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MAGNETIC DEVICE FOR FOCUSING AN ELECTRON BEAM

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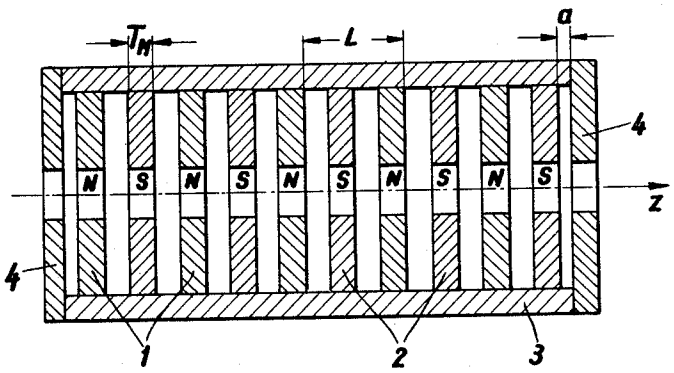


Fig.1

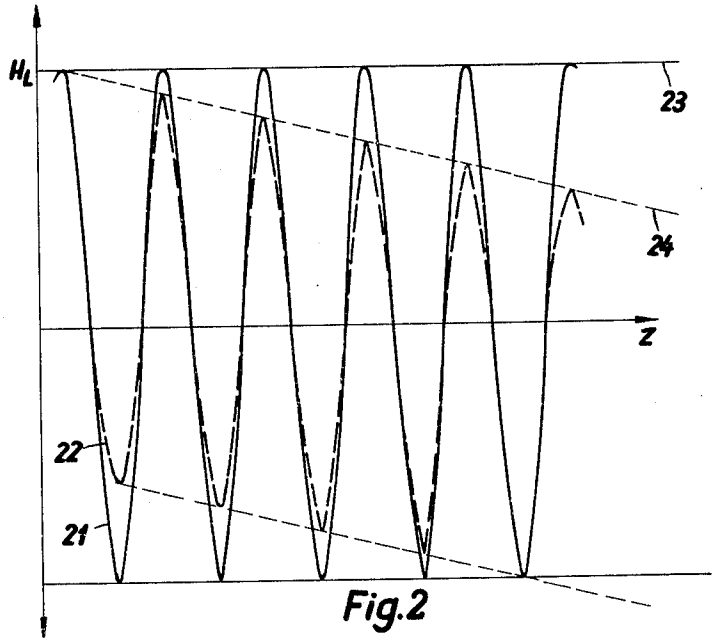


Fig.2

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MAGNETIC DEVICE FOR FOCUSING AN ELECTRON BEAM

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The present invention relates generally to the art of focusing electron beams, and, more particularly, to a permanent magnet arrangement for periodically focusing an electron beam which passes through a vacuum envelope.

Such types of arrangements comprise several rings of permanent magnet material which are disposed with alternately opposite polarity and arranged to be spaced from and coaxial to one another. This type of permanent magnet arrangement is preferably used in traveling wave tubes for guiding the electron beam in a focused manner.

The focusing of electron beams in traveling wave tubes with the aid of periodic permanent magnet arrangements is already known. Such arrangements essentially comprise a series of permanent magnet rings consecutively arranged one after the other and disposed in coaxial arrangement with each other. These rings may be either axially or radially magnetized and the tube is provided in an inner bore formed through the rings which will be subjected to the focusing action. Such types of periodic focusing arrangements having axially magnetized permanent magnetic rings are known wherein pole shoes are provided between the individual rings, and these pole shoes extend to the neck of the tube.

Attempts have been made in the past to arrange the individual permanent magnetic rings within a ferromagnetic cylinder. However, when ferromagnetic cylinders are used in connection with the radially magnetized permanent magnet rings, it is found that irregularities occur. They are found when the plotted course of the field strength measured along the axis is examined. The irregularities are especially noticeable due to the fact that the maximum amplitude values of the field strength curve decrease above the abscissa and increase below the abscissa.

With these defects of the prior art in mind, it is a main object of the present invention to provide a permanent magnet arrangement for periodically focusing electron beams in vacuum envelopes, which avoids the disadvantages of the prior art systems in an extremely simple manner.

It is another object of the present invention to use an arrangement of the type described having radially magnetized magnetic arrangements wherein a substantially uniform curve path of the field strength is provided with substantially the same amplitude height or value being provided over the length of the permanent magnet arrangement.

These objects and other ancillary thereto are accomplished according to preferred embodiments of the invention wherein ferromagnetic annular discs are provided at both ends of a ferromagnetic cylinder in which the magnets of annular or ring shape are disposed.

Another feature of the invention provides a method for determining the axial distance a between the ferromagnetic annular discs and a neighboring permanent magnetic ring, and this is accomplished in accordance with the formula

$$a=\frac{L-2T_M}{4}$$

Where a equals the axial distance between a ferromagnetic annular disc and an adjacent permanent magnet ring,

L is the distance between two successive magnet rings having similar polarity, and this may be considered as the periodic distance, and

T_M is the thickness of the ring magnets in the axial direction of the arrangement.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a longitudinal sectional view through a permanent magnet arrangement of the type comprising the present invention.

FIGURE 2 is a graphical view illustrating the field strength curve produced by the present invention in solid lines and the field strength curve produced by the prior art in dashed lines.

With more particular reference to the drawings, the permanent magnet arrangement of the present invention is illustrated in FIGURE 1. In this drawing a plurality of radially magnetized permanent ring magnets **1** and **2** are provided, these magnets having alternately opposite polarity. The ring magnets **1** are always magnetized with the north pole disposed at the inner circumference and the south pole at the outer circumference, whereas the ring magnets **2**, which are interposed between ring magnets **1**, are magnetized with their south pole at their inner circumference and the north pole at their outer circumference. The periodic distance between two magnetized permanent ring magnets having the same polarity is L and the thickness of the ring magnets in the axial direction is T_M.

The individual permanent ring magnets are disposed within a ferromagnetic cylinder **3** which also may serve as a means for supporting the rings and to which the rings may be mounted. At each end of the cylinder a ferromagnetic annular disc **4** is provided and each is arranged to be substantially coaxial with the permanent ring magnets. The thickness of the ferromagnetic annular discs **4** is advantageously arranged to be the same as that of the wall of the ferromagnetic cylinder **3**. In any event, the thickness of these discs should be such that they are not within the saturation region of the demagnetization curve. These ferromagnetic annular discs **4** effect a considerable uniformity to the amplitude of the magnetic field strength curve path within this magnetic arrangement. Thus, it may be observed that the positive and negative maximum values of the amplitude of the field strength are respectively substantially the same both at the beginning and at the end of the magnetic arrangement.

The distance between a ferromagnetic annular disc **4** and an adjacent permanent ring magnet is designated a in the drawing. As has been observed this distance influences the amplitude curve of the field strength within the magnetic arrangement. The distance a should be arranged to satisfy the relationship

$$a=\frac{L-2T_M}{4}$$

so that the field strength amplitude will be substantially uniform over the entire length of the magnet arrangement.

As illustrated in FIGURE 2, with a permanent magnet arrangement according to the invention the curve path **21** indicated by the solid black line will be provided. In contrast thereto, a permanent magnet arrangement of the type discussed as being part of the prior art is indicated by the dashed line curve **22** and is associated with a device which is not dimensioned as set forth according to the present invention, and particularly an arrangement in which the ferromagnetic discs **4** are not used at all. In curve **22** it may be noted that the positive amplitude on the abscissa decreases as distance z becomes larger, and this is schematically indicated by the inclined dashed line **24**. However, line **23**, which connects the maximum val-

lues of the amplitude of curve **21**, is substantially horizontal and thus provides the arrangement with considerably more advantageous focusing properties.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. In a permanent magnet arrangement for periodically focusing an electron beam in a vacuum envelope, the arrangement being of the type including several radially magnetized permanent ring magnets with consecutive magnets having opposite polarity and disposed coaxially to one another and spaced from each other, and a ferromagnetic cylinder surrounding the outer circumference of the rings, the improvement comprising a ferromagnetic annular disc disposed at each end of the ferromagnetic cylinder.

2. A permanent magnet arrangement for periodically focusing an electron beam in a vacuum envelope, comprising, in combination:

(*a*) a plurality of radially magnetized permanent ring magnets arranged coaxially with one another and being axially spaced from each other, consecutive magnets having opposite polarity;

(*b*) a ferromagnetic cylinder surrounding the outer circumference of said ring magnets; and

(*c*) ferromagnetic annular discs, each disposed at one end of the ferromagnetic cylinder.

3. A permanent magnet arrangement for periodically focusing an electron beam in a vacuum envelope, comprising, in combination:

(*a*) a plurality of radially magnetized permanent ring magnets arranged coaxially with one another and being axially spaced from each other, consecutive magnets having opposite polarity;

(*b*) a ferromagnetic cylinder surrounding the outer circumference of said ring magnets; and

(*c*) ferromagnetic annular discs, each disposed at one end of the ferromagnetic cylinder, and the axial distance of the ferromagnetic annular discs from the adjacent permanent magnet rings being equal to

$$\frac{L-2T_M}{4}$$

where L equals the distance between two successive magnet rings of equal polarity which is the periodic distance, and T_M equals the axial thickness of the ring magnets.

4. An arrangement as defined in claim 2, wherein the thickness of said ferromagnetic annular discs is substantially the same as the thickness of the wall of said ferromagnetic cylinder.

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