Oct. 21, 1958 W. KLEIN ET AL 2,857,547

TRAVELING WAVE TUBE

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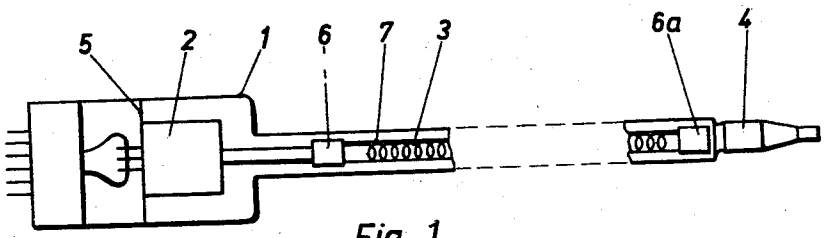


Fig. 1

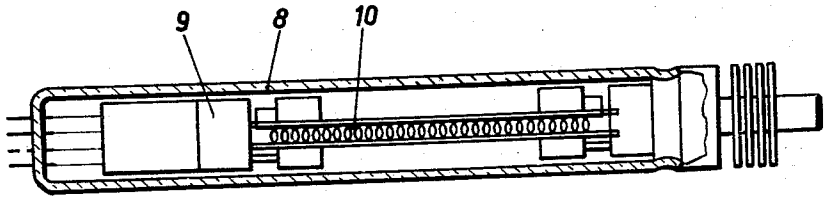


Fig. 2

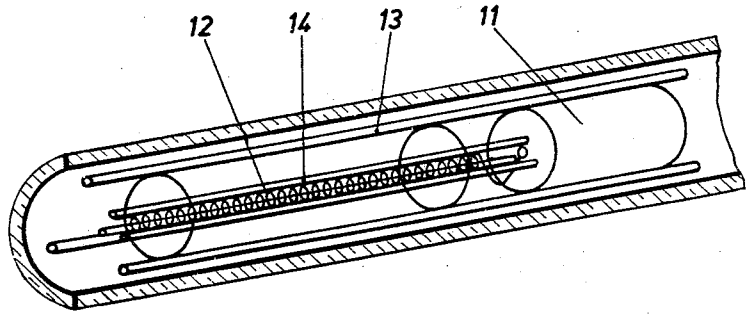


Fig. 3

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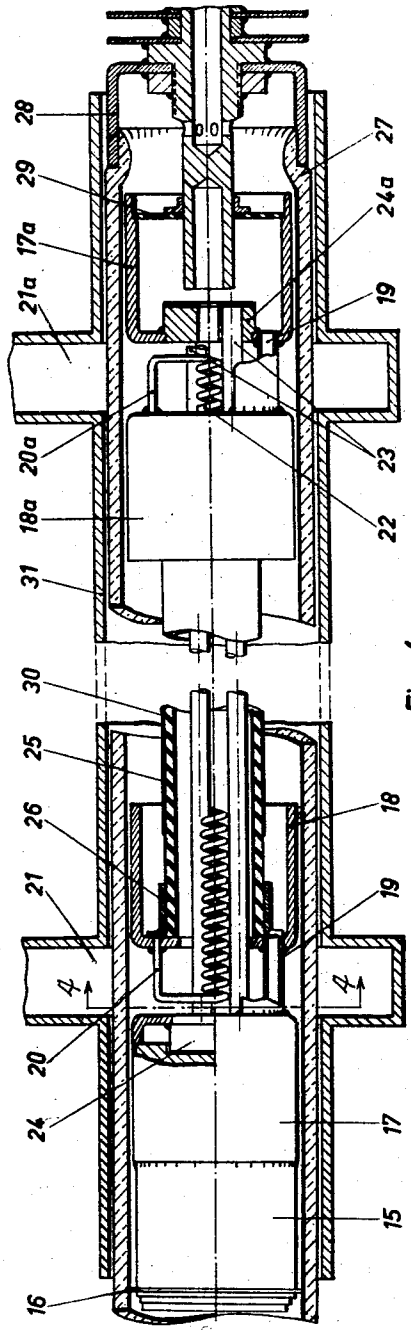


Fig. 4

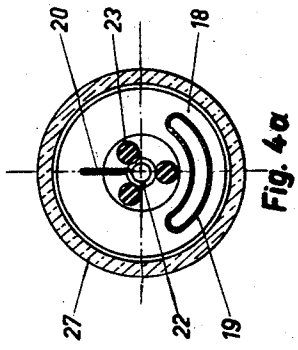


Fig. 4a

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TRAVELING WAVE TUBE

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6 Claims. (Cl. 315—3.5)

Traveling wave tubes consist of a beam generating system, of a retardation line and of a collector. For the proper functioning of the traveling wave tube it is important that the axis of the gun system (beam generating system), of the retardation line and of the collector are adapted to each other with a sufficient accuracy, whereby also the high frequency requirements, e. g. the prevention of a feedback, have to be considered. Up to now various arrangements have become known for achieving the aforesaid aim:

The invention will be better understood from the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Figs. 1 and 2 are diagrammatic illustrations of prior art tube constructions;

Fig. 3 is a diagrammatic illustration of a unitary assembly for traveling wave tubes in accordance with this invention;

Fig. 4 is a detailed fragmentary cross-sectional view of a traveling wave tube structure incorporating the features of this invention, and

Fig. 4*a* is a cross-sectional view made along the line 4—4 of Figure 4.

Fig. 1 of the accompanying drawings shows an embodiment in which the vacuum tube takes over the task of mutually holding the system components. To this end the vacuum tube **1** is enlarged in its diameter in the zone of the gun system **2**. The gun system is retained in position on the one side by a tight fitting disk **5** and is supported on the other side in the adjoining narrowed helix holding section of the vacuum tube by means of a tight-fitting helix terminating cylinder **6**. In this case the retardation line is constituted by the wire helix **3**, which is held in position between the dielectric rods **7**. Instead of the dielectric rods there also have been used dielectric pipes as holding arrangements for the helix. The collector-sided end of the helix is likewise retained in position by means of a second cylinder **6***a* on the side of the collector **4**. In this arrangement it is of a disadvantage that the vacuum tube takes over the holding of the system and that further the exact axis-true position of the thick and the thin glass section requires a rather difficult glass processing. Furthermore, also the method of holding the helix with the aid of a dielectric pipe bears various disadvantages. Besides the influence of the dielectric upon the phase velocity of the wave on the retardation line there still appears a weakening effect of the coupling between wave and beam which is due to the distortion of the electromagnetic field towards the holding arrangement. This causes a reduction of the amplification and, in the case of power tubes, also a reduction of the maximum high-frequency output power. The unavoidable loss factor of the dielectric, in addition causes an attenuation of the retardation line, which increases the aforesaid effect. Effects are being made, therefore, to provide, if possible, only a spot-shaped contacting of the helix with the dielectric, e. g. with the aid of holding rods.

Fig. 2 shows a type of embodiment in which the difficulty of the glass processing has been reduced insofar as there is employed a vacuum tube **8** with a constantly calibrated internal diameter. The system components (gun system **9** and helix section **10**) which are fitted into this glass container, as a matter of fact, have one common axis. However, in the demand for an exact accuracy to size with respect to the built-in components, there is also to be found its weakest point, because the mounting requires a very great care and the inside of the glass container can easily be injured or damaged during the assembly, which may be the cause of forthcoming cracks in the glass container.

Fig. 3 shows an arrangement in which the vacuum tube only serves as an envelope and in which the gun system and the helix section form a self-supporting structural unit. This is achieved in that the gun system **11** and the retardation line **12** are rigidly kept in their mutual position by means of a number of rods **13**. The retardation line may be fixed between the dielectric rods **14**. A disadvantage of the arrangement is seen in the fact that the mechanical stability against crossing when being mounted is not a very great one. In addition thereto, the embodiments of Figs. 2 and 3 bear disadvantages with respect to high frequency. The gun system, especially in the case of power tubes, has a certain minimum diameter which determines the smallest possible tube diameter in this type of embodiment. The tubes are provided with waveguide couplings. The coupling-in and coupling-out waveguides must thereby be joined by a metal pipe for providing a rigid connection and holding. This pipe, however, represents an unwanted transmission path having a high-pass filter character between the coupling-in and coupling-out waveguide, the cut-off frequency of which may easily fall within the range of the electronic amplification. This cut-off frequency increases with a decreasing hollow-pipe diameter. Hence in these types of embodiment there have to be provided additional means for excluding the unwanted transmission path, which may easily be the cause of a feedback. In accordance with the invention it is suggested, therefore, to employ a pipe as supporting means between the helix holding at the input—and at the output waveguide within the vacuum tube. The diameter of this pipe preventing the formation the said feedback. This arrangement will now be particularly described with reference to an exemplified embodiment.

Fig. 4 of the accompanying drawings shows an arrangement according to the invention. The gun system **15** is held in a coaxial position with respect to the glass tube **27** by means of a ring **16**. A pot-shaped metal cylinder **17**, forming the cathode-sided termination of the high frequency circuit, is slipped over the gun system **15**. With the aid of the metallic connecting component **19** the pot-shaped metal cylinder **17** is in a rigid connection with the pot-shaped metal cylinder **18**. The said connecting component **19**, with respect to the high frequency, at the same time establishes the proper impedance for the matching of the helix-loop antenna **20** to the waveguide **21**. The helix antenna is mounted to the side not facing the connecting component **19**. For making the useful helix length as great as possible, the helix antennas **20** or **20***a* respectively, are connected to the pot-shaped components **18** or **18***a* respectively, facing the helix zone. At the output circuit **21***a* of the tube there are arranged accordingly the pot-shaped metal components **17***a* and **18***a* together with the metallic connecting component **19***a*. The helix **22** is supported inside three dielectric rods **23**, the respective position of each of which is secured on the side of the

collector by means of the collecting part **24***a*. This component **24***a* is rigidly connected with the pot-shaped metal cylinder **17***a*. In the same manner the helix is fixed by means of the ceramic rods inside the pot **17** with the aid of the collecting part **24**. The connection of the structural group at the input waveguide **21**, with the structural group at the output waveguide **21***a* is established with the aid of a dielectric pipe (e. g. of ceramics of glass) **25**. This pipe of dielectric material is provided on both ends with flanges **26** and **26***a* which are rigidly joined to the pots **18** and **18***a* (e. g. by hard soldering). The second supporting point of the self-supporting tube system is represented by the collector **28** sealed to the other end of the vacuum tube. The pot **17***a* rests on the collector by means of a disk of dielectric material **29**. The pipe **25** serves two functions: With respect to high frequencies there is achieved an effective suppression of unwanted feedbacks. To this end the surface **30** of the pipe **25** is covered with a suitable resistive layer (e. g. carbon). At the same time the pipe can also be used for contributing towards a supporting, sag-free connection which is resistive to crossings. A propagation of hollow tube waves in the space between the dielectric pipe and the helix is no longer possible owing to the smaller diameter of the pipe within the operating range of the tube. It will be of advantage to carry out the dimensioning of the pipe diameter according to the following high frequency points of view: The diameter of the pipe is supposed to be so small that the longest possible waveguide wavelength in the space between the helix and the holding pipe is beyond the shortest amplified wave. On the other hand the diameter of the pipe is not to be chosen so small that its dielectric will start to have a substantial influence upon the helix wave form. With the aid of these conditions the following limits may be set up with respect to the diameter d_R of the dielectric pipe:

$$4\cdot10^{-3}\sqrt{U}<\frac{d_R}{\lambda}<0.3$$

whereby U represents the optimum D. C. operating voltage in volts and λ the optimum operating wavelength in the same units as d_R. It is assumed thereby, that the electronic amplification range of the tube extends over approximately one octave. Coaxial wave propagation is effectively suppressed by the attenuating layer on the dielectric pipe. Of course this attenuating layer may also be applied to the inside, or to the outside and the inside of the dielectric pipe. The space between the dielectric pipe and the case wall **31** represents a strongly attenuated coaxial line, the attenuation of which is sufficient for suppressing a coaxial wave for the feedback excitation. By means of this arrangement for the suppression of waveguide waves there is provided a greater freedom in the selection of the diameter of the vacuum tube which may now depend on the points of view regarding the dimensioning of the gun system. For further increasing the attenuation of the space between the pipe and the case wall the inside and/or the outside wall of the vacuum tube may be provided with an attenuation coating. The elimination of the feedback path by means of the conventional insertion of suppression elements is not as effective as the wideband loss attenuation described hereinbefore, because the said suppression elements are selective. Of course, there are provided attenuating means within the retardation line in order to suppress a self-excitation by the fundamental helix wave form.

The construction of the coupling zone with the metallic connecting part **19** is particularly shown in Fig. 4*a* of the drawings. The metallic connecting part **19** may e. g. have the shape of a "kidney" and, when being embodied as a hollow part, enables the leading through of further connecting leads, e. g. for a tube comprising a plurality of helix or helices within the vacuum container from the

side of the power supply. Likewise the connecting part may consist of an arrangement comprising a plurality of rods or small pipes. In this arrangement, at the same time, all elements which are required for the transformation, e. g. the components **17**, **18** and **20**, in particular the component **19**, are placed inside the pipe. By this there may be achieved a coupling of the helix to the output circuits in a manner which is independent on the position. The arrangement of the rigid connection of the pot-shaped components **17** and **18** by means of the part **19** bears the further advantage according to which the connecting pipe **25** does not project into the waveguide zone **21** or **21***a* respectively, thus avoiding additional transformer losses from the helix to the waveguide caused by the losses in the dielectric.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A traveling wave tube comprising a helical delay line, relatively rigid supporting means for supporting said line throughout its length, a tube of dielectric material supported in coaxial spaced relationship with said helix and extending along the helix to within a short distance of each end thereof, said dielectric tube having a diameter d_R complying with the limitation expressed by:

$$4\cdot10^{-3}\sqrt{U}<\frac{d_R}{\lambda}<0.3$$

where U is the optimum D. C. operating voltage in volts and λ is the optimum operating wavelength of the traveling wave tube in the same units as d_R, an attenuating coating provided on said dielectric tube, and an evacuated envelope enclosing said helix and tube.

2. A traveling wave tube according to claim 1, wherein said attenuation coating is on the inner and outer surface of said tube.

3. A traveling wave tube according to claim 1, further comprising coupling members at each end of said tube and positioned within said envelope for providing coupling to external wave guides, said tube being firmly attached at its opposite ends to respective of said coupling members.

4. A traveling wave tube as claimed in claim 3, characterised in that each of the coupling members consists of two cup-shaped cylinders, and a metallic supporting member rigidly inter-connecting said cylinders.

5. A traveling wave tube according to claim 4, further comprising an electron gun positioned at one end of said helical line for directing an electron beam therealong, and a collector electrode at the other end of said helical line for collecting the electrons of said beams, means for supporting one of said cup-shaped members on said collector electrode, and means for mounting said electron gun in the other of said cup-shaped members.

6. A traveling wave tube according to claim 5, further comprising a ring member on said gun member for supporting the gun end of said assembly within said envelope and a member on said collector electrode sealed with said envelope.

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