1. My present invention relates to circuits which are used in radio equipment and more specifically it relates to improvements in providing heating current for series connected filaments with economy of power and economy of circuit construction. The invention includes a novel rectifier construction which makes possible the circuit arrangement.

In circuits of the prior art commonly associated with heating the filaments of thermionic discharge tubes with power ordinarily dissipated in circuit resistors, it has been necessary to exclude the rectifier filament. This exclusion of the rectifier filament was necessary because of the difficulties in initially bringing the filament to emission temperature.

Because of the larger relative current ratings of rectifier tubes, their filaments are necessarily of higher wattage than those of other tubes used in conventional receiver circuits. It is clear that greater power economy would result from utilizing the high wattage rectifier filament as a circuit resistor, than from utilizing the lower wattage filaments of other tubes in the same manner.

My invention therefore contemplates utilization of the rectifier filament winding in the place of a separate circuit resistor thereby providing for economy in construction.

It is accordingly an object of my invention to provide a rectifier tube which is adapted to utilize the energy ordinarily dissipated in a separate circuit resistor to heat the cathode, thereby affording economy in operation.

Another object of my invention is to provide a novel means of protecting the emission surface of cathodes by allowing the plate potential to build up slowly as the filaments are heated.

According to one specific embodiment of my invention, these objects are achieved by constructing a thermionic discharge tube having a switching means and a plurality of at least two filamentary heaters. One filament is connected to the supply voltage source through a manual, thermal or magnetic switch which is opened when the emission surface is brought to operating temperature. Another filament is connected in series with the discharge path of the rectifier tube, and is utilized for the dual function of bleeder resistance and filamentary heater. The second filament will maintain the emitting surface at proper temperature when the first filament is taken out of the circuit. The second filament may, of course, be substituted for any suitable resistance and does not necessarily have to be in series with the rectifier discharge path, as is exemplified in the specific embodiment used for purposes of illustration.

The features of my invention which I consider novel are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages, will best be understood from the following description of a specific embodiment, when read in conjunction with the accompanying drawings wherein like reference characters designate similar parts throughout the several views, and in which:

Figure 1 is a schematic representation of a circuit arrangement embodying my invention.

Figure 2 is a schematic representation of a discharge device constructed in accordance with my invention and its associated circuit as used with manual switching means.

Figure 3 is a schematic diagram of my invention as used with an electromagnetic switching means.

Figure 4 is a plan view of one particular manner of construction of the discharge device used in my invention in conjunction with a thermostatic switching means, and.

Figure 5 is a front elevation view of Figure 4.

Referring more particularly to Figure 1, there is provided an alternating voltage 1, one side of which is connected to the plate 5 of a rectifier tube 4 which has a cathode 6 and a multiplicity of heater filaments, identified in this particular embodiment as the starter filament 3, and the maintaining filament 7. The other side of the supply voltage may be taken as the voltage reference point and it is connected to the maintaining filament 7, through a series combination comprising a resistor 8, and the filaments 13, of such tubes as are used in associated circuits. A common connection is made from the free end of the maintaining filament 7 and the cathode 6 of the rectifier tube, to the capacitor 10, which has its other side connected to the voltage reference point. Across the terminals of capacitor 10 is connected a pair of output terminals 11. An additional capacitor 9 is connected in shunt with the filaments 13 and the resistor 8. One side of the starting filament 3 is connected through a switch 2 to the anode side of the supply potential and the other side is connected through the resistance 8 and series filaments 13 to the other side of the alternating supply voltage.

Operation of the circuit as shown in Figure 1 is initiated by closing the switch 2, which energizes the filaments. When the cathode 6 of the...
rectifier reaches emission temperature, current will flow through the maintaining filament 1. The switch 2 may then be opened to conserve power, for the bleeder current flowing through the maintaining filament 1 is such as to maintain the cathode 6 at emission temperature. The filament itself should for ordinary bleeder circuits obviously be of small current capacity.

Operation of the circuit as shown is preferable for the filaments 16 of the associated tubes will have a chance to warm up before full plate voltage is applied, however, the starter filament 3, if designed to operate at the supply potential may be connected through the switch 2 directly to the supply voltage. A series resistance and a lower voltage starter filament may also be connected directly to the supply if desired, in which case the resistance could be of small wattage due to the short time in which it takes filament 3 to heat. The switch may be either manually, relay or thermally operated to open when the maintaining heater filament 7, which is connected in the discharge path of the rectifier tube, is brought to such a temperature as to maintain the emission surface at operating temperature by means of the bleeder current. Operation of the switches will be described more completely in the ensuing discussion.

Filament 1, which is energized by means of bleeder current that flows as soon as the cathode is brought to emission temperature, serves the double function of bleeder resistance and heater filament. Power is conserved by using the heat normally radiated by a bleeder resistance to keep the cathode at emission temperature. This operating filament may have a multiplicity of sections with external connections, each being used as a distinct portion of the bleeder resistance.

The high potential side of the rectified voltage output is taken from the cathode 6 if the red, and the voltage is filtered by the capacitor 10, which is connected across the voltage output. An additional capacitor 10 is connected across the external bleeder portion 9 and the filament 16 to provide further filtering of audio currents which pass through the filaments. The addition of the auxiliary tube filaments 15, in series with the resistor 5, obviously gives a greater conservation of power than would be possible with the rectifier filament alone.

Figure 3 represents schematically a circuit as used with manual switching means, in which the tube 4 comprises a plate 5, a cathode 6, a starter filament 3, an energizing supply 10, and a multiplicity of operating filaments 7, having distinct external connections. The starter filament is connected to a current source 1, through a switch 2, and an indicating device such as a lamp 17 is connected across a portion of the operating filaments. The energy supply is connected serially with the operating filaments in the discharge path of the tube 4. The tube functions identically as hereinbefore described, however, operation of the switch 2 is as follows:

When the switch is manually operated, it should be closed when the maintaining filaments 1 reach operating temperature due to the bleeder current flow through the rectifier tube. An indicating device is needed to show the proper time for closing the switch 2 since the lamp may be in the form of a lamp 17, as is illustrated in one specific embodiment of my invention.

The lamp 17 will light when the cathode 6 reaches emission temperature causing current to flow through the series filament 7, and causing a voltage drop across the portion of the filament to which the lamp is connected. The indicator lamp may also be used for a dial lamp, and it would additionally function as a meter. The filament 7, if suitably controlled, will give a very satisfactory method of magnetically operating the switch as adapted to my invention. It is obvious to those skilled in the art that other modifications could be made in the manner of switching which would not constitute a departure from the spirit of my invention.

Figure 3 shows a rectifier system employed with my invention in which a magnetically operated switch is used. A rectifier tube 4, having a starter filament 3 and a maintaining filament 1, has its anode 5 connected to one side of an alternating supply voltage 1, and its cathode 6, connected to the other side through a series circuit comprising its maintaining filament 7, a resistor 9, and a relay coil 15. A capacitor 10 or other voltage stabilizing device is connected across the filament and resistor combination, and a pair of output voltage terminals 11 are connected across the capacitor. Connections are made from the starter filament 3 through the switching contacts 2 of the relay to the supply potential 1.

The contacts 2 are closed when the relay coil is de-energized, allowing initial heating of the cathode from the starter filament 3, which is connected directly to the supply potential.

In operation, the cathode 6 will be energized when the cathode 6 reaches emission temperature and allows current to flow through the discharge path of the rectifier tube 4, thus opening its contacts 2 and allowing the maintaining filament 7 to keep the cathode at emission temperature.

An advantage of electromagnetic switching is the comparatively fast operation of the relay in the case of reduced current through the bleeder circuit, which would cause a noticeable period of non-operation in the case of a thermostatic switch due to thermal inertia.

Another advantage of the electromagnet switch is the protection of the cathode emission surface in the case of a drop in cathode temperature. It is well known in the art that if anode potential is applied during a period at which the cathode is heating or cooling, chunks of the cathode surface may be pulled off, reducing its efficiency and causing a premature failure of the tube. The electromagnetic switch would protect the cathode, should the temperature drop for any reason, by quickly energizing the starter filament which will assure a safe operating temperature.

One particular construction of a tube with a thermally operated switch mounted inside the envelope is shown in Figures 4 and 5. The plan view in Figure 4 and the front elevation view in Figure 5 have shown the constructional arrangement within the tube envelope of the anode 5, the mica insulating disks 12, the mounting post 14, the cathode 6, the filament 3 and 7, the switch 2, the bimetallic arm 12 and the welded connection 13.

Internal connections are made for operation as shown in Figure 1, with the bimetallic arm 12 connected directly to one supply voltage at the anode 5 by the welded joint 13 and mounted near to end coaxial with the cathode 6. This arm is mounted in such a manner that it is heated initially and is maintained by the cathode 6 at a temperature high enough to keep its con-
tacts 2 open. One side of the filament 1 is connected directly to the switch contact making with the bimetallic arm, preferably at the top of the tube.

The front elevation view shows the manner of externally connecting tube elements at the base. The multiplicity of maintaining filaments is shown in this embodiment for purposes of illustration as a single filament 1.

In operation, the thermal strip 12 is heated by the cathode 6. It is designed in such a manner that the contacts 2 are opened when the cathode reaches proper emission temperature. The thermal properties are such that if the cathode is decreased below safe emission temperature the contacts will close.

My invention in utilizing the rectifier filament as a circuit resistance provides for economy of power in the utilization of the heat developed in such a resistor to heat the cathode. The use of a rectifier filament in such a manner is made possible by the disclosed tube construction. It is to be understood, however, that in the specific embodiment of my invention herein submitted there may be suggested to those skilled in the art certain modifications which will not necessarily constitute a departure from my invention.

Having thus fully described the nature, construction, and operation of my invention, I wish to secure by Letters Patent and claim:

1. In combination an anode, an indirectly heated cathode, a filament arranged to heat said cathode initially to emission temperature, an auxiliary filament arranged to heat said cathode and a circuit connecting said auxiliary filament serially in the discharge path of said cathode and anode to maintain said temperature.

2. In combination an anode, an indirectly heated cathode, a filament arranged to heat said cathode initially to emission temperature, an auxiliary filament arranged to heat said cathode, a switching device, an energizing circuitserially connecting said switching device and said cathode filament, and a circuit connecting said auxiliary filament serially in the discharge path of said anode and cathode to maintain said temperature.

3. In combination, an electrical discharge tube provided with a thermal switching device opening when said tube reaches operational temperature, an anode, an indirectly heated cathode, and a plurality of filamentary cathode heaters, an electric energizing circuit serially connecting a first of said filament and said switch, and an electrical circuit connecting the remainder of said filaments in series with said cathode to maintain said temperature.

4. A thermionic discharge device comprising, in combination, a thermally operated switch, an anode, an indirectly heated cathode, and a plurality of filamentary heaters for heating said cathode, leads from each of said filaments, connections from one lead on the first of said filaments to one side of said switch, a connection from said anode to the other side of said switch, and connections from the remainder of said filament leads, said cathode, and said plate.

5. A thermionic discharge system comprising a sealed envelope containing an anode, an indirectly heated cathode, a thermally operated switch mounted concentrically with said cathode and having one side connected to said anode, and a plurality of filaments for heating said cathode electrically isolated therefrom, connections to an external electrical energizing circuit from the first of said filaments through said switch, and external connections from the remainder of said filaments and said cathode.

6. A thermionic discharge tube system comprising a sealed envelope containing a cathode, an anode, and a plurality of filamentary heaters for heating said cathode, a switching device having a pair of contacts and an electromagnetic operating coil, an external current source connected to a first of said filament through said switching contacts, and a circuit serially connecting the remainder of said filament and said electromagnetic coil with a second external current source, said anode and said cathode.

7. An electrical system comprising a thermionic tube having a filament, a rectifier having an anode, a cathode and a plurality of filaments, an electromagnetic switching means, an external source of current connected to the first of said rectifier filaments through a pair of contacts on said switching means, an electrical circuit connecting the remainder of said filament and said anode and said cathode of said rectifier tube and a circuit connecting the coil of said electromagnetic switch across a portion of said series filament.

8. An alternating current system comprising a thermionic tube having a filament, a rectifier tube having an anode, a cathode and a plurality of filamentary heaters, an electromagnetic switching means, an external source of current connected to the first of said rectifier filament through a pair of contacts and said filament filament and said anode and said cathode of said rectifier tube and a circuit connecting the coil of said electromagnetic switch across a portion of said series filament.

9. In a rectifier system, a tube having a cathode an anode and a plurality of heater filament, a switching device, a source of potential, an indicating device, a circuit connecting said potential to a first of said heaters through said switch, a circuit connecting the remainder of said filament in series with a second external current source, said anode and said cathode of said tube, an energizing circuit including said series circuit and said anode and a circuit connecting said indicating device in shunt with a portion of said series circuit.

10. An electrical system comprising a thermionic discharge tube having a filament, a thermally operated switch, an auxiliary thermionic discharge tube having an anode, an indirectly heated cathode, a starter filament and a maintaining filament each arranged to heat said cathode, a switching device, a supply potential, an energizing circuit connecting said supply potential in series with said heater filament, said switching device and said starter filament, and a maintaining circuit connecting said supply potential in series with said heater filament, said maintaining filament and said anode and said cathode of said auxiliary tube.

GEORGE D. HANCHETT, JR.

No references cited.
Certificate of Correction


GEORGE D. HANCHETT, JR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 19, claim 7, for the word "tubing" read *having*;

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of June, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.