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METHOD OF OBTAINING UNIFORM RESPONSE FROM A TELEVISION CAMERA DEVICE

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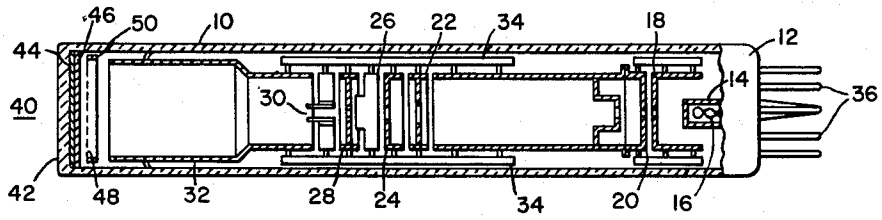


Fig. 1.

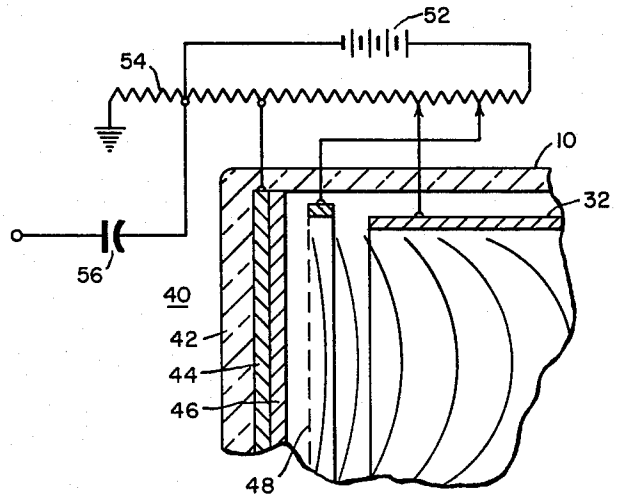


Fig. 2.

WITNESSES

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METHOD OF OBTAINING UNIFORM RESPONSE FROM A TELEVISION CAMERA DEVICE

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This invention relates to electron beam devices wherein a scanned electron beam is employed to bombard an electron sensitive target. The invention particularly relates to such electron beam devices wherein the scanning of the electron beam is accomplished by electrostatic means. Devices to which the present invention include, but is not limited to, low velocity scan devices such as video pickup tubes and buffer storage tubes.

Vidicon type pickup tubes are well known and the present invention will be herein discussed with particular reference to that type of tube as an example of one application of the invention. In the vidicon, the target comprising a light transmissive conductor and a layer of photoconductive material is disposed at the input end of the tube. An electron gun is disposed at the opposite end directed toward the photoconductive layer. Under conditions of uniform illumination the potential across the photoconductive layer established by a fixed potential on the transparent conductor and the electron beam is substantially uniform. When an image is imposed upon the target the conductivity of the photoconductive layer is increased in bright areas with resulting charge transfer. When the scanning beam next sweeps the discharged areas, it recharges the surface and this current surge is capacitively coupled to the signal output circuit.

It is found that the output signal uniformity which is ideal in the vidicon is seldom obtained in practice for various reasons. As photoconductive targets are most readily fabricated, they are formed having a surface contour such that the thickness in the center of the target is greater than that at the edges. Therefore, when uniform potentials are applied on opposite sides of the target, the voltage gradient varies with the thickness. This non-uniformity in thickness would be even more undesirable were it not for the fact that another non-uniformity tends to compensate for it. That is, the electron beam landing error which results from the off-axis abnormality of the beam incident on parts of the target away from the center has an opposite effect from the thickness non-uniformity. At relatively low target voltages, which may be used with scenes of high illumination, this combination may product adequately uniform signals. When it is desired to use the pickup tube with scenes of low illumination such as are encountered in certain industrial applications, the target voltage must be substantially increased to obtain the necessary sensitivity and as a result undesirable edge effects known as edge flare, edge crawl or waterfall effects are produced. The use of photoconductive layers having uniform thickness avoids to a considerable degree these undesirable edge effects but has other disadvantages. The off-axis abnormality of the electron beam produces an effect known as dark portholing and, furthermore, the fabrication of photoconductive layers of uniform thickness is still very difficult and substantial variations from one target member to another are often encountered. Further aspects of these problems are discussed in an article entitled "Beam Landing Errors and Signal Output Uniformity of Vidicons" by R. G. Neuhauser and L. D. Miller, Journal of the SMPTE, vol. 67, page 149 (March 1958).

Approaches to the problem of correcting for landing errors include the use of certain circuit modifications

whereby a modulating voltage of suitable waveform is supplied to the cathode of the vidicon. This method is successful generally with targets having uniform thickness but is undesirable in that it requires certain expensive additions to the camera tube system which cannot be incorporated directly in the tube and, furthermore, does not permit compensation for variations between different target members. Other solutions include a focus coil deflection yoke system which more nearly normalizes the beam landing angle. This has substantially similar disadvantages as the other solution mentioned.

The teachings of the present invention are applicable to any device wherein it is desirable to control the landing angle of a beam of charged particles on a target to obtain uniform response from the target. Devices of greatest interest are, of course, those which employ a beam of electrons to scan a target which in some manner is responsive to the electron bombardment. Means are known to accomplish beam normalization by using magnetic components for focussing and deflection. However, this requires a bulky and expensive system which is undesirable for many purposes such as for portable television cameras. For a more compact device, it is desirable to use electrostatic means for focussing and deflection. In such case, the angle of incidence of the beam on the target, if the landing angle is uncorrected, is determined by the deflection angle given to the beam. The beam landing angle will be exactly equal to the deflection angle if it is the case that the target is a plane perpendicular to the tube axis and also if the voltage of the target is substantially equal to the voltage in the deflection region. If the first of these conditions does not prevail, the angle of deviation of the target plane from perpendicularity to the tube axis will be algebraically additive to the deflection angle in determining abnormality of beam landing. If the potential of the target plane differs from that of the deflection region, the beam incidence at the target will be modified as follows: Higher target to deflection potential ratio improves normality, lower target to deflection potential ratio degrades normality.

In the case of vidicons which have electrostatic deflection means, the requirement that the target plane be perpendicular to the tube axis is met but the target potential is lower than the deflection region voltage and therefore beam landing abnormality is exaggerated. With no correction of the beam landing abnormality,

$$\alpha=\beta\sqrt{\frac{\phi_D}{\phi_T}}$$

where α is the angle formed by the arriving beam and the normal to the target surface, β is the angle of deflection, ϕ_D is the beam potential at the deflection plates and ϕ_T is the beam potential at the target.

It is therefore an object of the present invention to provide an improved electron beam device.

Another object is to provide an electrostatic electron beam device incorporating means for correcting electron beam landing error.

Another object of this invention is to provide an improved pickup tube having more uniform signal output characteristics.

Another object is to provide an electrostatic pickup tube which substantially avoids undesirable edge effects.

Another object is to provide a pickup tube which permits correction for beam landing errors for the particular target employed despite non-uniformity in surface contour.

Another object is to provide a pickup tube means permitting a short distance from the gun to target.

Another object is to provide a pickup tube wherein the

surface contour of the photoconductive target is not critical.

Another object is to provide a method of improving the output signal uniformity of pickup tubes.

According to the present invention, an apertured electrode or mesh is provided on the gun side of the electron target member transverse to the electron beam path and another electrode is disposed around the electron beam path. The two electrodes have independently variable potentials applied thereto to form an electrostatic electron lens which has a plano-convex configuration in the region near the target. Such an electrostatic lens may be either converging or diverging depending upon the potential difference between the two electrodes and, therefore, control of the potentials on these two electrodes permits control of the beam landing angle. As a result the beam can be caused to land either more normally to the target surface or less normally as required for any particular application.

According to a further feature of the invention, the potentials of the two electrodes is established for a target member which is light sensitive by providing uniform illumination on the target and adjusting the potential difference to optimize signal output uniformity and avoid undesirable effects.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its structure and manner of operation, together with the above-mentioned and further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a sectional view of a pickup tube in which the present invention is embodied; and

FIG. 2 is an enlarged schematic view of certain elements shown in FIG. 1 with circuit connections thereto.

FIGURE 1 shows a pickup tube which is generally of the well known vidicon type. The device shown in FIG. 1 differs from conventional vidicon type devices in that it is solely an electrostatic device, that is, electrostatic means are used for deflection, focussing and beam alignment rather than electromagnetic or a system using both electromagnetic and electrostatic elements. The device of FIG. 1 is, however, merely an example of a device in which the incorporation of the present invention is advantageous.

The device of FIG. 1 comprises a generally cylindrical envelope **10** having at one end thereof the elements of an electron gun with electrostatic focussing and an electrostatic deflection system. From the stem **12** of the tube, these elements include a thermionic cathode **14** having a heating element **16** therein, a control grid or first grid **18**, an accelerator grid or second grid **20**, a focussing electrode **22**, a third grid **24**, a pair of horizontal deflection plates **26**, a fourth grid **28**, a pair of vertical deflection plates **30** and a fifth grid **32**. These various elements are mechanically secured by beading or clamping to insulating rods **34** extending along the tube in a well known manner. Electrical connection may be made to external potential sources (not shown) by connection through leads **36** extending through the base **12** of the envelope or through the wall of the envelope **10**. The elements thus far described are such as to produce, upon application of suitable potentials to the various electrodes, a scanning electron beam emerging from the fifth grid **32**. The fifth grid **32** is shown as a cylindrical member spaced somewhat from the wall of the envelope **10**. However, the electrode **32** may also be a conductive coating applied directly to the tube wall and, for convenience, the expression "wall electrode" is used hereinafter to include any such electrode disposed around the electron beam path near the target **40**. Other combinations of elements which produce such a beam may also be used in the practice of this invention.

At the end of the tube opposite from the cathode **14**, there is located a vidicon type pickup target **40** comprising, on the face plate **42** of the envelope **10**, a light-transmissive conductive layer **44** such as tin oxide and a layer **46** of photoconductive material such as arsenic trisulphide. Spaced from the target **40** by a short distance, an apertured electrode **48** is disposed which may be in the form of a mesh supported by a ring **50**.

It will be noted that there is considerable structural similarity between the target area of the device described and the conventional vidicon type tube but with the very important exception that the mesh electrode **48** located near the target **40** and the wall electrode **32** of the beam forming system are not maintained at the same potential but are kept separate so that different potentials may be applied to them for the formation of an electrostatic lens in the region near the target **40** giving an equipotential surface configuration analogous to a plano-convex optical lens. In conventional vidicons, the mesh **48** and wall electrode **32** are at the same potential and, therefore, no electron lens is formed.

FIGURE 2 shows a portion of the target area and the elements which make up the electrostatic lens system and target member. The mesh electrode **48**, which may be made of a copper-nickel material having about 750 lines to the inch, is spaced from about ⅛ to ¼ inch from the surface of the photoconductive layer **46** of the target **40**.

The mesh electrode **48**, the conductive layer **44** and the wall electrode **32** are maintained at suitable potentials by the source **52**. The potentials of the mesh electrode **48** and wall electrode **32** are variable in accordance with this invention so that greatest improvement in output signal uniformity can be made. Generally, these potentials are held at the desired value during tube operation. The mesh electrode **48** is typically maintained at a relatively high positive potential, such as about 300 volts above cathode potential which is usually at ground. The wall electrode **32** is typically, but need not be, at a lesser positive potential than that at which the mesh electrode **48** is held. It is to be noted that this situation is not a critical one and in some cases the potential of the wall electrode **32** may be more positive than that of the mesh electrode **48**. In either case there is produced in the region near the target **40** between the mesh electrode **48** and the wall electrode **32** an electrostatic field through which equipotential surfaces extend having a plano-convex configuration as shown.

The conductive back plate **44** of the target **40** is typically maintained fixed in the range of from about 5 to 70 volts above ground, such as about 30 volts and the output signal is derived therefrom using a load resistor **54** and a coupling capacitor **56** as is well known.

The photoconductive layer **46** may be deposited by any of the well known methods including evaporation techniques which result in a layer appreciably thicker at the center than at the edges.

An electron beam traversing the tube axis will of course impinge the target **40** substantially normal thereto. A beam which is off the tube axis will under ordinary circumstances tend to impinge the target at an angle other than normal. As discussed before hand, this off axis abnormality may be desirable in some cases where the target is of non-uniform thickness. However, it is desirable to be able to control the extent of off-axis abnormalities for the particular target whether it is of substantially uniform thickness or is non-uniform.

As discussed previously non-uniformities in target thickness and non-uniformities in beam landing angle either separately or together, can result in signal output non-uniformity. That is, the signal derived from each element of the target should be substantially the same when the target is under uniform illumination. The present invention permits the optimization of output signal uniformity for the particular target used and substantial variation in surface contour from target to target may

be tolerated. This method consists of a simple operation which may be conveniently carried out by either the manufacturer or the user of the pickup device. After the tube has been completely fabricated, uniform illumination is provided on the target and the output signal is observed to determine whether substantial signal uniformity exists. If an undesirable signal pattern is obtained, e.g. if the signal varies from center to edge, potentials are applied to the mesh electrode 48 and to the wall electrode 32 which are different and which may be varied to increase or decrease the difference between the two electrodes or to make one more positive than the other in order to find the relationship between the two potentials which makes the output signal most uniform.

In the usual case, this may be accomplished by initially providing the two electrodes 48 and 32 at the same potential and subsequently increasing the potential on the mesh electrode 48 while observing the output signal by any suitable means such as a picture tube. If signal uniformity improves, the potential is increased until improvement ceases and the potentials applied are used in tube operation. If signal output deteriorates, the opposite procedure of increasing the potential of the wall electrode 32 relative to the mesh electrode 48 is then resorted to in a similar manner.

It is the usual case with targets as ordinarily fabricated that the beam landing abnormality is greater than desired for signal uniformity. Therefore, it is usually desirable that the electrostatic lens configuration be such as to converge the electron beam onto the target 40, that is, to reduce the off-axis abnormality. For this purpose, the mesh electrode 48 is maintained at a potential more positive than that of the wall electrode 32. However, a divergent lens can be formed if desired by placing the wall electrode 32 at a more positive potential than the mesh electrode 48.

The use of a highly convergent electrostatic lens is desirable to permit the use of a short deflection distance making a more compact and portable device. The electrostatic vidicon which is shown in FIG. 1 is designed for this purpose since it avoids the necessity of bulky magnetic coils encircling the device and the use of the present invention may permit further savings in space.

It should be noted that the method and structure in accordance with the present invention permits the compensation for signal non-uniformity on an individual tube basis. Few tubes need be rejected for excessive variation in target thickness because of the flexibility in correcting for beam landing errors for each target.

In the design of electrostatically deflected and focused vidicon tubes, it has previously been necessary to comprise between the desires for a high resolution device and a high deflection sensitivity device with low spurious signal. High resolution, requiring small spot size on the target, depends on the spacing from beam crossover to the focus lens being as large a fraction of lens to target distance as possible to minimize magnification of the spot. This follows from the familiar lens relationship that magnification is proportional to image distance divided by object distance. Previous to this invention, it was necessary that the deflection plate to target distance be as great a possible in order to minimize beam landing abnormality. This tends to enhance magnification because the beam must be focused before it is deflected, and, hence, provides a large image distance. If a correspondingly large object distance is provided so as to keep magnification low, a long tube results which is undesirable for portable compact television cameras, for example. According to the present invention, beam normality at the target plane can be maintained without resort to excessive lens to target spacing (image distance) by the use of the lens in accordance with the present invention. This restores the normality of the divergent beam and, also, deflection sensitivity may be improved because in this case well potential can be reduced relative to the mesh electrode. Object distance can be correspondingly reduced resulting in a small tube with high resolution.

While the present invention has been shown and described in certain forms only, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. A method of optimizing output signal uniformity of a television pickup tube comprising an electron beam source, a light sensitive target member, a first electrode disposed around the path of electrons from said electron beam source to said target member, a second apertured electrode disposed transverse to the path of electrons from said electron beam source to said target member, said first and second electrodes being electrically independent so that substantially different potentials may be applied thereto, said method comprising the steps of: illuminating said target member substantially uniformly, adjusting the potential difference between said first and second electrodes to establish a point at which the output signal is most uniform.

2. A method of optimizing output signal uniformity of a television pickup tube comprising an electron beam source, a light sensitive target member, a first electrode disposed around the path of electrons from said electron beam source to said target member, a second apertured electrode disposed transverse to the path of electrons from said electron beam source to said target member, said first and second electrodes being electrically independent so that substantially different potentials may be applied thereto, said method comprising the steps of: illuminating said target member substantially uniformly, observing the output signal from said target to determine the presence of signal non-uniformities, varying the potential on at least one of said first and second electrodes while observing the output signal pattern, maintaining the potential on said first and second electrodes at that value at which the output signal pattern is most uniform.

3. A method of optimizing output signal uniformity of a television pickup tube comprising an electron beam source, a light sensitive target member, a first electrode disposed around the path of electrons from said electron beam source to said target member, a second apertured electrode disposed transverse to the path of electrons from said electron beam source to said target member, said first and second electrodes being electrically independent so that substantially different potentials may be applied thereto, said method comprising the steps of: establishing said first and second electrodes at substantially the same potential, illuminating said target member substantially uniformly, observing the output signal pattern to determine the presence of signal non-uniformities, adjusting the potential on said second electrode more positive than said first electrode while observing a signal output pattern, fixing the potential of said second electrode at the value at which the output signal pattern is most uniform.

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