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A. SCHLEIMANN-JENSEN

2,250,187

SPACE DISCHARGE TUBE

Filed Sept. 29, 1938

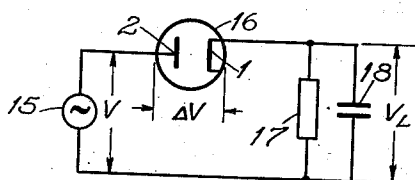


FIG. 1

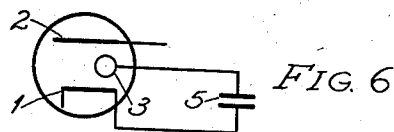


FIG. 6

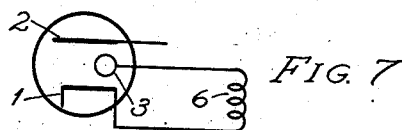


FIG. 7

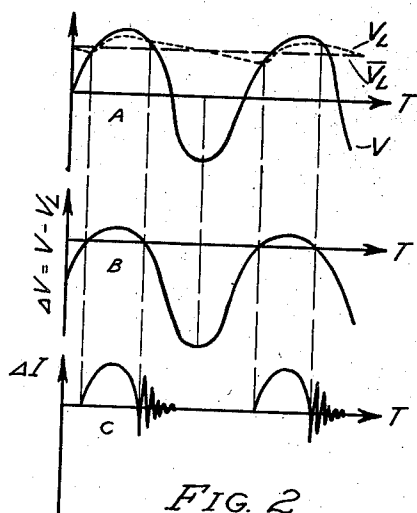


FIG. 2

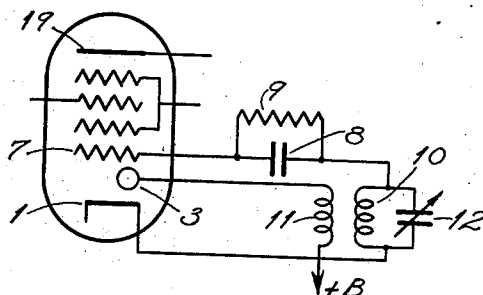


FIG. 8

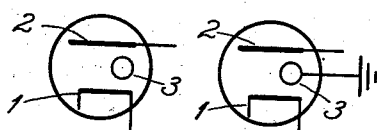


FIG. 3

FIG. 4

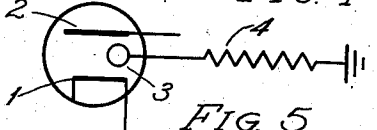


FIG. 5

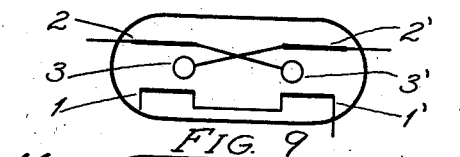


FIG. 9

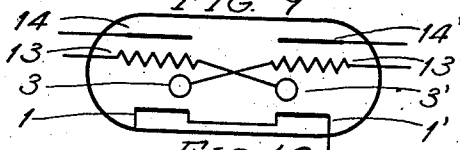


FIG. 10

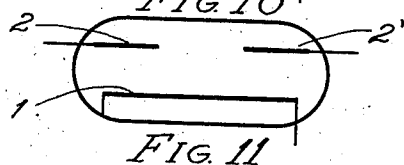


FIG. 11

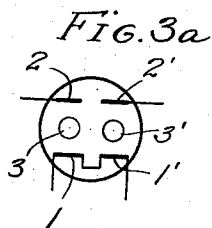


FIG. 3a

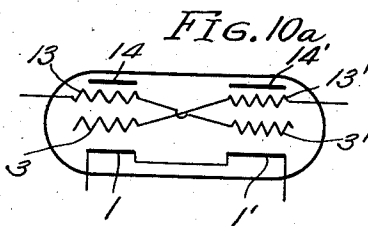


FIG. 10a

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SPACE DISCHARGE TUBE

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3 Claims. (Cl. 250—27.5)

This invention relates to vacuum or gas tube circuits in general and to the suppression of a certain class of disturbances occurring in these circuits.

There is a large number of causes for noises, distortions and other disturbances in radio circuits well-known to those skilled in the art. They may be divided roughly into two classes; one class is caused principally by undesired signals picked up by the antenna, antenna leads, or the supplying power line. They are generally called statics. The other class is connected with disturbances arising in the operation of the set itself. In between these two classes is the so-called hum, which is mostly caused by the (60 cycle) supply from the power line. The last type of disturbance can largely be avoided by appropriate filtering.

There is a hum-like noise which cannot be avoided by filtering or by the known means of hum prevention in A. C. heated thermionic tubes. The causes of this specific disturbance, which occurs in certain sets more than in others have not been identified so far.

By systematic investigation, I have been able to locate the source of this hum-like noise, and have subsequently devised means for its prevention. The essential result of this investigation is that spurious oscillations of an unexpected character may be produced in vacuum or gas tubes when the current or the voltage between cooperating electrodes changes its direction. In particular in the case of tubes used to rectify an A. C. voltage supply, these spurious oscillations are generally of a higher frequency than the frequency to be rectified. They are highly damped and therefore cover a wide frequency band in addition to their fundamental.

Though these spurious oscillations accentuate the hum, their fundamental frequency is practically independent of the frequency of the power supply to the rectifier. It is substantially determined by the electric field in the tube at the instant when the space charge changes its direction of transit between cathode and anode. It may happen that the field for which this condition is fulfilled is rather weak, and therefore this fundamental frequency may be rather low. This fact may be one of the reasons why these oscillations have not been suspected earlier. Space charge oscillations are generally of a very high frequency, when occurring in tubes to which D. C. voltages only are applied. Their frequency is related in a known manner to the applied D. C. voltage.

The kind of space charge oscillation dealt with according to the invention occurs when an A. C. voltage is applied to the elements of the tubes.

It is therefore a principal object of this invention to introduce a supplementary field between two cooperating electrodes of a vacuum tube which will decrease or eliminate the tendency for producing undesirable spurious oscillations, caused by a change in direction of voltage or current between such electrodes.

Another object of the invention is to eliminate the tendency of a radio tube to produce spurious oscillations by the introduction of an auxiliary electrode, which may be connected to an appropriate potential.

A further object of the invention is to connect the auxiliary electrode over an ohmic resistor, a capacitance or an inductance to an appropriate point in the circuit, e. g. one of the cooperating electrodes in a radio tube, between which the described spurious oscillations tend to be produced during operation.

In particular it is an object of this invention to introduce an auxiliary electrode between cathode and plate of a rectifier tube or between cathode and one of the grids of a converter tube, an audio detector tube or an audio amplifying tube.

Another object of the invention is the interconnection of the auxiliary electrodes of the different sections of multiple tubes, such as full wave rectifier, or class B amplifier, tubes with one of the electrodes of the other unit in the tube. Other objects not specifically enumerated will become apparent from the appended claims, the following detailed description and the drawing, in which

Fig. 1 is a typical half wave rectifying circuit as used for the plate supply in radio receivers.

Fig. 2 shows the voltage and current diagrams as observed at the screen of an oscillograph tube during the operation of the rectifying circuit of Fig. 1.

Figs. 3, 4, 5, 6 and 7 show schematically the auxiliary electrode and several ways of connecting it to other parts in the circuit, in order to prevent or suppress spurious oscillations.

Fig. 8 shows the circuit in which the auxiliary electrode in a converter tube may be connected.

Figs. 9, 10 and 11 show different methods for applying the desired field in multiple tubes, e. g., full wave rectifiers and class B amplifiers.

Referring now to Fig. 1 which represents a conventional half wave rectifier circuit, numeral 1 is a cathode, 2 the plate or anode of a rectifying tube 16. The anode of this tube 16

is connected to one side of an A. C. voltage source 15. The other side of the voltage source 15 is connected over the load 17 and the condenser 18 (the latter two in parallel) to the cathode 2 of the rectifier tube. The voltage between the terminals of the A. C. voltage source 15 is designated by V , the voltage drop over the load by V_L . The voltage drop over the rectifier tube, ΔV is therefore equal to $V - V_L$. When the circuit is in operation, and the voltages and the currents are observed at different points, their shape, as seen, say, on the fluorescent screen of a cathode ray tube oscillograph is represented in Fig. 2. In Fig. 2, three time axes, T , are drawn parallel and on top of each other. The uppermost diagram shows the different voltages which are relevant for the rectifying circuit. V is the curve of the voltage at the terminals of the generator 15, V_L is the fluctuating D. C. voltage over the load 17, and V_L is the average D. C. voltage over the load. The curve in the middle section of Fig. 2 represents the voltage drop over the rectifier tube 16 as explained before. The small sinusoidal elevations above the time axis corresponds to the period of time when the main part of the current ΔI passes through the rectifier. This is shown in the lowest part of Fig. 2. As indicated in this lowest current diagram of Fig. 2, a damped oscillation of a small number of full periods sets in after the positive current through the rectifier has come down to zero. This short surge of a damped oscillation is the spurious oscillation which has been referred to hereinabove and which is to be eliminated by the method means according to this invention.

Fig. 3 represents a rectifier tube similar to the one designated by number 16. In addition to the cathode 1 and the anode 2 shown in tube 16, it contains a small auxiliary electrode 3. The shape of this electrode does not need to be considered at this time. It has to be adapted to the desired shape of cathode and anode of the rectifier. If the rectifier is built as a cylindrical arrangement, in which an anode cylinder surrounds a small cathode cylinder coaxially, one or two side rods between cathode and anode may be used to make up the auxiliary electrode. In Fig. 3 the auxiliary electrode is shown floating. Fig. 4 shows that same electrode connected to ground. In Fig. 5 the electrode 3 is connected to ground over an ohmic resistor 4. Instead of ground, any suitable potential might have been shown in Figs. 4 and 5. Fig. 3a is similar to Fig. 3 and shows the invention embodied in a full wave rectifier.

If in the circuit of Fig. 1, the rectifier tube 16 is replaced by one of the rectifier tubes shown in Figs. 3, 4 and 5, the current through the rectifier does not have the shape shown on the lowest diagram of Fig. 2. The spurious oscillation has now disappeared, leaving only the conventionally known positive half waves above the time axis. The auxiliary electrode may be connected in other ways than those indicated in Figs. 3, 4 and 5. Connections of the auxiliary electrode 3 as shown in Figs. 6 and 7 have the same effect on the current through the rectifier: The auxiliary electrode 3 may also be connected to the cathode 1, or any other suitable potential, by a capacitance 5, or by an inductance 6. In all of these cases, the current curve on the oscillograph shows that the spurious oscillation, which occurred with tube 16 has disappeared, as for the connections of Figs. 3, 4 and 5.

By comparing the effect of the introduction of the auxiliary electrode on the ear when a set is equipped with a rectifier tube, with and without auxiliary electrode respectively, it has been established that the accentuated hum-like noise which was easy to observe with an ordinary rectifier tube had disappeared when the auxiliary electrode tube was introduced in the power pack.

Figs. 9 and 11 show two other methods of applying the oscillation-destroying field in full wave rectifier tubes. Fig. 9 shows two auxiliary electrodes 3 and 3' between the cathodes 1, 1' and the anodes, 2, 2' respectively. It will be noted that in Fig. 9, the auxiliary electrode 3 is metallically connected to the anode 2', and the electrode 3' is metallically connected to plate 2. This construction suggests the idea that it must be possible to introduce the disturbing field in a full wave rectifying tube without introducing new auxiliary electrodes 3 and 3'. This is shown in Fig. 11. Here the edge of plate 2 acts as auxiliary electrode for the rectifier system 1' 2' and the edge of plate 2', as the auxiliary electrode for the rectifier system 1, 2, similar to, but simpler than, the construction of Fig. 9.

As the spurious oscillations also may introduce disturbances in a radio receiver when produced by other tubes, conventional converter tubes and class B multiple audio amplifier tubes can be equipped with auxiliary electrodes between cathode and grid. In either case, definite improvement is noticeable in the performance of the tubes with auxiliary electrodes. Fig. 8 shows schematically the introduction of this auxiliary electrode 3 between cathode 1 and first grid 7 of the converter tube used in the conventional circuit shown in Fig. 8.

Fig. 10 shows, schematically, the auxiliary electrodes 3 and 3' in a class B output tube between cathode 1 and grid 13 of one of the units, and cathode 1' and grid 13' of the other. The electrodes 3 and 3' like the corresponding electrodes 3 of Figs. 3 to 9, may be in the form of rods, or if desired as shown in Fig. 10a, the electrodes 3 and 3' may be in the form of grids similar to the control grids 13 and 13'.

It is known in the theory of a diode with a constant voltage between cathode and anode, that oscillations of certain frequencies may be generated in the limiting case for infinitely small space current. The frequencies of these space charge oscillations are determined by the D. C. voltage applied. It is to be expected that the limiting case of zero space charge current becomes practical in a rectifier every time the current in the rectifier passes through zero, or in the neighborhood of that period of time. The same condition should be expected in a class B amplifier tube between cathode and grid, and e. g. between cathode and grid 1 of a converter tube. In rectifier as well as in converter and class B amplifier tubes, the voltage difference between the cooperating electrodes is periodically very small and the direction of the transit of the space charge from one electrode to another is periodically reversed. No positive D. C. voltage is supplied, and therefore the conditions for a continuous oscillation do not exist. Any oscillation of the space charge between the elements must be highly damped. While there has been given one theory for the suppression of the spurious oscillations resulting from change in direction of potential or current between two spaced

electrodes, it will be understood that the invention is not limited thereby. The important thing is the successful elimination of the spurious oscillation by means of auxiliary fields introduced between cooperating electrodes, either by means of auxiliary electrodes or by the mutual location and arrangement of the electrodes of a multiple tube with respect to each other.

What I claim is:

1. A full wave rectifier tube comprising a plurality of sets of cathodes and anodes, said anodes being energized by a voltage which changes polarity periodically with respect to the cathode, and an auxiliary electrode for each set to suppress spurious oscillations engendered by reversal of current or potential between the associated electrodes during the normal operation of said tube as a rectifier, said auxiliary electrode being at floating potential.

2. A tube having an electron emitter, an electron collector, means to impress upon said collector a voltage which changes periodically its

polarity with respect to said emitter whereby spurious oscillations are engendered within the tube of a damped higher periodicity and at each reversal of said polarity, and means within the tube for producing an electrostatic field between the emitter and collector to suppress the generation of said spurious oscillations, the last-mentioned means including a rod-like electrode which is connected to ground.

3. A tube having an electron emitter, an electron collector, means to impress upon said collector a voltage which changes periodically its polarity with respect to said emitter whereby spurious oscillations are engendered within the tube of a damped higher periodicity and at each reversal of said polarity, and means within the tube for producing an electrostatic field between the emitter and collector to suppress the generation of said spurious oscillations, the last-mentioned means being in the form of an auxiliary electrode at floating potential.

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