

Sept. 11, 1928.

A. MAVROGENIS

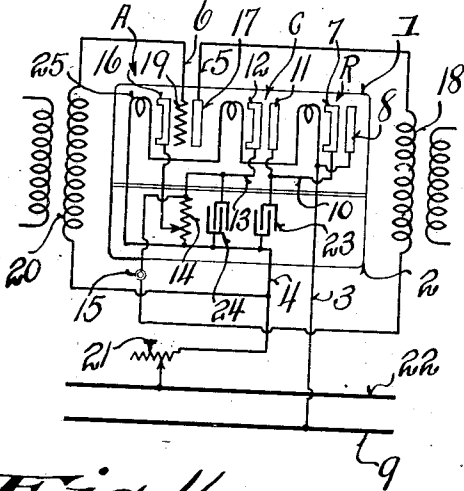
1,684,104

ELECTRON DISCHARGE DEVICE

Filed Feb. 21, 1927

2 Sheets-Sheet 1

Fig. 1



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Fig. 6

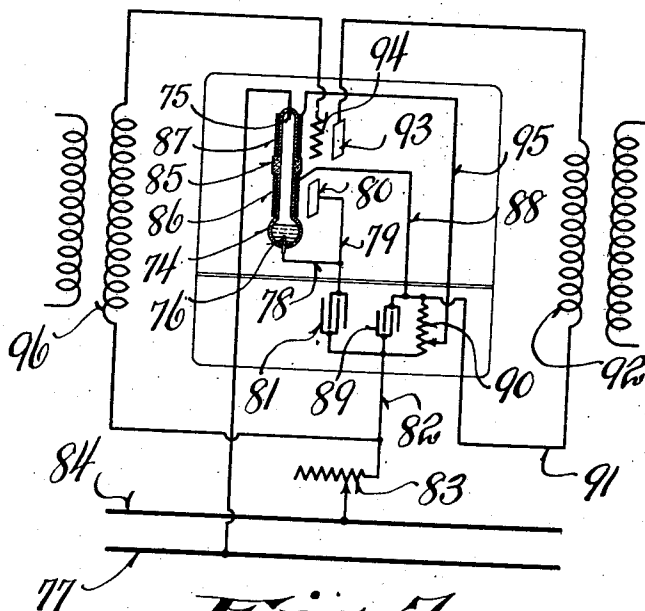
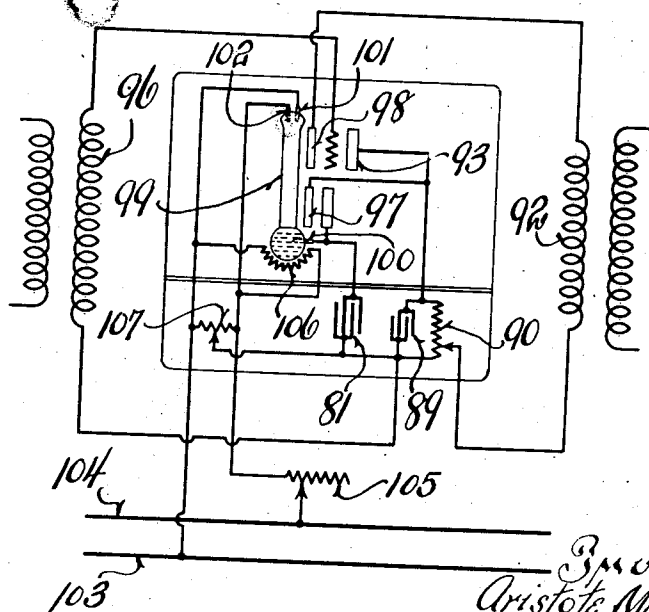


Fig. 7



Inventor:
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UNITED STATES PATENT OFFICE.

ARISTOTE MAVROGENIS, OF MILWAUKEE, WISCONSIN.

ELECTRON-DISCHARGE DEVICE.

Application filed February 21, 1927. Serial No. 169,876.

This invention relates to unitary electron discharge devices and is particularly directed to a device in which means are provided for maintaining a permanent negative potential on the controlling element with respect to the cathode of such unitary devices. 5

It has been the practice heretofore to insert a relatively small dry battery or storage battery or its equivalent C battery eliminator in the grid circuit of a vacuum tube in order to maintain the grid at a suitable negative potential with respect to the cathode of such tubes when used as detectors or amplifiers. 15

In case of a vacuum tube amplifier when used at audio frequency with a relatively large output plate current, a C battery is inserted in the grid circuit between the grid and the cathode of such amplifier in order to maintain a permanent negative potential of a suitable value on the grid, such potential being at least equal to the maximum amplitude of voltage variation of the incoming radio waves impressed on the grid in order to secure distortionless reception. 20

Such vacuum tube amplifiers are usually of the audion type known under the trade name of power amplifiers, and are usually used in the last stage of the audio frequency amplification of the radio receiver. These tubes necessitate a C battery in the grid circuit when their output plate current is equal to or above three to five milliamperes, in order to secure distortionless reception. 25

The tubes therefore require not only the usual filament and plate batteries, but also the additional C battery, or else their equivalent battery eliminators. 30

It is a well-known fact that the addition to any radio receiver of a third auxiliary C battery or its equivalent C battery eliminator not only increases the number of accessories of such radio receiver, but also necessitates auxiliary busbar connections and binding posts which thus produce an increase in the cost in the expense of operation and maintenance, and also in the expense of renewal. In addition to this, disturbances are more likely to result from accidents to, or defects in the several accessories associated with these sets. 35

Objects of this invention are to eliminate the disadvantages noted above in connection with radio receiving devices employing C 40

batteries, and to provide a unitary electron discharge device which not only avoids the necessity of both filament and plate batteries or their equivalent battery eliminators, but also eliminates the C battery or its equivalent C battery eliminator. 60

A further object is to provide a permanent means within the unitary structure of the electron discharge device for maintaining a permanent and suitable negative potential on the grid of the device. 65

Further objects are to provide means for impressing a permanent, suitable negative voltage on the controlling element of the unitary device by means which are permanently associated with the unitary structure of the device, and which do not require either renewals, adjustments, upkeep expense, or any additional element within the tube. 70

This invention is particularly applicable to vacuum tubes of the general type disclosed in my prior Patents, No. 1,570,444 of January 19, 1926, for wireless apparatus, and for electron discharge devices, No. 1,638,499, of August 9, 1927; No. 1,616,914, of February 8, 1927; No. 1,629,171 of May 17, 1927, and my copending applications for electron discharge devices, Serial No. 145,940, filed November 3, 1926; and Serial No. 159,313, filed Jan. 6, 1927. 75

Embodiments of the invention are shown in the accompanying drawings in which:—

Figure 1 is a diagrammatic view showing one form of the invention and disclosing particularly a unitary electron discharge device having a single wave rectifier; 80

Figure 2 is a view corresponding to Figure 1 showing the device adapted for double wave rectification; 85

Figure 3 is a perspective view partly in section showing the physical structure of the tube, diagrammatically shown in Figure 2;

Figure 4 is a sectional view on the line 4—4 of Figure 3; 90

Figure 5 is a diagrammatic view of a modified form of the invention;

Figure 6 shows a modified form of the invention in which a vapor rectifier is employed; 95

Figure 7 shows a further modified form in which a full wave vapor rectifier is used. 100

Referring to Figure 1, it will be seen that the device comprises a unitary structure which consists of an evacuated vessel 1 hav- 110

ing a base portion 2. The vessel 1 is preferably of the high vacuum type and encloses a rectifier, indicated generally by the reference character "R", a current limiting device, indicated generally by the reference character "C", and an audion, indicated generally by the reference character "A". Within the base 2 of the device which constitutes a permanent portion of the structure are mounted the condensers and resistance, as hereinafter described, so that the device may be inserted in a tube socket or removed therefrom as a unit.

The device is provided with four prongs indicated at 3, 4, 5, and 6, which extend outwardly through the base of the tube, although for convenience of illustration, they have been shown diagrammatically in their most easily illustrated positions in Figure 1.

The rectifier has an equipotential cathode 7 and an anode 8. The anode is connected directly to the prong 3 and from thence to one of the alternating current mains 9. The cathode is connected by means of the conductor 10 to the anode 11 of the current limiting device. The cathode 12 of the current limiting device is connected by means of the conductor 13 to one end of a resistance 14, as shown in Figure 1, to the upper end of such resistance. This upper end of the resistance is also connected to an auxiliary binding post 15 accessible externally of the tube, as described in detail in connection with Figures 3 and 4. At a suitable point along the resistance 14, the equipotential cathode 16 of the audion "A" is connected, the plate 17 of the audion being connected through the translating device, such as the primary 18 of an inter-valve transformer to the point 15 and, consequently, to the upper side of the resistance 14. Consequently, the audion has impressed between its plate and cathode the voltage drop between the point at which the cathode is attached to the resistance 14 and the upper end of the resistance or the point where the contact or binding post 15 is attached. The grid 19 is interposed between the cathode 16 and the plate 17 and is connected to one end of the secondary 20 of the input transformer, the other end of the secondary being connected to the prong 4. Further, it is to be noted that this prong is connected through a variable resistance 21 to the other main 22 of the alternating current supply system.

It is to be noted that a storage condenser 23 is connected between the conductor 10 and the prong 4 and also it is to be noted that the resistance 14 is paralleled or bridged by means of the bypass condenser 24. Further, it will be noted from a consideration of Figure 1 that the resistance 14 and the bypass condenser 24 are both in reality bridged around the audion.

It is to be noted further that the lower

end of the resistance 14 is connected to the common point of the condensers 24 and 23.

It is to be noted further that filaments, as indicated at 25, are provided for heating each of the equipotential cathodes 7, 12, and 16, and that these filaments are joined in series, although obviously they could be joined in parallel, if desired, and have their ends connected to the prongs 3 and 4. It is preferable to connect these filaments in series as it has been found more readily practicable to construct a filament so connected as to permit its direct connection to the 110-volt alternating current mains.

It will be seen that current rectified by the rectifier "R" passes along conductors 10 to the plate 11 of the current limiting device. From thence, current passes to the cathode 12 of such device. Further, it is to be noted that the storage condenser 23 is connected to the conductor 10 and to the prong 4 and consequently stores up a part of the pulsations. The current limiting device, as illustrated in Figure 1 is of the thermionic type described in greater detail in my co-pending applications noted above, and in my prior patents. It is intended that it be saturated at the minimum voltage supplied by the pulsating unidirectional current so that the current flow through the device is absolutely constant, irrespective of any variation of voltage impressed thereon.

Current from this current limiting device passes through the resistance 14 to the prong 4 and from thence to the other main. Further, it is to be noted that the upper end of the resistance 14 is positive with respect to the point at which the cathode 16 is attached. Consequently, the exact voltage desired for the audion may be obtained by selecting the point at which the cathode is connected, as it is to be noted that the plate is connected through the output device with the binding post 15.

It is to be particularly noted also that by adjusting the point at which the cathode 16 is connected to the resistance 14 that the exact negative potential desired upon the grid may be obtained. For example, the point at which the cathode is attached to the resistance 14 is positive with respect to the lower end of this resistance. The lower end of the resistance 14 is connected through the prong 4 and through the input device 20 to the grid 19 and, consequently, the grid is maintained permanently negative with respect to the cathode 16 of the audion.

It will be seen that the resistance 14 and the condensers 23 and 24 are permanently carried in the base of the unitary device and that the device is provided with only four prongs and with an auxiliary binding post hereinafter described in greater detail.

Further, it will be seen that the device

is so constructed that it eliminates not only the A battery and the B battery, but also the C battery, or the equivalent C battery eliminator. Instead of these auxiliary devices, the tube itself supplies the negative potential for the grid and this is secured without the addition of any extra element within the evacuated portion of the tube.

In the form of the invention shown in Figure 2, the same general inventive idea is followed. The device is provided with the prongs 26, 27, 28, and 29 and with the auxiliary binding posts 30 and 31. The filaments 32 are connected in series and directly across the alternating current mains 9 and 22 through the variable resistance 21. In this form of the invention, the prongs 26 and 27 which are connected to the two mains are directly connected to the anodes 33 and 34 of a full wave rectifier. Further, the prongs 26 and 27 are bridged by the resistance 35. The full wave rectifier is provided with an equipotential cathode 36 which is connected by means of the conductor 37 with the anode 38 of the current limiting device. Further, it is connected to one side of the storage condenser 39. The cathodes 40 of the current limiting device is connected to the anode or plate 41 of the audion and also to one side of the bypass condenser 42 and to the upper side of the resistance 43. The lower side of the resistance and the other sides of the condensers 39 and 42 mentioned previously are connected by a common conductor 44 with the center point of the resistance 35. Further, it is to be noted that the binding post 31 is connected to an intermediate point of resistance 43 preferably adjacent its lower end as indicated, and that the binding post 30 is connected to the lower end of the resistance by means of the common conductor 44. The cathode 45 of the audion is connected through the output device or transmuting device, indicated by the reference character 46, to the binding post 31 and consequently to the intermediate point of the resistance 43. The grid is connected through the prong 28 with one side of the input secondary 47, the other side of such secondary being connected to the binding post 30, and consequently, to the lower end of the resistance 43. It will be seen, therefore, that the point at which the binding post 31 is connected to the resistance 43 and the point at which the binding post 30 is connected to such resistance causes a negative potential to be impressed on the grid of the audion and, consequently, such grid is maintained negative with respect to the cathode of the audion. The full wave rectifier, of course, rectifies both of the half waves of the alternating current and consequently, a smaller storage condenser 39 may be used than with the form previously de-

scribed. Further, the resistance 35 provides a neutral point for the return conductor 44.

In both forms of the invention not only is the temperature of the filament controlled by the resistance 21, but also the voltage impressed on the audion is simultaneously controlled by such resistance.

In the physical embodiment of the invention disclosed diagrammatically in Figure 2, it will be seen particularly from Figures 3 and 4, that the tube base 2 of the unitary device carries the several prongs and also is provided with a pair of outwardly projecting members or lugs 48 which carry the binding posts 30 and 31. Further, the prongs 26, 27, 28, and 29 project through the base 2 in the usual manner. The evacuated vessel 1 is provided with an upstanding bridge 49 which supports the several elements of the device. The particular form of cathode and filament used in this tube is illustrated particularly in detail in my Patent No. 1,629,171, of May 17, 1927, for electron discharge devices.

Any suitable means may be provided for connecting the binding posts 30 and 31 with the respective conductors. For example, a brass or other metal sleeve 50 (see Figures 3 and 4) may be embedded in the arms 48 and may contact with the screw of the binding posts 30 or 31. Preferably, the metal sleeve is hollow and the conductor 51 leading thereto may be readily soldered, as indicated at 52. It is also preferable to roughen the exterior of the sleeve 50 so that the insulating base portion 2 may readily grip such sleeve. It is to be distinctly understood, however, that other forms may be employed than the forms specified herewith without departing from the spirit of this invention.

It is also to be understood that preferably the condensers 39 and 42, as well as the resistance 43 and 35, shown in Figure 2, are formed in a single block, as indicated at 53 in Figure 3, and that this block is mounted in the base portion 2 of the device. It is preferable also to separate the block from the tube by means of a mica or other insulating washer 54, as indicated in Figure 3.

With a tube constructed as illustrated, the usual type of tube socket may be employed into which the tube is inserted, as only four prongs are used, the auxiliary connections being furnished by the binding posts 30 and 31.

It is to be understood distinctly, however, that in any of the forms of the invention additional prongs may be employed in place of the binding posts, and a corresponding change in the tube socket into which the device is inserted must, therefore, be made. It is preferable, however, to provide the auxiliary contacts in the form of auxiliary binding posts so that the device may be inserted in standard sockets without requir-

ing any alterations and may, consequently, utilize and cooperate with standard equipment.

Referring to the form of the invention shown in Figure 5, it will be seen that the device comprises the evacuated vessel 1 having the base 2. However, this vessel is divided into three compartments 55, 56, and 57. The compartment 55 contains a pair of relatively small anodes 58 and a relatively large cathode 59 which encloses the anodes. The compartment 55 contains a rarefied gas, preferably of the helium group of such a pressure as to maintain a gaseous discharge between the electrodes 58 and 59. The cathode 59 is connected by means of a resistance 60 to the anode 61 of a voltage limiting device. The anode 61 of this device is relatively small and the cathode 62 thereof is relatively large and preferably cylindrical and encloses the anode. The gas in the compartment 56 is also of the helium group and of such a pressure as to permit a gaseous discharge between the electrodes. It is to be noted in this form of the invention that the member or anode 61 of the device in the compartment 56 is connected to the upper side of the resistance 63. The other side of the resistance being connected to the common wire 64. This connection, therefore, constitutes a direct connection from the cathode 59 of the rectifier to one end of the resistance 63 through the resistance 60. A storage condenser 65 is connected to the cathode 59 and also to the common conductor 64. A bypass condenser 66 is arranged parallel to the resistance 63. An intermediate point, preferably adjacent the lower end of the resistance 63 is connected to the cathode 67 of the audion, the plate 68' of the audion being connected through a translating or output device 68'' back to the upper end of the resistance 63. This connection is through one of the external binding posts 68 similar to the binding posts 30 and 31, previously described. The other binding post 69 is connected to the lower end of the resistance 63. Further, the binding post 69 which leads to the lower end of the resistance 63 or to the common conductor 64 is connected through the input secondary 70 to the grid 71 of the audion. The audion, it will be noted, is contained in the separate compartment 57.

It will be seen from the connections described that a negative potential is impressed upon the grid 71 of the audion or, in other words, the grid is maintained at a definite predetermined potential with reference to the cathode 67 of the audion. Also, it is to be noted that the device in the compartment 56 constitutes a voltage limiting device and is bridged across from one end of the resistance 60 to the common conductor 64. Thus current is supplied by means of the rectifier

whose anodes 58 are connected to the two supply mains 9 and 22 through the variable resistance 72. This rectifier, therefore, charges the condenser 65 and discharges through the resistance 60 and through the resistance 63. The current returns from the common conductor 64 to the neutral point of a filament 73 used for heating the equipotential cathode 67 of the audion. The filament 73 is connected directly across the two electrodes 58 of the rectifier and consequently directly across the mains. Thus the same prongs which are connected to the anodes of the rectifier are also used to supply the filament and an adjustment of the variable resistance 72 adjusts not only the voltage of the rectifier, but also the temperature of the filament and, consequently, the temperature of the equipotential cathode of the audion.

The metal selected for the anodes 58 and 61 of the rectifier and voltage limiting device and for the cathodes 59 and 62 of the rectifier and voltage limiting device may be of any suitable type. Preferably, however, the cathodes of each of these two devices is coated with an oxide or compound of alkaline metals.

It is to be noted further that the voltage limiting device has a voltage current characteristic which has a substantial portion thereof parallel to the current axis whereby a relatively great change in current flow may occur through the apparatus without appreciably altering the voltage between its terminals. Consequently, when the rectifier supplies pulsating unidirectional current and charges the storage condenser 65, such condenser discharges through the resistance 60 across which a voltage drop occurs. The apparatus in the vessel 56 constitutes in effect means for securing a constant difference in potential between the end of the resistance 60 and the common conductor 64 and, consequently, a constant voltage is impressed upon the audion.

The condenser 66 and resistance 63 furnish a bypass around the audion to take care of any variations that may occur due to variations in the signals received by the audion and, consequently, variations in the demand made upon the apparatus.

Referring to Figure 6, it will be seen that a further form of the invention has been shown in which a vapor rectifier is employed. By the expression, vapor rectifier, it is intended that either gaseous rectifiers or strictly vapor rectifiers be included.

In this form of the invention, the rectifier comprises a vessel 74 of high heat resisting characteristics and of good dielectric properties and of non-porous material, such for instance as quartz, silica, glass, etc., and is hermetically sealed. An anode 75 is sealed in the upper portion of the vessel 74 and in the lower bulb-like portion an electrode 76

is positioned. The lower bulb-like portion preferably contains a cathode of relatively low melting point or else one which emits vapors at a relatively low temperature, such vapors being the ionizing agents in the rectifier. A pool of mercury may be used or else other materials, such as alkali metals, for example, potassium, sodium, rubidium, caesium, or lithium. The anode 75 is small as compared with the cathode formed by the pool of mercury or other material, and the anode is preferably formed of a metal having a high melting point such as molybdenum, tungsten, carbon, iron, aluminum, platinum, tantalum, copper, constantan, or the like.

The anode 75 is connected with one of the alternating current mains 77. Preferably, the conductors to the electrodes 75 and 76 are relatively rigid so that they will act as supports for the rectifier.

The cathode is connected by means of the conductors 78 and 79 to the plate 80 of the current limiting device and to one side of the storage condenser 81. The other side of the storage condenser is connected by means of a conductor 82 through a variable resistance 83 to the other main 84.

The vessel of the rectifier has a central enlargement 85 and two coatings 86 and 87 separated by such enlargement. The coatings may be formed of electrically conducting and electroionically active material as described in my copending application, Serial No. 150,644, filed, November 26, 1926, for gaseous discharge device; and Serial No. 159,313, filed January 6, 1927.

The current passes from the anode 80 to the cathode 86 of the thermionic current limiting device and passes from the cathode 86 through the conductor 88 to one side of the bypass condenser 89, and bypass resistance 90.

The other side of the condenser 89 and resistance 90 are connected to the conductor 82. From the conductor 88 current passes by way of conductor 91 to one side of a translating device, such as the primary 92 of a transformer. The other side of the primary is connected to the plate 93 of the audion, such audion having a grid 94 and the cathode 87 previously described. The cathode 87 is connected by means of the conductor 95 to a point on the resistance 90 near its lower end. Further, it is to be noted that the grid 94 is connected through the secondary 96 of a transformer to the lower end of the resistance 90. In this manner, a negative potential is impressed upon the grid and the grid is maintained negative with respect to the cathode of the audion.

In the form shown in Figure 7 substantially the same arrangement is followed except that the rectifier is a full wave recti-

fier. Further, the cathodes 97 and 98 of the current limiting device and audion respectively, are shown as separate metal members and are preferably coated with a low electron affinity oxide. Obviously, either form of cathode, viz. the one previously described or the one just described, may be used on either the single or full wave rectifier, without departing from the spirit of the invention.

The rectifier vessel 99 has an electrode 100 sealed in its bulb-like lower end and a pair of anodes 101 and 102 sealed in its upper end. The anodes are connected to the mains 103 and 104 through a variable resistance 105. Preferably, a heating resistance 106 is connected across the conductors leading from the anodes 101 and 102 and further, a resistance 107 is bridged thereacross. The center point of this resistance is connected to one side of the storage condenser 81 and bypass condenser 89 and bypass resistance 90. The remaining connections are the same as those described for Figure 6.

This last form of the invention provides for full rectification and obviously a smaller storage condenser may be employed.

It will be seen that a novel form of unitary electron discharge device has been provided by this invention which is so constructed that it is adapted for energization wholly from alternating current mains and not only supplies energy for heating the several cathodes of the device and for furnishing current to the plate of the audion, but also furnishes the necessary difference of potential between the grid of the audion and the cathode of the audion, so that the apparatus may function at the most advantageous portion of its characteristic curve. In other words, this device insures distortionless reproduction and does not require any additional C battery or any auxiliary apparatus whatsoever. Instead, the device is a complete and self-contained unit and may be connected directly to the input and output portions of the system and may be directly supplied from commercial alternating current mains.

Although the invention has been described in considerable detail, such description is intended as illustrative rather than limiting as the invention may be variously embodied and as the scope of such invention is to be determined as claimed.

I claim:

1. A unitary electron discharge device including an evacuated vessel, an audion mounted within said vessel and having a plate, a cathode and an interposed grid, a rectifier mounted within said vessel for supplying energy to said audion, means carried by and forming a unitary portion of said device for impressing a negative voltage on said grid with reference to the cathode of

said audion, and means for smoothing out the pulsations in the energy supplied by said rectifier.

2. A unitary electron discharge device
5 adapted to be energized from a source of alternating current including an audion having a plate, a cathode, and a grid, a rectifier for supplying said audion, an energy
10 controlling device for smoothing out the pulsations of energy supplied said audion by said rectifier, and means for maintaining a predetermined voltage difference between said grid and cathode, said audion,
15 rectifier, and voltage maintaining means being permanently carried by and forming a unitary part of said electron discharge device.

3. A unitary electron discharge device including an evacuated vessel, an audion
20 mounted within said vessel and having a plate, a cathode, and an interposed grid, a rectifier mounted within said vessel for supplying said audion, means for smoothing out the pulsations of energy supplied by said
25 rectifier, and a resistance bridged around said audion and having a portion thereof connected with the grid of the audion for maintaining a definite predetermined voltage

difference between the grid and the cathode of said audion.

4. A unitary electron discharge device including an evacuated vessel having a base permanently attached thereto and provided with terminals, an audion mounted within
35 said evacuated vessel and having a cathode, a plate and an interposed grid, a rectifier mounted within said vessel for supplying energy to said audion, means for smoothing out pulsations of energy supplied said audion, a resistance and bypass condenser
40 bridged around said audion, said resistance having one portion thereof connected to the grid of the audion for maintaining said grid at a predetermined voltage with respect to said cathode, a storage condenser cooperating
45 with said rectifier, said condenser and said resistance being located in the said base, and connections leading from said terminals to the electrodes of the audion, rectifier, and
50 to said resistance.

In testimony that I claim the foregoing I have hereunto set my hand at Milwaukee, in the county of Milwaukee, and State of Wisconsin.

ARISTOTE MAVROGENIS.