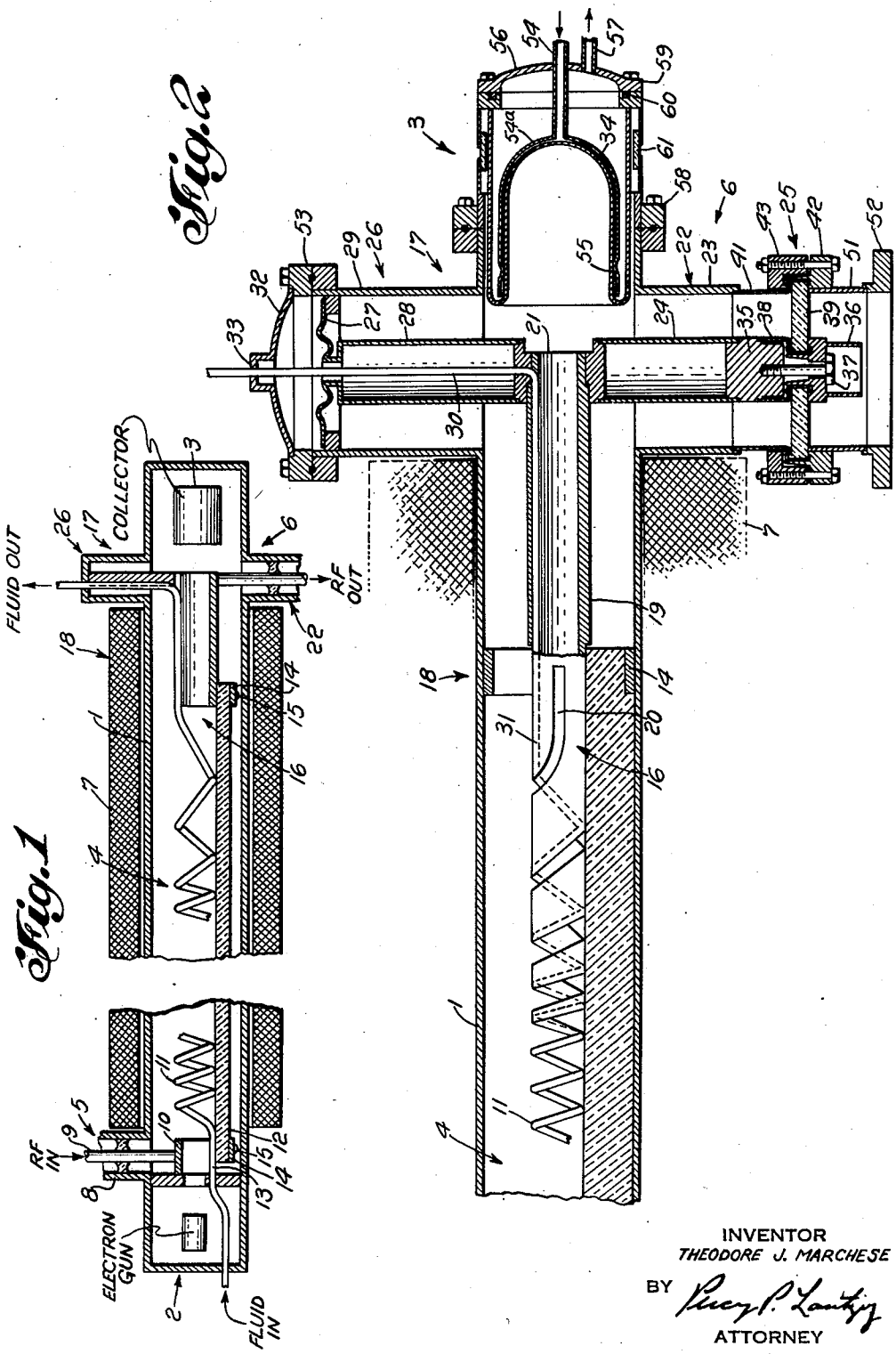
May 6, 1958 T. J. MARCHESE 2,833,955

TRAVELING WAVE ELECTRON DISCHARGE DEVICES

Filed Feb. 4, 1954 2 Sheets-Sheet 1



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Filed Feb. 4, 1954 2 Sheets-Sheet 2

Fig. 3

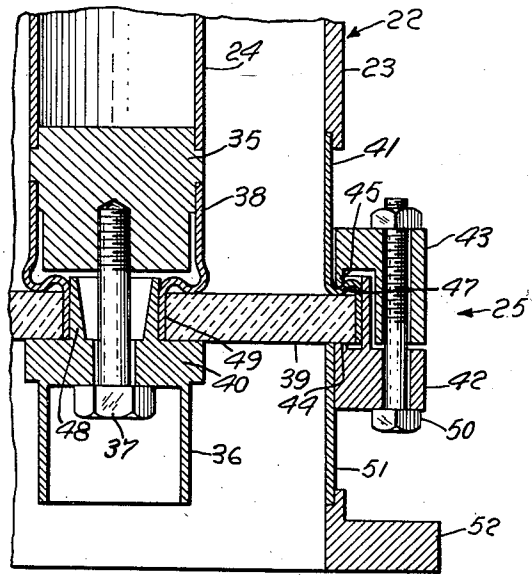


Fig. 4

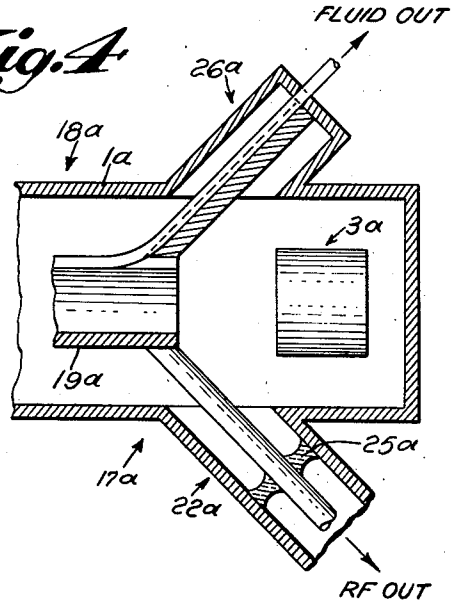


Fig. 5

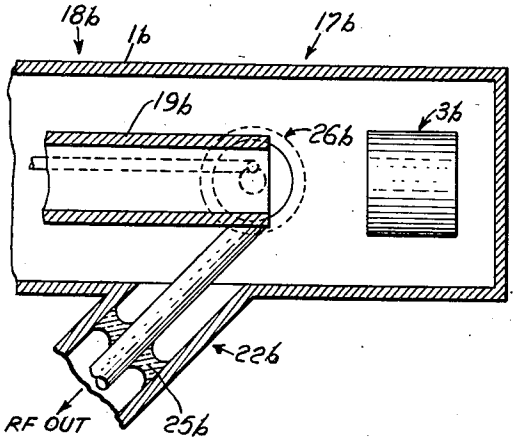
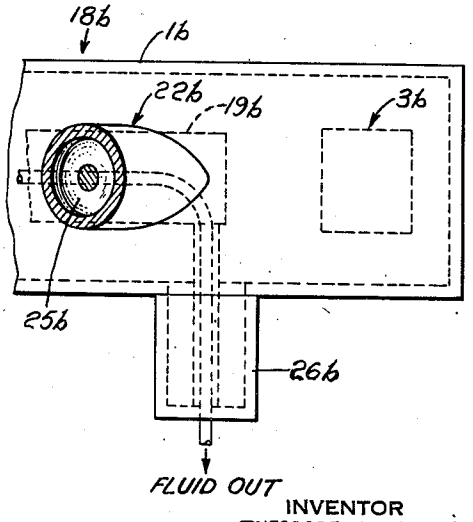


Fig. 6



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United States Patent Office 2,833,955 Patented May 6, 1958

2,833,955

TRAVELING WAVE ELECTRON DISCHARGE DEVICES

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Application February 4, 1954, Serial No. 408,266

20 Claims. (Cl. 315—3.5)

This invention relates to traveling wave electron discharge devices and more particularly to means for extracting radio frequency energy therefrom having practical application in high power traveling wave amplifier types.

Traveling wave amplifier tubes heretofore proposed have been of relatively low power and have been cooled by heat radiation from the components of the electron discharge device. However, when the power handling capability of a traveling wave electron discharge device is increased above say a kilowatt, it is necessary to provide a coolant to dissipate the heat.

An object of this invention is to provide a traveling wave tube having a structural configuration capable of being adapted to provide passages for a fluid coolant to increase the dissipation of heat from the transmission line and collector anode thereof.

Another object of this invention is to provide a furcated means at the output portion of the traveling wave electron discharge device capable of handling without interaction the three different energies present in the electron beam, the radio frequency energy and the fluid coolant.

A further object of this invention is to provide a novel combination of elements at the output portion of the traveling wave electron discharge device for matching the energy on a helical transmission line to a conventional coaxial type transmission line.

A feature of this invention is the provision of a furcated microwave energy junction having a transition section in a first branch thereof coupled to the helical propagating structure and a shorting element in a second branch thereof to cooperate with said first branch in transducing radio frequency energy from said propagating structure to a conventional microwave transmission line through a third branch of said junction. The first branch is adapted to pass the electron beam axially thereof to a water-cooled collector anode, and the second branch includes a passage for the circulation of a fluid coolant through said transmission line.

Another feature of this invention provides a furcated coaxial transmission line junction including a transition section as the inner conductor of a first branch thereof, said transition section including a cylinder having a helical slot longitudinally thereof whose pitch is gradually varied from an infinite pitch adjacent the junction of said branches to a pitch corresponding to the uniform pitch of a helical propagating structure. Cooperating with said first branch is included a second branch having shorted inner and outer conductors to provide a matched transition of energy from the propagating structure to a third branch of said junction for ultimate utilization of the energy externally of the traveling wave device.

A further feature of this invention is the provision of a novel metal to ceramic seal included in the third branch of the furcated junction device to provide a vacuum closure for a traveling wave electron discharge device, said seal incorporating as an intimate portion thereof

atmospheric terminal means for extraction of energy from said device.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic illustration in longitudinal section of a traveling wave electron discharge device incorporating a furcated microwave energy junction as the radio frequency energy output means in accordance with the principles of this invention;

Fig. 2 is a longitudinal sectional view illustrating the details of the radio frequency output means of this invention;

Fig. 3 is an enlarged sectional view of the radio frequency extracting branch of the furcated junction illustrating the metal to ceramic seal of this invention;

Figs. 4 and 5 are schematic sectional illustrations of other embodiments of the furcated microwave energy junction of this invention; and

Fig. 6 is a bottom plan view of Fig. 5.

Referring to Fig. 1, there is illustrated schematically a high power traveling wave electron discharge device capable of amplifying radio frequency energy having a power output in the order of 10 kilowatts. The traveling wave device is shown to comprise an envelope 1 enclosing the internal structure thereof, consisting of a non-magnetic material, such as Monel. At one end of envelope 1 is disposed an electron gun unit 2 for projecting an electron beam along the axis of envelope 1 toward the collector anode assembly 3 disposed at the opposite end of envelope 1. Intermediate electron gun unit 2 and collector assembly 3 is disposed an interaction section 4 adjacent the axial path of the electron beam to provide a means for propagating radio frequency energy therealong in an interacting relation with the electrons of the beam. An input coupling means 5 disposed adjacent electron gun unit 2 provides a means for coupling radio frequency energy into interaction region 4 whose primary purpose is the amplification of the thusly injected radio frequency. The amplified radio frequency energy is coupled from the interaction region 4 for further utilization by means of output coupling means 6 disposed adjacent collector assembly 3.

The electron gun unit 2 may take any known configuration including the necessary electrodes therein to provide an electron beam for travel axially of envelope 1. In high power operation, the unit 2 should provide an electron beam having high current density. A unit 2 capable of providing the required high current density would, for example, be of the rectilinear type; that is, the electrons leave the surface of the cathode normal thereto and travel in parallel paths along the axis of envelope 1, said gun unit having a rating in the order of 6,000 volts and 5 amps. To keep the beam collimated, the entire traveling wave device is immersed in an axial magnetic field as provided by a solenoid 7 or a permanent magnet structure replacing solenoid 7 as taught in the copending application of J. H. Bryant, Serial No. 318,060, filed October 31, 1952, or in the copending application of J. H. Bryant and H. W. Cole, Serial No. 321,342, filed November 19, 1952, now abandoned.

The radio frequency input transmission line 8, illustrated as being a coaxial type, forms a component of input coupling means 5 with the inner conductor 9 thereof being connected to transformer section 10 extending from gun unit 2 to the interaction section 4. Transformer 10 has the primary purpose of matching the impedance of transmission line 8 to the helical transmission line 11 forming the primary component of the interaction section 4. This impedance match between the input radio

frequency line and the helical propagating structure is necessary to provide a substantially reflectionless transfer of energy from a low impedance transmission line having an impedance in the order of 50 ohms to a high impedance helical transmission line having an impedance in the order of 600 ohms.

Referring to the interaction section 4, there is illustarted therein transmission line or propagating structure 11 formed from a hollow tubing in a manner to provide a helical propagating structure supported axially of the envelope 1 by means of ceramic support members 12. Transformer section 10 is adapted to have a passage therethrough as indicated at 13 to provide through section 10 and helix 11 a passage to enable the circulation of a fluid coolant for achievement of the desired dissipation of heat developed on propagating structure 11 by interception of the electron beam and by the ohmic losses of the R.-F. energy. In considering the support members 12, an ideal support should hold each turn of helix 11 rigid with respect to the helix axis and to all other turns, it should have minimum effect on the electromagnetic wave traveling therealong and it should be mechanically strong to withstand shock and vibration. The preferred material for the helix supporting members 12 is, of course, ceramic. A circular yoke 14 in cooperation with screws 15 disposed at each extremity of the interaction section 4 is employed to hold three helix supports 12 on a 120° spacing. The ceramic supports 12 engage transformer section 10 at the electron gun unit end of the envelope 1 and engage transition section 16 at the collector end of envelope 1 to establish the necessary axial alignment thereof. If the yoke 14 is made of spring material, such a molybdenum, the assembly may be spring loaded. An alternative to the positioning of support members 12 is to increase the radial thickness of the support members to engage the envelope 1 wherein the envelope 1 is utilized to hold these three supports on a 120° spacing.

As is the case in all traveling wave electron discharge devices, a certain amount of energy propagating along structure 11 will be reflected from the output coupling means back along propagating structure 11 causing an undesired oscillation to occur in the interaction region of a traveling wave electron discharge device. It has been recognized in the prior art that the application of a lossy material to a given portion of the interaction section will absorb the reflected waves and thereby reduce the possibilities of undesired oscillations. In the interaction region 4 of the traveling wave electron discharge device herein disclosed, it is to be understood that there is disposed a suitable attenuating material, such as aquadag, adjacent the electron gun end of region 4 in contact with the support members 12 or the structure 11 itself to provide the desired absorption of reflected wave energy.

The structural arrangement of electron gun unit 2, the collector anode 3, the interaction section 4 and the input coupling means 5 within envelope 1 in a coacting relationship has been established. The presence of three different energies within this structural organization presents a problem of matching the propagating structure 11 to an output transmission line for undisturbed transfer of amplified radio frequency energy out of the traveling wave electron discharge device to a desired utilization means and at the same time provide means for passage of the beam electrons to the anode of collector assembly 3 and the circulation of a coolant for cooling the propagating structure 11. The microwave junction section incorporated as means 6 satisfies the above requirements for handling the three energies independently, and is illustrated in Fig. 2 as a universal T-type junction section 17.

The drawing of Fig. 2 illustrates that output coupling means 6 includes a furcated microwave junction section 17 having a first branch or arm 18 including therein transition section 16 to cooperate in matching the high impedance of the structure 11 to the nominal 50 ohm impedance normally associated with coaxial type transmission lines. Transition section 16 is coaxial of envelope 1 and includes a cylinder 19 having a helical slot 20 therein whose pitch is gradually varied from an infinite pitch adjacent the junction of the branches of said junction section to the pitch of the uniform helix forming structure 11. The transition section 16 may be configured to transform wave energy from a helix to a coaxial type transmission line with small values of reflection coefficient over a wide frequency range such as normally employed in traveling wave type electron discharge devices. Other advantages of such a transition is the fact that it behaves as a transducer between a helical structure and a coaxial line with reasonable dimensions of the center conductor and is mechanically rigid compared with the kind of transition where the helix wire has the same dimension over the transition. Further, transition section 16 encloses the electron beam, introducing little if any, distortion into the electron optical system and allows the beam to pass axially thereof to collector assembly 3 by means of passage 21. Energy traversing section 16 is transformed from its helical mode of propagation to a TEM mode of propagation.

A second branch or arm 22 of junction section 17 includes an outer conductor 23 connected to envelope 1 which is maintained at a reference potential, normally ground, and an inner conductor 24 is connected to cylinder 19 of transition section 16. The coaxial structure of branch 22 enables the coupling of transduced energy from section 16 propagating in a TEM mode to an external coaxial transmission line (not shown) for ultimate utilization of the derived interacted energy. Branch 22 further includes as a component thereof a ceramic to metal seal 25 to assure a vacuum enclosed system for envelope 1 and to provide a support for atmospheric terminal means for connection of an external transmission line thereto for utilization of the radio frequency energy passing through the device. As an embodiment of the structure described, the physical size of structure 11 and section 16 required the use of a 3" external coaxial line for coupling to branch 22 of junction 17.

A third branch or arm 26 of section 17 cooperates with branch 18 and branch 22 to assure a reflectionless transfer of radio frequency energy from structure 11 to the external coaxial transmission line. This cooperation is afforded by a diaphragm 27 disposed crosswise inner conductor 28 and outer conductor 29 in a manner to reflect a predetermined condition at the junction between cylinder 19 and conductor 24 of branch 22. Branch 26 further functions to provide a passage 30 in the form of a tube associated with inner conductor 28, continuing the fluid passage established by the tubing of structure 11 and the passage 31 disposed in transition section 16 for adequate circulation of fluid coolant to remove heat from these structures. Passage 30 is extended through diaphragm 27 to end cap 32 and, hence, through nipple 33 to an external circulation arrangement (not shown).

The junction 17 when conventionally employed in broadband applications is used as a junction and as a bend. The application of the T-type furcated microwave junction in combination with a traveling wave tube functions as a bend to match the output transmission line (not shown) to the helical propagating structure 11 to afford a smooth transfer of energy therebetween. The structure of junction 17 further provides separate paths for the projection of the electron beam onto the anode of assembly 3 and the coolant passing internally of the material forming propagating structure 11 and structures associated therewith.

Having completed its interaction with the wave energy on propagating structure 11, the electron beam passes

through the hollow axial region of transition section **16** and emerges through the orifice **21** for collection by anode **34** of the collector assembly **3**. If there is no collimating magnetic field in this latter region, as is the case in the electron discharge device being described, the beam will spread and its power density upon reaching anode **34** will be a function of the amount of electron beam spread.

As is the case in all electron discharge devices, it is desirable to provide a complete vacuum system. As is the usual practice a vacuum seal is incorporated in the structure of the gun unit **2** and the assembly **3**. In the device therein disclosed, it is also necessary to provide a vacuum closure for branches **22** and **26** of junction **17**.

Branch **22** includes a seal **25** as an integral portion thereof in a contiguous relation with conductors **23** and **24**. An enlarged view of the structure of seal **25** is illustrated in Fig. 3 as including copper transition piece **35** inserted within inner conductor **24** which serves as a vacuum closure therefore and a lug to which the outer or atmospheric parts of the terminal means may be bolted, as is indicated by the inner conductor fitting **36** and bolt **37**. Fitting **36** may be proportioned to accommodate standard RTMA type coaxial type transmission lines. Concentrically disposed about and engaging the lower extremity of transition piece **35** is disposed an inwardly extending shouldered metallic cylinder **38**, an electrical continuation of conductor **24**. Cylinder **38** is composed of metal suitable for brazing to the ceramic washer or annulus **39** disposed crosswise branch **22** to be engaged by the shoulder of cylinder **38** on the top thereof and on the edge of the axial aperture **40** as illustrated. By suitable metal for cylinder **38** is meant a metal having suitable expansion characteristics.

The outer conductor **23** is extended by the outwardly extending shouldered cylinder **41**, similar in shape to cylinder **38**, for engagement of the outer periphery of ceramic annulus **39** to assure a vacuum tight seal between the vacuum portions of the traveling wave tube electron discharge device and the atmospheric parts attached thereto. Flanges **42** and **43** having lip portions **44** and **45**, as indicated in the drawing, engage the bottom surface of annulus **39** and the concave portion **47** of cylinder **41** to cooperate with annulus **39** and cylinder **38** to maintain a vacuum tight closure free from stresses other than compressional. It will be likewise recognized that the fitting **36** is configured to have a tapered portion **48** for insertion in aperture **40** to maintain a compressional force upon the lower portion **49** of cylinder **38** and bead **39** by means of bolt **37**.

The appropriate tension and tightness is likewise maintained on flanges **42** and **43** by employment of the bolt **50** extending therethrough at appropriately spaced locations about the circumference thereof. Flange **42** has secured thereto cylinder **51** carrying therewith an outer conductor fitting **52** which in cooperation with fitting **36** will accommodate a standard RTMA type coaxial transmission line.

The ceramic to metal seal as provided by annulus **39** and the associated shouldered cylinders is effected by first applying a glaze of suitable expansion characteristics to both the ceramic annulus **39** and the metal portions of cylinders **38** and **41** at contact points thereof. The reentrant aspect of the metal cylinders **38** and **41** makes it possible to isolate the sealed portion from external forces. The sealing flange system including flanges **42** and **43** is designed to apply a purely compressive stress to the seal system. On flange **43**, an annular lip **45** is shown in contact with the convolution in the metal cylinder **41**. On flange **42**, an annular lip portion **44** insures that the stress is normal to the peripheral surface of the ceramic annulus **39**. The annular lip **44** provides an electrical contacting arrangement, as well as applying the required normal stress, for the purpose of conducting R.-F. current to an external coaxial system. As is obvious from the accompanying drawing a sealing arrangement on the inner conductor is substantially identical to the sealing arrangement on the outer conductor in that a normal stress is applied to the walls of the axial aperture **40** thereby cooperating in isolating the sealed portion from external forces.

Referring to Fig. 2, branch **26** of the junction **17** is illustrated as including a tubing or passage **30** for carrying the fluid coolant from section **16** to the output nipple **33**. As hereinabove discussed, the coolant fluid traveling from the electron gun end of envelope **1** through the propagating structure **11** and hence to the output nipple **33** is employed to carry heat away from certain electrodes of unit **2** and that heat developed on the helical propagating structure **11**. There is provided in arm **26** a corrugated diaphragm **27** functioning to enable a differential expansion of the inner and outer conductors of arms **22** and **26** and also as an R.-F. short circuit between conductor **28** and conductor **29** to cooperate in the non-reflective transmission of the radio frequency energy from the transition section **16** down arm **22** and hence to the output coaxial transmission line adapted to be connected to the fitting **36** and **52**. To assure that the vacuum system is maintained, a copper gasketed flanged vacuum seal **53** is provided to seal conductor **29** by means of end cap **32**.

Having now discussed somewhat in detail the incorporation of a T type furcated junction section as the output means of a traveling wave electron discharge device, the arrangement and interconnection of the collector assembly **3** to envelope **1** will be described. Collector assembly **3** includes the collector anode **34** having a bell shape. Anode **34** is enclosed by member **54***a* having as an integral component thereof fluid input means **54**. Member **54***a* is spaced slightly from the rear surface of anode **34** by dimples **55** thereby providing a chamber of fluid coolant surrounding anode **34**. The anode **34** is extended in a reentrant manner from the active portion thereof to form a fluid closet or reservoir between member **54***a* and end cap **56**, said end cap **56** having an output passage **57** therethrough to provide a circulation of the coolant in contact with the active collector anode **34**. The collector assembly **3** is secured to the envelope **1** by means of the copper gasketed flange **58** which also functions to maintain a vacuum tight system in cooperation with end cap **56** and O-ring gasket assembly **59**, said O-ring gasket assembly including an O-ring gasket **60** to provide a water tight anode assembly. To insulate collector assembly **3** electrically from the envelope **1**, there is provided an insulator **61** which enables the application of an electrical potential to the collector anode different substantially from the potential applied to the envelope **1**, said potential difference being essential for the efficient operation of a traveling wave electron discharge device.

In operation, the electron discharge device herein described is immersed in the magnetic field producing means **7** up to cross branches **22** and **23** of the T-type furcated junction section **17**. This means that the magnetic field terminates for all practical purposes at these cross branches. The electron beam projected axially of the propagating structure **11** and the output coupling means **6** starts to spread due to inherent electron forces immediately upon leaving the region of the magnetic field. By careful construction of the elements within the traveling wave electron discharge device, it is possible to control the shape of the beam divergence after leaving the magnetic field such that the R.-F. transmission components including the helical propagating structure **11** and the transition section **16** do not intercept an undue amount of electron current. Practically all of the beam electrons land on the collector anode **34** and thereby the quantity and the rate of flow of coolant as well as the shape of collector anode **34** must be adequately controlled for removal of the heat generated by the bombarding electron beam.

The description hereinabove with reference to Figs. 2 and 3 has been directed toward a T-type furcated microwave junction section. It is to be understood, however, that the junction section **17** is not limited to that configu-

ration where the branches extending from the axis of the envelope are perpendicular thereto and 180° with respect to each other. Several representative alternative configurations are illustrated in Figs. 4, 5 and 6 wherein the branches **22** and **26** are at angles relative to the axis and to each other, other than 90° and 180°, respectively. Components shown in Figs. 2 and 3 are identified in Figs. 4, 5 and 6 by the same number having a suffix *a* or *b* attached thereto.

Fig. 4 illustrates schematically the identical structure shown and described in Figs. 2 and 3, but where the branches **22***a* and **26***a* are other than perpendicular to the axis of envelope **1***a* while still displaced 180° with respect to each other. The illustration shows that each branch is at the same angle with respect to the axis of envelope **1**, but it is within the scope of this invention to displace each of the branches at a different angle relative to the axis independent of each other.

Figs. 5 and 6 illustrate schematically the same structure of Figs. 2 and 3, but where branches **22***b* are other than perpendicular to the axis of envelope **1***b* and branches **22***b* and **26***b* are displaced at 90° relative to each other. A certain specific angular displacement between each branch and the branches and the axis is illustrated in the present showing, but it is well within the scope of this invention to dispose the branches at any required angle relative to each other and to the axis of envelope **1** to conform to the application of the device incorporating the output means **6** herein described.

While the transducing or output coupling means of this invention has been described herein with particular reference to a high power traveling wave electron discharge device thereby necessitating a fluid cooling system, it will be obvious to those skilled in the art that said output means may be utilized in low power traveling wave electron discharge devices without departing from the spirit of this invention. It is to be clearly understood therefore, that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A traveling wave electron discharge device comprising a vacuum envelope having conductive cylindrical portions, an electron gun unit disposed at one end of said envelope to project an electron beam along an axial path within said envelope, a collector at the other end of said envelope to collect the electrons of said beam, a wave propagating structure including a helical transmission line of hollow tubing providing therein a passage for a liquid coolant disposed adjacent said path for transmission of radio frequency energy in interacting relation with the electrons of said beam, input coupling means disposed adjacent said gun unit to couple radio frequency energy to said propagating structure, and an output coupling unit disposed adjacent said collector to remove radio frequency energy from said propagating structure, said output coupling unit including a furcated transmission line junction section having first, second and third branches, said first branch being disposed coaxially of said conductive cylindrical portion and coupled to said propagating structure, said first branch also having a passage therealong for coolant from said propagating structure in non-interfering relation with the field of said radio frequency energy, said second branch serving as an output for radio frequency energy, and said third branch having a fluid connection for the coolant passage of said first branch in non-interfering relation with the field of said radio frequency energy and means within said third branch and in coupled relation to the conductive portion of said envelope to provide an impedance matching stub for the junction between said second branch and said propagating structure.

2. A device according to claim 1, wherein said first branch includes a transition section coextensive with said transmission line having said passage therethrough for the circulation of the helical transmission line coolant and said second branch includes an outer conductor coupled to said envelope and an inner conductor coaxial of said outer conductor coupled to said transition section.

3. A device according to claim 2, wherein said transition section includes a hollow cylinder coaxial of said path having a helical slot longitudinally thereof whose pitch is gradually varied from an infinite pitch adjacent the junction of said branches to a pitch corresponding to the uniform pitch of said helical transmission line.

4. A device according to claim 3, wherein said inner conductor is connected to said hollow cylinder at a given point in the infinite pitch portion of said helical slot.

5. A device according to claim 1, wherein said first branch includes a transition section coextensive with said transmission line having said passage therethrough for the circulation of the helical transmission line coolant and said third branch includes an outer conductor coupled to said envelope, an inner conductor coaxial of said outer conductor carrying therewith a passage for said fluid coolant, and an end cap closing said outer conductor to provide a vacuum closure for said third branch including a nipple extending therethrough for external access to the passage for said fluid coolant.

6. A device according to claim 5, wherein said third branch further includes a diaphragm structure extending radially from said inner conductor to said outer conductor to provide a shorting element crosswise of said third branch.

7. A device according to claim 1, wherein said third branch includes an outer conductor coupled to the conductive portion of said envelope, an inner conductor coaxial of said outer conductor having therein a passage for said helical transmission line fluid coolant, an end cap closing said outer conductor to provide a vacuum closure for said third branch including an aperture therein for external access to the passage for said fluid coolant, and means extending radially from said inner conductor to said outer conductor to provide a shorting element crosswise said third branch.

8. A device according to claim 1, wherein said second branch includes an outer conductor coupled to the conductive portion of said envelope, an inner conductor coaxial of said outer conductor coupled to said transmission line, and a ceramic to metal seal disposed to extend between said inner and outer conductors to provide a vacuum seal for said second branch, said seal including terminal means for extraction of energy from said device.

9. A device according to claim 8, wherein said seal includes a ceramic disk having an axial aperture therein, said outer conductor having an outwardly extending shouldered portion to engage the top and peripheral portions of said disk, said inner conductor including a hollow cylindrical portion having an inwardly extending shouldered portion to engage the top of said disk and the edge of said axial aperture, an outer conducting cylinder engaging the bottom of said disk including a flanged portion having an upwardly extending lip to hold said outwardly extending shouldered portion against the periphery of said disk, an annular member having a downwardly extending lip to compress said outwardly extending shouldered portion against the top of said disk, means to secure said annular member to the flanged portion of said outer cylinder for application of a compressive stress to said outwardly extending shouldered portion, an inner conducting cylinder having a shank portion disposed in the axial aperture of said disk with a shouldered portion against the bottom of said disk, and means to apply a compressive stress to said inwardly extending shouldered portion, said outer and inner cylinders providing a coaxial output terminal.

10. A traveling wave electron discharge device comprising a metallic vacuum envelope, an electron gun unit disposed at one end of said envelope to project an elec-

tron beam along an axial path within said envelope, a collector at the other end of said envelope to collect the electrons of said beam, a wave propagating structure including therein a passage for a fluid coolant disposed adjacent said path for transmission of radio frequency energy in interacting relation with the electrons of said beam, input coupling means disposed adjacent said gun unit to couple radio frequency energy to said propagating structure, and an output coupling unit disposed adjacent said collector to remove radio frequency energy from said propagating structure, said output coupling unit including a transmission line junction section having first, second and third branches, said first branch being disposed coaxially of said envelope and coupled to said propagating structure, said first branch also having a passage therethrough for fluid coolant from said propagating structure in non-interfering relation with the field of said radio frequency energy, said second branch serving as an output connection for radio frequency energy, and said third branch having a passage therein in non-interfering relation with the field of said radio frequency energy coupled to the passage in said first branch for circulation of said fluid coolant, and a shorting element in said third branch to effect an impedance match between said second branch and said propagating structure.

11. In traveling wave electron discharge devices having an electron gun unit to project an electron beam along a given path and a wave propagating structure including a helical transmission line of hollow tubing providing therein a passage for a fluid coolant disposed adjacent said given path for transmission of radio frequency energy in interacting relation with the electrons of said beam, an output coupling unit to remove radio frequency energy from said propagating structure including a furcated transmission line junction having first, second and third branches, said first branch being disposed coaxially of said given path and electrically coupled to said transmission line, said first branch also having a passage therethrough coupled to the passage in said line in non-interfering relation with the field of said radio frequency energy, said second branch serving as an output coupling for radio frequency energy from said transmission line, and said third branch having a passage therein in non-interfering relation with the field of said radio frequency energy coupled to the passage in said first branch for circulation of said fluid coolant, and means disposed crosswise said third branch to provide an impedance matching stub for the junction between said second branch and said propagating structure.

12. In a device according to claim 11, wherein said first branch includes a transition section comprising a cylinder coaxial of said path having a helical slot longitudinally thereof whose pitch is gradually varied from an infinite pitch adjacent the junction of said branches to a pitch corresponding to the uniform pitch of said helical transmission line.

13. In a device according to claim 11, wherein said second branch includes an outer conductor coupled to a reference potential, an inner conductor coaxial of said first conductor coupled to said transmission line, and a ceramic-to-metal seal disposed to extend between said inner and outer conductors to provide a vacuum seal for said second branch.

14. In a device according to claim 13, wherein said seal includes a ceramic disk having an axial aperture therein, said outer conductor having an outwardly extending shouldered portion to engage the top and peripheral portions of said disk, said inner conductor including a hollow cylindrical portion having an inwardly extending shouldered portion to engage the top of said disk and the edge of said axial aperture, an outer conducting cylinder engaging the bottom of said disk including a flanged portion having an upwardly extending lip to hold said outwardly extending shouldered portion against the periphery of said disk, an annular member having a downwardly extending lip to compress said outwardly extending shouldered portion against the top of said disk, means to secure said annular member to the flanged portion of said outer cylinder for application of a compressive stress to said outwardly extending shouldered portion, an inner conducting cylinder having a shank portion disposed in the axial aperture of said disk with a shouldered portion against the bottom of said disk, and means to apply a compressive stress to said inwardly extending shouldered portion.

15. In a device according to claim 11, wherein said third branch includes a first conductor coupled to a reference point, a second conductor coaxial of said first conductor having therein a passage for said fluid coolant, an end cap to close said first conductor to provide a vacuum closure for said third branch including an aperture therein for external access to the passage for said fluid coolant, and a diaphragm extending between said second conductor and said first conductor to provide said impedance matching element.

16. A traveling wave electron discharge device comprising a vacuum envelope having conductive portions, an electron gun unit disposed at one end of said envelope to project an electron beam along an axial path within said envelope, a collector at the other end of said envelope to collect the electrons of said beam, a wave propagating structure disposed adjacent said path for transmission of radio frequency energy in interacting relation with the electrons of said beam, input coupling means disposed adjacent said gun unit to couple radio frequency energy to said propagating structure, and an output coupling unit disposed adjacent said collector to remove radio frequency energy from said propagating structure, said output coupling unit including a furcated transmission line junction having first, second and third branches, said first branch being disposed coaxially of a conductive portion of said envelope and coupled to said propagating structure to provide in conjunction with said envelope portion a coaxial waveguide, said second branch serving as a coaxial waveguide output terminal for radio frequency energy, and said third branch having a shorting element coupled to said envelope portion to provide an impedance matching stub for the junction between said second branch and said propagating structure.

17. A device according to claim 16, wherein said first branch includes a transition section coextensive with said propagating structure, said transition section including a cylinder coaxial of said path having a helical slot longitudinally thereof whose pitch is gradually varied from an infinite pitch adjacent the junction of said branches to a predetermined pitch.

18. A device according to claim 16, wherein said second branch includes an outer conductor coupled to said envelope, an inner conductor coaxial of said outer conductor coupled to said propagating structure, and a ceramic to metal seal disposed to extend between said inner and outer conductors to provide a vacuum seal for said second branch.

19. A device according to claim 18, wherein said seal includes a ceramic disk having an axial aperture therein, said outer conductor having an outwardly extending shouldered portion to engage the top and peripheral portions of said disk, said inner conductor including a hollow cylindrical portion having an inwardly extending shouldered portion to engage the top of said disk and the edge of said axial aperture, an outer conducting cylinder engaging the bottom of said disk including a flanged portion having an upwardly extending lip to hold said outwardly extending shouldered portion against the periphery of said disk, an annular member having a downwardly extending lip to compress said outwardly extending shouldered portion against the top of said disk, means to secure said annular member to the flanged portion of said outer cylinder for application of a compressive stress to said outwardly extending shouldered portion, an inner con-

ducting cylinder having a shank portion disposed in the axial aperture of said disk with a shoulder portion against the bottom of said disk, and means to apply a compressive stress to said inwardly extending shouldered portion, said outer and inner cylinders providing a coaxial output terminal.

20. A device according to claim 16, wherein said third branch includes an outer conductor coupled to said envelope, an inner conductor coaxial of said first conductor and closure means comprising a conductive short crosswise said third branch.

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