Sept. 6, 1966

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3,271,616

FOCUSING SYSTEMS WITH ALTERNATING MAGNETS FOR TRAVELING WAVE TUBES

Filed March 20, 1962

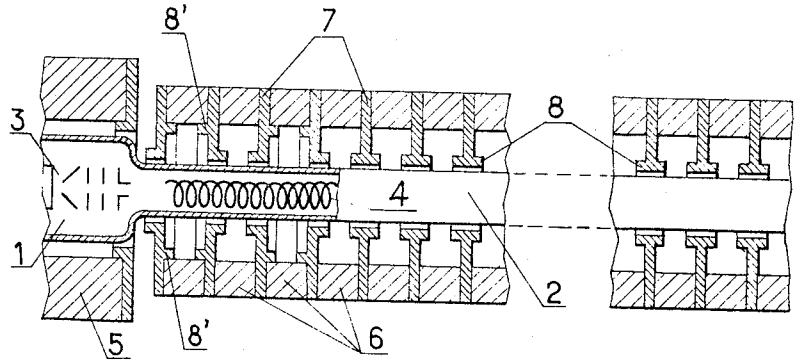


FIG. 1

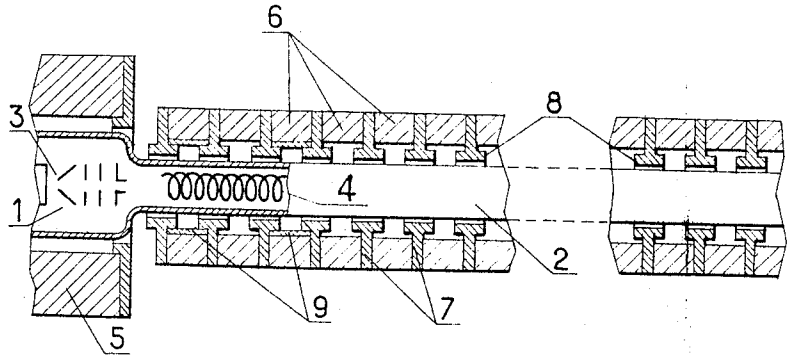


FIG. 2

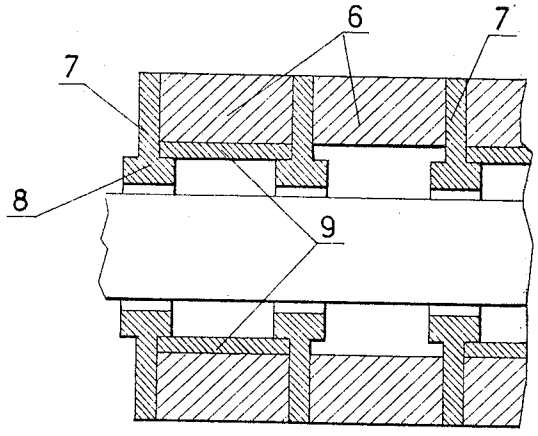


FIG. 3

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3,271,616

Patented Sept. 6, 1966

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FOCUSING SYSTEMS WITH ALTERNATING MAGNETS FOR TRAVELING WAVE TUBES

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Filed Mar. 20, 1962, Ser. No. 181,035
Claims priority, application France, Apr. 4, 1961, 857,631
7 Claims. (Cl. 315—3.5)

The present invention relates to traveling wave tubes and, more particularly, to those traveling wave tubes which are generally referred to as "O-type" tubes, and in which an electron beam issued from an electron gun and coupled to a delay line, constituted most commonly by a helix, is strongly concentrated along the axis of the helix by a magnetic focusing field.

The concentration or focusing of the beam may be realized by different arrangements, and particularly by a system of permanent alternating magnets of annular shape. Such a system comprises a magnet disposed around the portion of the tube containing the electron gun and a series of magnets surrounding the portion of the tube containing the helix, these latter magnets being positioned side by side with alternately opposed polarities in such a manner as to produce fields alternately directed in opposite directions along the axis of the system.

If, in such prior art system, the alternating magnets are all of identical shape from one end to the other within the area of the tube containing the helix, then the field will have larger values in proximity of the electron gun than in the rest of the helix because of the influence of the magnet surrounding the electron gun.

In order to correct this inequality in the distribution of the field, a correcting system has been proposed in U.S. Patent 2,965,782 which consists in connecting to some of the magnets in the vicinity of the electron gun polar pieces different from those connected to the other magnets of the unit or assembly.

This prior art correction, therefore, leads to the use of two different types of pole pieces and, moreover, renders it necessary to leave a large space between the magnets and the tube envelope, which brings about an increase in the volume of the magnets. This is especially true since in order to provide a constant field over the full length of the helix, all of the magnets must be of the same increased diameter even though only the few adjacent the electron gun require special polar pieces.

The present invention aims at an improved system having alternating magnets which enables elimination of the above-mentioned drawbacks while maintaining the correction in question.

According to the present invention, the focusing system with permanent alternating magnets for a traveling wave tube is characterized by the provision of magnetic shunts in the first, third and possibly fifth magnet of the permanent magnets surrounding the delay line formed, for instance, by a helix, and near the electron gun, the said shunts being constituted by ferromagnetic rings which have a relatively low magnetic permeability.

Accordingly, it is an object of the present invention to provide a focusing system for traveling wave tubes which avoids the aforementioned drawbacks and shortcomings encountered with the prior art systems by simple and efficient means.

It is another object of the present invention to provide a focusing system for traveling wave tubes which assures a completely even field distribution of the focusing field along the wave retarding structure by utilizing exclusively pole pieces of a single constructional type.

Still a further object of the present invention resides in the provision of a focusing system for traveling wave

tubes of the O-type utilizing permanent magnets which enables a decrease in the volume of the magnets and therewith a reduction in both bulkiness and weight of the tube assembly.

Another object of the present invention is a focusing system of the type described hereinabove for O-type traveling waves which achieves the aforementioned aims and objects in combination with a substantial simplification of the focusing system itself.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one embodiment in accordance with the present invention contrasted to the prior art, and wherein

FIGURE 1 is a partial longitudinal cross sectional view of a focusing system of the prior art;

FIGURE 2 is a partial longitudinal cross sectional view, similar to FIGURE 1, of an improved focusing system in accordance with the present invention, and

FIGURE 3 is a partial longitudinal cross sectional view, on an enlarged scale and illustrating certain details of FIGURE 2.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate corresponding parts, and more particularly to FIGURE 1 which shows a traveling wave tube focused by a known system of permanent alternating magnets, reference numerals **1** and **2** designate therein two portions of the tube, of which the former contains the electron gun **3** and the latter a helix or other known delay line **4**, and which are surrounded, respectively, by a magnet **5** and by a series of magnets **6**.

All of these magnets, of cylindrical form, are magnetized in a direction parallel to the axis of the tube, but magnets **6** are disposed in alternate senses, i.e., in opposite polarities: NS, SN, NS, etc. . . .

Between adjacent magnets and at the extremities of the assembly of magnets **6**, there are disposed pole pieces **7** in the form of crowns made of soft iron and provided on their two faces with annular shoulders or rings **8**.

The rings **8** are identical on all the pole pieces except for the first and third magnets starting from the electron gun where rings **8'** have a diameter larger than that of the other rings **8**.

This difference in the pole pieces has as purpose to compensate for the effect of the proximity of magnet **5**, which increases the field in that area, by the diminution of the fields produced by the first and third magnets.

When the pole pieces are correctly dimensioned, a field will thus be obtained by such prior art arrangement which has an identical distribution along the entire helix.

The same correction or compensation is obtained, according to the present invention, in an improved manner with the different arrangement illustrated in FIGURE 2.

The system shown in FIGURE 2 comprises alternating magnets **6**, as does that of FIGURE 1, but in FIGURE 2, the pole pieces **7** are all identical, as are also rings **8**. In contrast thereto, the first and third magnets, starting from the electron gun, are provided with magnetic shunts placed between the magnets and the rings of the pole pieces and constituted by cylindrical elements or sleeves **9** made of nickel or other metal alloy having a relatively low magnetic permeability.

A magnetic shunt may also be connected to the fifth magnet, but experience has shown that a completely sufficient correction is obtained in practice already with two correctly dimensioned shunts.

FIGURE 3 shows the alternating magnets in accordance with the present invention near the electron gun on an enlarged scale.

It is apparent that the system according to the present invention, as shown in FIGURE 2, utilizes magnets having a smaller diameter than the known prior art system of FIGURE 1, from which results reduced bulkiness and economy in the weight of the assembly. Additionally, the use of pole pieces of only a single type is a considerable simplification, as will be readily appreciated.

While I have shown and described one embodiment in accordance with the present invention, it is understood that the same is not limited thereto, but is susceptible of many changes and modifications within the spirit and scope thereof as known to a person skilled in the art, and I therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. An O-type traveling wave tube, comprising:
an elongated, substantially cylindrical envelope,
electron gun means located within a first portion of said envelope;
a wave retarding structure located within a second portion of said envelope substantially adjacent said first portion;
and a focussing system for said tube including a substantially permanent magnet within the area of and surrounding said first portion, a series of substantially identical annular permanent magnets, of alternately opposite polarities, within the area of and surrounding said second portion, pole pieces arranged between adjacent permanent magnets, and a flux-carrying element, disposed on the first and third permanent magnet of said series near said electron gun means interconnecting the pole pieces thereof.

2. An O-type traveling wave tube, comprising:
an elongated, substantially cylindrical envelope,
electron gun means located within a first portion of said envelope;
a wave retarding structure located within a second portion of said envelope substantially adjacent said first portion;
and a focusing system for said tube including a substantially annular permanent magnet within the area of and surrounding said first portion, a series of substantially identical annular permanent magnets, of alternately opposite polarities, within the area of and surrounding said second portion, and magnetic shunt means, disposed on the first and third permanent magnet of said series near said electron gun means, said shunt means being constituted by ferromagnetic rings having a relatively low magnetic permeability.

3. An O-type traveling wave tube, comprising:
an elongated, substantially cylindrical envelope;
electron gun means located within a first portion of said envelope;
a wave retarding structure located within a second portion of said envelope substantially adjacent said first portion;
and a focusing system for said tube including a substantially annular permanent magnet within the area of and surrounding said first portion, a series of substantially identical annular permanent magnets, of alternately opposite polarities, within the area of and surrounding said second portion, and magnetic shunt means, disposed on the first and third permanent magnet of said series near said electron gun means, said shunt means being constituted by ferromagnetic rings made of nickel and having a relatively low magnetic permeability.

4. An O-type traveling wave tube, comprising:
an elongated, substantially cylindrical envelope;

electron gun means located within a first portion of said envelope;
a wave retarding structure located within a second portion of said envelope substantially adjacent said first portion;
and a focusing system for said tube including a substantially annular permanent magnet within the area of and surrounding said first portion, a series of substantially identical annular permanent magnets, of alternately opposite polarities, within the area of and surrounding said second portion, pole pieces arranged between adjacent permanent magnets, and a flux-carrying element, disposed on the first and third as well as on the fifth permanent magnet of said series near said electron gun means interconnecting the pole pieces thereof.

5. An O-type traveling wave tube, comprising:
an elongated, substantially cylindrical envelope;
electron gun means located within a first portion of said envelope;
a wave retarding structure located within a second portion of said envelope substantially adjacent said first portion;
and a focusing system for said tube including a substantially annular permanent magnet within the area of and surrounding said first portion, a series of substantially identical annular permanent magnets, of alternately opposite polarities, within the area of and surrounding said second portion, and magnetic shunt means, disposed on the first and third as well as on the fifth permanent magnet of said series near said electron gun means, said shunt means being constituted by ferromagnetic rings made of nickel and having a relatively low magnetic permeability.

6. For a traveling wave tube having electron gun means including a permanent magnet disposed thereabout, a focusing system comprising a plurality of permanent alternating magnets surrounding the wave retarding structure of traveling wave tube and pole pieces arranged between adjacent permanent magnets, comprising magnetic shunt means disposed solely on the first and third of said magnets disposed near the end of the wave retarding structure adjoining the electron gun of the traveling wave tube between the pole pieces thereof, said shunt means being constituted by ferromagnetic rings having a relatively low magnetic permeability.

7. A focusing system for traveling wave tubes, especially O-type traveling wave tubes, having electron gun means and a wave retarding structure, comprising a series of permanent magnet means disposed along said wave retarding structure, and further magnet means within the area of said electron gun means and normally affecting the field distribution of said series of permanent magnet means, said permanent magnet means including pole piece structures exclusively of identical structure and correcting means effectively formed by magnetic shunts essentially consisting of annular members made of a material having relatively low permeability and operatively associated with some of the pole piece structures near said further magnet means for compensating for the effect thereof on the field distribution of said permanent magnet means so as to render said field distribution substantially uniform.

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