging sandwich to record a holographic interference pattern instead of a focused image. Those comments set forth above for FIG. **8** would apply here except it is noted that for readout the impinging wavefront must be coherent.

The system illustrated schematically in FIG. **11** employs a cyclic imaging member **51** according to the present invention and preferably the embodiment represented by FIG. **2.** The portion **52** represents the transparent substrate, conductive layer and photoconductor while portion **53** represents an elastomer layer overcoated with an opaque, reflective, electrically conductive layer which deforms with the elastomer. The system utilizes the imaging member **51** as a buffer storage device between devices such as a digital and/or analog computer, the output of which is represented by the arrow **54,** and the xerographic reproduction apparatus **55.** The buffer storage device permits asynchronous operation of the computer and xeropraphic apparatus.

Digital information is converted to analog information by the analog to digital converter **57** which develops appropriate signals for driving the cathode ray tube (CRT) **58.** Conventionally, electron beam position information is fed to the cRT through appropriate vertical and horizontal deflection circuits **59** and **60,** respectively, and beam intensity formation is fed to the CRT through an appropriate brightness circuit **61.** The CRT normally includes a phosphor screen **62,** or the like, which remains illuminated sufficiently long after the scanning beam has passed to form a full frame image over its face. Alternately, the screen may be illuminated substantially only at areas at which the scanning beam currently resides. In either case, the member **51** is able to record the loci of the beam and retains the information for a comparatively long period of time as long as an electric field is applied across the elastomer. Consequently, a two dimensional image may be formed on the surface of the CRT by any scanning or raster pattern and be simultaneously or subsequently recorded as a surface deformation image on member **51.** Appropriate lens elements **63** are interposed between the photoconductor on member **51** and the screen **62** to create the surface deformation image. The photoconductor in the member **51** must be sufficiently sensitive to respond to the relatively low levels of light available from CRT displays. Selenium and selenium arsenic alloys are examples of photoconductors having sensitivities in the order of 1 erg/cm^2 which are capable of rapid response to the light levels associated with CRT displays.

The surface deformation image created on portion **53** of member **51** is simultaneously or subsequently read out by appropriate means such as that including lamp **65** and lens **66.** The lamp is a non-coherent light source of high intensity. As explained earlier, the light is diffracted by the surface deformation image, is collected by appropriate lens elements **66** and focused onto a plane tangent to drum **71.** The image temporarily recorded on member **51** is permanently recorded by the xerographic recording system **55.** Lens element **66** scans an image on member **51** synchronously with rotation of the xerographic drum **71.** The temporary image is projected in a line-by-line fashion through the slot in light shield **70** to a line on drum **71** defined by point **72.** The scanning arrangement shown in representative and special consideration is given in an actual machine to compensate for changing distances between lens **66** and image point **72.** For example, the focal length of lens **66** may be that distance between the lens and point **72** when the lens is at the midpoint in its scanning path as shown. The amount of out-of-focus when the lens is at other points in the scan path indicated by the phantom lines of a lens is minimized by techniques known in the art.

The xerographic drum includes a photoreceptor coated onto a grounded conductive drum. The photoreceptor is charged by a corotron **73** and a latent electrostatic image is created on this charged surface as the drum moves past the shield **70.** The latent image is developed by appropriate apparatus such as a cascade developer **74** that pours microscopic toner particles onto the drum that adhere in the image areas. The developed latent image, i.e., the toner image, is transferred to web **75** by electrostatics when corotron **76** deposits

charge of appropriate polarity on the back side of the web. The toner image is permanently fixed to the web by heating the toner as with fuser 77. The drum surface is cleaned by means 78, e.g., a brush, flooded with light by lamp 79 and recharged by corotron 73 to prepare for the formation of another toner image.

When two or more imaging members 51 are arranged in parallel, one can be used to record information generated on the CRT while other imaging members are being read out by having their recorded information projected onto a recording medium such as the xerographic apparatus.

The above described systems are highly advantageous because analog and digital computers often generate information in irregular time intervals whereas xerographic and other recording apparatus operate on highly organized information and employ fixed operating cycles. The image device 51 bridges the gap because it is able to: record irregularly generated information; hold the information in a highly organized state for getting into phase with the reproduction cycle of xerographic or other imaging device; rapidly erase the recorded information; and immediately record new information.

The xerographic apparatus 55 may be replaced by other recording materials and/or apparatus. For example, photographic type films having sensitivities far too insensitive to respond to the light levels generated by a CRT display may be used because the necessary energy levels can be supplied by lamp 65. Vesicular duplicating films available from the Kalvar Corp. of New Orleans, La. are examples of such films.

In the foregoing there has been disclosed methods and apparatus indicating the application of elastomers to various imaging apparatus as described herein. By the use of an elastomer material, there is obtained a fully cyclical imaging apparatus on which images may be recorded, stored for short periods of time and erased at will. In the specification herein, specific materials and construction have been discussed with regard to the makeup of the imaging sandwich, but it is obvious that other construction may be available utilizing the elastomer material without deviating from the principles of the present invention. Therefore, while the invention has been described with reference to specific embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt to a particular situation without departing from the essential teachings of the invention.

What is claimed is:

1. Imaging apparatus comprising

an imaging member comprising a layer of photoconductive material, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising gold and indium, said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

2. The apparatus of claim 1 wherein said second light means includes lens means for gathering readout radiation diffracted by deformed areas of the imaging member for constructing said corresponding image.

3. The apparatus of claim 2 wherein said second light means includes spatial filter means for generating positive and negative images from said readout radiation gathered by said lens.

4. The apparatus of claim 2 wherein said input and readout radiation include coherent radiation and said first light means includes means for superimposing input radiation not modulated by an object and said modulated input radiation onto the imaging member to expose the imaging member to the interference pattern created by the superposition of the modulated and unmodulated input radiation.

5. The apparatus of claim 1 further including means for simultaneously directing said input and readout radiation onto said imaging member.

6. The apparatus of claim 1 wherein one of said input and output radiation includes coherent radiation and the other includes non-coherent radiation.

7. The apparatus of claim 1 wherein said imaging member is transparent and said first and second light means include means for directing said input and readout radiation onto said imaging member from the same side.

8. The apparatus of claim 1 wherein said flexible conductive member is substantially reflective of said readout radiation and said substrate is substantially transparent to said input radiation.

9. Imaging apparatus comprising

an imaging member comprising a layer of photoconductive material, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising gold and indium, said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

a cathode ray tube for generating on a screen radiation to which the photoconductive material of said imaging member is responsive and

means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

10. The apparatus of claim 9 further including means for directing readout electromagnetic radiation onto said deformable conductive layer to construct an image corresponding to deformations on the elastomer layer.

11. The apparatus of claim 10 further including recording means for recording the constructed image corresponding to deformations on the elastomer layer.

12. The apparatus of claim 11 wherein said recording means includes xerographic recording apparatus.

13. The apparatus of claim 12 wherein said xerographic recording apparatus includes a rotating xerographic drum.

14. The apparatus as defined in claim 1 wherein said imaging member further includes a substrate for supporting the layers of said imaging member.

15. The apparatus as defined in claim 14 wherein said substrate is a transparent conductive substrate.

16. The apparatus as defined in claim 1 wherein said imaging member further includes a layer of insulating liquid overlying said deformable conductive layer.

17. The apparatus as defined in claim 1 wherein said imaging member further includes means for spatially modulating an electric field across said elastomer layer at a frequency within the spatial frequency deformation capability of the elastomer layer.

18. The apparatus as defined in claim 9 wherein said imaging member further includes a substrate for supporting the layers of said imaging member.

19. The apparatus as defined in claim 18 wherein said substrate is a transparent conductive substrate.

20. The apparatus as defined in claim 9 wherein said imaging member further includes a layer of insulating liquid overlying said deformable conductive layer.

21. The apparatus as defined in claim 9 wherein said imaging member further includes means for spatially modulating an electric field across said elastomer layer at a frequency within the spatial frequency deformation capability of the elastomer layer.

22. Imaging apparatus comprising

an imaging member comprising an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm., said elastomer layer including photoconductive material, and a deformable conductive layer overlying said elastomer layer, said deformable conductive layer comprising gold and indium, said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing said photoconductive material to electromagnetic radiation to which it is responsive;

first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

23. The apparatus as defined in claim 22 wherein said imaging member further includes a substrate for supporting the layers of said imaging member.

24. The apparatus as defined in claim 23 wherein said substrate is a transparent conductive substrate.

25. The apparatus as defined in claim 22 wherein said imaging member further includes a layer of insulating liquid overlying said deformable conductive layer.

26. The apparatus as defined in claim 22 wherein said imaging member further includes means for spatially modulating an electric field across said elastomer layer at a frequency within the spatial frequency deformation capability of the elastomer layer.

27. The apparatus as defined in claim 22 wherein said second light means includes lens means for gathering readout radiation diffracted by deformed areas of the imaging member for constructing said corresponding image.

28. The apparatus as defined in claim 27 wherein said second light means includes spatial filter means for generating positive and negative images from said readout radiation gathered by said lens.

29. The apparatus as defined in claim 22 wherein said input and readout radiation include coherent radiation and said first light means includes means for superimposing input radiation not modulated by an object and said modulated input radiation onto the imaging member to expose the imaging member to the interference pattern created by the superposition of the modulated and unmodulated input radiation.

30. The apparatus as defined in claim 22 further including means for simultaneously directing said input and readout radiation onto said imaging member.

31. The apparatus as defined in claim 22 wherein one of said input and output radiation includes coherent radiation and the other includes non-coherent radiation.

32. The apparatus as defined in claim 22 wherein said imaging member is transparent and said first and second light means include means for directing said input and readout radiation onto said imaging member from the same side.

33. The apparatus as defined in claim 23 wherein said deformable conductive layer is substantially reflective of said readout radiation and said substrate is substantially transparent to said input radiation.

34. Imaging apparatus comprising

an imaging member comprising an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm., said elastomer layer including photoconductive material, and a deformable conductive layer overlying said elastomer layer, said deformable conductive layer comprising gold and indium, said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing said photoconductive material to electromagnetic radiation to which it is responsive;

a cathode ray tube for generating on a screen radiation to which the photoconductive material of said imaging member is responsive and

means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

35. The apparatus as defined in claim 34 wherein said imaging member further includes a substrate for supporting the layers of said imaging member.

36. The apparatus as defined in claim 35 wherein said substrate is a transparent conductive substrate.

37. The apparatus as defined in claim 34 wherein said imaging member further includes a layer of insulating liquid overlying said deformable conductive layer.

38. The apparatus as defined in claim 34 wherein said imaging member further includes means for spatially modulating an electric field across said elastomer layer at a frequency within the spatial frequency deformation capability of the elastomer layer.

39. The apparatus as defined in claim 34 further including means for directing readout electromagnetic radiation onto said deformable conductive layer to construct an image corresponding to deformations on the elastomer layer.

40. The apparatus as defined in claim 34 further including recording means for recording the constructed image corresponding to deformations on the elastomer layer.

41. The apparatus as defined in claim 40 wherein said recording means includes xerographic recording apparatus.

42. The apparatus as defined in claim 41 wherein said xerographic recording apparatus includes a rotating xerographic drum.

43. Imaging apparatus comprising

an imaging member comprising a substrate, a layer of photoconductive material overlying said substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising first and second metal materials, wherein said first metal material is chosen from the group consisting of gold, aluminium, silver, magnesium, copper, cobalt, iron, chromium and nickel, said second metal material is chosen from the group consisting of indium, gallium, cadmium, mercury and lead and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

44. Imaging apparatus comprising

an imaging member comprising a substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. overlying said substrate, said elastomer layer including photoconductive material and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising first and second metal materials, wherein said first metal material is chosen from the group consisting of gold, aluminium, silver, magnesium, copper, cobalt, iron, chromium and nickel, said second metal material is chosen from the group consisting of indium, gallium, cadmium, mercury and lead, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electric field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

45. Imaging apparatus comprising

an imaging member comprising a substrate, a layer of photoconductive material overlying said substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising first and second metal materials, wherein said first metal material is chosen from the group consisting of gold, aluminium, silver, magnesium, copper, cobalt, iron, chromium and nickel, said second metal material is chosen from the group consisting of indium, gallium, cadmium, mercury and lead and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

a cathode ray tube for generating on a screen rediation to which the photoconductive material of said imaging member is responsive and

means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

46. Imaging apparatus comprising

an imaging member comprising a substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. overlying said substrate, said elastomer layer including photoconductive material and a deformable conductive layer adjacent said elastomer layer, said deformable conductive layer comprising first and second metal materials, wherein said first metal material is chosen from the group consisting of gold, aluminium, silver, magnesium, copper, cobalt, iron, chromium and nickel, said second metal material is chosen from the group consisting of indium, gallium, cadmium, mercury and lead, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electric field across said elastomer layer by exposing the photoconductive material to electromagnetic radiation to which it is responsive;

a cathode ray tube for generating on a screen radiation to which the photoconductive material of said imaging member is responsive and

means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

47. Imaging apparatus comprising
an imaging member comprising a substrate, a layer of photoconductive material overlying said substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable layer of conductive gas adjacent said deformable elastomer layer, said conductive layer including means for ionizing said conductive gas, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing said member to electromagnetic radiation to which said photoconductive material is responsive;
first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

48. Imaging apparatus comprising
an imaging member comprising a substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. overlying said substrate, said elastomer layer including photoconductive material and a deformable layer of conductive gas adjacent said deformable elastomer layer, said conductive gas layer including means for ionizing said conductive gas, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electric field across said elastomer layer by exposing said member to electromagnetic radiation to which said photoconductive material is responsive;
first light means for generating input electromagnetic radiation to which said imaging member photoconductive material is responsive, for object modulating said input radiation and for exposing said imaging member to said modulated input radiation and

second light means for generating readout electromagnetic radiation and for directing said readout radiation onto said imaging member for constructing images corresponding to the deformations of the elastomer layer.

49. Imaging apparatus comprising
an imaging member comprising a substrate, a layer of photoconductive material overlying said substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. adjacent said photoconductive material layer and a deformable layer of conductive gas adjacent said deformable elastomer layer, said conductive gas layer including means for ionizing said conductive gas, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by altering an electrical field across said elastomer layer by exposing said member to electromagnetic radiation to which said photoconductive material is responsive;
a cathode ray tube for generating on a screen radiation to which the photoconductive material of said imaging member is responsive and
means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

50. Imaging apparatus comprising
an imaging member comprising a substrate, an electric field deformable elastomer layer having a volume resistivity above about 10^4 ohm-cm. overlying said substrate, said elastomer layer including photoconductive material and a deformable layer of conductive gas adjacent said deformable elastomer layer, said conductive gas layer including means for ionizing said conductive gas, and said elastomer layer being capable of deforming to correspond to an electric field pattern created by allowing an electric field across said elastomer layer by exposing said member to electromagnetic radiation to which said photoconductive material is responsive;

a cathode ray tube for generating on a screen radiation to which the photoconductive material of said imaging member is responsive and
means for projecting radiation generated on said screen onto said imaging member to deform the elastomer layer according to patterns formed by said radiation.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,842,406 Dated October 15, 1974

Inventor(s) Nicholas K. Sheridon

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 55 after "respectively" insert --- now U.S. Patent 3,719,483 and U.S. Patent 3,698,893, respectively --- .

Column 6, line 7 "ehtylene" should read --- ethylene --- .

Column 7, line 10 "teh" should read --- the --- .

Column 14, line 12 "embodiemnt" should read --- embodiment --- .

Column 16, line 7 "cRT" should read --- CRT --- .

Claim 4, line 1 "2" should read --- 1 --- .

Claim 8, line 1 "1" should read --- 14 --- .

Signed and sealed this 31st day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

ORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

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