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MAGNETIC ELECTRON LENS

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Fig. 1

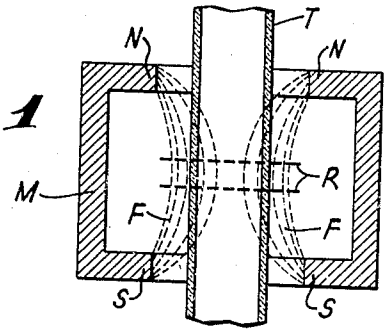


Fig. 2

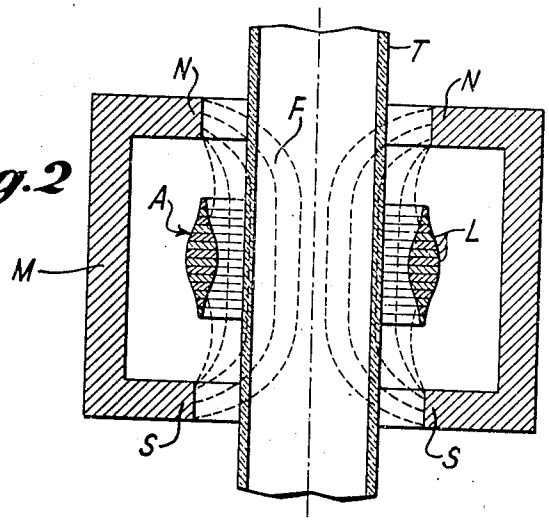
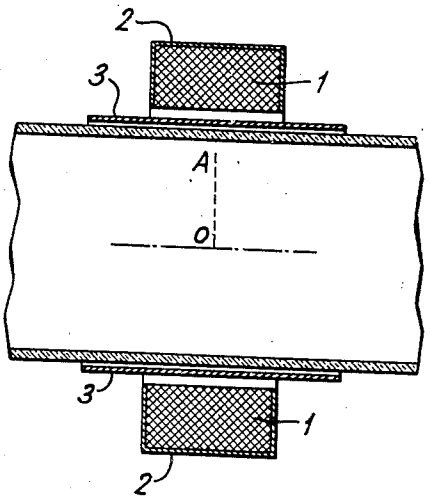


Fig. 3



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MAGNETIC ELECTRON LENS

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7 Claims. (Cl. 250—161)

The present invention relates to arrangements for setting up magnetic fields such as are introduced in the path of a composite electron beam in an electro-optical image transmitting or receiving device to produce an effect on the electron beam analogous to that of an optical lens on light rays. Such arrangements are said to constitute magnetic electron lenses in respect of the beams on which they act.

Magnetic electron lenses are usually produced by means of solenoid coils which may be provided with suitable magnetic shields and it has also been proposed, to set up magnetic electron lenses using an annular permanent magnet or a system of permanent magnets. In such arrangements difficulty is experienced in producing a magnetic field which will act on an electron beam to focus the beam to produce an electron image without spiral and spherical distortion.

The object of the invention is to reduce the distortion set up by a magnetic electron lens and to provide a method of "correcting" a magnetic lens.

According to the present invention, a magnetic electron lens is corrected by applying in the vicinity of the lens field auxiliary means comprising a member or members of such form and magnetic permeability that the lens field is only slightly weakened by the presence of said member or members whilst the field is wholly or partially corrected in the desired manner.

In carrying the invention into practice in connection with what may be termed simple spherical magnetic electron lenses, that is lenses analogous to spherical optical lenses, an arrangement is provided comprising principal means adapted to produce a magnetic field having rotational symmetry and auxiliary means adapted to co-operate with said principal means and disposed coaxially therewith in such manner as to produce a longitudinal extension of the region in which, in the absence of said auxiliary means, the lines of force are substantially parallel to each other, and to cause the radial distribution of lines of force in said longitudinally extended region to become uniform or nearly uniform, said auxiliary means being so formed that its weakening effect on said field is only slight.

In the case where the principal field producing means is an annular magnet or a solenoid, for example, the auxiliary means by which the magnetic field is corrected, in accordance with the invention, can comprise an annular member of magnetic permeability greater than unity but preferably not having a high permeability arranged within the magnet or solenoid, said member being thickest in the neighbourhood of the medial plane perpendicular to the axis of the magnetic field and tapering on either side of that plane in such a manner that the lines of force within the space girdled by the member are caused to become substantially parallel and substantially uniformly spaced, so that the lens field is substantially uniform in respect of direction and strength.

Alternatively, in an arrangement according to the present invention, the auxiliary means for correcting the field can be a thin cylinder of magnetic material, of a diameter slightly less than the internal diameter of the magnet or coil and extending on either side thereof.

In order that the nature of the invention may be clearly understood and the invention readily carried into practice, embodiments of the invention will now be described by way of example, reference being made to accompanying drawing in which:

Figure 1 is a cross sectional view of one form of annular permanent magnet which may be used in setting up a magnetic field to constitute an electron lens,

Figure 2 is a cross sectional view of an electron lens including the field producing magnet of Figure 1 and auxiliary means for correcting the lens field in accordance with the invention; and to the drawing

Figure 3 is a diagrammatic representation in section a further arrangement according to the invention.

The annular magnet M shown in Figure 1 of the drawing has inturned flanges N and S respectively, and is magnetised in such a way that, for example, the flange N is of north polarity and the flange S is of south polarity. The annular magnet M is normally mounted about a region of an electron discharge device through which an electron beam to be acted on by the lens field passes, for example the magnet may surround the neck of an electron discharge device as indicated at T in Figure 1 and in Figure 2 of the aforesaid drawing, electrons passing down the neck T, axially thereof, from a suitable source. Typical lines of force in the field produced by the magnet M within and in the neighbourhood of the neck T are shown at F extending between the flanges N and S of the magnet. It will be seen that these lines of force are substantially parallel to each other only

in a shallow region bounded by planes represented by the dotted lines R and that even within this region the lines of force are by no means equally spaced indicating that even here the field is not homogeneous. This variation of the field strength and also the fact that the direction of the field varies from one point to another transversely of the electron discharge path introduces undesirable distortion when the arrangement is used for focussing electrons to produce an electron image, this distortion being of both spherical and spiral type.

Now in order to improve the form of the field produced by the magnet shown in Figure 1, according to the invention, there is arranged within the space enclosed by the magnet M, and preferably outside the neck T, as shown in Figure 2, an annular correcting member A of material having a magnetic permeability greater than unity, the annulus A being thin at its edges and becoming gradually thicker towards the centre, the degree of taper preferably increasing away from the edge so that the cross-section of the member on each side of the central plane may resemble that of a "hollow-ground" razor. An annulus of this form will cause the lines of force passing through the region which it encloses to be drawn outwards slightly, the effect being most marked in the region of the central plane, and provided that the form and permeability of the annulus are properly selected, many lines of force in the region girdled by the member A can be caused to extend parallel to each other. This region will be seen to be much longer than the region between the planes R of Figure 1. Moreover, those lines F passing through the space enclosed by the annulus A are much more evenly spaced so that the field within the annulus has become substantially homogeneous. Substantial correction of the lens field can thus be produced by the use of a correcting member such as A.

The form of the correcting member such as A will, of course depend on the form of the region in which the field is to be corrected, and instead of a single correcting member, a plurality of correcting members can be arranged within the principal field producing means. Moreover, the magnetic lens field desired need not be one of parallel lines of force as described, and the invention can be applied to effect any desired modification of an existing magnetic lens field.

The correcting member or members used according to the invention can be built up in any suitable manner, for example the annulus A is shown in Figure 2 as being built up of laminations such as L, whereas the annulus might be formed by winding for example, iron wire, the shape of the annulus being modified, if desired, to suit the method employed in its construction. A correcting member or members used in accordance with the invention might also be formed by moulding a mass or masses of magnetic particles suspended in a suitable binder, the mass or masses being similar to any of those used as cores in so-called "dust-core" transformers. This allows low values of permeability and any desired shape of the correcting member to be obtained so as to effect a correction within close limits.

While the invention has been described in detail as applied in conjunction with a lens field produced by an annular permanent magnet, a member similar to the annulus A might be provided within a solenoid or in conjunction with a system of permanent magnets or in conjunction with any other lens field producing arrangement to effect a correction or modification of the field in a desired manner.

A further form of the invention is diagrammatically represented in Figure 3 of the drawing.

In this case, the principal means for setting up the axially symmetrical magnetic lens field is an electromagnetic coil 1. This is provided with a magnetic shield 2 embracing the coils on all sides except the inside in well known manner. According to the invention, the coil has arranged within it a thin cylinder 3 of magnetic material such as Swedish iron, the cylinder 3 being slightly less in diameter than the internal diameter of the coil and being of length at least equal to and preferably greater than the length of the iron shield arranged around the coil. The cylinder 3 can also conveniently be formed by winding iron wire on a suitable former.

Thus, for example, in one practical embodiment the electromagnetic coil 1 had a length of 5 cms. and an internal diameter of 11 cms. was used, and a cylindrical correcting member 3 of Swedish iron having a diameter of 10 cms. arranged within the coil, the arrangement being satisfactory with a shield 3 of length 5 cms. but giving better results with shields up to 10 cms. in length. With this arrangement conditions were investigated along the radius O—A in the centre plane of the field and it was found that from the point O on the axis to the point A which was 4 cms. distant radially from O, the field variation was only 5% in the case when the shield 3 was provided and that without the shield 3 the field at the point A was 40% in excess of the field at the point O. It was found that the effect of the correcting member 3 was to produce a reduction of only about 25% in the field strength at the centre O of the coil, this reduction being readily compensated for by increasing the magnetising current through the coil 1.

The length of the shield 3 is preferably longer than that of the coil 1 and its shield 2 so that excessive increase of the flux away from the axis in other planes perpendicular to the axis than the central plane including the radius O—A, is avoided.

Tests have been made using the arrangement described to focus electrons for the production of a picture on a cathode ray screen and for a given magnification of the electron image and after the necessary increase of the current to the extent of some 20%, over that required in the absence of member 3, a substantial reduction in the distortion in the picture has been obtained by using the correcting member. Moreover, it is found that the provision of a cylindrical correcting member such as 3 is also effective with unshielded coils or solenoids and with fields set up by annular permanent magnets, the provision of the correcting member being found to effect improvements in the radial distribution of the field on the central plane similar to those described in the case of a solenoid, and to produce similar reduction in the amount of spiral distortion produced by the lens. The provision of a rotationally symmetrical field in the manner described can in general be readily carried out in existing equipment as in the usual case electron lenses are arranged about a cylindrical portion of the hous-

ing of the electron discharge device in respect of which the lens field is set up.

While the invention has been described in connection with magnetic electron lenses for operating on composite electron beam of relatively large cross-section, it will be understood that, if desired, the method of the invention can be applied to magnetic electron lenses which are used to operate on fasciculated beams such as scanning beams in cathode ray oscillographs.

We claim:

1. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising means symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and low permeability magnetic means structurally independent of said first named means symmetrically located about said plane and positioned intermediate said envelope and said first named means for producing uniform radial distribution of said field within a substantial portion of said envelope.

2. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising magnetic means symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and a low permeability magnetic annulus structurally independent of said first named means symmetrically located about said plane and positioned intermediate said envelope and said first named magnetic means for producing uniform radial distribution of said field within a substantial portion of said envelope.

3. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising magnetic means symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and a coaxial low permeability magnetic annulus structurally independent of said first named means symmetrically located about said plane and positioned intermediate said envelope and said first named magnetic means for producing uniform radial distribution of said field within a substantial portion of said envelope.

4. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising a fixed magnet symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and a low permeability magnetic annulus structurally independent of said fixed magnet symmetrically located about said plane and positioned intermediate said envelope and said fixed magnet for producing uniform radial distribution of said field within a substantial portion of said envelope.

5. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising magnetic means symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and an auxiliary laminated magnetic annulus structurally independent of said first named means symmetrically located about said plane and positioned intermediate said envelope and said first named magnetic means for producing uniform radial distribution of said field within a substantial portion of said envelope.

6. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising a fixed magnet symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and an auxiliary laminated magnetic annulus structurally independent of said fixed magnet symmetrically located about said plane and positioned intermediate said envelope and said fixed magnet for producing uniform radial distribution of said field within a substantial portion of said envelope, said annulus having non-uniform cross-section.

7. A magnetic system for producing a homogeneous field within a cylindrical envelope comprising electromagnetic means symmetrical about a plane perpendicular to the axis of said envelope for producing an axially symmetrical magnetic field having non-uniform radial distribution, and a low permeability magnetic annulus structurally independent of said first named means symmetrically located about said plane and positioned intermediate said envelope and said first named means for producing uniform radial distribution of said field within a substantial portion of said envelope.

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