Nov. 3, 1964 K. M. POOLE 3,155,866

MAGNETIC FOCUSING STRUCTURE FOR TRAVELING WAVE TUBES

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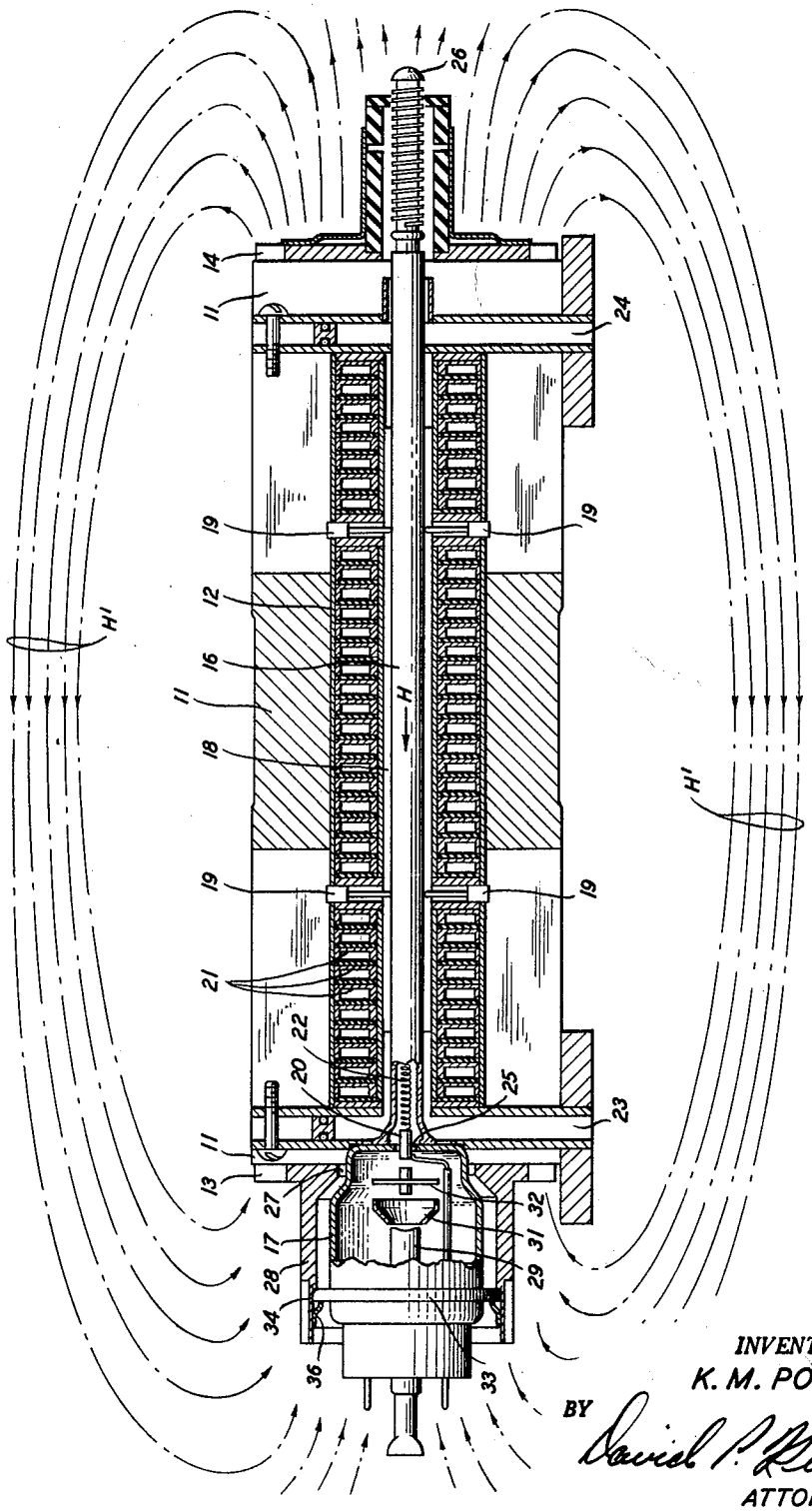
FIG. 1



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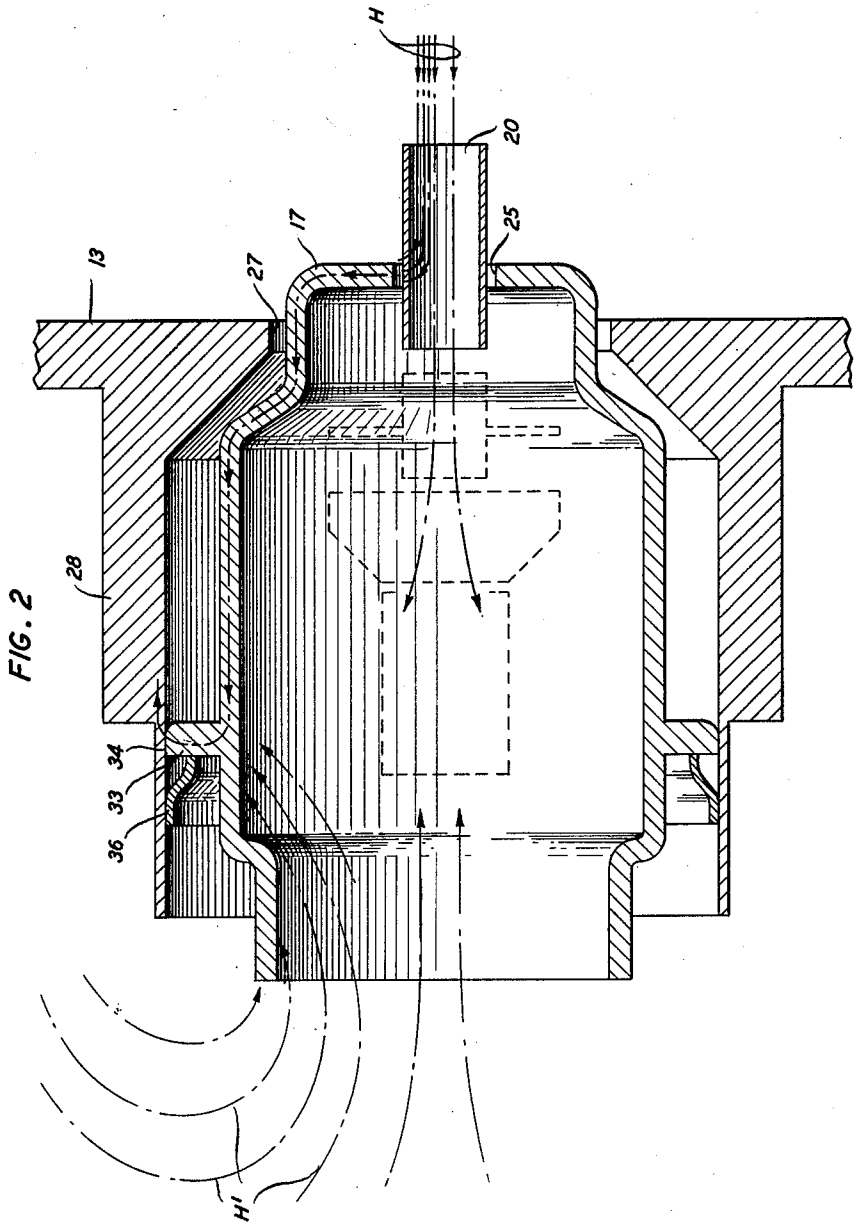

FIG. 2

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MAGNETIC FOCUSING STRUCTURE FOR TRAVELING WAVE TUBES

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This invention relates to traveling wave tubes and, more particularly, to a magnetic electron beam focusing arrangement for such tubes.

In a copending application of C. C. Cutler, Serial No. 168,202, filed June 15, 1950, now U.S. Patent No. 3,005,126, issued October 17, 1961, there is described a beam focusing arrangement for traveling wave tubes wherein the electron beam is first formed in a region free of magnetic flux, and then is made to encounter abruptly a magnetic field having radially directed flux which imparts a spin to the electrons in the beam. The beam thereafter is immersed in a longitudinal magnetic field. Such a focusing arrangement has several advantages. For example, where a high density electron beam is desirable, the above-described system permits the use of much smaller magnetic field than the ordinary confined flow type of focusing. This, in turn, means that less magnet weight is required to focus a beam of a given current density. A reduction in magnet weight is always desirable, for economic reasons as well as for reasons of space and portability. In the case of airborne or space applications, however, a minimum magnet weight is an absolute necessity.

In the aforementioned and similar focusing systems, ideally the electron gun is completely shielded from the magnetic field. In practice, however, some stray magnetic flux enters the electron gun region through the stem end of the traveling wave where there is no magnetic shield. This stray magnetic flux, the direction of which is counter to that of the main focusing field, produces undesirable perturbations in the beam which tend to degrade the focusing and reduce the usable beam current density. Much of the stray flux may be eliminated by the use of additional shielding; however, additional shielding means increased weight, which, as pointed out in the foregoing, is intolerable in airborne and space applications.

It is an object of this invention to eliminate the deleterious effects of stray magnetic flux in the gun region of a shielded gun type focusing system.

It is another object of this invention to eliminate the effects of such stray magnetic flux with no increase in the weight of the focusing system.

These and other objects of the present invention are achieved in an illustrative embodiment thereof which comprises an elongated, permanent magnet having a longitudinally extending centrally located bore for establishing a longitudinal magnetic focusing field in the bore. At each end of the magnet is an apertured pole-piece. A traveling wave tube is mounted within the bore of the permanent magnet with the cathode end of the tube situated outside of the magnetic structure. A magnetic shielding member extending from the pole-piece adjacent the cathode end of the tube surrounds the cathode end and, as taught in the aforementioned Cutler application, acts to shield the electron gun from the magnetic field. The portion of the tube envelope which surrounds the electron gun, hereinafter referred to as the "bulb," is made of a material of high permeability and is situated within the aperture of the adjacent magnetic pole-piece and extends outward therefrom, being surrounded by the magnetic shield.

It is one feature of the present invention that the outer diameter of that portion of the bulb which is located within the aperture in the pole-piece is smaller than the diameter of the pole-piece aperture so that there is provided between the pole-piece and the bulb an air gap forming a high reluctance path for the magnetic flux.

It is another feature of the present invention that the bulb has an integral external flange remote from the portion located within the pole-piece, the periphery of the flange being a slip fit within the magnetic shield whereby there is formed a low reluctance path for the magnetic flux.

These and other features of the present invention will be more readily apparent from the following detailed description, in conjunction with the accompanying drawings, in which:

FIG. 1 is a sectioned view of a traveling wave tube and focusing magnetic assembly embodying the principles of the present invention; and

FIG. 2 is a diagrammatic view of the electron gun region of the tube of FIG. 1.

Turning now to FIG. 1, there is shown in section a traveling wave tube and magnet assembly embodying the principles of the present invention. The assembly comprises a permanent magnet 11 having a longitudinally extending, centrally located bore 12. At either end of the magnet 11 are apertured pole-pieces 13 and 14. A traveling wave tube 16 having a bulb portion 17 of Kovar or other suitable material having high magnetic permeability and an elongated envelope portion 18 of glass is mounted in the magnet assembly with the glass portion 18 extending through the bore 12. A plurality of pins 19 serve to fix the envelope portion 18 centrally within the bore.

Between the envelope portion 18 and the wall of bore 12 are a plurality of magnetic field straighteners 21 which are advantageously of the type disclosed and claimed in United States Patent 2,942,141 of C. C. Cutler. As is explained in that patent, the field straighteners 21 act to minimize transverse components of the magnetic field, which produce undesirable perturbation of the electron beam.

Within the envelope portion 18 of tube 16 is a slow wave circuit 22. As shown here circuit 22 is a helix, but it may take any one of a number of forms known to workers in the art. A helix connector 20 is located within an aperture 25 in bulb 17 and enables the application of a voltage to circuit 22. Energy to be amplified is applied to circuit 22 by means of an input wave guide 23, and amplified energy is abstracted by means of an output wave guide 24. The electron beam, after passage through the circuit 22, is collected by a collector 26 in a manner well known in the art.

Pole-piece 13 has an aperture 27 within which is located a portion of the bulb 17. In accordance with the present invention and for reasons which will be discussed more fully hereinafter, the diameter of aperture 27 is made larger than the other diameter of that portion of bulb 17 within the aperture. A magnetic shield 28 extends from pole-piece 13 and surrounds bulb 17 over a major portion of its length.

Within bulb 17 are mounted an electron emissive cathode 29, a beam forming electrode 31, and an accelerating anode 32 which coact to produce an electron beam. For clarity, the mounting arrangement and electrical leads to these elements have been omitted, and it is to be understood that they may take any one of a number of forms well known in the art. In accordance with the present invention, bulb 17 has formed thereon a flange 33 having a machined surface 34 the diameter of which is such as to form a slip fit with the inside diameter of shield 28. A plurality of tabs 36, which are welded to shield 28 bear against flange 33 and act to prevent translational movement of the tube 16.

When the magnet 11 and the tube 16 are assembled, magnet 11 produces an axial magnetic focusing field within tube 16, as indicated by the arrow H. In addition, an external magnetic field, as indicated by the arrows H', is also produced. Because the shield 28 is open at its end, some of this external field H' enters the stem end of tube 16 and threads the cathode, tending to produce undesirable perturbations in the beam.

For an understanding of the present invention and how it counteracts the effect of the field H' in the cathode region, reference should now be made to FIG. 2. In FIG. 2, the relationship of pole-piece 13 and bulb 17 in accordance with the present invention is shown. For clarity, the various electrodes of the electron gun have been omitted, although the outline of the cathode 29 is shown in dotted lines. As is readily apparent from FIG. 2, the magnetic focusing field H passes into connector 20 and then into bulb 17, which, as was pointed out heretofore, is of a material of high permeability such as Kovar. With such an arrangement, the requisite radial components of magnetic flux for producing a spiraling motion to the electrons, as taught in the aforementioned Cutler application, is produced. Because the diameter of aperture 27 in pole-piece 13 is greater than the diameter of that portion of bulb 17 within the aperture, a high reluctance air gap is produced and the flux H, instead of crossing this air gap, passes through the bulb 17 to the flange 33 where a low reluctance path is formed between machined surface 34 and shield 28. Because the low reluctance path is toward the end of cathode 29 remote from its emissive surface, a portion of the flux H tends to pass through the cathode region, as indicated by the arrows, instead of, as in the case of prior art devices, passing directly to pole-piece 13. This portion of flux H which passes through the cathode region is opposite in direction to the stray flux H' in the cathode region, as seen by the arrows in FIG. 2, and tends to buck it out. By proper choice of materials and dimensions, such as the size of the air gap formed in aperture 27, the amount of flux H in the cathode region can be made sufficient to cancel the flux H' in the cathode region so that the electron beam in fact remains unaffected by any magnetic field, until it encounters the radial field in connector 20. In practice it has been found that with the arrangement of the present invention, as discussed in the foregoing, the advantages of the focusing arrangement of the aforementioned Cutler application are fully realized without the necessity of additional shielding or more complicated structure and the attendant, highly undesirable, increase in weight.

It is to be understood that the foregoing illustrative

embodiment is for the purpose of illustrating the principles of the present invention only. Other embodiments of these principles may readily occur to workers in the art without departing from the spirit and scope of the present invention.

What is claimed is:

1. In combination a traveling wave tube and a focusing structure therefor, said traveling wave tube having a cathode having an electron emissive surface and an envelope comprising an elongated portion and a bulb portion of magnetic material surrounding the cathode, said focusing structure comprising magnet means and pole-pieces for producing a magnetic focusing field axially of said elongated portion of said envelope and a magnetic shield member extending from one of said pole-pieces and surrounding said bulb portion over at least a portion of its length, and means for establishing a low reluctance flux path between said bulb and said shield comprising a flange on said bulb remote from the emissive surface of said cathode, said flange being in contact with said shield.

2. In combination a traveling wave tube and a focusing structure therefor, said traveling wave tube having a cathode having an electron emissive surface and an envelope comprising an elongated portion and a bulb portion surrounding the cathode, said focusing structure comprising magnet means coextensive with said elongated portion of said envelope and apertured pole-pieces at either end of said magnet means for producing a magnetic focusing field axially of said elongated portion, a magnetic shield member extending from one of said pole-pieces adjacent said bulb portion and surrounding said bulb portion over at least a portion of its length, the aperture in said one pole-piece being of greater diameter than that portion of the bulb adjacent said pole-piece whereby a high reluctance air gap is formed between said pole-piece and said bulb, and means establishing a low reluctance flux path between said bulb and said shield comprising a portion of said bulb remote from the emissive surface of said cathode in contact with said shield.

3. The combination as claimed in claim 2, wherein said bulb portion is of magnetic material.

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