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 APPARATUS FOR REPRODUCING ELECTRIC SIGNALS,
 PARTICULARLY TELEVISION REPRODUCERS
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2,472,988

Fig. 1.

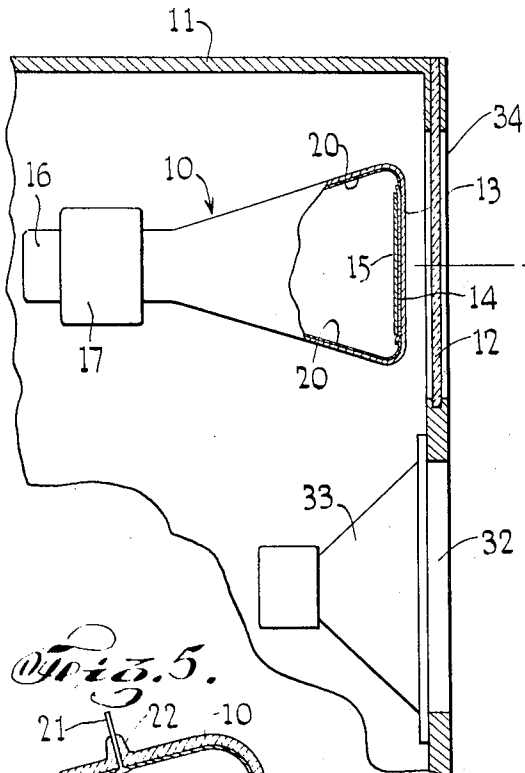


Fig. 2.

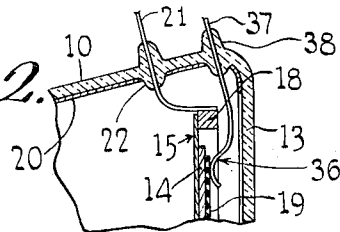


Fig. 3.

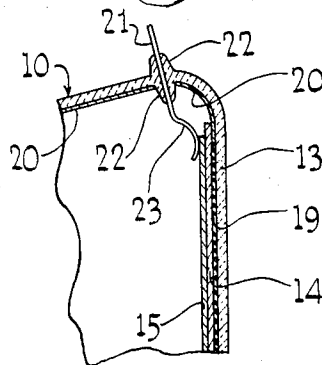


Fig. 5.

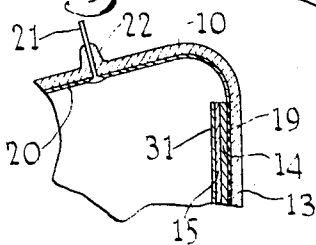
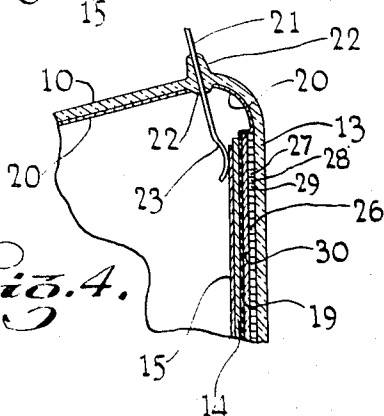


Fig. 4.



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UNITED STATES PATENT OFFICE

2,472,988

APPARATUS FOR REPRODUCING ELECTRIC SIGNALS, PARTICULARLY TELEVISION REPRODUCERS

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6 Claims. (Cl. 250-164)

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This invention relates to apparatus for visibly reproducing electric signals representative of intelligence impressed upon an electron stream, and in particular to television receivers and reproducers.

The invention comprises apparatus for visibly reproducing signals, and in particular television projection receivers in which an electron stream or beam upon which the signals are impressed, changes the optical qualities of the impinged screen which can be viewed directly.

It is an object of the invention to provide reproducers of the type hereinbefore defined which can be observed without darkening the room in which the reproducer is operated.

It is another object of the invention to utilize diffuse light in a room which may be day light or artificial light, for making visible, or aid the visibility of signals reproduced in screens of the type hereinbefore defined, and particularly screens the optical qualities of which are changed by signals impressed upon an electron beam.

It is a further object of the invention to increase the contrast effects in reproducer screens of the type hereinbefore defined, and particularly in screens the optical qualities of which are changed by signals impressed upon an electron beam.

It is a general object of the invention to provide what I call a "day light" reproducer of signals impressed upon an electron beam for visibly reproducing signals representative of intelligence of any kind, and in particular television pictures or images which can be observed to full effect in day or room light and also utilizes the latter for this purpose.

These and other objects of the invention will be more clearly understood when the specification proceeds with reference to the drawings in which rather schematically Fig. 1 shows in cross-section and partly in elevation a part of a housing or compartment with a cathode-ray producer of signals representative of intelligence, and Figs. 2 to 5 cross sections through a portion of such a reproducer embodying various modifications according to the invention.

Referring to Fig. 1, a cathode-ray tube 10 is arranged within compartment 11. The screen structure of and within the tube, in which signals representative of intelligence are to be reproduced, faces aperture 34 through which the screen can be directly viewed by an observer 35. Aperture 34 may be covered, e. g. by a removable glass plate 12. An electron gun including a cathode and electrostatic focussing means as well as

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electrostatic deflecting means is arranged within neck 16 of tube 10 in well known manner; if electromagnetic focussing and deflecting means are used, they are comprised in coil assembly 17 around neck 16.

The evacuated glass envelope of tube 10 is provided with a preferably flat front wall 13 on the inside of which a layer 14 is arranged which essentially consists of ionic crystal material of the type which under the impingement or bombardment by electrons changes locally its optical qualities by the creation therein of color or opacity centers and comprises, for instance, certain alkali and/or alkaline earth halides, as described more in detail in my Patent No. 2,330,171. These salts are preferably evaporated upon wall 13 or settled upon it from a suspension e. g. in alcohol.

Screen or layer 14 is sufficiently translucent so that changes in its optical qualities and particularly color or opacity centers formed in it, are visible to an observer 35 from the outside through wall 13. Layer 14 can be given a white appearance when illuminated by incident day or room light, for instance by proper control of the evaporation process mentioned above; thus quick evaporation, or small amounts of gases present during the evaporation process, cause the layer to assume a high albedo or whiteness. Color or opacity centers created in the layer or screen illuminated by diffuse light from the same side as it is viewed, will therefore appear dark on a white background to an observer 35.

A coating 20 of electrically conductive material is applied to the inside of tube envelope 10 except its front wall 13 and neck 16. If graphite is used, it is precipitated from a proper solution, for instance a colloidal graphite solution known as aquadag. This coating usually forms also an anode of the tube for accelerating the electrons toward screen 14, and is on a high positive electric potential. Electrons of a beam impinging upon and entering through the front face of layer 14 opposite glass wall 13, create color or opacity centers and are drawn in the layer toward its other side facing glass wall 13 by the high potential on that side, and finally diffuse into coating 20. When the translucent layer is illuminated by diffuse room light from the same side as it is viewed, opacity centers thus created and traveling across the layer will be seen by an observer 35 against the white background formed by areas of the layer in which no opacity centers are created.

In certain cases, depending upon the crystal

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material or its crystallisation, the reflection power, albedo or whiteness of screen 14 can be inadequate, or it can be too transparent. In such cases a backing 15 is provided for screen layer 14 of a metal of high optical reflective or light scattering power and pervious to or "transparent" to electrons. Metals which permit electrons to pass therethrough without appreciable or detrimental loss and also exhibit great light reflecting power, are for instance aluminum, beryllium, magnesium and other metals of light atomic weight; aluminum is preferred. Backing or layer 15 is preferably deposited upon screen layer 14 by evaporating the selected metal or metals in well known manner, or produced by cathode sputtering the metal or metals upon the screen layer. Even a relatively thick aluminum layer, of a thickness of about 5 microns, which is available in the market in the form of an aluminum foil, permits about 95% of the electrons impinging thereon at a velocity of 50,000 electron volts to pass therethrough. Smaller thicknesses down to e. g. 0.1 micron required for a highly reflective layer can be obtained by evaporation or sputtering and will exhibit a far greater electron permeability, particularly also for slower electrons of only a few thousand volts velocity, and still be perfect reflectors of incident light.

If the set illustrated in Fig. 1 is also to reproduce sound, a loud speaker 33 can be arranged within compartment 11 behind another aperture 32.

Instead of applying a reflecting backing 15 upon a screen layer 14 formed on glass wall 13, a self-supporting arrangement can be made as illustrated in Fig. 2. In this exemplification of the invention, a metal foil 15, for instance an aluminum foil of about 5 micron thickness, is fastened to a stiff metal frame 18 mounted spaced from but close to wall 13 and connected with a terminal conductor 21 sealed at 22 through the envelope of tube 10.

A crystalline screen layer 14 of the type hereinbefore described is applied upon metal foil 15 on its side facing wall 13, for instance by evaporation or settling from a suspension. A thin electrically conductive layer 19 which is transparent to light, is applied to the other side of layer 14 and may consist of a conductive oxide, such as zinc oxide, or of a thin layer of metal either the same as used for foil 15 or for instance platinum, rhodium, etc. which e. g. is deposited by evaporation or in any other suitable manner as a layer of minute thickness upon the crystalline layer 14. The springy extension 36 of terminal conductor 37 passed through seal 38 contacts layer 19; terminal 37 is connected with a suitably high positive electric potential or may be connected with coating 20 outside (or inside) the tube. If a somewhat lower positive potential is applied through terminal 21 to layer 15 than is applied through terminal 37 to layer 19, a substantially homogeneous electrical field is produced between layers 15, 19 in and across screen layer 14, whereby—and particularly with larger tubes and screen layers—the uniform migration through and removal from the screen layer of electrons injected into the latter by a modulated cathode ray beam is improved.

One of the advantages of the embodiment of the invention illustrated in Fig. 2 consists in that the crystal layer 14 and the conductive transparent layer 19 can be applied to foil 15 outside

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and before assembly of the tube. Furthermore, the halo caused by reflection of light inside thin glass wall 13 is reduced compared with tubes on the glass wall 13 of which layer 14 is applied in direct optical contact with it, and hence an increase in contrast results.

It will be appreciated that in this manner the day- or room-light is utilized to greater effect for illuminating and making visible the signals reproduced in screen layer 14. The incident light passes screen layer 14 on its way to backing or reflector 15 once, and the opacity centers produced therein absorb a portion of that light; upon reflection from the backing or reflector, the light passes the screen layer a second time on its way out, and thereby another portion of it is absorbed by the opacity centers at the same screen area. Thereby the desired contrast between unaffected areas of the screen layer through which "white" day- or room-light is reflected and areas the optical qualities of which are changed, in particular rendered opaque by the opacity centers produced therein, is greatly increased and practically doubled.

A further advantage of the invention as illustrated consists in that the electron gun can be arranged co-axially with tube 10, i. e. perpendicular to screen layer 14. Thereby the least distortion in the reproduction of signals occurs compared with other arrangements which require positioning of the electron gun obliquely to the optical axis of the screen so as to permit visible light to be projected along that axis through the screen layer unobstructed by the gun. The latter asymmetrical arrangement causes certain keystone distortions which have to be corrected by compensating the scanning and focussing effects accordingly.

Referring to Fig. 3, a portion of a cathode-ray tube is shown in which again a conductive coating 20 is applied inside tube envelope 10 and connected with conductive layer 19 of suitable oxide or of evaporated or sputtered metal inside front wall 13; layer 19 is substantially transparent to light. On top of layer 19 a screen layer 14 of ionic crystal material of the type hereinbefore defined is formed with or without binder, preferably by evaporation or by settling from a suspension or solution thereof. On top of crystal layer 14 the reflecting metal layer 15 is formed which is pervious to electrons and consists e. g. of evaporated aluminum. Leading-in wire 21 passes glass seals 22 and is electrically insulated by the inner portion of the seal from coating 20; its springy end 23 contacts metal layer 15. A suitable potential intermediate between the highest positive potential on electrode 19 and the cathode potential, is applied to wire 21 and thereby a substantially homogeneous electric field of desired strength created in and across screen layer 14 between metal layer 15 which acts as a reflector as well as an electrode, and the other electrode 19.

The invention is also applicable to color reproduction of signals representative of intelligence, in particular color television. Fig. 4 illustrates a portion of a cathode-ray tube used for instance for color television reproduction of the additive type. On the inside of front wall 13 of tube 10 a color filter screen 26 is applied which consists of groups of alternate filter sections or bands 27, 28, 29 parallel to picture lines. Assuming that the color picture is transmitted by three fundamental partial colors, for instance of suitable red, green and blue hue, each group of

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filter sections 27, 28, 29 will consist of a red, green and blue section, and each section substantially cover a picture line. On the back of screen filter 26 an insulating coating or sheet 30 is applied which is transparent to light, for instance a suitable varnish or a sheet of mica of extreme thinness. In back of and upon insulation 30, a conductive layer 19 is applied, for instance by sputtering metal upon insulating layer 30; layer 19 is also transparent to light and serves as an electrode which is connected with a conductive coating 20 inside envelope 10. Upon and in back of layer 19, a screen layer 14 the optical qualities of which can be changed by an impinging electron beam, such as of the type described hereinbefore for layer 14 in Fig. 1, is applied, and upon and in back of screen layer 14, metal backing 15 pervious to electrons and of high light reflecting power is applied in the manner hereinbefore described. Leading-in wire 21 passes glass seal 22, is insulated thereby from coating 20 and contacts backing 15 with a springy extension 23. Thus reflector 15 acts as an electrode on one side and metal layer 19 is another electrode on the opposite side of screen layer 14, for the purposes and effects stated hereinbefore.

A cathode ray beam upon which the signals to be reproduced are impressed, is swept over backing 15 and passes therethrough into screen layer 14, producing therein opacity centers in a way well known in the art and described more in detail in my Patent No. 2,330,171. With television transmission, the cathode-ray beam scans the screen structure 14, 15 in concurrence with the transmitter and in such a manner that during one color field period only lines of the screen structure are scanned adjacent to the red filter sections 27, during the next color field period only lines adjacent to the green filter sections 28, and during the third color field period only lines adjacent to the blue filter sections 29. The incident day- or room-light passing wall 13 and the sections of filter 26 can be completely reflected by backing or reflector 15 if no cathode-ray beam impinges the screen structure and add up to create the impression of white light for the observer. Upon scanning the screen structure in the manner indicated above, however, and depending upon the instantaneous intensity and position of the cathode ray beam, light of green, red or blue color passing the respective filter section 27, 28 or 29 will be absorbed to a greater or smaller degree along the lines just undergoing scanning by the modulated beam, and the combined reflection of light during a total frame scan comprised by the three color field scans described above, adds up in creating a proper additive color mixture for the observer. Similarly this color system can be employed in the case of suspension screens.

Other color systems in which e. g. the colors alternate in line or element frequency can of course be used. In all cases proper methods of scanning and modulation are to be applied which follow from the characteristics of the respective system and not form a subject matter of this invention.

While in the foregoing and with respect to the screen layers the optical qualities of which can be changed by an impinging modulated electron beam, the creation of a particularly defined electric field gradient in or across the screen layer has been described, obtained by applying proper potentials to its surfaces, Fig. 5 illustrates a feature of the invention in which such a defined field

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gradient is set up by an emission of secondary electrons from the back surface of the screen layer. To this end, a conductive coating 20 inside envelope 10 is electrically connected with an electrode 19 inside and on wall 13; electrode 19 is transparent to light, and on top of it a layer 14 of ionic crystal material of the type hereinbefore defined is formed. On top of layer 14 an optical high reflecting metal layer 15 pervious to electrons is applied in the manner and for the purposes hereinbefore described. On back of layer 15, another layer 31 of low secondary to primary electron emission ratio, for instance consisting of carbon black, is applied. The highest positive potential is applied in this exemplification through leading-in wire 21, passing seal 22, to coating 20 and electrode 19 and thereby to the surface of screen layer 14 in contact therewith. The opposite surface of screen layer 14 facing layer 31 will after operation of the tube has started, soon assume a negative potential with respect to that of electrode 19, between that of the source of electrons (cathode), and that of electrode 19, depending upon leakage resistance; this potential is maintained thereafter during operation of the tube. This is due to the fact that at the start of operation more primary electrons of the cathode-ray beam enter layer 31 than secondary electrons leave it, until layer 31 has assumed an equilibrium potential at which the sum of primary electrons leaving the layer towards the crystal screen and secondary electrons being emitted therefrom, equals the total amount of entering primary electrons (minor effects of reflected primary electrons, etc. being neglected). The intermediate potential thus created on layer 31 is therefore well defined and, in cooperation with the fixed highest potential put on the other side of screen layer 14, produces an electric field in and across layer 14 which is substantially homogeneous and of desired strength.

Useful screen potentials of the inner surface of screen layer 14 can also be obtained without layer 31 of low secondary to primary electron emission ratio on metal layer 15. Most metal layers have a secondary to primary electron emission characteristic of such a form that for low and high voltages of the primary electrons the secondary to primary electron emission ratio is smaller than one, whereas for intermediate velocities of the primary electrons this ratio is larger than one. Thus the curve representing the ratio of secondary to primary emission as a function of the velocity of the primary electrons will cut the straight line representing emission ratio one at a low voltage (usually below 100 volts) and at a high voltage of a few thousand volts, depending upon the metal. For aluminum, for instance, the upper intersection occurs between 2000 and 3000 volts of the primary electrons. By giving the inner coating 20, which also acts as accelerating anode of highest potential for the beam electrons, and thereby the transparent conductive layer 19 a potential of say 500 volts above the potential of this upper point of intersection of the secondary emission ratio curve with the ratio one line, the primary electrons impinging upon the aluminum layer 15 will have a speed of 500 volts above the upper intersection speed, and therefore will produce a smaller number of secondary electrons; thereby the potential of aluminum layer 15 is changed to a potential more negative than the potential of the opposite electrode 19 and which it had at the begin-

ning of the operation due to leakage through screen layer 14. Thus the potential of layer 15 is lowered from that of its initial value equalling that of layer 19 until it reaches the potential of the upper intersection point. It cannot become more negative because then more secondary electrons would be liberated and it would immediately revert to the potential of the upper intersection point. Therefore layer 15 will assume very soon an equilibrium potential equal to the potential of the upper intersection point of the secondary emission curve of its material, and since the opposite layer 19 is fixed to a potential of say 500 volts above this intersection potential, screen 14 will be subjected to a substantially constant potential gradient of 500 volts. By adjusting the potential applied to terminal 21 to any desired value above the fixed upper intersection potential of metal surface 15, any desired potential gradient or electric field can be produced and maintained across the light valve screen layer 14.

It should be understood that the features of the invention explained above are equally applicable for color-television screens of the type as illustrated in Fig. 4.

The effects just described as to creation of a defined electric field can also be obtained if the light transparent electrode 19 is omitted, particularly with smaller screens and in a manner as illustrated in Fig. 1. In all these cases a high positive potential to be applied to the reflector electrode and leading-in wire 21, can be dispensed with.

From the above it will be appreciated that the invention is concerned with reproducers of electric signals representative of intelligence of any kind impressed upon a cathode-ray or electron beam, in particular television reproducers, which include a screen the optical qualities of which to transmit or intercept visible light can be changed locally in accordance with those signals. The intelligence thus represented in that screen is made visible to an observer from the outside by the combined effect of screen portions the optical qualities of which are more or less changed or left unchanged, and visible day or room light incident upon the screen. The cathode ray beam upon which the signals are impressed, may be caused to move over the screen in order to affect its optical qualities according to any desired course, and in particular swept over the screen in order to perform recurrent line and frame scanning motions. The screen may consist for instance of a layer of ionic crystal material of the type in which an impinging electron beam or stream creates opacity or color centers represented by loosely bound electrons which may travel in and across the layer under the influence of an electric field and be removed or dissipated by the latter or by another source of suitable quenching radiation, for instance infrared or heat radiation. In this case the screen is substantially transparent or translucent, and appears white to the observer with or without a reflecting backing, as the case may be, whereas areas affected by the cathode-ray beam appear with a darkness proportionate to the intensity of the cathode-ray beam.

The backing associated according to the invention with a cathode-ray controlled light valve screen, is either predominantly and highly light reflecting or scattering, or predominantly light absorbing.

From the above it will be appreciated that instead of excluding outside screen illumination as

in signal reproduction, particularly television systems heretofore known which require a darkened room, the invention utilizes this room illumination for the production of the screen picture. The screen should be illuminated as much as possible, either by daylight or by any artificial light, such as provided by room or reading lamps. The reproduction in the screen results from varying light reflecting or absorbing powers of the screen and can be observed to maximum advantage, the better the screen is illuminated and particularly a high degree of ordinary illuminating light, whether day or artificial light, is provided; thus the disadvantage of observing the reproductions in a darkened room is avoided.

It should be understood that the invention is not limited to any exemplification hereinbefore described but to be derived in its broadest aspects from the appended claims.

What I claim is:

1. In an apparatus utilizing incident visible light, particularly diffuse day or room light, for visibly reproducing intelligence represented in a screen by local changes of its qualities to transmit or absorb visible light incident upon it, in combination, a screen essentially comprised of ionic crystal material of the type which is permeable to visible light and in which an impinging electron beam which is modulated by signals representative of intelligence to be reproduced creates color centers which absorb visible light, and a backing associated with said screen essentially of aluminum, the thickness of said backing not exceeding about 5 microns in order to minimize absorption of impinging electrons, so that visible light incident upon and transmitted through portions of said screen instantaneously permeable to said light is reflected by said backing through such screen portions.

2. In a cathode ray tube including a cathode emitting electrons, means for directing the emitted electrons as a beam upon a screen within said tube, means for modulating the electron beam by signals representative of intelligence to be reproduced in said screen, said screen arranged to utilize incident visible light, particularly diffuse day or room light, for visibly reproducing said intelligence, in combination: a translucent screen essentially of ionic crystal material in which an impinging electron beam can create color centers capable of absorbing visible light, means for producing a positive potential on the front side of said screen exposed to visible light and observation, and a backing of great optical reflecting power for visible light and pervious to electrons associated with the opposite side of said screen exposed to said electron beam, said backing of a material capable of emitting secondary electrons upon impingement by primary electrons at low ratio of the secondary to the primary emission for the velocity of the primary electrons of said impinging beam, so that the latter causes the accumulation of a negative charge on said backing until an equilibrium potential is produced thereon intermediate between said positive potential on the front side of said screen and the negative potential of said cathode.

3. In a cathode ray tube as set forth in claim 2, said backing essentially comprised of a substance of a low ratio of secondary to primary electron emission and exemplified by carbon black, applied as a layer upon another thin metallic layer pervious to electrons and of high visible light reflecting power on the back of said screen.

4. A cathode ray tube adapted to utilize in-

ident visible light, particularly diffuse day or room light, for visibly reproducing fundamental partial color signals representative of intelligence, essentially comprising, in combination, means for developing a cathode ray beam, means for modulating said beam with said color signals to be reproduced, a screen upon which said modulated beam can impinge, said screen essentially of ionic crystal material which is permeable by visible light and in which an impinging electron beam can create color centers capable of absorbing visible light, a backing of optically high reflecting or scattering power for visible light associated with said screen so that visible light incident upon portions of said screen instantaneously permeable to said light is reflected by said backing through said screen portions, and a color filter composed of groups of fundamental partial color filters arranged in bands parallel to picture lines associated with said screen on its front side exposed to incident visible light and observation.

5. A cathode ray tube adapted to utilize incident visible light, particularly diffuse day or room light, for visibly reproducing signals representative of intelligence, essentially comprising, in combination, means for developing a cathode ray beam, means for modulating said beam with signals to be reproduced, and a self-supporting structure including a screen upon which said modulated beam can impinge and a backing of optically high reflecting or scattering power of visible light associated with said screen, said screen essentially of ionic crystal material which is permeable to visible light and in which an impinging electron beam can create color centers capable of absorbing such light so that visible light incident upon portions of said screen instantaneously permeable to such light is reflected through said screen portions.

6. A cathode ray tube adapted to utilize incident visible light, particularly diffuse day or

room light, for visibly reproducing signals representative of intelligence, essentially comprising, in combination, means for developing a cathode ray beam, means for modulating said beam with signals to be reproduced, a screen layer upon which said modulated beam can impinge, said layer essentially of ionic crystal material permeable to visible light and in which an impinging electron beam can create color centers capable of absorbing visible light, a backing of aluminum foil for said layer, said foil pervious to electrons and of high light reflecting or scattering power so that visible light incident upon portions of said screen layer instantaneously permeable to said light is reflected through said screen portions, and a frame-like support on which said backing and screen layer are mounted.

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