

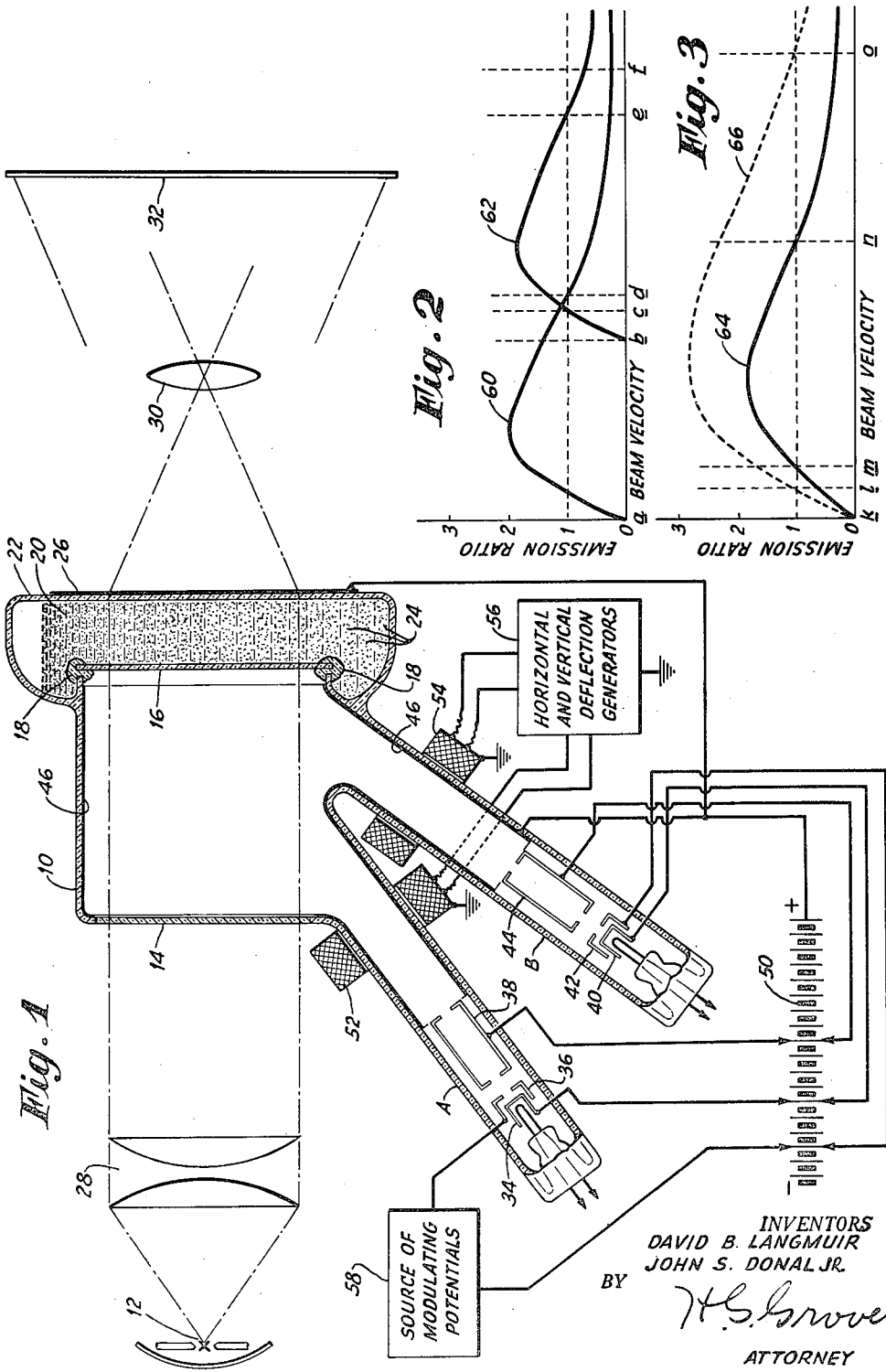
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TELEVISION PROJECTOR TUBE

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TELEVISION PROJECTOR TUBE

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The present invention relates to light valves, and more particularly to light valves for use in the reproduction of television images.

In most television receivers, particularly those used in the home, the television image is produced on a fluorescent or luminescent target or screen positioned on the end wall of a cathode ray tube. The target or screen has the characteristic that, when bombarded by an electron beam, a fluorescent or luminescent effect is produced, with the result that light is emitted from the bombarded area. Accordingly, when a cathode ray beam is scanned over the screen surface, and when the current intensity of the cathode ray beam is varied in accordance with the received television signals, a light image will result. Such a method of producing television images is entirely satisfactory when large images are not required, and when the number of persons viewing the image is limited.

There are conditions, however, when it is desirable to produce large television images on a screen suitable for viewing by a large audience, and under these conditions the use of a direct viewing cathode ray tube is impractical.

Various devices, generally in the form of a projection "Kinescope," are well known to those skilled in the art for use in the production of large screen television pictures, and such devices include a high voltage cathode ray tube of special design which is capable of emitting a large amount of light sufficient, when projected through an appropriate optical system, to produce a satisfactory large screen picture. In devices of this nature, the cathode ray beam must generate the power which is later converted into light, and if brilliant images of large dimensions are to be produced, a relatively large amount of power is required.

In order to be able to utilize a separate source of light so that the cathode ray beam would not have to generate the power to be converted into light, but would merely control the light from a constant source of high intensity, various systems have been devised in which means are provided which operate in response to a cathode ray beam to control the transmission of light from the source to the viewing screen. In such devices some form of a light valve must be used in order to control and modulate the amount of light which is permitted to pass from the source to the viewing screen.

The present invention is therefore concerned with such a light valve which will respond to current modulations of a cathode ray beam in order

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to control the passage of light through a normally opaque medium, together with means for reconditioning the medium or valve so that it may properly respond to the current intensity of the scanning cathode ray beam during the next scanning cycle.

Light valves for accomplishing these results are shown and described in the patents to Donal Nos. 2,290,581 and 2,290,582, granted on July 21, 1942. In each of these patents a special form of a cathode ray tube is shown which includes a scanning cathode ray beam and a target surface. Positioned adjacent the target surface is a medium which contains a large number of particles for normally preventing the transmission of light through the medium. When an electrostatic potential is applied across the medium, the particles are caused to orient themselves in such a manner that light projected parallel to the direction of the electrostatic field may pass there-through. The degree of orientation is a function of the electrostatic field intensity and the current intensity of the scanning cathode ray beam, with the result that the medium acts as a variable and controllable light valve for modulating the light beam projected through the medium.

The electrostatic field or potential difference to which the medium is subjected, as stated above, is a function of the current intensity of the scanning cathode ray beam. After the cathode ray beam has traversed a predetermined portion of the target or screen surface adjacent the medium, the electrostatic field persists for a predetermined length of time, and some provision must be made for removing the produced field prior to the next scanning cycle in order that a new field may be established in accordance with the current intensity of the cathode ray beam during the next succeeding field scanning cycle.

During the time interval (one field cycle) between one bombardment of a particular portion of the screen area and the next bombardment of that portion, it is desirable to have the electrostatic field, and hence the valve action, persist as long as possible in order to obtain high optical efficiency. When a medium is used in which opaque particles are in suspension, it is not convenient to rely upon leakage for the removal or dissipation of the electrostatic fields produced by the scanning operation, since the resistance of the wall surfaces retaining the medium is generally too high. Furthermore, if leakage is relied upon, the electrostatic field condition and the light valve action do not persist to their full extent for an appreciable portion of a field cycle,

with the result that the optical efficiency of the light valve is reduced. It is, therefore, desirable that some means be provided for removing the produced electrostatic field just prior to the establishment of a new field in accordance with the new current conditions of the scanning cathode ray beam. When such a result is accomplished, the light valve may then be operated at near its optimum efficiency.

In the present invention the light valve cathode ray tube includes two electron gun structures for producing separate and independent cathode ray beams. One of these beams is modulated by the received video or picture signals to produce variable electrostatic charge potentials across the light valve structure, and the other cathode ray beam, which is generally of constant current intensity, is used to destroy or remove the produced electrostatic field just prior to the re-establishment of a new field by the modulated beam. In order that the two cathode ray beams may have opposite effects on the light valve, i. e., one to produce an electrostatic field for permitting the transmission of light, and the other to destroy or remove that field, the two beams cannot be identical in all respects. The two beams and their relation to the target screen may differ from each other in different respects in order to produce the desired result. In one instance, the two beams may be operated at different velocities, or in another instance, the two beams may be projected against the target or screen surface at different angles. It is also possible to employ a combination of intensity difference and impact angle difference. In each case, however, the desired result is accomplished by the resulting secondary electron emissive effects produced at the target surface.

In accordance with the present invention, the modulated cathode ray beam which operates to produce the desired electrostatic field is directed against the target surface in such a manner and at such a velocity that the number of secondary electrons produced is less than the number of arriving or impinging primary electrons. Under these conditions the target surface is caused to accumulate a negative charge, or, in other words, its potential is driven in a negative direction in accordance with the current intensity of the impinging or scanning cathode ray beam. This action establishes a variable electrostatic field in accordance with the beam modulations, so that the light valve may modulate a light beam projected therethrough to produce the desired image.

An interval of time later (corresponding to less than one field cycle), the second cathode ray beam is directed against the target surface at such a velocity and at such an angle that the number of secondary electrons produced is considerably in excess of the number of arriving or impinging primary electrons. The second cathode ray beam is generally of constant current intensity. Since more electrons are driven from the target surface than arrive thereat, the potential of the surface is altered in a positive direction, with the result that the previously produced electrostatic field is eradicated. The light valve is then conditioned for a subsequent re-establishment of an electrostatic field in accordance with the new modulated conditions of the scanning cathode ray beam.

When an electronic light valve is operated as described above and in accordance with the present invention, a large screen television picture may be produced due to the modulation of the

amount of light permitted to pass through the light valve. Furthermore, under these conditions the effect of the light valve may be caused to persist for almost one entire television field cycle, with the result that the optical efficiency of the system is materially enhanced.

It is, therefore, one purpose of the present invention to provide an electronic light valve of improved efficiency.

Another purpose of the present invention resides in the provision of an electronic light valve for use, for example, in the production of television images in which the effect of the light valve may be caused to persist for substantially an entire television field cycle.

Still another purpose of the present invention resides in the provision of an electronic light valve for controlling or modulating the amount of light that is permitted to pass therethrough in accordance with the current modulations of a scanning cathode ray beam.

A still further purpose of the present invention resides in the provision of an electronic light valve wherein two separate cathode ray beams are provided, one of which is effective to produce the desired electrostatic field, and the other of which is effective to cancel or eliminate the produced field.

Another purpose of the present invention resides in the provision of an electronic light valve in which an electrostatic field or potential difference is produced as the result of a scanning operation of one cathode ray beam, the intensity of which is modulated in accordance with the potential variations, and the destruction of the produced electrostatic field by another cathode ray beam of substantially constant current intensity.

A still further purpose of the present invention resides in the provision of an electronic light valve in which two separate cathode ray beams are used, each of which produces different secondary electron emissive effects on a target surface to alter the potential of the surface in one direction or another.

Another purpose of the present invention resides in the provision of an electronic light valve in which two cathode ray beams are used, the velocity and/or impact angle of one beam being such that a secondary electron emission ratio less than unity is produced, and in which the velocity and/or impact angle of the second beam is such that a secondary electron emission ratio in excess of unity is produced.

Still other purposes and advantages of the present invention will become more apparent to those skilled in the art from the following detailed description, particularly when considered in connection with the drawing, wherein

Figure 1 shows one form of the present invention; and

Figures 2 and 3 are curves used in explaining the theory of operation of the present invention.

Referring now to the drawing, and more particularly to Figure 1 thereof, there is shown a cathode ray tube 10 and a source of light 12. The cathode ray tube is provided with light transmitting walls 14 and 16, both of which are preferably optically flat and made of uniform material so that no light distortion results. The wall 14 may be made of glass or similar transparent material, whereas the wall 16 is preferably made of mica and is, in fact, the target surface against which cathode ray beams are directed. It is not necessary that the target or wall 16 be made of mica, but it should be com-

posed of high electrical resistance material having the desired quality of being optically transparent, and having sufficient mechanical strength to withstand the hydrostatic or vapor pressures to which it is subjected. Even though the interior of the cathode ray tube 10 is exhausted to a very low pressure, it has been found that a sheet of mica, even when reduced to a few thousandths of an inch in thickness, is sufficiently strong to withstand the pressures exerted thereon.

Since the target 16 forms one wall of the cathode ray tube, it is sealed to the glass envelope of the tube by means of a vitreous material 18. The coefficient of expansion of the material is so chosen that a good bond may be maintained between the envelope of the cathode ray tube and the sheet of mica 16. One manner in which the mica may be sealed to the glass envelope of the cathode ray tube 10 by the vitreous material 18 is suggested in the specification of Patent No. 2,290,581, referred to above.

The end of the cathode ray tube adjacent the mica target 16 is provided with a compartment or container in which is located a suspending medium or liquid 20. The end 22 of the reservoir is preferably made of optically flat glass or similar transparent material, in order that an optical image may be passed therethrough without distortion.

The suspending medium or liquid 20 that is contained in the reservoir may be any liquid having the desired characteristics as regards electrical resistance, transparency, vapor pressure and viscosity. The suspending medium or liquid preferably has very high electrical resistance and transparency, and low vapor pressure and viscosity. A number of suitable materials may be used as the suspending medium or liquid, these materials including liquids such as n-amylsebacate, ethyl-hexyl-phthalate, ethyl-hexylacetate and tetrabromoethane.

Suspended within the liquid or suspending medium is a large number of flat particles or "platelets" 24. It has been found that small particles of graphite of a size larger than colloidal may be used, or commercial aluminum foil having a thickness less than 0.5 micron which has been subdivided into particles that are very thin compared to their other dimensions may satisfactorily be used. Other light opaque particles having the proper characteristics may also be suspended by the liquid or suspending medium 20.

Since the particles are slightly larger than colloidal, they will not remain permanently in suspension, with the result that some means should be provided for preventing precipitation of the particles. For this purpose an agitator may be provided, as suggested in the above mentioned Patent No. 2,290,581, and, if desired, a heating element may be provided reducing the viscosity of the suspending medium, as suggested in the same patent.

It has been found that when the liquid 20 and the suspended particles 24 are subjected to an electrostatic field, the particles are caused to orient themselves in a plane parallel to the impressed electrostatic field, and if light is directed through the medium parallel to the electrostatic field, the particles, due to their orientation, do not intercept an appreciable amount of the light. In the absence of such an electrostatic field, however, the particles assume a random orientation, and by reason of the fact that

the particles are opaque, light cannot be passed through the liquid or suspending medium. Accordingly, the medium may operate as a light valve to permit or prevent, and thereby to control, the transmission of light therethrough.

For impressing the desired electrostatic field upon the liquid 20, the mica target 16 operates as one electrode, and for the other electrode an exceedingly thin film of metal 26 is deposited, preferably on the outside surface of the container or reservoir wall 22. This metal, which, for example, may be gold or platinum, is applied as a conducting layer over the surface of the end wall 20, and since it must conduct or transmit light, should be exceedingly thin. The metal or conducting surface may be applied by any desired method known to those skilled in the art, such as by sputtering or by vapor condensation.

For projecting substantially parallel light rays through the cathode ray tube and through the suspension liquid 20 from the light source 12, a lens system 28 is provided. As stated above, the rays should pass substantially normally through the plane of the suspension medium 20. Since the suspension medium 20 and the particles 24 contained therein operate as a light valve, a second lens system 30 is provided for projecting the modulated light beam upon a screen or observation surface 32.

The cathode ray tube 10 also includes two electron gun structures represented generally at A and B. Gun structure A includes cathode 34, control electrode 36 and first anode or accelerating electrode 38. The second electron gun structure B includes a cathode 40, a control electrode 42 and a first anode or accelerating electrode 44. The second anode or accelerating electrode (common to both gun structures A and B) is preferably in the form of a conducting coating 46 on the inside surface of the tube, and may be in the form of a carbonaceous layer or film produced as a result of a deposit of aquadag thereon. Naturally, the conducting coating is not present on the surfaces through which light is projected.

For applying operating potentials to the electron gun structures, a source of potential 50 is provided which is represented schematically as a battery. Furthermore, for causing the desired deflections of the cathode ray beams produced by each of the gun structures A and B, deflecting yokes 52 and 54, respectively, are provided. These deflecting yokes may be energized from appropriate horizontal and vertical deflection generators represented schematically at 56. Since the deflection sensitivity and the angle at which the cathode ray beams are directed against the target 16 is different for each of the two beams, separate deflection generators would, in most cases, be required. The present invention is not concerned with the specific deflection generators used, and since such generators and deflecting means are well known to those skilled in the art, further discussion of this apparatus is believed to be unnecessary.

The second anode 46 and the conducting layer 26 are preferably connected together, and are, in turn, connected to the positive terminal of the source of potential 50. The other elements of the gun structure are connected to potential sources negative with respect to the potential of the second anode, and the potentials of these electrodes are determined in accordance with the desired

focal conditions of the produced cathode ray beams and the desired velocity of the beams.

Since the cathode ray beam generated by the cathode ray gun B may be of uniform current intensity, the control electrode 42 of the gun structure B is connected to a point negative with respect to its associated cathode 40, and the current intensity of the beam produced by this gun may naturally be controlled by an adjustment of the potential of the control electrode 42 relative to the cathode 40. Since the cathode ray beam generated by the gun structure A is preferably modulated by voltage variations such as, for example, the video signals of a television receiver, the control electrode 36 of this gun structure is connected to a point negative with respect to the cathode 34, and in this connection is included a source of modulating potentials represented schematically at 58.

The patents to Donal referred to above show an electronic light valve in which a modulated cathode ray beam is used for varying the light transmitting characteristics of the liquid in which a multiplicity of particles are suspended. A similar provision is made in the present invention, and for this purpose the cathode ray beam produced by the gun structure A and modulated by the source of potentials 58 is provided. The present invention also includes a cathode ray beam generated by the gun structure B for removing or obliterating the electrostatic field produced by the cathode ray beam from electron gun A. As explained above, the production and the cancellation of the electrostatic charges are produced as a result of secondary electron emissive effects at the target surface 16.

For the purpose of explaining the operation of the present invention, reference is now made to the curves shown in Figure 2. This figure shows two curves, 60 and 62, in which the ordinate represents secondary emission ratio, while the abscissa represents electron beam velocity.

It will be assumed that the potential of the second anode 46 and the potential of the conducting film 26 is that represented by point *f* in Figure 2. If the cathode potential of electron gun A is at point *a*, then the produced secondary electrons will be as represented by curve 60. Furthermore, if the cathode potential of the electron gun B is chosen to have a value *b*, then the produced secondary electrons will be as represented by curve 62. If all of the factors and parameters, including the angle of incidence of the two electron beams, are identical, the two curves 60 and 62 will be identical but will be displaced, as shown in Figure 2, by reason of the difference in the potential of the cathodes of electron guns A and B.

Since the conducting surface 26 is at a potential represented at *f*, it may be assumed that before any scanning operation takes place the target surface 16 will also be at the same potential. If now the target surface 16 is scanned by the cathode ray beam produced by gun structure A, the number of secondary electrons produced at the target surface 16 will be considerably less than the number of arriving or impinging primary electrons, as represented by the curve 60, with the result that the potential of the scanned portion of the target surface 16 will change in a negative direction, and if the scanning operation persists, the potential of the target surface 16 will change from point *f* to point *d* along curve 60. Continued scanning by the electron beam from gun A will not result in any further change in

a negative direction in the potential of the target surface 16 because, if the potential of the surface of target 16 were more negative than point *d*, a number of secondary electrons would be produced in excess of the arriving primary electrons, which would bring about a change in a positive direction. Accordingly, the extent of the change of the potential of the target surface 16 in a negative direction is limited to point *d*, the second cross-over point of the curve 60.

It will now be assumed that the scanning operation of the electron beam from gun A is discontinued, and that the target surface 16 is scanned by the cathode ray beam from the electron gun structure B. Since the cathode potential of the gun structure B is assumed to be at potential *b*, the effective velocity of the cathode ray beam at the target electrode will be such that the number of produced secondary electrons will be in excess of the number of arriving primary electrons, as indicated by the intersection of curve 62 with potential point *d* in Figure 2. Under these conditions, more electrons will be emitted from the target surface 16 than arrive thereat, with the result that the potential of the surface will change in a positive direction along curve 62, and continued scanning by the cathode ray beam produced by gun B will cause the surface of the target 16 to reach a potential *e* of Figure 2. However, the potential of the surface cannot go beyond that represented at *e* since at this point the number of produced secondary electrons equals the number of arriving primary electrons.

If the target surface is again scanned by the cathode ray beam produced by gun structure A, the potential of the target surface 16 will be changed in a negative direction from *e* to *d* as a maximum along curve 60. Accordingly, it may be seen that with alternate scanings of the cathode ray beams produced by gun structures A and B, the potential of the target electrode 16 may be caused to vary between points *e* and *d* as extreme limits.

In the operation of the device for the production of television images, the current intensity of the cathode ray beam produced by the gun structure A is modulated in accordance with the received video signals. This current modulation affects the extent to which the potential of the surface of the target 16 is driven in a negative direction, and if the cathode ray beam is caused to scan the target surface 16, and is simultaneously current modulated by the received picture signals, an electrostatic charge image may be produced on the target electrode. Since the target electrode is composed of an insulating medium, a charge image may be retained thereon, and the difference of potential (and resulting electrostatic field) between the elemental areas of the target surface 16 and the conducting film 26 causes different orientation effects upon the particles 24 contained within the suspension medium 20. These different orientation effects cause a variation in the modulation of the light transmitted through the medium along lateral dimensions thereof, with the result that an optical image of the electrostatic charge image is produced at the viewing screen 32. This electrostatic charge condition will persist for a length of time depending upon leakage resistance and other factors, and for best efficiency of operation, as explained above, it should persist for at least the major portion of one field cycle.

The electron beam produced by the gun struc-

ture B is of sufficient current intensity to always bring the potential of each elemental area of the surface of the target electrode 16 to its most positive potential, i. e., to the potential represented at *e* in Figure 2. Accordingly, after the surface 16 has been scanned by the electron beam from gun structure B, the potential of each element of the surface of the target 16 is always brought to the same datum potential level. The extent to which elemental areas of the surface of target 16 are charged in a negative direction by the cathode ray beam from the gun structure A depends upon the current intensity of this cathode ray beam as determined by the modulations produced by the applied modulating potentials.

Since it is desirable that the electrostatic charge image be retained for a large percentage of one television field cycle, the scanning operations as produced by the two cathode ray beams are slightly out of phase with the scanning operation produced by gun B, preceding slightly the scanning operation produced by gun A. When such a phasal condition exists, the potential of each elemental area of the target surface 16 is brought to the datum level *e* by the cathode ray beam from electron gun B just prior to the establishment of a new electrostatic condition or potential at that elemental area by the cathode ray beam from electron gun structure A.

When the electronic valve is operated in this manner, satisfactory television images may be projected on a viewing screen 32, and the optical efficiency of the light valve is at substantially optimum value. In order that a minimum differential potential may exist between the target surface 16 and the conducting film 26 when the elements of the screen 16 are in a discharged condition, it is preferable that the potential of the second anode 46 and that of the conducting film 26 be at a value such as represented at *e* in Figure 2, rather than at *f*.

For the operation of the system as described above, it is necessary that the cathodes of the two electron gun structures be at considerable variance insofar as their relative potentials are concerned. It has been found that such a condition is not absolutely necessary, and, in fact, the cathodes of the two gun structures may be operated at identical potentials. When such is the case, the beam velocities of the two cathode ray beams are similar, and in order to produce the desired effects, some means other than beam velocity must be relied upon for producing different secondary electron emissive effects at the target electrode 16. To produce the desired different secondary electron emissive effects, the two electron beams may be directed against the target electrode 16 at different angles. For best results and to eliminate undesired shading effects, it is preferable that the two electron gun structures lie in a plane parallel to the vertical scanning direction, with the electron beam of one gun structure directed toward the target surface at a more acute angle than the other beam.

Since the angle of incidence of the two cathode ray beams is different, a different secondary electron emission effect will result, since it is known that when the impinging electrons strike normally to a surface they emit fewer secondaries than when they strike at a glancing angle with respect to that surface. Inasmuch as it is desired that the number of produced secondary electrons be less than the number of arriving primary electrons for the modulated cathode ray beam that is to produce the electrostatic charge,

electron gun structure A and the cathode ray beam produced thereby is directed toward the target surface 16 at a less acute angle than is the beam from gun structure B. Since the cathode ray beam from gun structure B strikes the target surface 16 at a more acute angle, a larger number of secondary electrons will be produced, and for cancellation of the charge image the number of produced secondary electrons should exceed the number of arriving primary electrons.

To explain the theory of operation of the present invention when the cathodes of the two gun structures are at the same potential, reference is now made to the curves shown in Figure 3. In this figure, curve 64 represents the second electron response characteristics of the target surface 16 when scanned by the cathode ray beam produced by the electron gun structure A, and similarly, curve 66 represents the secondary electron response characteristics of the target surface 16 when scanned by the cathode ray beam generated by the electron gun structure B. Since the cathode ray beam from the gun structure B is directed against the target surface 16 at a more acute angle than is the cathode ray beam from gun structure A, a larger number of secondary electrons will be produced, and, as a result, the first cross-over point *l* of curve 66 occurs at a lower beam velocity than the first cross-over point *m* of curve 64, and also the second cross-over point *o* of curve 66 occurs at a higher velocity than the second cross-over point *n* of curve 64. The curves both start at the same point *k* since, in accordance with the above assumptions, the cathodes of the two electron gun structures are operated at approximately the same potential.

In explaining the operation of the present invention with the cathodes of the two gun structures A and B at approximately the same potential, it will be assumed that the potential of the second anode 46 and of the conducting film 26 is of the order of the voltage represented at point *o* in Figure 3. If, under these assumed conditions, the target surface 16 is scanned by the cathode ray beam generated by the gun structure A, the potential of the surface of the target 16 will change in a negative direction along curve 64 from *o* to *n*, due to the fact that at this effective beam velocity, the number of produced secondary electrons is less than the number of arriving or impinging primary electrons. The surface of the target 16 will, therefore, be driven in a negative direction with point *n* as the limit, since, as explained above in connection with Figure 2, continued scanning of the target surface 16 with the cathode ray beam from electron gun structure A will not produce any further change in the potential of the surface of the target 16. If then scanning by the cathode ray beam from electron gun structure A is discontinued and the target surface 16 is scanned by a cathode ray beam generated by the electron gun structure B, the number of secondary electrons produced for each arriving primary electron will be considerably in excess of the ratio one-to-one, as indicated by the intersection of curve 66, and the vertical line *n* of Figure 3. Since the number of secondary electrons produced exceeds the number of arriving primary electrons, the surface of the target 16 will change in a positive direction along curve 66 until a potential represented by point *o* is reached. The target surface 16 cannot be driven beyond point *o* even though the scanning operation from the electron gun B may continue

since point o corresponds to the second cross-over point of the secondary electron emission ratio curve.

When the present invention is used for the production of television images with the cathodes of the two gun structures at substantially the same potential, variations in the change of the potential of the target surface 16 in a negative direction are produced by variations in the current intensity of the scanning cathode ray beam. In order that the cathode ray beam may be current modulated, a source of modulating potentials is applied to the control electrode 36 of the electron gun structure A in a manner described above. Furthermore, in operating the device under these conditions, the scanning of the target surface by the two cathode ray beams is slightly out of phase, so that the cathode ray beam from the electron gun structure B scans a predetermined portion of the target surface 16 just prior in point of time to the scanning of this same portion by the electron beam produced by electron gun structure A. When this phasal condition exists, the produced electrostatic charge on the target surface 16 is retained for almost an entire television field cycle in order that maximum optical efficiency may be obtained. Furthermore, by reason of the secondary electron response characteristics of the target surface 16 when scanned by the cathode ray beam from gun structure B, and by reason of the fact that the current intensity of this electron beam may be relatively heavy, all portions of the surface of the target area 16 are brought to the same datum potential corresponding to point o in Figure 3 just prior to the re-establishment of a new potential by the modulated cathode ray beam from electron gun structure A.

The extent to which individual elemental areas of the target surface 16 are driven in a negative direction from a potential corresponding to point o in Figure 3 is a function of the current intensity of the modulated cathode ray beam, with the result that an electrostatic potential image is produced on the surface of target area 16 which is effective, in conjunction with the conducting film 26, to cause varying degrees of orientation of the particles 24 suspended in the liquid 20. Light projected against the surface 16, may, therefore, be modulated throughout its cross-sectional area with the result that an optical image may be projected on the viewing screen 32.

From the foregoing it may be seen, therefore, that an electron light valve may be controlled by two electron gun structures and their produced cathode ray beams, so that the surface of the target electrode may be caused to vary within predetermined limits, even though the cathodes of the two electron gun structures are maintained at approximately the same potential.

If the potential deviation limits between n and o do not afford the necessary differential potential to produce the desired result, then curve 66 may be shifted to the right relative to curve 64 to thereby increase the potential deviation limits by merely making the potentials of the cathode (and associated electrodes) of electron gun structure A negative with respect to the corresponding electrodes of electron gun structure B. When this is done, a combination of effects will result, including the operation of the device as described in connection with Figure 2, as well as the operation of the device as described in connection with Figure 3. Under these circumstances the

different secondary electron response characteristics are brought about by reason of both a beam velocity variation and an angle of incidence variation.

It is, therefore, possible to exercise the present invention by relying upon either a difference in beam velocity or a difference in the incidence angle of the beams, or a combination of these two variables may be employed at the same time.

Although the present invention is described as being particularly applicable for the reproduction of television images, such a system may also be used for the production of other images in response to potential variations. Furthermore, the present invention is described as applicable to a light valve using a suspension liquid and a plurality of opaque platelets contained therein, but it is to be understood that the present invention may also be applied to other types of light valves where the light transmitting efficiency, the opacity or transparency of a medium is controlled or varied by potential means or by an electrostatic field. In this respect the present invention may be used in connection with a crystal mosaic operating to rotate the plane of polarization of polarized light in a manner shown and described in Von Ardenne patents, Nos. 2,276,359 and 2,277,008 issued on March 17, 1943.

Naturally if the present invention is to be used in connection with television, the horizontal and vertical deflection generators represented at 56 would operate under the control of synchronizing signals, in order that the deflections of the cathode ray beams may be maintained in synchronism with the television transmitter, and in order that their phase of operation may be properly maintained.

Various other alterations and modifications may be made in the present invention without departing from the spirit and scope thereof, and it is desired that any and all such alterations and modifications be considered within the purview of the present invention, except as limited by the hereinafter appended claims.

Having now described our invention, what we claim as new and desire to have protected by Letters Patent is:

1. An electronic valve comprising a medium whose light transmitting characteristics are altered in response to a potential change comprising a target area associated with said medium, a pair of electron gun structures for developing independent cathode ray beams of substantially identical beam velocities, means for varying the current intensity of one of the developed beams, means for scanning the target area by said one cathode ray beam at such an angle of incidence that the number of produced secondary electrons will be less than the number of arriving beam electrons thereby to cause a variable change in the potential of the surface of the target area in a negative direction, and mean for subsequently scanning the target area by the second cathode ray beam at an increased angle of incidence that the number of produced secondary electrons will be in excess of the number of arriving beam electrons thereby to remove the potential established by said one beam and to return the target area to a datum potential level.

2. An electronic light valve for use in production of television images which includes a medium the transparency of which is altered by a change in an electrostatic field impressed thereon comprising a pair of electrodes associated with the medium, means for maintaining one of the elec-

trodes at a substantially uniform and fixed potential, the other electrode functioning as a target surface having high lateral resistivity, a pair of gun structures for developing individual focused cathode ray beams, of substantially identical predetermined velocity, means for scanning the target surface in substantially bilateral directions by one of the cathode ray beams, the angle of incidence of the one cathode ray beam at its predetermined velocity being such that the number of secondary electrons produced at the target surface is less than the number of arriving primary electrons, means for modulating the current intensity of the first cathode ray beam by television image signals during the scanning operation so that the potential of the target surface is altered in a negative direction by an amount determined in accordance with the current modulations of the cathode ray beam to produce a variable electrostatic field across said medium, means for simultaneously scanning the target area in substantially bilateral directions by the other cathode ray beam, the angle of incidence of the other cathode ray beam being greater than the angle of incidence of said one cathode ray beam so that at its predetermined velocity the number of secondary electrons produced at the target surface is greater than the number of arriving primary electrons in order that the potential of the target surface may be altered in a positive direction to a predetermined datum level thereby to remove the electrostatic field produced by the scanning operation of said one beam the scanning operation of the two cathode ray beams being displaced, in point of time, by a predetermined amount.

3. In an electronic light valve comprising a tube having a double end wall, a suspension of light intercepting particles in a liquid medium between said double end wall, electronic means to vary the light transmitting properties of said suspension in accordance with signal variations, said means including an electron gun structure for developing a focused cathode ray beam having a predetermined velocity, means for scanning the surface of one of the walls by the developed cathode ray beam, the angle of incidence of the scanning cathode ray beam at its predetermined velocity being such that the secondary electron emission during the scanning action has a ratio less than unity, means for modulating the scanning cathode ray beam by the signal variations whereby the potential of the surface of the scanned wall may be altered in a negative direction by an amount determined by current intensity of the modulated beam, means for electronically returning the potential of the surface of the wall to a predetermined datum potential level comprising a second electron gun structure for developing a second focused cathode ray beam having a velocity substantially identical to the predetermined velocity of the first cathode ray beam, and means for simultaneously scanning the wall by the second cathode ray beam, the angle of incidence of said second cathode ray beam being greater than the angle of incidence of the first cathode ray beam and being so chosen that at the predetermined beam velocity the secondary electron emission during such scanning action has a ratio greater than unity whereby the potential of the surface of the wall may be altered in a positive direction to thereby cancel the previously produced negative potential change.

4. In an electronic light valve for producing television images comprising a tube having a double end wall, a suspension of light intercepting particles in a liquid medium between said double end wall, electronic means to vary the light transmitting properties of said suspension in accordance with received television image signals, said means including an electron gun structure for developing a focused cathode ray beam, means for scanning the surface of one of the walls by the developed cathode ray beam, the angle of incidence of the scanning cathode ray beam being such that the secondary electron emission ratio is less than unity, means for current intensity modulating the scanning cathode ray beam by the television image signals whereby the potential of the surface of the scanned wall may be altered in a negative direction by an amount determined by the beam current intensity, means for returning the potential of the surface of the scanned wall to a predetermined datum level comprising a second electron gun structure for developing a second focused cathode ray beam having a velocity substantially identical to that of the first cathode ray beam, means for simultaneously scanning the said wall by the second cathode ray beam, the angle of incidence of the second cathode ray beam being such that the secondary electron emission ratio is greater than unity whereby the potential of the surface of the scanned wall may be altered in a positive direction thereby to cancel the effects produced by the scanning operation of the modulated cathode ray beam, and means for projecting light through the liquid medium.

5. An electronic light valve for reproducing television images comprising a tube having a double end wall, a liquid medium positioned between the double end wall, said liquid medium suspending a multiplicity of light intercepting particles the orientation of which are responsive to the presence and intensity of an electrostatic field, one of the walls including a target area having low lateral conductivity, a pair of electron gun structures for developing individual focused cathode ray beams of substantially identical velocity, means for current modulating one of the cathode ray beams by received television signals, means for scanning the surface of the target area by the modulated cathode ray beam at such an angle that the secondary electron emission ratio of the surface of the target area is less than unity or the particular beam velocity whereby the potential of the surface of the target area may be altered in a negative direction in accordance with the current modulations of the scanning cathode ray beam thereby to produce an electrostatic charge image on the surface to effect different degrees of orientation of the particles, means to project substantially parallel light rays through the liquid medium in order that the transmission of the light rays through the medium may be altered in accordance with the orientation of the particles, means for subsequently scanning the surface of the target area by the other cathode ray beam at such an angle that the secondary electron emission ratio of the surface of the target area is greater than unity for the particular beam velocity whereby the potential of the surface of the target area may be altered in a positive direction to remove the effects produced by the scanning operation of the modulated cathode ray beam.

6. In an electronic light valve wherein a medium is provided whose light transmitting

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efficiency is altered in response to a variation in an applied electrostatic field, the method of altering the potential of one of two electrodes for producing the electrostatic field which comprises the steps of generating a first focused cathode ray beam, modulating the current intensity of the generated cathode ray beam by signal potentials, scanning the electrode by the current modulated cathode ray beam, the angle of incidence of the scanning cathode ray beam being such that the number of produced secondary electrons will be less than the number of arriving primary electrons thereby to alter the potential of the surface of the electrode in a negative direction in accordance with the current modulations of the scanning beam, developing a second focused cathode ray beam of substantially constant current intensity having a velocity substantially identical to that of the first generated cathode ray beam, and simultaneously scanning the electrode by the second developed cathode ray beam, the scanning operation by the second cathode ray beam being subsequent in point of time, to the scanning operation by the first cathode ray beam, the angle of incidence of the second cathode ray beam being such that the number of produced secondary electrons will be greater than the number of arriving primary electrons so that the potential of the surface of the scanned electrode is altered in a positive direction thereby to eliminate the effects of the first scanning operation by the modulated cathode ray beam.

7. In an electronic light valve wherein a medium is provided whose light transmitting characteristics are altered in response to a variation in an applied electrostatic field, the method

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of altering the potential of one of two electrodes associated with the medium for producing the electrostatic field which comprises the steps of generating a first focused cathode ray beam, modulating the current intensity of the generated cathode ray beam by television image signals, scanning the electrode by the current modulated cathode ray beam, the angle of incidence of the scanning cathode ray beam being such that the secondary electron emission ratio is less than unity thereby to alter the potential of the surface of the scanned electrode in a negative direction in accordance with the current modulations of the beam, developing a second focused cathode ray beam of substantially constant current intensity and having a velocity substantially identical to that of the first generated cathode ray beam, simultaneously scanning the electrode by the second developed cathode ray beam, the second scanning operation being phase displaced from the first scanning operation by a predetermined amount, the angle of incidence of the second cathode ray beam being greater than the angle of incidence of the first cathode ray beam with the result that the secondary electron emission is greater than unity so that the potential of the surface of the scanned electrode is altered in a positive direction to a predetermined datum level thereby to remove the effects of the first scanning operation by the modulated cathode ray beam, and projecting light rays through the medium in a direction parallel to the produced electrostatic field.

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