

March 17, 1942.

M. VON ARDENNE

2,276,359

TELEVISION IMAGE PROJECTION DEVICE

Filed Aug. 26, 1939

5 Sheets-Sheet 1

Fig. 1a

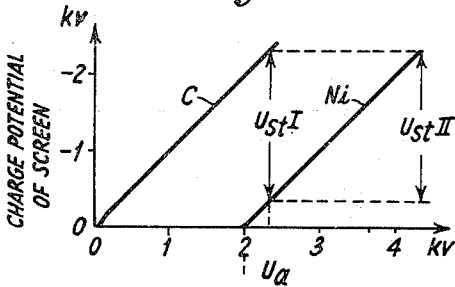


Fig. 1b

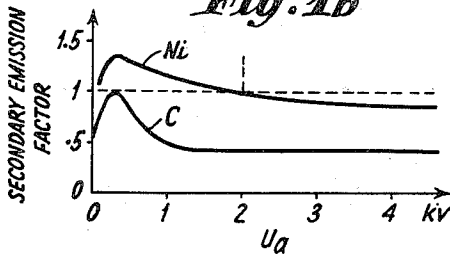


Fig. 3

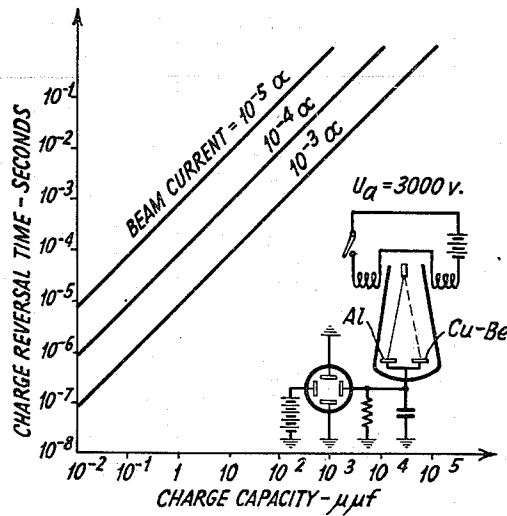


Fig. 2

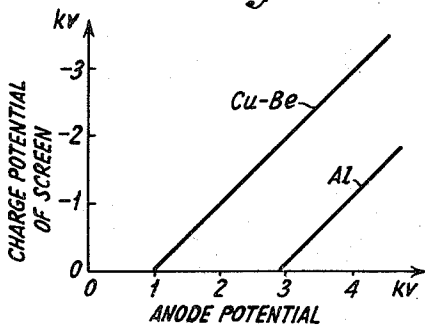


Fig. 4b

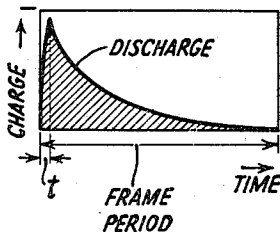
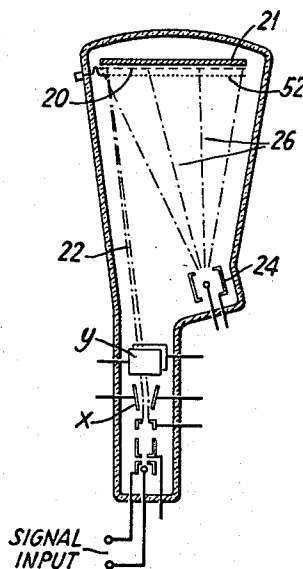


Fig. 4a



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Fig. 5a

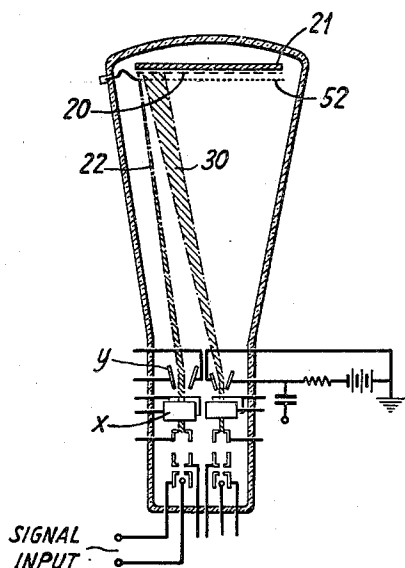


Fig. 5b

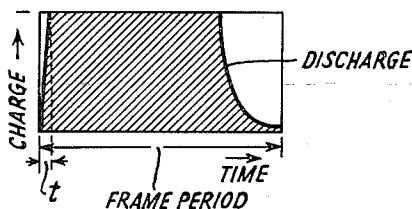


Fig. 6

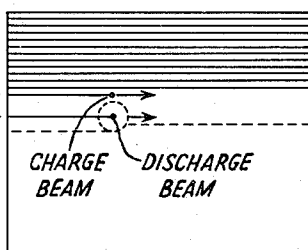


Fig. 7

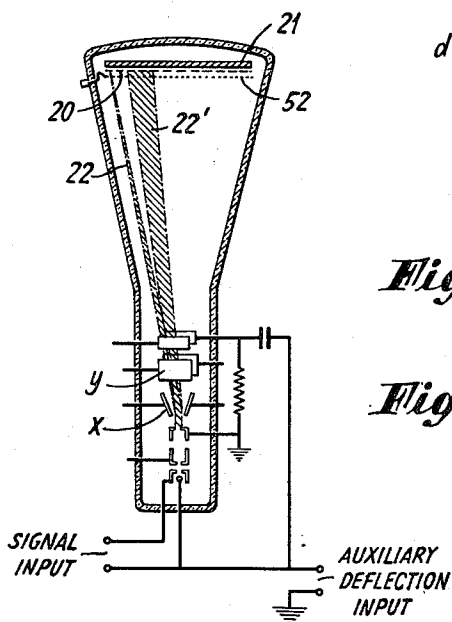


Fig. 8

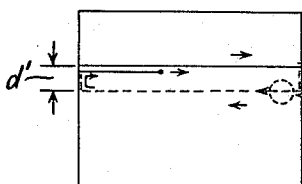


Fig. 9a

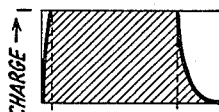
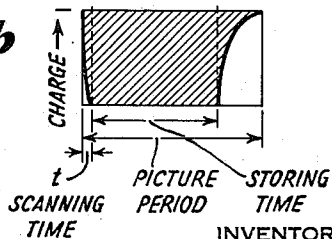


Fig. 9b



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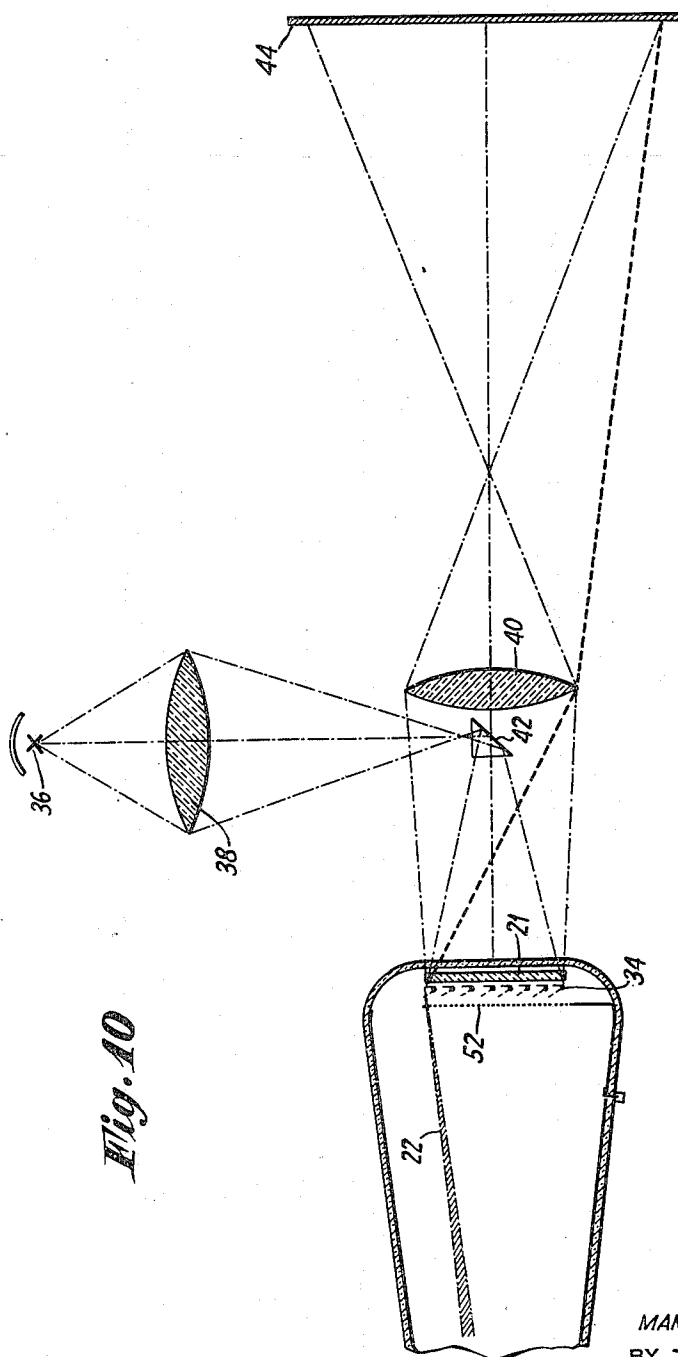


Fig. 10

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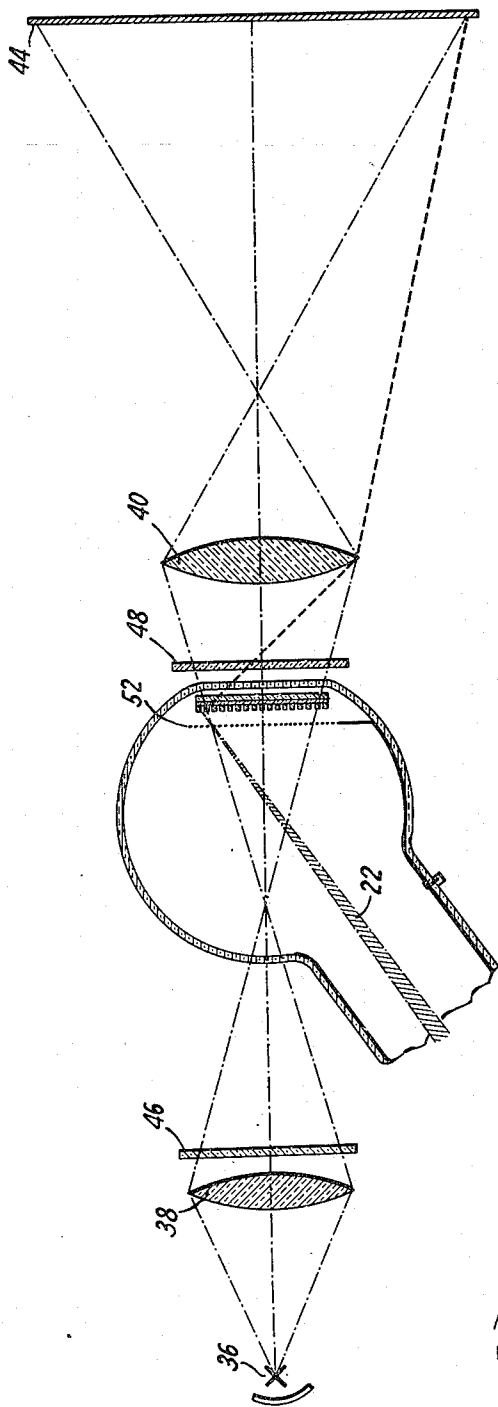
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Fig. 11



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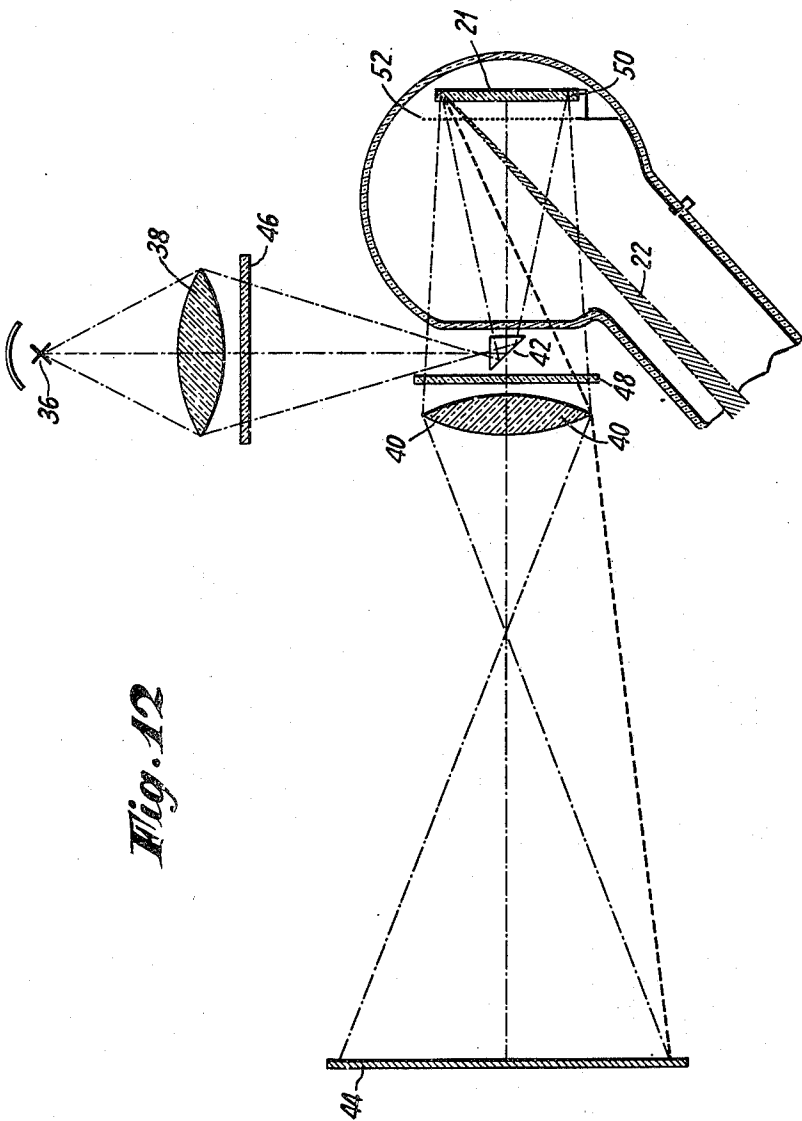
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UNITED STATES PATENT OFFICE

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TELEVISION IMAGE PROJECTION DEVICE

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GermanyApplication August 26, 1939, Serial No. 292,017
In Germany September 10, 1938

2 Claims. (Cl. 178—7.5)

One of the most important problems of the television arts is that of producing, at the television receiver, an enlarged and brilliant image of the transmitted subject matter. This invention accordingly relates to the application of the image storage principle to a television receiver.

The ideal form of solution to this problem may be set forth roughly as follows: Instead of the fluorescent or luminescent screen conventionally mounted in a television receiver tube of the cathode or electron ray type, there is mounted in the tube a screen the permeability or transparency to light, or the light reflecting characteristics of which are controlled from one picture point to the next by the amount of cathode ray energy incident upon the picture element. But the accumulated or stored luminous brightness or brilliance, or the distribution of light absorption must be extinguished or wiped out again between frames if the reproduction of animated pictures is to be made feasible. If it were feasible to carry the arrangement into practice in such a way that such extinction occurs a brief instant prior to a new scan of the same screen element, then a storage effect will be obtainable practically for the entire frame period, and this offers the advantage of a more intense picture and of perfect freedom from flicker in the reproduction or projection of the pictures, just as in the case of film projectors comprising optical compensator means. The screen so controlled is to be inserted in a projector type equipment where it is to play the part of the diapositive. In the ideal form of solution as just described the cathode ray unit merely plays the part of a two-dimensional light relay or valve for the light current or flux produced by any desired projector light source. Thus, it is the luminous intensity of the latter rather than the energy conversion in the cathode ray unit that governs the brightness or brilliance of the projected television picture.

Now, the likelihood of discovering a technical solution which will come close to the ideal solution hereinbefore outlined is more nearly approached the stronger the charge reversals of insulated raster elements upon the said screen that are practicable; for the higher will be also the field intensity values between the raster elements and a conducting auxiliary plate mounted opposite thereto which may be built up during the period of a picture unit or point, subject to the control or modulation of the frame signal potential prevailing at the Wehnelt cylinder or control grid of the electron ray system. The

higher the field intensities obtainable at the screen, the greater will be the number of the electro-optic and the electro-static effects and methods that are adapted to insure control, point by point, of the light permeability or transparency, or the light reflection of the screen. Fully understanding the fundamentals of the situation, ways and means have first been sought which will be adapted to create high potential variations at the insulated raster element. The physical bases of the solution shall now be briefly described as follows, seeing that this explanation is essential for the purpose of grasping the present invention.

The invention may best be understood by reference to the accompanying drawings wherein like reference characters represent like parts and wherein:

Figure 1a and Figure 1b show the relationship between beam intensity and produced secondary electrons,

Figure 2 shows curves indicating the relationship between produced secondary electrons or screen charge potential as a function of anode potential for various metals or alloys,

Figure 3 shows the charge reversal time of raster elements as a function of their capacity for three different values in beam current and potential variation of about 1500 volts,

Figure 4a represents a simple storage arrangement based upon secondary electron control action while Figure 4b shows a curve representing the time of charge and discharge of the stored potential,

Figure 5a shows a storage arrangement utilizing two electron beams to produce greater efficiency while Figure 5b shows a curve representing the storage effect produced between apparatus shown in Figure 5a,

Figure 6 shows the relationship between the two beams used in the apparatus shown in Figure 5a,

Figure 7 shows a system based on charge storage wherein a single electron beam is used,

Figure 8 shows the manner in which the single beam of Figure 7 is deflected in order to produce the desired charge and discharge condition on the screen,

Figure 9 shows the relationship between charge potential and the time consumed for one picture scanning cycle,

Figure 10 shows a projection type television receiving tube in which the principle of stored charges is utilized,

Figure 11 shows a modified form of a projec-

tion type receiving tube in which the principle of stored charges is utilized,

Figure 12 shows a still further modification of a projection type television receiver tube based upon double utilization of the electron optical effect.

The basic idea is that the various raster elements operate with two distinct secondary emission factors (two secondary emissivities). The physical bases therefore will be found in an exhaustive earlier publication of Knoll ("Charging Potential and Secondary Emission of Electron Irradiated Bodies" in *Zeitschrift fuer Technische Physik*, vol. 16, p. 467, 1935). The two methods or ways adapted to create a control potential at insulated raster elements by the aid of secondary emission are illustrated graphically in Figures 1a and 1b. Namely, either by a shift of the impact point from a surface having lower secondary emissivity to a kind of surface possessing higher secondary emission power; or else by the introduction of disparities or modulation in the speed of the incident electrons, while using one and the same (that is, a uniform) kind of secondary emission material, it is feasible to secure potential variations of an order of magnitude of several thousand volts.

Control (modulator) action predicated upon the change or difference in the nature of the surface is particularly suitable for an investigation of the charge reversal time of raster elements as a function of their capacity and the ray current, for the reason that in this case means designed to produce control actions in the cathode ray generator system are entirely dispensable. Measurements made on the charge potential of the screen as a function of the anode potential are shown graphically in Figure 2 for aluminum and for a copper-beryllium alloy. It will be noticed that, starting with electron speeds of over 3000 volts the change from the aluminum surface to the copper-beryllium surface of the impact screen results in a potential change of 2 kv.

To make a check-up on the question which is extremely important in television work as to whether potential variations of this order of magnitude are actually possible in charge reversal times equalling in size to the picture element period, a series of tests were made the results of which are illustrated graphically in Figure 3. What will be concluded from this representation is that, in the case of picture element or picture point periods of 10^{-6} seconds and a cathode ray current of 10^{-4} amperes, the capacity of the individual raster or screen element may be as high as 10^{-2} micro-microfarad. By other measurements a check-up was made regarding the influence of defective insulation between the raster elements and the counter or opposite plate. The outcome of these tests was that in the presence of a beam current of an order of magnitude of 10^{-4} amperes, the insulation resistance may decrease down to 10^{-8} ohms, without any critical decline in the control potential at the raster element being brought about. In order that there may be no leakage or drain of the accumulated charge during the storing period, however, the insulation resistance must be higher at the ratio of picture point period. The high values thus resulting, however, are readily maintainable in vacuum, particularly when piezo-electric screens of the kind disclosed further below are used. What follows from the preceding is that the utilization of this control principle in television work is not

disturbed or affected by consideration of a dynamic nature and insulation requirements.

This statement applies also to arrangements in which change of raster potential is not accomplished by variation of the irradiated surface, but rather by variation of the accelerator or electron gun potential. Operation with different electron speeds entails solutions that are simpler from a technical angle. Now, various practical possibilities to carry into effect the second mode of control shall be explained in greater detail in what follows:

As soon as the elements of a raster screen exhibit potential differences which are not very small in contrast to the anode potential—and this is nearly always true of the method here disclosed—reactions produced by the raster screen upon the deflection of the cathode ray beam make themselves felt. The fact is that anteriorly of screen regions or zones subject to strong charges in respect to the anode, potential fields are set up which produce an effect very closely resembling that of a divergent lens inhering marked faults or distortion, with the result that a more marked deflection of the cathode ray beam is produced. This, in turn, occasions defects or faults (distortion) of the light control or modulation. The critical action by the raster screen upon such portions of the path of the electron beam located anteriorly or in front of the screen is avoidable, without incidentally causing any disturbing actions upon the other functions of the tube, if, according to a further object of the present invention, a network or gauze comprising wires as tenuous as feasible and made up of the finest possible mesh is mounted directly in front of the impact screen. In fact, if the wires of this grate or gauze have been chosen extremely fine, it is possible to make screen grids which combine extremely low transparency with an electron or light flux absorption ranging between only 5 and 10 percent. Thus the effect of irregularities in the meshes upon the quality of the picture may be neglected. The mesh width of the screen grid should preferably be low compared with the diameter of a raster element. A grid of such fineness causes marked diffraction of light waves. Hence, when mounting the raster screen combined with the screen grid in the path of the projection rays, it will be recommendable to place the screen grid upon the illumination end of the beam path or else, if it is imperative to dispose it upon the imaging side for other reasons, then to arrange it at close proximity to the raster screen.

A simple storage arrangement comprising a screen grid or network or grate of the kind just discussed, with the screen comprising raster elements of a uniform sort of surface material, is illustrated in Figures 4a and 4b of the drawings. The raster or screen elements 20, positioned on support plate 21 are here charged up by means of a cathode ray beam 22 composed of high-speed electrons in the course of the scanning time t of a picture unit or element to a value that is highly negative in respect to the anode potential. The absolute value of this charge is a function of the beam current and thus of the instantaneous value of the picture or video signal voltage at the Wehnelt cylinder or control grid of the charge system. In a way similar to the "iconoscope," the ratio between the maximum beam current and the capacity of the raster element must here be of a certain size. The said relationship should be chosen so that, in the

course of the scanning time of a picture element, the operating point of the charge characteristic will never approach the asymptotic portion if the brightness or brilliance values are to be correctly reproduced. Immediately after the charging of the various elements of the raster screen, the discharge process commences in the manner shown in Figure 4b. The discharge is here occasioned by a source of electrons 24 adapted to irradiate the raster surface 20 uniformly and permanently by a flooding stream of electrons 26 of low velocity. The electron current of the discharge means is regulated in such a way that the electron volume corresponding to a picture unit will just suffice in order that, in the course of the frame period, there will be brought about complete discharging of the raster elements 20 even if charged to crest value. In this case as well as in a number of other arrangements later to be described, the discharge should follow an exponential law and vary as an e -function. In reality, however, the discharge law is a function between the e -law and a straight-line function.

Care should be taken in carrying an arrangement of the invention into effect so that the phase in the creation of the optical image by the distribution of potentials over the raster surface will be so that the raster elements, in discharged state, will appear dark. In fact, pictures exhibiting adequate contrast will be obtainable only if the said condition is fulfilled. The same rule applies, although to a greatly reduced extent, to arrangements hereinafter to be disclosed which are predicated upon charge control action.

An arrangement of the kind shown in Figure 4 involves the shortcoming that, as a result of the discharge being initiated immediately, the storing effect (shown shaded) will be imperfect and incomplete, and that the pictures give the impression of intermittence (lack of continuity). This difficulty is obviated by a twin-beam storing arrangement as shown in Figures 5a and 5b. In this embodiment the discharge is produced by the aid of a second beam 30 of electron rays only a brief instant prior to re-charging. The position and the motion of the charge and the discharge electron beam will be seen from the representation Figure 6. The discharge spot, according to another object of this invention, is made of a larger diameter in order to dispense with the necessity to cause sharp rasters to coincide or register. The diameter of the discharge pencil, to be sure, should not be made any larger than what is imposed by necessary tolerance, for otherwise a substantial portion of the top edge of the picture would be lost in this method. The distance d between the charge and the discharge spots is insured either by a permanent auxiliary deflection or by suitable adjustment relative to each other of the two electron beam developing systems when mounting the same in the tube.

The task of carrying an arrangement of the kind shown in Figure 5 into practice is not attended with any serious difficulties. Yet, an arrangement as shown in Figure 7 here shown as a further exemplified embodiment of the invention may be of greater practical interest in which, by somewhat more elaborate circuit organization means, the same end is attainable with a single and unitary beam generating system.

For a better understanding of this arrangement, reference is here made to Figure 8 showing and representing the motion of the electron

beam spot upon the raster plate. The operation of the single beam arrangement is predicated upon the fact that the electron beam is first caused to scan or sweep at high potential and optimal focus a line of the raster plate with the result that the potential distribution corresponding to the picture content is stored up. During the brief flyback or return period, with reduced anode potential, and with an unfocused or blurred beam 22' traversing a displaced track or path, the discharge of the lines coordinated to the preceding frame is caused. Because of the width of the spot, just as in the case of the twin-pencil storing arrangement, the extinction is distributed over several line scans. The auxiliary and slight vertical deflection d' during the flyback may be brought about either by a derivation of the accelerating voltage control, or when the static point is outside the raster area, be produced by the control or regulation of the deflection sensitivity occurring simultaneously with the anode potential control. Inasmuch as the discharge is produced with reduced anode potential, it follows that the extinction raster is larger than the charge raster so that complete extinction throughout the entire length of the line is obtained in the single beam arrangement.

But this advantage will be realizable only if, as in all of the embodiments here disclosed, picture or video signal storing is produced by charging with a beam formed by electrons of high velocity. Fundamentally speaking, also the inverse procedure would be imaginable as shown in Figures 9a and 9b. Figure 9a is similar to Figure 5b while Figure 9b shows a graph indicating charging of the raster or screen elements by a constant electron beam of high speed and a discharge immediately thereafter by the electron beam of lower speed modulated by the video signals. One fact and feature of basic importance in connection with storing systems as here disclosed is that the modulation should invariably and always be impressed upon the beam operating with higher electron velocities, for the reason that higher electron speed always means maximal focus of the spot.

In what precedes arrangements have been disclosed which will insure the storing, during the course of a frame period, upon a rastered screen of field intensities of an order of magnitude of 10^5 V/cm. In order that the presence of such high field intensities may be rendered visible point by point, or to use the same for the control point by point of luminous fluxes, a great number of ways and means are conceivable from among which only a few shall here be mentioned by way of illustration and example.

One embodiment comprising the use of an electrometer type of rastered screen is illustrated in Figure 10. In line with what has been suggested in other places in the technical literature, the raster elements consist of tiny electrometer platelets or "scales" 34. Nearly all metals, looked at from the viewpoint of secondary-emission characteristic, will be suitable for these minute plates. But preferably the platelets 34 should be made from metals possessing high light reflecting powers. The powerful potential distribution produced by any one of the methods previously described is indicated by the electrometer platelets. The latter, according to their particular state of charging, will assume more or less marked light inclinations in a direction normal to the plane of the recording or re-creating screen. The screen electrode which is at anode

potential and which is mounted anteriorly of the rastered surface in this arrangement acts at the same time as the cooperating electrode of the electrostatic system. The point-by-point control of the light flux issuing from the projection lamp 36 is here insured by a change in the direction of the light reflected from the screen elements in conjunction with an obturator (masking) effect due to the aperture of the projection optical means. Lens systems 38, 40 and a prism 42 are used to properly project and focus the image upon an image screen 44.

Another procedure which seems very promising both from an optical as well as a constructional angle and which constitutes another important object of the invention is illustrated graphically in Figure 11. In this embodiment the raster screen 20 is not formed by metallic raster elements, but rather by satisfactorily light-permeable and insulation layers which possess to the highest possible degree so-called "voltage" or crystal birefringence. Particularly suited therefore are Rochelle crystals, for instance, or other kinds of crystal possessing piezo-electric properties. In this important embodiment of the rastered screen, the face turned towards the scanning electron beam, as already pointed out above, does not require a metallic film or coat. In fact, the secondary emission of insulation crystal surfaces is just as suited to practice the present method as the secondary emission of metallic surfaces. This affords the essential advantage and merit that a conducting surface which always absorbs light, need not be provided upon the anterior face of the screen. Only the supporting plate 21 must have a conducting layer which is permeable to light, acting as a counter or cooperative electrode. When a screen is used which is crystalline or crystallized in nature or which assumes crystalline characteristics, light control, point by point, will be brought about as a result of the fact that, due to the influence of the high field intensities there occurs mechanical deformation or warping of the layer elements; and this, in turn, results in double refraction or a variation of double refraction of transmitted light or a change in the rotatory powers. The relay screen is mounted in the cathode ray beam path between two generally crossed or normal polarizers 46 and 48. To secure optimal electro-optical control action, the additional interposition of a compensator plate with path difference may prove advantageous. In order that for the same potential there may always be produced the same brilliance, care is to be taken according to a further object of the invention so that the relay screen, throughout its entire area, will present uniform electron-optic properties. This end is attainable, for instance, by the use of crystallites of the same electron-optic properties, more particularly of uniform dimensions and orientations or else by the use of a single crystal in disk form.

A still more favorable solution is embodied in the arrangement shown in Figure 12. The metallic deposit 50 of the raster screen is here reflecting and the polarization-optical effect is doubled as a result of the double passage of the light across the coat consisting of piezo-electric crystals. If the screen grate 52 or grid above referred to is mounted at sufficiently great proximity to and anteriorly of the layer of crystals, the diffraction of light occasioned in the narrow mesh grate or grid 52 will not occasion any distortions of the pictures in an arrangement as

shown in Figure 12. The latter, when combined with one of the storing means hereinbefore described, accomplishes a solution of the entire problem outlined in the beginning which offers particularly great advantages in optical, electron-optical and constructional regard.

This invention, although described more or less specifically with respect to television, is equally and obviously applicable to measuring and testing systems of the cathode ray type wherein the stored curve paths or patterns are to occur as a rule not periodically and at time intervals of an order of magnitude of one-fiftieth of a second (as in television work); but that extinction is caused only after longer periods of time or time intervals. In connection with measuring work arrangements of the kind here disclosed offer the advantage that in a great many cases, photographic recording may be dispensed with for the reason that numerical evaluation is directly feasible in the projected and stored screen pattern. The long retention of the trace makes this possible.

For use in television it may be mentioned that there are no fundamental difficulties in making the screen of a size equal to several square decimeters. Through the picture windows of such size, as known from the art of projection, light fluxes may be transmitted which will be adequate to practice projection in daylight upon immense projection surfaces or walls.

Furthermore, in the motion picture art the same arrangements with the use of a large screen may render valuable service, that is, in the following combination. In conventional motion picture projection work, the light flux and thus the brightness of the picture screen brightness and screen size are restricted by the reduced size of the film frame. By the combination of a television pickup device with reproducer means as here disclosed, subsequent enlargement of the format is feasible without necessitating any alteration of the film format itself.

Various other uses, alterations or modifications of the present invention may become apparent to those skilled in the art and it is desired that any and all such modifications be considered within the purview of the present invention except as limited by the hereinafter appended claims.

What I claim is:

1. A television receiving device comprising a cathode ray tube, means in said tube for generating a focused beam of electrons, means for deflecting said beam horizontally at a predetermined rate, means for simultaneously deflecting said beam vertically at a predetermined slower rate in order to systematically scan a predetermined area on a target electrode, said target electrode comprising a plurality of discrete secondary emissive elements, the charged condition of which depends upon the intensity of the impinging cathode ray beam, means for modulating the cathode ray beam during one direction of its horizontal deflection in order to produce varying charged conditions on the target electrode, means for reducing the velocity of the cathode ray beam during the return deflection in the horizontal direction and for simultaneously de-focusing the beam to produce a spot size at the target electrode several times larger than the spot size of the focused beam, in order to remove the charged condition of the target electrode, the return deflection of the cathode ray beam being displaced vertically from the preceding horizontal deflec-

tion of the cathode ray beam in the opposite direction by an amount greater than the radius of the de-focused beam spot, the vertical displacement being in the direction of the vertical scanning deflection whereby the charged conditions of the target electrode is retained for nearly the entire time required to scan the predetermined area on the target electrode.

2. A television receiving device comprising a cathode ray tube, means in said tube for producing a narrow focused beam of electrons, means for deflecting said beam of electrons in horizontal and vertical directions simultaneously in order to scan a target electrode in a line-by-line manner, said target electrode comprising a plurality of secondary electron emissive elements, the charged condition of which depends upon the intensity of the impinging cathode ray beam, means for modulating the cathode ray beam in accordance with a received picture signal series during the deflection of the cathode ray beam

in one direction horizontally in order to produce a charge image on said target electrode, means for reducing the intensity of the cathode ray beam during the return horizontal deflection and for simultaneously de-focusing the beam to produce a spot size at the target electrode several times larger than the spot size of the focused beam in order to remove the charged condition of the target electrode, said return horizontal deflection of the cathode ray beam being displaced vertically from the path of deflection in said one direction by an amount equivalent to at least several scanned lines, the vertical displacement being in the direction that the target electrode is scanned vertically whereby the charge produced by any horizontal deflection will not be removed by the subsequent return deflection so that the produced charge image remains on the target for just less than the time required to scan the entire target electrode.

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