

April 7, 1942.

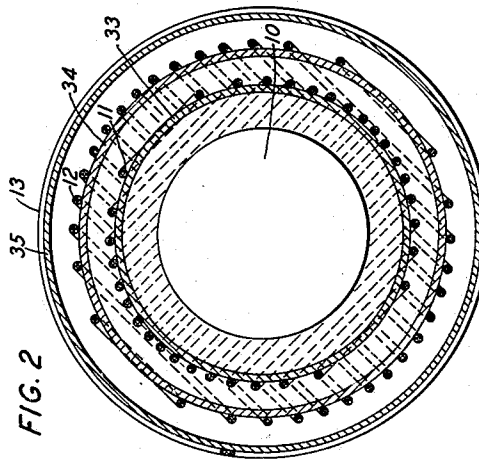
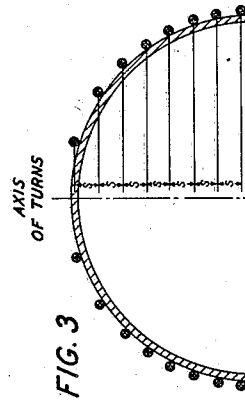
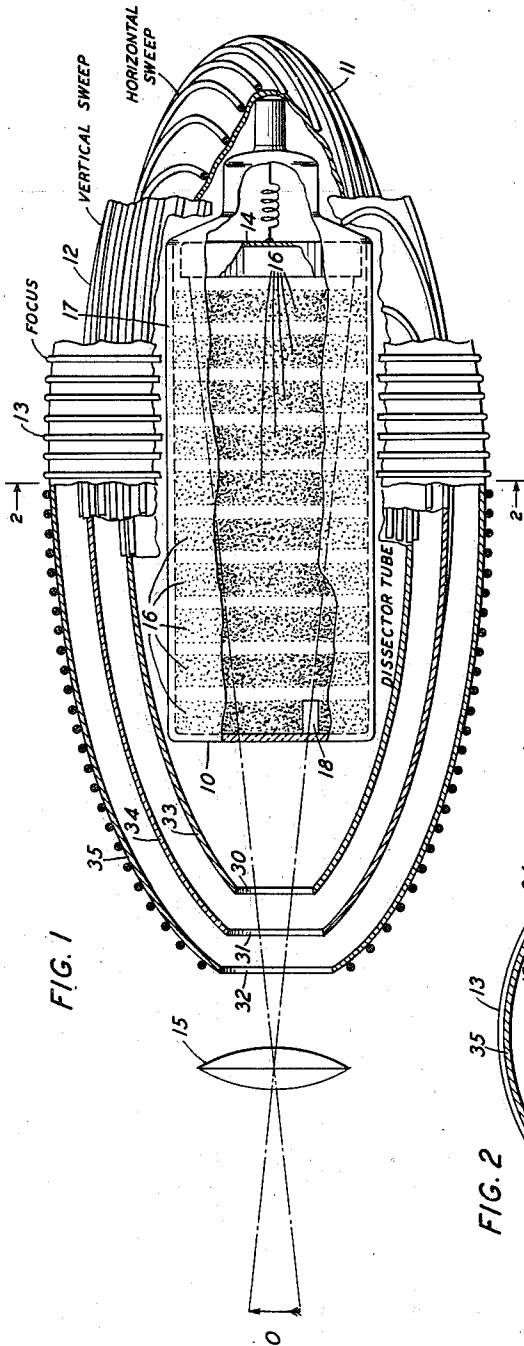
B. M. OLIVER

2,278,478

MAGNETIC COIL AND ARRANGEMENT UTILIZING THE SAME.

Filed Jan. 10, 1941

3 Sheets-Sheet 1



INVENTOR
B. M. OLIVER
BY *Chas. Sprague*
ATTORNEY

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B. M. OLIVER

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3 Sheets-Sheet 2

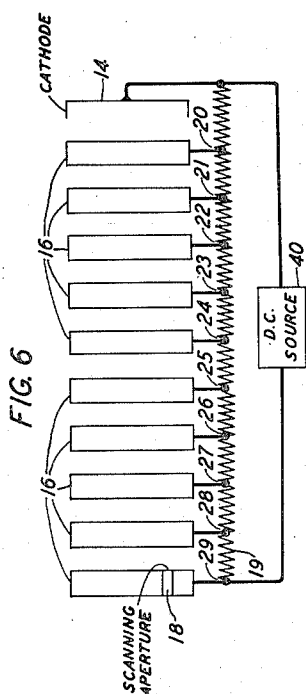


FIG. 4

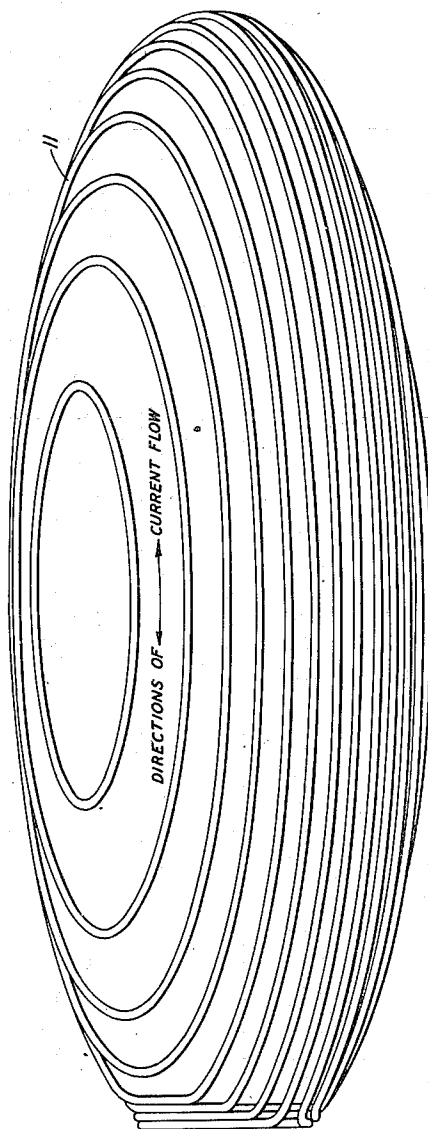
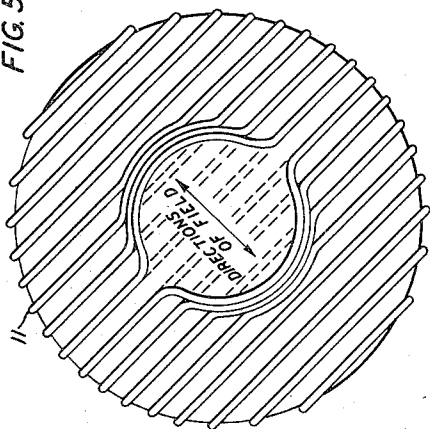


FIG. 5



INVENTOR
B. M. OLIVER
BY *Chas. Sprague*
ATTORNEY

April 7, 1942.

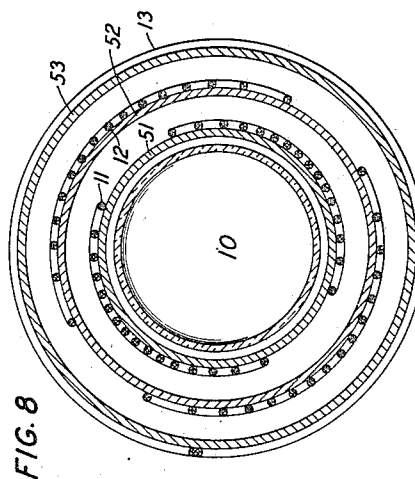
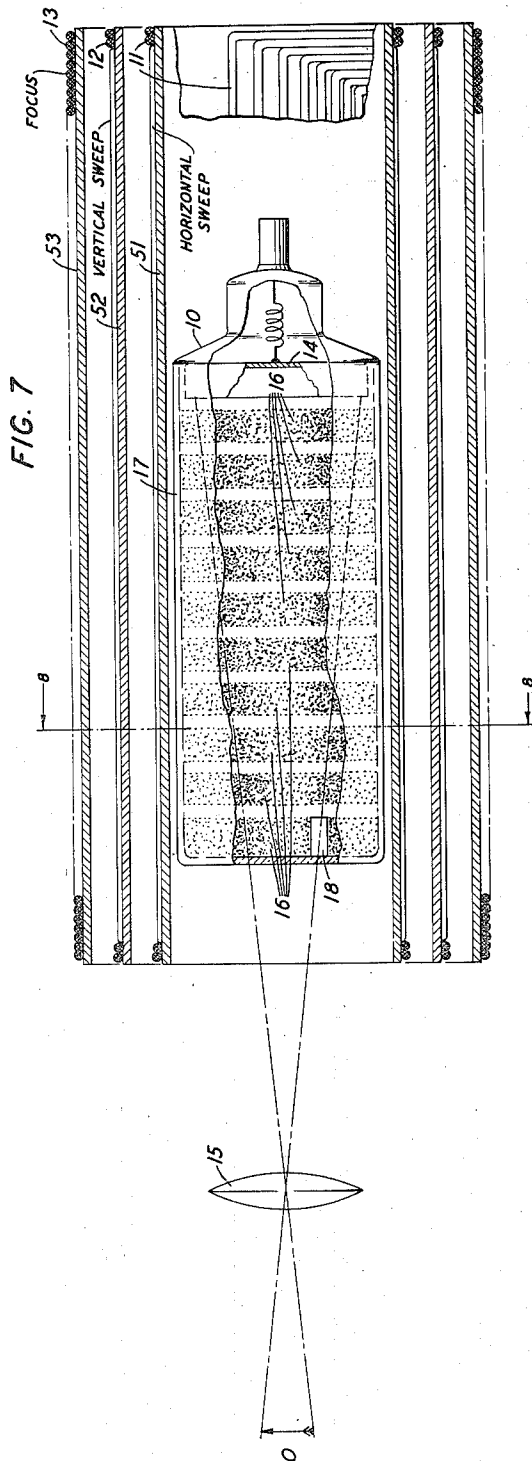
B. M. OLIVER

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MAGNETIC COIL AND ARRANGEMENT UTILIZING THE SAME

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3 Sheets-Sheet 3



INVENTOR
B. M. OLIVER
BY *C. C. Sprague*
ATTORNEY

UNITED STATES PATENT OFFICE

2,278,478

MAGNETIC COIL AND ARRANGEMENT
UTILIZING THE SAMEBernard M. Oliver, New York, N. Y., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application January 10, 1941, Serial No. 373,984

3 Claims. (Cl. 178—7.2)

This invention relates to electron discharge devices and more specifically to magnetic focussing and deflecting coil arrangements for electron discharge devices used in television.

It is an object of this invention to provide improved means for forming fields in electron discharge devices.

While the present invention is applicable to many forms of electron discharge devices, one important use therefor is in connection with cathode ray pick-up or receiving tubes for television.

One well-known form of cathode ray pick-up device is called the dissector. In the usual dissector tube, an image of the object is formed on a photoelectric cathode, thereby giving rise to a stream of electrons, various elemental portions of a cross-section of which, taken at a plane containing a scanning aperture, correspond respectively to the elemental areas of the object. The electrons are accelerated towards the aperture by an axial electrostatic field. In order to use the tube as a television pick-up device, three independently variable magnetic fields are usually necessary. First, an axial magnetic field is required to form an electron image at the end of the tube remote from the photocathode. This axial magnetic field is produced by a magnetic focussing coil. Next, two transverse magnetic fields, known as the horizontal and vertical deflecting (or sweep) fields, are required in order to deflect the electron stream from side to side and up and down and thus displace the electron image in these directions. By means of these two transverse magnetic fields it is possible to move all elemental parts of the electron image in succession over a fixed aperture located in the image or "scanning" plane. The number of electrons received by an electrode directly behind the aperture depends on the electron density of that portion of the electron image which falls on the aperture at any instant, and hence in turn is proportional to the light intensity of that element of the cathode surface being imaged on the aperture at that instant. In certain special applications, such as those in which the material to be scanned is a moving film, one set of deflecting coils may be omitted.

It is another object of this invention to provide novel magnetic coils which are especially suitable for setting up fields within a given space which are uniform throughout said volume.

In television systems employing the usual dissector tube as a pick-up device, it has been noted that the picture produced on the screen of the

receiving tube has been distorted due, at least in large part, to the fact that the magnetic sweep coils and, in some cases, the focussing coil have been so formed as to inherently produce a non-uniform field. The usual way to provide sweep fields has been to use concentrated windings, that is, coils producing substantially the same field distribution as a single turn of wire. In using deflecting coils with a concentrated winding it has been found that the transverse fields inside the dissector tube have not been uniform throughout (although they may be uniform for certain portions of the space therein). In such windings it is difficult to obtain a sufficient number of ampere turns without increasing the inductance and distributed capacity to a point where the self-resonance of the coil will seriously affect the linearity of the sweep. Moreover, such coils are not as efficient as desired due to the relatively high power input required because of their high inductance.

It has been discovered that if all of the fields within the dissector tube, that is, the magnetic fields produced by the focussing coil, the horizontal sweep coil and the vertical sweep coil, and the electrostatic field produced between the photocathode and the plane of the scanning aperture, are made uniform, an image current can be obtained which is a geometrically undistorted electrical counterpart of the original image.

In accordance with one embodiment of this invention, the three uniform magnetic fields desired are produced within at least substantially the entire space enclosed by the dissector tube by placing said tube within the space surrounded by three coils each of which is formed by distributing the individual windings (which may be of one or more turns each, there being the same number of turns in each winding) on the surface of a separate ellipsoidal shell in such a way that there is a constant number of turns per unit of length, measured along the axis about which the particular winding is wound. Separate coaxial ellipsoidal shells are provided for the three magnetic windings, the horizontal sweep winding being placed nearest the dissector tube, the vertical sweep winding being outside of the horizontal sweep winding and the focussing winding being outside of the vertical sweep winding. Normally the coils are so adjusted and positioned that the fields produced are mutually perpendicular. Also because of the circular cylindrical shape of the dissector, it is convenient to use prolate spheroidal shells, rather than ellipsoidal ones in which all three semi-axes are different.

An electrostatic field is provided to accelerate the electrons within the dissector tube from the photocathode to the scanning aperture plane which field is uniform in intensity and axial in direction everywhere within the tube. This field is formed by providing a plurality of accelerating conducting rings (this term is intended to include coatings on the walls of the tube) between the photocathode and the scanning aperture, which rings are placed at progressively increasing potentials. The field produced by such an arrangement is substantially uniform throughout a cylinder whose radius is somewhat less than that of the rings. The combination of such a uniform axial electrostatic field, a uniform axial magnetic focussing field and uniform transverse magnetic deflecting fields ensures that the electron image produced at the scanning plane is a true reproduction of the original optical image and free from any curvilinear or shear distortion. If one or more of the fields present is not uniform this optimum condition does not exist and distortions are accordingly present in the electron image.

In a modification of the ellipsoidal form of coil, each of the windings may be formed on a cylinder long enough to completely enclose the dissector. If the cylinder is infinitely long and the turn distribution made exactly uniform by making the number of turns per unit length, measured along the axis of the winding, equal throughout the coil, such an arrangement will produce a magnetic field which is absolutely uniform throughout the entire space within the cylinder. In practice, because of the finite number of turns, slight field irregularities are produced near the cylinder wall and the finite length of the coil causes some non-uniformity near the end due to the bunched end turns.

While the invention in certain of its aspects is applicable to electron discharge devices, in other aspects it is not so limited as the coils of this invention may be used in other cases where magnetic fields are required.

The invention will be more readily understood by referring to the following description and the accompanying drawing forming a part thereof, in which:

Fig. 1 shows, with portions broken away, a dissector tube together with its associated sweep and focussing windings, in accordance with the invention;

Fig. 2 is a cross-sectional view taken at the plane indicated by the line 2—2 of Fig. 1;

Fig. 3 is a schematic view of a half section of one of the sweep windings;

Fig. 4 is a side view of one of the sweep windings;

Fig. 5 is an end view of the coil shown in Fig. 4;

Fig. 6 is a schematic view showing the electrostatic focussing means and the means to apply potential thereto;

Fig. 7 shows a modification of the arrangement of Fig. 1; and

Fig. 8 is a cross-sectional view taken at the plane indicated by the line 8—8 of Fig. 7.

Referring more particularly to the drawings, Fig. 1 shows a dissector tube 10 and associated horizontal sweep winding 11, vertical sweep winding 12 and focussing winding 13, which windings are formed and wound in accordance with this invention so that a uniform magnetic field is produced within the space enclosed by the dissector 10.

The dissector tube 10 comprises a photoelectric

cathode 14 upon which radiations from an object O are focussed by any suitable optical system represented schematically by the single lens 15. An electrostatic accelerating field producing means comprising a plurality of conducting rings 16, preferably being conducting coatings on the envelope walls 17 of the dissector tube, and a pick-up or anode member 18 at the end of the tube 10 remote from the photoelectric cathode 14. The anode member 18 preferably comprises a metallic finger having an aperture therein of elemental size and an electrode back of the aperture for receiving electrons which pass through it. In order that the electric field which accelerates the photoelectrons from the cathode 14 toward the pick-up anode 18 be uniform in intensity and axial in direction, the conducting rings 16 are connected by means of connections 20 to 29, inclusive, to a potentiometer 19 (see Fig. 6) in such a way that the potential applied to the rings increases uniformly in the direction of the electron flow. The source of direct potential 40 supplies the required current to the potentiometer. Any suitable electron multiplier (not shown) may be enclosed within the pick-up finger 18 in a manner well known in the art. The connection to the external circuit from this anode member 18 also has not been shown for simplicity in the drawing but this connection is similar to that employed with the usual dissector.

Surrounding the dissector tube 10 and completely enclosing it except for openings 30, 31 and 32, respectively, at the end near the object O are three ellipsoid shells 33, 34 and 35 upon which are wound respectively the horizontal sweep coil 11, the vertical sweep coil 12 and the focussing coil 13. It can readily be shown that the field inside an ellipsoidal coil is a constant if the windings are so distributed that each unit of length, measured along the axis of the windings, contains the same number of turns.

Each of the individual windings shown in the coils 11, 12 and 13 may be of several turns. The directions of current flow through the horizontal sweep winding are shown by the double-ended arrow in Fig. 4 which is a side view of, for example, the horizontal sweep coil 11. The direction of the field produced by this coil is shown in Fig. 5 which is an end view of the coil, the side view of which is shown in Fig. 4. The connections between the various windings have not been shown for simplicity in the drawing but it is to be understood that the windings making up a coil are connected in series in any well-known manner. As shown in Fig. 3, which is a schematic section of a sweep coil, the individual windings are distributed so that the distances S between windings, as measured along the axis of the entire coil, are equal.

The sweep coil 12 for the vertical sweep is similar to that of the horizontal coil except that more turns are permissible because of the lower frequency required for the frame sweep. The vertical sweep coil 12 is arranged in such a manner that the directions of the field produced thereby are approximately at right angles to those produced by the horizontal sweep coil 11.

Surrounding the vertical and horizontal sweep coils and mounted on form 35 is a focussing coil 13 which may also consist of a number of individual windings of several turns each. The axis of each of these coils is at right angles to the axes of the horizontal and vertical sweep coils. Due to the fact that this coil is also wound on

an ellipsoidal shell, the magnetic focussing field within the dissector tube is uniform throughout the entire space therein.

When the focussing magnetic field is of the intensity required to focus properly the electron image, the direction of scan produced by each of the sweep coils is not perpendicular to (as would be the case with no axial magnetic field), but rather makes an angle whose tangent is $1/\pi$ with the direction of the sweep field. The sweep coils are thus rotated so that the axis of their turns makes in each case an angle of $\tan^{-1}1/\pi$ with the direction of scan desired from the field of the coils. The sense of this angle is the same for both coils and may be reversed by reversing the focussing field. An opening is left at least at one end of each of the coils to admit light but each coil is so proportioned that the field irregularities resulting from this opening and from the finite number of coil bundles are negligible.

To permit assembly, the shells supporting the sweep coils are split into two half shells, each by meridional plans perpendicular to the axis of the turns while the focussing coil is also split into two half shells by an equatorial plane. Means (not shown) are provided for holding the three coils and the dissector tube in a mutually coaxial position.

Fig. 7 shows a side elevation section view with portions broken away of a modification of the arrangement shown in Fig. 1 and Fig. 8 is a cross-sectional view taken along line 8-8 of Fig. 7. In these figures, like elements have been given the same reference characters as in the arrangement shown in Fig. 1. The dissector tube 10 is similar to that shown in Fig. 1. The sweep and focussing coils 11, 12 and 13, however, have been wound on long cylindrical forms 51, 52 and 53, respectively, surrounding the tube and coaxial therewith. These forms may be of any suitable material such as Micarta, or may be omitted if the windings are sufficiently stiff. The windings of the sweep coils are terminated by any suitable means such as, for example, by bringing each turn at the end directly around the surface of the cylinder to the corresponding position on the other side by the shortest path, as shown by the end turns of the coil 11 shown at the right-hand end of Fig. 7 through the broken away portion of the form 51. While theoretically the cylinders 51, 52 and 53 on the surface of which are the coils 11, 12 and 13 should be of infinite length in order to produce uniform fields, as a practical matter very little distortion is introduced when they are of a length sufficient to at least cover the entire dissector cylinder. It has been found that the field irregularities produced by the arrangement shown in Figs. 7 and 8 are unimportant provided the volume over which uniform field is desired extends no nearer to the coil end than about three-halves of the coil-form radius. This type of construction has the advantage over the arrangement shown in Fig. 1 of being simpler and also in that openings are left for light and wires. Experimental exploration showed the field produced to be sufficiently uniform.

Since it is more important in the dissector to have the field uniform near the cathode than it is near the scanning plane, the tube is so disposed within the coil arrangement of Fig. 7 that the cathode is farther from the end of the winding than the scanning plane is from the other end.

In Figs. 1, 2, 4, 5, 7 and 8, each winding is shown, for simplicity, as unconnected to adjacent windings. In practice, each of these separate windings, which in general would consist of a group of wires though in special cases a single wire would be sufficient, is serially connected to adjacent windings. These connections may be made at any position but are preferably made at one end of the structure.

In addition to producing a more uniform field, distributed coils of the type shown in Fig. 1 and Fig. 7 have a very definite advantage as sweep coils in that their inductance is much lower than any form of concentrated winding. As a matter of fact, the greater field uniformity and hence the smaller coil size permissible with the distributed coils together with their inherently lower inductance makes necessary a sweep power only about 50 per cent of that required with concentrated sweep windings in order to produce comparable deflection. Moreover, the lower distributed capacity of the distributed coils of this invention increases their self resonant frequency considerably making a linear sweep obtainable at a higher frequency than is possible with concentrated coils.

Instead of the windings being distributed on the surface of an ellipsoid or a long cylinder in such a fashion that each unit of length, measured along the axis of the winding, contains the same number of turns and hence produces the same number of ampere turns (as the windings are connected in series), the latter result can be obtained in other ways such as, for example, by varying the turn distribution among the unit sections and compensating for this variation by varying the current among the various sections to produce the required constancy of ampere turns per unit axial length. The current may be varied by shunting certain of the windings or by any other convenient means. Current for the focussing coil may be supplied by any suitable means (not shown) and the value of this current adjusted to produce the desired focus. The saw-toothed currents to apply to the deflecting windings 11 and 12 may be obtained from any suitable sweep generators for supplying saw-toothed current to magnetic coils. One of these generators has a frequency corresponding to the frame frequency while the other has a frequency corresponding to the line scanning frequency. A suitable generator is shown in Patent 2,214,077 issued September 10, 1940 to P. T. Farnsworth.

The method of operation of the dissector tube 10 is well known but will be described here briefly. An image of the object O is formed on the photoelectric cathode 14 which may be of the caesium-silver-oxide type. Saturated photo-emission is obtained from this cathode by means of a positive potential of about 300 volts applied between the cathode 14 and the conducting ring 15 nearest the anode member 18, said potential difference being obtained from the potentiometer 19 which is energized by the source of direct potential 40. The uniform axial field set up by the focussing coil 13 in cooperation with the substantially uniform electrostatic field produced within the tube by the potentials applied to the conducting rings 16 bring the photoelectrons to a focus in the plane of the apertured anode 18, thus forming an electron image of the object in this plane. The horizontal and vertical sweep coils 11 and 12 produce saw-toothed magnetic fields uniform in intensity throughout the dissector volume and in directions trans-

verse to the axis of the dissector. These fields, which are continuously varying with time due to the saw-toothed currents applied to the coils, sweep the entire electron image across the multiplier aperture, thereby allowing successive elements of the electron image to pass through the aperture to the pick-up electrode of the multiplier. The output of the electron multiplier is then conducted to the first stage of the video amplifier (not shown). If motion picture film comprises the object $\bigcirc$ one of the sweep coils of the dissector might not be used, one direction of scan being supplied by the motion of the film.

Various modifications may be made in the embodiments above described without departing from the spirit of the invention, the scope of which is indicated in the appended claims.

What is claimed is:

1. Cathode ray directing and deflecting means for the type of cathode ray tube in which a relatively large bundle of cathode rays emitted by the cathode is subjected to a magnetic field produced by a surrounding coil structure to cause said rays to travel in generally parallel

paths and said bundle is magnetically deflected as a whole in a direction substantially transverse to said paths by means of a second magnetic surrounding coil structure, said means comprising a coil structure of general ellipsoidal shape the windings of which lie substantially in planes perpendicular to the direction of the emission of the rays from the cathode and a second substantially ellipsoidal coil structure concentric with said first coil structure the windings of which second coil structure lie substantially in parallel planes transverse to said first coil structure.

2. The combination of the means of claim 1 with a third ellipsoidal structure concentric with said first and second coil structures comprising windings lying in substantially parallel planes which are transverse to the planes of the windings of the other two coil structures.

3. The combination of claim 1 in which each of said coil structures is open ended to form an optical window, said windows being aligned with each other.

BERNARD M. OLIVER.