June 5, 1956 L. M. FIELD 2,749,472

TRAVELLING WAVE TUBES

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Fig. 1.

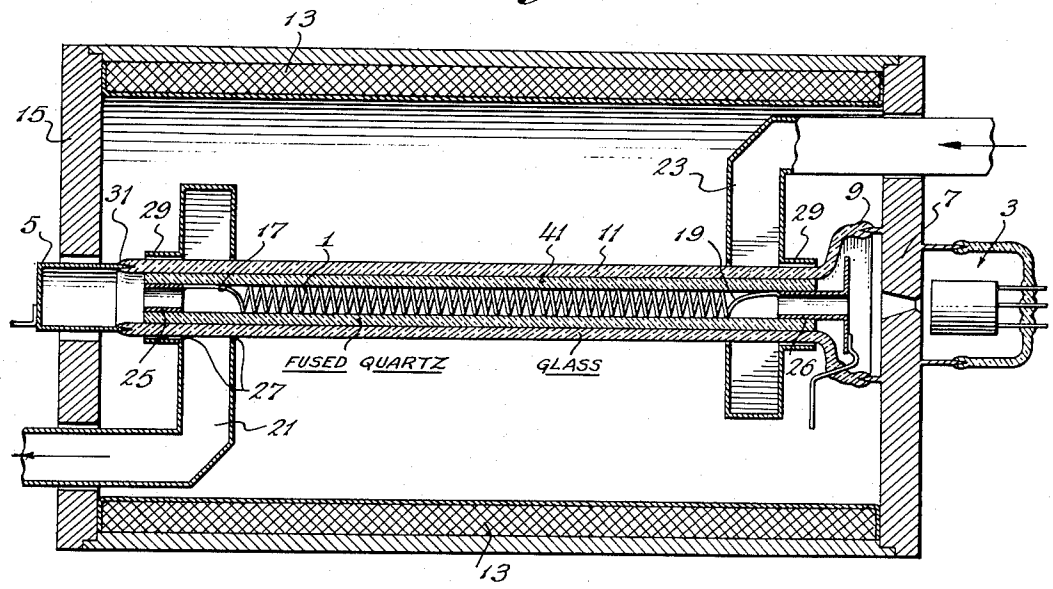


Fig. 3.

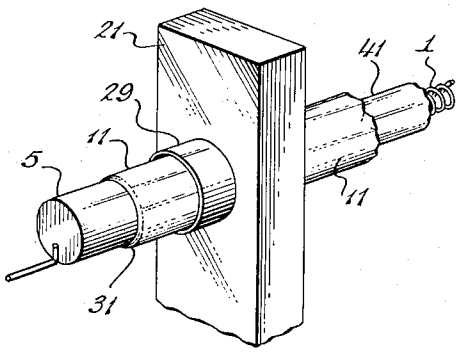


Fig. 2.

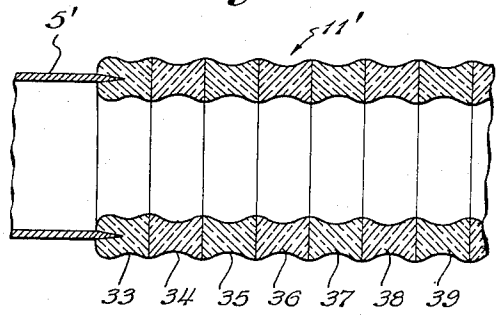
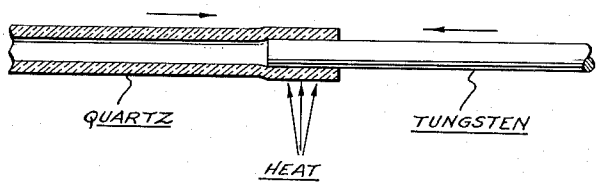


Fig. 4.



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TRAVELLING WAVE TUBES

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Application January 2, 1952, Serial No. 264,494

5 Claims. (Cl. 315—3.5)

This invention relates to improvements in high frequency tube structures, and more particularly to travelling wave amplifiers of the helix type, intended for operation at high frequencies and at power levels considerably greater than those attainable with corresponding prior art devices.

As is known in the art, the helix type travelling wave tube consists of a conductive helix adapted to carry electromagnetic waves at a velocity which is low compared to the velocity of light, and means including an electron gun at one end and a collector at the other for producing and directing an electron beam along the axis of the helix, at a velocity approximately the same as the velocity of wave propagation thereon. Signals applied to the end of the helix near the electron gun set up waves on the helix which interchange energy with the electrons in the stream, causing the electrons to give up some of their kinetic energy to the waves, which grow in amplitude and arrive at the output end of the helix as an amplified replica of the input signals.

It is characteristic of such tubes that the dimensions of the helix must be made smaller as the frequency at which the tube is designed to operate is made higher. Also, as the power output requirement is increased, the heating of the helix, as by interception of electrons from the stream, becomes more and more of a problem. Thus higher powers at higher frequencies have been increasingly difficult to obtain because the helix must be made smaller and at the same time must withstand more heat.

The helix may be made of heat resistant material, such as tungsten, and the tube envelope may be made of quartz instead of glass in order to avoid softening and failure under extremely high temperature conditions of operation. However, this construction brings up new problems involving considerable practical difficulty. Quartz tubing, as manufactured at present, cannot be controlled exactly as to size, but must be selected for size as well as uniformity and straightness, to obtain approximately the required dimensions. Furthermore, quartz cannot be sealed directly to metallic closure members, such as the collector and anode of a travelling wave tube, nor can it be sealed directly to glass which has the characteristics necessary for effective sealing to metal. So-called "graded seals," requiring as many as eight different kinds of special glass may be required in some instances to produce a vacuum tight seal, resistant to temperature changes, between quartz and metal.

The principal object of the present invention is to provide travelling wave tubes which have the heat resistance and low electrical loss characteristics of a quartz envelope, but avoid the disadvantages and constructional difficulties thereof.

Another object is to provide tubes of the described type which can be readily constructed to have uniform cylindrical outer surfaces, suitable for insertion into and through coupling holes in wave guides which are used to conduct high frequency signals to and from the tube.

A further object is to provide an improved method of making travelling wave tubes with helices supported inside quartz tubing of substantially any desired diameter.

The invention will be described with reference to the accompanying drawing, wherein:

Fig. 1 is a longitudinal section of a travelling wave amplifier including a tube constructed according to the invention,

Fig. 2 is a sectional view of a typical graded seal between quartz and metal,

Fig. 3 is a perspective view of a part of the structure of Fig. 1, showing the relationship between the tube envelope and one of the wave guides coupled to the tube, and

Fig. 4 illustrates the process of enlarging the inside of a piece of quartz tubing to a predetermined uniform diameter.

The amplifier in Fig. 1 is largely of conventional design, including a tube with a conductive helix **1**, an electron gun **3** disposed at one end of the helix, and a collector electrode **5** at the other end. The electron gun includes an accelerator electrode **7** which in this example forms part of the vacuum enclosure, and is sealed at **9** to one end of the envelope **11**, which may be made of any known type of glass readily sealable to metal. The member **7** may also be designed as shown to function as a magnetic pole piece, cooperating with an external magnet **13** and a pole piece **15** surrounding the collector **5** to provide an axial magnetic field to maintain the electron beam focussed inside the helix.

The end turns of the helix are stretched out as at **17** and **19** to provide small probes or antennas for coupling the ends of the helix to output and input wave guides **21** and **23** respectively. The parts **17** and **19** terminate in short conductive coaxial sleeves **25** and **26**. The output wave guide **21** is provided with openings **27** in its broad walls to accommodate the envelope **11**, and has a short collar **29** adapted to surround the envelope **11** outside the sleeve **25**. The collar **29** and openings **27** are of such diameter as to have a sliding fit over the envelope **11**, as indicated in the perspective view of Fig. 3. The input wave guide **23** is similarly designed to slide over the collector end of the tube and cooperate with the coupling member **19** and sleeve **26**.

As shown in Fig. 1, the seal **31** between the envelope **11** and the collector **5** may be made extremely smooth and of the same or slightly less diameter than the body of the envelope. This permits the wave guide openings **27** and collars **29** to be made to fit closely to the envelope, and yet be slidable over the end to their proper positions.

Fig. 2 shows for comparison the type of seal that would be necessary if the envelope, here designated **11'**, were made of quartz. A series of ring shaped segments **33** through **39** are required to be sealed together in succession, each ring being made of a different kind of glass having a slightly different temperature coefficient of expansion from the previous one. The first ring **33** must match closely the characteristic of the metal piece **5'**, and the last ring must nearly conform to the quartz envelope **11'**. Not only are these seals difficult and expensive to construct, but they also present a corrugated outer surface, like that shown in Fig. 2, and furthermore require considerable axial space, making the overall tube longer than would otherwise be necessary.

Returning to Fig. 1, a tubular liner **41** of fused quartz surrounds and supports the helix **1** and fits closely within the glass envelope **11**. The liner **41** should have a substantially straight internal bore of uniform diameter just large enough to accommodate the helix at operating temperature. Quartz tubing as ordinarily made is supplied in more or less random sizes, and may be non-uniform as

to diameter and straightness. Such tubing is prepared for use in the structure of Fig. 1 by selecting a piece having an average internal diameter slightly less than the required size, heating it near one end as indicated in Fig. 4 to a temperature at which it begins to soften, and forcing it over a smooth tungsten rod of the required diameter while continuing to supply heat at the point where the tube goes onto the rod. After cooling, the tube can be slipped off the rod and it will have a smooth interior surface of uniform diameter.

From the foregoing description it will be apparent that the device of Fig. 1 can be fabricated easily, without resort to complex sealing technique, and will have the same advantages as a tube with a quartz envelope, and in addition may be made shorter and in closer conformance to the dimensions of standard input and output coupling elements. The tube may be operated with the helix at white-hot incandescent temperatures without damage to the quartz liner or the surrounding envelope. For such high power operation, it is preferable to make the helix and its terminal sleeves of tungsten or similar material. A tube constructed as described can be operated, without failure due to overheating, at power levels in excess of ten times the safe operating level of similar tubes of conventional design.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A travelling wave tube including a helix of conductive wire, an electron gun assembly adjacent one end of said helix, said assembly including a peripheral portion made of a material readily sealable to glass, a tubular glass envelope sealed at one end to said assembly, and a tubular quartz sleeve lining said glass envelope and closely surrounding said helix, said quartz sleeve acting as a low-loss support to maintain said helix on a rectilinear axis, and also as a heat resistant thermal insulator to protect said glass envelope from heat generated in the operation of the apparatus.

2. A travelling wave tube including a helix of conductive wire, an electron gun assembly adjacent one end of said helix, said electron gun assembly including a magnetic pole piece of a material readily sealable to glass, a collector electrode adjacent the other end of said helix, a tubular glass envelope sealed at one end to said pole piece and sealed at the other end to said collector, and a tubular quartz sleeve lining said glass envelope and closely surrounding said helix.

3. A travelling wave tube including a tubular glass envelope and metallic end members, said envelope being sealed at its respective ends to said end members, a conductive helix within said envelope, and means for supporting said helix coaxially inside said envelope comprising a tubular body of fused quartz surrounding said helix and in contact therewith, the outside of said body being in contact with and supported by the inner surface of said envelope.

4. A travelling wave tube including an evacuated tubular glass envelope and metallic end closure members, said envelope being sealed at its respective ends to said members, a conductive helix within said envelope and adapted to operate at incandescence, and means for supporting said helix coaxially inside said envelope comprising a tubular body of fused quartz surrounding said helix and in contact therewith, the outside of said body being supported upon the inner surface of said envelope.

5. A travelling wave tube including a helix of conductive wire, an electron gun assembly adjacent one end of said helix, said assembly including a peripheral portion made of a metal readily sealable to glass, a tubular glass envelope sealed at one end to said assembly, a collector electrode, the outer periphery of which does not extend radially beyond said glass envelope, sealed to said tubular glass envelope at its other end by a smooth seal, a tubular quartz sleeve lining in contact with said glass envelope and closely surrounding said helix, said quartz sleeve acting as a low loss support to maintain said helix on a rectilinear axis, and also as a heat resistant thermal insulator to protect said glass envelope from said heat generated in the operation of the apparatus, and two apertured wave guides, each being positioned adjacent a different end of said helix, said glass tube passing through said apertures, the edges of which surround said glass tube in a relatively close sliding fit.

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