

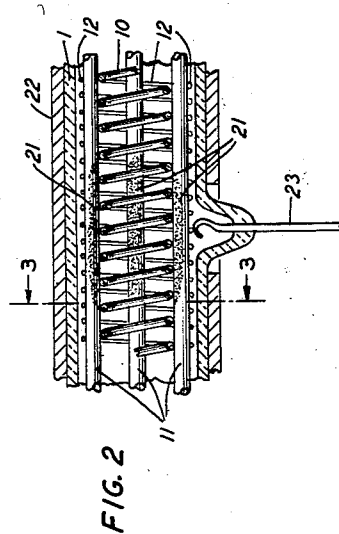
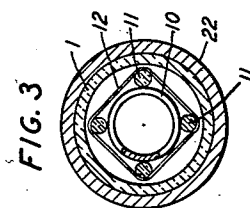
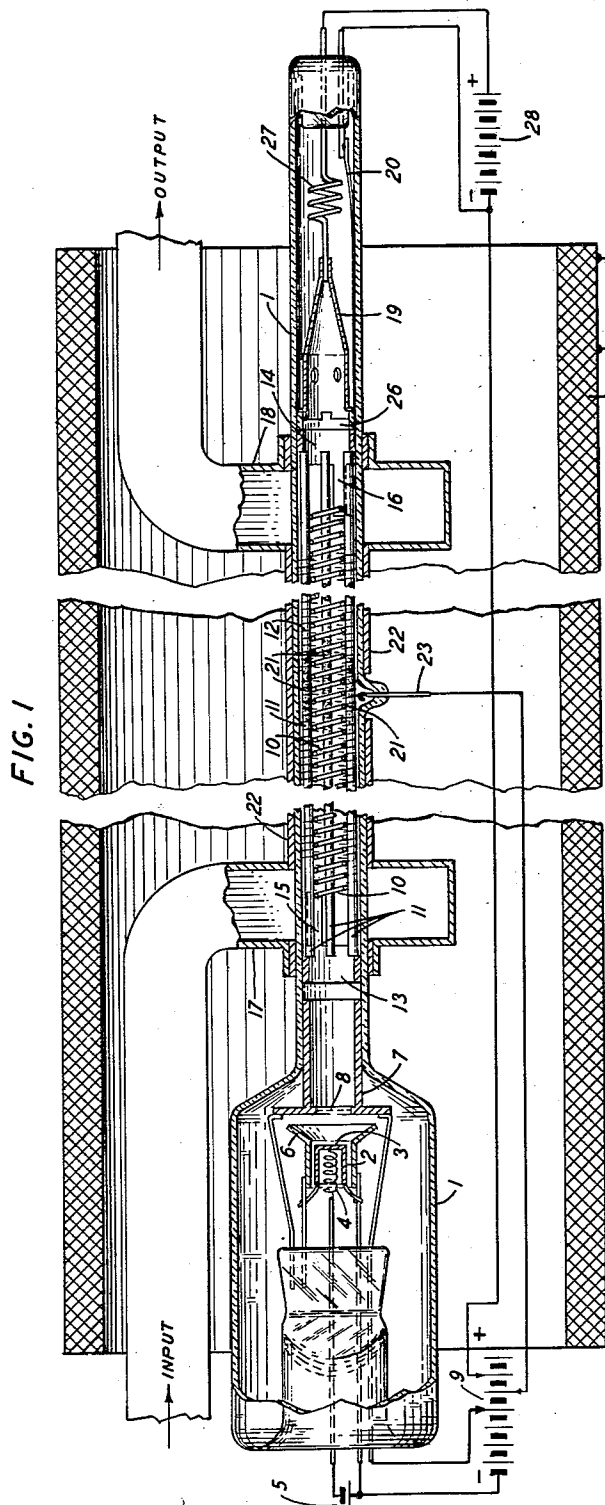
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ELECTRONIC AMPLIFIER

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1

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ELECTRONIC AMPLIFIER

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This invention relates to high frequency electronic amplifiers, particularly those of the traveling wave type in which a relatively long electron beam is projected along an electrical wave transmission circuit in such proximity as to be coupled thereto.

The general objective of the invention is to provide improved electron beam type traveling wave amplifiers.

A more specific objective is to reduce the undesirable noise components in the output signal of such devices.

Another objective is to provide an improved means generally useful for reducing the accumulation of positive ions in long electron beams.

Another objective is to provide means for reducing the production of secondary electrons in long beam tubes.

Another objective is to provide improved electron collecting means suitable for use in reducing secondary electron production.

It has been found in the operation of long beam amplifier tubes that troublesome noise may occur in the output circuit, which appears to be due to the trapping of positive ions along the electron beam where a potential depression is formed by space charge.

It has also been found that some noise components are affected by the amount of secondary electron emission and that the output noise may be reduced by suppressing the production of secondary electrons.

According to this invention the noise due to positive ion trapping is reduced by providing an electrode in the form of a helix which surrounds both the electron beam and the transmission circuit with which the beam interacts and which may also be a helix. This outer helical electrode is held at a potential different from that of the transmission circuit and cooperates to produce a transverse static electric field which tends to move the positive ions transversely out of the electron stream and so prevent their accumulation there to a troublesome degree. The construction of this outer ion removing electrode in helical form is an important feature of the invention as it presents an important advantage in that by its use it is possible to heat all the tube parts including this electrode by high frequency induction heating to effectively remove occluded gases during vacuum pumping.

The second type of noise referred to above, that resulting from secondary emission is reduced by utilizing an electron collector which is maintained at a high potential and has novel features to provide for expansion due to heat and for heat radiation.

The details of the invention are explained more fully in the following description and the accompanying drawings, in which:

Fig. 1 shows a complete traveling wave amplifier, the tube of which incorporates the features of the invention;

Fig. 2 is an enlarged view of a portion of Fig. 1 to show details of construction more clearly; and

Fig. 3 is a sectional view of Fig. 2.

Referring now to Fig. 1, this drawing shows the tube and circuits broken in the center in a conventional man-

2

ner so that the elements may be shown in a scale sufficiently large. To show the entire length of the typical tube at the scale employed would require about twice the length of the drawing space.

The description which follows is directed first to Fig. 1 but reference should also be made to the larger scale drawings Figs. 2 and 3 which show more clearly some of the details of Fig. 1. Similar elements are similarly designated in the three figures. Therefore, the following description where applicable refers to all three figures and is fully descriptive of them.

In the drawings the evacuated envelope of the amplifier tube which may be of glass or other suitable material is indicated by the designation 1. Within this envelope are electronic and high frequency circuit elements. The cathode 2 has an emissive coating on the surface 3 which is heated by means of heater 4. Energy for the heater is derived from the battery 5 to which it is connected. The electron beam-forming electrode 6 is shaped and positioned with respect to the cathode to direct the electrons in parallel paths toward the electron collector 19. Element 7 is an electron accelerating electrode with an associated grid 8. The helix 10, of conducting material, provides the high frequency electrical wave transmission path through the tube and is designed so that the phase velocity of the wave along the axis of the helix is substantially the same as the velocity of the electron beam projected along the axis. Ceramic rods 11 support and position accurately the helix 10 and at the ends are fitted into notches in the metallic collars 13 and 14. These rods 11 support the helical ion removing electrode 12 which is shown as wound on the four ceramic rods 11 outside of the helix 10 and is thus positioned between the helix 10 and the envelope 1. This is shown clearly in Figs. 2 and 3. The helix 12 is preferably of finer wire than that of helix 10 and wound with finer pitch. Also it should not be coupled to the input and output circuits as is the helix 10, and is therefore restricted in length so that the ends do not extend into the coupling regions of the input and output wave guides 17 and 18. With this lack of coupling and the type of construction of this helix 12 there is substantially no transfer of high frequency energy to it. This helical electrode 12 as shown is maintained at a potential negative with respect to the potential of the helix 10 by means of the lead 23 which is connected to a tap on battery 9, a more positive potential point of which is connected to the helix 10 through the lead 20 which passes between the ceramic ring 26 and the envelope 1 to connect with the collar 14 and thence through the coupling stub or connector 16 to helix 10. Without departing from the invention the helix 12 may be held at a potential positive rather than negative with respect to helix 10. The above-illustrated difference of potential between the helices 10 and 12 produces a field penetrating into the helix 10 which will tend to pull positive ions in the axial electron beam out between the turns of helix 10 to helix 12 where they will be collected and neutralized. If the potential difference is reversed so that the helix 12 is positive with respect to helix 10 the penetrating field will tend to collect the positive ions on the helix 10.

The connector 16 between the output end of helix 10 and the collar 14 couples the output end of the helix to the output wave guide 18. The collar 14 terminates the output end of the helix 10 and by-passes the electric wave from the output end of the helix to the output wave guide 18. The connector 15 between the input end of helix 10 and the collar 13 couples the input end of the helix to the input wave guide 17. The collar 13 terminates the input end of the helix 10 and by-passes the electric wave from the input end of the helix to the input wave guide 17. The potential source 9 provides potential dif-

ferences between the cathode and electron accelerator 7, the ion removing helix 12 and the helix 10 by means of the leads shown and referred to above. An additional potential source 28 is connected between the positive terminal of source 9 and the electron collector 19 to maintain the collector at a potential higher than that of the helix 10. Operating the collector at this higher potential has the effect of suppressing low velocity secondary electrons which in turn has the effect of reducing the noise induced in the output circuit of the tube. Novel features of the collector and its mounting are the shape of the collector, which is conical so that the electrons impinge uniformly over a large surface for uniform temperature and heat radiation, and the helical spring support 27, which provides a long path for reduction of heat conduction to the glass seal and also holds the assembly together while permitting expansion with heating. These features are obviously of importance with relatively large dissipation of energy in the form of heat at the collector. Dissipative material 21 capable of absorbing high frequency energy is deposited on the ceramic rods 11 on the inwardly facing surfaces only so that it is not in contact with the turns of helix 12. This loss material 21 provides a certain amount of attenuation to the high frequency wave in the transmission circuit along which the electron beam amplifies the wave energy which is important in a wave amplifier of this type. The solenoid 24 which may be energized from any direct current source such as battery 25 serves to provide an axial magnetic focusing field throughout the length of the electron beam. It should be noted in this connection that with this type of focusing arrangement the tube material must be non-magnetic.

In operation of the amplifier of Fig. 1 the wave to be amplified enters through the input wave guide 17, is transferred to the input end of the helix 10 through the coupling connector 15 which is in the field of the wave guide, and is transmitted along the helix to the coupling connector 16 at the output end of the helix by which it is transferred to output wave guide 18. The electron beam originating at the cathode surface 3 is projected along the axis of the helix 10 to the collector 19. The helix 10 provides a wave transmission path several wavelengths long (in a typical case as many as forty wavelengths). The velocity of the high frequency wave along the axis of the helix is dependent upon the radius of the helix and the pitch of the winding and is approximately the velocity along the wire of the helix divided by the circumference of the helix in inches and the number of turns per inch. Thus, the helix may be designed so that the velocity of the wave along the axis of the helix is reduced to be near the velocity of the electron beam projected therealong, such a velocity being necessary to allow amplification of the wave. Final adjustment of the electron beam velocity may be made by adjustment of the electron accelerating voltage.

With the tube adjusted and in operation there is interaction between the high frequency field of the helix 10 and the electron beam, so that the input high frequency wave applied to the helix 10 induces a similar wave in the electron beam, which increases along the beam path and transfers high frequency energy from the beam to the electric wave traveling along the helix to the output wave guide 18. Thus the electric wave is amplified in its passage between the input guide 17 and the output guide 18.

The helix 12 which functions to remove positive ions from the electron beam is maintained either at a lower potential than the helix 10 as shown in Fig. 1 or, as it may be, at a higher potential than the helix 10 and in either case the electric field configuration produced, having radially directed components transverse to the direction of the electron beam, tends to move positive ions out of the beam and to either the helix 12 or the helix 10, depending upon which is at the lower potential, where they are collected. This tends to prevent the accumulation of ions in the beam to a degree where noise oscilla-

tions may occur. In this manner the noise current at the output of the tube originating in the electron beam is reduced.

The use of a high potential electron collector at the end of the beam path as shown in Fig. 1 also effects a reduction in output noise currents by reducing the production of secondary electrons below what may be produced with a lower potential collector. The novel features of the collector and its mounting which facilitate the radiation of heat and provide for temperature expansion have been described.

The utility of the helical type of ion removing electrode, the high potential electron collector and the mechanical features of the collector is not limited to the embodiment of Fig. 1 or to other types of traveling wave amplifiers and any or all features of the invention may find application to other devices employing a long electron beam in which it is desired to accomplish the results of their use.

What is claimed is:

1. An electronic device comprising an evacuated envelope containing a cathode and an electron collector spaced apart, electric potential means connected to said cathode for producing a beam of electrons along an extended path between said cathode and said collector, a high frequency electrical wave propagating circuit comprising an elongated helix of predetermined pitch disposed along and surrounding said path in proximity thereto, said wave propagating circuit having an energy input end and an energy output end, insulating support means for said wave propagating circuit, an ion removing electrode in the form of a helix surrounding both said electron beam and said wave propagating circuit, said ion removing helix having a pitch different from that of said first-mentioned helix whereby the propagation constant of the two helices are different and substantially no coupling is effected between the two, said ion removing helix being out of coupling relation with said wave propagating circuit input and output, said insulating support means supporting and positioning said ion removing helix relative to said wave propagating circuit, and electric potential means connected to said ion removing helix for maintaining a difference of direct-current potential between said circuit and said ion removing helix.

2. An electronic device comprising an evacuated envelope containing an electron emitter and an electron collector spaced apart, electric potential means connected to said emitter for producing a stream of electrons along an extended path between said emitter and said collector, a high frequency electrical wave transmission circuit having an energy input end and an energy output end disposed along and surrounding said path in proximity thereto, a helix of conducting material extending along and surrounding said path, said helix being out of energy coupling relation to said wave transmission circuit and out of energy coupling relation to said input and output ends, common non-conductive support means for supporting and positioning said helix and said wave transmission circuit relative to each other, electric potential means connected to said helix for maintaining said circuit at a higher direct-current potential than that of said helix, and electric potential means connected to said collector for maintaining said electron collector at a substantially higher direct-current potential than that of said transmission circuit and that of said helix.

3. A wave amplifying device comprising in combination a wave transmission circuit including a first conductor in the form of an elongated first helix having an energy input end and an energy output end, nonconductive support means for said first helix, means for producing a beam of electrons traveling lengthwise of and inside said first helix, a second conductor in the form of a second helix surrounding said beam of electrons and said first helix, the pitch of said first helix being different from the pitch of said second helix whereby the propagation constants of the two helices are substantially different and

5

substantially no coupling is effected between the two, said second helix being restricted in length so that its ends do not extend into the coupling regions of said input and output ends of said first conductor, said support means being adapted to support and position said second conductor relative to said first conductor, and direct-current potential means connected to said helices for maintaining the two said helices at different direct-current potentials.

4. An electronic device comprising an electron emitter, means connected to said emitter for producing a stream of electrons along a path extending from said emitter, an electrical wave transmission path comprising a first helical member of conducting material extending along and surrounding said path in coupling relation for signal energy to said stream of electrons, means for applying signal energy to said wave transmission path, a plurality of longitudinal support members of insulating material extending along and bearing against the outer periphery of said first helical member to support and position said first helical member, a second helical member of conducting material wound about and supported by said support members, the pitch of said second helical member being substantially different from the pitch of said first helical member for minimizing signal energy coupling between said helical members, means for establishing an

6

electrical gradient between said helical members to remove ions from said stream of electrons comprising means for maintaining a difference of direct-current potential between said helical members, electron collector means at the end of said helical members remote from said emitter, and means for maintaining said collector means at a substantially higher direct-current potential than either of said helical members.

5. A device according to claim 1 in which the circuit is maintained at a direct-current potential higher than that of the helix.

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