July 16, 1957 R. W. PETER 2,799,797

COUPLING CIRCUIT FOR HELICAL DELAY LINES

Filed Aug. 29, 1952 2 Sheets-Sheet 1

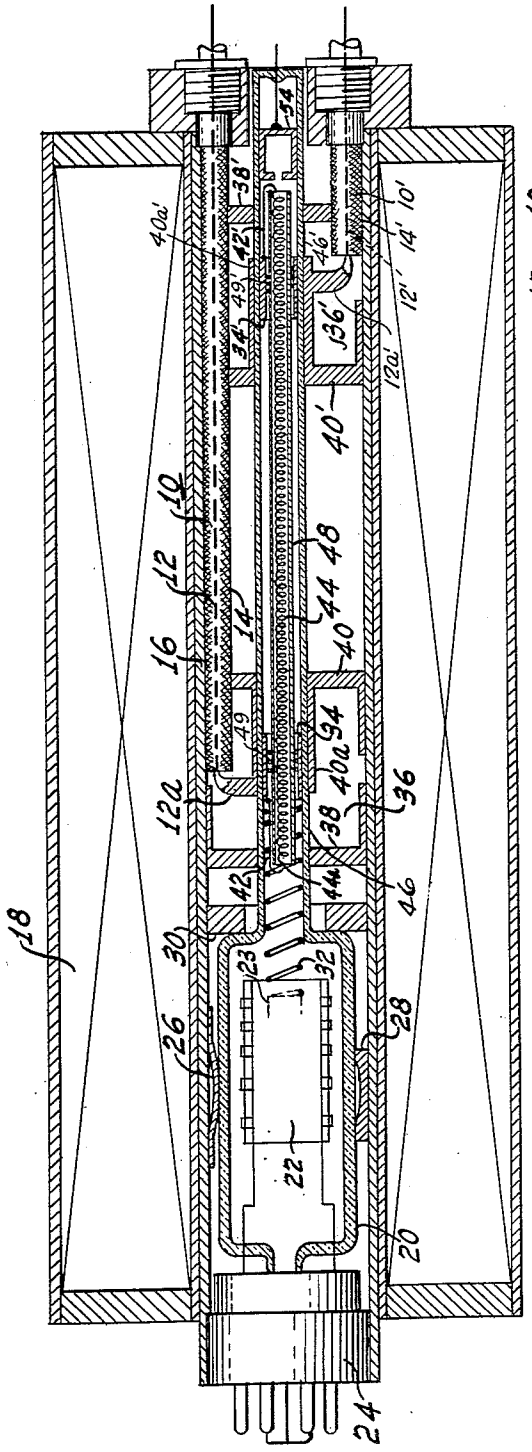



Fig_1

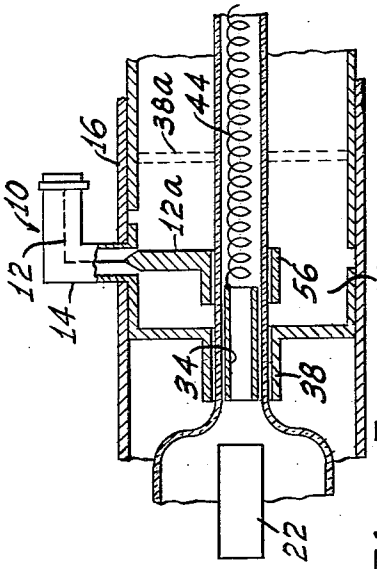



Fig_3

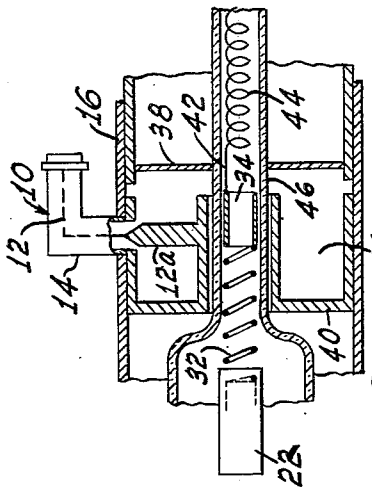



Fig_2

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COUPLING CIRCUIT FOR HELICAL DELAY LINES

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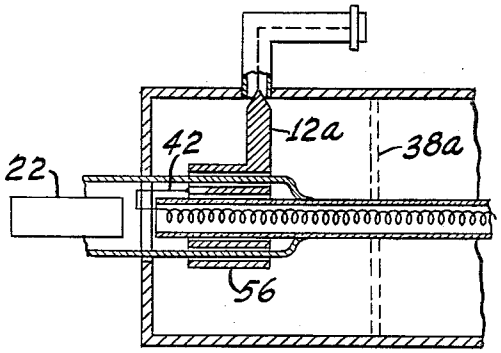



Fig_4

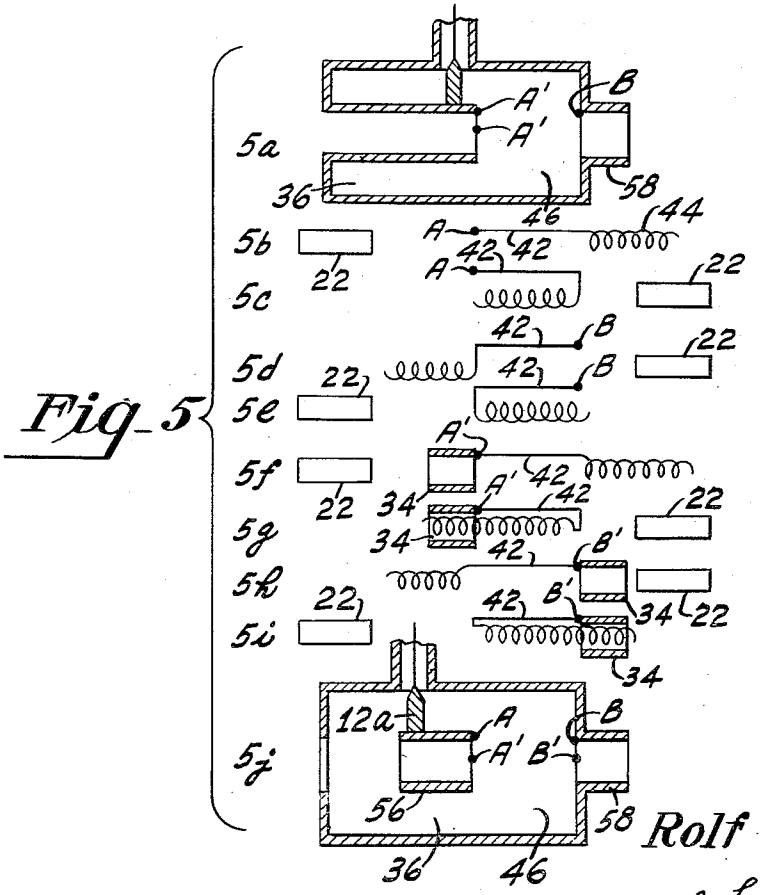



Fig_5

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# COUPLING CIRCUIT FOR HELICAL DELAY LINES

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Application August 29, 1952, Serial No. 307,050

19 Claims. (Cl. 315—3.5)

The present invention is related to a coupling circuit for a helix transmission line, and particularly to a coupling circuit especially well adapted for coupling to the helix of a travelling wave tube.

Various coupling circuits have been proposed heretofore for coupling to the helix of a travelling wave tube. These couplings have been efficient, but not as efficient as desired where a coaxial line is to carry the signal into or out of the helix. Where efficient couplings are known that might be employed, they detract from the operation of the tube by their undue length between the electron gun input end (or collector on the output end), and the interaction space along the helix.

In my copending application Serial No. 291,225, filed June 2, 1952, now Patent No. 2,758,243, and in the copending application of Wellesley J. Dodds, Serial No. 291,189, now Patent No. 2,758,244, are disclosed and claimed means for coupling to a travelling wave tube helix which in considerable measure alleviate the above-mentioned difficulties. However, these means, as disclosed in the said applications, are not especially adapted for coupling from coaxial lines but are disclosed for hollow pipe wave guide couplings to a helix.

It is an object of the present invention to preserve the advances taught in the above-mentioned applications, and to improve thereon by adapting the teachings of the said applications to coupling a coaxial line to a helix in an advantageous and desirable manner.

It is another object of the invention to provide an improved coaxial line-to-helix coupling.

A further object of the invention is to provide such a coaxial line to helix coupling which is improved in efficiency over, and provides better matching qualities than, prior coaxial line to helix couplings.

It is still another object of the invention to provide a coaxial line to helix coupling which has improved qualities of compactness to allow close positioning of an electron gun when the helix is employed in a travelling wave tube.

According to the invention, a resonant section of coaxial line has an inner conductor-gap. A helix is coupled to the resonant section by a coupling probe connected to the helix at an end thereof and either extended beyond this end of the helix or folded back, and coacting with the fields in the resonant section at the inner conductor gap. The inner conductor of the section is tubular to permit passage of an electron beam. Preferably, the arrangement permits positioning of the helix and the electron gun of a travelling wave tube close to each other. Preferably, the helix probe is conductively connected to a capacitive sleeve which couples capacitively to the inner conductor or an end wall of the resonant section by being positioned coaxially of the resonant line section but spaced from any of the resonant boundary walls, either that of the inner or that of the outer conductor.

The foregoing objects and other objects, advantages, and novel features of the invention will be more apparent from the following description when read in connection with the accompanying drawing, in which like reference numerals refer to like parts, and in which:



Fig. 1 is a longitudinal cross-sectional view of a complete travelling wave tube illustrating one preferred embodiment of the invention as constructed, with the like couplings at input and output, each coupling having a folded-back coupling probe and a capacitive coupling sleeve, the sleeve being capacitively coupled to the inner conductor and internally thereof;

Fig. 2 is a longitudinal cross-sectional view of another coupling arrangement according to the invention using an extended probe connected to the helix and a capacitive sleeve similar to that of Fig. 1, and showing a portion of a travelling wave tube with helix coupled thereto;

Fig. 3 is a longitudinal cross-sectional view of still another embodiment of the invention, in which an extended coupling probe but no capacitive sleeve is employed;

Fig. 4 is a longitudinal cross-sectional view of another embodiment of the invention using a folded-back probe and omitting a wall of the coaxial resonator which is unnecessary for its operation, for reasons discussed hereinafter more fully;

Fig. 5 comprising as parts Figs. 5*a* to 5*j* inclusive shows, in Figs. 5*a* and 5*j*, in longitudinal cross-sectional views, alternative coaxial resonator portions with each of which may be combined any one of the forms of helix couplings with probes shown in Figs. 5*b* to 5*j* inclusive.

Referring to Fig. 1, a travelling wave tube amplifier has an input coaxial line 10 with inner conductor 12 and outer conductor 14. A cylindrical shield 16 is surrounded by a magnet winding 18. In an envelope 20 is mounted at one bulbous end an electron gun 22. The envelope 20 has a suitable base 24 with pins for applying voltages to the gun elements (not separately shown). A spring 26 mounted on shield 16 presses the enevlope against a bracket 28 mounted on the shield opposite spring 26 to protect and hold firmly the envelope 20.

An annular stop 30 tightly fitted into the shield 16 positions the shoulders of the bulbous end of the envelope 20. A metallic spiral shield 32 (although helical in form, not to be confused with the travelling wave helix) is connected at one end to the final accelerating electrode 23, of the electron gun 22 and at the other end to a capacitive sleeve 34.

A resonant section or resonator 36 of coaxial line has as one portion a cup shaped member 38 having a central opening and as a second portion a second member 40 which may be described as a section of coaxial line short-circuited at one end, open-circuited at the other end 40*a*, and with a tubular center conductor. The resonator 36 is completed by fitting the two members 38 and 40 into the shield 16 with the cup concavity of member 38 and the open circuited end of second member 40 facing and next adjacent each other. The resonator 36 wall between the outer conductor portion of second member 40 and the cup walls of cup member 38 is completed by the cylindrical shield 16 with which both members 38 and 40 make contact. Also the opening in the cup shaped member 38 and the tubular center conductor and opening thereof of second member 40 are held in coaxial alignment.

Energy may be supplied to this resonator 36 by the coaxial line 10 the outer conductor 14 of which is in contact with shield 16 from the tube input-output end (right end as viewed in the drawing) through a side opening at the periphery of the second member 40 into the resonator 36. At about the longitudinal mid-point (though other points may be selected) in the resonator cavity, the outer conductor 14 is terminated. The inner conductor 12 is extended in a right angle turn to form a coupling loop 12*a* which at its end contacts near the

end the center conductor of the second member **40**, whereby the input line **10** and the resonator **36** are coupled.

The envelope **20** is supported coaxially and fits within the aligned openings of the two members **38** and **40**. There is a gap **46** between the inner conductor comprising the end **40***a* of second member **40** inner conductor and the cup shaped member **38**. The spiral shield **32** extends in contact with the envelope along the opening length across this gap **46**. The contact with the end of sleeve **34** is made preferably at the same point as the end of the open-circuited end **40***a* of the second member **40** center conductor. The sleeve **34** is held by the envelope, which supports it in capacitive relationship to the inside of the center conductor of coaxial member **40**. A coupling probe **42** is folded back from the end **44***a* of a travelling wave helix **44**. The folded back coupling extends across the gap and may, if desired, be in contact with the spiral shield **32** along the gap **46**. The wave helix **44** may start at its connection to probe **42**, and in fact may be a continuation of the wire of which the probe is made. The wave helix proper may begin in the plane of the base of cup member **38**. It is then continued toward the output end through a cylindrical tubing **48** preferably of quartz, which functions primarily as a support. At the input end the tubing **48** is supported by a ring **49** preferably of ceramic fitted into sleeve **34**. The tubing **48**, supports the wave helix **44** coaxially with the shield **16** and in alignment with the gun **22** and the electron beam produced thereby.

At the output end of the tube an output coaxial line section or resonator **36'** is provided which is similar to the input resonator **36**, with a few exceptions. Only the differences in the two resonators will be pointed out, as the similarities will be apparent to those skilled in the art. In resonator **36'**, parts corresponding to those of resonator **36** bear corresponding numbers, but with a prime. The same travelling wave helix passes through both resonators. Resonator **36'** has its corresponding parts assembled in reverse order (left to right as viewed in the drawing) from those of resonator **36**. One pair of aligned apertures near the periphery of members **38'** and **40'** permits passage of the input line **10** with its outer conductor **14** in immediate contact with shield **16**. Another aperture near the periphery of cup member **38'** receives an output coaxial transmission line **10'** having an outer conductor **14'** and an inner conductor **12'**. The line **10'** may be considered the counterpart of the line **10**, although it enters the resonator through the cup-member **38'**. An extension **12***a'* of inner conductor **12'** completes a coupling loop by making contact near the end of the center conductor of the second member **40'** of resonator **36'**.

No spiral shield, such as **32**, is required at the tube output end. The quartz tubing **48** extends coaxially through the coaxial openings in the members **38'** and **40'**. The ceramic ring **49'** fitted into sleeve **34'** supports the quartz tubing **48** at the output end of the tube. The sleeve **34'** is mounted within the central aperture in the coaxial member **40'** and terminates adjacent to coaxial end **40***a'*. A folded back coupling probe **42'** makes contact with sleeve **34'** at its end adjacent the gap **46'**, is continued across the gap and is connected to the termination of the travelling wave helix **44** at the end of the helix, the helix extending across the gap.

In alignment with the helix **44** adjacent the output end, is a collector electrode **54** a lead to which is brought out of the end of envelope **20** at the tube input-output end.

In operation, suitable voltages are applied through the pins of base **24** to the electron gun **22**. A beam of electrons is produced by the gun directed coaxially through the spiral shield **32** and the helix **44** to the collector **54**. The electromagnet **18** has suitable currents applied to produce a magnetic field parallel to the electron beam.

This magnetic field aids in keeping the beam diameter small enough to stay within the helix and maintaining the parallel flow of electrons of the beam. The metal parts enclosed within the magnet **18** winding are preferably of non-magnetic metal to allow uniformity of the magnetic field along the axis. The input high frequency voltage to be amplified is applied at the input end of the coaxial line **10**. The line **10** is coupled to the resonator **36** to transfer energy to and resonate the resonator by the coupling loop formed by the inner conductor extension **12***a*.

The folded-back probe **42** couples energy from the resonator **36**. The probe **42** is connected for direct current through sleeve **34** or by direct contact to the spiral shield **32**. The spiral shield **32** provides a space field free with respect to direct-current voltage, but allows penetration of the high frequency fields in the space within the spiral shield. The high frequency fields penetrate to the space within the spiral shield **32** because the electric vectors are substantially normal to the spirally wound conductor. For low frequency or D. C. voltages, however, the spiral acts as a Faraday cage, and the D. C. fields do not penetrate to any substantial degree. As a result, the electron beam is not distorted as it passes through the spiral shield. All the conductors within the spiral shield **32** including the travelling wave helix **44** are at the D. C. voltage of the final accelerating electrode of the electron gun **22**. At the same time, the high frequency fields from the resonator **36** penetrate the spiral shield **32** to couple with probe **42** and with the travelling wave helix **44** to apply energy at the input end of the helix. The coupling probe **42** is effectively connected for high frequency energy to the open-circuited end **40***a* of the center conductor of the coaxial resonator by the capacitive coupling of sleeve **34**. The sleeve is preferably a quarter wave length at the mid-band operating frequency for this purpose.

The resonator **36** affords special advantages in making the coupling for high frequency energy between the input line **10** and the travelling wave helix **44**. As a rule, the helix has a high impedance (for example of 200–1000 ohms) compared to the impedance of the input line (for example of 50 ohms). The resonator **36** may be employed as a transformer. The coupling loop **12***a* from the coaxial line extension is connected to the resonator so that a transformation of the input line impedance through the resonator and coupling probe **42** matches the travelling wave helix **44** impedance. Therefore, the resonator **36** acts as a transformer, which is in fact broad band in effect. Through this means the input line **10** in a particular device was matched to the helix with a voltage SWR less than 1.5 over a $\pm$ 30% frequency band in the vicinity of 3000 mc./s. The resonator in the form illustrated is readily assembled. It will be observed that different envelopes **20** complete with enclosed electrodes and helix may be interchangeably inserted in the remainder of the assembly. Thus one magnet, shield, and resonator assembly may be used to test or operate different tubes. Also, the orientation of insertion with respect to the angular position about the axis of the assembly of the parts within envelope **20** is substantially immaterial. The fields in the coaxial resonator **36** are substantially rotationally symmetrical about the tube axis.

The high frequency power applied to helix **44** travels as a wave toward the helix output end in the same direction as the electron beam. There is an interaction between this wave and the electron beam, if the velocities are appropriately selected, as is well known.

At the output end, the high frequency power is coupled from the helix by the coupling probe **42'** to the output resonator **36'**. The operation of the output resonator **36'** is converse of that of the input resonator **36**, that is, energy flow is in the direction from the coupling probe to the resonator to the coaxial transmission line. It may be noted that the output transmission line **10'** is inserted into the output resonator **36'** from an end of the resonator chamber which corresponds to the end opposite the entry of input line **10** into the input resonator **36**. That

is, in the one case (the input) the entry is from the end of the second coaxial member **40**; in the other case, the entry of the coupled line is from the cup member **38'**. Notwithstanding, the coupling loop in each case formed by the extension of the inner conductor of the coupled line is at a point of low impedance to match the resonator to the coupled resonator. On the other hand, the coupling probe **42** is at a point of high concentration of the electric field lines of the high field resulting at the gap **46** or **46'** of the center conductor of the resonator, and parallel to said lines at that point. Therefore, the coupling probe is coupled at a point of high impedance in the resonator to match the coupled helix **44** to the resonator.

In the arrangement of Fig. 2, only the input resonator is shown. A similar arrangement for the output resonator of the travelling wave tube is readily understood from the input resonator arrangement illustrated. The resonator **36** may be similar to that of Fig. 1, but reversed in axial relation to the electron gun. The coupling probe **42** extends across the gap **46** and is not folded back. The input line **10** comes into the resonator through aligned apertures in the side of the shield **16** and the side of the resonator **36**. The sleeve **34** is within the envelope **20** and the travelling wave helix **44** is supported by the envelope. The arrangement of Fig. 1 with the probe folded back is preferred because the electron gun **22** may be positioned more closely to the travelling wave helix **44**. On the output end, the collector of Fig. 1 is positioned more closely to the helix than may be accomplished with an arrangement corresponding to Fig. 2 at the output end.

The operation of the device of Fig. 2 should be clear from what has been said hereinbefore. The extension **12***a* of the inner conductor **12** of line **10** provides a low impedance broad band coupling matched to the line **10** at the operating frequency, as in Fig. 1. The extension **12***a* is tapered to be broader at its base where it connects to the center conductor of resonator **36**. This is also true in Fig. 1. Such taper aids in securing broad band results.

The cup member **38** of Fig. 2 may be omitted entirely. The performance with this omission is in the same manner as with the member **38**. The end wall of the resonator **36** remote from coaxial member **40** is physically omitted. At the operating frequencies for which waves are suitably guided within the travelling wave helix **44**, the wave channel which might be supposed to exist between shield **16** and the helix **44** is non-existent. At such frequencies, this supposed wave channel acts like a waveguide dimensioned below or less than cut-off dimensions. Physically, a simplified explanation is that at these operating frequencies, the wave velocity in or on the helix is so much less than that of the surrounding shield, that the shield and concentric helix cannot support the propagation of the waves between them. Here the waves are exponentially decayed, and not propagated. The energy is constrained to travel close to the helix **44**, that is, within about three helix radii from the helix axis. Consequently, there is a pseudo-wall, or virtual wall on the travelling wave helix side of the resonator, at a point corresponding to the removed wall. There are substantial reflections which make a real wall unnecessary. In other respects operation is the same.

In Fig. 3, the coaxial resonator has its inner tubular conductor **56** connected to probe **12***a*, but only capacitively connected to the resonator external walls by coupling to a tubular wall projection **58**. The tubular conductor **34** is capacitively coupled at the end of the resonator to the external wall thereof and extends across the gap between tubular inner conductor **56** and the coaxial tubular projection **58**. The extension of member **34** across the gap serves the function of probe **42**, by coupling to the resonator fields to which it is exposed.

In operation, the impedance presented to the coaxial line **10** by the resonator is made to provide a match as near as possible. The helix is also substantially matched by the probe coupling to the resonator. Hence the use of the resonator provides a highly efficient coupling between the coaxial line **10** and the helix **44**. The mode of operation will be clear from what has been said heretofore and the structure illustrated in Fig. 3. The virtual wall **38***a* corresponding to the omission of second member **40** is indicated by dotted lines.

In Fig. 4, the coupling probe **42** is folded back as in Fig. 1. The probe is connected to a capacitive coupling sleeve **34** to the tubular center conductor **56**. The spiral shield **32** is omitted from the showing for the sake of clarity of illustration, but may be included if desired. The tubular wall projection **58** is unnecessary and is therefore omitted.

Fig. 5 illustrates sixteen different embodiments of the invention by separately showing (lines **5***a* and **5***j*) two different resonators, and eight different coupling probe and helix arrangements (lines **5***b* to **5***h* inclusive). Any one of the eight probe and helix arrangements may be used with either one or the other of the resonators. For example, the probe and helix arrangement of Fig. **5***b* may be positioned with the helix **44** aligned with the coaxial resonator **36**. The point A at the end of probe **42** is to be connected to the point A in the resonator **36**. The tubular projection **58** is to be removed, as not needed in this combination. Projection **58** of line **59** is also to be omitted in the arrangements resulting from the combination of the resonator **36** of Fig. **5***a* with the probe and helix arrangements illustrated in lines **5***c*, **5***d*, **5***e*, **5***f*, and **5***g*.

In all of the combinations illustrated by Fig. 5, the helix is to be located coaxially of the resonator **36**. The relative axial positions of the parts is unchanged and is indicated by the two light vertical lines.

In combining either, lines **5***b* or **5***c*, with lines **5***a* or **5***j* points A are to be connected. In combining lines **5***d* and **5***e* with lines **5***a* or **5***j* points B are to be connected.

In combining lines **5***f* and **5***g* with lines **5***a* or **5***j*, points A' are to be positioned together, this being the point of the effective capacity coupling of the probe (by means of the sleeve **34** to the tubular center conductor of the coaxial resonator).

In combining lines **5***h* and **5***i* with lines **5***a* or **5***j*, points B' are to be positioned together. Only in these four arrangements (lines **5***h* or **5***i* combined with lines **5***a* or **5***j*) is the projection **58** required. In the other cases it is preferred to omit it.

In each of lines **5***b* to **5***i*, an appropriate position for the electron gun **22** is illustrated. It will be appreciated that if the coupling is to be employed at the output end of the tube, the electron gun **22** is to be replaced by a suitable collector.

The manner in which a cavity resonator such as that shown in Figs. 1, 2, 2*a*, or line **5***a* of Fig. 5 and that shown in Figs. 3, 4, or line **5***j* of Fig. 5 operates to provide the desired transformation of impedances may be explained in a qualitative manner. Referring to line **5***a* of Fig. 5, the stub **12***a* is connected at a point an electrical quarter wavelength from the short circuit at the left hand end of the resonator (as viewed in line **5***a*). This short circuit is imaged as a virtual open circuit at the connection of extension **12***a*. However, to the right hand side there is a shorter section of coaxial line. At the high voltage point across the gap **46** is the probe coupling to the high impedance travelling wave helix. This high impedance is stepped down or transformed to match the connection of the low impedance coaxial line terminating at the extension **12***a* by virtue of the intervening length of line and the gap.

Similarly, line **5***j* of Fig. 5 makes clear the similarity in operation. The extension **12***a* is connected to the tubular inner conductor **56** near its left hand end (as

viewed in line 5*j*) so that the resonator space to the left of the end of that tubular inner conductor appears as an open circuit, both physically and electrically. To the right, as in line 5*a*, the extension 12*a* sees a short section of line which offers a low impedance to energy flow. The coupling gap 46 again matches the probe coupling to the high impedance helix.

It will now readily be recognized that the arrangement of Fig. 1 is the equivalent of the combination of lines 5*a* and 5*g*. The arrangement of Fig. 2 is the equivalent of the combination lines 5*a* and 5*f*. The arrangement of Fig. 2*a* is the same, except that the end resonator wall on the helix side is omitted, which may always be done where a shield such as 16 is employed. The arrangement is the equivalent of the combination of lines 5*j* and 5*h*, but with the end wall on the side of the helix omitted. Fig. 3 should be turned right to left to make the equivalence obvious, and the extension of sleeve 34 across the gap 46, is considered the equivalent of probe 42. The arrangement of Fig. 4 is the equivalent of the combination of line 5*j* with line 5*g* and with the end wall on the side of the resonator 36 toward the helix omitted (turn Fig. 4 right to left to readily see the equivalence). Of the various embodiments, those resulting from a combination of lines 5*c* and 5*g* with the resonators of lines 5*a* and 5*j* are desirable because they allow close proximity of the helix and the gun. The combination of line 5*g* with lines 5*a* or 5*j* is preferred because the capacitive coupling through sleeve 34 permits the direct connection, as through the spiral shield 32, of the last accelerating electrode of the electron gun and the helix, which permits preservation of the shape of the projected electron beam.

It will be apparent from the foregoing that the invention provides an efficient means of coupling a coaxial line to a travelling wave tube helix over a wide frequency band.

What is claimed is:

1. A coupling arrangement comprising a resonator having metallic walls which include a tubular outer conductor, a coaxial tubular inner conductor having an axial gap and at least one end wall, a coupling probe extending axially across said gap, a helical transmission line axially aligned with the resonator axis and extending into said tubular inner conductor, one end of said helical line being connected to one end of said probe, the other end of said probe being coupled to one of said metallic walls, and a coaxial line having inner and outer conductors, said coaxial line outer conductor being connected to said tubular outer conductor, said coaxial line inner conductor extending in radial direction through the space between said resonator tubular conductors and terminating at a connection with said tubular inner conductor.

2. The arrangement claimed in claim 1, said gap being between said end wall and one axial termination of said tubular inner conductor.

3. The arrangement claimed in claim 1, said helical line being the delay line of a traveling wave tube, and said coupling probe being folded back from the said one end of said helical line and positioned axially coextensive with said helical line for the probe length.

4. The arrangement claimed in claim 1, said helical line forming the delay line of a traveling wave tube, and said probe being folded back from said one end of said helical line and positioned axially coextensive with said helical line for the probe length, the coupling of the said other end of said probe to said one metallic wall being a capacitive coupling.

5. The arrangement claimed in claim 4, said capacitive coupling being to the tubular inner conductor.

6. The arrangement claimed in claim 5, said capacitive coupling to the tubular inner conductor comprising a conductive sleeve positioned coaxially within and spaced from said tubular inner conductor and to which said other probe end is connected.

7. The arrangement claimed in claim 1, the coupling of the said other end of said probe to said one metallic wall being a capacitive coupling.

8. The arrangement claimed in claim 7, said capacitive coupling comprising a tubular sleeve coaxial with said resonator and to which said other end of said probe is connected.

9. A coupling arrangement as set forth in claim 1, wherein the portion of the inner conductor of said coaxial line extending through the space between said resonator tubular conductors is tapered, the larger end of said tapered line terminating at said connection with said tubular inner conductor.

10. In a traveling wave tube including a helical delay line of relatively high impedance, a coaxial transmission line of relatively low characteristic impedance for supplying wave energy to or extracting wave energy from said delay line; and coupling means including a coaxial line cavity resonator resonant at the frequency of said wave energy and having a first portion of relatively low impedance at said frequency and a second portion of relatively high impedance at said frequency, said cavity resonator including a hollow center conductor portion, said coaxial transmission line being coupled to said portion of relatively low impedance, and one end of said helical delay line extending into said hollow center conductor portion of said cavity resonator and being coupled to said portion of relatively high impedance.

11. In a traveling wave tube including a helical delay line, and electron beam generating means, including a high voltage electrode, for directing an electron beam along the center axis of said helical delay line, a transmission line of relatively low characteristic impedance for supplying wave energy to or extracting wave energy from said delay line; coupling means including coaxial line cavity resonator means resonant at the frequency of said wave energy and having a first portion of relatively low impedance at said frequency and a second portion of relatively high impedance at said frequency, said cavity resonator being formed with an outer conductor portion and a hollow center conductor portion, said transmission line being coupled to said first portion of said resonator, and an end of said delay line extending through said hollow center conductor portion and being spaced therefrom, said end of said delay line being coupled to said second portion of said cavity resonator; and shielding means located in the space between said delay line and said hollow center conductor of said cavity resonator and connected to said high voltage electrode, said shielding means providing shielding of said delay line with respect to low frequency and direct current fields and permitting the passage of fields at the frequency of said wave energy.

12. In the arrangement set forth in claim 11, said shielding means comprising a helix of wire connected to said high voltage electrode.

13. In the arrangement set forth in claim 11, said shielding means comprising a helix of wire concentrically arranged about said end of said delay line and connected to said high voltage electrode.

14. A traveling wave tube comprising, in combination, a helical delay line of relatively high impedance; electron beam generating means located at one end of said delay line, including a high voltage electrode, for directing an electron beam through said delay line; a collector located at the other end of said delay line; input coaxial transmission line means of relatively low characteristic impedance for supplying wave energy to said delay line; input coupling means including a coaxial line cavity resonator resonant at the frequency of said wave energy formed with a hollow center conductor portion, and including a first portion of relatively low impedance at said frequency and a second portion of relatively high impedance at said frequency, said one end of said delay line extending into said hollow center conductor portion of said cavity

resonator and coupled to said second portion of said cavity resonator, the center conductor of said input coaxial transmission line extending radially into said cavity resonator, and said coaxial transmission line being terminated at said first portion of said cavity resonator; an output coaxial transmission line of relatively low characteristic impedance for extracting wave energy from said delay line; and second coupling means including second coaxial cavity resonator means resonant at said frequency of said wave energy coaxially arranged with respect to said other end of said delay line, said second cavity resonator including a hollow center conductor portion and having a first portion of relatively low impedance at said frequency and a second portion of relatively high impedance at said frequency, said other end of said delay line extending into said hollow center conductor portion of said second cavity resonator and being connected to said second portion of said second cavity resonator, and said output coaxial transmission line being connected to said first portion of said second cavity resonator.

15. In combination, a helix of wire; a two-conductor transmission line; and means for coupling said helix of wire to said transmission line including a coaxial line type cavity resonator formed with an outer conductor and a tubular inner conductor, said inner conductor being formed with a coupling aperture, said helix of wire extending into said tubular inner conductor and being coupled to said cavity resonator at said coupling aperture, one of the conductors of said transmission line being connected to the outer conductor of said cavity resonator, and the other of the conductors of said transmission line extending in and coupled to said cavity resonator.

16. In the combination as set forth in claim 15, said two-conductor transmission line comprising a coaxial line, the outer conductor of said line being coupled to the outer conductor of said resonator.

17. In the combination as set forth in claim 16, said two-conductor transmission line comprising a coaxial line having an impedance substantially lower than that of said helix of wire, and said coaxial line cavity resonator having an impedance close to that of said coaxial line at the portion thereof to which said coaxial line is coupled, and an impedance close that that of said helix of wire at the portion thereof to which said helix of wire is coupled.

18. An arrangement for coupling an external coaxial transmission line to the conductive helix of a traveling wave tube, said conductive helix being of relatively high impedance compared to the impedance of said coaxial line, comprising, in combination, a coaxial line type cavity including an outer conductor and a tubular inner conductor, said tubular inner conductor being formed with a coupling aperture, said conductive helix extending into said tubular inner conductor and being coupled to said coaxial line type cavity at said coupling aperture, said coaxial line type cavity acting as an impedance transformer for matching the impedance of said conductive helix to that of said coaxial line, and means coupling said coaxial line to said coaxial line type cavity.

19. A coupling arrangement for a traveling wave tube having a delay line, comprising a coaxial line type cavity formed with an outer conductor and a tubular inner conductor, said inner conductor being formed with a coupling aperture, said cavity being positioned so that said tubular inner conductor surrounds at least a portion of said delay line, said cavity being coupled to said delay line through said coupling aperture, and means for coupling a two-conductor transmission line to said cavity, one of the conductors of said transmission line being connected to said outer conductor of said cavity and the other of the conductors of said transmission line extending in and being coupled to said cavity.

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