United States Patent

Donjon et al.

[15] **3,637,931**

[45] **Jan. 25, 1972**

[54] OPTIC RELAY FOR USE IN TELEVISION

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Feb. 5, 1969	France	690611

[52] **U.S. Cl.** ..... **178/7.5 BD**, 250/199, 350/150

[51] **Int. Cl.** **H04n 5/38**

[58] **Field of Search** ..... 178/5.4 BD, 7.5 D; 250/199; 350/150

[56] **References Cited**

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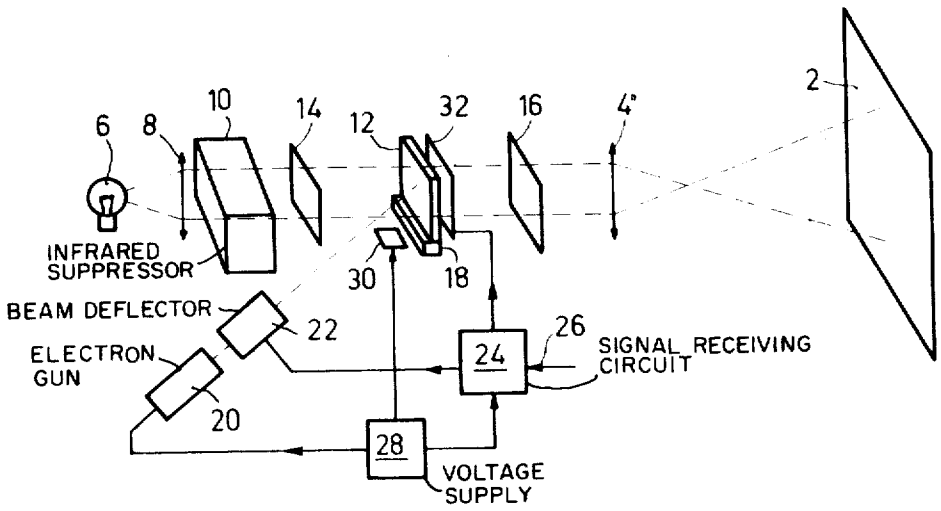
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Primary Examiner—Robert L. Griffin
Assistant Examiner—Donald E. Stout
Attorney—Frank R. Trifari

[57] **ABSTRACT**

An optical relay device with an insulating plate which is ferroelectric below its Curie temperature. The plate is scanned by an electron beam. The plane of polarization of light incident on the plate is variably rotated in dependence upon the electric field created by means of the interaction between the electron beam and a signal voltage applied to the plate, due to the Pockels effect. The temperature of the plate is stabilized in the proximity of its Curie temperature. This stabilizing device uses a capacitor as a temperature sensing element. The dielectric of the capacitor is formed by a material having a Curie temperature differing from that of the plate by between 1° and 20°.

6 Claims, 13 Drawing Figures



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SHEET 1 OF 6

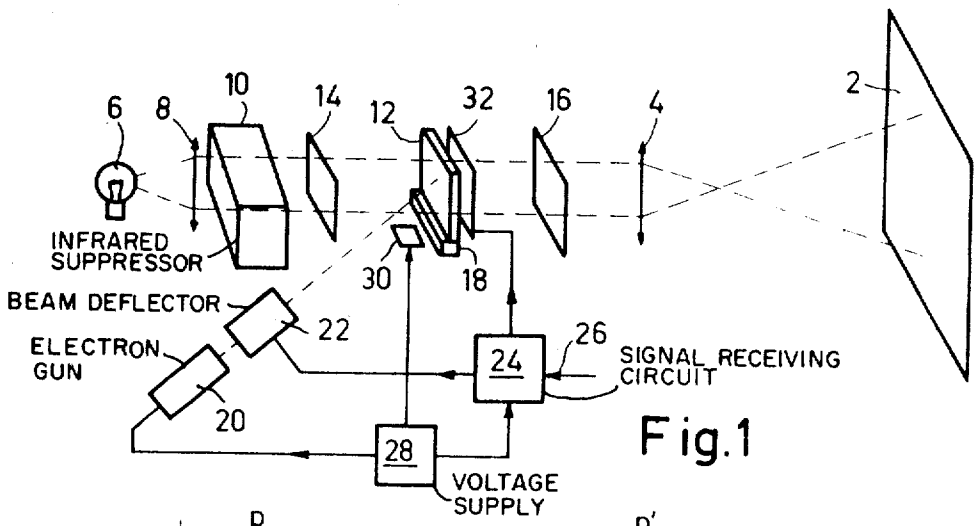


Fig.1

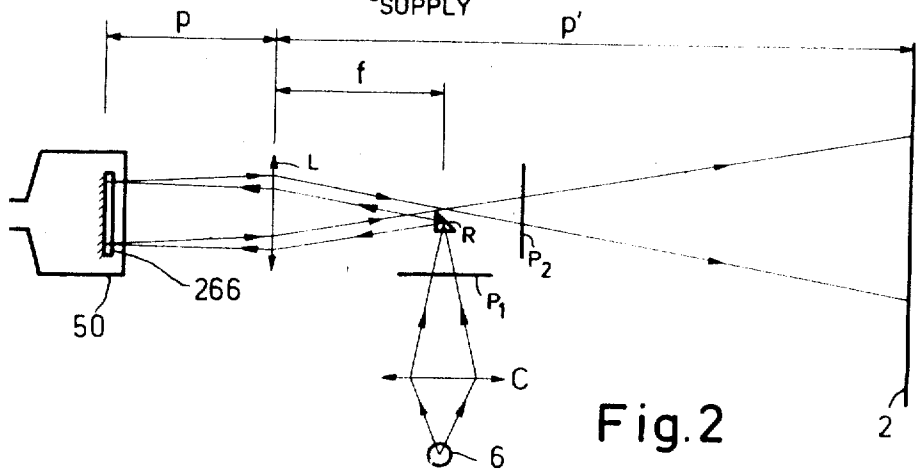


Fig.2

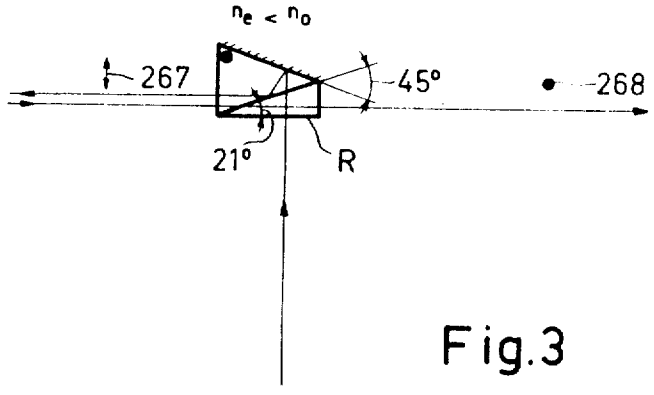


Fig.3

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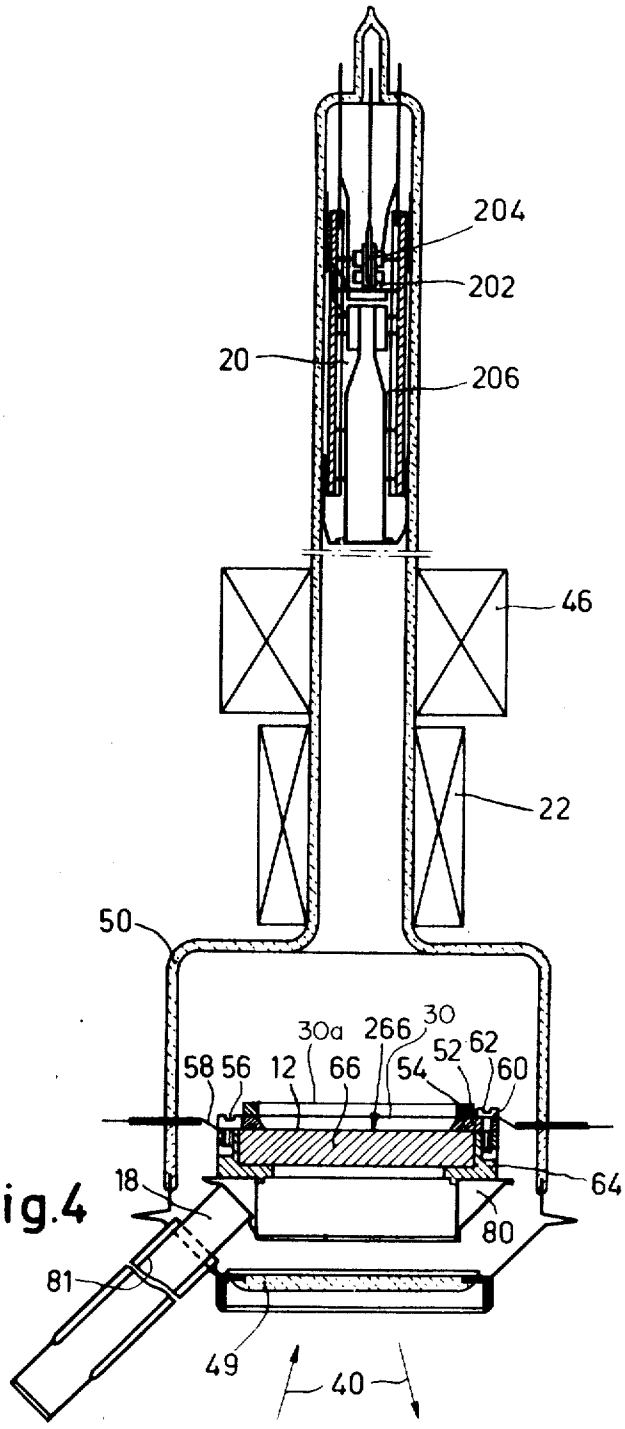


Fig.4

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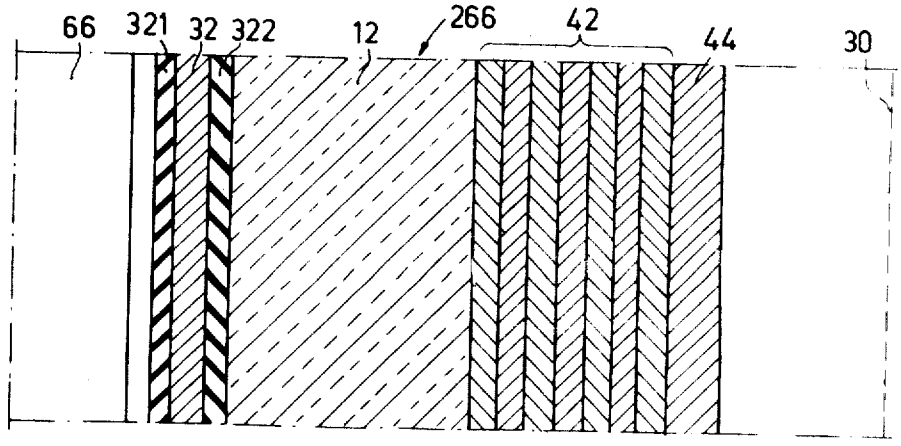


Fig.5

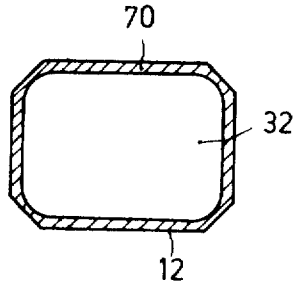


Fig.6

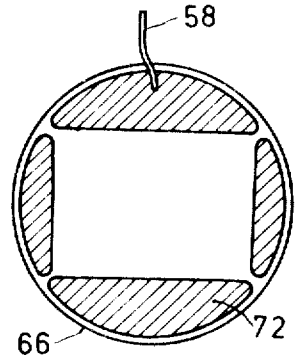


Fig.7

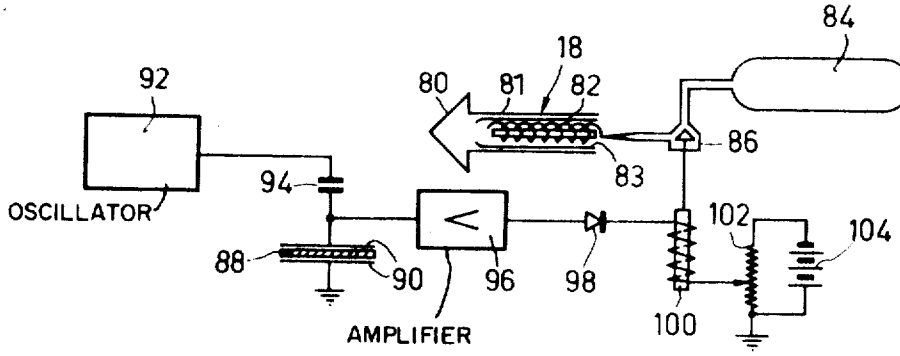


Fig.8

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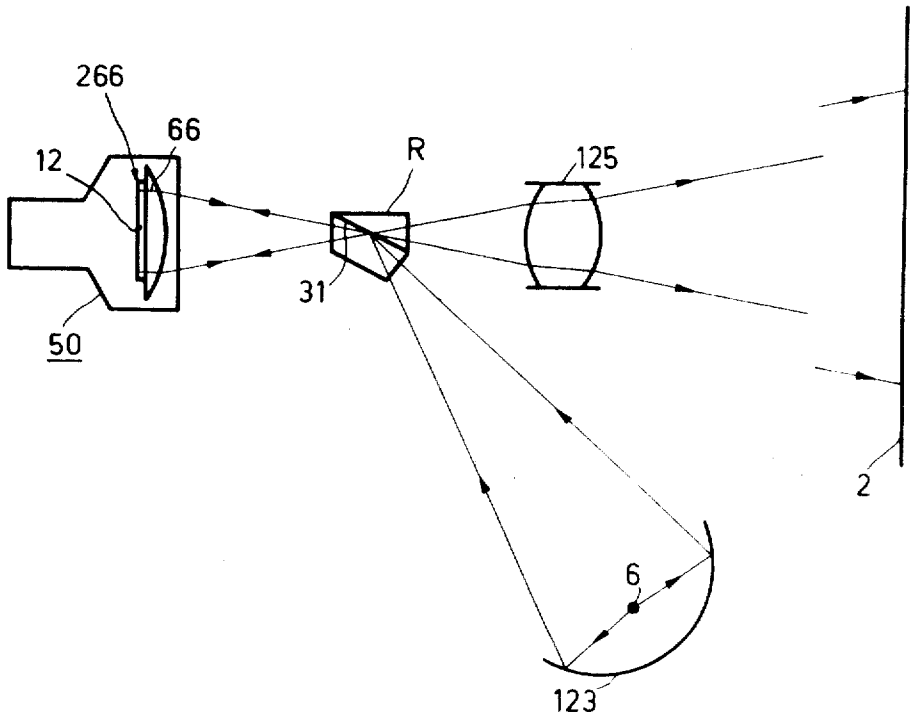


Fig.9

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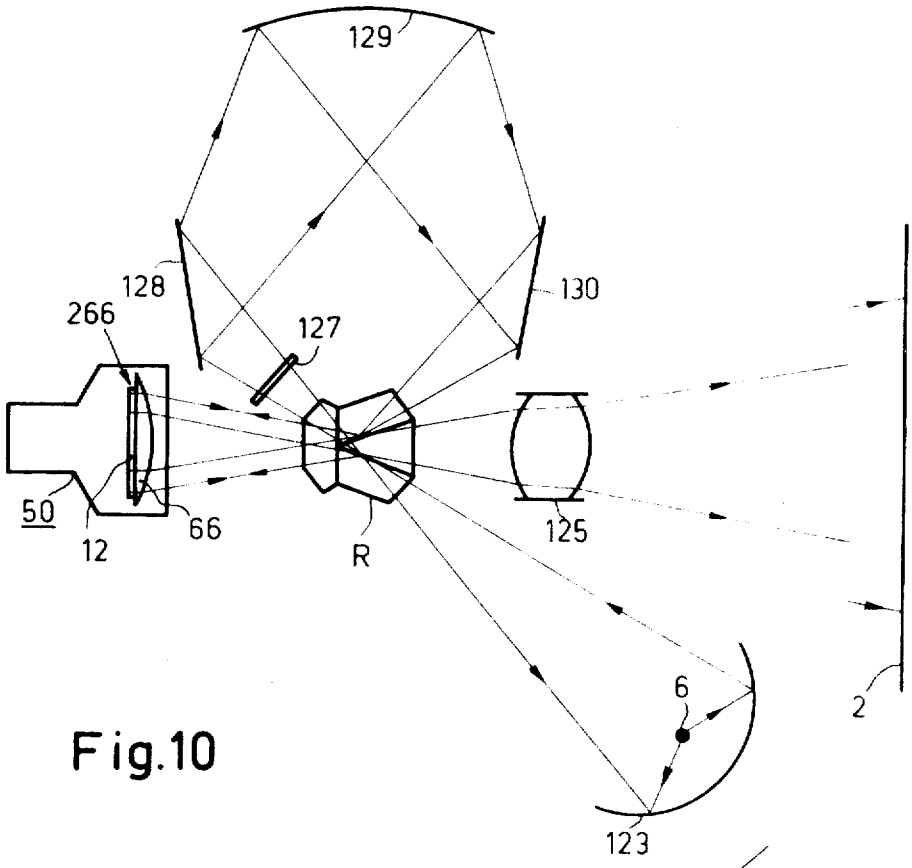


Fig.10

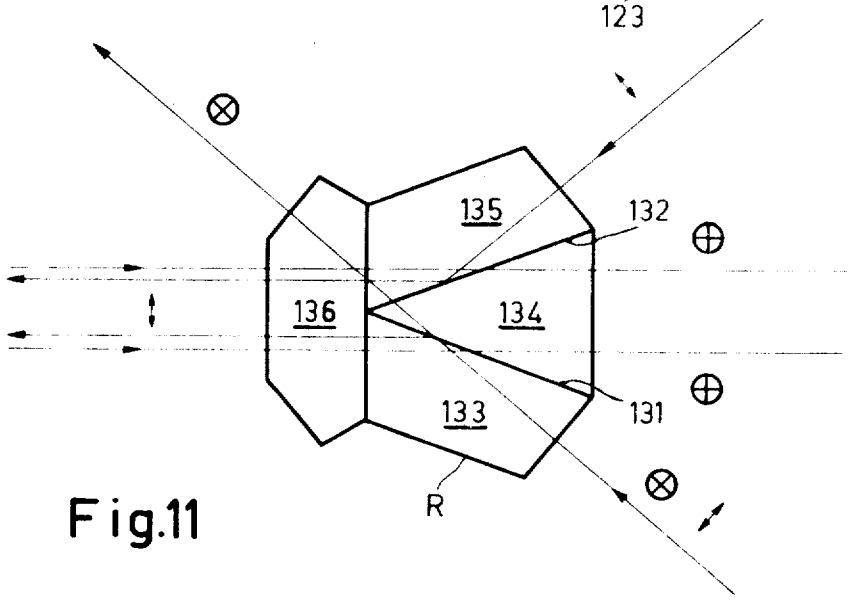


Fig.11

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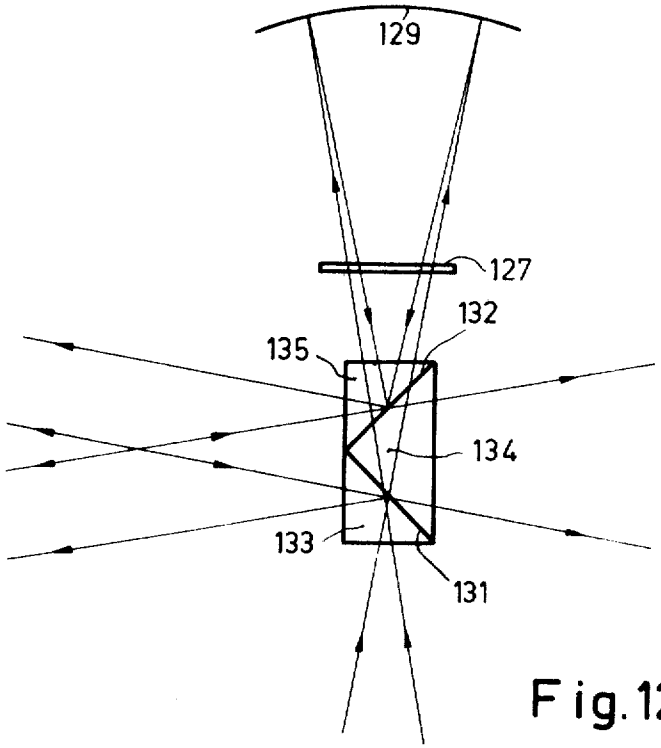


Fig.12

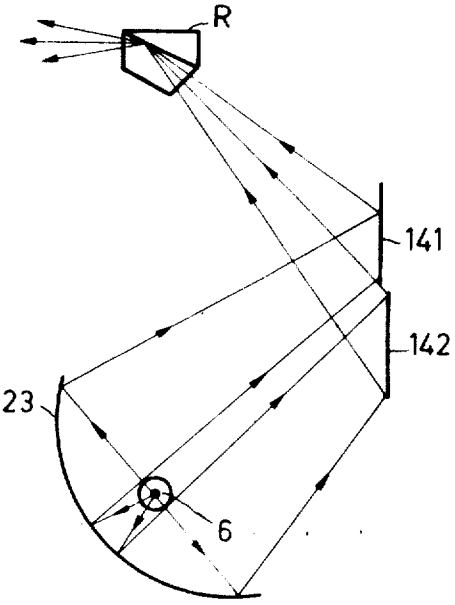


Fig.13

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OPTIC RELAY FOR USE IN TELEVISION

The invention relates to a device having an optic relay, particularly for use in television. The relay comprises a plate of electrically insulating material consisting of an acid salt which becomes ferroelectric below the Curie temperature thereof. The salt is enriched with deuterium to increase the Curie temperature thereof. The plate rotates the plane of polarization of light transmitted by a polarizer in accordance with a variable electric field which is applied by means of a control electrode, so that it appears substantially parallel to the direction of propagation of said light across the plate. An analyzer transmits a selected component of the light originating from the plate. Means are provided for scanning a surface of said plate by an electron beam. An anode receives the secondary electrons produced by the electron beam. A temperature control device for stabilizing the temperature of the plate at a value in the proximity of the Curie temperature of the plate is provided. The temperature control device comprising as a temperature-determining element a capacity, the capacity of which is measured as a measure of the temperature.

In the picture tube of a television receiver the electron beam usually fulfills the following three fundamental functions:

a. the beam supplies the energy to be converted into light (the light-transmitting power of the tube hence is always lower than the power transferred by the beam).

b. The beam scans the surface of the picture;

c. The beam transmits the video information.

With respect to functions (b) and (c), the power of the beam and hence the brightness of the picture cannot be increased to such an extent as would be necessary for projection on a large screen.

It has therefore been suggested to separate these functions and to have the function (a) fulfilled, for example, by an arc lamp and the functions (b) and (c) by a so-called "optic relay." Various types of such relays have been designed. The most frequently used relay(Eidophore) is heavy, bulky and hard to actuate. Another relay has been proposed by Rissmann and Vosahlo ("Untersuchungen zur Lichtsteuerung und Bildschriebung mit Hilfe elektrooptischer Einkristalle," Jenar Jahrbuch 1960, first volume p. 228). In this case a crystal is used which has an electro-optic effect, the so-called "-Pockels" effect. A crystal of KH_2PO_4 has proved suitable. This material will hereinafter be referred to as KDP.

In so far as necessary, this effect can briefly be explained as follows: when the electrically insulating crystal is exposed to an electric field parallel to its crystal axis c (the three crystal axes a, b and c constitute a trihedron of three rectangles; in this case the axis c forms the optical axis) the index of refraction of this crystal for light rays in the c-direction with linear polarization in the plane ab depends upon the direction of polarization. If X and Y denote the bisectors of the axes a and b, and if the parameters of the crystal with respect to these various directions are represented by the letters denoted for these directions, it can be said that the diagram of the indices in the plane ab becomes an ellipse with the axes X and Y instead of a circle and that the difference $nx-ny$ is proportional to the applied electric field. From this it follows that if the incident light rays are polarized parallel to the axis a, the intensity of the light I which traverses an output polarizer is $I=I_o \sin^2 kV$ if the direction of polarization of this polarizer is parallel to the axis b, and is $I=I_o \cos^2 kV$ if the said direction is parallel to the axis a, while I_o is equal to the incident light intensity, if no parasitic absorption occurs, wherein V is the electric potential difference between the two faces of the crystal and K is a coefficient which depends upon the crystalline material used.

For the last-mentioned optic relay a thin monocrystalline plate of KDP is used the thickness of which extends parallel to the axis c, said plate being provided between two polarizers. In order to obtain a projected picture by means of a lamp with this device, it is sufficient, as described above, to apply an electric field parallel to the axis c and to cause the value of the field to correspond at any point with the brightness of the corresponding point of the picture to be obtained. For this purpose, an electron beam from an electron gun is caused to scan the plate by means of conventional deflection members so that the beam fulfills the function b. The function c, here the control of the electric field, is likewise fulfilled by the beam and that in the following manner. The electrons of the beam which are incident on the surface of the plate produce secondary electrons but with a secondary emission coefficient smaller than 1. As a result of this, negative charges are formed at the points of the insulating plate on which the beam was incident, which charges vary the electric field perpendicular to the plate at the relative points. The charges thus produced depend upon the accelerating voltage of the electron beam and in particular on the anode voltage and the quantity of electricity supplied by the beam. This quantity is the product of the beam intensity and the duration of the passage of the beam over the relative point of the plate. The term "point" in this case has the meaning of an elementary plane. The video signal can previously be used for the modulation of one of these four quantities. In the relay described, either the anode voltage or the beam intensity can be modulated but only the latter possibility is found to be realizable. This possibility, however, has also several drawbacks. For example, the negative charge produced on the plate is not a linear function of the beam intensity: a further important drawback is that it is necessary for the variation of the picture that said charge is dissipated at least partly between two successive pictures. This dissipation involves flicker of the picture seen by the spectator the effect of which usually is reduced only by a complication of the scanning system (interlacing). The dissipation furthermore has for its result that the transparency is always low. When a KDP crystal is used, it is necessary in order to dissipate the charges within less than one-tenth of a second to operate at the ambient temperature which involves important variations of the potential of the screen of a few kV., as a result of which the focusing of the electron beam is seriously hampered.

It is already known to avoid the said drawbacks by a device of the type mentioned in the first paragraph. This device is described in U.S. Pat. No. 3,520,589, the contents of which are herein incorporated by reference. In the target plate described in this application to be scanned by the electron beam and showing the Pockels effect, a temperature is used in the proximity of the Curie temperature thereof. This is possible in that the target plate consists of a salt of the KDP type, for example, a double acid phosphate or arsenate of potassium, rubidium or caesium which is enriched with deuterium, as a result of which enrichment the Curie temperature is considerably increased. The dielectric constant ϵ reaches a very high value, so that, in order to obtain an adequate modulation of the light, small control voltages (V) can be applied across the target plate by means of a control electrode, since the Pockels effect is proportional to the product ϵV. It has been proposed to control the temperature by means of a temperature control device which comprises as a temperature-determining element a capacitor the capacitance of which is measured as a measure of the temperature, the dielectric of said capacitor being formed by a plate cut out of the same material as the said target plate. This has the advantage that the measured capacity is proportional to the dielectric constant of the crystal and hence proportional to the electro-optic sensitivity which is to be stabilized. However, it is difficult to approach the optimum operating temperature, since the optimum operating temperature lies at the temperature at which the dielectric constant of the target plate and hence also of the capacitor has a maximum.

It is the object of the invention to avoid this drawback and to provide a device which comprises an efficaceous control device which is simple of construction and with which the optimum operating temperature can also be adjusted.

According to the invention, in a device of the type mentioned in the first paragraph the dielectric of the capacitor is formed by a material the Curie temperature of which differs

from that of the said plate by a few degrees. Thus the capacity of the capacitor varies uniformly in the proximity of the optimum operating temperature. The dielectric of the capacitor preferably has a Curie temperature which is lower than the Curie temperature of the target plate between 5° and 20°. The capacity of the capacitor varies in a particularly suitable manner as a function of the temperature in the neighborhood of the optimum operating temperature and that in such manner that the capacity is always increasing, when the temperature is decreasing, and the control device can be very simple. The device is of particular advantage if, according to a further aspect of the invention, it has the particular characteristic that the dielectric consists of the same acid salt as the said plate but is enriched with a lower percentage of deuterium than the material of the plate. The plate may consist, for example, of a double-acid phosphate or arsenate of potassium, rubidium or caesium enriched with 80 to 100 percent deuterium and the dielectric of the capacitor may consist of the salt of the same chemical composition enriched with from 5 to 20 percent less deuterium.

In order that the invention may be readily carried into effect, embodiment of the device according to the invention will now be described in greater detail, by way of example, with reference to FIGS. 1 to 13 of the accompanying drawings. Corresponding components are referred to by the same reference numerals in the various Figures.

FIG. 1 is a diagrammatic representation, partly in a perspective view and partly as a block diagram, of a known part of an embodiment in which the light traverses the target plate only once.

FIG. 2 shows a known part of an embodiment in which the light is reflected at a surface of the target plate.

FIG. 3 shows a known modification of a part of the device shown in FIG. 2.

FIG. 4 is the cross-sectional view of the known vacuum tube shown in FIG. 2.

FIG. 5 is a diagrammatic cross-sectional view of the screen of the tube shown in FIG. 4.

FIGS. 6 and 7 show a front elevation of two elements of the tube shown in FIG. 4.

FIG. 8 is a block diagram of an embodiment of the thermal control device in a device according to the invention.

FIGS. 9 and 10 show modifications of the embodiment shown in FIG. 2,

FIG. 11 shows the beam separation polarization device shown in FIG. 10,

FIGS. 12 and 13 show modifications of parts of FIGS. 9 and 10.

FIG. 1 diagrammatically shows members of an optic relay and the members which cooperate with said relay so as to obtain a visible picture on a screen 2 via a projection lens 4. The light is supplied by a lamp 6 shown in the drawing as a filament lamp; of course, any other type may be used. The light passes a collimator lens 8, then a space 10 which serves for suppressing the infrared thermal rays. The optic relay is mainly constituted by a plate 12, consisting of a parallelepiped-shaped monocrystal of KDP which contains approximately 95 percent deuterium ions calculated on the H-ions; this crystal the optical axis (c) of which is perpendicular to the major planes is arranged between the two crossed polarizers 14 and 16 the planes of polarization of which are parallel to the two other crystal axes (a and b) of the monocrystal. According to the invention, the plate 12 is kept substantially at the value of the Curie temperature (approximately −55° C.) by means of the temperature control device to be described below with reference to FIG. 8. Of this control device, FIG. 1 shows only the known thermal control 18. On the left-hand surface of the plate 12 in FIG. 1, an electron beam impinges which is denoted by a broken line and originates from an electron gun 20. This beam periodically scans the whole effective surface of the plate 12 by means of deflection means 22 which is controlled by scanning signals of a receiver 24 which receiver receives the synchronization signals at the input 26 with the actual video signal. A block 28 supplies the required direct voltage for a few of the said members, as well as to an anode 30. For the sake of clarity the anode is denoted by a plate parallel to the light beam; it will be obvious that this arrangement is very favorable for passing the light but not for receiving the secondary electrons originating from all points of the plate 12 on which the electron beam impinges. Therefore, in practice the anode is provided parallel to the surface of the plate 12 and in the immediate proximity thereof. Since the incident electron beam and the light beam have to traverse the anode, the anode is constructed, for example, in the form of a grid.

FIG. 1 furthermore shows a thin plate 32 which is electrically conductive and optically transparent and which in practice is formed by a thin metal layer (gold, silver, chromium) and which is surrounded by one or more metal oxide layers (SiO, SiO_2, Bi_2O_3, Ag_2O) so as to improve the adherence. Between this thin metal layer and the anode, the video information signal is applied. It is possible to fix the potential of the layer at a particular value, and to supply the information signal to the anode, but in the example described the conductive transparent layer receives the signal so that said layer constitutes a control electrode.

The mechanism of this control may be described as follows.

When the electrons of the electron beam reach the surface of the plate, they produce, if the energy lies within the desirable limits and if the anode potential is sufficiently high, secondary electrons the number of which is larger than that of the incident electrons. As a result of this the potential of the point of incidence is increased so that the potential difference between the anode and the point of incidence becomes smaller. If the electrons of the beam are incident on said point in a sufficient number, the said potential difference becomes negative and reaches such a value ($-3V$, for example) that every incident electron produces only one single secondary electron. The potential of the point thus reaches a limit value with respect to the anode potential. Dependent upon the scanning rate, the intensity of the beam must for that purpose be chosen to be sufficiently high. If the potential of the relative point would initially not have been lower but higher than the said limit value, the secondary emission would not have compensated for the charges produced by the beam, so that said potential would have gradually reduced to the said value.

The control electrode will now be considered; if the anode potential is constant, every passage of the electron beam, as described above, fixes the potential of an arbitrary point A of the surface at a value V_o independent of the point of incidence and of the instant of passage. The corresponding electric charge at the relative point, however, depends upon the potential of the control electrode which is provided in the proximity of the other surface of the plate. It is sufficient to consider the "capacitor" the dielectric of which is formed by the said plate and the electrodes by the control electrode and the element of the surface of incidence around the point A to see that, if V_A denotes the potential of said electrode at the instant of passage, the charge is proportional to $V_o - V_a$. Since the charge occurs on an electrically insulating surface, this remains constant till the next passage of the beam over the same point A as well as the potential difference $V_o - V_A$ between the two surfaces of the plate at the relative point and the relative electric field which is perpendicular to the plate and the control electrode. The electric field which controls the passage of the light through the plate at the point A hence is in itself constant between two passages of the beam and during said passages is controlled by the video information signals. This also holds good for a further point B where the fixed potential difference when the beam passes is $V_o - V_B$, V_B being the value of the video information signal at the instant of passage.

The constancy of the electric field between two successive passages of the beam prevents flicker of the picture in such manner that, if the picture to be reproduced is developed only very slowly, only a few pictures per minute need be transmitted.

The above described device (FIG. 1) hence operates as follows: the electron beam scans the plate **12**; the resulting charge occurring at every point of plate **12** depends upon the signal voltage applied to the thin plate **32** at the moment when the electron beam passes that point; in this way an image of electric field strengths is formed on the plate **12**, the electric field being directed perpendicular to the plate **12**. According to the Pockels effect the plane of polarization of light incident on the plate **12** is variably rotated in dependence upon said field. As a result of the crossed polarizers **14** and **16** on either side of the plate **12**, the amount of light reaching a point of the screen **2** is dependent on the electric field strength of the corresponding point of the plate **12**, and in this way an image is projected on screen **2** by the projection lens **4**, corresponding with the image of electric field strengths on plate **12**. In consequence of the rotation of the plane of polarization the amplitude of the light waves passing the polarizer **16** and projected on a point of the screen **2** is proportional with the sin of the electric field strength of the corresponding point of the plate **12**, thus sin kV if V is the potential over the plate and k is a constant. The light intensity is the square of this amplitude and thus $\sin^2 kV$.

For clearness' sake the plate **12** in the Figure is shown perpendicular to the light beam, only the electron beam is incident at an acute angle. In practice, it may be preferable, as a result of the presence of the grid in front of the screen which serves as an anode **30**, to use a minimum inclination of the beam in the axis of the beam so that both beams are at an angle. It is found, however, that the KDP crystal causes a phase shift as a result of its double refraction when a light beam passes through it which encloses a given angle with its optical axis c.

This phase shift is compensated by providing a crystal plate (not shown) between the polarizer, **14** and **16**, the optical axis of which plate is parallel to that of the plate **12** and which shows a double refraction of opposite signs.

In FIG. **2** the target plate (not shown) which rotates the plane of polarization of the light and at the surface of which the light is reflected, forms part of the screen **266** shown in the vacuum tube **50**. The incident light originates from an arc lamp **6**, A capacitor C projects the picture of the arc on a small mirror (here a totally reflecting prism R), which mirror is placed in the focus of an optic system L having a focal distance f (for example, a doublet to reduce the aberration and the chromatism). As a result of the small dimensions of the picture of the source **6**, the rays originating from the optic system L and incident in the tube **50** are substantially parallel. The normal to the screen **66** is slightly inclined to the axis of the beam (approximately 1°) so that the reflected beam is focused on a plane near the mirror R prior to the beam impinging upon the screen **2**. The reciprocating paths can be varied by using the mirror R for the projection on the screen **2**. The optic system L operates as a projection objective. The adjustment is carried out by controlling the distance p between L and the screen **266**; in this case $1/p'+1/p$ must be equal to $1/f$, where p' is the distance between the objective L and the screen **2**. In FIG. **2** the position is shown of the crossed polarizers P_1 and P_2 of the polaroid type, which are arranged in the forward and return path, respectively.

In a known modification of this arrangement a beam separation polarization device is used. This polarizer may comprise several dielectric layers or be derived from the Glazebrook prism of spar as is shown in FIG. **3**. This polarizer or prism replaces the mirror R of FIG. **2** and in this case the polaroids P_1 ad P_2 may be omitted. This has the advantage that overlapping forward and return beams can be used as a result of which the angle between the light beam and the screen of the tube **50** approaches 90° even more accurately. The electric field of the light beam has a direction denoted by **267** on the left-hand side of the prism R in FIG. **3** and denoted by **268** on the right-hand side of the prism R.

The vacuum tube **50** of FIG. **2** can be constructed as shown in FIGS. **4** and **5** to which reference is now made. The target plate shown in FIGS. **4** and **5** is of the same type as that of FIGS. **1** and according to the invention is kept at the value of the Curie temperature by means of the temperature control device to be described hereinafter with reference to FIG. **8**. The reference numerals **18** and **81** in FIG. **4** denote a known part hereof. The light denoted by the arrows **40** (FIG. **4**) which impinges upon the plate **12** substantially perpendicularly, is reflected on the rear surface of the plate by a mirror **42** (FIG. **5**) which is electrically nonconductive. This mirror could be formed by a metal layer vapor deposited in a vacuum through the grid **30**; in the example shown, the mirror has a multiple dielectric and is formed by seven layers alternately of zinc sulphide and cryolite; the thickness of each layer is equal to one-fourth wavelength of the light. In order to increase the secondary emission coefficient a cryolite layer **44** with double thickness is added. The rear surface of the plate **12** receives the electron beam supplied by the gun **20**. This beam is accelerated by a voltage of 2,000 volt between the cathode **202** with the filament **204** and the electrode **206**. The beam passes a gridlike electrode **30***a* and the gridlike anode **30** before reaching the plate **12**. The gridlike anode **30** receives secondary electrons from the plate **12**. Secondary electrons not intercepted by the anode **30** are intercepted by the gridlike electrode **30***a* having an appropriate potential. The beam is then deflected magnetically by the four coils **22** after focusing by means of the coil **46**, so that in the case of an intensity of 26 μa. the current density at the level of the layer **44** is 1A/sq.cm. In this manner a scanning of 600×800 discrete points on a surface area of the plate **12** of 27 mm. × 36 mm. is obtained.

The layer **44**, the mirror **42** and the various other layers are provided one after the other.

As a result of the use of the mirror **42**, various advantages are obtained with respect to the device shown in FIG. **1**.

As a result of the use of the mirror **42** the light has to traverse the plate **12** two times, as a result of which with a given thickness of the plate and a given electric voltage the resulting phase shift is doubled. The analysis by the electron beam is also facilitated when said beam is incident perpendicularly. Moreover the light does not traverse the anode **30**, so that a better permeability is obtained.

FIG. **5** shows on the right-hand side the anode **30** formed by a grid and covered with a receiving member for the secondary electrons originating from the layer **44**, under the action of the incident electrons of the beam transmitted by the gun **20**. The receiving grid consists of copper. The pitch is 50μ and the thickness is approximately 10μ. The diameter of the apertures is approximately 45 μ so that the permeability for the incident electrons lies between 60 and 70 percent. This grid is stretched on an annular support **52** (FIG. **4**) consisting of a copper-nickel alloy having a coefficient of expansion which is approximately equal to that of copper. This support has an effective circular passage of 40 mm. diameter and comprises a narrowed portion **54** in which a copper-nickel ring can be accommodated. In order to secure the grid to the support, the ring is forced into the narrow portion **54** while the grid is taken along, after which the ring and the support are secured together by spot-welds. After mounting the grid is thermally hardened so as to obtain a suitable mechanical stress of the grid.

The support **52** of the grid **30** comprises a gap **56** for passing the connection wire **58** of the control grid **32** and six holes as denoted by **60**. The support is secured by screws **62** on a tray **64**; both components are applied to earth potential. The depth of the tray is equal to the thickness of a disc **66**, the function of which will be described below. The disc has a thickness of 8 mm. and a diameter of 5 cm. In order to maintain the space of 50μ chosen between the grid **30** and the layer **44**, mica spacing members (not shown) are provided between the support **52** and the tray **64**. In front of the plate **12** is arranged the control electrode **32** which must have a sufficient thickness to have a low resistance per square which in this case is lower than 500 ohm, (the resistance per square is measured between two parallel sides of a square with the layer). However, the electrode must be thin so as to obtain a good transparency. In

the example described, the electrode is formed by a metal layer (gold, silver, chromium) coated with one or more metal oxide layers **321** and **322** to improve the adherence (SiO, SiO_2, Bi_2O_3, Ag_2O, for example).

Reference is now made to FIG. **6** and FIG. **7**.

The sensitive layer **12** has substantially the shape of a rectangle of 3×4 cm. (FIG. **6**). An aluminum layer **70** which leaves an effective aperture of 27 mm × 36 mm. and which enables a good electrically conductive connection to the control electrode **32**, is provided at the edges of said rectangle on the rear surface. When the plate **12** is provided on the disc **66**, said layer **70** contacts an aluminum layer **72** (see FIG. **7**) which is provided in four sectors on the front surface of the disc **66**. These four sectors which are separated from each other enable the electric contact between the layers **70** and **72** to be checked after the provision. On the layer **72** the connection wire **58** is situated through which the video information signal is supplied to the electrode **32**. The thickness of the plate **12** is 0.2 mm. which is compatible with the said definition (600×800 points) in the proximity of the Curie temperature the dielectric constant is much higher in the direction of the optical axis of the crystal than in any other direction. As a result of this the lines of force of the electric field cannot deviate from the normal to the plate, while throughout the thickness hereof the definition obtained in the division of the charges on the layer **44** can be maintained.

It has already been noted above that in the examples described the plate **12** is kept substantially at the Curie temperature by means of the control device to be described with reference to FIG. **8**. In the embodiments described, as shown, (only) in FIG. **4**, the plate **12** is for that purpose secured to a fluorine plate **66** having a coefficient of expansion approaching that of KPD provided in a tray **62** of copper which is cooled by the hollow ring **80** which is connected to a Joule-Thompson cryostat **18**, to which nitrogen under a pressure of 150 kg./sq.cm. is supplied. Only the plate **81** of the cryostat is denoted in FIG. **4**. With reference to FIG. **8**, the cryostat is formed by a narrow tube **82**, which ends in a small aperture and is wound within an inner tube **83** having a thermally insulating wall. The gas expands via said aperture, so that it is cooled and said gas in turn cools the in-flowing gas during its escape along the narrow tube. The temperature gradually decreases. The supply of nitrogen from a bottle **84** is controlled by an electrically operated valve **86** which in itself is controlled on the basis of the measured capacity of the capacitor **90** consisting of the plate **88** covered with two electrodes. The plate **88** has a diameter of from 3 to 10 mm., and a thickness of approximately 0.5 mm. It consists of KDP which is enriched with 5 to 20 percent less deuterium than the plate **12** and is provided near the plate **12** (not shown). In the tube shown in FIG. **4** it is adhered, for example, to the free surface of the grid support **52**. The characteristic of the dielectric constant of the material of the plate **88** in accordance with the temperature, enables the optimum operating temperature to be adjusted for the plate **12**.

The other elements of the control device are: and electric oscillator **92** of 2 mc./s., a capacitor **94** which forms a capacitive bridge with the capacitor **90**, an amplifier **96**, a detector **98**, the electromagnetic part **100** of the valve **86** and finally a controllable threshold formed by a potentiometer **102** and a direct voltage generator **104**.

The device according to the invention can be improved by the measure shown in FIGS. **9** to **13**.

Whereas in FIG. **2** the optic system L operates as a collimator and as a projection objective, FIG. **9**, to which reference is now made, shows the collimator separated from the objective. The collimator is constituted by the plane-convex lens formed by the fluorine plate **66** which also serves for the heat dissipation of the target plate **12**. A beam separation polarization device R is used. It may comprise several dielectric layers or be derived from the Glazebrook prism of spar as is shown in the Figure. The objective **125** is arranged between the beam separation polarization device R and the projection screen **2**. The lens **125** can as a result be manufactured without special measures with respect to thermal or mechanical stresses since it is avoided that the objective serves as L in FIG. **2**, as if it were placed between two crossed polarizers, whereby each stress in the objective lens is expressed in the appearance of parasitic light on the projection screen and results in errors in the uniformity of the brightness of the picture and a reduction of the contrast. Since the collimator **66** is arranged substantially in the objective plane, it has only an extremely weak influence on the operation of the objective **125**. For the calculation of the objective **125** only the curvature of the field as a result of the collimator need be taken into account as regards the collimator. The light source in FIG. **9** is of the film projection type and consists of a lamp **6** having a mirror **123** in the form of an ellipsoid of revolution.

The device shown in FIG. **9** may furthermore be improved by using the measures shown in FIG. **10**. Whereas in the device shown in FIG. **9** only half of the light intensity which is incident on the prism R is used, since the surface **31** reflects only one of the polarized components of the light to the plane **12**, the whole light intensity in the device shown in FIG. **10** is used by making use of a multiple beam separation polarization device R, a plate **127** which shifts the phase by half a wavelength, two flat mirrors **128** and **130** and one concave mirror **129**.

FIG. **11** shows in detail the multiple beam separation polarization device R of FIG. **10** derived from the Glazebrook type of spar and the direction of the electric vectors of the components of the incident and emanating polarized light. The optic axis of the spar is perpendicular to the plane of the drawing. Along the surfaces **131** and **132**, three prisms equivalent to the two prism of R of FIG. **9** are combined by a glue the index of refraction of which lies in the proximity of the extraordinary index of refraction of the spar ($n_e = 1.486$) which is lower than the ordinary index of refraction ($n_o = 1.658$). The prism **136** allows the light which passes the surface **131** to emanate. This prism **136** is equivalent to a layer with parallel surfaces for the projection beam and may consist of glass or another transparent isotropic material which is united with the three other prism by means of a suitable glue the index of refraction of which may be different from the said index of refraction n_3.

As shown in FIG. **10**, the mirror **12** forms a picture of the source **6** in the beam separation polarization device R. The component of the light the electric vector of which is parallel to the plane of the drawing, is reflected at the surface **131** to the collimator **66** (see FIGS. **10** and **11**). The component the electric vector of which is perpendicular to the plane of the drawing traverses R directly and then the plate **127**. Beyond the plate **127** the electric vector is parallel to the plane of the drawing. By means of the flat mirrors **128** and **130** the concave mirror forms a second picture of the source of the beam separation polarization device. The concave mirror which operates with a magnification equal to 1, may be spherical. By moving the concave mirror to the right or to the left in FIG. **10** only one of the flat mirrors **128** and **130** is sufficient.

The multiple beam separation polarization device R may also be manufactured entirely from glass when several dielectric layers are used at the separating surfaces **131** and **132**. In this case the directions of the electric vectors are the inverses of those which are shown in FIG. **11**.

With suitable choice of the indices of refraction the faces **131** and **132** may enclose angles of 45° with the axis and, as shown in FIG. **12**, when a quarter wavelength plate **127** is used which is passed two times, the prism **136** and the flat mirrors **128** and **130** may be omitted.

In the device shown in FIGS. **9** and **10** the light source **6** for the mirror **123** a shadow which involves a nonuniform illumination of the target plate and hence brightness errors on the screen **2**. In order to avoid this the devices may further be improved by using the measure shown in FIG. **13**. In FIG. **13** an assembly of two mirrors **141** and **142** which are shifted from each other by a few millimeters and enclose an angle of a few

degrees with each other is arranged between the mirror **121** and the beam separation polarization device R so that the light source **6** in front of the mirror **123** is not visible when the mirror is observed through the beam separation polarization device by means of the mirrors **141** and **142**. The mirrors **141** and **142** are preferably "cold mirrors," which are transparent to infrared radiation so that heating of the beam separation polarization device, of the target plate and of other optical means used is counteracted.

In order to prevent that secondary electrons originating from the point of the screen **266** hit by the electron beam impinge upon points which may have higher potentials than the point of the grid **30**, this grid may be provided, according to a known measure, very close to the screen by adhering the grid **30** to the screen after the surface of the grid has been covered with an insulating layer. Furthermore, in order to prevent incident electrons on the screen **266**, according to a known measure, a magnetic field perpendicular to the surface of the screen is used. These measures prevent efficaciously that the secondary electrons originating from the point hit by the electron beam are received by adjacent points. Upon using these measures alone, however, it remains possible that secondary electrons, after having covered a path of several millimeters or several centimeters, can return to all points of the screen which have a potential equal to that or higher than that of the screen. In order to remove this drawback, the last electrode of the electron-optical lens system in the tube is preferably set up at a potential which is equal to or higher than the highest potential which any point of the screen can reach. Since this highest potential with respect to the potential of the grid in absolute value is equal to the potential difference between a "white" point and a "black" point, a potential difference which is at least equal to the maximum peak-to-peak control voltage must be applied between the said last electrode and the grid. In practice the last electrode then has a potential which is approximately 100 to 200 volts higher than that of the grid. The last electrode preferably is a second grid provided in front of the first grid **30** at a few millimeters distance therefrom on the cathode side, to which second grid a potential is applied which is 100 to 200 volt higher than that of the first grid. This provides the advantage that a particularly uniform collection of the secondary electrons is also obtained. Since the second grid is not placed in the focal plane of the beam it may have wider meshes than the first grid, the advantage of a great transparency being obtained. The second grid preferably consists of parallel wires stretched perpendicularly to the direction of the scanning lines in order to avoid Moire phenomena. When the first grid has a rectangular structure, the two orthogonal directions of said structure preferably are oriented so that they enclose angles of 45° with the scanning lines and with the direction of the wires of the second grid. When the first grid has a "hexagonal" structure, the orientation thereof with respect to the scanning lines and the wires of the second grid is not critical. It is to be noted that the above-mentioned second grid can be used together with a first grid secured to the screen and a magnetic field, but, if desirable, for the sake of particular requirements, may also serve to replace a first grid adhered to the screen or a magnetic field.

What is claimed is:

1. An optical relay device, comprising a plate of electrically insulating material positioned in an optical path between a polarizer and an analyzer, said material consisting of an acid salt which is ferroelectric below the Curie temperature thereof, said material being enriched with deuterium whereby the Curie temperature thereof is higher than in the absence of deuterium, means for applying a variable electric field across the plate with a direction parallel to the general direction of propogation of light in said path whereby the plane of polarization of the light is variably rotated in dependence upon said field, means for generating an electron beam, means for scanning the electron beam across a major face of said plate, an anode for collecting secondary electrons released from said plate by said electron beam, and a temperature control device for stabilizing the temperature of the plate at a value differing at most 5° from the Curie temperature of the plate, said temperature device comprising a capacitor as a temperature-determining element the capacity of which varies as a function of the temperature, the dielectric of the capacitor comprising a material having a Curie temperature differing from that of the plate by between 1° and 20°.

2. A device as claimed in claim **1**, wherein said anode is a gridlike anode between the major face of said plate and said scanning means, said anode being disposed parallel to and within 1 mm. from said surface, said device further comprising means for applying a potential to said anode, a gridlike electrode disposed parallel to said gridlike anode on the side of said scanning means and means for applying a potential to said gridlike electrode having a voltage higher than the potential applied to said anode.

3. A device as claimed in claim **1**, wherein the dielectric of the capacitor has a Curie temperature which is between 5° and 20° lower than the Curie temperature of the said plate.

4. A device as claimed in claim **1**, wherein in that the dielectric of the capacitor consists of the same acid salt as the said plate but is enriched with a lower percentage of deuterium than the material of the said plate.

5. A device as claimed in claim **2**, wherein said gridlike electrode comprises parallel wires stretched perpendicular to the lines of the scanning.

6. A device as claimed in claim **5**, wherein the gridlike electrode has a wider pitch than said anode.

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