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MEANS FOR TRANSLATING MAGNETIC VARIATIONS INTO ELECTRIC VARIATIONS

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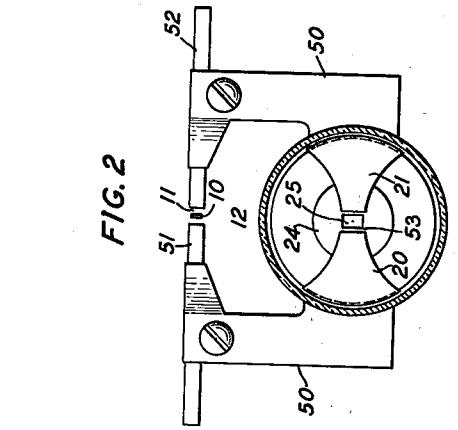

FIG. 2

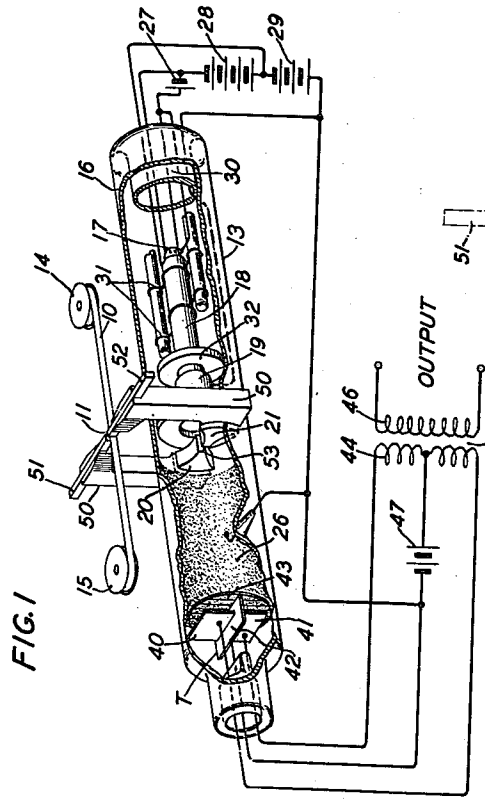

FIG. 1

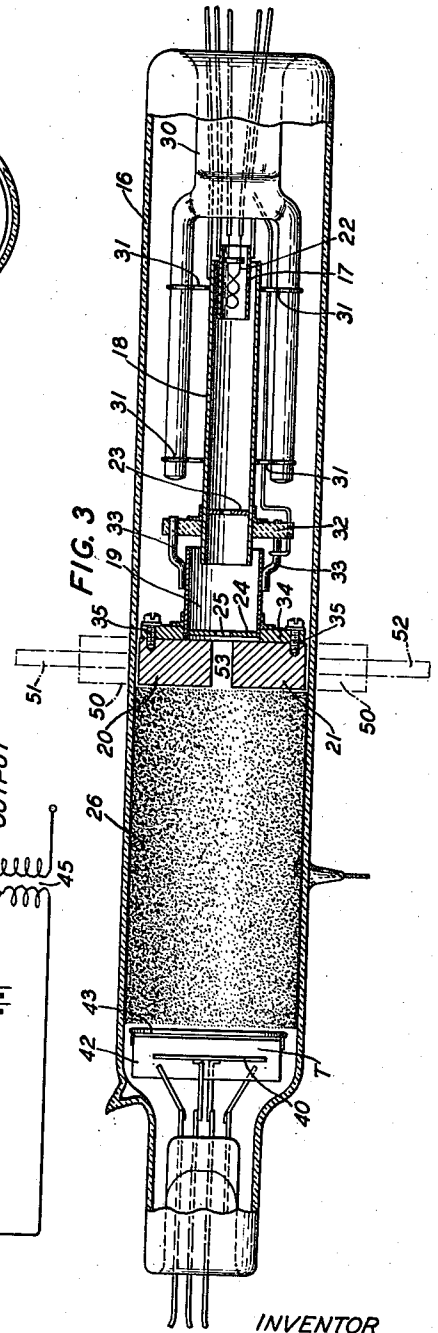

FIG. 3

INVENTOR
A. M. SKELLETT
BY
O. G. Sprague.
ATTORNEY

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MEANS FOR TRANSLATING MAGNETIC VARIATIONS INTO ELECTRIC VARIATIONS

Albert M. Skellett, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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22 Claims. (Cl. 178—5)

This invention relates to means for transforming magnetic variations into electric variations and more specifically to means for "reading" a magnetic record upon which signals representative of the light-tone values of a picture or view are recorded.

When an ordinary magnetic pick-up device is used for reading a magnetic record, the currents delivered by the pick-up coil have all been shifted in phase by 90 degrees from that of the original current. This is caused by the fact that in the magnetic pick-up the output current is proportional to the rate of change of flux rather than to the flux itself. This shift in phase of 90 degrees is not important in the case of sound recording as the human ear is insensitive to this shift. In the case of television image currents, however, the shift is enough to make the image unrecognizable because a shift of 90 degrees is a variable shift with respect to time even though it is a constant angular shift. For example, a shift of 90 degrees for a 30-cycle signal is a displacement in time of 1/120 of a second, while a shift of the same phase angle for a 5000-cycle signal is a time displacement of only 1/20,000 of a second.

It is an object of this invention to provide a reading or translating device for a magnetic record which does not produce the above mentioned phase shifts and which is suitable for use with records of signals representative of a picture or view which is to be reproduced in the form of a facsimile or image by television methods.

It is a further object of the invention to provide inductionless means for translating magnetic variations into variations of an electronic beam.

Another object is to provide means for translating magnetic variations into electric current variations the amplitudes of which are proportional to those of the magnetic variations and not dependent upon the frequency of the latter.

In the ordinary magnetic pick-up device used to translate a magnetic record and similar devices used elsewhere for translating magnetic variations into electric variations, the amplitudes of the electric variations are in part dependent upon the frequency of the variations, thus producing distortion of the current variations.

In an embodiment of the invention which is given by way of example to illustrate the invention, a yoke of soft iron is set up around a cathode ray tube adjacent some pole-pieces of similar material therein in such a manner that there are two gaps in the magnetic circuit (in addition to the gaps filled by the walls of the tube), one just large enough for the magnetic tape or other movable means carrying magnetic variations to pass therethrough and the other through which the electron beam passes. No magnetic coils are used on this yoke which serves to guide the magnetic flux from the tape directly to and into the cathode ray tube so as to deflect the cathode ray beam in such a manner that it divides its energy between a pair of anode plates connected in push-pull manner. A relatively small accelerating voltage, that is, of the order of hundreds of volts or less, is preferably used for accelerating the beam generated in the cathode ray device so that the beam is appreciably bent for the small fluxes available. The two anode plates are preferably connected, in opposition, to the primary winding of a transformer, the mid-point of which is connected through a battery to the accelerating anode of the cathode ray tube. The output current in the secondary winding of the transformer is thus always substantially in phase with the flux in the magnetic tape and the amplitude is independent of the frequency of the signal. Another advantage of this arrangement is the high output due to the amplification of the original energy because the entire energy of the electron beam is controlled by the small flux in the tape.

It is found that this device operates satisfactorily when the yoke is of soft iron but a preferred material is permalloy or other similar material having high permeability at low magnetizing forces.

The invention will be more readily understood from the following description taken in connection with the accompanying drawing forming a part thereof, in which:

Fig. 1 is a perspective view of an electronic pick-up device for magnetic recording;

Fig. 2 is a transverse cross-sectional view of the device shown in Fig. 1; and

Fig. 3 is a longitudinal cross-sectional view of the device shown in Fig. 1 taken from the top.

Referring more particularly to the drawing, Fig. 1 shows in perspective an electronic pick-up device for reproducing signals previously recorded on a magnetic tape. The electronic pick-up arrangement comprises a tape 10 adapted to be passed through a narrow gap 11 in a magnetic circuit 12 through a second gap 53 of which the beam generated in a cathode ray device 13 is adapted to pass, the deflection of the beam being controlled by the signals on the magnetic tape. The record member 10 is preferably a tape or any suitable magnetic material about .001 inch thick and .125 inch wide, the ends of which are

secured to and wound on reels 14 and 15, respectively. The tape 10 has been previously magnetized with signal currents in a manner well known in the art. For an example of a suitable arrangement for recording varying signals on magnetic tape, reference may be made to Patent 1,944,238 to Clarence N. Hickman, issued January 23, 1934. The tape is preferably moved in the gap 11 at the speed at which the signals were recorded, any suitable means, such as the driving means shown in the Hickman patent, being suitable for this purpose.

For the sake of clarity in describing the cathode ray device 13, reference will now be made to Fig. 3 which shows a longitudinal cross-section of the cathode ray device 13 taken from the top. The position of the yoke surrounding the tube is indicated by dotted lines in this figure. The device 13 preferably comprises a gas-tight container 16 enclosing a cathode 17, an accelerating anode 18, a second anode 19, a pair of magnetic pole-pieces 20 and 21, and a target or screen T.

The cathode 17 comprises a metal cylinder which is heated by a filament 22 supplied with current by a suitable source of potential 27. The cathode 17 may have a coating of material which produces a large electron emission when heated.

The accelerating anode 18 comprises a long cylinder surrounding the cathode 17 and having an aperture plate 23 therein. The plate 23 is located near the end of the cylinder remote from the cathode. Accelerating anode 19 comprises a cylinder around one end of the cylinder 18 and extending toward the target T. The cylinder 19 has a diaphragm 24 at the end near the target T. This diaphragm 24 has an aperture 25 therein which is of substantially square or rectangular cross-section. The anodes 18 and 19 together comprise an electron lens system which focuses a beam of electrons of a cross-section determined by the shape of the aperture 25 upon the target T. The inside of the container 16 contains a coating 26 of aquadag, this coating extending substantially from the region of the target T to the pole-pieces 20 and 21. Accelerating anode 18 is placed at a positive potential with respect to the cathode 17 by means of a source of potential such as the battery 28, and the anode 19 is placed at a positive potential with respect to the anode 18 by means of a source of potential such as the battery 29. The screen 26 is preferably placed at the same potential as the anode 19.

The cathode 17 and the accelerating anodes 18 and 19 are supported from a bifurcated press 30. Supporting wires 31 support the anode from the outstanding portions of the bifurcated press. A flange 32 of insulating material surrounds the end of the cylinder 18 near the target T and the cylinder 19 is partially supported from this flange by supporting wires 33, the cylinder 19 being further supported by a disc 34 which is fastened to the pole-pieces 20 and 21 by screws 35.

The target T comprises plates 40 and 41, a screen or partition member 42 located between the plates, and a mesh or grid member 43 parallel to the plates and located a small distance in front thereof. The plates 40 and 41 are electrically connected to the primary winding 44 of an output transformer 45, the secondary winding 46 of which may be connected to any suitable circuit. The partition member 42 is electrically connected to the mesh screen or grid member 43 and to the mid-point of the primary winding 44 of the transformer 45 through a source of potential 47 which is so poled that the partition member 42 and the screen 43 are placed at a negative potential with respect to the plates 40 and 41. The negative terminal of battery 47 is also connected to the coating 26 and to the second accelerating anode 19.

Surrounding the cathode ray device 13 and completing the magnetic circuit 12 between the magnetic tape 10 and the cathode ray beam (which is adapted to pass between the pole-pieces 20 and 21) is a yoke 50 of soft iron which is shown diagrammatically in Fig. 1 and in further detail in Fig. 2. Supported in grooves in the two parts of the yoke 50 are metallic pole-pieces 51 and 52 which are so placed as to leave a very narrow air-gap 11 through which the magnetic tape 10 is adapted to pass. The yokes 50 terminate around the cathode ray tube 13 adjacent the pole-pieces 20 and 21 located within the tube.

The magnetic circuit 12 thus has two gaps therein, the gap 11 which is large enough for the magnetic tape to pass therethrough and the gap 53 through which the beam generated by the cathode and accelerated and focussed by the anodes 18 and 19 is adapted to pass on its path to the divided target T.

The operation of the electronic pick-up arrangement shown in Fig. 1 will now be described. Electrons are emitted by the cathode 17, accelerated by the anodes 18 and 19, and focused by these anodes in cooperation with the coating 26 into a beam of electrons which is directed toward the target or screen T. A relatively low voltage is used to accelerate this beam as, for example, of the order of 100 volts. Because of this low voltage the beam may be appreciably bent when it passes between the pole-pieces 20 and 21 due to the magnetic flux present in the gap between the pole-pieces. Let it be assumed that a portion of the tape 10 having no signals impressed thereon is in the gap 11 of the magnetic circuit 12. When this condition exists, the electron beam is not bent as it passes between the pole-pieces 20 and 21 and the energy of the beam is evenly divided between the two target plates 40 and 41. Due to the fact that the plates 40 and 41 are hooked up in push-pull fashion, no current will flow in the secondary winding 46 of the transformer 45. Now assume that the portion of the tape 10 having a signal current impressed thereon is passing through the gap 11. The flux from this magnetic tape thus passes through the magnetic circuit 12 and causes the beam to be bent in such a manner that its energy is divided unequally between the two plates 40 and 41. The balance between the currents flowing in the primary winding 44 of the transformer 45 is thus disturbed and an output current flows in the secondary winding 46 of the transformer 45 which is proportional to the signal magnetically recorded on the tape.

The accompanying drawing shows one preferred dimensioning of the various parts of a structure in accordance with the invention. The main diameter of the actual cathode ray tube shown is one and three-fourths inches, all dimensions in the drawing being scaled down in the same ratio.

In order to more fully study the operation of this device let it be assumed that the recording electromagnet used with the ordinary magnetic tape recorder induces magnetization proportional to the amplitude of the current flowing in the coils. Suppose that an alternating current of the form $a=A \sin \omega t$ is put into the recorder. The intensity of the resultant flux through the tape will be $\varphi=KA \sin \omega t$. The voltage delivered

by the pick-up coils (assuming for the moment that an ordinary electromagnetic pick-up device is used) will be given by the equation

$$\frac{d\varphi}{dt}=A\omega\cos\omega t$$

Thus with this form of pick-up device all frequencies are shifted in phase by 90 degrees and the output is proportional to frequency. For example, for equal input amplitudes a 30-cycle signal will be down 40 decibels as compared with a signal of 3000 cycles in the output current. This seriously limits the frequency range of the recorder. Also as pointed out above the shift of 90 degrees in the phase angle is very serious in television or high speed telephotography as it produces great distortion of the image.

These limitations are, however, imposed only by the magnetic pick-up device of the ordinary arrangement, little or no distortions in amplitude or phase being introduced by the recording mechanism. In the electronic pick-up device of this invention, the output is directly proportional to the flux in the tape, so consequently a considerable gain in frequency range and fidelity is realized, the phase distortion of the kind referred to above will be eliminated, and in consequence the utility of the recorder is increased. In the arrangement of Fig. 1, the flux from the tape is guided to the cathode ray beam in such a manner that the deflection of the beam is proportional to the flux and the anode or target arrangement is such that the output current is proportional to the deflection of the beam, and thus also the flux.

As the tape moves through the gap 11, its flux is guided by the yoke 50 to the cathode ray tube 13 where it deflects the electron beam by shifting it away from anode plate 40 towards the other plate 41 and vice versa, depending upon the signal strength. Due to the push-pull connection of the anodes, even-harmonic distortion introduced by non-linearity of the tube characteristic is eliminated. A further advantage of this arrangement is that the tape may be stopped and the intensity of the flux at any point measured by measuring the differential anode current in the tube.

The output current from the secondary winding 46 is greatly amplified by this arrangement due to the addition of the energy of the electron beam or, stated differently, the small signals recorded on the tape 10 control a much larger energy stream in the form of the cathode ray beam generated in the device 13. This output may be further amplified if desired.

Even with the low accelerating voltages used in this tube, there is some secondary emission from anode plate 40 to anode plate 41 and vice versa which tends to distort the signal in the output circuit. In order to prevent this, the partition member 42 and the screen 43 which are placed at a negative potential with respect to the average value of the plates 40 and 41 are used. The negative potential applied to the members 42 and 43 tends to cause the secondary electrons emitted from the plates 40 and 41 to return to the plates from whence they came rather than go to the other plate. For a more complete description and method of operation of partition members and mesh screens to prevent secondary emission in tubes of this character, reference may be made to an application of A. M. Skellett, Serial No. 134,068, filed March 31, 1937.

Various modifications may obviously be made without departing from the spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. The combination with an electron beam discharge tube of beam deflecting means comprising a magnetic flux path terminating at one end within the tube in the vicinity of the beam, a magnetic signal record member adjacent the other end of said path, and means for producing relative movement between said flux path and said record member.

2. The combination with an electron beam discharge tube of beam deflecting means comprising a magnetic flux path of high permeability terminating at one end within the tube in a pole-piece in the vicinity of said beam and at the other end in a surface of area small enough to read a magnetic tape record of the kind used to record speech and other signals.

3. The combination with a magnetic circuit, of an electric beam discharge tube in a gap in said circuit, a magnetic signal record member in a second gap in said circuit, and means for producing relative movement between said circuit and said member.

4. The combination with a magnetic circuit comprising a yoke of material of high permeability and a pair of metal pole-pieces in opposite legs of said yoke arranged so as to define an air-gap of small area, of an electron beam discharge tube located between the legs of said yoke, said discharge tube having therein a pair of pole-pieces of magnetic material which pole-pieces have a narrow gap therebetween through which said beam passes.

5. In combination, a magnetic tape record of a varying current, an electron discharge device comprising means for generating a flow of electrons, and a path of high permeability between said magnetic record and said electron discharge device for causing the successive variations of said magnetic record to control the deflection of said flow of electrons.

6. A cathode ray device comprising means for generating a beam of electrons, a pair of anode members in the path of said beam, each anode being normally contacted by substantially half the electrons of said beam, a magnetic record member, and a path of high permeability between said magnetic record and said beam for causing said beam to be deflected in accordance with the successive variations of said record member to thereby change the distribution of electrons between the anodes.

7. A cathode ray device comprising means for generating a beam of electrons, a pair of anode members in the path of said beam, each anode being in the neutral position of the beam contacted by substantially half the electrons of said beam, a magnetic record member, a path of high permeability between said magnetic record and said beam for causing said beam to be deflected in accordance with the successive variations of said record member to thereby change the distribution of electrons between the anode members, and electrode members associated with said pair of anode members to prevent secondary electrons emitted from one anode member from passing to the other anode member.

8. A cathode ray device comprising means for generating a beam of electrons, a pair of anode members in the path of said beam, each anode being in the neutral position of the beam con-

tacted by substantially half the electrons of said beam, a magnetic record member, a path of high permeability between said magnetic record and said beam for causing said beam to be deflected in accordance with the successive variations of said record member to thereby change the distribution of electrons between the anode members, and an external circuit connected to said anode.

9. The combination with a yoke of magnetic material of a pair of tapered pole-pieces within an electric discharge tube, and adjacent the respective legs of said yoke, said yoke having a gap therein external to said tube, and means within said tube for directing the electric discharge between said pole-pieces.

10. The combination with a yoke of magnetic material of a pair of tapered pole-pieces within an electric discharge tube and adjacent the respective legs of said yoke, said yoke having a gap therein external to said tube, means within said tube for directing the electric discharge between said pole-pieces, and means for applying a varying magneto-motive force to said yoke from within said external gap.

11. The combination with a yoke of magnetic material of a pair of tapered pole-pieces within an electric discharge tube, said yoke having a gap therein external to said tube, means within said tube for directing the electric discharge between said pole-pieces, means for applying a varying magneto-motive force to said yoke from within said external gap, and means for utilizing the resultant change of direction of the electric discharge to set up corresponding current variations in a circuit external to said tube.

12. The combination with a yoke member of magnetic material, a vacuum tube extending between the extremities of the legs of said member, and tapered members of magnetic material mounted inside said vacuum tube in such position that their outer extremities register respectively with the extremities of said yoke member and their inner extremities are spaced apart to form a small gap therebetween.

13. A cathode ray tube comprising a cathode for emitting electrons, a target, means for forming said electrons into a beam and directing said beam toward said target and members of magnetic material mounted between said cathode and said target, each member consisting of a tapered element having its outer and larger portion shaped to conform to the contour of the tube wall and its inner and smaller portion adjacent the path of the cathode beam.

14. The combination with an electron beam discharge tube, of means for deflecting said beam comprising a magnetizable element having different portions differently magnetized, a magnetic flux path extending from pole pieces within the tube in the vicinity of said beam to the vicinity of said element, and means for moving said element so that said portions in succession vary the flux of said flux path.

15. The combination with an electron beam discharge tube, of a magnetic flux path including a yoke of material of high magnetic permeability and having a gap through which said beam passes and a second gap at a distance from said beam, a magnetic record element located in said second gap, and means for moving said element through said second gap.

16. A device for reading magnetic record elements comprising the combination with an electron beam discharge tube, of a magnetic flux path including a yoke of material of high permeability, said yoke being divided into two legs and each leg being divided into two parts with one part of each being external to said tube and the other in alinement therewith within said tube, both said parts being shaped to closely fit the contour of the tube wall and being substantially in contact therewith, said parts within said tube being spaced to form a narrow gap between which the electron beam passes, and said external parts being spaced to form another narrow gap suitable for having a magnetic record element passed therethrough.

17. The combination with an electron beam discharge tube, of a magnetic flux path including a yoke of material of high magnetic permeability outside said tube, each of the two legs of said yoke terminating at opposite sides of the wall of said tube and conforming to the shape of said wall, tapered pole-pieces within said tube and respectively in alinement with said shaped outside portions of said legs and shaped to fit the wall of said tube, said pole-pieces being positioned to form a gap therebetween, means for forming and projecting a beam of electrons through said gap, the dimension of said gap perpendicular to the axis of said beam being only slightly greater than the dimension of the beam in that direction, and a target for said beam at a distance from said gap many times the dimension of said gap in the direction of the axis of the beam, each of said legs being tapered at its extremity opposite the one at said wall and forming with the corresponding extremity of the other leg a small gap of the order of the size of said first-mentioned gap.

18. The combination with an electron beam discharge tube of a magnetic flux path including a yoke of material of high magnetic permeability outside said tube, each of the two legs of said yoke terminating at opposite sides of the wall of said tube and conforming to the shape of said wall, tapered pole-pieces within said tube and respectively in alinement with said shaped outside portions of said legs and shaped to fit the wall of said tube, said pole-pieces being positioned to form a gap therebetween, means for forming and projecting a beam of electrons through said gap, the dimension of said gap perpendicular to the axis of said beam being only slightly greater than the dimension of the beam in that direction, and a target for said beam at a distance from said gap many times the dimension of said gap in the direction of the axis of the beam, each of said legs being tapered at its extremity opposite the one at said wall and forming with the corresponding extremity of the other leg a small gap of the order of size of said first-mentioned gap, the dimensions of said gap within said tube in the direction of the axis of the beam being much greater than its dimensions at right angles thereto.

19. The combination with an electron beam discharge tube of a magnetic flux path including a yoke of material of high magnetic permeability outside said tube, each of the two legs of said yoke terminating at opposite sides of the wall of said tube and conforming to the shape of said wall, tapered pole-pieces within said tube and respectively in alinement with said shaped outside portions of said legs and shaped to fit the wall of said tube, said pole-pieces being positioned to form a gap therebetween, means for forming and projecting a beam of electrons through said gap, the dimension of said gap perpendicular to

the axis of said beam being only slightly greater than the dimension of the beam in that direction, and a target for said beam at a distance from said gap many times the dimension of said gap in the direction of the axis of the beam, each of said legs being tapered at its extremity opposite the one at said wall and forming with the corresponding extremity of the other leg a small gap of the order of size of said first-mentioned gap, said means for producing and projecting said beam comprising a gun structure and means for supporting said pole-pieces within said tube on said gun structure.

20. The combination with an electron beam discharge tube comprising an evacuated container substantially free of gas content enclosing means for generating a beam of electrons, a target comprising two elements spaced from each other, and a pair of pole-pieces on opposite sides of the beam, and means outside said enclosure for deflecting said beam from one of said target elements to the other so that the energy of the beam is divided between said elements comprising a magnetizable element having different portions differently magnetized, and magnetic flux paths extending from the vicinity of said pole-pieces within the tube to the vicinity of said magnetizable element, and means for moving said magnetizable element so that said differently magnetized portions in succession vary the flux in said paths to vary the distribution of said beam between said target portions.

21. A cathode ray device comprising means for generating a beam of electrons, a target for said beam having two portions displaced from each other, a transformer, means for connecting the primary of said transformer between said two portions of said target, means for connecting substantially the midpoint of said primary to said beam generating means, means for connecting the secondary of said transformer to an output circuit, a pair of pole-pieces within said tube between said beam generating means and said target member, a magnetic signal record member, a magnetic flux path comprising two leg members of magnetic material extending from a region closely adjacent said pole-pieces to a region on opposite sides of and closely adjacent the magnetic record member, and means for moving said magnetic record member in the gap created by the space between said legs so that said beam is caused to divide its energy between the two portions of the target member in such a manner that an amplified output current is produced in the secondary of said transformer.

22. A cathode ray device comprising means for generating a beam of electrons, a target for said beam having two portions displaced from each other, a transformer, means for connecting the primary of said transformer between said two portions of said target, means for connecting substantially the mid-point of said primary to said beam generating means, means for connecting the secondary of said transformer to an output circuit, a pair of pole-pieces within said tube between said beam generating means and said target member, a magnetic signal record member, a magnetic flux path comprising two leg members of magnetic material extending from a region closely adjacent said pole-pieces to a region on opposite sides of and closely adjacent the magnetic record member, means for moving said magnetic record member in the gap created by the space between said legs so that said beam is caused to divide its energy between the two portions of the target member in such a manner that an amplified output current is produced in the secondary of said transformer, and means between said two portions of said target for preventing secondary electrons caused to be emitted by the primary beam impinging upon each of said target portions from passing to the other of said target portions.

ALBERT M. SKELLETT.