[Second Edition.]

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in Vacuum Tubes.

We, ARCTURUS RADIO COMPANY, of 255, Sherman Avenue, Newark, State of New Jersey, United States of America, a corporation organised under the laws of the State of Delaware, United States of America (Assignees of WALTER LOUIS KRAHL, formerly of 404, Davis Avenue, Harrison, New Jersey, and now of 78, Orange Road, Montclair, New Jersey, United States of America, a citizen of the United States of America), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to electron discharge devices of the general type known as vacuum tubes and more particularly of the type utilizing as a cathode a surface coated or treated with material adapted to emit electrons when heated and provided with a heater disposed in such relation to said surface as to maintain it at a temperature such that it emits electrons.

It is an object of this invention to provide a tube of the character described capable of use as an amplifier, detector, rectifier and the like and which may have its cathode energized directly from the house lighting circuit without the necessity of using rectifiers, battery eliminators and the like.

It is a further object of this invention to provide a tube of the character described which is relatively inexpensive to manufacture and which will operate at high efficiency with maximum freedom from "hum" and other disturbing noises usually characteristic of devices of the same general nature operable from commercial lighting and power circuits, and which will have a long operating life of high reliability.

It is still a further object of this invention to provide a tube of the character described which shall be mechanically as strong and rugged as possible and which will be characterised by high thermal efficiency and minimum operating lag.

It is still a further object of this invention to provide a tube of the character described which is provided with four terminals to be mounted in a standard socket without requiring any changes in the wiring of the socket or the apparatus with which the socket is associated; for example, when it is desired to use the tube in a radio receiver, the tube may be inserted in any standard type of radio receiver without requiring any changes whatsoever in the wiring of said receiver, to convert said receiver to operate from the house lighting circuit.

Still other objects of our invention will be apparent from the Specification.

In accordance with a principal feature of the invention a single straight filament of carbon is used the filament being heated by alternating current and heating a tubular cathode by radiation only. Because of this filament a relatively high voltage of about fifteen volts may be applied to the tube and correspondingly low currents may be used, due to the high resistance of the filament. We have found that one of the chief causes of hum in an alternating current tube is an electrostatic effect which may be cut down by the use of low currents. Also, the low current makes it possible to use the ordinary wiring of the standard set for the filament current instead of providing special heavy wires for that purpose. The use of carbon filaments has been suggested in tubes having a platinum tubular cathode the filament being heated by a battery and being arranged in the cathode to heat it by radiation. It has also been proposed to provide a construction in which a tubular cathode surrounds and is heated by radiation only from a single straight filament, the cathode shielding the filament.

In accordance with a further feature of the invention the cathode is made longer than the energised portion of this single straight carbon filament and the plate and grid of the tube are made considerably shorter than the cathode. The grid and plate are thus shielded from the electrostatic condition arising from the alternating current.

Still another feature of the invention is that the filament is spaced from the cathode which provides even heating of

[Price 1/-]

the cathode and prevents uneven cooling of the filament which would result in stresses and strains being set up in the filament shortening the life thereof.

The invention is illustrated in the accompanying drawing in which

Fig. 1 is a diagrammatic view of a tube according to our invention; and

Fig. 2 is a perspective view of a detail thereof.

In accordance with our invention, we provide a cathode comprising a cylindrical sleeve of conducting material such as nickel, coated on the outside or treated with substances adapted to emit electrons when heated, such as oxides of barium and strontium. We arrange a carbon heater within this sleeve in such manner that the heat developed by the heater when an electric current is passed therethrough is transmitted to the cathode by radiation and maintains it at such a temperature that a stream of electrons is emitted.

In order to provide a tube as strong and rugged as possible and at the same time as economical as possible, the electrodes are all supported from a single stem or press and the supporting members extending into said press form the sole support and the sole contacting leads to the electrodes.

In order to eliminate the necessity for using an insulating shield between the heater and the cathode, we arrange the cathode with its longitudinal axis parallel to the lead-in wires and arrange a direct metallic connection between the outer end of the heater and the cathode. The inner end of the heater is supported in spaced relation with respect to the cathode by a relatively short and stiff lead-in wire embedded in the press, and the lower end of the cathode is similarly supported, thereby positively maintaining said heater out of contact with said cathode at the lower end and eliminating the necessity for an insulating shield interposed between the heater and cathode. By this construction the heater and cathode are spaced apart and yet are electrically connected.

The tubular cathode or an extension thereof extends to the press or support so that the heater is shielded from a point adjacent the low potential junction point of cathode and heater throughout its length to the press. This construction is deemed to accomplish an important result as will be pointed out hereinafter.

To obtain a filament of long life and extreme reliability, we make use of a carbon filament which performs the function of heater, and in order to support said filament in a manner to compensate for variations of temperature, the outer end is resiliently supported, and as a support, we prefer to use a spring of tungsten or other suitable material. It is evident that carbon cannot be welded to tungsten and for the purpose of making a welded joint possible, we prefer to coat the end of the carbon filament with a material capable of being welded to the hook. This may be done by first electroplating upon the end of the filament a deposit of copper and then electroplating upon the copper a coating of nickel. The copper adheres to the carbon, the nickel adheres to the copper and the nickel may be welded to tungsten. A similar arrangement may be utilized at the lower end of the filament, but in case the lead-in wires are of nickel, it will be unnecessary to make a separate plate of nickel upon the copper as the nickel and copper may be welded directly.

The tube is arranged to be provided with a standard base comprising a pair of filament terminals or contact prongs adapted to make contact with appropriate contacts in a standard socket. In order to permit of the use of alternating current derived from the house lighting system without making changes in the wiring of the usual radio receiver necessary, we prefer to connect the two filament prongs of the base together and to connect these prongs to one end of the heater, the other end of which is connected to a terminal carried by the tube in some way which will not interfere with the insertion of the tube in a standard socket; for example, this terminal may be in the form of a spring clip carried on the side of the tube and above the base, whereby one terminal of the power lead may be connected to the positive or negative low-tension battery terminals of the receiver in order to obtain the benefit of a variable rheostat which may be connected in the filament circuit, and the other terminal will be connected to the clip mentioned.

Referring now to Figure 1, 1 designates the anode in the form of a cylindrical plate, and 2 the control electrode or grid in the form of a helix if desired disposed within the anode 1. 3 is the cathode comprising a sleeve of suitable metallic material coated with a substance adapted to emit electrons when heated. Preferably for the sleeve we employ a magnetic metal, such as nickel in the form of a cylindrical shell, the diameter or which is small compared with the length. For the coating various mixtures of the general type referred to are known and it is clear that any suitable mixture may be used. We have found, however, that excellent results may be obtained when the coating

is prepared and applied as follows: Barium carbonate is mixed with paraffin wax in the proportion of one part of barium carbonate to three parts of paraffin and strontium hydroxide is similarly mixed with paraffin wax. The nickel sleeve to be coated is then heated and the strontium paraffin mixture applied and the wax burned off by heating. The process is repeated until an even coating is obtained on the cylinder, which may take as many as six applications. After the completion of the strontium coating, the barium coating is applied in a single application and the wax burned off after which the cylinders are placed in an oven in an atmosphere of hydrogen and baked at red heat until the oxides are transparent, after which the cylinders are allowed to cool and are ready to be mounted in the tube assembly.

4 is the heater comprising, as already stated, a carbon filament. As shown the cathode with its extension 34 is longer than the energised portions of the filament. The object of this longer cathode is to prevent any radiation from the energised portion of the filament from reaching the plate or grid, and in order to acomplish this result the cathode must extend out at each end beyond a direct line between the outermost heat radiating portion of the filament and the ends of either the grid or plate. The energizable portion of the filament will be that portion indicated by a single line below the tab 18 at the top of Figure 1, and that portion ends just below the top of the cathode, the lower end of the filament being similarly positioned with respect to the lower end of the cathode. 5 is a stem or press through which the lead-in wires pass formed in the flare tube 6. 7 is the envelope sealed to the flare tube 6. The envelope may be of clear glass or may have a metallic deposition on the inner or outer surface thereof. The envelope with the elements enclosed is mounted in base 8 provided with contact pins 9, 10, 11 and 12, and a suitable spring clip 13 is held in position by means of a rivet 15*a* and by a fibre extension 14 passing within the base 8 between the cathode terminals 10 and 11. The connector 65 between these electrodes passes over and holds the extension 14 in place. 16 designates the coating on the lower end of filament 4, and 17 the support wire connected to lead-in wire welded thereto. 18 designates a similar coating on the upper end of heater or filament 4, and 19 a spring preferably of tungsten welded to the filament on one end and having the other end welded to filament supporting wire 20; wire 20 is embedded at its lower end in press 5.

The cathode may be provided with a collar 22 at its lower end which may be welded to a suitable support wire 22*a* also embedded in press 5 and contacting with led-in wire 22*b*, and connected likewise to pins 10 and 11. A suitable collar 23 may be formed on the top of the cathode and welded to support 20 by connection 50, which it will be seen, provides a direct and positive metallic contact between the cathode 3 and the top of the filament or heater 4. The grid or control electrode 2 is preferably formed of a coil of wire wound upon grid supports 24 and 25 embedded in the press 5 and making contact with grid lead 26. In a similar manner the plate is supported by wires 27 and 28 embedded in the press 5, and to provide additional rigidity, the plate support 27 may be extended in the element 51 which is bent outward and downward and embedded in glass bead 30 formed on support 20. The grid element 68 is also supported by rod 69 in the bead 30. Plate support 27 makes contact with plate lead 29 passing through the press to the appropriate prong 12 of base 8. The lower end of the filament to which the coating 16 is applied is connected to supporting wire 17 embedded in the press which in turn is connected with lead-in wire 17*a* passing through the press and making contact with terminal 15.

A suitable transformer 31 comprising primary and secondary windings may be provided for stepping down the voltage derived from the house lighting system designated at 32. It will now be seen that if one of the secondary leads from transformer 31 is connected to terminal 15, which may be done without in any way disturbing the connections of the receiving apparatus, the other terminal of the secondary winding of transformer 31 may be connected to either the positive or negative low tension battery terminals of the receiver, in which case the heater will be energized, and the current flowing therein may be controlled by the rheostat usually found in the receiver provided the connection has been made to the low tension battery terminal which includes the rheostat in circuit.

The sleeve 34 which is connected to the cathode and which surrounds the lower support 17 for the filament prevents the electrostatic changes in the lower end of the filament support from affecting the plate or grid or the supports connected thereto. It will be noted that the cathode is connected to the upper end of the filament by means of the connector 50, and hence the cathode will have an alternating current potential similar to the upper end of the filament. This potential will be

different from the potential at the lower end of the filament, owing to the high resistance of the filament. Thus at any given instant the potential of the cathode will be either greater or less than the potential of the lower end of the filament, depending upon the direction of flow of current at that instant. As the plate and grid are connected to the cathode through their respective circuits, these elements are maintained at an alternating current potential similar to the potential of the cathode, and hence, there will be a tendency for the current to pass between the lower end of the filament and the grid and plate owing to the difference in potential. The sleeve at the lower end of the cathode absolutely prevents this and, therefore, prevents the hum which would result especially from current passing from the lower end of the filament to the grid.

Since no insulating sleeve is provided between the heater or filament 4 and the cathode 3, the cathode will very quickly reach temperature equilibrium and the tube will therefore quickly reach normal operating condition when the filament is energized.

It is also to be noted that since the top end of the filament or heater 4 is directly connected to cathode 3, no harm can result in case the top end of filament 4 comes directly in contact with the nickel sleeve forming the cathode 3. Since, however, the lower end of the filament 4 is at a different potential from cathode 3, this end must not be permitted to come in contact with the cathode, but by reason of the proximity of the lower end of the electrodes to the press, these ends are rigidly supported against movement, whereby it will be seen that by this construction we are enabled to avoid the use of an insulating shield between the filament 4 and the cathode 3 and at the same time provide a cathode very closely encircling the heater, whereby a high thermal efficiency is realized, and time lag in operation minimized.

The coating, as prepared in the above or similar manner, is applied to a length of the sleeve such as is included between the ends of the enclosing cylindrical plate, so that a minimum amount of electronic discharge occurs to the tube interior and envelope beyond the plate.

Due to various electrical conditions within and without the tube, giving rise to a relatively high potential on the envelope, it has been found desirable in some instances to ground the envelope surfaces 66 and 67, or otherwise make connection to a point of low potential. This may be accomplished either by metallic deposition on the glass interior or exterior, forming a film, or by the use of metallic strip applied to the bulb, and in either instance, a ground connection made as at 70 to the outside surfacing.

The structure of the units with the relatively high resistance carbon heater rod 4 and the cathode 3 in series is advantageous, moreover, as it reduces the current and hence the induction effective in the production of hum. The filament life is also increased. Also the parallel relationship of the heater and cathode cylinder tends to diminish the inductive effects due to variable current flow through these elements. In addition the nickel shell acts as a shield serving to neutralize the electrostatic action of the heater circuit and hence it complements the other factors mentioned in reducing hum arising from the low frequency power current.

While the outstanding object of the invention—to reduce alternating current hum—is facilitated by the above mentioned factors, stress should be laid on the use of the completely shielded heater filament. Since the potential of cathode and filament adjacent their junction 50 is practically equal, no shielding is there necessary but the difference in potential between the exposed vertical length of the filament and base connection 16 on the one hand and adjacent cathode on the other hand, is appreciable, and we have discovered that complete shielding of these parts is desirable to obviate hum to the greatest possible degree.

Also, the active material coating the cathode, if not within the space defined by the cylindrical anode has been found to transmit variable electrical impulses to the tube interior and cause hum. The limitation of the coating within the space defined by the enclosing cylindrical plate practically eliminates this disturbance. Note should be made further of the utility of the series connection which permits elimination of one base terminal and lead wire of the tube.

It is clear that the construction described is useful not only in amplifiers and detectors, but is also capable of use as a rectifier, in which case it is unnecessary to provide the grid. It is also clear that another terminal such as a spring clip may be arranged on the side of the tube and suitably connected to the filament so that heating current may be supplied to the filament without passing through the wiring of the receiver.

While we have shown and described a preferred embodiment of our invention, it is clear that modifications and changes may be made within the scope of our

invention as will be understood by those skilled in the art.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a vacuum tube, a tubular cathode and a single straight filament of carbon energised by alternating current and adapted to heat the cathode by radiation only and shielded by the cathode throughout its energised length.

2. In a vacuum tube, the construction claimed in Claim 1, characterised by the fact that the tube comprises an envelope and an anode within the envelope surrounding the cathode and the single filament heater, a control electrode within the anode, a base and terminals carried by the base and connected to the anode, control electrode, cathode and heating element.

3. In a vacuum tube, the construction as claimed in Claims 1 and 2, characterised by the fact that the filament is resiliently supported by a metallic spring to compensate for variations in length due to temperature variations, said filament having a layer of metal formed on the end of the filament and a second layer of metal formed over the first layer to which the spring is welded.

4. In a vacuum tube, the construction as claimed in Claim 1, characterised by the fact that a standard base is provided, the filament contacts of which are connected together and connected to one end of the heater while the other end of the heater is connected to a contact carried by the base in such position as to be accessible when the tube is inserted in a socket.

5. In a vacuum tube, the construction as claimed in Claim 4, characterised by the fact that the terminals do not exceed four in number.

6. In a vacuum tube, the construction as claimed in Claim 1, characterised by the fact that the cathode is formed of a nickel shell and that the heating element is in close proximity to the cathode whereby the heat losses due to radiation are effectively diminished.

7. In a vacuum tube as above claimed the feature that the cathode including its extension is longer than the energised portion of the filament and the plate and grid are both made shorter than the cathode.

Dated this 8th day of October, 1927.
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Agents for the Applicants.

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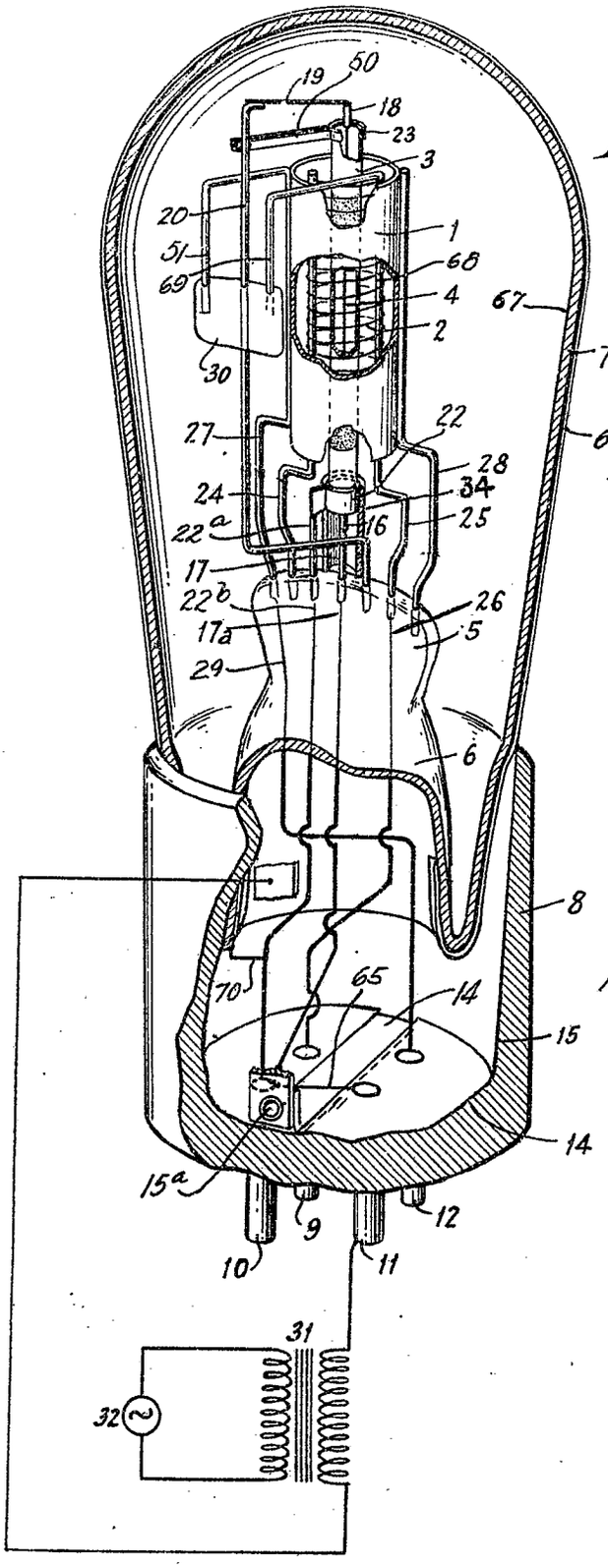

Fig. 1

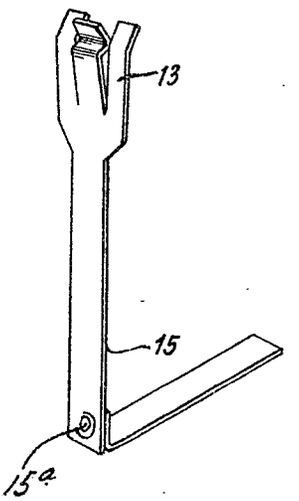

Fig. 2

Malby & Sons, Photo-Litho