Aug. 22, 1961 A. M. SKELLETT 2,997,640

COLD CATHODE RECTIFIER

Filed May 12, 1959

Fig. 1.

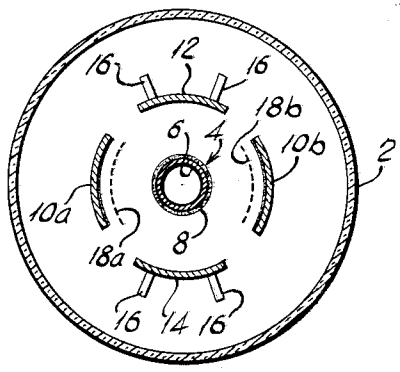
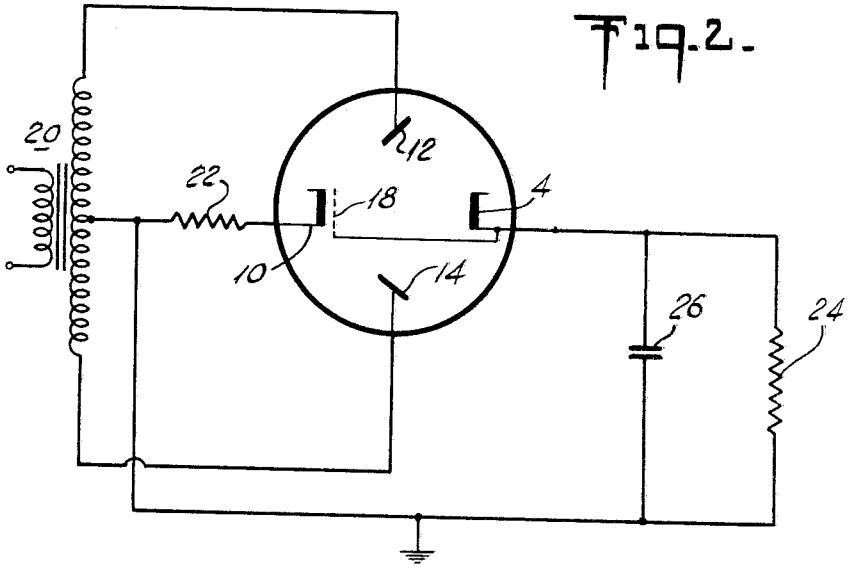


Fig. 2.



INVENTOR
ALBERT M. SKELLETT
BY
Cyrus, Mann & Lucas
ATTORNEYS

United States Patent Office 2,997,640 Patented Aug. 22, 1961

2,997,640

COLD CATHODE RECTIFIER

Albert M. Skellett, Madison, N.J., assignor to Tung-Sol Electric Inc., a corporation of Delaware

Filed May 12, 1959, Ser. No. 812,620
6 Claims. (Cl. 321—32)

The present invention relates to cold cathode vacuum tube devices and comprises a novel device of this character particularly adapted for use as a full wave rectifier. The cold cathodes employed in the vacuum tube devices of the present invention are of the type comprising a metal sleeve of nickel or the like coated with a porous sponge-like layer of magnesium oxide with or without the addition of other materials. Such coatings have the characteristic of copious electron emission once emission is initiated. The emission is self-sustaining, provided another electrode at a higher potential is present to serve as a sustaining grid. Although the advantages inherent in the use of cold cathodes of this type, due to the omission of any cathode heater, have been recognized, the requirement that an electrode of higher potential be present to sustain emission has heretofore prevented use of such type of cathode in a full wave rectifier where, during voltage reversal, the anode-cathode voltage goes through zero. Thus in order to use a cold cathode in a full wave rectifier some means had to be found to insure either that electron emission from the cathode is sustained during voltage reversal or that emission is automatically restarted after voltage reversal.

In the full wave rectifier of the present invention the problem of electron emission from a cold cathode is solved by the expedient of using two such cold cathodes so connected to an external circuit that the potential of one cathode is always higher than that of the other and therefore, during voltage reversal the cathode of higher potential serves as a sustaining grid for the other cathode. Emission from the cathode of higher potential will be automatically restarted because the electrons drawn thereto serve as primary electrons to knock out additional electrons therefrom. Thus in the new rectifier one cathode is the main cathode for connection to the output circuit and the other cathode is an auxiliary cathode which serves to insure that there will be electron emission from the main cathode when the potential of either of the two anodes is positive with respect to that of the main cathode.

For a better understanding of the invention and of a particular embodiment thereof reference may be had to the accompanying drawing of which:

FIG. 1 is a diagrammatic transverse sectional view through a cold cathode rectifier tube embodying the invention; and

FIG. 2 is a diagram of the rectifier circuit of the invention showing the tube of FIG. 1 schematically connected therein.

The structure of the new rectifier tube is shown diagrammatically in FIG. 1 as comprising an outer envelope 2 of glass or the like and having mounted therein a generally centrally disposed cold cathode 4 of circular cross section and comprising a sleeve 6 of nickel on which is a porous coating 8 of magnesium oxide. The particular coating 8 may be that described in Dobischek et al. Patent 2,802,127 which coating is of minute stalactite formation. Greater emission may be obtained when the coating comprises a mixture of magnesium oxide and magnesium carbonate and is sprayed onto the sleeve during rotation of the sleeve. Such coating, which is described and claimed in the pending application of Bernard G. Firth, Serial No. 795,514, filed February 25, 1959, gives a fine porous and sponge-like structure rather than the stalactite type of structure resulting from the

method of application of the magnesium oxide described in the Dobischek et al. patent.

In addition to the cathode 4 a second or auxiliary cold cathode of similar construction is provided within the envelope. For purposes of symmetry the second cathode is made of two arcuate parts 10*a* and 10*b* which are connected together to serve as a single electrode. In the case of the cathode parts 10*a* and 10*b* the coating is confined to the surface facing the main cathode 4. Two arcuate anodes 12 and 14 are also mounted within the envelope 2 and equally spaced from the cathode 4. Preferably cooling vanes 16 are provided on the anodes 12 and 14. Preferably also in front of the coated surface of each cathode part 10*a* and 10*b* there is a grid element 18*a* and 18*b* which grid elements are tied to the cathode 4 so as to be at the potential thereof. Any suitable means for initiating electron emission from the cathodes 4, 10*a*, and 10*b* are provided. Such means have not been shown in the drawing as they form no part of the present invention. Starting can be effected by the provision within the envelope of a pointed electrode maintained at a high negative potential, the electrode emitting electrons by field emission which strike the cold cathodes and cause secondary emission therefrom. Such starting means are disclosed and claimed in the pending application of the present applicant and Bernard G. Firth, Serial No. 697,928 filed November 21, 1957, now Patent No. 2,942,146 dated June 21, 1960. Other known methods for starting emission comprise bombardment of the coating with electrons given off by an incandescent filament within the envelope, illumination of the cathode coating by ultraviolet light and excitation by high frequency energy from a Tesla coil.

In the circuit of FIG. 2 the elements of the rectifier have been shown conventionally, the cathode parts 10*a* and 10*b* being shown as a single cathode 10, the grid elements 18*a* and 18*b* being shown as a single grid 18 and the anodes 12 and 14 being shown as planar. The circuit of FIG. 2 includes an input transformer 20 having a secondary winding connected across the anodes 12 and 14 and a mid-point connected to ground and through a resistor 22 to cathode 10. An output circuit, symbolized by the resistor 24 is connected across the cathode 4 and ground. A capacitor 26 is connected in parallel with the load 24.

With the above described circuit, once electron emission has been started from the cathodes 4 and 10 and alternating voltages have been applied across the anodes 12 and 14 the current drawn by cathode 4 during one-half cycle of the voltage wave will charge capacitor 26 positively with respect to ground and this potential will be higher than that impressed upon auxiliary cathode 10. Accordingly during reversal of the voltage, that is at the moment that neither anode 12 nor anode 14 is positive with respect to cathode 4, electrons will be drawn from cathode 10 to the cathode 4. Thus the cathode 4 serves to sustain emission from cathode 10 and cathode 10 serves to supply primary electrons to cathode 4 to insure that there will be a supply of electrons from such cathode at such time as one or the other of the anodes 12 and 14 is sufficiently positive to attract the secondary electrons emitted from cathode 4. Emission from cathode 10 is stabilized when, as shown, grid 18, at the potential of cathode 4, is positioned adjacent the emitting surface of cathode 10. Most of the electrons emitted by cathode 10 will pass through the mesh of grid 18 and bombard the coating 8 of cathode 4, only a negligible current being drawn by the grid. Resistor 22 is of such magnitude as to minimize the current drawn by cathode 10 during rectification. The capacitor 26 serves not only to insure that the potential of cathode 4 will be maintained above that

of cathode **10** but also as a filter to smooth the ripple in the direct current voltage appearing across the load.

The invention has now been described in connection with a single embodiment thereof. Obviously various changes in the described physical construction of the new rectifier could be made without departing from the spirit of the invention or the scope of the accompanying claims. For example, the device will operate as described without the grid elements **18***a* and **18***b* but as more stable operation is obtained when these elements are present they are preferably included. The symmetrical arrangement of anodes and auxiliary cathode elements about a main cathode of circular cross section is preferred but other configurations of the electrode assembly or of the individual electrodes could be employed. Although the capacitor **26** and resistor **22** have been shown as fixed, obviously these elements could be adjustable if desired.

The following is claimed:

1. A full wave rectifier comprising an evacuated envelope, two cathodes in said envelope each comprising a metal base having a porous coating thereon of a material adapted to emit a copious stream of electrons once electron emission has been initiated and provided an electrode of higher potential is present to sustain emission, a pair of anodes in said envelope, a source of alternating voltage connected across said anodes, and circuit elements connecting said cathodes to said source for maintaining said cathodes at different potentials during periods when the potential of neither anode is positive with respect to the cathodes whereby the cathode of higher potential sustains emission from the other cathode, which emission initiates emission from the cathode of higher potential when an anode becomes positive with respect to such cathode.

2. The cold cathode vacuum tube according to claim 1 including a grid in said envelope positioned between said cathodes and connected to be at the potential of that one of said cathodes that is operative to sustain emission from the other, said grid stabilizing electron emission from said other cathode during periods of anode-cathode zero voltage.

3. A full rectifier comprising an evacuated envelope having two cathodes therein each comprising a metal base having a porous coating thereon of a material adapted to emit a copious stream of electrons once electron emission has been initiated and provided an electrode of higher potential is present to sustain emission, and a pair of anodes in said envelope of a source of alternating voltage connected across said anodes and having a mid-point connected through a resistor to one of said cathodes and through a capacitor to the other of said cathodes and an output circuit connected across said capacitor, said capacitor serving during rectification to maintain said last mentioned cathode at a potential above that of the other cathode, whereby during periods of voltage reversal electrons from the cathode of lower potential bombard that of higher potential causing electron emission therefrom.

4. The full wave rectifier according to claim 1 wherein one of said cathodes is a main cathode and is centrally disposed in said envelope and the other of said cathodes is an auxiliary cathode formed of two parts disposed on opposite sides of, and spaced from, said main cathode, and wherein said anodes are disposed on opposite sides of, and spaced from, said main cathode.

5. The cold cathode vacuum tube according to claim 4 including a grid element disposed adjacent each auxiliary cathode part between such part and the main cathode, said grid elements being connected to said main cathode to be at the potential thereof.

6. A full wave rectifier comprising an evacuated envelope, main and auxiliary cathodes in said envelope each comprising a metal base having a porous sponge-like coating thereon containing magnesium oxide, a pair of anodes in said envelope, an input transformer having a secondary winding connected across said anodes, an output circuit connected across the mid-point of said secondary winding and said main cathode, a capacitor connected across said output circuit and a resistor connected between the mid-point of said secondary and the other of said cathodes.

References Cited in the file of this patent

UNITED STATES PATENTS

2,842,706 Dobischek et al. ---------- July 8, 1958