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ADJUSTABLE PERMANENT MAGNET FOCUSING ARRAY

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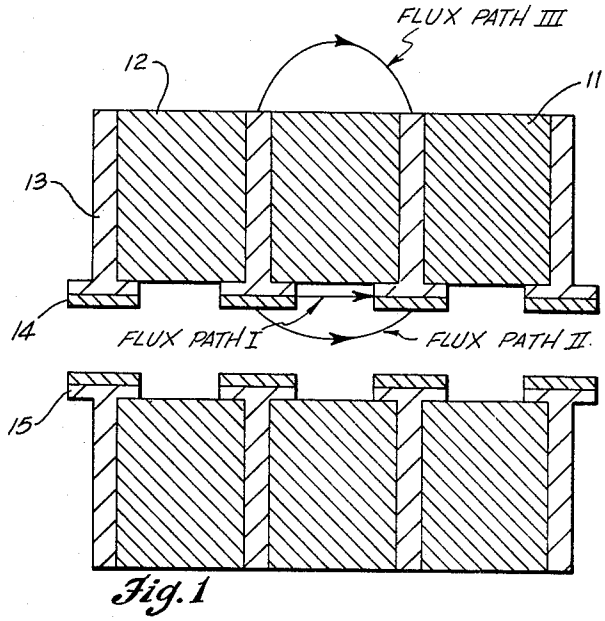


Fig. 1

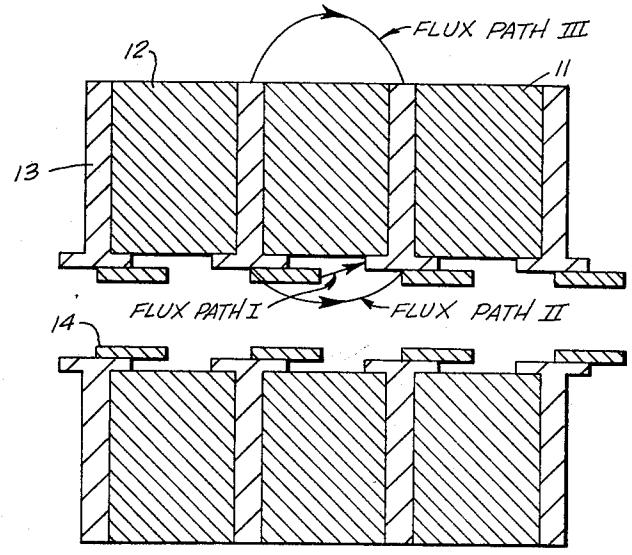


Fig. 2

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ADJUSTABLE PERMANENT MAGNET FOCUSING ARRAY

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The present invention relates to the periodic permanent magnet focusing of a traveling wave tube, and more particularly to a permanent magnet array or stack which can be adjustable.

A traveling wave tube, often referred to as a TWT consists of a structure for producing an electron beam which traverses the tube; a transmission line often referred to as the slow wave structure which propagates a microwave signal in a manner permitting interaction between the electron beam and the signal; a collector for removing unused beam energy, transducers for introducing and removing this signal; and an attenuator which isolates the input and output sections of the slow wave structure to prevent oscillations. The structure for producing the electron beam is comprised of an electron source in the form of a cathode and one or more anodes or grids which control, guide and direct the electron beam. The slow wave structure may take the form of a helix or resonant cavities, or other means may be used to permit interaction between the beam and the signal.

The electron beam in the tube may be confined magnetically by employing a sinusoidally varying magnetic field. TWTs of this type, because of their field pattern are usually referred to as periodically focused traveling wave tubes. The magnetic structure itself is usually called a periodic TWT array or stack.

The introducing to periodic field focusing of low voltage electron beams was made by J. R. Pierce, "Spacially Alternating Magnetic Felds for Focusing Low Voltage Electron Beams," Journal of Applied Physics, volume 24, page 1247, 1953. Later, Mandel Quate, and Yocum published the results of their work "Electron Beam Focusing with Periodic Permanent Magnet Fields," Proceedings IRE, volume 42 page 800, 1954. Still later, the design of periodically focused TWT arrays or stacks was described by Kern K. N. Chang, in an article entitled "Optimum Design of Periodic Magnetic Structures for Electron Beam Focusing" R.C.A. Review, volume 16, page 65, 1955. These articles as well as later patents and publications explain the disposition of the magnets as well as the means required to design the periodically varying magnetic structure. The described structures include a plurality of ring shaped magnets and pole pieces so disposed that adjacent poles of magnets are of the same polarity, i.e., North-South; adjacent South-North; adjacent North-South etc. The axial field of the magnetic structure is made to coincide with the axis of the slow wave structure, i.e., the helix of the TWT. In the ferrite permanent magnets of the type used in periodic magnetic focusing arrays for TWTs the amount of flux developed is a function of the magnetic material. The direction in which the flux travels outside of the material is a function of the external permeance or magnetic circuits. This is a relatively fixed thing, varying of course with ambient conditions. In the tubes presently in use, it is not possible to adust the field strength of the stack; and yet, this is a highly desirable feature as the same stack may be used with several tubes and the field strength should coincide with that needed to focus the TWT. Although many attempts were made to overcome the foregoing difficulties so as to provide a stack which could be adjustable, none, as far as I am aware were completely

satisfactory from the operational viewpoint when put into practice commercially or on an industrial scale.

Thus, the object of the present invention is to provide an adjustable permanent magnet stack for use with a TWT.

With the foregoing and other objects in view, the invention resides in the novel arrangement and combination of parts and in the details of construction hereinafter described and claimed, it being understood that changes in the precise embodiment of the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

The accompanying drawings, illustrative of one embodiment of the invention, together with the description of their construction and the method of operation and utilization thereof, will serve to clarify further objects of my invention. Other advantages will become apparent from the following description taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a longitudinal cross-sectional view of a portion of a periodic array contemplated herein; and,

FIGURE 2 shows a view similar to FIGURE 1 illustrating the adjustability of the contemplated periodic array.

Looking first at FIGURE 1, there is seen a stack or array **11** having a plurality of ring shaped magnets **12** and iron pole pieces **13**. The magnets are disposed as hereinbefore mentioned, i.e., adjacent poles of the magnet are of the same polarity. Forgetting for the moment iron ring **14**, there are three flux paths to be considered in the arrangement shown in FIGURE 1. Flux path I is the route of the flux which travels between the hubs of the high permeable iron pole pieces. Flux path II is the route of the flux which travels through the axis of the array and provides the axial field strength necessary to focus the traveling wave tube. Flux path III is the route of the flux which travels around the outside of the structure. The structure is designed to allow the greatest amount of flux possible to travel along flux path II. The array shown in FIGURE 1 has been modified somewhat from the conventional design. The pole piece hub **15** normally a single unit has been split around the hub into a pole piece and an iron ring **14**. The ring **14** may be held in place by a plexiglass brushing or any other suitable means which are not shown. The design considerations remain the same as those of the conventional array.

In the arrangement of FIGURE 1, the flux traversing flux path I is a minimum, and the flux traversing flux path II is a maximum providing the maximum amount of field strength available along the axis of this array. The array should be designed so that this field strength coincides with that needed to focus the traveling wave tube for which the array is designed. This coincidence cannot be achieved however, due to variations in the magnetic material and the traveling wave tubes.

FIGURE 2 shows a vernier arrangement for adjusting the field strength. The iron rings have been displaced along the axis by some external positioning device. A non-magnetic screw or any other convenience means can be used for this purpose, or, the iron rings **14** may even be positioned by hand. The displacement of rings **14** causes a decrease in the reluctance along the pole piece hubs, thereby increasing the amount of flux traversing flux path II and flux path III. The axial strength is accordingly reduced. In practice, it is possible to reduce or change the filed strength of the arrangement shown in FIGURE 1 from 100% down to about 30% shown in FIGURE 2.

It is to be observed therefore that the present invention provides for an improvement in a permanent mag-

net focusing array used in connection with a traveling wave tube. To a conventional array or stack which includes a plurality of ring shaped magnets so disposed that adjacent poles are of the same polarity with ring shaped pole pieces disposed between each magnet including a hub on said pole pieces, there is provided inner longitudinally adjustable rings within the cylindrical space defined by said pole piece hubs, the width of said ring being preferably about the width of said pole piece, whereby the flux which travels through the axis of the array and provides the axial field strength necessary to focus the traveling wave tube is at a maximum when said inner rings are so positioned that the width of said inner ring is centered on or coincides with the width of the pole piece and said flux is at a minimum when said inner ring straddles the space between two succeeding pole pieces.

It will be apparent to those skilled in the art, that the present invention is not limited to the specific details described above and shown in the drawings, and that various modifications are possible in carrying out the features of the invention and the operation and the method of support, mounting, adjustment and utilization thereof, without departing from the spirit and scope of the appended claims.

I claim:

1. An improvement in a permanent magnet focusing array used in connection with a traveling wave tube, wherein to said array which includes a plurality of ring shaped magnets disposed so that adjacent poles are of the same polarity with ring shaped pole pieces disposed between each magnet including a hub on said pole pieces, there is provided in combination therewith inner longitudinally adjustable rings of ferromagnetic material within the inner cylindrical space defined by said pole piece hubs, whereby, the flux which travels through the axis of the array and provides the axial field strength necessary to focus the traveling wave tube is at a maximum when said inner rings are so positioned that the width of said inner ring is centered on the width of the pole piece and said flux is at a minimum when said inner ring straddles the space between two succeeding pole pieces.

2. An improvement in a permanent magnet focusing array used in connection with a traveling wave tube, wherein to said array which includes a plurality of ring shaped magnets disposed so that adjacent poles are of the same polarity with ring shaped pole pieces disposed between each magnet including a hub on said pole pieces, there is provided in combination therewith inner longitudinally adjustable rings of ferromagnetic material within the inner cylindrical space defined by said pole piece hubs, the width of said inner rings being about the width of said pole piece hubs, whereby, the flux which travels through the axis of the array and provides the axial field strength necessary to focus the traveling wave tube is at a maximum when said inner rings are so positioned that the width of said inner ring coincides with the width of the pole pieces and said flux is at a minimum when said inner ring straddles the space between two succeeding pole pieces.

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