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POWER OPERATED VACUUM TUBE CONSTRUCTION

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Fig. 1.

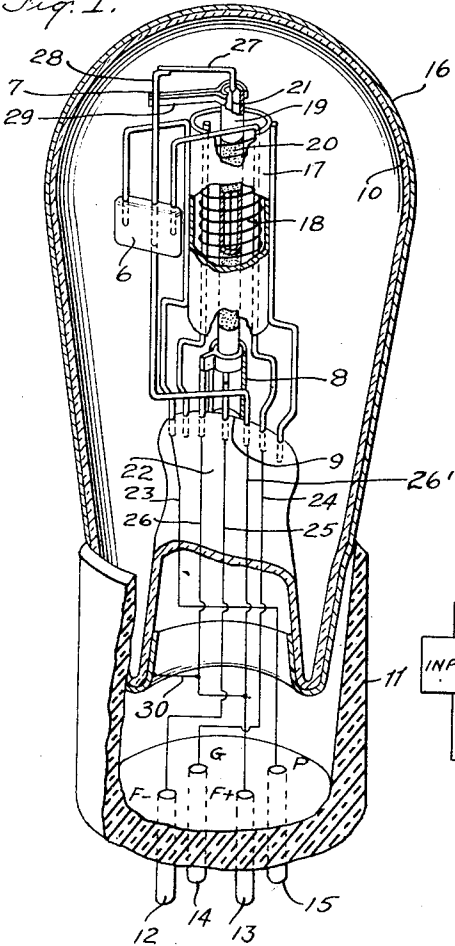
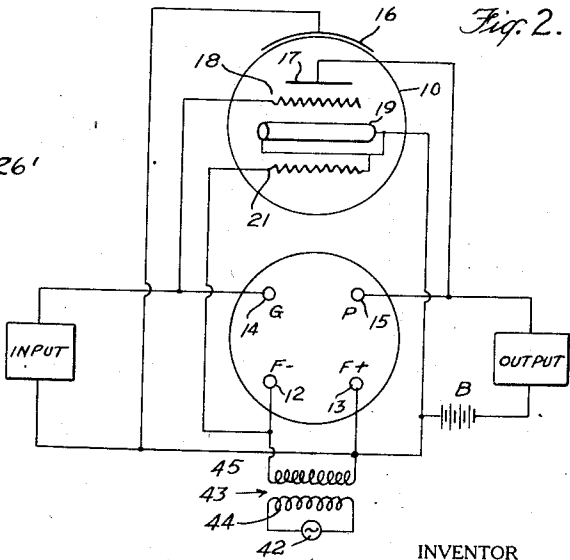


Fig. 2.



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POWER OPERATED VACUUM TUBE CONSTRUCTION

Original application filed December 24, 1926, Serial No. 156,946, and in Canada October 4, 1927. Divided and this application filed January 27, 1928. Serial No. 249,903.

This invention relates to electron emitting devices of the general type known as thermionic vacuum tubes, and more especially to tubes of the type in which the cathode is heated by radiation transferred thereto from another source of energy, and is a division of my co-pending application, Serial No. 156,946, filed Dec. 24, 1926.

More particularly, the invention relates to a thermionic tube so constructed as to permit the use of ordinary household or fluctuating lighting current as a power source for heating the cathode material of the tube to electron emitting temperatures.

One of the objects of the present invention is to provide a thermionic device, which is adapted to operate if desired, on an alternating or fluctuating current for cathode exciting purposes, and the output of which is independent of fluctuations in heater current, and particularly is free of "hum" heretofore usual in such devices when used on alternating currents of commercial frequency. Another object of the invention is to provide a device of the class described which is simple and economical to construct, and positive and reliable in operation.

Another object of the invention is to provide a vacuum tube of the four element type including plate, grid, cathode and heater with such connections as will permit its use in an ordinary or standard type of four terminal socket, the terminals of the tube being four in number and all positioned upon the base of the tube in the ordinary manner, and with all leads passing through the base and through a single press into the evacuated envelope, so that the insertion of a tube according to my invention into a standard four contact socket to which circuit connections are established, closes all necessary contacts.

Still another object is the provision of a vacuum tube adapted to operate in a circuit arrangement which when employed with a radio receiving set, will permit optional use of said set without modification of internal wiring, either with alternating or fluctuating direct current tubes as disclosed in this application and in my copending applica-

tion Serial No. 140,245, Patent No. 1,869,566, on the one hand, or with standard constant direct or battery current tubes on the other hand.

Another object is the utilization of a tube construction in which the cathode is separated from the heater element, and insulated therefrom by vacuous space only throughout the energizable length of the heater. Further objects will become apparent on consideration of the following specification and accompanying drawing which is descriptive of an embodiment of the invention which may be preferred, and in which

Fig. 1 is an elevational section of a vacuum tube incorporating the novel base construction of the invention, and a portion of the circuit arrangements; and

Fig. 2 is a diagrammatic showing of the tube circuits of the tube itself.

The type of thermionic vacuum tube now in general use is provided with three internal elements, the anode, cathode and control electrode or grid, the cathode being in the form of a filament adapted to be heated by a dry or storage battery or other source of approximately constant potential unidirectional current. For this tube four base terminals are utilized, affording connection to grid and plate, and a series connection through the filament. This type of tube is in most cases unsuited for use in connection with a fluctuating or alternating current, commonly used for house lighting, because of the pronounced hum produced in the output circuit.

In the present invention, use is made of a four element tube operative on alternating current without substantial hum as described in my co-pending case Serial No. 140,245, Patent No. 1,869,566, in which the cathode and heating element are physically separated, the heater being substantially enclosed by the cathode, but electrically connected in series therewith as regards heating current at a point spaced far enough from the energizable length of the heater to prevent heat conduction from the heater to the cathode.

Heretofore, it has been the usual practice in four element tubes to keep the cathode physi-

cally and electrically separated from the heating filament which made it necessary to provide such a device with at least five external terminals, two for the heater circuit, one
5 for the cathode, and one each for the plate and grid. In the present arrangement, however, I utilize only four terminals for these four elements, by including the cathode in the heating circuit in series. All of these
10 terminals are positioned in the tube base in the usual relationship so that the ordinary commercial type of vacuum tube socket is adaptable for the use of the tube, and the insertion of the tube therein completes all
15 necessary connections.

In accordance with my invention, I have illustrated an embodiment of the vacuum tube construction in Fig. 1, in which the envelope 10 is preferably formed of glass or
20 similar material in the usual elongated tubular shape with a base 11 attached thereto, this base being adapted for insertion in the ordinary type of socket, and for this purpose having four terminals 12, 13, 14 and 15 extending from the end. The envelope 10 is
25 optionally covered with a metallic deposition forming a film 16 which may extend partially or wholly about either the exterior or interior surface, although I have herein shown the exterior surface as so covered as that is the preferred construction.

Within the tube there are provided among others, certain of the usual elements necessary for the amplification or rectification of
35 radio signals, including the anode which may be in the form of a cylindrical plate 17, the control electrode in the form of a grid 18, and the cathode 19. The cathode may be of the type described in my co-pending application, filed October 8, 1926, Serial No. 140,245, Patent No. 1,869,566, as for example a tube of nickel or other suitable metal having
40 a coating 20 of a substance or mixture such as oxides of barium or strontium possessing high electron emitting properties when heated. The limits of the cathode coating terminate well within the plane fixed by the plate ends. Also in some instances, I may slit the tube axially to diminish inductive
50 reactions arising from the heater element.

Where this is done it is preferable that the shielding of the heater be maintained undisturbed; and this may be accomplished by omitting that portion of the grid structure
55 adjacent the cathode slot or by forming the cathode in a spiral sheet corresponding to the spirally wound grid.

The heater for the cathode is separate therefrom and consists of the filament 21, preferably but not necessarily carbon, extending co-axially within the cathode and connected to the cathode at one end, preferably the end remote from the press, through the spring arm 27, support rod 28, and conductor
65 29, so that both cathode and filament are in

series when heating current is supplied as contemplated. The function of the spring 27 is to permit adjustment of the heater in accordance with temperature variation. The cathode tube 19 encloses the heater filament 21
70 and extends preferably above and below the same, so as to form an effective shield for the heater and to diminish hum arising from difference in potential between heater and other tube elements. Preferably the cathode tube should enclose the heater filament from the point adjacent the junction 7 of cathode and filament to the tube stem support at 9, and for this purpose I have illustrated the sleeve 8 as an extension of the cathode tube and
80 resting on the stem and in electrical contact with the cathode tube 19 completing a shield which encloses that part of the alternating current supply within the vacuous space which has a potential value different from that of the cathode. The sleeve 8 is axially slit to facilitate assembly, the slit being disposed away from the grid lead so that a solid shield is interposed between the grid lead and alternating current lead having a potential
90 different from that of the cathode.

The cathode and heater are separated by vacuous space rather than by a solid dielectric primarily to facilitate manufacture of tubes as a mass of solid material within the space
95 to be evacuated would greatly increase the difficulties of proper evacuation, and secondarily to avoid time lag in reaching temperature equilibrium in operation due to the mass of the solid dielectric. The electrical
100 connection of cathode and heater at a common point in conjunction with the spacing apart of these elements and separation only by vacuous space and the use of carbon and the use of circuits hereinafter described, permit the use of relatively high potentials and low current values within the tubes, which may be as high as sixteen volts, and as low as twenty-five hundredths ampere. As electromagnetic disturbances are usually more
110 troublesome than electrostatic disturbances when alternating currents are used for cathode heating, since electrostatic disturbances are easily cared for by thin metal shielding, I prefer to employ a low current preferably
115 not exceeding five tenths amperes and high voltage, and the advantages which I have been able to obtain are apparent in the freedom from disturbing noise and "hum" even in multi-stage amplifiers.

Note should be made further of the advantageous use of carbon as a heater element for the cathode. The use of a single straight stiff filament of high resistance such as carbon and of short length and small linear expansion positioned concentrically within the cylindrical cathode, permits close positioning of the cylindrical cathode even without a solid dielectric, thereby decreasing the area of cathode in direct proportion to the diameter
120
125
130

as will be understood. If we assume a constant amount of energy transfer from the heater per unit of area of the cathode to maintain said unit area of the cathode at electron emitting temperature then since the cathode area is decreased proportionally as the diameter is decreased, the energy required is also decreased and the current supplied to the filament may be reduced as the square of the cathode diameter, thereby reducing the magnetic fields which tend to cause hum. It will be seen, therefore, that a close fit of the cathode around the heater made possible by the use of single short straight high resistance carbon filament concentric with the cathode sleeve and separated only by a vacuum space, makes possible the reduction of heater current and magnetic field to a point where disturbing noise and hum is substantially eliminated even for many tubes in cascade. Also at the relatively low temperature of operation, averaging below white heat, the heating element has exceptionally long life. Where carbon is used as the material of the heater, I preferably make use of copper as an intermediary welding element between the carbon filament and its support. The use of carbon as well as copper is found to be advantageous, moreover, as these materials function as getters in the tube exhausting process, absorbing or occluding the gas residue in the tube after sealing.

The cathode being in tubular form has a considerably larger effective emitting surface than filamentary cathodes and hence has ample electron emitting capacity for all ordinary uses including operation as a so-called "power tube".

The plate, grid, cathode and heater filament are each supported upon the single tube stem 22 by means of appropriate connections and standards as clearly shown in Fig. 1, the glass bead 6 being necessary as a support for the grid and plate.

The base 11 is preferably but not necessarily formed of insulating material and is provided at its end with the four terminals 12, 13, 14 and 15, hereinabove referred to. Connections from the tube elements to the base terminals are made as follows: from the plate 17 by wire connection 23 to the terminal 15; from the grid 18 by wire 24 to terminal 14; from the heater filament 21 to the terminal 12 by wire 25; from the cathode 20 to terminal 13 by wire 26; and from the other end of the cathode 20 and heating element 21 to the terminal 13 by means of the support rod 28 and wire 26'. Connection is also made from the external surface film 16 to the terminal 13 by means of wire 30 for the purpose of grounding the metallic film on the envelope.

With the above connections it is apparent that I have provided a four element vacuum tube adapted to be heated by alternating cur-

rent, and all of the connections for which are in the base of the tube, and having the standard spacing and disposition so that the mere act of inserting the tube in a standard socket makes all the necessary connections, there being only four required terminals for the operation thereof. As brought out in my co-pending application Serial No. 140,245, Patent No. 1,869,566, the use of alternating or variable current as a power source is made possible by utilizing in the tube heating means for the cathode physically distinct from and electrically shielded by the cathode, and by providing a common connection between cathode and heater filament, so that the cathode functions primarily as an electron emitting body without appreciable effect on the grid and plate arising from potential variation introduced by the heating current.

Since the filament resistance is high and the cathode tube resistance relatively low, it suffices to connect the grid return to any point on the cathode tube 19, or to the end of the heater filament 21 which is connected to cathode tube 19. This metallic low resistance connection of the grid return to the cathode heater circuit fixes the potential between grid and cathode for low frequencies so that for any fluctuations of cathode potential due to heating current, the grid fluctuates similarly and no potential difference appears between cathode and grid; thus preventing or minimizing the possibility of noise being introduced by the voltage drop through the heater affecting the grid-cathode potential through unbalanced capacity effects, as might occur if the cathode were electrically isolated from the heating circuit.

As shown in Fig. 2, the tube may be connected with appropriate input and output circuits, including a B-battery or its equivalent. The filament or heater is supplied with alternating current from a generator or other source 42 through the intermediate agency of a transformer 43 including a primary 44 and secondary 45.

Since the noise as well as the signal produced by each tube is amplified by all the successive tubes, it will be seen that my tube and circuit arrangements are highly effective in eliminating noise and hum, as five, six or even more tubes may be arranged in cascade without the production of appreciable or disturbing noise or hum effects.

In the construction of the thermionic tube of my invention, it is of course understood that the exact dimensions of parts may be varied within limits in accordance with the uses to be made of the tube. As illustrative, however, of a precise tube construction which has been found advantageous, the following values are given: diameter of heater filament 0.005 inch, length of heater $1\frac{1}{8}$ inch, diameter of cathode 0.095 inch, length of cathode $1\frac{1}{4}$ inch, length of oxide coating

11 inch, diameter of grid envelope $\frac{1}{16}$ inch, length of grid envelope $\frac{3}{4}$ inch, diameter of plate tube $\frac{1}{16}$ inch, length of plate tube $\frac{3}{4}$ inch. The cathode tube has a wall thickness
 5 of approximately 0.0025 inch.

The voltage of commercial current used in connection with my tube is assumed to be approximately 110 although any ordinary value will give satisfactory results. The
 10 transformer 45 has preferably such constants as will produce a voltage ranging around 16 in the secondary 45.

It is to be understood that the tubes herein described are also applicable to fluctuating direct current for cathode heating. When application is made to direct current, a resistance inserted in series with the filaments of the tubes is used to reduce the
 15 voltage to proper value.

It is to be understood that various modifications of the base connections and of wiring of the circuit may be made in accordance with specific requirements in applications of the invention, and hence I desire to include
 20 all of such modifications and alterations within the scope of the claims hereto appended.

Having thus described my invention, what I desire to claim is:

30 1. A thermionic tube comprising a container having therein an anode; an electron emitting cathode of relatively low resistance; a heating element for said cathode, said heating element being connected in series with a circuit containing the cathode; a
 35 shunt connection around said cathode also in series with said heating element; a base secured to said container; contact prongs positioned on said base; and leads in said
 40 container and base, one lead from one prong and another lead from another prong completing the series connection to the heating element and from the cathode and shunt
 45 whereby electrical current may flow from the one prong through the said lead, heating element, cathode and cathode lead as well as the shunt connection back to the said other prong, said cathode and shunt connection being
 50 in parallel with respect to each other and together in series with respect to the filament, whereby the said relatively low resistance of the combined cathode and shunt will avoid production of an objectionable hum in
 55 the anode circuit.

2. A thermionic tube comprising an envelope having a press therein; a filament, cathode, grid and anode in said envelope mounted from the press grid and filament
 60 lead wires projecting from said press, and a shield resting on said press substantially as a continuation of the cathode and substantially surrounding the filament lead and interposed between said filament and grid
 65 leads whereby both leads may extend

through the same press and be shielded one from the other.

3. A thermionic tube comprising an envelope having a press therein; grid and filament lead wires projecting from said press, and a longitudinally split shield substantially surrounding one of said leads with its split side away from the other lead, whereby said sleeve is readily applied and will completely shield one lead from the other.

In testimony whereof, I affix my signature.
 WALTER LOUIS KRAHL.