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MAGNETIC FOCUSING SYSTEMS FOR TRAVELLING WAVE TUBES

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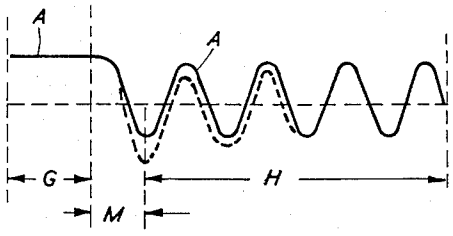


FIG. 1.

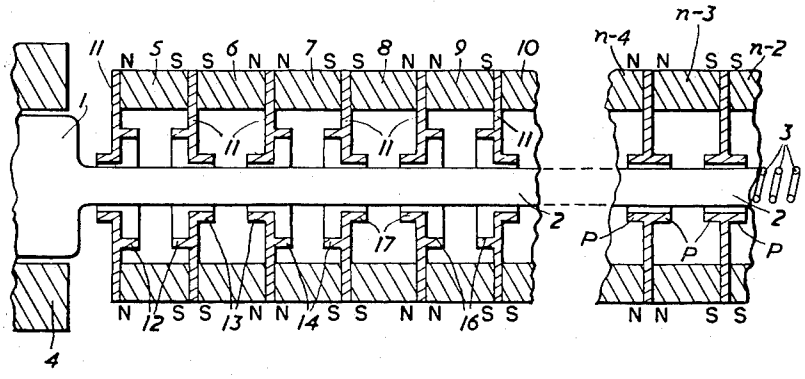


FIG. 2.

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# MAGNETIC FOCUSING SYSTEMS FOR TRAVELLING WAVE TUBES

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5 Claims. (Cl. 313—84)

This invention relates to magnetic focusing systems for travelling wave tubes and more specifically to magnetic focusing systems of the kind including so-called periodic magnetic field generating means operative over the delay line portion of the tube.

A stringent requirement with travelling wave tubes, and in particular with low noise travelling wave tubes, is that the electron beam from the gun shall be accurately focused to travel in the required manner along the delay line which is usually, though not necessarily, a helix. One well known magnetic focusing system for this purpose comprises means for producing a substantially constant, spatially uniform, magnetic field over the electron gun region of the tube and means for producing a substantially constant so-called periodic magnetic field over the delay line region of the tube. The periodic magnetic field referred to is periodic in the sense that it is spatially alternating, i.e. being first in one direction, than in the opposite direction and then in the said one direction . . . and so on, along the length of the delay line.

The object of my invention is to provide a method and apparatus for compensating for the leakage field due to a magnet surrounding the gun structure of a travelling wave tube.

Another object of my invention is to provide a novel assembly of magnets for a magnetic focusing system in a travelling wave tube.

Other and further objects of my invention reside in the arrangement of pairs of magnetic pole pieces in association with the delay line region of a travelling wave tube as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Fig. 1 is a theoretical diagram showing the distribution of a magnetic field in a travelling wave tube required for securing correct focusing; and

Fig. 2 is a cross sectional view showing the manner of assembling pairs of pole pieces in a travelling wave tube for obtaining compensation for the leakage field due to a magnet surrounding the gun structure of the travelling wave tube.

The full line curve A of Fig. 1 of the accompanying drawings shows in conventional graphical manner the nature of the magnetic fields required to be obtained in order to produce correct focusing. The field over the electron gun region of the tube, which is the region indicated by the reference G, is spatially uniform and the field over the delay line region of the tube, which is the region H, is periodic, i.e. spatially alternating. The uniform field line is caused to merge smoothly into the periodic field line by providing a suitable so-called matching field over the region marked M. In accordance with known practice and taking as an example the usual case of a tube with a helical delay line down which the electron beam is axially projected, the periodic field is produced by a sequence of successively oppositely directed ring permanent magnets each having a pair of pole pieces which axially encircle the delay line portion of an inserted tube, all the pole pieces being similar and all the magnets being similar so that the said magnets with their pole pieces will, if acting alone, produce fields as shown by curve A in Fig. 1 for the region marked H. In practice, however, the magnetic system employed to produce the uniform field over the region G of Fig. 1 will have substantial leakage and this affects the field produced over a portion of the delay line region near the gun region. The result is shown in Fig. 1 by the broken line curve over a portion of the region H near the matching region M. The leakage field from the magnetic system provided for producing the uniform field for the region G causes the full line sinusoidal curve to degrade into something like the distorted curve shown in broken lines, with consequent serious deterioration of the focusing. The object of the present invention is to avoid this defect in a simple and practically convenient manner.



According to this invention a magnetic focusing system for a travelling wave tube includes means for producing a substantially constant spatially uniform magnetic field over the electron gun region of the tube and means for producing a substantially constant spatially alternating magnetic field over the delay line region of the tube, the last mentioned means comprising a sequence of permanent magnets, successive pairs of which, over a portion of said delay line region adjacent said gun region, have fields of different strengths whereby the effect of leakage field from said first mentioned means into said portion is substantially compensated for.

According to a feature of this invention a magnetic focusing system for a travelling wave tube includes a permanent magnet positioned to produce a substantially uniform field axially threading an inserted travelling wave tube over the electron gun region thereof, and a sequence of successively oppositely directed permanent magnets each having a pair of pole pieces positioned axially to encircle the delay line region of said inserted tube, successive pairs of said pole pieces over a portion of said delay line region adjacent said gun region being of different diameters such that the effect of leakage field from the first mentioned permanent magnet into said portion is substantially compensated for.

In a preferred construction the permanent magnet producing the substantially uniform field is a ring magnet positioned axially to encircle the electron gun region of an inserted tube, and the magnets of the sequence of oppositely directed permanent magnets are also ring magnets which are in line with one another and encircle the delay line region of said inserted tube, pole piece supporting members being interposed between the successive ring members of said sequence. Preferably there is only one pole piece supporting member between each successive pair of the magnets of said sequence, said member being formed to have two annular pole pieces, one on one side thereof and the other on the other, one being a pole piece appropriate to one magnet and the other being a pole piece appropriate to the next magnet.

Theoretically the diameters of the pairs of pole pieces should be graded over the portion of the delay line region near the gun region but a practically sufficiently close approximation to the theoretical ideal can be achieved by making alternate pairs of pole pieces (over the said portion of the delay line region) of one diameter and the other alternate pairs of pole pieces of a different diameter and it is preferred to do this for obvious reasons of manufacturing economy.

The invention is illustrated in Fig. 2 of the accompanying drawings which shows in schematic cross section, and so far as is necessary to an understanding of the invention, a preferred embodiment thereof.

Referring to Fig. 2, this shows a low noise travelling wave tube of well known type employing a helical delay line, the tube being shown inserted in position in a magnetic focusing system in accordance with this invention. The tube is shown broken away at both ends and intermediately and is represented in the main merely by its envelope, though three turns of the helical delay line are shown at the broken away final electrode end of the tube. The tube itself, which forms no part of this invention, is of well known construction and has an envelope with an enlarged diameter portion 1 at one end continuing into a smaller diameter elongated portion 2 for the rest of its length. Within the envelope portion 1 is an electron gun (not shown) adapted and arranged to project a fine beam of electrons axially down the helical delay line 3 towards the usual final electrode system (also not shown). The delay line 3 of course extends over nearly the whole length of the small diameter portion of the tube envelope though, so as not to complicate the drawing, only three turns of it are actually shown.

The axial spatially uniform magnetic field required over the gun region of the tube, as represented at G in Fig. 1, is produced by a ring permanent magnet 4 magnetized to have opposite poles at its two ends. The spatially alternating magnetic field required over the delay line region of the tube is produced by a sequence of ring permanent magnets 5, 6, 7, 8, 9, 10 . . . *n*–4, *n*–3, *n*–2 . . . each of which is magnetized to have opposite poles at its two ends, the succesisve ring magnets in this sequence being oppositely directed, i.e. there are, successively, north poles together, then south poles together, then north poles together . . . and so on. Between each successive pair of this sequence of ring magnets and also at the far ends of the sequence are pole-piece supporting members 11 of suitable soft ferromagnetic material and each formed integrally with two oppositely directed annular pole pieces. Thus each pole piece supporting member which is between two ring magnets of the sequence has two pole pieces, one of which is a pole piece appropriate to one of two successive magnets and the other of which is a pole piece appropriate to the next of said two successive magnets. In magnetic focusing systems in accordance with known practice, all the pole pieces would be alike, i.e. as shown in the broken away portion of Fig. 2 at the right hand end of that figure. In accordance with this invention, however, successive pairs of pole pieces are of different sizes over a portion of the delay line region H (Fig. 1) of the tube near the gun region G. As shown in Fig. 2 the pair of pole pieces 12 appropriate to the magnet 5 are of larger diameter than the pair of pole pieces 13 appropriate to the maget 6. The pole pieces 14 and 16 are of the same diameter as the pole pieces 12 while the pole pieces 17 are of the same diameter as the pole pieces 13. The different pole piece diameters are chosen in accordance with known principles to compensate for the effect of leakage field from the magnet 4 in the portion of the delay line region of the tube which is affected by that leakage field. Over the remainder of the delay line region of the tube, i.e. over that portion of the region which is in any event not reached by any substantial leakage field from the magnet 4, the pole pieces are in accordance with usual present day practice, i.e. they are all alike, as shown for the pole pieces marked P associated with the magnets *n*–4, *n*–3 and *n*–2.



Theoretically the diameters of the pole pieces over the portion of the delay line region of the tube affected by leakage field from the magnet 4 should be graded, i.e. the pairs of pole pieces 12, 14 and 16 should be of progressively reducing diameters and the pairs of pole pieces 13, 17 of progressively increasing diameters, such grading being continued until, at the end of the portion of the delay line region affected by the leakage field from the magnet 4, the progressively decreased diameters and the progressively increased diameters have both reached the same value. Such grading, however, is obviously fairly expensive and experiment has shown that a sufficiently close approximation to the theoretical ideal can be achieved by an arrangement as shown in which the pairs of pole pieces over that portion of the delay line region affected by leakage field from the magnet 4 are all of one or other of two different diameters.

In the drawing the first pole piece supporting member is identical with the next one and has a pole piece on each face. Obviously, however, the small diameter pole piece which is on the said first pole piece supporting member and which projects towards the electron gun region of the tube is unnecessary, it being provided in the illustrated arrangement only because of the convenience of using a standardised form of pole piece supporting member.

In the drawing, no means are shown for providing a matching field over the space M. Such means as known per se may be provided if required, but in general a separate matching field source will not be required and the magnetic system producing the periodic field may be so designed that good matching is obtained between the field of the magnet 4 and the field at the adjacent end of the periodic magnetic system. Such matching can be obtained by choosing the diameter of the pole piece 12 immediately adjacent the magnet 4 to strengthen the field due to the magnet 5 to the known required value and obtaining the correct value for distance M by suitable choice of the diameter of magnet 4.

I claim:

1. A magnetic focusing system for a travelling wave tube including an electron gun region and a delay line region, a permanent magnet encircling said gun region to produce a substantially uniform field axially threading an inserted travelling wave tube over the electron gun region thereof, a sequence of successively oppositely directed annular permanent magnets, of substantially uniform dimensions, pole pieces arranged between each pair of magnets, said pole pieces being positioned axially to encircle the delay line region of said inserted tube, successive pairs of said pole pieces over a portion of said delay line region adjacent said gun region being of different diameters such that the effect of leakage field from the first mentioned permanent magnet into said portion of the delay line is subsantially compensated for.

2. A system as claimed in claim 1 wherein the substantially uniform field is produced by an annular magnet positioned axially to encircle the electron gun region of an inserted tube, and the magnets of the sequence of oppositely directed permanent magnets are also annular magnets which are in line with one another and encircle the delay line region of said inserted tube, pole piece supporting members being interposed between the successive annular members of said sequence.

3. A system as claimed in claim 1 wherein there is only one pole piece supporting member between each successive pair of the magnets of said sequence, said member being formed to have two annular pole pieces, one on one side thereof and the other on the other side thereof, one being a pole piece appropriate to one magnet and the other being a pole piece appropriate to the next adjacent magnet.

4. A system as claimed in claim 1 wherein the diameters of the pairs of pole pieces are graded over the portion of the delay line region near the gun region of an inserted tube.

5. A system as claimed in claim 1 wherein alternate pairs of pole pieces over the portion of the delay line region near the gun region of an inserted tube are made of one diameter and the other alternate pairs of pole pieces over said portion of the delay line region are made of another, different diameter.



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