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2,200,039

PERMANENT MAGNET DEVICE FOR PRODUCING AXIALLY SYMMETRICAL MAGNETIC FIELDS

Filed Oct. 28, 1938

2 Sheets-Sheet 1

Fig. 1

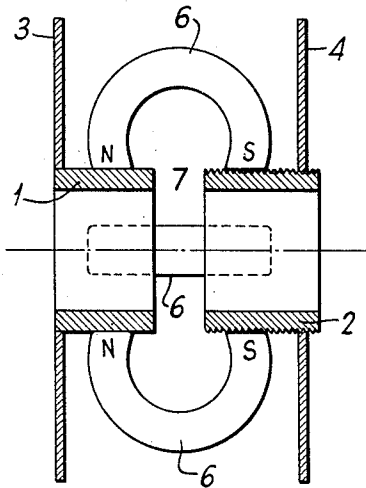


Fig. 2

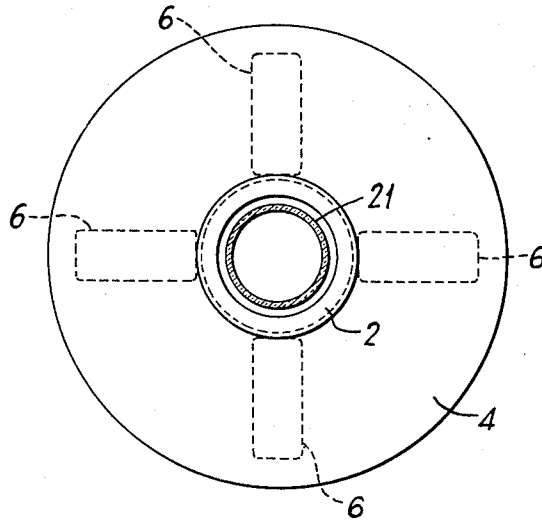
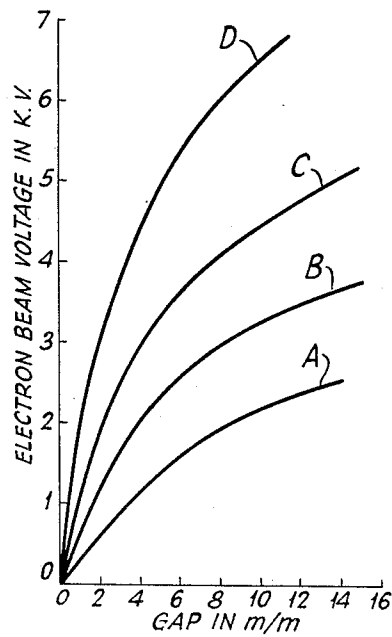


Fig. 3



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2 Sheets-Sheet 2

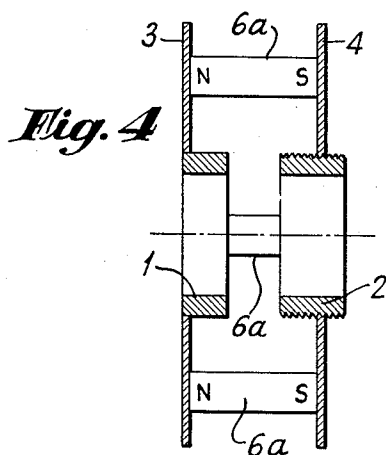
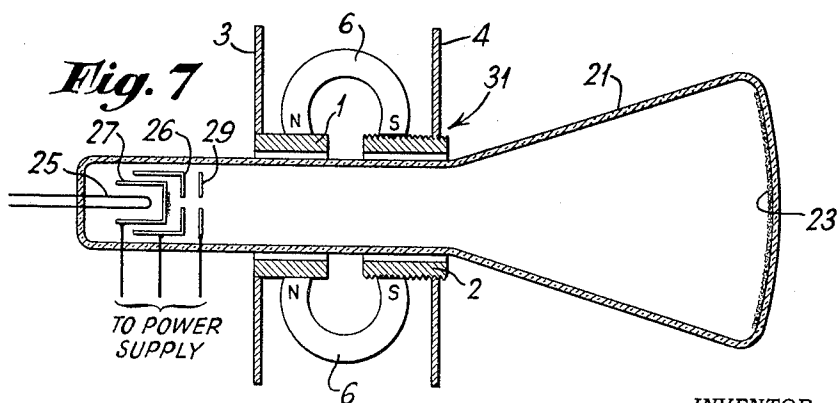
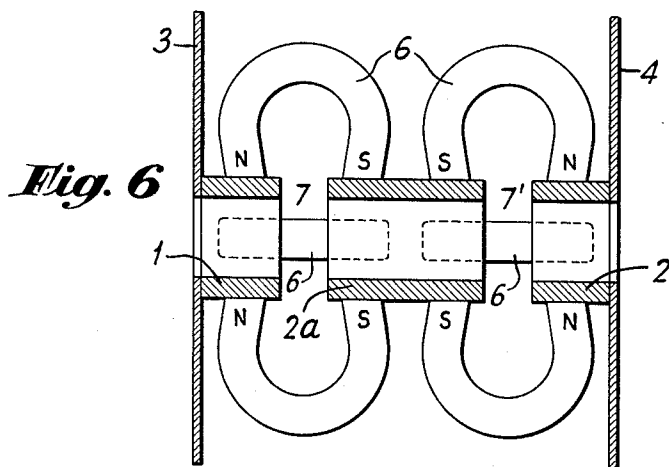
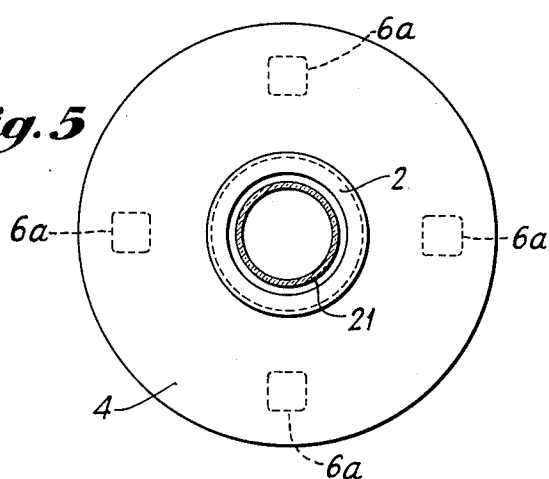


Fig. 5



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PERMANENT MAGNET DEVICE FOR PRODUCING AXIALLY SYMMETRICAL MAGNETIC FIELDS

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7 Claims. (Cl. 250-161)

The present invention relates to permanent magnet devices for producing axially symmetrical magnetic fields and more especially to arrangements which are used to form magnetic electron lenses.

Known permanent magnet devices for setting up magnetic lenses in cathode ray discharge tubes and the like have hitherto usually been constituted by an arrangement of substantially annular members, the field producing member being, in general, an annular permanent magnet with or without pole pieces. Such arrangements have the disadvantage, especially in the case of lenses of large diameter used for focussing composite electron beams, that the ratio of the length of the magnet to its width or cross-sectional area is small and consequently the magnetisation of the magnet becomes weakened or destroyed fairly quickly.

The object of the present invention is to provide a permanent magnet device for setting up a magnetic field more especially for serving as an electron lens in respect of a composite electron beam, the device being so formed that it will retain its magnetism for a long period.

According to the present invention, a permanent magnet device, more especially for setting up a magnetic field for focussing a composite beam of electrons, is provided, said device comprising two pole pieces spaced from each other and each having an aperture through which the electron beam may pass, and a plurality of individual permanent magnets straddling the gap between said pole pieces, like poles of each magnet being associated with one of said pole pieces.

According to one method of carrying the invention into practice the lens field may be formed within a pair of equidiameter co-axially arranged cylindrical pole pieces separated by an air gap. The pole pieces may carry flanges of magnetic material constituting end shields for the field producing arrangement, permanent magnets of bar or horse shoe form being arranged with their ends in contact with either the pole pieces or said flanges, the magnets being symmetrically disposed about the axis of the pole pieces each having a north pole on one pole piece or its flange and a south pole on its other pole piece or its flange. Preferably the air gap between the pole pieces is adjustable.

The nature of the invention and the method of carrying the invention into practice will be more fully understood from the following description with reference by way of example to the accompanying drawings in which:

Figure 1 shows a sectional side elevation of one embodiment of the invention in which horse shoe permanent magnets are used and Figure 2 shows a plan view of the arrangement of Figure 1 with the front flange removed.

Figure 3 shows curves referred to in describing a method of adjusting the arrangement of Figure 1,

Figures 4 and 5 are views corresponding to Figures 1 and 2 of another embodiment of the invention in which bar form permanent magnets are used,

Figure 6 is a view corresponding to Figure 1 of another embodiment of the invention, while Figure 7 shows a cathode ray tube together with the improved focusing means embodying the invention.

Referring to Figures 1 and 2, it will be seen that the arrangement therein shown comprises two cylindrical pole pieces 1 and 2 which may be of magnetic material, for example, soft iron, these pole pieces being supported on or provided with soft iron flanges or shields 3 and 4 respectively between which are mounted horse shoe magnets 6 shown as arranged each with a north pole N resting on pole piece 1 and a south pole S resting on pole piece 2 and straddling the air gap 7 which is formed between the cores 1 and 2. Preferably one of the cores, such as the core 2 as shown, is threaded in its shield such as 4 whereby it can be screwed in or out to adjust the width of the air gap 7. If desired, of course, both cores could be threaded in their shields. In the arrangement shown, four magnets 6 are provided arranged symmetrically about the axis 8 of the cores 1 and 2 but a different number of magnets may be provided if desired. Experiments performed with the arrangements similar to that illustrated in Figures 1 and 2 have shown that as few as three horse shoe magnets about 1 1/4" long produce a sufficiently uniform field to give a substantially round spot on a cathode ray tube for a beam of approximately a quarter of the diameter of the cylindrical pole piece. These magnets will focus a 2000 volt electron beam for an object distance of 8 cms. and image distance of 30 cms. and a gap between the pole pieces of .5 cm. The adjustment of the gap 7 gives a fine control of the strength of the field on the axis and hence the focal length of the electron lens.

Figure 3 shows curves connecting the electron beam voltage and the length of the gap 7 for an arrangement required to have a focal length of 9 cms. curve A corresponding to the case when three magnets 6 are provided, curve B corresponding to the case when four magnets 6 are

provided, curve C corresponding to the case when five magnets are provided and curve D corresponding to the case when six magnets are provided.

- 5 Considerable variation in the shape of the pole pieces 1 and 2 may be made and their radii may not necessarily be the same.

Figures 4 and 5 relate to an embodiment of the invention similar to that shown in Figures 1 and 2 with the exception that bar magnets 6a are used instead of the horse shoe magnets 6. These magnets 6a are connected between the shields 3 and 4 as shown with their north poles N on the shield 3 and their south poles S on the shield 4. In this case the shields 3 and 4 form pole pieces for the magnets 6a, the magnetic circuit of these magnets being completed through the magnets through shield 3, pole piece 1, air gap 7, pole piece 5 and shield 4.

- 20 In a case when a number of small permanent magnets are used symmetrically disposed about the axis of the lens the effect of the soft iron cylinders 1 and the soft iron cylinders 1 and 2 is to smooth out the irregularities of the field produced by the individual magnets. However, the fact that a number of relatively long permanent magnets are employed instead of a single annular member is found to improve the "permanence" of the magnetism in the device.

- 30 If desired, the electron lens formed according to the invention may be provided with a plurality of air gaps such as 7, the arrangement then being analogous to a multiple element lens such as is found in optical systems. For example, a particular arrangement with two air gaps is shown in Figure 6 of the drawings. The arrangement in this case having two pole pieces 1, co-operating with a central pole piece 2a to form gaps 7 and 7'. The arrangement may comprise horse shoe magnets 6 as shown, arranged between two shields or flanges 3 and 4 and, if desired, a central flange or flanges might be provided on the coil 2a for the purpose of affording support to bar magnets such as the magnets 6a of Figure 4, for example, or any other suitable arrangement of magnets may be used.

- In Fig. 7 is shown how the improved magnetic focusing device is used with a cathode ray tube such as one having a screen adapted to luminesce under impact of electrons for example. The cathode ray tube 21 has a luminescent screen 23 positioned on its end wall. Opposite the screen 23 and supported by a stem structure is a heater 25 for heating the electron emitting cathode 27. A cylindrical electrode structure 26 serves to concentrate the emitted electrons while the anode electrode 29 serves to accelerate the concentrated electrons toward the screen 23. The magnetic focusing structure, which may have any of the forms shown in Figs. 1, 2 and 4 through 6, and by way of example the form in Fig. 1 is shown, is positioned concentrically with the neck of the tube 21 and serves to focus the electrons passing therethrough so that they all impact upon the screen 23 in a very small area. It will thus be observed that considerable variation of adjustment is possible so that optimum focusing can be readily obtained.

I claim:

- 70 1. A permanent magnet device for setting up a

magnetic field for focussing a composite beam of electrons, said device comprising two co-axial pole pieces spaced longitudinally from each other and each having an aperture through which the electron beam may pass, and a plurality of individual permanent magnets straddling the gap between said pole pieces, like poles of each of said plurality of magnets being associated with one of said pole pieces.

2. A permanent magnet device according to claim 1 in which at least one of said pole pieces carries a flange of magnetic material serving as an end shield for the device.

3. A permanent magnet device for setting up a magnetic field for focussing a composite beam of electrons, said device comprising two co-axial pole pieces spaced longitudinally from each other and each having an aperture through which the electron beam may pass, and a plurality of individual permanent magnets of substantially horse shoe form straddling the gap between said pole pieces, like poles of each of said plurality of magnets being associated with one of said pole pieces.

4. A permanent magnet device for setting up a magnetic field for focussing a composite beam of electrons, said device comprising two co-axial pole pieces spaced longitudinally from each other and each having an aperture through which the electron beam may pass, ferro-magnetic flanges mounted on said pole pieces, and a plurality of individual permanent magnets of bar form mounted between said flanges and straddling the gap between said pole pieces, like poles of each of said plurality of magnets being secured to the flange of one of said pole pieces.

5. A permanent magnet device for setting up a magnetic field for focussing a composite beam of electrons, said device comprising a plurality of more than two co-axial pole pieces spaced longitudinally from each other, each pole piece having an aperture through which the electron beam may pass and a plurality of individual permanent magnets straddling the gap between each pair of adjacent pole pieces, like poles of each of said plurality of magnets being associated with one of said adjacent pole pieces.

6. A permanent magnet device for setting up a magnetic field for focussing a composite beam of electrons, said device comprising a plurality of co-axial pole pieces spaced longitudinally from each other and each having an aperture through which the electron beam may pass, and at least one of said pole pieces being adjustable, and a plurality of individual permanent magnets straddling the gap between said pole pieces, like poles of each of said plurality of magnets being associated with one of said pole pieces.

7. In combination, means to emit electrons, means to concentrate electrons from the emitting pieces spaced from each other through which the concentrated electrons may pass, a plurality of individual permanent magnets intermediate and in contact with the two pole pieces for focusing the electrons passing through the pole pieces, and an electron sensitive screen positioned to receive the focused beam of electrons.

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