

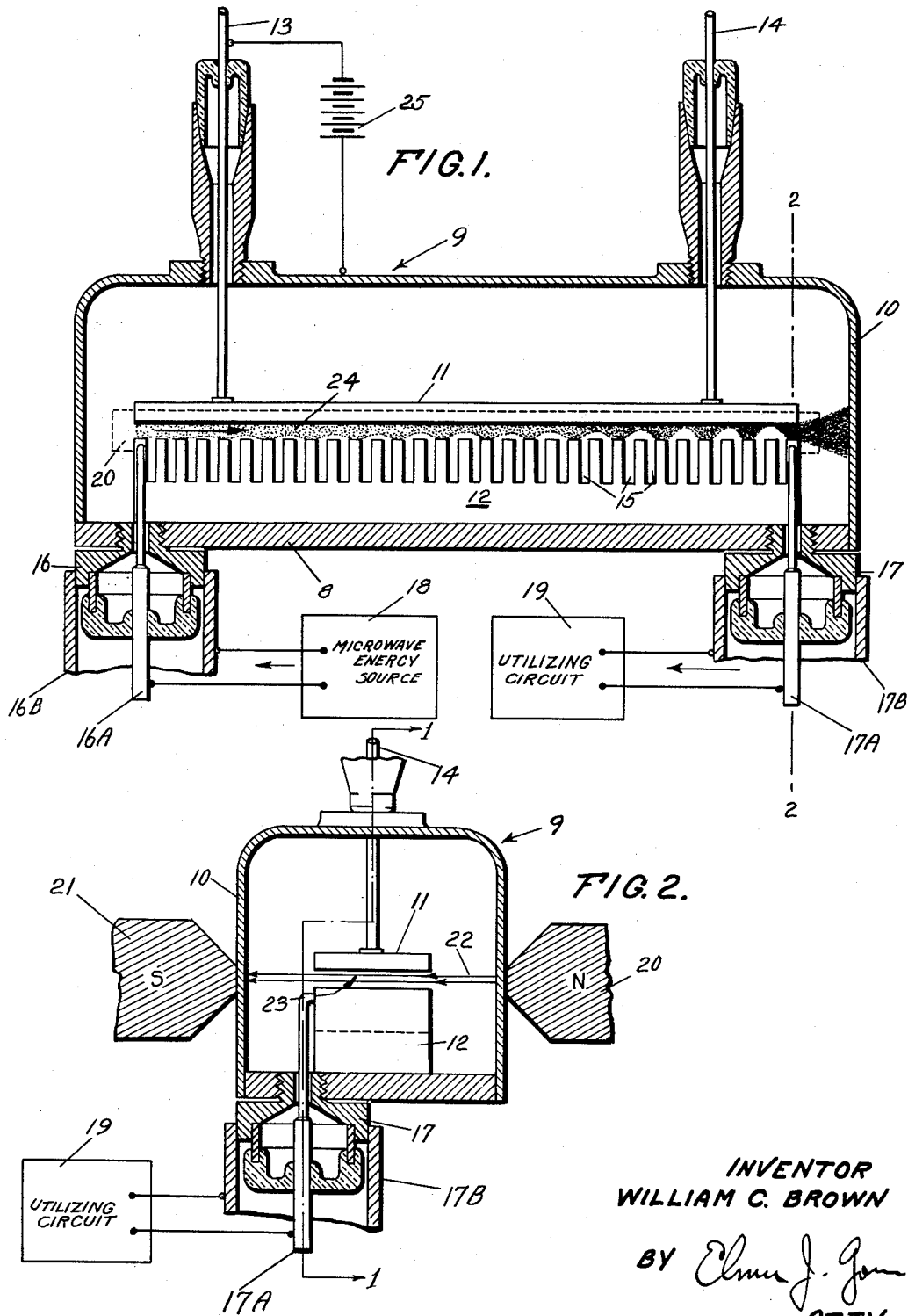
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ELECTRON DISCHARGE DEVICE OF THE TRAVELING WAVE TYPE

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ELECTRON DISCHARGE DEVICE OF THE TRAVELING WAVE TYPE

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This invention relates to radio frequency amplifiers employing electron discharge devices for amplification and oscillation production in the microwave spectrum.

It is a main object of the present invention to provide a very broad band radio frequency amplifier of the traveling-wave type.

Other and further objects and advantages will become apparent and the foregoing will be understood in relation to the following exemplification thereof, reference being had to the drawing, in which:

Fig. 1 is a cross-sectional view of an illustrative embodiment of the present invention taken along line 1—1 of Fig. 2; and

Fig. 2 is a cross-sectional view taken along 2—2 of Fig. 1 illustrating the relation of the electrodes of the illustrative embodiment with respect to the external magnetic means.

Referring now more particularly to Fig. 1 the numeral 9 represents an electron discharge device comprising an evacuated vessel 10, preferably of copper, other non-magnetic metal or a vitreous material, containing therein an elongated electron-emissive cathode 11 and an elongated anode 12. The cathode 11 may be heated to a temperature of thermionic emission by a heater (not shown) and is suitably supported within the evacuated vessel 10 by a pair of electrically-conductive members 13—14. The anode 12 consists of an elongated member preferably constructed of copper and having cut into one surface thereof a plurality of slots 15, which constitute wave retarding means. The slots 15, in the illustrative embodiment, are cut transversely with respect to the length of said anode and are so disposed that they face the electron-emissive surface of the cathode 11. When said cathode is suitably energized the electron population present in the space between said cathode 11 and anode 12 will be statistically constant.

The anode may be supported by being secured to the lower conducting wall 8 of the vessel 10. Microwave energy is coupled into the anode structure by the central conductors 16A and 17A of a pair of coaxial transmission line members 16—17 extending within said envelope 10 and suitably sealed therein. The central conductor 16A and outer conductor 16B of the coaxial member 16 is connected to a source of microwave energy 18 and represents the input to the electron discharge device 9 while the inner and outer conductors 17A and 17B, respectively, of the coaxial member 17, functioning as the output means, is connected to a utilizing circuit 19. Although the illustrative embodiment utilizes input and output conducting means in the form of coaxial lines, the invention is readily adapted for coupling directly to wave guide systems in any well-known manner.

Disposed adjacent the envelope 10 are pole pieces 20—21, respectively designated N for the north pole and S for the south pole. When suitably energized, the field 22 between said pole pieces will traverse the space 23 between the cathode 11 and anode 12 in a direction which is transverse to the normal path of the electron population

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between said last-named electrodes. Therefore, according to well-established electromagnetic principles, the electron population will be caused to move in a direction, with respect to the drawing, for example Fig. 1, from left to right, or in Fig. 2, from out of the paper toward the observer. The velocity of the electrons will depend on the magnitudes of the two fields acting upon them, that is the field between the pole pieces 20—21 and the field between the cathode 11 and anode 12.

Let it be assumed that the electrodes 11—12 are energized by a source of potential 25 and the pole pieces 20—21 have been suitably energized by external means (not shown) and that a radio frequency potential from source 18, in the microwave spectrum, has been applied to the anode 12 via the input 16. The retarding means or slots 15 will reduce the velocity of the phase of the wave, as it travels in the space between the cathode 11 and anode 12, well below that of the velocity of light, and well within the velocity obtainable by the electrons in the path of such wave travel. Now as the electron population 24 is deflected from left to right as above described, said electron population interacts with the microwave radio frequency energy as said energy is propagated along the space 23 between the electrodes 11—12 to the output means 17. In the course of its travel, said input energy produces a wave along the slotted anode 12 and "bunches" the electrons in the electron stream 24. The electrons in the "bunches" should be traveling at a slightly greater velocity than the phase velocity of said microwave propagation in said space between said cathode and anode. Under these conditions said electrons give up energy to the microwave field in progressively larger amounts as they travel in the direction of the output means 17, to produce at that terminus a substantially amplified signal. The aforementioned electrons, after having given up a substantial part of their energy, continue on from the right-hand end, with respect to the drawing, of the path between the cathode 11 and anode 12 and are absorbed by the electrically conductive vessel 10.

The use of the expression "bunches" in the electron stream is a part of a wave phenomenon. The electrons forming a given bunch are continually changing, for the electrons are traveling faster than the wave. This difference in the velocity of the electron stream with respect to the phase velocity of microwave propagation is brought about by the novel construction of the anode, namely, the slot arrangement illustrated and described. This arrangement provides the means for adjusting the velocity of the wave through the space between said cathode 11 and anode 12 to correspond to or be less than the average velocity of the electron, so that said electron encounters approximately the same phase condition throughout the length of the space between said electrodes 11—12.

While the illustrative embodiment shows the use of a slotted anode, different configurations will suggest themselves to those versed in the art, the object of the present invention being to provide a path for the microwave energy which will be suitably related to the time of travel of electrons between the points of reaction since the wave velocity along the path described exceeds possible velocities of the electrons present in said path. Final adjustment of the relative time of the waves and electron stream between points of interaction is possible by selection of the magnitude of the fields acting on the electron stream.

The embodiment of the present invention which has been illustrated and described has been selected for the purpose of setting forth the principles involved. It will be obvious that the present invention may be modified to meet various conditions and it is, therefore, intended to cover by the appended claims all such modifications which fall within the spirit and scope of the present invention.

What is claimed is:

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1. A high frequency electronic device comprising an electron source and a non-reentrant signal wave transmission delay network disposed in substantially extended parallel space relation, means for directing electrons from said source along a path in proximity to said network in a direction substantially parallel to the direction of transmission of waves along said network and at velocities at which substantial interaction occurs between signal waves along said network and said electrons, said network consisting of a plurality of periodically spaced elements, each having one extremity attached to a common base and having the other extremity free and signal means tightly coupled to said network adjacent at least one end of said network, said coupling means being conductively connected directly to the end of said network and including a conductive portion attached to one of said elements adjacent to its free extremity.

2. A high frequency electronic device comprising an electron source and a non-reentrant signal wave transmission delay network disposed in substantially extended parallel spaced relation, means for directing electrons from said source along a path in proximity to said network in a direction substantially parallel to the direction of transmission of waves along said network and at velocities at which substantial interaction occurs between signal waves along said network and said electrons, said network consisting of a plurality of periodically spaced elements, each having one extremity attached to a common base and having the other extremity free and signal means tightly coupled to said network adjacent at least one end of said network, said coupling means being conductively connected directly to the end of said network and including a conductive portion attached to one of said elements at a region thereof adjacent the path of said electrons.

3. A high frequency electronic device comprising an electron source and a non-reentrant signal wave transmission delay network disposed in substantially extended parallel spaced relation, said electron source having substantially constant electron emission properties along its surface thus presented to said network, means for directing electrons from said source along a path in proximity to said network in a direction substantially parallel to the direction of transmission of waves along said network and

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at velocities at which substantial interaction occurs between signal waves along said network and said electrons, said network consisting of a plurality of periodically spaced elements, each having one extremity attached to a common base and having the other extremity free and signal means tightly coupled to said network adjacent at least one end of said network, said coupling means being conductively connected directly to the end of said network and including a conductive portion attached to one of said elements adjacent to its free extremity.

4. A high frequency electronic device comprising an electron source and a non-reentrant signal wave transmission delay network disposed in substantially extended parallel spaced relation, means for directing electrons from said source along a path in proximity to said network in a direction substantially parallel to the direction of transmission of waves along said network and at velocities at which substantial interaction occurs between signal waves along said network and said electrons, said direction means including means for producing a magnetic field substantially transverse to an electric field between said electron source and said network, said network consisting of a plurality of periodically spaced elements, each having one extremity attached to a common base and having the other extremity free and signal means tightly coupled to said network adjacent at least one end of said network, said coupling means being conductively connected directly to the end of said network and including a conductive portion attached to one of said elements adjacent to its free extremity.

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