Oct. 15, 1946. B. SALZBERG 2,409,591

ELECTRON DISCHARGE DEVICE AND CIRCUIT

Filed Nov. 11, 1942

Fig. 1.

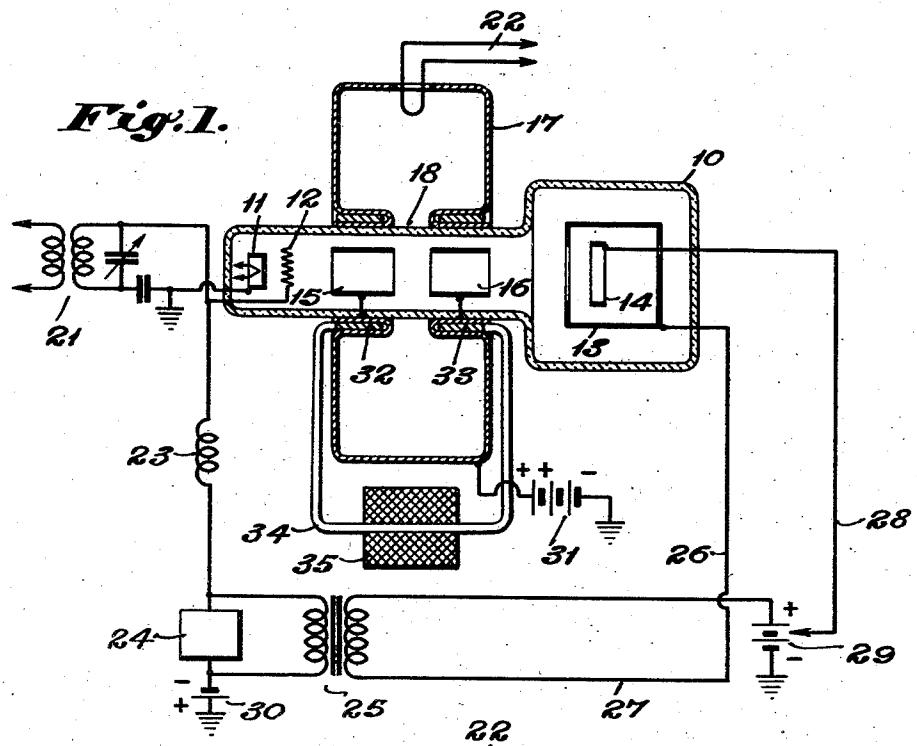
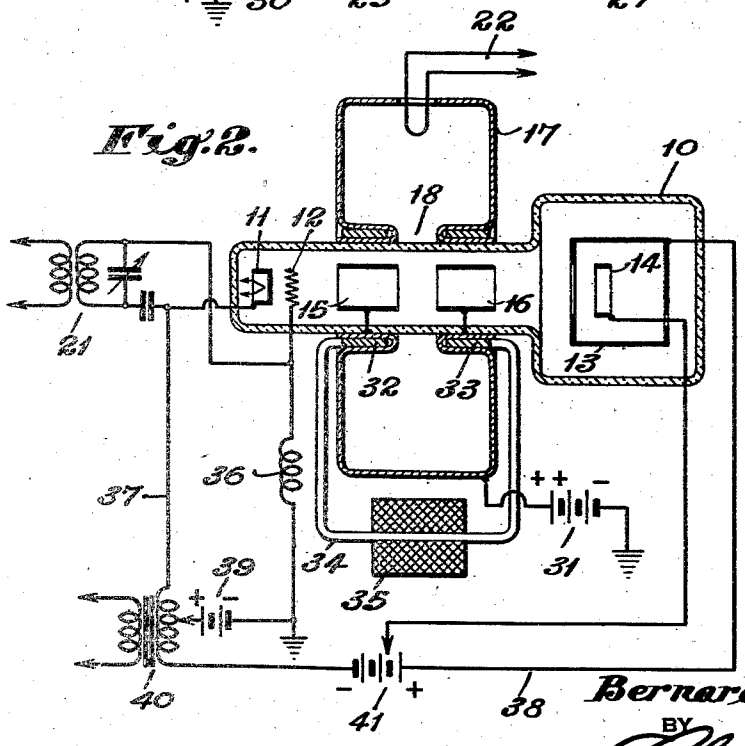


Fig. 2.



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Patented Oct. 15, 1946

2,409,591

UNITED STATES PATENT OFFICE

2,409,591

ELECTRON DISCHARGE DEVICE AND CIRCUIT

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Application November 11, 1942, Serial No. 465,247

7 Claims. (Cl. 179—171.5)

1

My invention relates to electron discharge devices and circuits therefor, particularly to such devices utilizing inductive output and suitable for use at ultra high frequencies.

In one form of election discharge device utilizing the inductive output method of operation, a cathode supplies a directed beam of electrons which is received by an oppositely disposed collector. Positioned adjacent to the cathods is a grid for modulating the electron beam. A pair of longitudinally spaced screening and accelerating electrodes are positioned between the grid and collector. Positioned between the grid and the collectod and surrounding the electron stream is a resonator or hollow conducting member provided with a centrally positioned passageway through which the electron beam passes. The passageway is provided with a gap surrounding the electron stream and lying in a plane transverse to the beam and registering with the space between the accelerating electrodes. In operation an r. f. field is induced within the resonator and across this gap and coacts with the beam to produce an interchange of energy between the beam and the field. The time of passage of the electrons in the modulated beam is so related to the r. f. field across the gap that normally the electrons are decelerated to give up energy to the r. f. field of the resonator or tank circuit after which the electrons are collected at a reduced velocity by the collector. The device may be used either as an amplifier or with feedback as an oscillator. An electron discharge device of the above type is more fully described and claimed in Patent No. 2,237,878 Haeff, issued April 8, 1941, and assigned to the same assignee as the present application.

In this type of tube the power input is equal to the product of the collector voltage and the D.-C. collector current. The power dissipated at the collector is the difference between this power input and the power taken from the electron stream by the resonator or loaded tank circuit. Therefore, for reasons of efficiency, it is desirable that the collector voltage be kept low, that is, only high enough to collect electrons that have been decelerated on passage through the tank circuit gap, thus reducing the power dissipated at the collector. A more detailed explanation follows.

Assuming that an alternating voltage of fixed frequency and amplitude is applied to the control grid there will be a certain critical collector potential above which there will be no increase in collector current. That is, at this critical potential all the electrons from the cathod passing the gap of the resonator are being collected. This critical potential will be equal approximately to the voltage required to collect the electrons under static conditions, that is with the resonator unexcited plus the peak r. f. voltage appearing across the gap of the resonator. If now the alternating voltage is decreased in amplitude the r. f. voltage across the gap is also decreased so that the amount of deceleration of the electrons is decreased, which means that the electrons arrive at the collector with more energy than in the first case, resulting in greater dissipation at the collector and hence loss of energy. This additional loss may be overcome by lowering the voltage on the collector so that the electrons are again all collected but at a lower velocity.

2

Thus, if a tube of the type described be modulated by impressing a modulating voltage in series with the control grid polarizing voltage, the efficiency will be relatively low and consequently for a given rated collector dissipation the radio frequency output will be relatively low. The reasons for the low efficiency are as follows: When the modulating voltage is adjusted to its maximum value, the greatest value of peak r. f. voltage will be obtained across the gap of the resonator. Thus, as can be understood from what has been said above, the value of the collector voltage must be equal to the sum of this peak r. f. voltage and a certain knee voltage to obtain good efficiency. However, when the modulating voltage is decreased, say to zero, which corresponds to the carrier condition or voltage of fixed frequency and amplitude, the peak r. f. voltage across the resonator gap will be decreased. But as explained above the collector voltage is now too high for the optimum value and, therefore, the collector input is too great for the carrier condition, resulting in a carrier efficiency that is low.

If on the other hand the collector voltage be readjusted to obtain good efficiency at the carrier condition, its value will be too low for the fully modulated condition. That is, because of the greater deceleration of the electrons across the resonator gap when the modulating voltage is applied, the collector voltage will be too low to collect all of the electrons passing the gap with the result that the electrons will be returned to the space between the collector and the grid and may be collected by the accelerating electrodes, resulting in overheating of these electrodes and possibly other undesirable effects. Thus the optimum value of the collector voltage is equal

approximately to the sum of the collector voltage shown at the knee of the static collector characteristics and the peak r. f. voltage across the gap of the resonator.

It is, therefore, the principal object of my invention to provide an electron discharge device of the inductive output type and its associated circuit which will result in high efficiency of the device and circuit.

More specifically it is an object of my invention to provide such a device and circuit in which the operating voltages are automatically maintained at optimum value during operation of the device.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a schematic longitudinal section of an electron discharge device and its associated circuit made and connected according to my invention, and Figure 2 is a modification of the electron discharge device and circuit shown in Figure 1.

Referring to the drawing, Figure 1, the electron discharge device comprises an elongated envelope 10 containing at one end the indirectly heated cathode 11, control grid 12 and at the other end a collector 13 provided with a secondary electron emission suppressor 14. Positioned between the grid and the collector are a pair of screening and accelerating electrodes 15 and 16 spaced from each other in a longitudinal direction. Surrounding the envelope is a resonator comprising a hollow conducting member preferably symmetrical about said envelope and provided with a gap 18 registering with the gap between the electrodes 15 and 16. In order to provide a properly focused beam at the gap to prevent dispersion, collars 32 and 33 of magnetic material may be disposed about the envelope and within the conducting material of the resonator as shown. These electromagnetic elements or collars may be energized by means of yoke 34 and electromagnet 35.

In input voltage may be applied by means of circuit 21, the grid 12 being properly polarized by means of the polarizing potential source 30, the cathode being grounded as shown. The modulating voltage is applied by means of the modulation device 24 through an r. f. choke 23. The electrodes 15 and 15 and resonator 17 may be maintained at a high positive potential by means of voltage source 31. The modulator is coupled to the collector 13 by means of the coupling transformer 25. The collector and suppressor voltage is supplied by means of the polarizing source of potential 29. This voltage is adjusted for optimum conditions with no modulating voltage applied to the grid by modulating device 24. In operation the excitation voltage is applied to the grid 12 by means of the input circuit 21. The grid is generally biased for class C operation so that spaced groups of electrons cross the gap 18, the phase relation being such that these electrons cross the gap when the r. f. voltage across the gap is in such a direction as to decelerate the electrons so as to extract energy from the modulated stream of electrons in the manner now well known and describel in the Haeff patent identified above. The decelerated electrons are then collected by collector 13.

As explained above, if the voltage applied to the collector 13 is optimum for no modulation, when modulation is applied to grid 12, the voltage on the collector 13 is not sufficient to collect all the electrons. By means of the arrangement shown a modulating voltage in phase with the modulating voltage applied to the grid is applied by means of the transformer 25 to the collector. Thus when the modulating voltage on grid 12 is increased to peak voltage, the voltage on the collector 13 is also increased in proportion, so that the collector voltage always has such value that optimum conditions are obtained. The transformer 25 is designed to supply modulating voltage to the collector of an amount, relative to that of the grid, which will insure that the instantaneous collector voltage is at its optimum value, and to handle the direct currents through its windings without saturating.

The modification shown in Figure 2 employs a different arrangement for connecting the audio modulator to the grid 12 and collector 13. Like numbers are used in Figure 2 to designate like parts.

In the arrangement shown in Figure 2 the secondary of the modulating transformer 40 is provided with a tap which is connected to one side of the grid through the r. f. choke 36. One side of the transformer is connected to the cathode by means of conductor 37 and the other side to collector 13 by means of conductor 38, the sources of potential 39 and 41 supplying polarizing voltages for the grid 12 and collector 13. Since the cathode and collector are connected at opposite sides of the secondary of the transformer, the modulating voltage on the collector will be positive with respect to the tap when that on the cathode is negative, so that the voltage on the grid 12 and collector 13 are in phase with respect to the voltage on the cathode. Here again the modulating voltage on the grid and collector are in phase to bring about optimum operating conditions. The result is high collector efficiency over the whole modulation cycle and a consequently higher r. f. output is obtained.

While I have indicated the preferred embodiment of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having means for supplying a stream of electrons and a collector for receiving said electrons, electrode means for modulating said stream of electrons, and other electrode means between said modulating electrode means and collector and through which said stream of electrons passes, and means for applying a modulating voltage on said collector in phase with the voltage on said modulating electrode means.

2. An electron discharge device having means for supplying a stream of electrons and a collector for receiving said electrons, electrode means for modulating said stream of electrons and means between said modulating electrode means and collector for inductively extracting energy from the modulated stream of electrons, and means for applying a modulating voltage on said collector in phase with the voltage on said modulating electrode means.

3. An electron discharge device having means

for supplying a stream of electrons and a collector for receiving said electrons, electrode means for modulating said stream of electrons, means between said modulating means and said collector for inductively extracting energy from the modulated stream of electrons, means for applying a first modulating voltage on said modulating means and a second means for applying a second modulating voltage on said modulating means and a modulating voltage on said collector in phase with the second modulating voltage on said modulating means.

4. An electron discharge device having means for supplying a beam of electrons, and a collector for receiving said beam of electrons, a grid for modulating said stream of electrons and means including a resonator having a gap surrounding said stream between said grid and collector for inductively extracting energy from said beam of electrons, means for applying an exciting voltage to said grid, means for applying a modulating voltage to said grid, and means for coupling said modulating means and said collector for applying a modulating voltage to said collector in phase with the modulating voltage on said grid.

5. An electron discharge device having a cathode for supplying a beam of electrons, and a collector for receiving said electrons, a grid adjacent said cathode for modulating said beam of electrons, a pair of screening and accelerating electrodes positioned between the grid and the collector and spaced to provide a gap therebetween, a resonator surrounding said electron discharge device having a gap lying in a plane transverse to the electron beam and registering with the gap between the screen and accelerating electrodes, means for applying an exciting voltage on said grid and means for applying a modulating voltage on said grid and including means for applying a modulating voltage on said collector in phase with the modulating voltage on said grid.

6. An electron discharge device having a cathode for supplying a beam of electrons, and a collector for receiving said electrons, a grid adjacent said cathode for modulating the electron stream, a pair of screening and accelerating electrodes positioned between the grid and the collector and spaced to provide a gap therebetween, and a resonator surrounding said electron discharge device having a gap lying in a plane transverse to the electron beam and registering with the gap between the screen and accelerating electrodes, means for applying an exciting voltage on said grid and means for supplying a modulating voltage on said grid and including means for applying a modulating voltage on said collector in phase with the modulating voltage on said grid, said modulating means including a transformer having a secondary provided with a tap, said tap being connected to said grid and one side of said secondary being connected to said cathode and the other side of said secondary being connected to said collector.

7. An electron discharge device having a cathode for supplying a beam of electrons, and a collector for receiving said electrons, a grid adjacent said cathode for modulating said electron beam, a pair of screening and accelerating electrodes positioned between the grid and the collector and spaced to provide a gap therebetween, and a resonator surrounding said electron discharge device having a gap lying in a plane transverse to the gap in the electron beam and registering with the gap between the screen and accelerating electrodes, means for applying an exciting voltage on said grid and means for supplying a modulating voltage on said grid and including means for applying a modulating voltage on said collector in phase with the modulating voltage on said grid, said modulating means including a transformer having a secondary provided with a tap, said tap being connected to said grid and one side of said secondary being connected to said cathode, and the other side of said secondary being connected to said collector, and a radio frequency choke connected between said center tap and said grid.

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