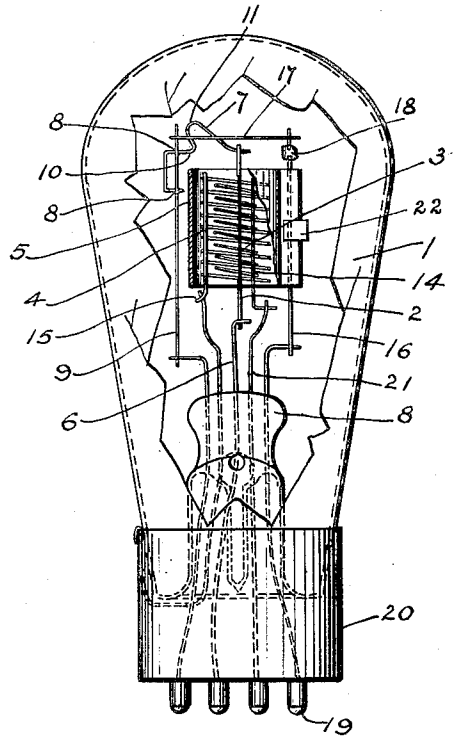
Aug. 16, 1932. E. A. LEDERER 1,871,537

ELECTRON DISCHARGE DEVICE

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FIG. 1



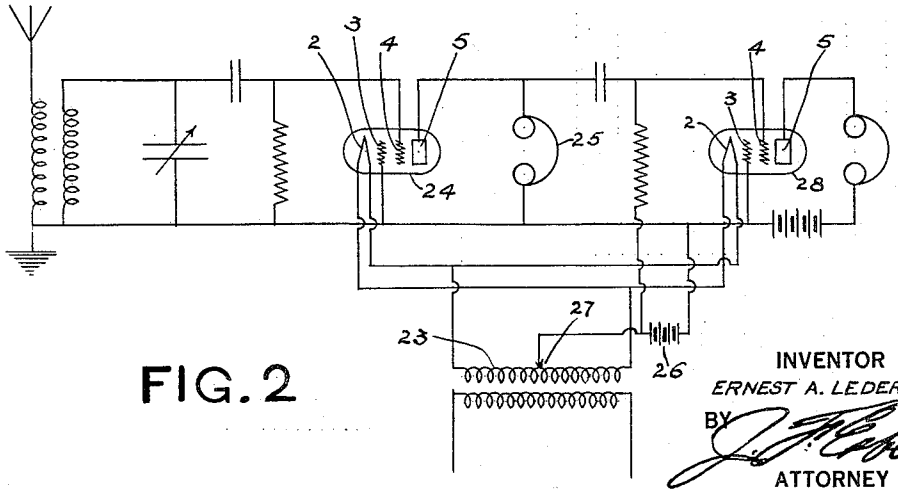


FIG. 2

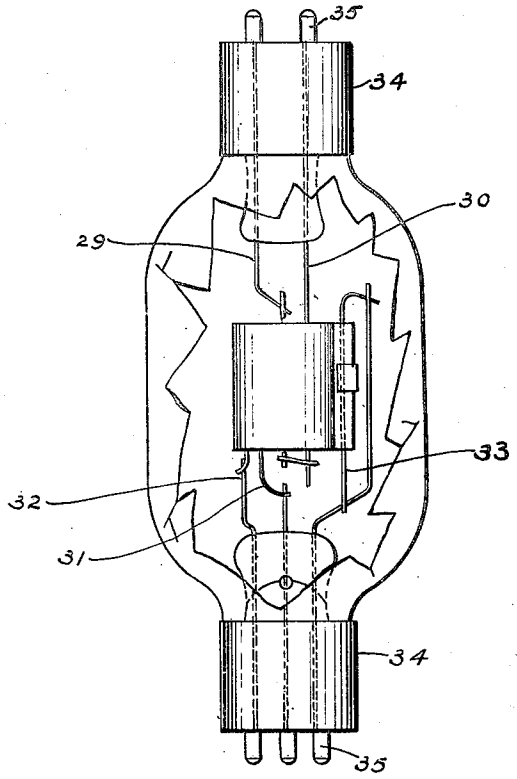
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ELECTRON DISCHARGE DEVICE

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FIG. 3



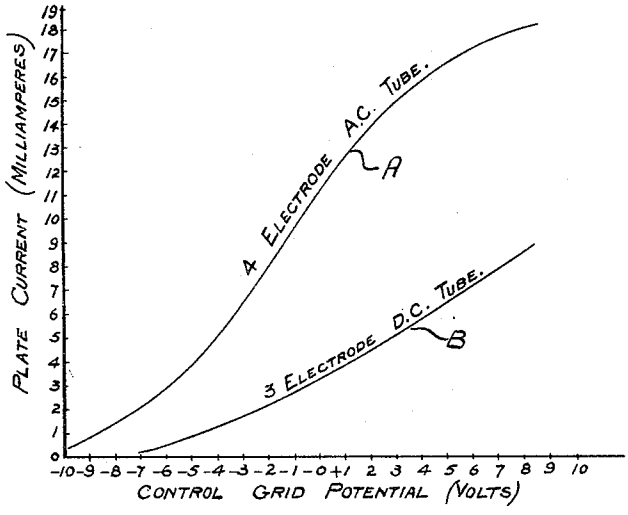


FIG. 4

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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

Application filed October 22, 1925. Serial No. 64,074.

This invention relates to electron discharge devices and circuit arrangements employing the same. More particularly it relates to a space current device capable of use for the detection and amplification of small variable currents such as, for example, those produced in radio receiving systems, although it is not limited to such uses.

One of the objects of the invention is to produce an electron discharge device of the hot cathode type and a circuit arrangement therefor by which the cathode may be heated from an alternating current source and in which the usual alternating current hum will be eliminated.

Another object is to produce an electron discharge device which has a high amplification constant and high mutual conductance, either or both of which may be readily varied.

Another object is to produce a device of the above nature which is simple in construction and efficient in operation.

Other objects and advantages will hereinafter appear.

Heretofore great difficulty has been experienced in utilizing alternating current for heating the cathode of an electron discharge device for use in radio receiving apparatus due to the hum which is produced in the telephone receiver by the alternating current and which seriously interferes with the reception.

This alternating current hum I have found to be due to several causes, first among which may be mentioned the capacity effect between the grid and filament due to the periodic or alternating current potential variations along the cathode and the irregularities in the mechanical construction of the device, such, for example, as the use of filaments of non-uniform cross section, unequal or unsymmetrical spacing of grid and filament, etc. This capacity effect causes a fluctuating charge on the grid which is amplified in the plate circuit.

Another cause of the alternating current hum is the variation in temperature of the cathode during the alternations of the heating current and the consequent fluctuations in the electron emission from the cathode.

A still further cause of noise or humming in the receiver when using alternating current for heating the filament is due to the constantly changing magnetic field surrounding the filament set up by a passage of current therethrough. This field exerts an irregular effect on the emitted electrons causing them to shoot out from the cathode in various and constantly changing directions and preventing the electron stream from maintaining any definite path. This results in a variable or irregular plate current.

The present invention aims to avoid all the above-mentioned difficulties or to reduce the effects thereof to a negligible degree so that they are not detectable in the output circuit.

In accordance with my invention I provide a supplemental electrode or shield between the cathode and the other electrodes which serves to reduce or eliminate the capacity effect between the filament and the control electrode or grid.

This supplemental electrode forms a part of the cathode system and constitutes a virtual source of electrons. It is preferably connected to the ground and serves to screen the control grid from the varying potential along the cathode.

Another function of the supplemental electrode is to attract electrons from the cathode and direct them towards the grid. The supplemental electrode may be of any suitable mesh construction and, in order to provide a minimum obstruction of the electron flow from the filament to the grid and plate, the opening or meshes in the electrode should be as large as is consistent with a proper screening of the control grid from the electrostatic effects of the filament. The supplemental electrode should be spaced from the filament, sufficiently far to exert the maximum directive effect on the electron stream, care being taken, however, not to arrange it so close to the control grid as to interfere with the proper functioning of this latter electrode. The supplemental grid electrode serves, in addition to eliminating the

capacity effects, in also overcoming the weak and irregular magnetic field surrounding the cathode by strongly attracting the electrons so that they assume a uniform and regular path in their migration towards the grid.

In order to still further reduce the electrostatic effects of the cathode on the control grid I prefer to make the cathode relatively short and heavy so that there will be only a small difference in potential between the ends thereof. By making the filament of large cross section I also reduce the temperature variations of the cathode due to the alternating heating current, thereby rendering the emission more uniform.

I prefer to employ a single straight filament since it permits the use of a short heavy wire and at the same time enables the filament to be arranged more symmetrically with respect to the other electrodes than is possible with looped or coiled filaments. This symmetrical arrangement has a decided advantage in eliminating capacity effects between the electrodes. In case it is desired to use filaments other than straight filaments, however, the ends of the filament should be brought as close together as possible and the filament made to coincide as nearly as practical with the geometrical axis of the device. The filament may be of the thoriated-tungsten type or of any other suitable material having the requisite electron emission, but I prefer to employ a filament of the dull emitter type, such as a platinum iridium filament coated with the oxides of barium and strontium, since the lower temperature at which the filament operates, the less the fluctuations in temperature due to the alternating heating current. If so desired, the cathode may be a conductor of the second class, similar to a Nernst glower, containing oxides having good electron emitting properties and the gaseous filling composed of air. In such case the supplemental electrode may be made in the form of a coil, through which current may be passed to heat the cathode by radiation, to a conductive temperature to initiate the operation of the device.

The device may be operated in vacuum but I have found that better results are obtained when the envelope contains a gas at a low pressure. The nature of the gas should be such that it does not react with the materials of which the tube is constructed, i. e., either the glass or the electrodes and lead wires. Among gases which may be used may be mentioned air, hydrogen, helium, oxygen, nitrogen, neon, argon, krypton, Xenon, sulphur hexafluoride, etc., or a mixture of such gases. I have found that a mixture of neon and air produces exceptionally good results. Gases having high ionization potentials appear to be preferable but other gases may also be used, such as argon, therefore, I do not desire to be limited to any particular gases.

The pressure does not appear to be critical and I have found that it may vary from one-half a micron to over 500 microns of pressure, but the higher pressures appear to give the best results. The gas helps materially to eliminate the alternating current hum and improves the sensitivity and volume of the device. One manner in which the gas may serve to reduce the alternating current hum is by equalizing the temperature of the cathode, although its beneficial effect may also depend on an ionization phenomena.

In order that the invention may be more fully understood, reference will be had to the accompanying drawings in which;

Fig. 1 illustrates an electron discharge device partly in section, embodying the present invention;

Fig. 2 is a circuit arrangement with which the device may be employed for the detection and amplification of radio signals;

Fig. 3 is a modified form of the device shown in Fig. 1; and,

Fig. 4 illustrates comparative characteristic curves showing the relation between grid voltage and plate current under one condition of operation.

The device shown in Fig. 1 comprises an envelope 1 which may be either evacuated or filled with a suitable gas or a mixture of gases, a cathode 2, supplemental electrode 3, control grid 4 and anode or plate 5. The filament preferably is of the linear type and the remaining electrodes are of symmetrical form arranged concentrically with respect thereto. The cathode is relatively short and thick and is coated with the oxides of barium and/or strontium as is well known in the art and is supported between the leading-in wire 6 and a spring 7 welded as at 8 or otherwise suitably secured to the support wire 9. The spring 7 maintains the filament under a slight tension and, due to the reverse bands 10 and 11, the end 12 of the spring moves vertically in a substantial straight path.

The supplemental electrode 3 may be of any suitable mesh formation but for convenience, I have shown it in the form of a wire helix having the adjacent turns secured to a support 14 carried by the press. The turns of the supplemental electrode are spaced apart a sufficient distance so as not to materially obstruct the passage of electrons to the grid 4 but should not be spaced so far apart as to interfere with the shielding of the control grid from alternating current interference from the filament. In general, however, the spacing of the turns of this shielding electrode depends upon the size of the electrodes, their shape and relative spacing.

The spacing of the supplemental electrode between the cathode and control grid is of

importance since, if it is arranged too close to the cathode, the efficiency of the tube will be impaired, whereas if it is spaced too close to the control grid the operation of the device will be somewhat noisy. I have found that good efficiency and quiet operation will be obtained if the supplemental electrode is spaced slightly closer to the control grid than to the cathode. The proper spacing depends upon the characteristics which it is desired that the device shall have.

The control grid 4 is also shown in helical form secured to a support 15 carried from the press 8 of the device and the plate 5 of tubular form is disposed about the other electrodes and is supported from the press by the wire 16. A brace 17 extending from the support wire 9 is connected to the plate support 16, through an insulating bead 18. The filament, control electrode and plate are connected to their supports to suitable leading-in conductors which terminate in the contact pins 19 provided on the base 20 of the device. If desired, a fifth contact may be provided for the leading-in conductor 21 of the supplemental electrode 3, although in the embodiment illustrated, the base 20 is composed of a metal shell and the conductor 21 is secured in electric contact therewith. It is understood, of course, that the contact pins 19 are insulated from each other and from the metal shell of the base.

In order to purify the gases or to create a high vacuum in the device, if desired, a small amount of suitable clean-up agent 22 may be carried by the plate and vaporized therefrom by high frequency induction or in any other suitable manner. With the rare gases, such as neon, argon, etc., I prefer to use misch metal or magnesium for this purpose. Various other getters may be used, however, such as calcium, barium, zinc, phosphorus, etc., depending on the particular gas filling desired and the impurities contained therein.

In the operation of the device which has just been described as a detector and amplifier of radio signals in a circuit arrangement such as that shown in Fig. 2, a source of alternating current such, for example, as the secondary 23 of a transformer may be provided for supplying current for heating the cathode 2 to incandescence. The control electrode 4 of the detector tube 24 is connected to the input circuit in the usual manner and the anode or plate 5 is connected to the output circuit which comprises the telephone receiver 25, battery 26 and the filament 2. The negative side of the battery is preferably connected to the point of zero potential or mid point 27 of the secondary 23 of the transformer in order to eliminate any superimposed alternating current variations from the positively charged shield 3. The shield 3 is connected to the ground or other point of neutral potential to lead away the capacity charge collected from the alternating current variations along the filament and which otherwise would be impressed upon the control grid. In order to impose a positive potential on the shield or supplemental electrode 3 it may be connected to the battery 26 or other source of positive potential.

It will be noted that the capacity effect between the filament 2 and the grid 4 is dissipated by the supplemental electrode 3 and any charge which accumulates thereon is discharged to the earth. Due to the positive potential of the supplemental electrode with respect to the filament, the electrons emitted from the cathode are attracted towards this electrode with a relatively high velocity and directed to the plate 5 thus increasing the mutual conductance of the device. By varying the potential impressed on the supplemental electrode 3, the electrical characteristics of the tube may be varied within wide limits.

The telephone receivers 25 may also serve as a choke coil for coupling the detector tube 24 with an audio frequency amplifier tube 28, although if desired a transformer or a resistance coupling may be utilized. The cathode of the tube 28 may be connected to the secondary in the transformer 23 and the supplemental electrode 3 may be connected to the ground and a source of positive potential in the same manner as the corresponding elements of the detector tube. The control grid 4 and plate 5 are connected to the input and output circuit, respectively, in the usual manner.

The circuit arrangement illustrated, is by way of example only, since the tube described can be used in any form of a circuit either as a radio frequency amplifier, a detector, or an audio frequency amplifier.

While a grid leak has been illustrated in connection with the detector tube, such grid leak may be disposed of by using a properly designed tube having the correct gas pressure, since the ionized gas will perform the function of the grid leak.

I have found that extremely good results may be obtained with this device with an extremely small current consumption. For example, I have constructed tubes which employed a filament power consumption of .6 watt and which when using 40 volts on the collector with about 45 volts on the plate, had an amplification constant of 9 and a mutual conductance of approximately 1500 micro-mhos. These results compare favorably with power tubes using about five times the heating current and about three times the plate voltage.

The amplification constant of this device checks very closely with Van der Bijl's formula for determining the same by structural parameters, the constant for such formula

in the case of the present tube, being only about 20.

In order to eliminate any capacity between the leading-in wires, due to the alternating heating current, the filament leading-in wires may be arranged remote from the leading-in conductors for the supplemental electrode, control electrode and anode. In Fig. 3 I have shown the leading-in conductors 29 and 30 for the filament, extending through one end of the envelope and the leading-in conductors 31, 32, 33 for the supplemental electrode, control grid and anode, respectively, extending through the opposite end of the envelope. A separate base 34 may be provided for each end of the envelope from which terminal contacts 35 connected to the respective leading-in wires extends. The electrode arrangement shown in Fig. 3 is the same as that illustrated in Fig. 1.

In Fig. 4 I have illustrated some characteristic curves of the present device in comparison with one of the common forms of three-electrode tube now in commercial usage. Curve "A" is the anode-current, grid-voltage characteristic curve of the present device utilizing 50 volts on the plate. Curve "B" is a similar characteristic curve of a 201—A tube also employing 50 volts on the plate electrode. It will be noted from an inspection of these curves that the characteristic curve for the present tube is not only considerably steeper than that for the three-electrode tube thus indicating a considerably higher amplification constant, but for a given grid potential, the present device has a much larger plate current and consequently a higher mutual conductance.

In obtaining curve "A" a potential of about 40 volts was impressed upon the control electrode. By varying the control electrode voltage the characteristic curve may be readily varied. The power utilized in heating the filament in the case of the present tube was about one-quarter of that utilized in heating the filament of the three-electrode tube from which the comparative curve was obtained.

It will be noted that I have produced a thermionic device capable of use as a detector or amplifier of radio signals and in which troublesome alternating current hum has been eliminated. The tube has a high amplification constant and a high mutual conductance, thereby resulting in the production of extremely strong signals. The tube is noiseless, sensitive, economical to operate and simple in construction. It is obvious, of course, that many changes may be made in the construction thereof without departing from the invention.

What is claimed is:

1. The method of producing a substantially uniform electron flow from a cathode heated by passage of alternating current therethrough which consists in reducing the electrostatic effects of the cathode.

2. The method of producing a substantially uniform electron flow from a cathode heated by passage of alternating current therethrough in an electron discharge device having an anode and a control electrode which consists in shielding said control electrode from capacity effects due to the varying potential along the cathode.

3. In an electron discharge device comprising anode, grid and a thermionically active hot cathode energized by the passage of an alternating electric current therethrough, means for substantially eliminating deleterious "hum" characteristics in said device incident to the use of said alternating electric current in the cathode, said means comprising a cathode electrode of relatively high heat storage capacity and relatively low electrical resistivity, substantially enclosed within a perforated grid type supplemental electrode which is maintained during operation of the device at an electrical potential positive with respect to said enclosed cathode electrodes.

4. The method of reducing the hum incident to the use of alternating current heating the cathode of a three electrode tube comprising a grid, an anode and a cathode heated by alternating current which comprises reducing the capacity between said grid and cathode.

5. The method of reducing the hum incident to the use of alternating current heating the cathode of a three electrode tube comprising a grid, an anode and a cathode heated by alternating current which comprises modifying the electrostatic effects of the cathode on the grid and modifying the capacity between the grid and cathode.

In testimony whereof, I have hereunto subscribed my name this 21st day of October, 1925.

ERNEST ANTON LEDERER.