April 28, 1936. G. JOBST 2,038,738

ELECTRON DISCHARGE TUBE

Filed June 17, 1933

Fig. 1

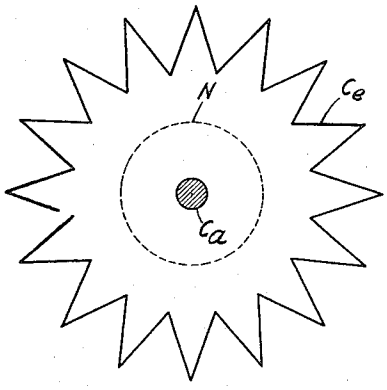


Fig. 2

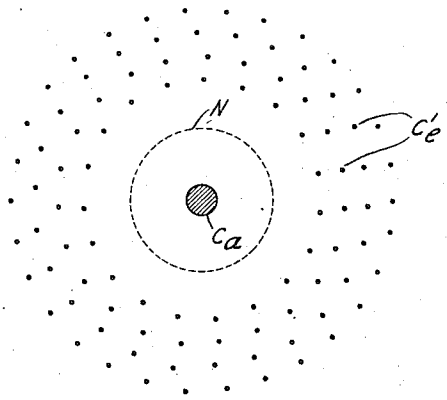


Fig. 3

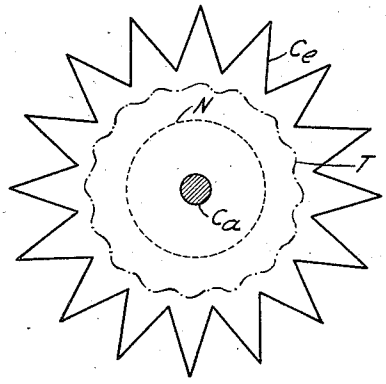


Fig. 4

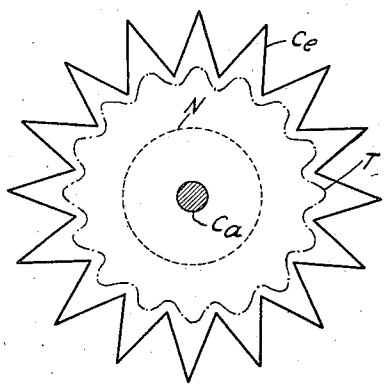


Fig. 5

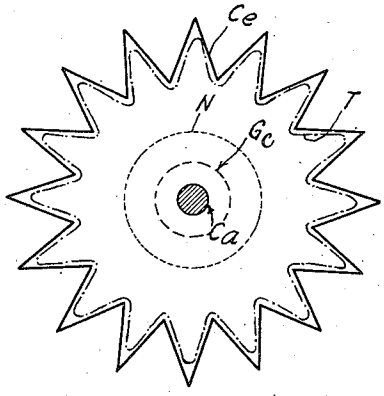
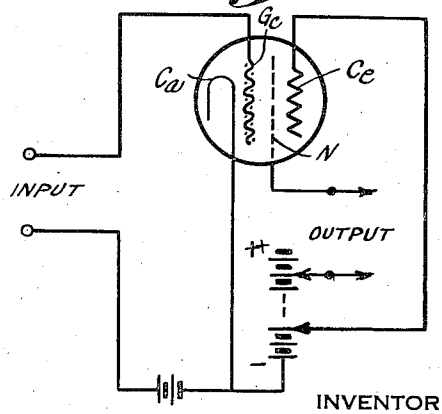


Fig. 6



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2,038,738

ELECTRON DISCHARGE TUBE

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Application June 17, 1933, Serial No. 676,257
In Germany June 18, 1932

6 Claims. (Cl. 250—27)

The object of the present invention is to provide an improved electron discharge device having a negative resistance characteristic. A further object of the invention is to provide an amplifier tube whose output electrode has a very high resistance characteristic or a negative resistance characteristic, thus providing increased amplification and increased selectivity in a tuned amplifier.

In my copending application, Serial No. 667,244, filed April 21, 1933, electron tubes used as negative resistances have been disclosed wherein the falling plate voltage-plate current characteristic results from the effect of space charge, and not from secondary emission, as is the case in other negative resistance devices known in the art. In the aforementioned application it was assumed that the ratio of current emitted from the cathode to the voltage impressed upon the electrode exhibiting negative resistance, was rather high in order to insure sufficient space charge density to produce the negative resistance phenomenon. When it is desired to use relatively high voltages upon the negative resistance electrode however, it will often be inconvenient to provide sufficient cathode emission to obtain the necessary space charge density. According to the present invention, the negative resistance characteristic is obtained without the necessity of providing excessively large cathode emission, by suitable construction of what will hereafter be termed the "counter electrode". This counter electrode is not the electrode exhibiting negative resistance, but is the electrode whose absorption of electrons causes the reduction of electron flow to the negative resistance electrode.

The operation of the invention is as follows: First there is provided a cathode capable of emission saturation, or else a cathode having one or more grids or screens surrounding it and insuring the fixed value of electron flow to the exterior of these screens. Located in the path of this fixed electron flow is a grid-like electrode which is the one exhibiting the negative resistance characteristic and which will be called the "negode" of the device, to indicate that it is the anode or output electrode which has the negative characteristic. Beyond the negode is another electrode, previously referred to as the counter electrode. It has been found that as the potential of the negode is raised, electrons passing therethrough tend to reach the counter-electrode in greater and greater numbers due to the fact that the space charge grows less with increasing electron velocities and constant electron current. The increasing absorption of the electrons by the counter electrode causes a decrease in the number of electrons falling back upon the negode.

In the present invention the counter electrode is so shaped as hereinafter described to provide recesses or cavities wherein the voltage gradient is greatly reduced as compared to the voltage gradient at the surface of a smooth counter electrode. It has been found that this type of construction greatly increases the negative resistance action and allows it to be obtained even when rather small electron currents issue from the cathode or surrounding grid. It is thought that the space charge density is increased within the recesses due to the low voltage gradient therein, and thus providing space charge densities comparable with what could only be obtained in the case of a smooth counter electrode by using excessively large currents.

Figs. 1 to 5 show different forms of electrode arrangement.

Fig. 6 shows the potential relationship between the several electrodes.

Fig. 1 shows diagrammatically in cross section a form of the invention wherein the counter electrode C_e is made to have a zig-zag shape. The dotted circle represents the negode N, and the interior small shaded circle the cathode C_a. Fig. 2 is a similar view and shows another means for obtaining spaces of low potential gradient which consists in making the counter electrode C_e' in the form of a number of wires or concentric grids all connected together. Fig. 3 is an attempt to show the limits of the trajectory of electrons streaming out from the negode when the negode potential is rather low. The dot and dash wavy line T indicates the limits of the electron trajectory. The counter electrode potential is supposed to be slightly positive so that the only reason why electrons do not reach this counter electrode is that they are stopped by the large space charge in a region of the counter electrode. As the negode voltage is raised, electrons shoot through with a higher velocity and approach the counter electrode still more closely, as shown in Fig. 4. Upon still further raising the potential of the negode the electrons do not fall back upon it until they have penetrated deeply into the recesses of the counter electrode as indicated in Fig. 5. Upon a still further increase in the negode potential most of the electrons actually reach

the counter electrode, and thus the negode current diminishes rapidly at this point. This diminution of current with increasing voltage constitutes the desired negative resistance characteristic.

While it has been assumed that the electron flow from the cathode toward the negode is maintained absolutely constant, it is only necessary in actual practice that it remain sufficiently nearly constant so that the loss of electrons to the negode due to the operation here described overcomes any tendency for electron flow to the negode to increase as a result of increasing negode potential producing an increased flow of current outward from the cathode.

One use for the negode resistance device described herein is the generation of oscillations. When such a device has a tunable circuit connected in series with its negode, oscillations will occur if the negative resistance of the device is less than the impedance of the tunable circuit at the resonant frequency. If regeneration rather than oscillation is desired, it is only necessary to control either the negative resistance or the circuit impedance so as to fail to meet this condition by a desired amount.

A very great practical advantage in this type of oscillation or regeneration is that the tunable circuit needs only two connections, thereby facilitating switching in case it is desired to change from one circuit to another.

In addition to its use as a means for regenerating a circuit or causing it to oscillate, the device herein described may be used as an amplifier of improved characteristics. For this purpose it is only necessary to insert a control grid G_c between the negode and the cathode as shown in Fig. 5, Fig. 6 showing the potential relationship between the several electrodes, and to adjust the negative resistance of the device to a value sufficiently high so that oscillations are not produced in the resonant load circuit attached to the negode. If the negode resistance is made infinitely high, the amplification of the device is similar to that of a screen grid tube whose screening action is perfect. If the negode resistance is finite but negative, the selectivity of the resonant output circuit is improved. It will be obvious that by the use of this principle a screen grid tube having imperfect screening so that its plate resistance is undesirably low, can be transformed into a device whose plate resistance is as high as desired or negative in character. All that is necessary is to convert the anode of the unsatisfactory screen grid tube into a negode by providing it with apertures through which electrons may flow, and locating a counter electrode of the type above described beyond the negode.

I claim:

1. A negative resistance device comprising a cathode capable of emitting a substantially constant electron flow, an electrode surrounding said cathode and having a substantially high positive potential impressed thereon, a second electrode surrounding the first electrode and having a relatively low positive potential impressed thereon, said second electrode being provided with depressions to accentuate space charge in the vicinity thereof, whereby with an increase of potential on said first named electrode there will result an increase in current through said second electrode and a simultaneous decrease in current through said first electrode.

2. An amplifying tube comprising a cathode, a control electrode, a perforated output electrode having applied thereto a relatively high positive potential, and another electrode mounted externally of the output electrode and having applied thereto a lower positive potential such that it robs the output electrode of current to an increasing extent as the potential of said output electrode is increased.

3. An amplifying tube comprising a cathode, a control electrode, a perforated output electrode having applied thereto a relatively high positive potential, and another electrode mounted externally of the output electrode and having applied thereto a lower positive potential such that it robs the output electrode of current to an increasing extent as the potential of said output electrode is increased, by preventing the major portion of the electrons which have passed through the perforated output electrode from returning thereto.

4. An electron discharge tube having a cathode, at least one control grid, an apertured anode, and a counter electrode mounted posteriorly of the anode, with this characteristic feature that the said counter electrode is provided with a series of cavities which face toward the anode.

5. An electron discharge tube according to claim 4, with this characteristic feature that the counter electrode comprises a plurality of concentric grid-like electrodes electrically connected together, and which conjointly constitute the series of cavities which face the anode.

6. An electron discharge tube according to claim 4, with this characteristic feature that the apertured anode is supplied with the maximum voltage to be applied to the tube.

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