June 10, 1969 W. J. GALLAGHER 3,449,618

WAVEGUIDE COOLING SYSTEM FOR LINEAR ACCELERATOR

Filed July 15, 1966 Sheet 1 of 2

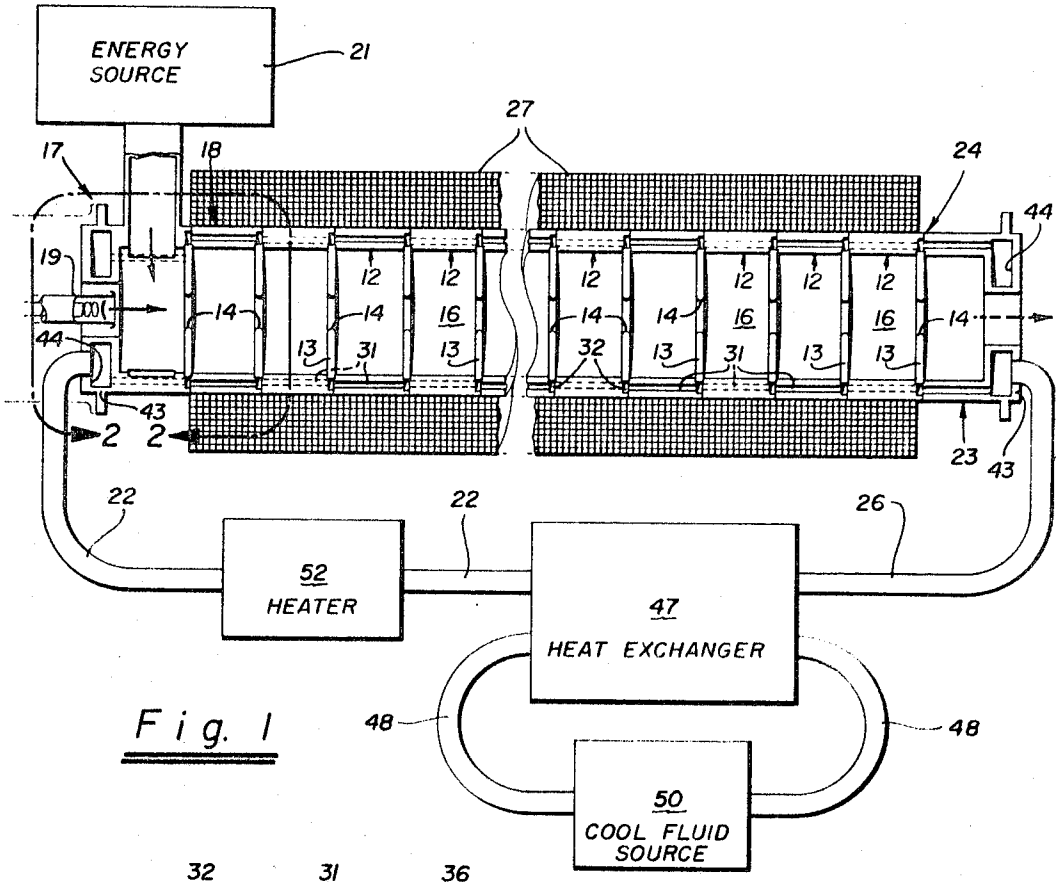


Fig. 1

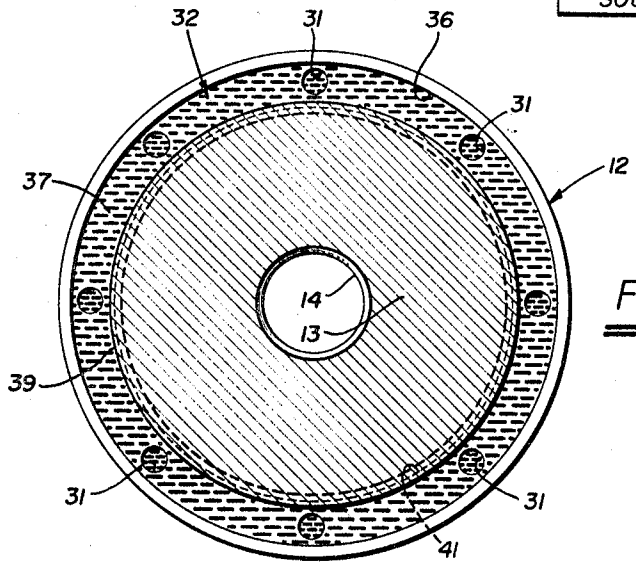


Fig. 3

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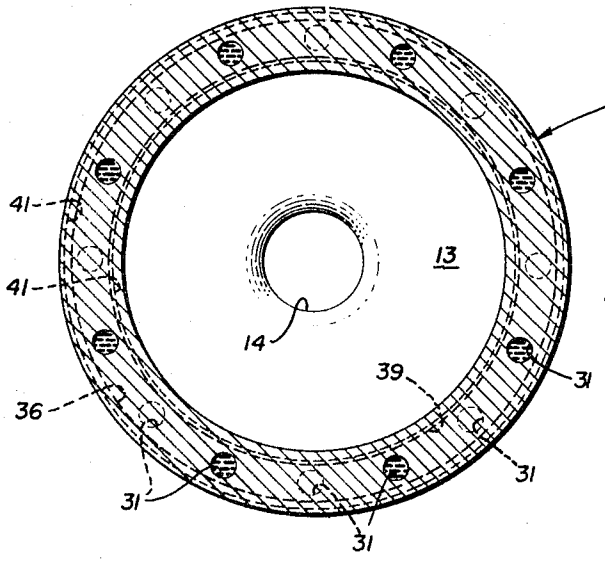


Fig. 4

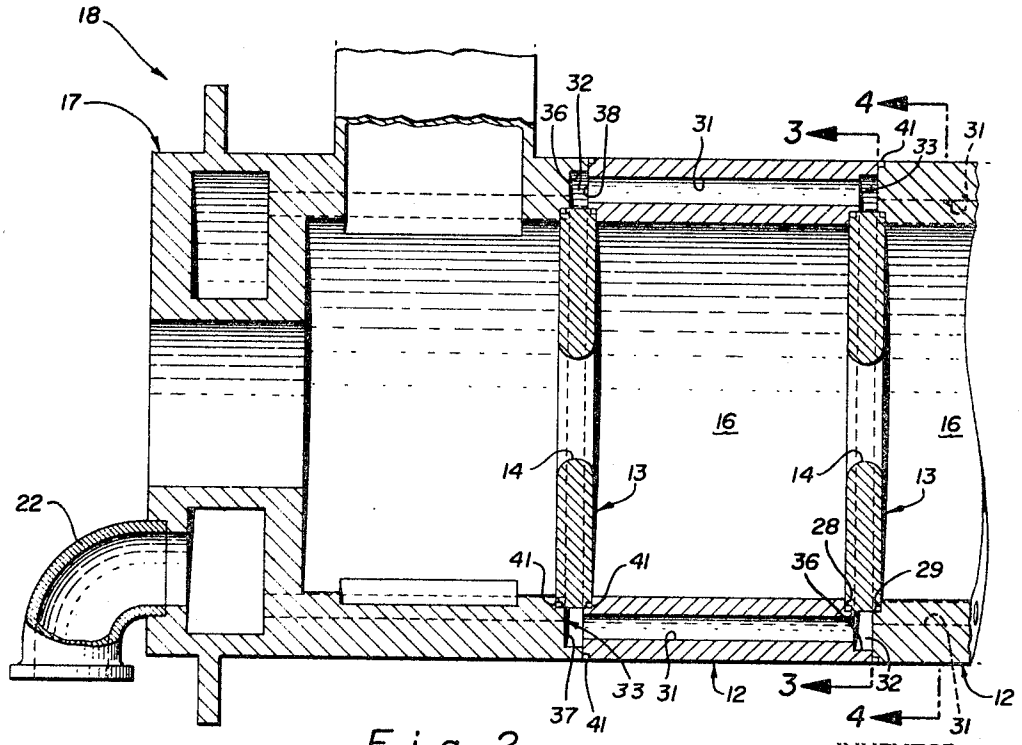


Fig. 2

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WAVEGUIDE COOLING SYSTEM FOR LINEAR ACCELERATOR

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ABSTRACT OF THE DISCLOSURE

A waveguide cooling system for linear accelerator utilizing a plurality of longitudinally extending passageways formed in the waveguide walls and interconnected by annular passageways surrounding the waveguide iris disks.

This invention relates to waveguides for linear accelerators and in particular to such a waveguide including structure for cooling the same.

Heretofore, linear accelerator waveguides have been cooled by circulating fluids in thermal contact with the exterior of the waveguide. Such cooling has not been completely satisfactory in many applications since effective thermal contact is not established with all the members of the waveguide structure especially the iris members thereof. Without effective thermal contact, it is difficult to maintain precise tuning of the waveguide. There is, therefore, a need for new and improved waveguide structure including structure for cooling the same.

In general, it is an object of the present invention to provide a waveguide structure and cooling circuit therein which overcomes the above named limitations and disadvantages.

Another object of the invention is to provide a waveguide structure and cooling circuit of the above character in which the cooling circuit is in intimate contact with a large part of the waveguide structure and in particular with the iris forming disks therein.

Another object is to provide a waveguide and cooling circuit of the above character which, in association with heating means, provides a bake out capability for the waveguide.

Another object of the invention is to provide a waveguide structure and cooling circuit therein of the above character which is self-jigging when assembled and which requires no alignment pins.

These and other objects of the invention will become apparent from the following description in which the preferred embodiment is set forth in detail in conjunction with the accompanying drawing.

Referring to the drawings:

FIGURE 1 is a schematic side view in elevation of the waveguide structure with associated components (shown schematically) and constructed according to the present invention.

FIGURE 2 is an enlarged cross-section view of a portion of the waveguide structure of the FIGURE 1 taken within the lines 2—2.

FIGURE 3 is a cross-sectional view of the waveguide structure taken along the lines 3—3 of FIGURE 2.

FIGURE 4 is a cross-sectional view of the waveguide structure taken along the lines 4—4 of FIGURE 2.

Referring now to the drawings. The waveguide **10** comprises a generally elongate tubular shell including a plurality of hollow cylindrical ring-like sections **12** arranged end-to-end in axially abutting alignment with each abutting pair of sections **12** forming a junction therebetween. A disk **13** having an iris aperture **14** therein is mounted transversely at each junction to form together with sections **12** an iris loaded waveguide structure providing a series of coupled electromagnetic cavities **16**.

Suitable manifold means **17**, hereinafter described in greater detail, couples one end **18** on waveguide structure to an electron gun **19**, a source of electromagnetic energy **21**, and to a coolant supply piping **22**. Other means **23** couples the other end **24** of the waveguide structure to coolant return piping **26**. Magnetic means such as a solenoid electromagnet **27** is provided for establishing a magnetic field longitudinally throughout the waveguide structure. The above described arrangement is known in the art of electron linear accelerators to be useful as a slow wave structure for coupling electromagnetic energy to a charged particle beam for accelerating the same. In the form shown, the sections **12** and disks **13** take cylindrically symmetric form in cross-section, but it will be understood that the invention is not so limited but may be used in other geometries, such as rectangular, if appropriate.

Each of the disks **13** is provided with an over-all dimension lying between the inside and outside dimensions of the section **12**. The ends of each section **12** are provided with inwardly and longitudinally facing annular recesses **28** and **29** having a diameter approximately the same as the outside diameter of disk **13**. Recesses **28, 29** have a combined depth or dimension in the longitudinal direction sufficient to accommodate the thickness of an interposed disk when adjacent sections are abutted. Thus, recesses **28, 29** cooperate to form an inwardly facing annular groove between adjacent sections for tightly accommodating and aligning an interposed disk at the junction of such adjacent sections.

A plurality of passageways **31** is formed in the wall of each section **12** to extend from one end to the other in longitudinal direction. Preferably passageways **31** are formed intermediate the thickness of the wall and are equally spaced about the wall of the section.

Sections **12** and disk **13** are adapted to cooperate with each other at the junction to form an annular coolant channel **32** thereat and within the wall. Channel **32** communicates with the passageways **31** of each adjacent section so that coolant passes through a channel **32** as it proceeds between the passageways **31** of adjacent sections **12**.

The channel is defined by recess **33** provided in one end of each section **12**, the opposite end of the next adjacent section and the included disk. More particularly, the recess **33** faces longitudinally and inwardly, being defined by a cylindrical wall **36** at the outside, and a wall **37** by lying in a plane transverse to the structure, wall **37** opening into at least certain of the passageways **31** of the respective section. Thus, the annular coolant channel **32** is defined by walls **36** and **37** of one section, and by the end face **38** of the adjacent abutting section, and inwardly by the outer cylindrical peripheral wall **39** of the included disk.

Sections **12** and disk **13** are assembled together as follows to form a waveguide structure: a first section is selected and disks **13** set into recesses **28** and **29** thereof. A second section is selected and placed over the disk at

either end of the first section such that recess **28** and recess **29** of adjacent sections encompass the disk therebetween. Successive sections and disks are added in the same manner until the desired member has been assembled. Suitable braze rings **41** are provided for facilitating permanent joiner of the setcions and disks into unitary structure as by brazing the same together.

Each successive section is preferably angularly shifted or offset with respect to the preceding sections so that the passageways **31** are not in longitudinal alignment whereby coolant passing from one section to the next section is shifted circumferentially about the peripheral wall **39** of the disk as it passes through the waveguide structure. Preferably, each successive section is angularly shifted approximately one-half the angular distance between the passageways so that when the coolant passes through the annular channel **32** it is forced into circumferential motion about the disk and along its entire periphery to thereby provide intimate and uniform cooling action.

To facilitate accurate angular alignment of each successive section, there are provided witness marks (not shown) on the outer wall surface at the ends of each section, the witness marks at one end being displaced half the angular distance between passageways with respect to that at the other end. Thus, each successive ring is easily located rotationally to its proper angular position by merely aligning the witness marks of adjacent sections.

End **18** of the waveguide structure **10** is then connected to the coolant supply manifold **17** and the other end **24** to a coolant manifold means **23**. Each of the manifolds includes an annular member **43** sealably engaging the end of the waveguide and having a channel **44** therein which communicates with passageways **31** and channel **32**, respectively. In a typical installation, manifolds **17, 23** connect through suitable piping **22, 26** to one side of a heat exchanger **47** to form a closed coolant circuit. The other side of heat exchanger **47** is coupled through other piping **48** to a source **50** of cooled fluid.

In operation, the coolant is circulated through the manifolds, waveguide passages **31**, and channels **32**. After passing through the passages **31** in a respective section **12** and into the channel **32** formed at the other end, the coolant fluid circumferentially passes about the annular perimeter of disk **13**, making good thermal contact therewith to provide complete cooling of that section of waveguide. This pattern is repeated through each section of the waveguide to thereby achieve uniform cooling through all parts of the waveguide structure.

Thus there has been shown a particularly effective waveguide structure including a cooling circuit in which coolant is brought in direct thermal contact with each element of the waveguide. Among the advantages of the structure of the invention include the ability to utilize oil as the coolant, which oil can be heated by a heater **52** connected in series in piping **22** to a temperature suitable for baking-out the waveguide. Another advantage of the waveguide structure of the invention results from the use of recesses **28, 29** which accommodate disks **13** therein. In this manner, it is possible to provide a self-aligning waveguide structure in which the various elements are constructed to keep together for proper alignment. In all, the structure of the invention is especially compact and efficient since the cooling circuit is incorporated directly into the walls. By so doing, the bulk of the required associated magnet structure is reduced.

I claim:

1. In a waveguide structure, a plurality of hollow cylindrical sections of substantially the same dimension in cross section, said sections being arranged end-to-end in series abutting relationship with each abutting pair of sections forming a junction therebetween, a disk having an aperture therein mounted at each junction to form with the sections an iris loaded waveguide structure in

which a disk is located at the junction of each pair of sections, each of said sections having a plurality of spaced longitudinally extending coolant passageways formed within its wall and extending therethrough from one end to the other, at least one of the sections having an annular recess at one end cooperating with the adjacent end of the next abutting section to form part of an annular cooling channel therebetween which surrounds the interposed disk, said recess and said section opening into at least some of the passageways of the said section, the next adjacent section being annularly offset with respect to the preceding section so that the passageways within said sections are not in longitudinal alignment and so that coolant passing from section to the next section is shifted circumferentially as it passes through said annular recess.

2. A waveguide structure as in claim **1** in which each disk is bounded by an outer annular surface and one wall of the annular channel at each junction is formed by the outer annular surface of the associated disk.

3. In a waveguide structure for use in an electron linear accelerator, a plurality of hollow cylindrical sections of substantially the same dimension in cross sections, said sections being arranged end-to-end in a series of abutting relationship with each abutting pair of sections forming a junction therebetween, a disk having an aperture therein mounted at each junction to form with said sections an iris loaded waveguide structure in which a disk is located at the junction of each pair of sections, each of said sections having a plurality of longitudinally extending cooling passageways formed within its wall and extending therethrough from one end to the other, the sections being arranged so that the passageways in abutting sections communicate with each other, each of said disks having a dimension intermediate the inner and outer transverse dimension of said cylindrical sections, the ends of which are provided with longitudinally and inwardly facing annular recesses having the same diameter as the disk, said recesses cooperating with the next adjacent section to provide a gap therebtween having the same thickness as the thickness of the disk to thereby receive the same and render said waveguide components actually self-aligning when assembled.

4. In an electron linear accelerator, means forming an iris loaded waveguide structure having longitudinally extending walls and iris members extending transversely of the walls at regular spaced locations therealong, an electron gun, a source of electromagnetic energy, first coolant piping, means for coupling one end of said structure to said electron gun, to said source of electromagnetic energy, and to said first coolant piping, magnet means for establishing an electron confining magnetic field throughout said waveguide structure, said waveguide structure comprising a plurality of hollow cylindrical sections of substantially the same dimension in cross section, said sections being arranged end-to-end in series abutting relationships with each abutting pair of sections forming a junction therebetween, a disk having an aperture therein mounted at each junction to form with the sections an iris loaded waveguide structure in which a disk is located at the junction of each pair of sections, each of said sections having a plurality of spaced longitudinally extending coolant passageways formed within its wall and extending therethrough from one end to the other, at least one of the sections having an annular recess at one end cooperating with the adjacent end of the next abutting section to form part of an annular cooling channel therebetween which surrounds the interposed disk, said recess and said section opening into at least some of the passageways of the said section, the next adjacent section being annularly offset with respect to the preceding section so that the passageways within said sections are not in longitudinal alignment and so that coolant passing from section to the next section is shifted circumferentially as it passes through said annular recess, second

coolant piping, means for coupling the other end of said waveguide structure to said second coolant piping, and means for supplying a coolant to one of said coolant pipings and for receiving spent coolant from the other of said coolant piping so that said coolant circulates through the walls of the waveguide structure.

5. An electron linear accelerator as in claim 4 in which a channel is formed in the wall of the waveguide structure and surrounding each iris member, said channel communicating with and interconnecting the longitudinal passageways.

References Cited

UNITED STATES PATENTS

2,993,143	7/1961	Kelliher et al.	315—5.42 X
3,344,306	9/1967	Levin	313—18 X

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313—24, 63; 315—3.5; 333—95, 31