Nov. 20, 1951 P. K. WEIMER 2,575,477

PICKUP TUBE RESIDUAL SCANNING ELIMINATOR

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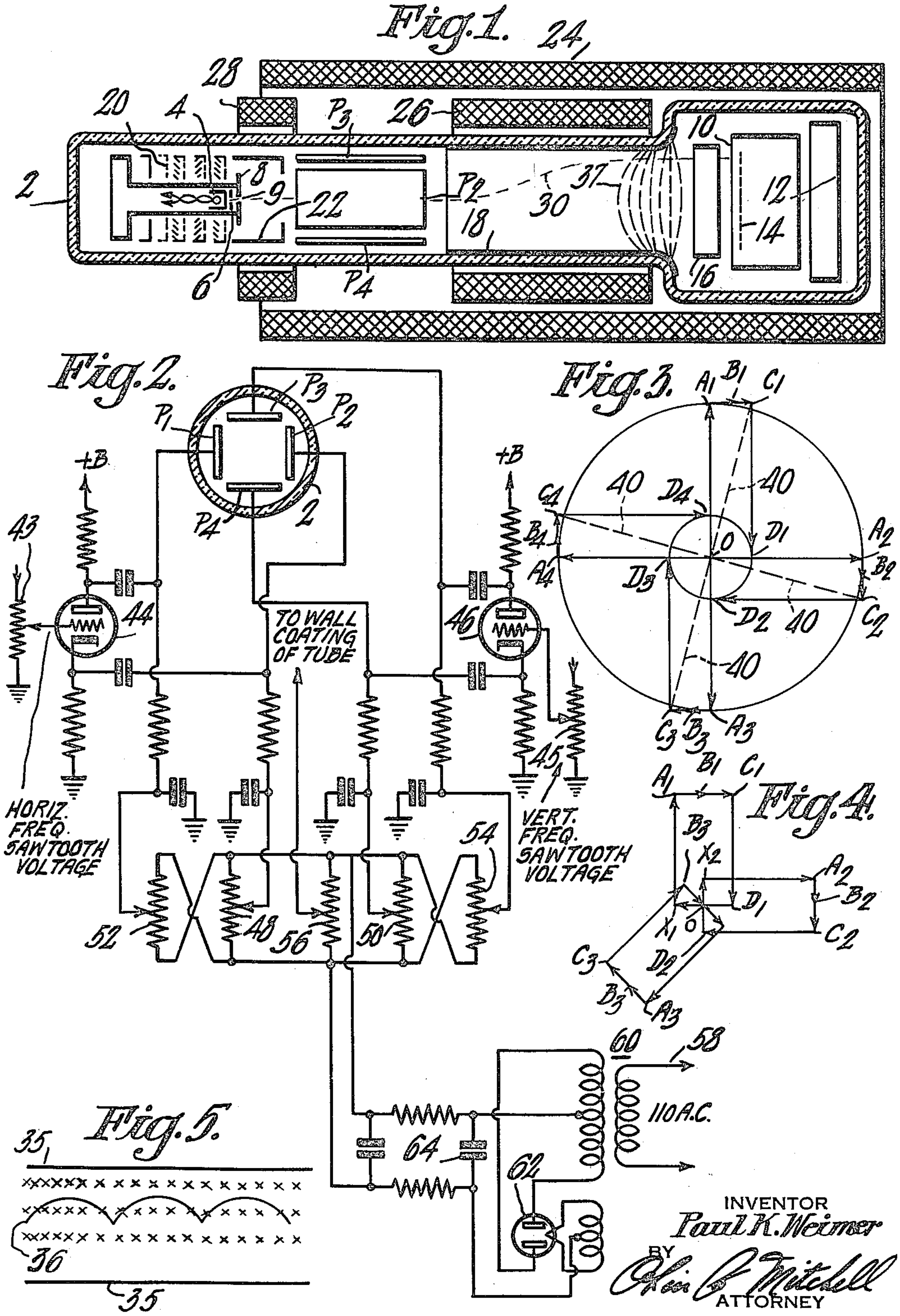


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## PICKUP TUBE RESIDUAL SCANNING ELIMINATOR

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1

This invention relates to a type of cathode ray tube in which magnetic focusing is employed and, in particular, provides a means for counteracting the translational movement of the electron beam produced therein by radial components of electrostatic fields generally present.

In the type of tube wherein the electron beam is guided to a target by a magnetic field and certain portions of the beam are absorbed by the target and other portions repelled, an electron collector or multiplier is mounted so as to intercept the return beam and extract intelligence therefrom. If the response developed by the pick-up device is not the same at every spot on which the return beam lands, and the return beam moves about, a modulation will be introduced into the intelligence carried by the return beam that is a function of the sensitivity of the electron pick-up device at various points in its surface. Therefore, if such a tube is used as a pick-up tube in a television system, any scanning of the return beam will appear in the transmitted image as shading.

Such scanning is produced in tubes not employing this invention due to the presence of a varying transverse electrostatic field generally found in the vicinity of the target.

Although this invention is to be described in connection with the solution of this particular problem, it is intended that the principles taught are to be applied to any tube having a beam guided by a magnetic field over a substantially large portion of its path whether there is any return beam or not. The problem is merely more acute with respect to the type of tube having a return beam as the effect is double that of a single beam.

An understanding of the invention necessitates an appreciation of the causes of this translation of the electron beam. A beam of electrons projected parallel to a magnetic field follows the field but it is well established that when a beam of electrons is projected parallel to a magnetic field and encounters a transverse electrostatic field, it will be forced in a direction mutually perpendicular to the two fields. Such a condition exists in the type of tube discussed above for a magnetic field is generally established parallel to the axis of the tube between the electron gun and the target, and an electrostatic field having a component that is transverse to the axis of the tube and to the magnetic field exists between the coating and the target. Consequently, when the electron beam encounters

2

this electrostatic field, it is moved in the direction that is mutually prependicular to the two fields and, the return beam will be moved a like amount in the same direction.

Of course, if this shift were uniform over the whole target area, no discrepancy would be involved, and no shading observable, but the amount of shift depends upon the strengths of the magnetic and electrostatic fields, and although the magnetic field remains uniform, the transverse electrostatic field is stronger at the edges of the tube than it is at the center. Therefore, as the beam is swept back and forth over the target it is shifted by varying amounts and this variation in the shift of the return beam, with respect to the magnetic field, causes the scanning of the electron collector, as the nearest magnetic field is always in the same relative position. In other words, the electrons return first along one part of the magnetic field, then another.

According to the teachings of this invention, the translation of the electron beam directed toward the target and of the return beam as it proceeds from the target through the transverse electrostatic field still exists, but a means is provided for shifting both the direct beam and the return beam so as to compensate for the shifting of the beam produced by the electrostatic field near the target.

Accordingly, it is an object of this invention to provide an improved means whereby the shifting of an electron beam with respect to the focusing magnetic field may be compensated for.

It is a further object of the invention to provide an improved means whereby the scanning of the electron collector or multiplier in an orthicon-type tube by the return beam can be reduced.

These and other objects will become apparent from a detailed consideration of the figures in which:

Figure 1 shows the structure of an orthicon-type tube employing the principles of this invention;

Figure 2 shows the connection of a special set of electrostatic plates located within the tube of Figure 1 to the sweep circuits;

Figure 3 is an explanatory diagram illustrating the translation of the electron beam in a tube not employing the principles of this invention;

Figure 4 shows how the translation of the electron beam is compensated for in a tube employing the principles of this invention; and

Figure 5 is an explanatory diagram that shows in detail how the electron beam that is moving parallel to a magnetic field behaves when it encounters a transverse electrostatic field.

Figure 1 illustrates an image orthicon tube that is used in television cameras and is comprised of evacuated envelope **2** having a cathode **4**, first anode **6** and a second anode **8** mounted at one end so as to form a gun for projecting a beam of electrons through the opening **9** along the axis of the tube. In the other end there is a target **10** upon which a charge image is formed by electrons proceeding from a photo-cathode **12**. The electrons produced by secondary emission formed by the photo-electrons impinging on the right hand side of the target **10** are picked up by screen **14**. In front of the target **10** there is a deceleration ring **16** that shapes the electrostatic field so that it is nearly uniform with respect to the target. A coating **18** on the inside of the envelope **2** is provided to prevent the electrons from slowing down and becoming defocused by charges that would otherwise be on the bare glass. Surrounding the gun there is an electron multiplier, and a persuader electrode **22** is provided to insure that the secondary electrons emitted by the second anode **8**, also the first dynode of the multiplier, when it is struck by the return beam will be directed to the subsequent stages of the electron multiplier.

An electromagnetic field is established parallel to the axis of the tube between the electron gun and the photo-cathode **12** by a focusing coil **24**. Deflection of the electron beam is achieved by two pairs of coils **26** that establish transverse magnetic fields so as to form a resultant field at a desired angle with respect to the axis of the tube along which the electrons may be guided. A single pair of coils **28** provides a transverse field which may be oriented with respect to the electron gun so as to compensate for its misalignment. So far, the structure of the image orthicon is the same as that described in U. S. Patent 2,433,941 and in article "The Image Orthicon—A Sensitive Television Pick-Up Tube" Proceedings of the I. R. E. July 1946, page 424.

The general operation of this tube is as follows: The electron beam, upon emerging from the opening **9** is directed along the axis of the tube by the alignment coils **28** and the gun and if no current is present in the deflection coils **26**, it will strike the target **10** at its center. If a current is present in the deflection coils **26**, however, the resultant magnetic field will no longer be parallel to the axis and the electrons will follow a flux line of this resultant field indicated by numeral **30** and strike the target near one edge. Thus, it can be said that to the first approximation the electrons follow the same magnetic line of force all the way from the gun to the target. In this type of tube the cathode **4** and the target **10** are at the same potential, usually ground, and the accelerating anode **8** and the coating **18** are at a positive potential. Accordingly, the electrons are accelerated as they leave the cathode and travel at high velocity down the tube. The decelerating ring **16** is generally at the same potential as the cathode **4** and the target **10** and, therefore, after the electrons leave the part of the tube that is coated, they are decelerated as the coating is positive with respect to the decelerating ring. If the various potentials are properly adjusted relative to one another, the electrons in the beam will just barely arrive at the target **10**, and if they are not attracted to the target by the positive image thereon, they will turn around and accelerate towards the coating **18** and eventually impinge upon the anode or dynode **8**. The path followed would be the same as the original path followed in approaching the target if the magnetic field produced by the focusing coil **24** and the direction of the beam exactly coincided and if there were no electrostatic field between the coating and the decelerating ring. However, since there is an electrostatic field having a transverse component between the decelerating ring and the coating, the electrons that are not attracted to the target **10** will follow a different magnetic line of flux back to the dynode **8** and, accordingly, will not land at the aperture **9**. If the electron collecting device is a multiplier such as described in the above article and patent, the potentials are adjusted so that the return beam strikes the dynode **8** with sufficient speed to cause secondary emission. The secondary electrons thus produced are guided by the electrostatic field created by persuader **22** to the second stage of the electron multiplier **20**. The number of electrons that return depend upon the charge present on the target **10**, and it will be noticed that the return beam is also focused because it is also in the focusing field.

It has been stated that if the return beam scans the dynode **8** and the secondary electrons accordingly fall on different points in the stages of the electron multiplier **20**, that the modulation will appear in the output signal of the tube depending upon variations in sensitivity of its surface. Accordingly, therefore, it is desirable that the return beam land on the same point of the dynode **8** regardless of the point which target **10** it is returning from. This means that the return beam must follow a magnetic line of flux bearing a fixed relationship to the line of flux upon which the direct beam traveled on its way to the target. If this is the case, the return beam will strike the same point on the dynode **8** because, regardless of the direction of the resultant field produced by the deflection coil **26**, the focusing field always stays fixed relative to the anode **8** and the electron multiplier **20**, and, therefore, if an electron is always returning on the same magnetic flux line, it will always strike the same point of the dynode **8**.

An explanation will now be given of the effect of a transverse electrostatic field on a stream of electrons moving in a magnetic field. It is well known that if an electron beam is traveling parallel to a magnetic field and encounters a transverse electrostatic field, that it will be moved in a direction that is mutually perpendicular to the two fields. The projection of its path on a plane perpendicular to the magnetic field is a cycloid, as shown in Figure 5. It must be realized that, as the electron travels from its initial position, indicated by the numeral **36**, that it is also traveling in a direction toward the paper. This means that an electron beam directed into the paper will be moved to the right. If the electron beam should turn around and pass through the magnetic field shown in Figure 5 in the opposite direction, that is, perpendicular to the plane of the paper and towards the observer, it will be further moved to the right following a cycloidal path that is the same as that shown and, consequently, it will be shifted from the initial line of flux indicated at **36** to another line of flux. If the electrostatic field created by the plates **35** remains constant, the electrostatic flux line followed by the return beam will always bear a fixed relationship to that of the direct beam regardless of where the direct beam might pass between the plates **35**. However, if the potential gradient between the plates **35** should vary from place to place, then the amount of deflection both upward and to the right produced on both the direct and return beams would depend upon their position in the electrostatic field. The explanation of this is that the distance the electron beam moves is proportional to the strength of the electrostatic field. Now, if the electrostatic gradient is greater in part of the field than the other, it will be seen that the displacement of the electron beam in a direction transverse to the magnetic field will vary as the beam encounters different gradients.

Let us now apply these principles to the type of tube under discussion. Because the motion of the electron beam through the tube and back to the dynode **8** is very complicated, all the refinements are omitted except the ones which are involved in an understanding of the present invention, but it is understood that the presence of these other refinements does not in any way interfere with the operation of this invention, as will be apparent after the following discussion.

Consider Figure 3 showing a view of the target as seen from the gun. The point "O" is on the axis of the tube and coincides with the defining aperture **9** of the gun. An electron leaving the aperture starts out from O and upon entering the region the tube influenced by the deflection coil **26** may be deflected through a distance $OA_1$ (or $OA_2$, $OA_3$, $OA_4$ for the other parts of the target). However, when the electron reaches the region in front of the target the transverse component of the electrostatic field, having equal potentials as illustrated by the dotted lines **37** between the target **10** and the wall coating **18**, causes the electron to be deflected or shifted through a distance $A_1, B_1$. We saw in a discussion of Figure 5 that the translation of the beam follows a cycloidal path and, for the sake of simplicity, only the horizontal component of such translation is considered. The force which this field exerts on the electron is outward, but the magnetic field constrains it to move at right angles to both the magnetic and electrostatic fields. This means that the path, as a whole, is slightly rotated, as indicated by the vectors $A_1 B_1$, $A_2 B_2$, $A_3 B_3$, $A_4 B_4$. The vectors $B_1 C_1$, $B_2 C_2$, $B_3 C_3$ and $B_4 C_4$ indicate a similar rotation produced after the return beam reaches the target and returns through the same electrostatic field. Upon returning through the deflection coil **26**, the electron return beam follows the magnetic lines so that it is moved back towards the axis of the tube. The de-scanning effect on the return beam may be represented by the vectors $C_1 D_1$, $C_2 D_2$, $C_3 D_3$, and $C_4 D_4$ which may be considered to be substantially equal and opposite to the original scanning vectors $OA_1$, $OA_2$ and etc., which represent the amount of deflection in their particular directions. The size of the return pattern on the anode **8** and consequently on the successive stages of the pick-up device **20** is then given by the points $D_1$, $D_2$, $D_3$ and $D_4$.

It will be noted that the return pattern would be zero in size (that is, all electrons would have returned to O) if the rotational motion $A_1 C_1$, $A_2 C_2$, etc., were eliminated. It was the purpose of the screen of the disclosure in the U. S. Patent No. 2,452,619 issued on November 2, 1948, in the name of Weimer to eliminate this motion, but in the present invention the motion is not eliminated but is compensated for by an equal and opposite motion given to the electron beam as it passes between deflection plates $P_1$, $P_2$, $P_3$ and $P_4$. Figure 4 shows how the diagram of Figure 3 is modified by the electrostatic plates. The vector $OX_1$ represents the horizontal translation produced in the outgoing beam by the field between the plates $P_3$ and $P_4$ in Figure 2. The potential difference between $P_3$ and $P_4$ must be adjusted so that $OX_1$ is equal and opposite to $A_1 B_1$. The return beam will also be deflected by an amount $D_1O$. This last deflection cancels out the displacement $B_1 C_1$ which was acquired by the return beam as it passed through the electrostatic field **35**. The electron then strikes a multipler at the defining aperture O. This, of course, is undesirable but can be avoided by placing a bias on either one or both of the pairs of plates $P_1$ through $P_4$.

This explanation shows how the translation of the electron beam as it goes to and from the target can be compensated for a given amount of deflection. Examination of the electrostatic field indicated by the dotted lines **37** shows, however, that this transverse electrostatic field is zero at the axis of the tube and that it increases as the outside edges of the tube are approached. Due to the fact that the tube is usually cylindrical in shape, the field is symmetrical about the axis. By proper adjustment of the potential of the decelerating ring **16** and the coating **18**, it is possible to make the variation of the intensity of the transverse component of the electrostatic field vary linearly with the distance from the axis of the tube. In other words, a plot of the transverse potential gradient as against the radius would be a straight line. It was explained in connection with Figure 5 that the amount of translation varied as the strength of the electro-static field varied, and this is the case in the tube under discussion, for, as the electron beam is deflected from the axis, it experiences a stronger and stronger transverse electrostatic field and consequently the distance $A_1 C_1$ indicates the total translation. The dotted lines **40** indicate what the translation would be as the deflection varies between O and $A_1$ and $A_2$, etc. Because the amount of shifting of the return beam with respect to the magnetic field varies with deflection, the return beam will not remain in a constant position relative to the magnetic field and will accordingly scan the surface of anode **8**.

For the reasons given above, it is apparent that the amount of correction introduced by the plates $P_1$ through $P_4$ must vary as the beam is scanning the target in order that the translation it gives will always be equal and opposite to the translation produced by the electrostatic field of the coating and decelerating ring. This is accomplished by applying the horizontal sweep voltages to plates $P_1$ and $P_2$ and the vertical sweep voltages to $P_3$ and $P_4$. A circuit for accomplishing this is shown in Figure 4 in which a horizontal sawtooth voltage is applied to the grid of a first tube **44** via a potentiometer **43**, the plate of said tube being coupled to an electrostatic deflection plate $P_1$, and the cathode being connected to electrostatic deflection plate $P_2$. The vertical frequency sawtooth voltage waves are applied via potentiometer **45** to the grid of a second tube having its plate coupled to electrostatic deflection plate $P_3$, the opposite deflection plate $P_4$ being connected to the cathode of the second tube. By adjusting the potentiometers **43** and **45**, the amplitudes of the horizontal and vertical frequency sawtooth voltage waves can be determined, and, accordingly, the shifting of the electron beam can be made equal and opposite to the shifting introduced by the electrostatic field **35** explained in connection with Figure 3. In practice the pick-up tube is directed toward a black target and the potentiometers **43** and **45** are varied until no shading is apparent. The plate $P_1$ is connected to a potentiometer **52** which is opposite in polarity to the potentiometer **48** so that an upward motion of the contact points of the potentiometers **52** and **48** will cause the D. C. level of the plate $P_1$ to increase as much as the D. C. level of the plate $P_2$ decreases. A similar arrangement exists between plates $P_3$ and $P_4$ and potentiometers **50** and **54**, respectively. The wall coating **18** of the tube is connected to a potentiometer **56** in order that balanced deflection may be obtained. The power supply for all of these potentiometers consists of an A. C. line **58** connected to transformer **60**, the secondary of which is connected to a double rectifier **62** which is, in turn, connected to storage condenser **64** and smoothing resistances and condenser.

The relative potentials between the decelerating ring and the wall coating may be adjusted so as to produce an electrostatic field whose radial component increases linearly from the center to the edge.

This type of de-scanning of the return beam is especially useful in a type of tube wherein the return beam is directed to a specific point such as that described in the U. S. Patent No. 2,545,982 patented on March 20, 1951, in the name of Weimer.

It is believed that the elimination of scanning of an electron beam, especially when the beam encounters an electron collector, provides a definite advance in the television art because it eliminates shading of the televised image, without any reduction in the signal to noise ratio or any other deleterious effect on the signal.

Having thus described my invention, I claim:

1. A cathode ray tube having a target, means for directing a beam of electrons toward said target, means for creating a substantially parallel magnetic field around said beam, means for cyclically varying the vertical component of the magnetic field through which the beam of electrons passes, means for cyclically varying the horizontal component of the magnetic field through which the beam of electrons passes, means for shifting the beam in a vertical direction with respect to said magnetic field, said latter means operating in synchronism with the means for cyclically varying the horizontal component of the field, and means for shifting the beam in a horizontal direction with respect to said magnetic field, said latter means operating in synchronism with said means for cyclically varying the vertical component of the field.

2. A cathode ray tube comprising an evacuated container, an electron gun mounted in one end of said container, said gun having an opening in its front face, an electron pick-up device mounted adjacent to said gun, means for creating an electrostatic field between the face of the gun and the electron pick-up device such that electrons reflected by said face are directed to said device, a target mounted in the other end of said tube, a deflection coil surrounding a part of said tube lying between the electron gun and the target, a focusing coil coaxial with said deflection coil, said focusing coil being capable of producing a substantially parallel field, and two pairs of electrostatic plates mounted so as to surround the beam, said plates being located within the parallel field produced by said focusing coil.

3. A system for shifting the beam in a cathode ray tube comprising means for creating a first magnetic field that is substantially parallel to the axis of the cathode ray tube with which it is employed, means for establishing a second magnetic field having a component that is transverse to the first magnetic field, means for forming a cyclically varying waveform, the output of said latter means being applied to said means for establishing said second magnetic field, means for creating an electrostatic field that is co-existent with and transverse to said first magnetic field, said latter means also being connected so as to receive the cyclically varying waveform.

4. A cathode ray tube and circuit for controlling it comprising an evacuated envelope, a target located in one end of the envelope, an electron gun directing an electron beam toward said target, a focusing coil for creating a magnetic field that is substantially parallel to a line between the electron gun and said target, a first pair of deflection coils, a second pair of deflection coils, said deflection coils being so located that their field alters the field created by the focusing coil, a third pair of deflection coils mounted so that their field lies within the weaker region of the focusing field adjacent to the electron gun and in the opposite direction to said first pair, a fourth pair of deflection coils mounted so that their field is transverse the field of said third pair of deflection coils and in a direction that is opposite to said second pair, a first source of sweep voltage waves, said first source being connected to said first and third pair of deflection coils, and a second source of sweep voltage waves, said second source being connected to said second and fourth coils.

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