Sept. 16, 1952 R. WALLAUSCHEK 2,611,101

TRAVELING WAVE AMPLIFIER TUBE

Filed April 13, 1948 2 SHEETS—SHEET 1

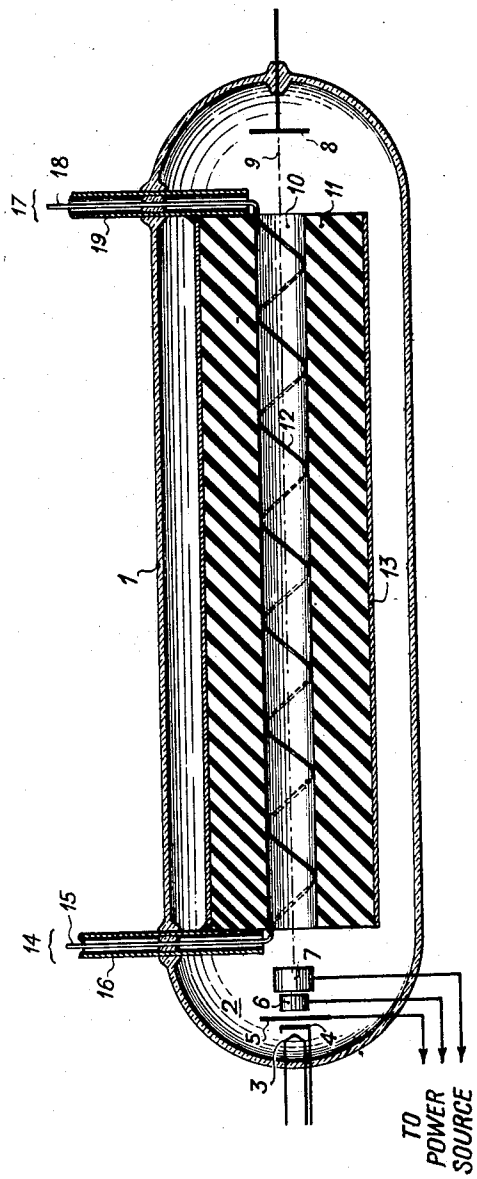


Fig. 1

INVENTOR:

RICHARD WALLAUSCHEK.

by: Richard Wallauschek

Attorney.

Sept. 16, 1952 R. WALLAUSCHEK 2,611,101

TRAVELING WAVE AMPLIFIER TUBE

Filed April 13, 1948 2 SHEETS—SHEET 2

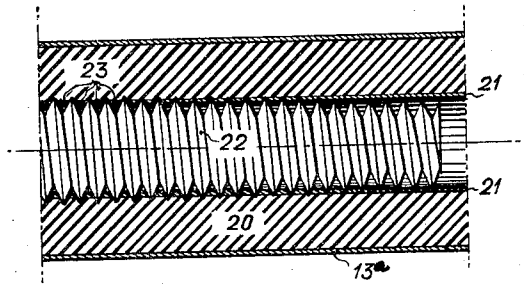


Fig. 2

Fig. 3a

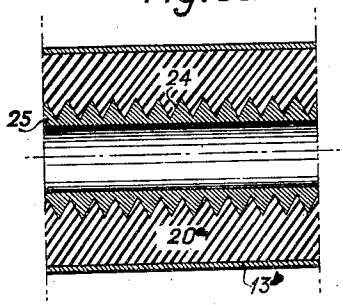


Fig. 3b.

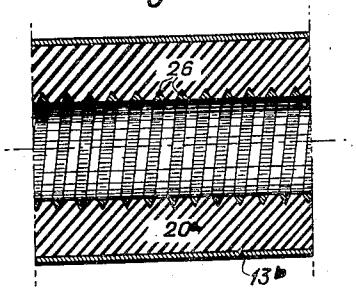
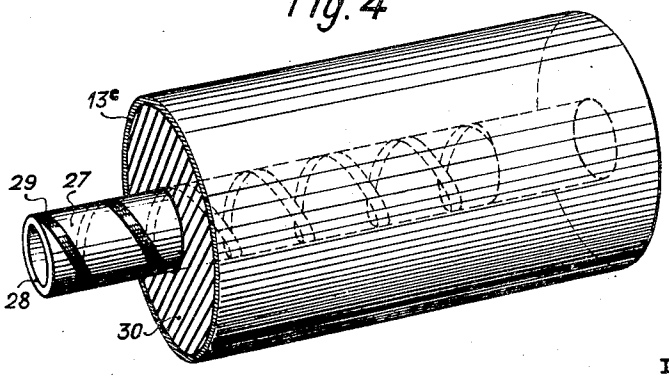


Fig. 4



INVENTOR:

RICHARD WALLAUSCHEK.

by: Edward Abraitis

Attorney.

Patented Sept. 16, 1952 2,611,101

UNITED STATES PATENT OFFICE

2,611,101

TRAVELING WAVE AMPLIFIER TUBE

Richard Wallauschek, Marly Le Roi, France

Application April 13, 1948, Serial No. 20,667
In France April 15, 1947

6 Claims. (Cl. 315—3)

1

This invention relates to travelling wave amplifier tubes and more particularly to a delay or lag line for use in such an amplifier.

The use of so-called travelling wave amplifiers is common in the art of ultra-high frequency apparauts and such amplifiers are basically characterized in that they are the seat of an interaction between an electromagnetic wave and an electron beam both propagated at velocities which differ little from each other and in that the electric field of said wave presents a component directed conformably to the electron beam. Such an arrangement provokes in certain conditions a progressive modulation of the beam's density and an amplification of the wave during its propagation. An essential part of said travelling wave amplifier is a delaying line in which the wave to be amplified propagates at a velocity which is notably lower than the velocity of light. Velocity v of the beam's electrons is always lower than the propagation velocity of free waves in a vacuum; furthermore, it is limited by the need not to set in action continuous accelerating tensions that are too high. Too high values cannot, therefore, be considered for v and to generate waves propagating at approximately the velocity v very effective delaying lines must be devised. The delaying lines to be placed into action must have very constant properties for a good portion of their length at the risk of introducing useless reflections which would lower the amplifier's gains.

Thus the invention relates to travelling wave amplifier tubes in which an electron stream and electromagnetic waves circulate and react on each other. As indicated above it is necessary to strongly retard the travel of the electromagnetic waves because they proceed in a straight line at the speed of light while the electrons practically cannot travel at such speed. It is however necessary that their speed be of about the same order.

In order to delay the travel of the electromagnetic waves, means for forcing them to follow a helical path may be employed, and this provides for some retardation. However, in such an arrangement, in order to effect a sufficiently great retardation, the windings of the helix must be crowded very close together and this creates certain difficulties, in that, from the mechanical point of view, it is difficult to produce a very narrow helical conductor with sufficient precision, and that the waves, if the windings are crowded very close together, may jump across the gap between the windings instead of following the helical course.

2

I have now found that it is possible to build up a helical delaying path for the electromagnetic waves which slows them up considerably, without the windings being placed close together if the helix is supported by a cylinder of dielectric material. This material is then instrumental in producing a substantial retardation. The same cylinder may also serve as a carrier for the outer electrode.

This combination provides the following advantages: The helix can be constructed with great precision and since it adheres to the cylinder, no deformation can take place. The delaying action of the helix is supplemented by the presence of the dielectric material. Finally, it is possible to bring about the maximum amplification of the travelling wave tube by incorporating in the dielectric material conducting substances, in such manner as to regulate the attenuation, i. e. the reduction of power.

The invention is illustrated, diagrammatically by way of example, in the accompanying drawings, in which:

Fig. 1 is an axial sectional view of a travelling wave tube embodying a delay line in accordance with the present invention;

Fig. 2 is a part section illustrating the method of manufacture;

Figs. 3*a* and 3*b* are fragmentary axial sectional views of another embodiment of the present invention showing the delay line in two stages of its production; and

Fig. 4 is a perspective view, partly broken away and in section, of another embodiment of the invention.

Referring initially to Fig. 1, the numeral 1 thereon designates a conventional, elongated, evacuated glass envelope. An electron gun, generally indicated by the numeral 2, of the conventional kind employed in cathode ray tube structures, is arranged with its electrodes at one end of the envelope 1 and includes a heater 3 and its associated cathode 4, a disc-like, centrally perforated, control grid 5 and focusing and accelerating hollow, cylindrical electrodes 6 and 7. When the electrodes of gun 2 are energized by a suitable power source (not shown), an axial beam of electrons is generated and directed toward a disc-shaped collector electrode 8 arranged at the other end of the elongated envelope 1.

In accordance with the broad principles of the present invention, the axial path of travel 9 of the electron beam extends through and is enclosed within a central bore 10 extending axially

through a cylindrical member 11 formed of dielectric material and disposed within the envelope 1.

An internal conductor 12 is provided in the bore 10 in the form of a helicoidal strip or helix of thin metallic material coated upon the inner surface of the hollow cylindrical member 11. An external conductor 13 is provided in the form of a metallic coating covering the entire outer surface of the cylindrical member 11. The conductor 13 acts as the outer conductor of a helicoidal co-axial line and also as a screen for the electro-magnetic field.

A co-axial input line 14, including an inner conductor 15 and an outer conductor 16, extends into the envelope 1 at the end of the cylindrical member 11 adjacent the electron gun 2, with the inner conductor 15 being electrically connected to the adjacent end of the helicoidal internal conductor 12 and with the outer conductor 16 being electrically connected to the adjacent end of the external conductor 13 on the outer surface of cylindrical member 11. A similar co-axial output line 17, including an inner conductor 18 and an outer conductor 19, extends through the evacuated envelope 1 at the end of the cylindrical member 11 which is adjacent to the collector electrode 8, with the conductor 18 being electrically connected to the adjacent end of the helicoidal internal conductor 12 and with the conductor 19 being electrically connected to the adjacent end of the outer conductor 13. In addition to acting as parts of the co-axial input and output lines 14 and 17, the conductors 16 and 19 may also serve to position and support the cylindrical member 11 within glass envelope 1.

In the structural arrangement described above, the cylindrical member 11 of dielectric material performs three functions:

1. The field of the wave proceeding along the internal helicoidal conductor 12 is considerably delayed by the dielectric; the propagation velocity would be divided by the square root of the dielectric constant if the influence of the central channel were neglected. The increase in delaying efficiency thus obtained permits the use of electron beams of lower velocities which has the advantage of reducing the necessary accelerating tensions.

2. The dielectric acts as a support for the helicoidal conductor 12. This is a support which, for a suitable dielectric, such as one of ceramic material, for example, has a great rigidity; it is not very sensitive to the temperature variations of the helicoidal conductor which means that the delaying line's dimensions during the mounting and the operation thereof is retained with precision.

3. Varying the losses in the dielectric material of the member 12 provides a means of giving the attenuation exactly the value desired for the return wave existing in the amplifier to be suitably attenuated. The losses of the dielectric can, for instance, be properly proportioned by a suitable addition of scattered conducting substances in the dielectrical substance.

It may be advantageous to progressively vary the attenuation rate along the line so that the attenuation is at a maximum at the line's inlet and at a minimum at its outlet. This enables one, for a given total attenuation to dissipate in the line an energy which is weaker than that which would be dissipated for a value of the attenuation which is constant along the line. Thus the efficiency of the amplifier tube can be improved.

The properly chosen dielectric can if desired constitute part of the jacket of the amplifier tube inside of which there is a vacuum.

In the modification illustrated by Fig. 2, the inner surface of the cylindrical member 20 of dielectric material, as well as the outer surface thereof, is initially coated completely with a metallic, electrical conducting material, as shown at 21. After the coating 21 is applied to the inner surface of member 20, the helicoidal internal conductor is formed by means of a screw tap 22 of suitable dimensions. This operation, which can eventually be carried out before the last baking of the dielectric, removes from the cylindrical member's inner surface all the metal except the metallic ribbon 23 which is to constitute the helicoidal internal conductor. Thus, the completed cylindrical member has a solid coating 13*a* on its outer surface, to constitute the external conductor, and a helicoidal strip or ribbon 23 on its inner surface, to constitute the internal conductor.

In the modifications illustrated in Figs. 3*a* and 3*b*, a helical groove 24 is first formed in the inner surface of the dielectric cylindrical member 20*a* before any metal coating is applied thereto. Then metal is applied, as indicated at 25, to the whole inner surface as schematically shown in Fig. 3*a*. The inside of the dielectrical member 20*a* is then reamed or turned so as to leave only the metallic part 26 (Fig. 3*b*) located at the bottom of the previously excavated groove 24 and forming the helicoidal internal conductor. The external conductor is again provided by a continuous metallic coating 13*b* on the outer surface of cylindrical member 20*a*.

In the arrangement shown in Fig. 4, a helicoidal strip of metal 29 is applied on the outer surface of a dielectrical cylinder 28, the walls of which are relatively thin, and the whole constituted by the cylinder 28 with the strip 29 thereon is inserted into a second dielectric cylinder 30 in which is propagated the outer field of the helicoidal internal conductor. Such metallization or coating carried out on the outside of a cylinder 28 can be more easily performed. The interior insulating surface of this apparatus can take a negative potential during the operation of the amplifier tube under the action of the electrons falling on this surface, and this can serve as an additional means of focusing the electron beam.

In the embodiment of Fig. 4, the internal conductor, provided by the helicoidal strip 29, is disposed on cylinder 28, but it is in contact with the internal surface of the outer cylinder 30, while the external conductor is provided by a continuous metallic coating 13*c* applied to the outer surface of cylinder 30.

While a number of modifications have been disclosed, it is to be understood that the invention is not limited thereto but is coextensive in scope with the appended claims.

What is claimed is:

1. An ultra high frequency traveling wave amplifier tube comprising an evacuated envelope having therein an electron gun at one end providing a cylindrical electron beam traveling with a predetermined velocity, a collector electrode located at the opposite end to receive said electron beam, a cylindrical member of dielectric material coaxial with said electron beam, and a low

velocity of propagation line having input terminals to receive ultra high frequency energy and output terminals to deliver amplified ultra high frequency energy, said line including a thin conductive coating on the exterior surface of said cylindrical member to provide an external conductor, and a thin conductive coating contacting the interior surface of said cylindrical member and in the form of a helix to provide an internal conductor, the helical form of said internal conductor having a pitch operative to produce a propagation velocity of the electromagnetic wave traveling along said line substantially equal to said predetermined velocity of the electron beam.

2. An ultra high frequency traveling wave amplifier tube according to claim 1; wherein said cylindrical member is formed of a ceramic material.

3. An ultra high frequency traveling wave amplifier tube according to claim 1; wherein said thin conducting coating in the form of a helix is formed on said interior surface of said cylindrical member.

4. An ultra high frequency traveling wave amplifier tube according to claim 1; further comprising an inner cylindrical member formed of dielectric material and fitting closely and coaxially into the first mentioned cylindrical member, said thin conducting coating in the form of a helix being formed on the external surface of said inner cylindrical member.

5. An ultra high frequency traveling wave amplifier tube according to claim 1; including conductive particles scattered within the dielectric material of said cylindrical member to provide a predetermined amount of attenuation for the ultra high frequency energy.

6. An ultra high frequency traveling wave amplifier tube according to claim 5; wherein the density of said conductive particles decreases in the axial direction of said line to provide maximum attenuation of the input end of said line and minimum attenuation at the output end of said line.

RICHARD WALLAUSCHEK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,957,538	Jensen	May 8, 1934
2,096,460	Llewellyn	Oct. 19, 1937
2,122,538	Potter	July 5, 1938
2,123,636	Schwartz	July 12, 1938
2,297,488	Luderitz	Sept. 29, 1942
2,300,052	Lindenblad	Oct. 27, 1942
2,304,540	Cassen	Dec. 8, 1942
2,338,558	Wickwire, Jr.	Jan. 4, 1944
2,367,295	Llewellyn	Jan. 16, 1945
2,368,031	Llewellyn	Jan. 23, 1945
2,413,608	DiToro	Dec. 31, 1946
2,541,843	Tiley	Feb. 13, 1951

OTHER REFERENCES

Article by R. Kompfner, pp. 124–127, Proc. I. R. E., February 1947, (Copy in U. S. Patent Office Scientific Library.)