Dec. 20, 1966 R. H. WINKLER 3,293,478

TRAVELING WAVE TUBE WITH LONGITUDINAL RECESS

Filed March 28, 1963 3 Sheets-Sheet 1

FIG. 1

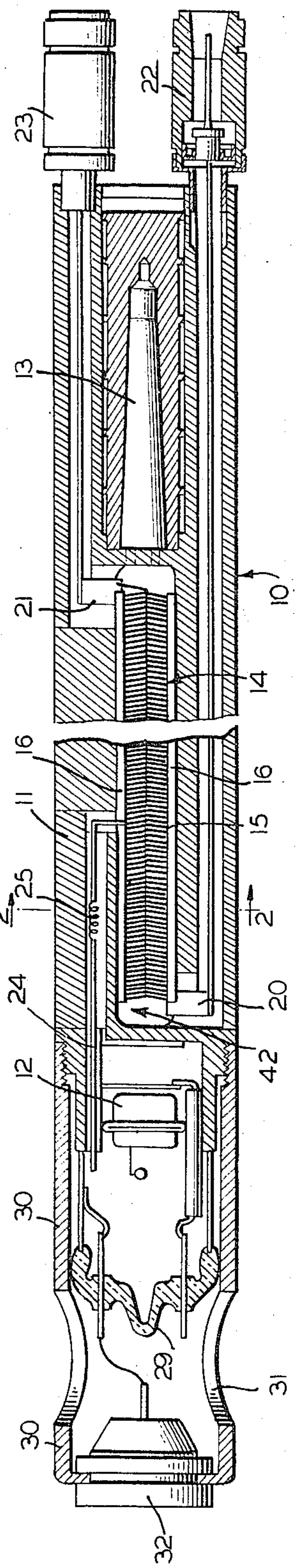
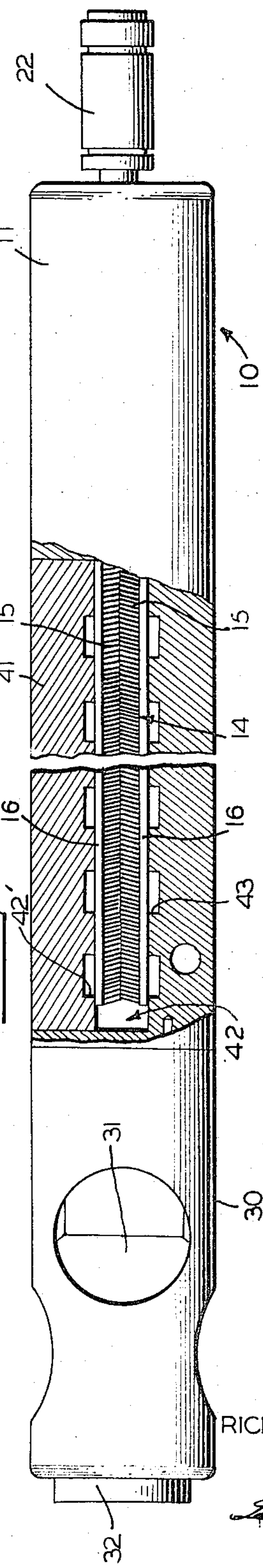


FIG. 3



INVENTOR.
RICHARD H. WINKLER

ATTORNEY

Dec. 20, 1966 R. H. WINKLER 3,293,478

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Fig 4.

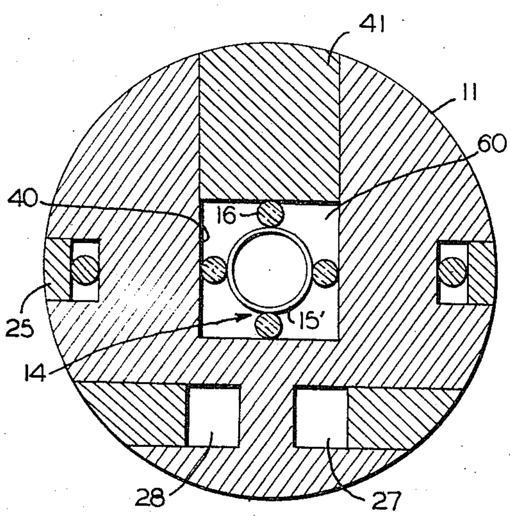


Fig 2.

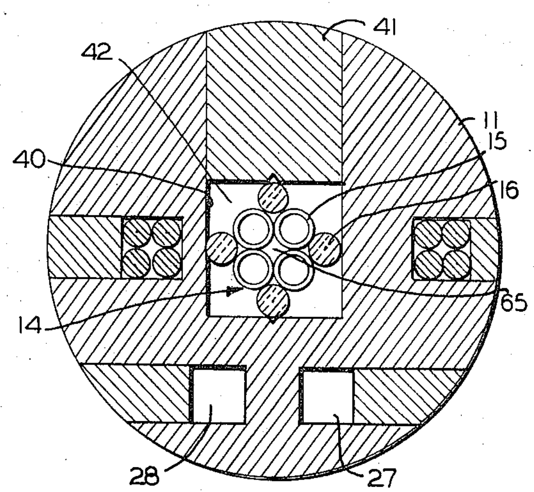


Fig 5.

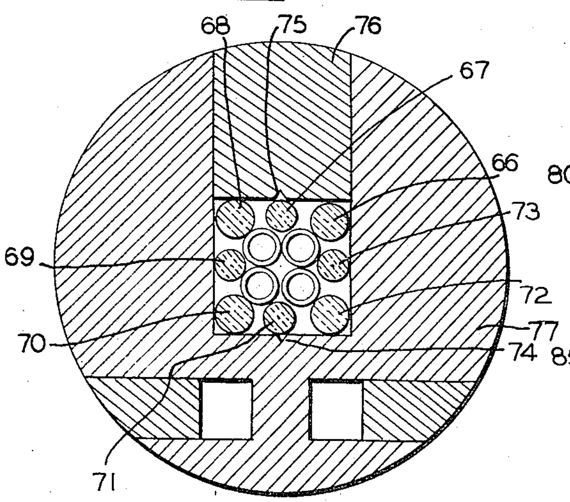
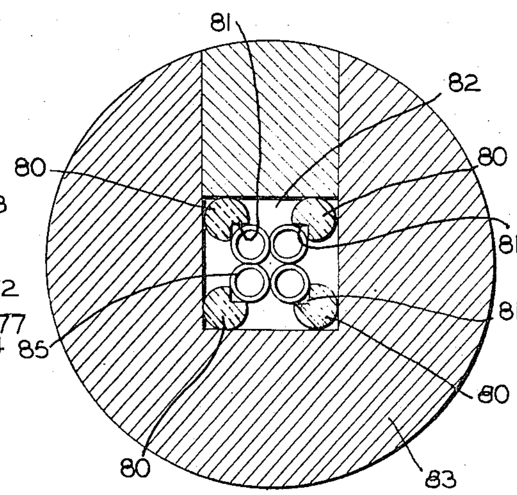


Fig 6.



INVENTOR
RICHARD H. WINKLER

BY

Louis P. Elbinger

ATTORNEY

TRAVELING WAVE TUBE WITH LONGITUDINAL RECESS

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FIG. 7.

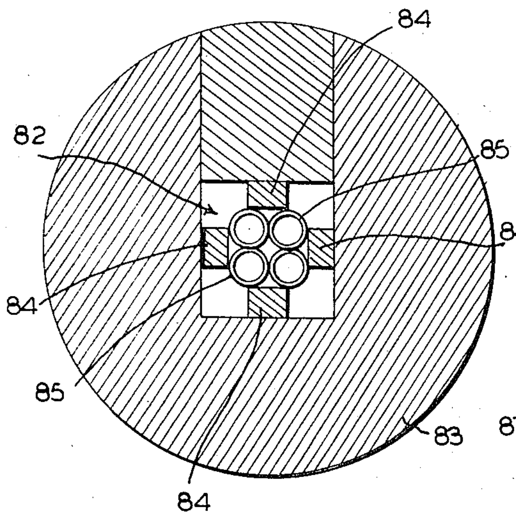


FIG. 8.

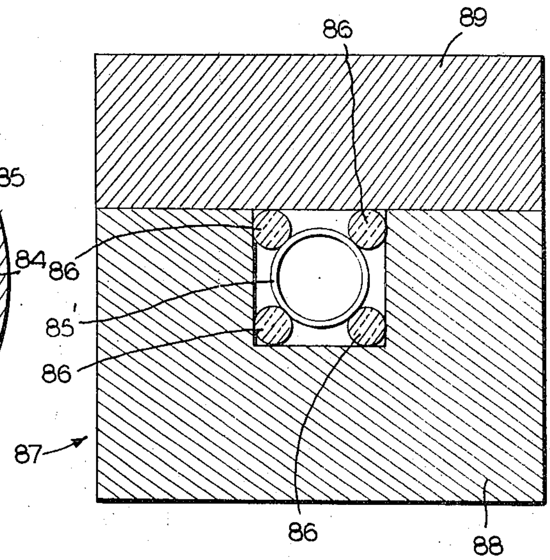


FIG. 9.

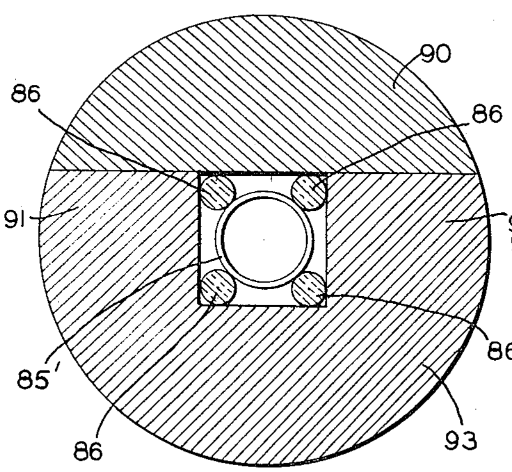
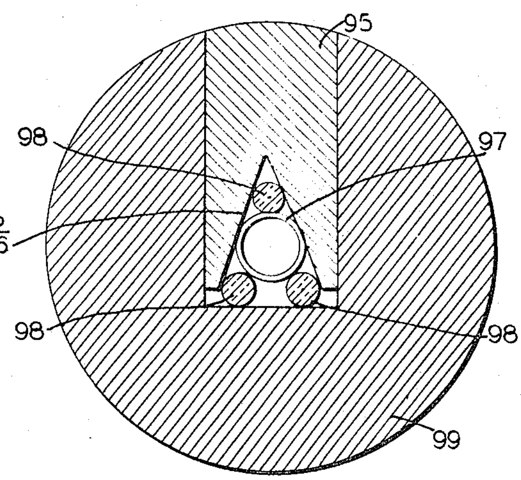


FIG. 10.



INVENTOR
RICHARD H. WINKLER

BY

Louis P. Elbinger

ATTORNEY

United States Patent Office

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TRAVELING WAVE TUBE WITH LONGITUDINAL RECESS

Richard H. Winkler, Palo Alto, Calif., assignor to General Electric Company, a corporation of New York

Filed Mar. 28, 1963, Ser. No. 268,753
12 Claims. (Cl. 315—3.5)

This invention relates generally to electron discharge devices, and more particularly electron discharge devices of the traveling wave type.

Traveling wave type tubes generally involve interaction of an electron beam with an electromagnetic wave propagated on a waveguide structure disposed adjacent to the path of electron beam. One type of traveling wave tube comprises a waveguide conductor of generally helical configuration several wavelengths long. The helical conductor is proportioned and arranged to produce an electric field directed along the axis of the helical conductor and moving at a velocity substantially less than the velocity of the wave along the conductor itself. Such waveguide structures which have the effect of producing a component of electric field of an electromagnetic wave which moves at a lower velocity than the wave itself on the structure are commonly referred to as slow-wave structures. A variety of conductive structures have such properties and are suitable for use in traveling wave devices.

In such devices there is associated with the helical conductor a means which may be, for example, an electron gun for producing an electron beam oriented on the axis of the helical conductor. When the tube is energized to produce an electron beam therein, an electromagnetic wave is applied to the beam entrance end of the helical conductor. The wave travels along the helical conductor producing an axially-directed component of electric field traveling at a velocity less than the velocity of the wave along the helical conductor. The average velocity of the electron beam is arranged with respect to the velocity of the axially-directed component of electric field of the applied wave to effect a conversion of energy associated with the electron beam into electromagnetic wave energy. Accordingly, as the applied electromagnetic wave moves along the helical conductor, it is augmented in amplitude. The wave, augmented in amplitude, is removed at the beam exit end of the helical conductor.

Traveling wave devices of the kind described above are useful as amplifiers, oscillators and the like operating at radio frequencies, and are capable of delivering appreciable amounts of power at these frequencies. However, traveling wave tubes have earned the reputation of being fragile devices and a need exists in the art for obtaining a device of rugged construction and capable of high power output. One of the factors influencing the power output of a traveling wave tube is the conversion of beam power into radio frequency power. Patent No. 3,054,017, Putz, assigned to the assignee of this invention, shows an arrangement for obtaining higher power outputs from traveling wave tubes. In this patent, it is proposed to replace a single helical conductor slow-wave structure with a composite slow-wave structure having a plurality of helical conductors in parallel, each helical conductor operating with its own respective electron beam.

In view of the fact that the length of a slow-wave structure as measured along the axis of the structure is many times, for example, twenty to fifty times, the slowed-down wavelength of an applied electromagnetic wave, a slight variation in the dimensions, particularly length, of one slow-wave structure from that of another (when using the multiple helix slow-wave structure) has the effect

of producing an appreciable differentc in the phase of the output obtainable from one of said structures with respect to the output of the other of said structures. Hence, when such outputs of different phase are combined, a resultant output less than the sum of the individual outputs is obtained. Additionally, juxtaposition of two helical conductors in a composite slow-wave structure electrically connected only at the input and output thereof permits modes of propagation of electromagnetic waves on the structures other than the desired mode, particularly when the structures are not appreciably separated or shielded from one another.

In devices such as those described in the Putz patent, hereinbefore referred to, and those using a single helical conductor slow-wave structure, the slow-wave structure must be rigidly supported to achieve close adjacency between the electron beam and the electromagnetic wave. To this end, the helical conductor is usually either mounted in a snug fit within an elongated, nonconductive envelope or supported in a coaxial spaced relation with respect to the envelope by means of three equally spaced insulating rods positioned around the helical conductor. However, such helical conductor support arrangements have several disadvantages.

For example, in the first arrangement, the snug fit required between the helical conductor and the envelope sometimes results in fabricating difficulties and breakage of the usually fragile envelope. In addition, the dielectric loading of the helical conductor is very high. In the second arrangement, the helical conductor and insulating rods are generally assembled together within the enevelope by means of clamp rings and resilient members. The supporting insulating rods, which are disposed between the helical conductor and the clamp rings, are resiliently pressed against the helical conductor. This arrangement introduces considerable fabricating difficulties, and in addition, a slight misalignment or a slight vibration may appreciably affect the operation of the device.

Another problem encountered in traveling wave tubes of the single helical conductor slow-wave structure or multiple helical conductor slow-wave structure, such as described in Patent 3,054,017, Putz, has been that of dissipating a substantial amount of heat. This is particularly true at high power levels, i.e. when power requirements are in excess of 100 watts.

Accordingly, it is an object of this invention to provide an improved electron beam-electromagnetic wave interaction type tube that is relatively simple in construction yet highly effective and efficient in operation.

Another object of this invention is to provide an improved electron beam-electromagnetic wave interaction type tube capable of developing a high power output.

A further object of this invention is to provide an improved electron beam-electromagnetic wave interaction type tube having improved heat-dissipating qualities.

Yet another object of this invention is to provide a simple, yet mechanically rugged and electrically effective, electron beam-electromagnetic wave interaction-type tube for high frequency and high power operation.

In carrying out the present invention, in one illustrative form thereof, there is provided a one-piece body member or envelope which combines the slow-wave structure, the electron gun and the collector. The envelope or body member is made from a substantially solid bar of metal having its opposite ends bored out to receive the electron gun and the collector. A longitudinally extending opening or groove is cut into one side of the envelope to receive the slow-wave structure and a closing member or plug is inserted into the opening to form a central cavity. Coaxial conductors for the input and output are brought from the collector end of the tube envelope parallel to the tube axis and are connected to opposite ends of the helical conductor. The plug for the envelope is designed to place the slow-wave structure under compression at normal operating temperature, and the metal envelope serves to provide heat conduction from the slow-wave structure.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarding the invention, it is believed that the invention will be better comprehended from the following description taken in connection with the accompanying drawings.

FIG. 1 shows a top cross-sectional view of a traveling wave tube embodying the present invention.

FIG. 2 shows an enlarged cross-sectional view of the tube of FIG. 1 taken along section **2—2** of FIG. 1.

FIG. 3 shows a side cross-sectional view of a traveling wave tube embodying the present invention.

FIGS. 4 and 5 show enlarged cross-sectional views of alternate embodiments of the present invention for supporting different arrangements of slow-wave structures.

FIG. 6 through 10 show cross-sectional views of alternate embodiments of the traveling wave tube embodying the present invention.

Referring to FIGS. 1–3 of the drawings, there is shown in accordance with one form of the present invention a traveling wave tube **10** comprising an evacuated, elongated, single-piece body member or envelope **11** which may be of circular cross-section. The envelope **11** may be made of a thermally conductive, non-magnetic metal, such as stainless steel, Monel metal, brass or copper; however, other materials having non-magnetic and good heat transfer properties are also suitable for use. The envelope **11** has its opposite ends bored out and is arranged to receive at one end thereof a composite electron gun or source **12** for producing a stream of electrons in the evacuated space of the envelope. At the other end of the envelope **11** is mounted a collector electrode structure **13** for intercepting the electrons ejected from the electron gun **12**. A wave transmission circuit or waveguiding structure **14**, commonly referred to as a slow-wave structure, for developing from electromagnetic waves applied thereto a component of electric field moving along a dimension thereof at a velocity substantially less than the free space velocity of the electromagnetic waves, is centrally mounted between the electron gun **12** and collector structure **13** in energy interchanging relationship with the electron beam. An elongated coil (not shown) of generally cylindrical configuration for developing a unidirectional magnetic field directed along the axis of the envelope **11** for focusing the electron stream is located substantially concentrically with respect to the envelope **11** and substantially surrounds the envelope **11** along its length.

The structural and operational features of the electron gun **12** and collector structure **13** are known in the art and will not, therefore, be described in further detail. It should be noted that in the above arrangement the traveling wave tube may untilize a slow-wave structure having multiple helical conductors **15** as shown in FIGS. 1–3 or a single helical conductor **15'** as shown in FIG. 4.

Slow-wave structure **14** comprises one or more conductors of helical configuration having a helix diameter relatively small compared to the wavelength of an applied electromagnetic wave in free space. The helical conductors are made of such a length as to produce the desired gain in the tube. The axial length of helical conductors commonly used in traveling wave tubes is usually many wavelengths long; i. e. from about twenty to fifty wavelengths. When the length of the helical conductors is made very long, the increment of length over an optimum length becomes increasingly less effective in the conversion of beam energy into electromagnetic energy.

The helical conductors **15** are mounted in the envelope **11** so that the helical conductors are concentric with respect to the electron beam from the electron gun **12**. Suitable elongated insulating supporting members or dielectric rods **16** are used to hold or wedge the helical conductors **15** in the cavity formed in the envelope **11** in proper alignment with the electron beam, as is more clearly shown in FIG. 2. The ends of the helical conductors **15** are connected to input and output couplers **20** and **21** respectively which are in turn respectively connected to coaxial connectors **22** and **23** located at the collector end of the envelope **11**. Input coaxial connector **22** is connected to a suitable source of electromagnetic waves which may be applied through input coupler **20** between the beam entrance end of helical conductors **15** and electron gun **12**, and which may be removed from output coaxial connector **23** through output coupler **21** between the beam exit end of helical conductors **15** and collector **13**.

A D.C. voltage is supplied to the helical conductor through conductor **24** and serially connected radio frequency coil **25**. Radio frequency coil **25** serves to isolate electron gun **12** and prevents radio frequency energy from helical conductors **15** from feeding into the electron gun region. External electrical connections to the electron gun **12** and the helical conductors **15** are made in a manner well known in the art through dielectric seal **29** of electron gun **12** to a suitable power source.

If desirable, a coolant may be arranged to circulate through the envelope **11** to aid in the dissipation of heat. To this end, coolant fittings are provided at the collector end connected to suitable coolant channels **27, 28** extending longitudinally through the envelope **11**. The coolant, thus, not only passes around the collector **13**, but also along the tube body or envelope **11**.

To protect the electron gun **12** from the hazards of external shock and vibration, there is provided a protective guard **30** having access holes **31**. The protective guard **30** surrounds the electron gun **12** and is constructed from the same material as the main body member or envelope **11**. A suitable plug **32** is provided for conveniently making the external electrical connections. The electron gun and electrical connections are mounted within the metal protective guard **30** in such a way that if any extremity of the tube is accidentally hit, the shock is concentrated on the metal parts and not on the relatively fragile electron gun structure.

FIG. 2 shows a cross-sectional view of the traveling wave tube of FIG. 1, and in particular illustrates the positioning of the helical conductors **15** of composite slow-wave structure **14** and the insulating supporting members or dielectric rods **16**. Slow wave structure **14** and rods **16** form a slow-wave assemblage. The main body member or envelope **11** is provided with a longitudinally extending recess or groove **40** for receiving the slow-wave assemblage. The groove **40** may be sealed at its upper end by suitable means such as a cap or plug member **41** to form a central cavity **42** within the envelope **11**. As shown in FIGS. 1 and 2, the cavity **42** is centrally located along the length of the envelope **11** and extends longitudinally thereof.

The helical conductors **15** are suspended by a plurality of dielectric rods **16**, which may be for example four, as shown in FIG. 2, disposed about the helical conductors **15** and extending axially along the length thereof. The slow-wave structure **14** may be assembled within the elongated groove **40** and positioning of the plug member **41** within the groove provides an extremely tight fitting assembly. After positioning of the plug member **41**, it may be secured in place by welding, brazing or any other suitable joining or bonding process adapted for the particular material utilized.

During heating of the members for the welding operation, the plug member **41** is forced against the dielectric rods **16** and expands inwardly. Member **41** is then welded in place. Upon cooling, the metal body member shrinks longitudinally, as well as radially, to compress the dielectric rods **16** against the helical conductors **15** and form a rigid sub-assembly. To avoid the problem of excessive longitudinal compression, the dielectric rods **16** may be segmented longitudinally and the segments assembled with small spaces between the segmented sections. Since the helical conductors **15** are under compression from the metal body member or shield at all points, the relation of one part of a helical conductor to another part is held by the envelope and not by the dielectric rods.

The dimensions of the solid body member or envelope **11** may be varied as desired to provide an extremely rugged, shock resistant device, and in addition, since the inner walls of the formed cavity surround the slow-wave structure, the envelope **11** serves as an effective shield for the slow-wave structure **14**.

It should be readily apparent that the envelope **11** is readily adapted to support various arrangements of slow-wave structures for traveling wave tubes using one or more helical conductors. FIG. 4 illustrates a cross-sectional view of the traveling wave tube similar to that of FIG. 2, but replacing the multiple helical conductor slow-wave structure of FIG. 2 with a single helical conductor slow-wave structure.

The provision of a substantial surface area facing the slow-wave structure **14** and a substantially solid metal body of good thermal conductivity for the envelope **11** permits the dissipation of a large amount of heat power to permit operation at high ambient temperatures, for example, in the region of 250° C. To further increase the heat-dissipating qualities of the traveling wave tube **10**, the dielectric rods **16**, which conventionally are formed from glass or ceramic, may be replaced by rods of greater heat conductivity, such as sapphire.

In the operation of the device of FIG. 1 as a forward traveling wave amplifier having a single helical conductor slow-wave structure, such as shown in FIG. 4, a high frequency signal from a suitable source is applied through the input coaxial connector **22** and the input coupler **20** between the electron beam entrance end of the helical conductor **15'** and electron gun **12** to initiate a wave on the helical conductor **15'**. As previously mentioned, the helical conductor **15'** is arranged such that application of signals thereto produces an electromagnetic wave having a component of electric field which is directed along the axis of the helical conductor **15'** and which travels at a velocity substantially less than the free space velocity of the electromagnetic wave. This velocity of the electromagnetic wave along the axis of the helical slow-wave structure **14** is commonly referred to as the phase velocity. The average velocity of the electron beam is adjusted to be slightly greater, i.e., about ten to fifteen percent, than the velocity of the aforementioned axially-directed component of electric field or phase velocity. Under these conditions the electromagnetic wave on the helical conductor interacts with the electron beam and a net interchange of energy from the beam to the electromagnetic wave is effected. Thus, as the wave travels along the helical conductor from the entrance to the exit end thereof, it is continuously augmented in amplitude. A wave of augmented amplitude is taken from the output coupler **21** and translated through the output coaxial connector **23** to a suitable utilization or load circuit.

The exact nature of the fields associated with the slow-wave structure and their modes of propagation are complex. However, it is generally recognized in traveling wave tubes that traveling wave structures will support a number of traveling waves including a forward traveling wave and a reflected traveling wave. When traveling wave tube devices are suitably energized, both the forward traveling wave and the reflected traveling wave may appear on the structure.

In order to minimize the effect of the reflected traveling waves on the operation of the device, attenuators may be placed along the helical conductors to attenuate the reflected traveling waves. Each attenuator may take the form of conductive strips distributed along the length of the dielectric rods **16**. Aquadag, an aqueous suspension of graphite, commonly used in the electron tube art because of its good heat absorption properties, is suitable for this purpose.

Additionally, backward waves may appear on the structure. In present usage, the term backward wave has been applied to any space-harmonic component of a propagated wave which has phase and group velocities in opposite directions. The most important of such space-harmonic components as far as traveling wave tubes are concerned is the so-called minus one component. When this component is present, the tube will tend to oscillate at a frequency for which the phase velocity of this minus one component is nearly equal to the velocity of the beam. The frequency of oscillation is considerably higher than, for example, two to three times, the normal operating frequency of the tube, but nevertheless, it interferes with normal operation. The presence of the attenuator does not appreciably affect this backward wave interaction, except to determine the length of the tube over which the interaction can take place.

Many things affect the beam current level at which this type of oscillation starts, and some traveling wave tubes are not troubled by it. For example, when using multiple helical conductor slow-wave structures, the introduction of an effective velocity spread in the various beams (by operating them at different velocities) reduces the tendency of a tube to backward wave oscillate. Since the oscillation frequency is normally very much a function of beam velocity, a number of velocities would "confuse" the operation with regard to the backward waves. At the same time, such a velocity spread, if moderate, does not have too much of an effect on the normal forward wave interaction.

In a single helical conductor slow-wave structures where only a single beam is available, the spurious output caused by the backward wave mode may prove objectionable. It is known that a stop band or band pass filter may be employed to reduce the backward wave interaction. In accordance with one aspect of this invention, a stop band is constructed in the envelope. As shown in FIG. 3, a periodic discontinuity is provided in the plug member **41** by machining transverse slots **42'** with a periodicity so as to cause a stop band to be at the frequency of backward wave oscillation. Additional discontinuity slots **43** may be placed in the bed of the envelope **11** on which the helix structure is assembled.

Referring particularly now to FIG. 2, there is shown a composite slow-wave structure **14** consisting of four helical conductors **15**, each having the same diameter, pitch and axial length. Each of the helical conductors of FIG. 2 are wound in the same sense, that is they may be all wound right-handed or all wound left-handed. With such an arrangement, each helical conductor contacts two other adjacent helical conductors along their length at points that are spaced a turn apart. The resultant composite structure **14** may be associated with a composite electron gun which projects a beam of electrons down the axis of each helical conductor **15** or with an electron gun which produces but a single beam. Thus, a particularly useful manner of operation of the slow-wave structure of FIG. 2 is in conjunction with beam-producing means forming a single beam axially directed through axial opening **65** of the composite helical structure.

When utilizing a multiple slow-wave structure, the considerations entering into the design and construction of the individual conductors are very similar to the considerations used for traveling wave tubes employing a single helical conductor. The helical conductors are arranged so that, when viewed in cross-section, their axes, when joined, form the four sides of a rectangle, each side of which is equal to the diameter of the helix formed by each of the conductors. With such an arrangement, the helical conductors are in conductive contact along the entire length thereof at points one turn apart as measured along the helical conductors. Conductive engagement of the conductors may be assured by soldering or brazing the conductors at the points of contact.

Referring to FIG. 5, there is shown a slow-wave structure providing a large amount of conductive surface or attenuator area for minimizing the effect of reflected waves and for providing excellent heat dissipation qualities. The slow-wave structure comprises eight dielectric rods **66** through **73** disposed adjacent a composite array of four helical coils. Suitable slots or reliefs **74** and **75** may be provided in the plug member **76** and envelope **77** to provide ample electrical clearance between the slow-wave structure and the envelope. The dielectric rods **66** through **73** provide an abundance of surface area for application of an attenuator, such as Aquadag, for minimizing the effect of reflected traveling waves and increasing the heat dissipation. This arrangement produces only minor dielectric loading since only a relatively small part of the circuit, hence only a small part of the total electric field, is near the material of the rods.

FIGS. 6 and 7 show two ways in which the dielectric rods for the composite slow-wave structure may be constructed and arranged to reduce the dielectric loading factor. Referring to FIG. 6, each dielectric rod **80** has a portion of the dielectric material removed or cut out as at **81**. The cut-out portion may be wedged-shaped, as shown, and the dielectric rods are arranged at the four corners of the cavity **82** within the envelope **83**. FIG. 7 shows an alternate arrangement where dielectric rods **84**, polygonal shaped in cross-section, are disposed adjacent each pair of helical conductors forming the composite helical structure. Each dielectric rod **84** has one of its sides in juxtaposition with one of the surfaces forming the cavity **82**. The corners of the dielectric rod **84**, opposite the abutting side, contact adjacent coil members **85** to hold them rigidly in place.

In FIG. 8 there is shown a further arrangement in which a single helical conductor **85′** is supported by four dielectric rods **86** within the envelope **87**. The envelope is rectangular and comprises a main body member **88** and a cap member **89**. The main body **88** and cap **89** are machined to provide an extremely tight fit so that the parts can be pre-assembled, that is, assembled with the slow-wave structure inside the groove provided in the main body **88**.

If desired, the structure can be constructed as shown in FIG. 9 with the cap **90** being secured on the upstanding leg portions **91** and **92** of the main body member **83**. The use of a rectangular recess and metals of high thermal expansion permits accurate machining and enables a tight fit to be obtained between adjoining members and an effective seal when the members are bonded. An extremely tight fit may be achieved by securing the plug or cap and main body member or envelope with several turns of molybdenum wire or other low expansion alloy wire wrapped around the circumference of the structure. This places the structure under compression during the increase in temperature as the envelope and plug or cap are welded. On cooling, the envelope shrinks tight on the helix and support rod assembly placing it under compression. An alternative arrangement is to place a weight or apply a force on the top of the plug or cap to hold the assembly snug during the welding operation.

It should be readily apparent that several arrangements of the helix and dielectric support rods assembly may be made using one or more dielectric rods and one or more helical conductors. In addition, the plug or cap and body member forming the cavity for the slow-wave structure in the envelope may be shaped in accordance with the arrangement chosen.

For example, the plug member may be shaped as illustrated in FIG. 10. The plug member **95** is provided with

an upwardly extending triangular recess **96**. The helical conductor **97** is supported by three dielectric rods **98** disposed around the helical conductor **97**. The axes of the dielectric rods, viewed in cross-section, form, when joined, a triangle whose sides are spaced from the adjacent faces of the plug member **95** and envelope **99** by a distance equal to the radius of the rods **98**. The arrangement thus provides a rigid, compact structure capable of withstanding severe shock.

From the foregoing description, it is apparent that there is provided a mechanically rugged and electrically effective traveling wave capable of high frequency and high power operation. To this end there is provided a substantially solid body member or envelope which combines the electron gun, the slow-wave structure and the collector within the envelope. The envelope is provided with a longitudinally extending groove within which the slow-wave structure is mounted. The grove is plugged or capped to place the slow-wave structure under compression and to hold the slow-wave structure rigidly in place. The solid envelope serves to protect the internal elements from shock and vibration, and provides a large surface area for effective heat dissipation.

Although particular embodiments of the subject invention have been described, many modifications may be made, and it is intended by the appended claims to cover all such modifications which fall within the true spirit and scope of the invention.

What is claimed is:

1. A traveling wave tube of the type wherein an electron beam interacts with a traveling wave comprising: a substantially solid body member having a central cavity and a wall thickness approximately equal to the size of the cavity and including an electron source for providing the electron beam, a slow-wave assemblage arranged in energy interchanging relationship with said electron beam and a collector arranged to intercept said electron beam, said electron source and collector being disposed within said body member, said body member having a longitudinally extending rectangular recess therein for receiving said slow-wave assemblage, said recess beginning at the outer surface of the body member and communicating with the central cavity, and means extending along the length of said recess for maintaining said slow-wave assemblage mechanically tight within said cavity of said body member.

2. The traveling wave tube set forth in claim **1** wherein said means for maintaining said slow-wave assemblage mechanically tight comprises a plug member disposed within said recess and joined to said body member for sealing said recess and maintaining said slow-wave assemblage under compression transverse to the axis of the slow-wave assemblage.

3. The traveling wave tube set forth in claim **1** wherein said means for maintaining said slow-wave assemblage mechanically tight comprises a cap member extending over said recess and joined to said body member for sealing said recess and maintaining said slow-wave assemblage under compression transverse to the axis of the slow-wave assemblage.

4. The traveling wave tube as set forth in claim **1** wherein said slow-wave assemblage comprises at least one elongated helical coil and an array of spaced insulating rods surrounding and engaging said helical coil.

5. The traveling wave tube as set forth in claim **4** wherein said insulating rods are sapphire.

6. An electron discharge device of the type wherein an electron beam interacts with a traveling wave tube comprising: a substantially solid body member having a central cavity and a wall thickness approximately equal to the size of the cavity, and including an electron source for providing the electron beam, a slow-wave assemblage arranged in energy interchanging relationship with said electron beam and a collector arranged to intercept said electron beam, said electron source and collector being disposed within said body member, said body member comprising a thermally conductive, non-magnetic material having a longitudinally extending rectangular recess therein for receiving said slow-wave assemblage, said recess beginning at the outer surface of the body member and communicating with the central cavity, and means extending along the length of said recess, said means being joined to said body member and formed of the same material as said body member for sealing said recess and maintaining said slow-wave assemblage mechanically tight within said cavity of said body member.

7. The traveling wave tube set forth in claim **6** wherein said thermally conductive, non-magnetic material is metal.

8. The traveling wave tube as set forth in claim **7** wherein said thermally conductive, non-magnetic, metallic material is selected from the group consisting of stainless steel, copper, brass and Monel metal.

9. An electron discharge device of the type wherein an electron beam interacts with a traveling wave comprising: a substantially solid, thermally conductive, non-magnetic, metallic body member having a central cavity and a wall thickness approximately equal to the size of the cavity, an electron source mounted at one end and within said body member for providing an electron beam, a collector mounted at the other end and within said body member, said collector being arranged to intercept said electron beam, a slow-wave assemblage centrally mounted between said electron source and said collector in energy interchanging relationship with said electron beam, said body member including a longitudinal rectangular recess for supporting said slow-wave assemblage said recess beginning at the outer surface of the body member and communicating with the central cavity, and means formed of the same material as said body member extending along the length of said recess and joined to said body member for sealing said recess and maintaining said slow-wave assemblage mechanically tight and under compression transverse to the axis of the slow-wave assemblage within said cavity of said body member.

10. The traveling wave tube as set forth in claim **9** wherein said thermally conductive, non-magnetic, metallic material is selected from the group consisting of stainless steel, copper, brass and Monel metal.

11. A traveling wave tube of the type wherein an electron beam interacts with a traveling wave comprising: a substantially solid body member having a central cavity and a wall thickness approximately equal to the size of the cavity, and including an electron source for providing the electron beam, a slow-wave assemblage arranged in energy interchanging relationship with said electron beam and a collector arranged to intercept said electron beam, said electron source and collector being disposed within said body member, said body member having a longitudinal rectangular recess for receiving said slow-wave assemblage said recess beginning at the outer surface of the body member and communicating with the central cavity, and means extending along the length of said recess and joined to said body member for sealing said recess and maintaining said slow-wave assemblage mechanically tight and under compression within said body member, said means having transverse slots facing said cavity for minimizing backward wave interaction.

12. A traveling wave tube of the type wherein an electron beam interacts with a traveling wave comprising: a substantially solid body member having a central cavity and a wall thickness approximately equal to the size of the cavity and including an electron source for providing the electron beam, a slow-wave assemblage and a collector arranged to intercept said electron beam, said electron source and collector being disposed within said body member, said body member having a longitudinal rectangular recess for receiving said slow-wave assemblage said recess beginning at the outer surface of the body member and communicating with the central cavity, said cavity being provided with transverse slots for minimizing backward wave interaction, and means extending along the length of said recess and joined to said body member for sealing said recess and maintaining said slow-wave assemblage mechanically tight and under compression transverse to the axis of the slow-wave assemblage within said body member.

References Cited by the Examiner

UNITED STATES PATENTS

2,813,990	11/1957	Robertson	315—3.5 X
3,107,312	10/1963	Kennedy	315—3.5

FOREIGN PATENTS

947,566	1/1964	Great Britain.

HERMAN KARL SAALBACH, *Primary Examiner.*

R. D. COHN, E. LIEBERMAN, *Assistant Examiners.*