United States Patent [19]

Swart

[11] **3,774,070**

[45] **Nov. 20, 1973**

[54] **DEFLECTION COIL SYSTEM, IN PARTICULAR FOR A CAMERA TUBE**

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[22] Filed: **May 22, 1972**

[21] Appl. No.: **255,531**

[30] **Foreign Application Priority Data**

May 26, 1971 Netherlands 7107285

[52] **U.S. Cl.** ..... **315/27 XY,** 335/213

[51] **Int. Cl.** **H01j 29/70**

[58] **Field of Search** ..... 335/213; 313/84, 313/79, 76, 79 SP; 315/10, 11, 27 XY

[56] **References Cited**

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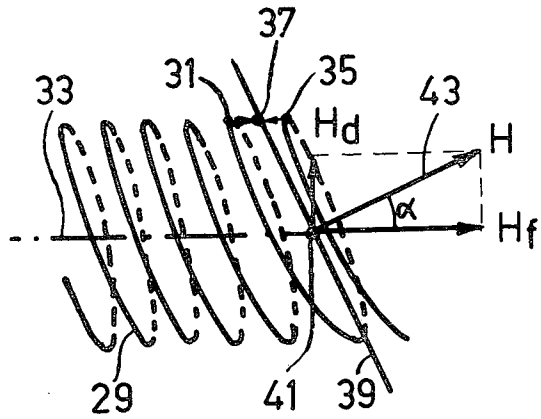
[57] **ABSTRACT**

A deflection coil system, in particular for a camera tube, consisting of two pairs of coaxial cylindrical coils. Each coil consists of a helical conductor with turn planes which are arranged at an angle. The normals of the turn planes are arranged in a half-plane on one side of the cylinder axis in each coil. The four half-planes together form two mutually perpendicular planes.

10 Claims, 7 Drawing Figures



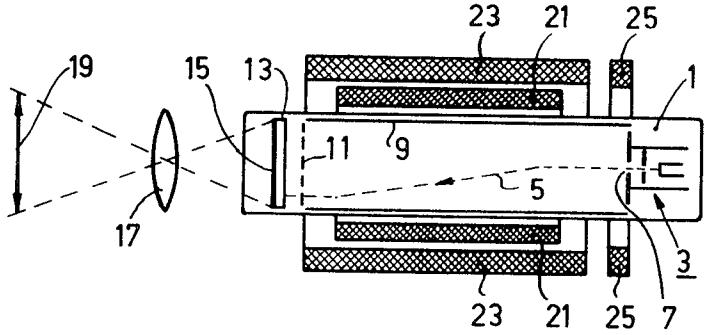


Fig.1

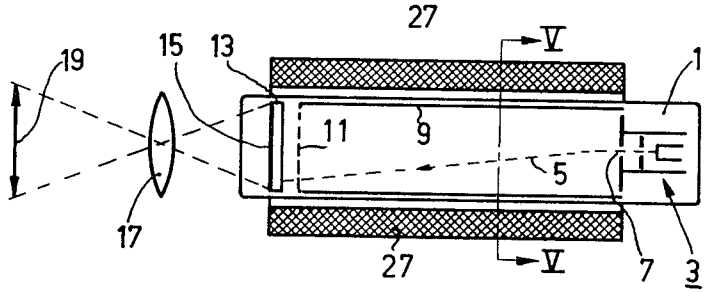


Fig.2

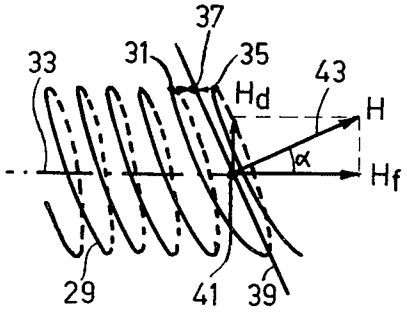


Fig.3

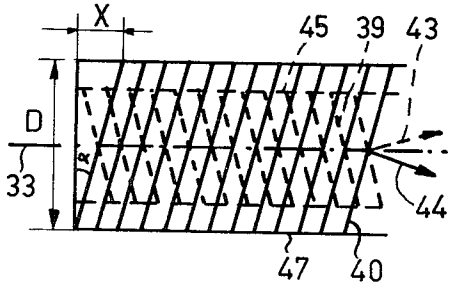


Fig.4

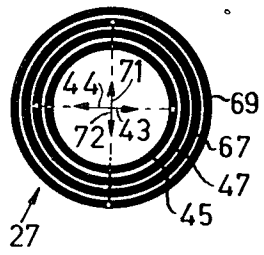


Fig. 5

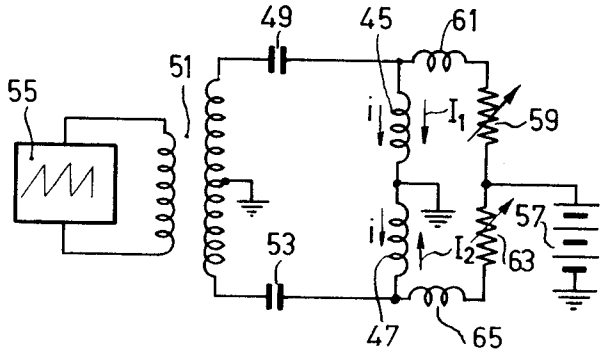


Fig. 6

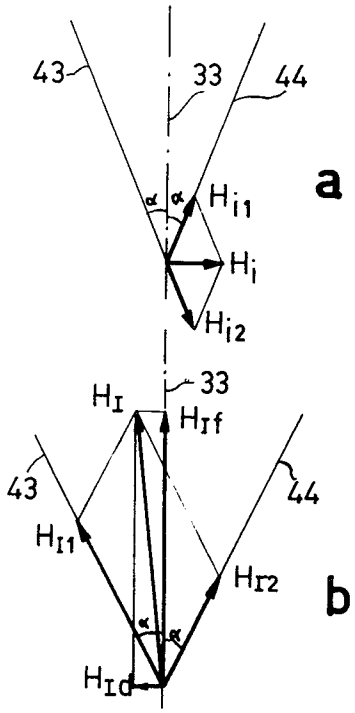


Fig. 7

DEFLECTION COIL SYSTEM, IN PARTICULAR FOR A CAMERA TUBE

The invention relates to a deflection-coil system for deflecting a beam of charged particles, in particular a beam of electrons in a camera tube, comprising a first pair of coils for deflecting the beam in a first direction which is perpendicular to the direction of movement of the particles, and a second pair of coils for deflecting the beam in a second direction which is perpendicular to the direction of movement and perpendicular to the first direction.

The coil systems for focussing and deflecting the electron beam in cathode-ray tubes which are commonly used at present comprise a focussing coil for generating a constant magnetic field which extends mainly parallel to the tube axis and which serves for focussing the electron beam, and two coil pairs for generating varying and, as already described, mutually perpendicular magnetic fields for deflecting the electron beam.

Camera tubes generally also require four alignment coils by means of which the beam emitted by the electron gun is made parallel to the tube axis. Consequently, the complete coil system is rather complicated and bulky and hence expensive. In particular the application in colour television cameras in which a separate camera tube is used for each of the three basic colours requires very high reproducibility of the coil systems as the three images are required to coincide. In practice this requirement gives rise to rejections during production, which also has a cost-increasing effect.

The invention has for its object to provide a deflection coil system having a construction which is so simple that it can be readily manufactured with a high reproducibility, whilst a separate focussing coil and the alignment coils can be dispensed with. To this end the invention is characterized in that at least one of the said coil pairs is composed of two coaxial cylindrical coils, each of which consists of a conductor which is helically wound such that the central normal of each plane of a turn encloses an acute angle with the cylinder axis, all central normals of one coil being arranged in one plane and on one side of the cylinder axis, the central normals of the second coil being arranged in the same plane and on the other side of the cylinder axis. The plane of a turn is the plane in which a turn (this is a portion of the conductor which extends exactly once around the cylinder) is situated if the two ends of the turn are cut loose and are moved towards each other over equal distances until they are colinear. The central normal of such a turn plane is the perpendicular to the turn plane extending from the intersection of the turn plane and the cylinder axis in the direction of the foremost end of the coil. The choice as regard, which end of the coil foremost is arbitrary, be it that it must be the same for both coils forming a pair. The described advantages of the construction according to the invention become most apparent if the configuration of the second coil pair is the same as that of the first coil pair, the axes of the two coil pairs coinciding and the plane in which the central normals of the second coil pair are arranged being perpendicular to the plane in which the central normals of the first coil pair are situated. It is then advantageous to provide a television camera with an inner coil pair which is connnected to a generator for image-frequency deflection currents, and with an outer coil

pair which is connected to a generator for line-frequency deflection currents. By connecting the four coils not only to circuits for the deflection currents but also to a circuit for generating a direct current, the coils can be utilized both for deflecting and for focussing the electron beam.

The invention will be described with reference to the drawing, in which:

FIG. 1 is a diagrammatic view of a camera tube provided with a commonly used coil system,

FIG. 2 is a diagrammatic view of the same camera tube provided with a deflection coil system according to the invention,

FIGS. 3, 4 and 5 illustrate the construction of a coil system according to the invention,

FIG. 6 is a circuit diagram of a circuit for supplying the required currents to a coil pair according to the invention, and

FIG. 7 shows the magnetic fields generated in this coil pair by means of the circuit shown in FIG. 6.

The camera tube 1 shown in FIG. 1 comprises an electron gun 3 for generating an electron beam 5 which can be emitted via a diaphragm-aperture 7. Influenced by a cylindrical anode 9, the electrons arrive on a target 13 of a photoconductive material via a fine-meshed grid 11, the side of the target which is remote from the electron gun 3 being provided with a transparent electrode 15. An image of an object 19 is projected onto the target 13 by means of a lens system 17. This image is scanned by the electron beam 5 so that the image can be converted into an electrical signal in known manner.

For the scanning of the target 13 by the electron beam 5 a deflection coil system 21 is provided, usually consisting of two pairs of flat coils which have at least been partly bent to the shape of a cylindrical surface after winding. For the focussing of the electron beam a focussing coil 23 is provided, usually consisting of a conductor which is helically wound about a cylindrical surface. Four alignment coils 25 serve to ensure that deviations between the direction of the electron beam and the tube axis are corrected. Deviations of this kind are caused, for example, by the electron gun not being mounted completely straight in the tube.

The camera tube shown in FIG. 2 is fully identical to that shown in FIG. 1. However, the coil system 21, 23, 25 is replaced by a deflection coil system 27 consisting of four coaxial cylindrical coils. Each of these coils is formed by a conductor 29 which is helically wound as shown in FIG. 3.

Parts of the conductor 29 which are situated behind the plane of the drawing are denoted in FIG. 3 by broken lines for the sake of clarity. One turn of the helix consists of a portion of the conductor 29 which, starting at an arbitrary point 31, extends once about the cylinder axis 33 and terminates in a point 35. The plane in which the relevant conductor portion is situated if the conductor 29 is cut in the points 31 and 35 and the two ends of the turn are moved towards each other over equal distances in the direction of the arrows shown at the points 31 and 35 until the ends of the turn are colinear so that the points 31 and 35 coincide in the point 37, is the turn plane 39 which is denoted in FIG. 3 by its line of intersection with the plane of the drawing. The turn plane 39 intersects the cylinder axis 33 in a point 41. The perpendicular to the turn plane 39, extending from this intersection 41 in the direction of the foremost end (to the right in FIG. 3), is the central nor-

mal 43 of the turn plane. This central normal encloses an angle α with the cylinder axis 33. In the commonly used helically wound coils, such as the focussing coil 23, this angle is 0°. In the coils according to the invention, however, α is an acute angle.

The magnetic field strength H generated in the described turn when current is passed through the conductor 29, is directed substantially parallel to the central normal 43. The field strength H can be decomposed into two components. One component thereof, H_f, is parallel to the cylinder axis 33 and can serve for focussing an electron beam passing through the coil in the axial direction. The other component, H_d, is directed perpendicular to the cylinder axis 33 and deflects the electron beam in a direction which is perpendicular to the plane of the drawing.

In practice it is necessary that the axial component H_f remains substantially constant, whilst the radial component H_d varies between a maximum positive and a maximum negative value. This can be achieved by using two coaxial cylindrical coils 45 and 47 for the deflection in one direction. A system of this kind is shown in FIG. 4, the inner coil 45 being denoted by broken lines for the sake of clarity. The central normals 43 of the inner coil 45, only one of which is shown, are all arranged in the plane of the drawing and on one side (the upper side in FIG. 4) of the cylinder axis 33. The central normals 44 of the outer coil 47 are also arranged in the plane of the drawing, but on the other side of the cylinder axis 33.

The desired magnetic fields can be generated in the coil pair 45, 47 by means of the circuit shown in FIG. 6. To this end, the coils 45 and 47 are earthed on corresponding ends, for example, the right-hand end in FIG. 4. The non-earthed end of coil 45 is connected, via a capacitor 49, to one of the secondary winding of a transformer 51. The corresponding end of coil 47 is connected, via a capacitor 53, to the other end of the secondary winding of the transformer 51. The secondary winding is earthed at its centre. The primary winding of the transformer 51 is connected to a known sawtooth generator 55. It will be obvious that the varying currents i, generated by the sawtooth generator 55 and applied to the deflection coils 45 and 47 via the transformer 51 and the capacitors 49 and 53, respectively, pass through the deflection coils in opposed directions. The currents i generate a magnetic field H_{f1} in a turn of coil 45 (see FIG. 7*a*) and a magnetic field H_{f2} in a turn of coil 47. The resultant H_f of these two magnetic fields is directed perpendicular to the cylinder axis if the central normals 43 and 44 of the turn planes of the two coils 45 and 47 enclose equal angles with the cylinder axis 33 and if the winding direction of the two coils is the same. H_f varies in time between two extreme values.

The deflection coils 45 and 47 are not only connected to the sawtooth generator 55, but also to a direct-voltage source 57. These connections extend via a variable resistor 59 and a choke 61, and via a variable resistor 63 and a choke 65, respectively. The voltage source 57 causes constant currents, I_1 and I_2, respectively, in the two deflection coils 45 and 47, the said constant currents passing through the deflection coils in the same direction. The value of the magnetic field strength H_{f1} and H_{f2}, respectively, which is thus generated can be varied by means of the resistors 59 and 63, respectively. The resultant field strength H_f (see FIG. 7*b*) generally contains a component H_{ff} which is directed along the cylinder axis 33, and a component H_{fd} which is perpendicular to the cylinder axis. If $H_{f1} = H_{f2}$, H_{fd} becomes equal to zero. The circuit shown in FIG. 6, used for the deflection coil pair shown in FIG. 4, thus produces a constant magnetic field in the direction of the cylinder axis 33 and a constant magnetic field with a superimposed magnetic field in a direction perpendicular to the cylinder axis. Focussing as well as deflection of the electron beam can be realized by means of the coil pair shown in FIG. 4 by a suitable choice of the various currents and of the angles α.

The following considerations are of importance in choosing the angle α. On the one hand, the angle may not be too small as then excessively large deflection currents would be necessary as is obvious from FIG. 7. On the other hand, an excessively large angle α is not desirable either as this causes the coil to become unnecessary long. This is because the magnetic field is too distorted beyond the last turn to be suitable for use for deflection. This means (see FIG. 4) that a portion $x = D tg \alpha$ of the coil is not usable. The larger α, the larger x will be.

This is particularly disadvantageous because it was found that the deflection coil system 27 according to the invention must preferably extend from the electron gun 3 to the target 13 as is shown in FIG. 2. If this is not the case, the electrons are liable to impinge upon the target 13 under an incorrect angle. This means that the portion x projects beyond the target so that the deflection coil system 27 may come into conflict with the lens system 17. In practice an angle α of 3° — 20° was found to be satisfactory. If desired, the angles α may have different values for the different coil pairs. The angles are readily reproduceable if the coils are wound on formers which are provided with grooves situated at the desired angle with respect to the axis.

Using the coil pair shown in FIG. 4, the electron beam can be deflected in one direction which is perpendicular to the cylinder axis 33. If desired, the deflection in the other direction can be realized by means of other, for example, electrostatic means. However, preference should be given to the use of a second coil pair having the configuration shown in FIG. 4, said second coil pair coaxially enveloping the first coil pair. FIG. 5 is a cross-sectional view, perpendicular to the cylinder axis 33, of a deflection coil system 27 thus formed. The inner coil pair comprises the deflection coils 45 and 47. Their central normals 43 and 44, respectively, the projection of which is shown on the plane of the drawing, are arranged in a horizontal plane. These coils serve as image deflection coils. The line deflection coils 67 and 69 envelop the image deflection coils 45 and 47 coaxially. Their central normals 71 and 72 are arranged in a vertical plane.

The inner coil pair 45, 47 of the deflection coil system 27 is connected to a generator 55 for image-frequency deflection currents in the manner shown in FIG. 6, the outer coil pair 67, 69 being connected in an analogous manner to a generator (not shown) for line-frequency deflection currents. Moreover, the four coils 45, 47, 67, 69 are connected to a direct-voltage source 57 in the manner shown in FIG. 6 for two coils 45, 47.

As already stated, the deflection coil system according to the invention is particularly suitable for use in a camera tube. This deflection coil system, however, is

also very suitable for use in other cathode-ray tubes, such as display tubes having small deflection angles.

What is claimed is:

1. A deflection coil system for deflecting a beam of charged particles, in particular a beam of electrons in a camera tube, comprising a first pair of coils for deflecting the beam in a first direction which is perpendicular to the direction of movement of the particles, and a second pair of coils for deflecting the beam in a second direction which is perpendicular to the direction of movement and perpendicular to the first direction, characterized in that at least one of the said coil pairs is composed of two coaxial cylindrical coils (45,47), each of which consists of a conductor (29) which is helically wound such that the central normal (43 and 44, respectively) of each turn plane (39 and 40, respectively) encloses an acute angle with the cylinder axis (33), all central normals (43) of one coil (45) being arranged in one plane and on one side of the cylinder axis 33, the central normals (44) of the second coil (47) being arranged in the same plane and on the other side of the cylinder axis (33).

2. A deflection coil system as claimed in claim 1, characterized in that the angle between the central normals (43, 44) and the cylinder axis (33) is larger than 3° and smaller than 20°.

3. A deflection coil system as claimed in claim 1, characterized in that the configuration of the second coil pair (67, 69) is the same as that of the first coil pair (45, 47), the axes (33) of the two coil pairs (45, 47 and 67, 69) coinciding, the plane of the central normals (71, 72) of the second coil pair (67, 69) being perpendicular to the plane of the central normals (43, 44) of the first coil pair (45, 47).

4. A deflection coil system as claimed in claim 3, characterized in that the first coil pair (45, 47) is arranged inside the second coil pair (67, 69).

5. A deflection coil system as claimed in claim 3 and intended for a camera tube comprising an electron gun and a target, characterized in that the length of the deflection coil system (27) is at least equal to the distance between the electron gun (3) and the target (13).

6. A television camera provided with a deflection coil system as claimed in claim 4, characterized in that the inner coil pair (45, 47) is connected to a generator for image-frequency deflection currents, the outer coil pair (67, 69) being connected to a generator for line-frequency deflection currents.

7. A television camera as claimed in claim 6, characterized in that the four coils (45, 47, 67, 69) are also connected to a circuit for generating a direct current which is capable of generating a magnetic field in the deflection coil system which serves for the focussing of the electron beam (5).

8. An apparatus for deflecting and focusing a beam of charged particles moving in a given direction in a direction perpendicular thereof comprising first and second helical coaxial coils each having a cylinder axis substantially parallel to said given direction, the central normals of the turn planes thereby formed being at a first acute angle with respect to said given direction, said first coil central normals being on one side of said axis in a given plane, and said second coil central normals being on the other side of said axis in said given plane.

9. An apparatus as claimed in claim 8 wherein said angle is greater than 3° and less than 20°.

10. An apparatus as claimed in claim 8 further comprising third and fourth helical coaxial coils each having a cylinder axis substantially parallel to said given direction, the central normals of the turn planes thereby formed being at a second acute angle with respect to said given direction and perpendicular to said first and second coils central normals.

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