Dec. 15, 1959 J. R. MILLBURN 2,917,655

ELECTRIC TRANSMISSION LINE

Filed Dec. 28, 1955

FIG. 1

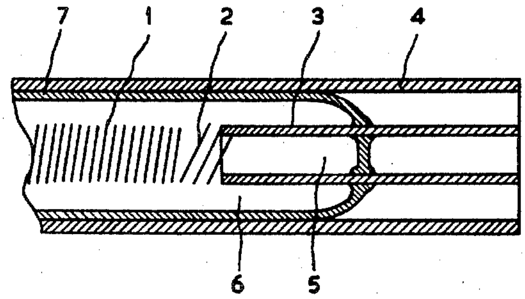
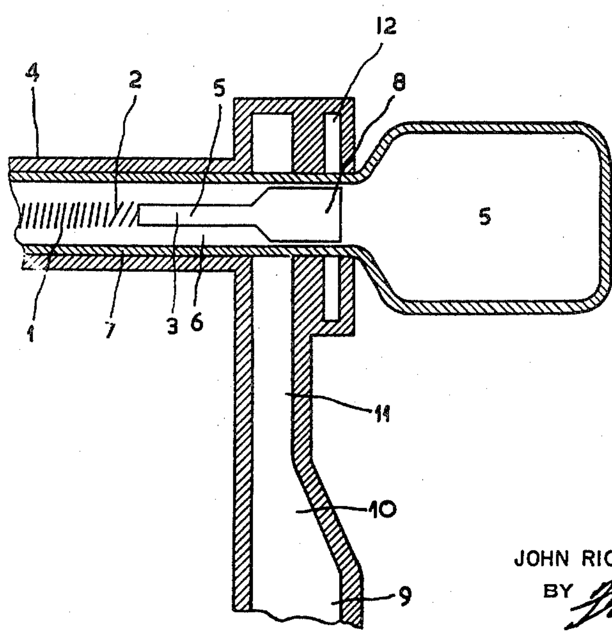


FIG. 2



INVENTOR
JOHN RICHARD MILLBURN
BY Fred M. Vogel
AGENT

United States Patent Office

2,917,655

Patented Dec. 15, 1959

1

2,917,655

ELECTRIC TRANSMISSION LINE

John Richard Millburn, Aylesbury, England, assignor, by mesne assignments, to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

Application December 28, 1955, Serial No. 555,954

Claims priority, application Great Britain December 31, 1954

4 Claims. (Cl. 315—3.5)

This invention relates to travelling-wave tubes comprising a delay-line helix, which is spaced from a surrounding conductive cylinder, and comprising input- and output-coupling means.

The conductive cylinder surrounding the delay-line helix limits the mode of oscillation of the helix to one mode of oscillation and moreover prevents stray radiation.

The input- and output-coupling serve to match the impedance of a coaxial line or hollow wave guide to the impedance of the delay-line helix and moreover to convert the mode of oscillation of the delay-line helix into the mode of oscillation of the input- and output line.

In general, the input- and output-coupling should be of simple construction, high mechanical rigidity and, in particular, small axial dimensions.

Transition couplings are known, in which the delay-line helix has a pitch angle following an exponential law in order to secure matching to the impedance of a hollow wave guide.

Furthermore, input- and output-coupling means are known, by which the pitch angle of the delay-line helix gradually increases to 90° so that the end can be directly coupled to the inner conductor of the coaxial line. Since the helix is usually wound from thin wire, the impedance of the coaxial line formed therefrom at the end would become extremely high. Therefore, it is necessary for the diameter of the transition part to increase with an increase in spacing from the delay-line or for the diameter of the conductive cylinder surrounding the delay-line to decrease with an increase in spacing from the delay-line, since otherwise the impedance does not acquire a suitable value.

Both the aforesaid known constructions have the disadvantage of a fairly considerable length and difficult manufacture.

In another known construction, the end of the delay-line helix is connected to a tube having an equal outside diameter, and a helical slot is cut into the tube, the pitch angle of which increases gradually to 90°. In this way direct coupling to a coaxial line is possible. However, the manufacture is extremely difficult, particularly of tubes for frequencies above 10,000 mc./s.

The object of the present invention is to provide input- and output-coupling means which are simpler than the existing couplings.

In accordance with the invention, in a travelling-wave tube comprising a delay-line helix, which is spaced from a surrounding conductive cylinder and furthermore comprising input- or output-coupling means, the coupling consists of a helix having an outside diameter equal to that of the delay-line and a constant pitch the conductor length being $\frac{1}{8}\lambda$ to $\frac{3}{8}\lambda$, where λ is the wave-length at the centre of the frequency band for which the tube is designed, while the helix has a pitch angle 2 to 6 times that of the delay-line and is connected to a straight cylindrical tube of equal diameter.

The invention makes use of the so-called quarterwave

2

transformer in travelling-wave tubes and therefore the impedance Z_m is preferably chosen to be such that if Z_h is the impedance of the delay-line helix and Z_c the impedance of the coaxial line, into which the straight conductor passes over, $Z_m^2 = Z_h.Z_c$.

It is to be noted that the impedances of the delay-line together with the surrounding cylinders are not necessarily the same as those given by E_r^2/β_p^2 in Pierce's notation. Preferably, the axes of the delay-line, transition helix and coaxial conductor coincide.

The delay-line helix is preferably between $\frac{9}{40}\lambda$ and $\frac{11}{40}\lambda$ long, and the pitch angle is 3 to 5 times that of the delay-line.

The fact that the transition now has a constant pitch renders manufacture extremely simple, while the axial length of the transition is extremely small.

In order that the invention may be readily carried into effect two examples will now be described with reference to the accompanying drawing, in which

Fig. 1 shows an input- and output-coupling means to a coaxial line, and

Fig. 2 shows a coupling to a hollow wave guide.

Referring now to Fig. 1, the delay-line helix is denoted by **1**, the constant-pitch transition by **2** and a cylindrical conductor by **3**. The outside diameters of the parts **1**, **2** and **3** are equal and these axes coincide. A coaxial conductive cylinder **4** surrounds the glass wall **7**. An electron gun or collecting electrode is arranged in the space **5** or **6** according as to whether the beam extends inside or outside the delay-line.

In Fig. 2, parts corresponding to Fig. 1 are provided with the same reference numerals.

The cylindrical conductor **3** passes over, via a conical transition, into a part **8** of greater diameter in order to couple the coaxial line to a hollow wave guide **10** and particularly to its narrow part **11**. The impedance of the narrow section **11** is equal to that of the coaxial line **3**, **4**. The diameter of the trickened part **8** is at least 0.15 *a*, where *a* is the width of the normal part **9** of the hollow wave guide **10**.

Leakage of energy is limited by a quarter wave-length space **12**.

In both examples, the delay-line is a helix having a pitch of 0.028 cm. and an axial length of 18.5 cms. The transistion **2** had a pitch of 0.1 cm. and was 0.25 cm. long. In this instance, the length of the transition was only 1.3% of the transition jointly with the delay-line. the helix and the transition may be wound on an ordinary lathe.

Although the transition may only be one quarter wave-length long for a given frequency, yet the travelling-wave tube according to the invention may advantageously be used over a wide frequency band. In a given case, coupling to a coaxial line proved feasible with a power loss less than 1 decibel over a band-width of 2.000 mc./s., the centre of this band being situated at 10.000 mc./s. In the case of coupling to a standard hollow wave guide, the band-width was 3.000 mc./s. with the same centre and a loss less than 2 decibels.

What is claimed is:

1. A travelling-wave tube comprising a delay-line helix having a given pitch angle; a cylindrical conductor; a coupling helix having a constant pitch angle and having one end connected to one end of said delay-line helix and the other connected to one end of said cylindrical conductor, the diameter of said delay-line helix being substantially equal to the diameter of said coupling helix and the diameter of said cylindrical conductor, said constant pitch angle of said coupling helix being between 2 and 6 times as great as said pitch angle of the delay-line helix, the length of said coupling helix being between $\frac{1}{8}\lambda$ and $\frac{3}{8}\lambda$ where λ is the wave length of the center frequen-

cy of the band of frequencies over which the tube operates; and the surrounding conductive cylinder coaxial with and extending over at least a portion of said cylindrical conductor.

2. A travelling-wave tube as claimed in claim 1 in which the impedance of said delay-line helix is Z_h and the impedance of the coaxial line formed by said cylindrical conductor and said outer conductor is Z_c and the impedance of said coupling helix is Z_m, where $Z_m^2=Z_h.Z_c$.

3. A travelling-wave tube as claimed in claim 1 in which the length of said delay-line helix is between $\frac{9}{40}\lambda$ and $\frac{11}{40}\lambda$ and said pitch angle of said coupling helix is between 3 and 5 times the pitch angle of said delay-line helix.

4. A travelling-wave tube as claimed in claim 3 in which said outer cylindrical conductor also extends over said delay-line helix and said coupling helix.

References Cited in the file of this patent

UNITED STATES PATENTS

2,575,383	Field	Nov. 20, 1951
2,637,775	Lund	May 5, 1953
2,673,900	Mumford	Mar. 30, 1954
2,708,727	Quate	May 17, 1955
2,719,936	Peter	Oct. 4, 1955
2,724,775	Field	Nov. 22, 1955
2,757,310	Robinson	July 31, 1956
2,823,333	Quate	Feb. 11, 1958
2,828,440	Dodds et al.	Mar. 25, 1958