

May 28, 1968

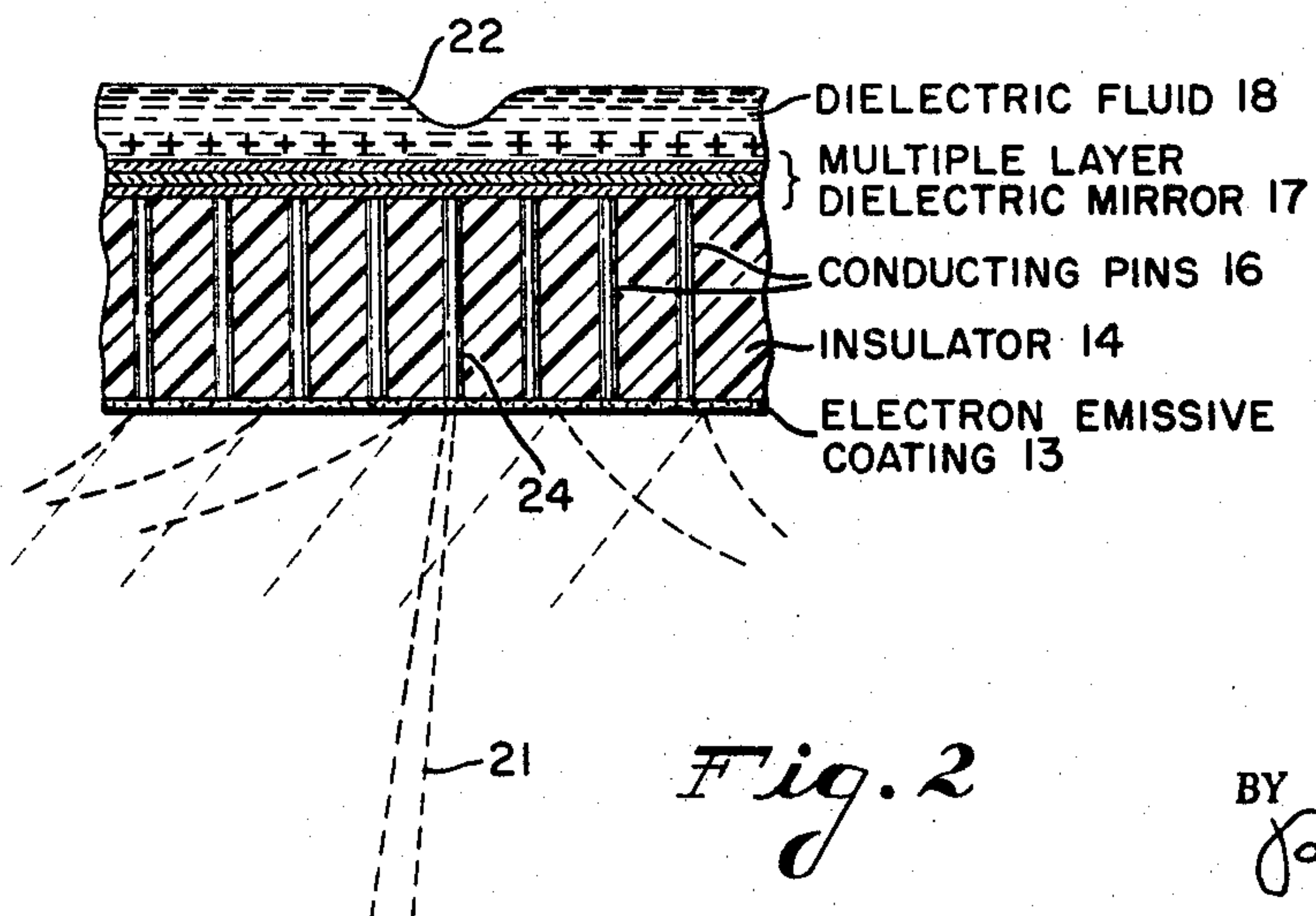
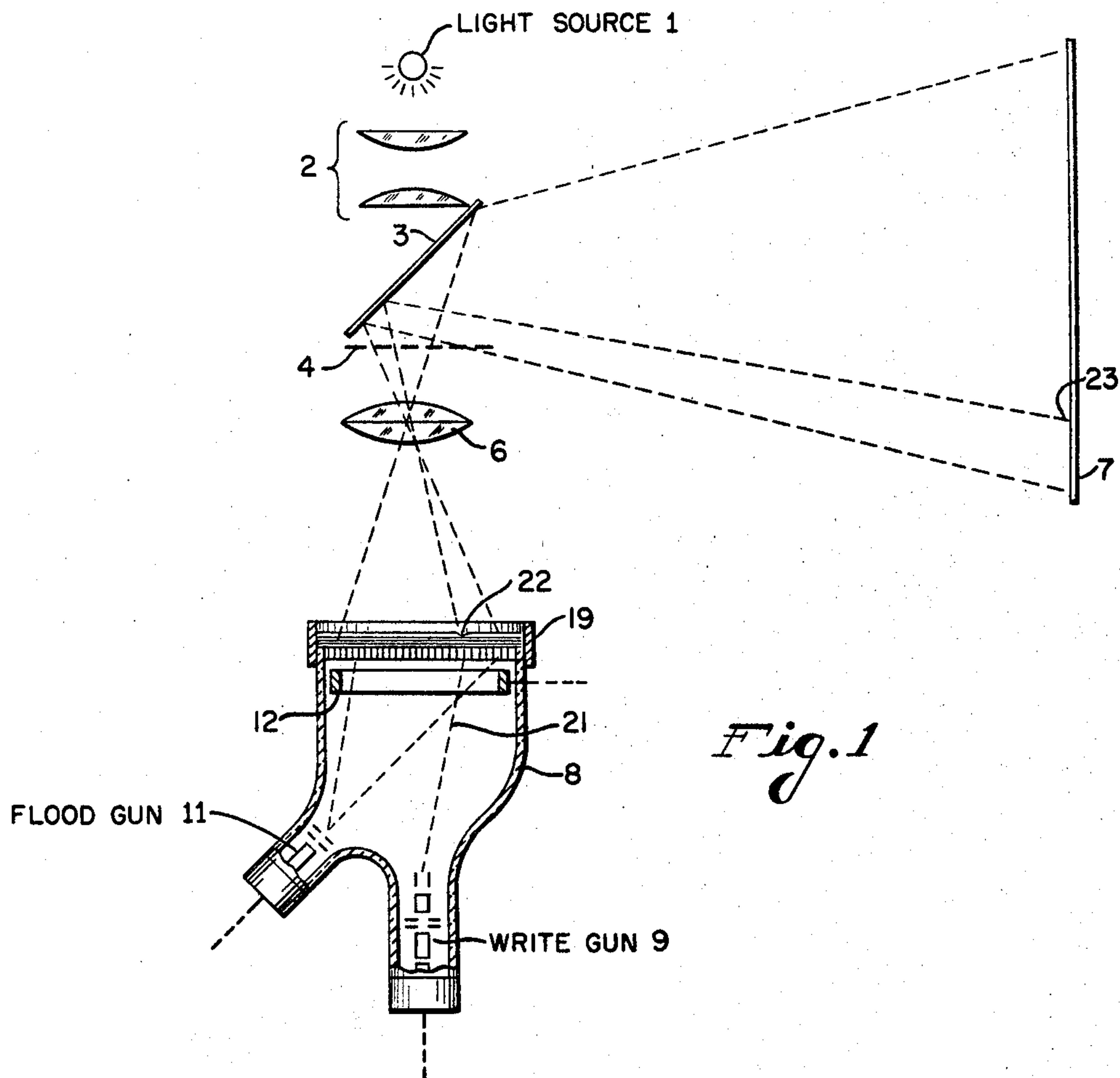
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3,385,927

DISPLAY DEVICE UTILIZING A MEDIUM THAT ALTERS  
THE DEGREE OF REFRACTION OF LIGHT

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2 Sheets-Sheet 1



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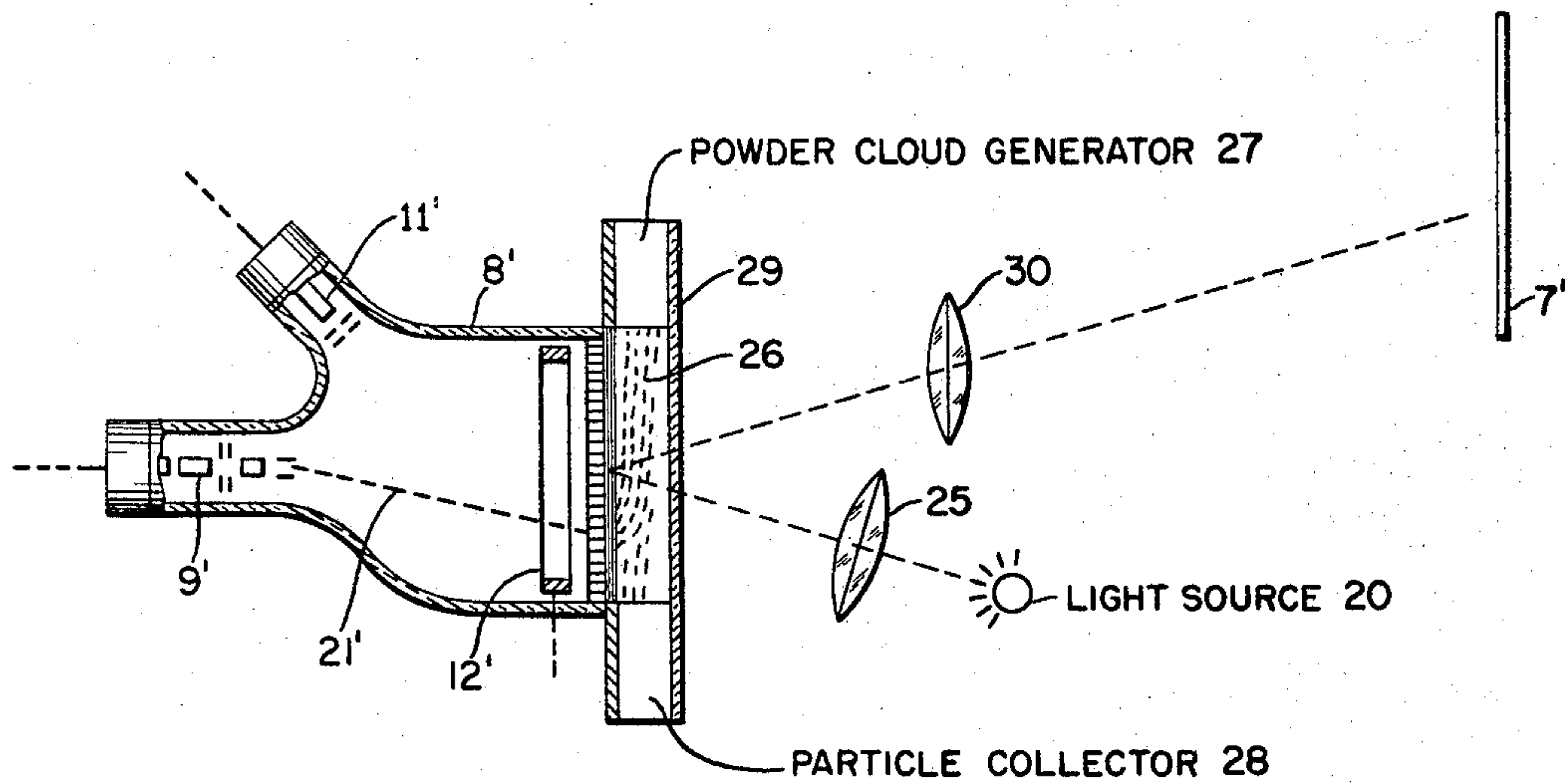
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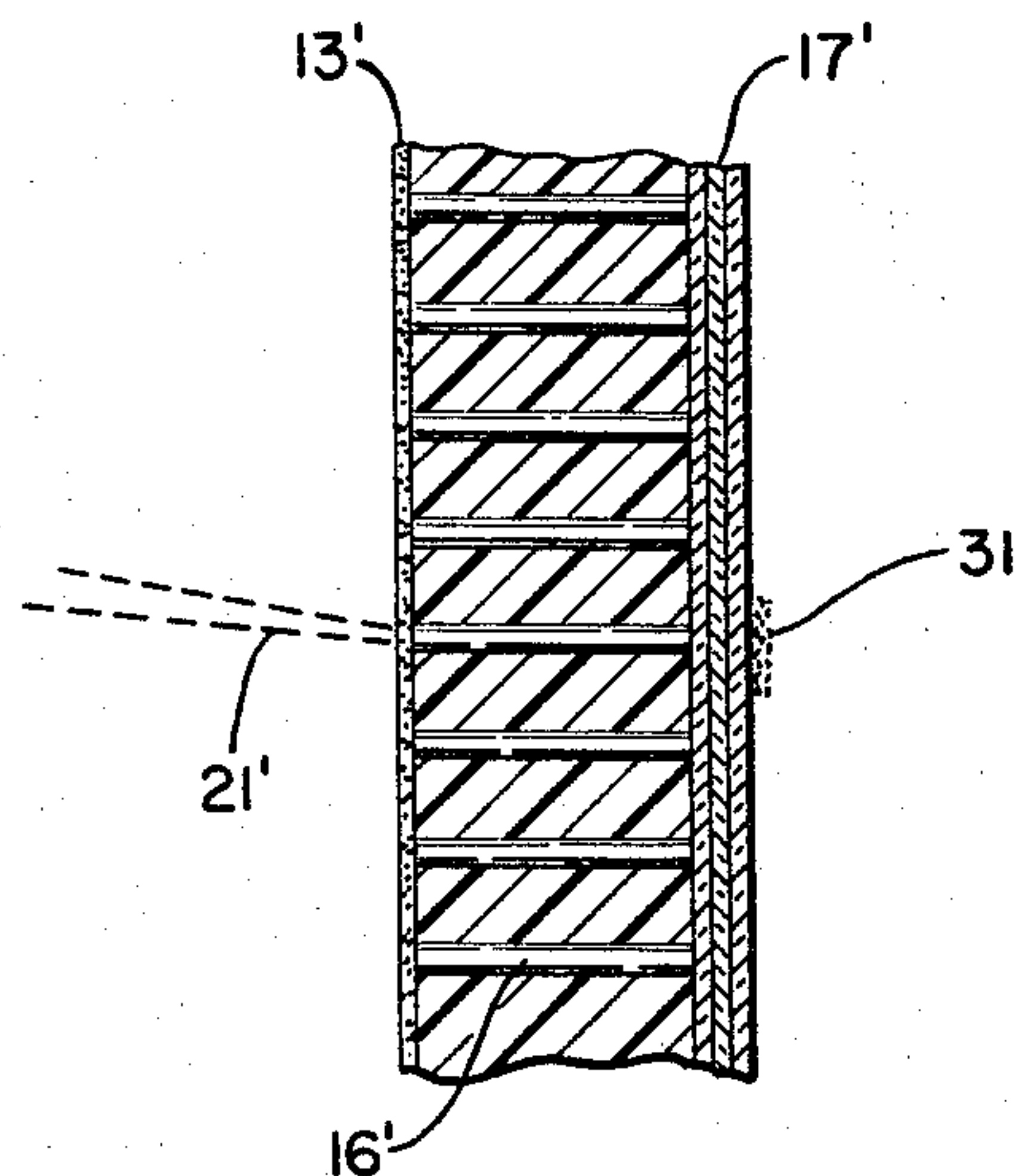
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*Fig. 3*



*Fig. 4*



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## DISPLAY DEVICE UTILIZING A MEDIUM THAT ALTERS THE DEGREE OF REFRACTION OF LIGHT

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### ABSTRACT OF THE DISCLOSURE

A display system including an electron discharge device capable of generating a charge pattern on the screen thereof, a multi-layer dielectric mirror mounted outside the envelope of the discharge device adjacent the screen thereof, means for transferring the charge image to the dielectric mirror, optical control means mounted over said dielectric mirror for altering the degree of refraction of light in the area of the electrostatic image, and means for projecting a visible image corresponding to said electrostatic image from said mirror.

The present invention relates to display devices and, more particularly, to large screen visual display devices for displaying images having a high degree of resolution and brightness.

It is often desirable, particularly in the military field, to visually display information emanating from a data processor on a large screen. It has been found that light images generated upon an electroluminescent layer located within a conventional cathode-ray tube are of insufficient brightness when considerably magnified. Prior art systems have been developed to meet this need which utilize a Schlieren optical system including a dielectric fluid which is selectively deformed within an evacuated chamber by an electron stream. However, efficient electron emission is not maintained for very long because the vapors from the dielectric fluid poison the cathode and shorten its life. Additionally, bulky vacuum pumps must be employed and as a result these prior art systems are uneconomical and unreliable.

Accordingly, it is the principal object of the present invention to provide an improved large screen visual display system having a high degree of resolution and brightness and which is long lasting, reliable and economical in contrast with prior art systems.

This and other objects and advantages of the present invention will become more apparent from the following detailed description, taken together with the accompanying drawings, in which:

FIG. 1 shows one embodiment of the present invention;

FIG. 2 discloses an enlarged view of a portion of the wall of the evacuated chamber of FIG. 1;

FIG. 3 discloses another embodiment of the present invention; and

FIG. 4 discloses an enlarged view of a portion of the wall of the evacuated chamber of FIG. 3.

In accordance with the present invention, a latent electrostatic image is generated upon a surface within a permanently evacuated glass envelope. This image is transferred through the wall of the envelope by virtue of pin conductors embedded in the wall and is manifested upon the surface of a dielectric mirror associated with the outside of the envelope. In one embodiment of the invention, a dielectric fluid is deformed in accordance with the charge pattern and the deformation is translated into a visual image by means of a Schlieren optical system. A second embodiment of the present invention employs a powder

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cloud generator which provides particles which adhere to areas upon the dielectric mirror having high non-uniformity in electric field intensity so as to block the reflection of incident light in these areas and produce an enlarged visual image having high resolution and brightness.

FIG. 1 discloses the well known Schlieren optical system comprising light source 1, condensing lens system 2, half-silvered mirror 3, illuminating grating 4, imaging lens system 6, and large screen 7. A permanently evacuated tube 8 contains write electron gun 9 and flood electron gun 11 together with a ring-shaped collector electrode 12. The front wall of the evacuated tube is disclosed in detail in FIG. 2 and comprises electron emissive coating 13, an insulated wall portion 14, conducting pins 16 embedded within the insulated wall portion 14, and a multiple layer dielectric mirror 17. Dielectric fluid 18 is positioned over dielectric mirror 17, as shown, and is held in place by means of ring 19. In operation flood gun 11 floods the entire electron emissive coating 13 to produce a net positive charge upon its surface. This is accomplished by operating the flood gun 11 at a potential to give a secondary electron yield in excess of unity; i.e., more electrons leave the surface of coating 13 than are incident upon the surface and thus surface potential becomes positive. On the other hand, the write gun 9 accelerating voltage is operated so that fewer electrons leave those areas hit by the write gun electron stream 21 than are incident upon the surface, and, accordingly, the net effect is for these areas to become negative with respect to the "background" which is affected merely by flood gun 11. Reference is made to Kenneth G. McKay, Secondary Electron Emission, "Advances in Electronics," Academic Press, 1948, page 98, for typical secondary emission yields of various insulators. An aluminum oxide surface for coating 13 would operate well for a flood gun accelerating voltage of 400 volts where the writing gun voltage exceeds 1700 volts.

In the absence of the operation of write gun 9, a uniform positive charge will be produced on the surface of dielectric mirror 17 so that no deformation of dielectric fluid 18 is produced. Under this condition, light from light source 1 passes through condensing lens system 2, half-silvered mirror 3, and illuminating grating 4. Half of the light energy passes through grating 4, lens 6 and dielectric fluid 18 to dielectric mirror 17. In the absence of any deformation of dielectric fluid 18, this incident light is refracted uniformly over the entire area of the dielectric fluid 18 and is reflected back from dielectric mirror 17 through lens system 6 and is intercepted by the bars of grating 4 by virtue of the proper selection of the focal length of lens system 6. On the other hand, deformation of dielectric fluid 18, such as the creation of a surface dimple 22, causes the incident light to be refracted differently in the area of the dimple due to the variation in thickness of the dielectric fluid at this point with the result that a corresponding light image 23 reflected from the dielectric mirror 17 passes the grating 4 and is produced upon display screen 7.

Dimple 22 is produced by directing electron stream 21 at coating 13, as shown in FIG. 2. Unlike the "background" created by the operation of flood gun 11, the area immediately surrounding conducting pin 24 will become negative with respect to the remaining portions of coating 13. These electrons will be transmitted to dielectric mirror 17 by virtue of conducting pin 24 just as the positive "background" charges are transferred to dielectric mirror 17 by virtue of the remaining conducting pins shown in FIG. 2. Accordingly, a charge pattern will be produced at dielectric mirror 17, as shown. The electrostatic field produced due to the charge pattern will influence the dielectric fluid to move in the direction of the greatest non-uniformity of electric field. This effect is called dielectrophoretic action



and is described by Pohl, Some Effects of Nonuniform Fields on Dielectrics, "Journal of Applied Physics," vol. 29, No. 8, August 1958, pages 1182-1188. It should therefore be apparent that by producing "islands" of negative charges within a "sea" of positive charges at dielectric mirror 17, the entire surface of dielectric fluid 18 may be deformed, pursuant to any particular visual image to be displayed on screen 7. Such images may assume the form of alphanumeric data, maps, or virtually any other type of data to be displayed.

FIG. 3 discloses evacuated envelope 8' containing flood gun 11' and write gun 9' together with secondary electron collecting ring 12'. The front wall of the tube is similar to the front wall of the tube of FIG. 1, shown in detail in FIG. 2. A light source 20 and lens system 25 directs incident light to dielectric mirror 17', shown in FIG. 3. In the absence of the generation of electron stream 21' by write gun 9', the entire surface of the dielectric mirror 17' is uniformly charged as described hereinabove in connection with the operation of the embodiment of FIG. 1. An enclosed chamber 26 is built up about the front face of envelope 8', as shown in FIG. 3. A powder cloud generator 27, a particle collector 28, and a transparent wall 29 are positioned as shown in FIG. 3 to define the aforesaid chamber. Powder cloud generator 27, which could be any of the well known types utilized in the field of xerography, produces positively charged particles of opaque material and causes these particles to be blown into chamber 26. Particle collector 28 collects these particles by suction and transmits them back to powder cloud generator 27. In the absence of the generation of electron stream 21', the dielectric mirror would be positively charged, as explained hereinabove, and the powder particles would not adhere to the surface of dielectric mirror 17' owing to the mutual repulsion of the positive charges associated with the mirror and the powder particles. Under this condition, all of the light incident upon mirror 17' would be reflected and would pass through lens system 30 to illuminate screen 7'.

Now let it be assumed that a narrow electron stream 21' is directed at emissive surface 13', as shown in FIG. 4. A negative "island" is produced within dielectric mirror 17 as in the formerly described embodiment. This action causes an "island" of particles 31 to adhere to the negative area. Incident light from light source 20 is not reflected from this area and, as a result, a visual image is generated upon screen 7'. In other words, the powder particles adhere where the electric field gradient is greatest. As the information to be projected is changed, the electrostatic field pattern, of course, is also changed. Particles that previously adhered to mirror 17' are released by weaker field gradients and air pressure produced by cloud generator 27.

As in the embodiment of FIG. 1, the persistence of the display may be controlled by suitable adjustment of the flood gun control grid and accelerating voltage. The persistence may be controlled from the millisecond range to the hours range. Additional erase guns could be provided in either embodiment for selective erasure, if desired.

By virtue of these configurations, the cathode life of write gun 9 and flood gun 11 may be estimated in thousands of hours in contrast to the one hundred hour cathode life of the electron guns of prior art systems. Again, it

should be pointed out that my invention utilizes a permanently evacuated envelope 8 in contrast to prior art systems which employ continuously pumped apparatus with its associated bulky and expensive vacuum pumps.

While there has been shown and described specific embodiments of the invention, other modifications will readily occur to those skilled in the art. It is not, therefore, desired that this invention be limited to the specific arrangements shown and described, and it is intended in the appended claims to cover all modifications within the spirit and scope of the invention.

What is claimed is:

1. A display system comprising an evacuated envelope, an electrostatic image manifesting coating on the inner surface of the end face of said envelope, electron gun means mounted within said evacuated envelope for establishing oppositely charged areas which make up electrostatic images upon said coating, a multiple layer light reflective dielectric mirror in intimate contact with the outer surface of the end face of said envelope, transfer means for causing said electrostatic images on said electrostatic image manifesting coating to be duplicated upon the outer surface of said dielectric mirror, and light refraction means in intimate contact with and supported on said dielectric mirror for selectively providing a different refraction of light incident upon and reflected from said dielectric mirror for the areas in contact with said electrostatic images as opposed to those areas where no electrostatic images are present.

2. A display system as defined in claim 1 further including a Schlieren optical system associated with said dielectric mirror directing light onto and intercepting light reflected from said dielectric mirror for projecting a visual image corresponding to said electrostatic images.

3. A display system as defined in claim 1 wherein said light refraction means consists of a thin film of dielectric liquid in intimate contact with and supported by said dielectric mirror over substantially the entire surface thereof, wherein the unsupported surface of said liquid film is selectively deformed by the electric field of said electrostatic image which penetrates said mirror.

4. A display system as defined in claim 1 wherein said dielectric mirror consists of a plurality of laminae of dielectric materials.

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