Oct. 10, 1933. E. G. GAGE 1,930,165

HIGH CURRENT FILTER

Original Filed April 2, 1923 2 Sheets-Sheet 1

Fig. 1

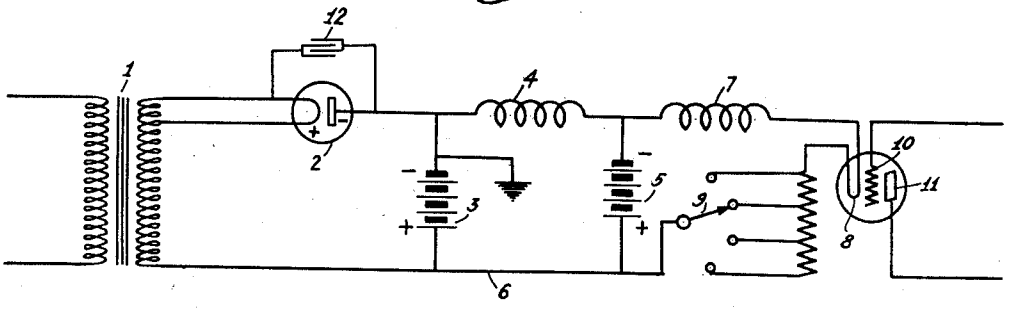



Fig. 2

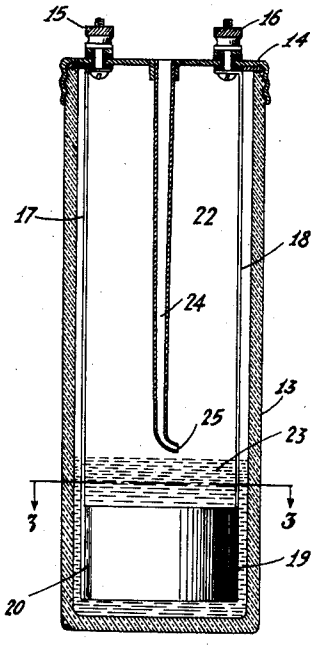
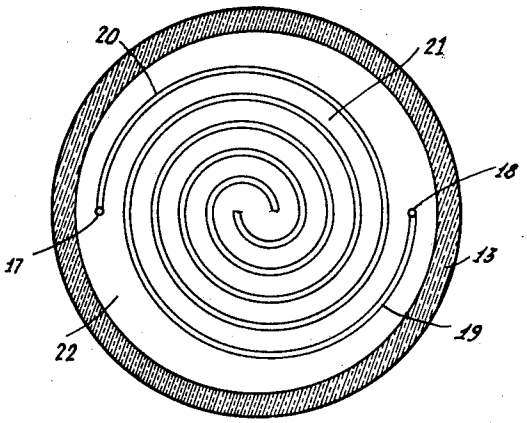



Fig. 3




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Fig. 5

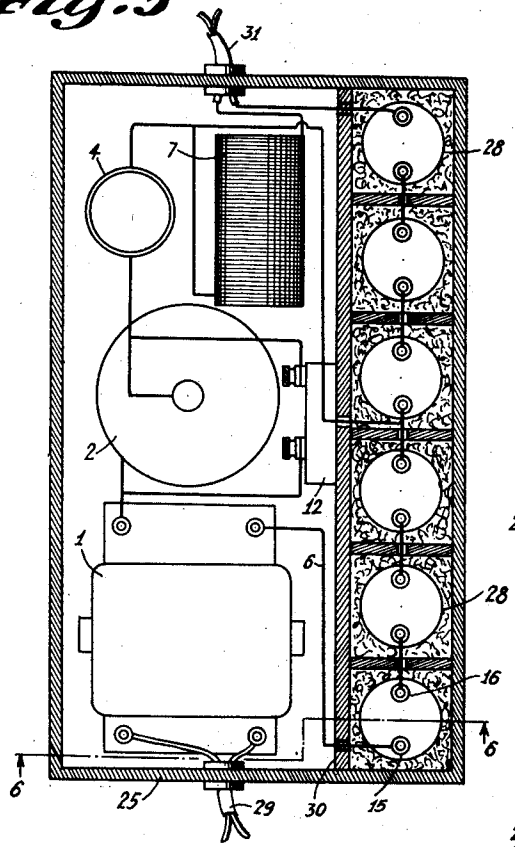



Fig. 6

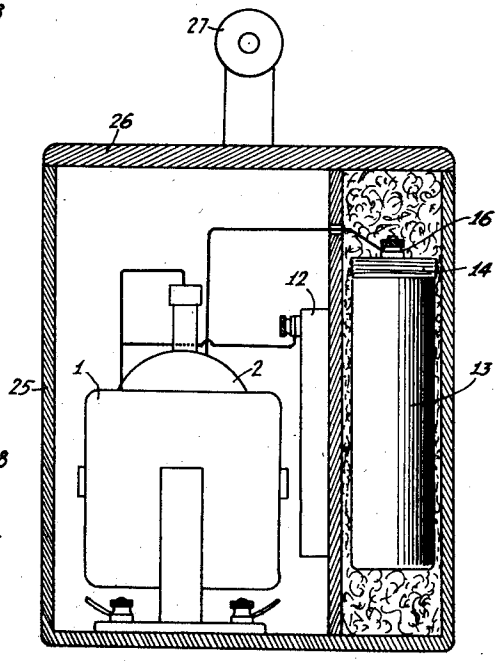
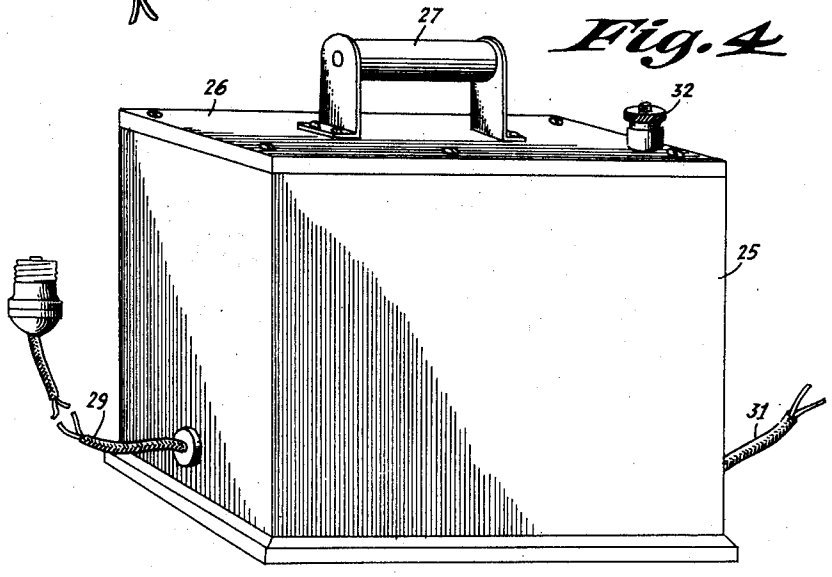



Fig. 4




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Patented Oct. 10, 1933 1,930,165

# UNITED STATES PATENT OFFICE

1,930,165

## HIGH CURRENT FILTER

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Original application April 2, 1923, Serial No. 629,292. Divided and this application May 21, 1931. Serial No. 538,899

12 Claims. (Cl. 175—363)

This application is a division of my copending application Serial No. 629,292, filed April 2, 1923, entitled "High current filter".

This invention relates to means for providing a direct current, free from variations, such current being derived from a source of variable voltage. It relates to that type of apparatus known as current filters, such apparatus being adapted to suppress or filter out variations of the current so that substantially pure direct current may be delivered to desired apparatus.

In the electron tubes of the audion type which are employed in radio apparatus, the heated element must be energized by a current substantially free from variations otherwise it will be unfitted for the desired purpose, and the more perfectly free the current is from variations the more satisfactory is the operation of the tube.

The expense of maintaining batteries to supply current for the heated element of the electron tube as well as the necessity for frequently renewing or recharging batteries renders them very objectionable so that it is of great advantage to be able to supply this current from the usual electro-dynamic sources, and it is desirable in many instances that such electro-dynamic sources be of alternating current for the reasons that such current may be the only current available in certain locations, and also it lends itself readily to simple voltage transformation.

Means, somewhat similar to that here proposed, has heretofore been employed for rectifying and filtering alternating current for the purpose of supplying substantially invariable current, but such apparatus has involved the use of condensers and so has been limited to the supplying of extremely small currents, the size of condensers necessary to supply large currents being absolutely prohibitive both as to expense and cumbersomeness.

The main object of the present invention is to provide an apparatus of the character referred to but which shall be capable of supplying relatively large currents and avoid the objections as indicated, the present invention providing for the use of electro-chemically operating current storing means, the electrical energy supplied on charging being transformed by reason of chemical action into a chemical form of energy, which energy is delivered on discharge as electrical energy produced by chemical changes, such as storage batteries, in conjunction with impedances.

A further object of the invention is to provide such an arrangement deriving its energy from an alternating current source through a rectifier as will be hereinafter more particularly referred to.

A further object of the invention is to provide apparatus embodying features as referred to above which shall be in compact form so as to be readily handled as a unit and transported if desired.

A further object of the invention is to provide an improved form of storage battery.

A further object of the invention is to eliminate objectionable variations of current due to a rectifier.

Other and ancillary objects of the invention will appear hereinafter.

In the accompanying drawings which illustrate the invention:—

Fig. 1 is a diagram showing the electrical connections of the apparatus;

Fig. 2 is a vertical axial section of a cell of storage battery;

Fig. 3 is a section on an enlarged scale on the line 3—3 of Fig. 2;

Fig. 4 is an exterior perspective view of a unit of apparatus;

Fig. 5 is a top plan view of the apparatus of Fig. 4 with the cover removed; and

Fig. 6 is a section on the line 6—6 of Fig. 5.

Referring to the drawings the apparatus comprises a step-down transformer 1 having its primary connected to a suitable source of alternating current and so wound and constructed that the secondary voltage (in this case 50 volts) will be suitable for the purposes desired. One terminal of the transformer is connected through a suitable rectifier 2 which may be of the gas or vapor type. That form of gaseous rectifier known commercially as a "Tungar" is suitable, and as is well known, such a device provides an asymetric current path. The other terminal of the transformer secondary is connected with one terminal of the three cell storage battery 3 which may be of the usual Planté or other suitable type, the other terminal of the battery 3 being connected with the other terminal of the rectifier. It will be observed that the polarity of the battery 3 is such that it is opposed to that supplied through the rectifier and consequently charging current will be supplied through the rectifier whenever the voltage exceeds that of the battery. On the other hand, the battery can never discharge back therethrough because it tends to send current in the opposite direction from that which will be permitted to pass by the rectifier.

One terminal of the battery 3 is connected through the impedance coil 4 with one terminal of the three cell battery 5, the other terminals of the batteries 3 and 5 being connected together by a conductor 6. The battery 5 is connected through the impedance coil 7 with one terminal of the filament 8 of an electron tube of the audion type which may act as a detector in wireless receiving sets or any other applications wherein such a tube is of use. The other terminal of the filament 8 is connected through a variable resistance 9 with the other terminal of the battery 5. The electron tube shown is of the audion type having the usual grid 10 and plate 11. The circuit of the filament may be opened by moving the movable contact of the resistance 9 off of the resistance contacts.

The coil 4 has such self-induction as to practically bar the passage of all variable current such as the pulsating direct current through the rectifier, but these pulsations operate to charge the battery 3 and the even direct current supplied from this battery readily passes through the coil 4. It will thus be seen that the circuit including the inductance coil 4 is of high reactance with relation to the circuit through the transformer secondary rectifier and battery 3 which is of low reactance so that as little opposition as possible may be presented to the passage of current from the transformer secondary through the battery.

The electro-motive force delivered to the terminals of the battery 5 is substantially constant, but it is not possible to absolutely bar all variable current by means of the coil 4 although this condition may be approached as nearly as desired by increasing the self-induction of the coil. Any slight variations are again barred by means of a second impedance coil 7 and the battery 5 equalizes these variations by charging and discharging in a similar manner to the battery 3 so that the voltage, as delivered to the filament of the audion tube, is so nearly constant as to involve no perceptible variation. If a still further refinement were desired, other batteries and impedance coils might be added to the system in succession in the same manner as the batteries and impedance coils shown.

In addition to the above property of filtering out the variable current the impedances have the effect of preventing the possibility of burning out the tube filament in case the batteries should become disconnected or inoperative. The impedances therefore serve the double purpose of protecting the tube filament from the line voltage which might be applied to it and also filter out substantially all variable current which might otherwise be applied to the filament.

It is desirable that the battery 3 shall never be exhausted or drained as sufficient current cannot be supplied through the rectifier of appropriate size to compensate for this drain, and a variation or ripple in voltage is caused which causes a humming sound in the tube. To prevent any chance of this draining of the cells an excess of rectified current is supplied to the cells so that their voltage may not substantially vary. This causes gassing and the escape of the hydrogen gas in quantities is prevented as will be hereinafter referred to as will also the structure of the cell.

The impedance of the coil 7 and resistance 9 is so adjusted that an amount of current not greater than a fraction of that supplied to the battery 3 may flow in the filament circuit. The cells 3 are thus never drained as above referred to.

The battery cells may be made very small as it is only necessary that they shall be able to store the energy for a very short time and preferably the resistance of the battery 3 should be less than that of the load circuit.

It has been found that variations in the current occur due to the gaseous rectifier and that these noises are removed by shunting the rectifier by a condenser 12.

Referring now particularly to Figs. 2 and 3 the cell there shown and which is suitable for use in the batteries of the system explained above, comprises a casing 13 of glass or other suitable insulating material which may have a screw cover 14 of hard rubber in which are mounted the terminals or binding posts 15 and 16 to which the exterior wires are secured. These posts are insulated in the cap 14 as shown, and upon the interior of the casing or jar are conductors 17 and 18 leading respectively to the positive and negative plates of the cell. Each of the plates 19 and 20 of the cell comprises sheet lead, the battery being of the Planté type. The sheets of lead are rolled together as shown particularly in Fig. 3 and separated by a suitable insulating material 21 through which the electrolyte may pass such as perforated celluloid, and the usual electrolyte 23 such as a sulphuric acid solution envelopes the plates.

It will be seen that above the plates and their electrolyte is a large space 22 in the container. A leaden vent tube 24 extends from the cover of the container to a point in proximity to the surface of the electrolyte. In order to prevent spilling of the electrolyte in case the cell should be turned up-side-down, the tube 24 should be at least as long as the electrolyte is deep. The space 22 is much greater than that occupied by the plates and electrolyte and the vent hole 25 in the tube is extremely small, about one-sixty-fourth of an inch in diameter. At least one-half of the interior of the container is taken up by the space referred to.

In the operation of this cell a peculiar phenomenon has been observed in that while the cells are overcharged and violent gassing takes place in the cells, there is no discharge of gas or at least no appreciable discharge of gas from the vent. Owing to the smallness of the vent there is an accumulation of pressure within the container due to the evolution of the gases and then there is an apparent condensation within this space, and inasmuch as tests by smell and combustion fail to indicate the escape of the usual hydrogen gas, I have come to the conclusion that in view of the appearance of condensation and failure of hydrogen to be emitted through the vent, the peculiar space and pressure conditions within the cell lead to the re-absorption by the electrolyte of the gases evolved or that any gas emitted through the vent is not the usual hydrogen and is not objectionable. As I view it the vent forms simply a safety device which prevents such undue accumulation of pressure as would burst the container. Whatever may be the true explanation, although the cells are very much overcharged and show every evidence of gas evolution within the container, there is no appreciable emission of disagreeable gases, and there is no bursting of the cell notwithstanding that they have been operated over long periods of time.

The apparatus referred to is arranged in a compact unit which may be carried about and connected with the usual lamp socket on a light-

ing circuit at any points desired, the whole forming a handy portable outfit for energizing a receiving set from the usual lighting or other desired circuit.

Thus, referring to Figs. 4, 5 and 6, the unit comprises a wooden case 25 having a cover 26 to which is secured a handle 27 for carrying it about. Within the case are the storage battery cells 28 which may be constructed as described in connection with Figs. 2 and 3 and which constitute the two batteries 3 and 5, these batteries being suitably enclosed in compartments and packed so as to avoid breakage. Upon the bottom of the casing is mounted a transformer 1 to the primary of which are connected the conductors 29 which may be of the usual lamp cord connected in the usual 110 volt alternating current lighting socket by a suitable and well known plug. Also mounted upon the bottom of the casing is the Tungar rectifier 2, the condenser 12 connected across its terminals being mounted upon the side of the partition 30 for the battery compartments. Also mounted upon the bottom of the casing are the impedance coils 4 and 7, the conductors 31 leading to the rheostat and filament of the audion tube. In order that there may be no disturbing induction between them, the axes of the coils 4 and 7 and the coils of the transformer are at right angles to each other.

In order to protect the outfit a fuse plug 32 mounted in the cover of the casing may be connected in the primary circuit of the transformer.

It will now be seen that the device as shown in Figs. 4, 5 and 6 is compact and readily portable and that in order to energize the filament of an electron tube, it is only necessary to insert the plug on the conductors 29 in the ordinary alternating current lighting lamp socket and connect the conductors 31 in any suitable way with the filament of the tube.

While the invention has been illustrated in what is considered its best applications it may have other embodiments without departing from its spirit and is not therefore limited to the structures shown in the drawings.

I claim:

1. A current rectifying and filtering system comprising a source of alternating current, a rectifying tube having an anode and a cathode, transformer coupling means between said source and the rectifier tube and forming energizing circuits for the cathode of the tube and the anode-cathode circuit thereof whereby the alternating current energy is changed into fluctuating direct current energy and appears as such in the anode-cathode circuit of the rectifier tube, a capacity shunted across the rectifying tube, a positive lead and a negative lead associated with the rectifier tube output and adapted to allow a flow of rectified current therein, a reactor connected in series in said negative lead and two electrolytic storage devices connected across said leads in parallel and connected to the negative lead at opposite sides of said reactor.

2. A current rectifying system comprising line conductors for commercial alternating current, a transformer having its primary connected to said line conductors, a rectifying tube of the heated cathode type having its anode-cathode circuit connected so as to be in series with the secondary of said transformer, a negative lead for rectified current connected to the rectifier anode, a step-down transformer arrangement providing a cathode heating circuit, a condenser shunted directly across said rectifier, a positive lead for rectified current connected to the cathode of the rectifier tube, a reactor connected in series in the negative lead and two electrolytic storage devices connected in parallel across said leads and being connected respectively at opposite sides of the reactor in the negative lead.

3. A current rectifying system comprising a source of alternating current, a rectifying device connected to said source, a condenser shunted across said rectifying device, a lead for direct rectified current connected to said device, a return lead for the direct rectified current, a reactor connected in series in the negative lead and two electrolytic storage devices connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

4. A current rectifying system comprising a source of alternating current, a rectifying device connected to said source, a capacity shunted across said rectifying device, a positive lead for direct rectified current connected to said device, a negative return lead for the direct rectified current, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

5. A current rectifying system comprising line conductors for commercial alternating current, a transformer having its primary winding connected to the line conductors, a rectifying device connected to the secondary of said transformer, a condenser shunted across said rectifying device, a positive lead for direct rectified current connected to said device, a negative lead for direct rectified current connected to said secondary, a reactor connected in series in the negative lead, and two electrolytic storage devices connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

6. A system for modifying electric currents comprising a source of pulsating direct current, a condenser shunted directly across said source, positive and negative leads connected from said source, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

7. A current rectifying and filtering system comprising a source of alternating current, a rectifying tube having an anode and a cathode, transformer coupling means between the source and the rectifier tube and forming an energizing circuit for the cathode and for the anode-cathode circuit of the tube whereby the alternating current energy is changed into fluctuating direct current energy, a positive lead and a negative lead associated with the anode-cathode circuit of the rectifier tube and adapted to allow a flow of rectified current therethrough, a reactor connected in series in said negative lead, and two electrolytic storage devices connected across said leads in parallel and connected to the negative lead at opposite sides of the reactor.

8. A current rectifying system comprising line conductors for commercial alternating current, a transformer having its primary connected to said line conductors, a rectifying tube of the heated cathode type having its anode-cathode circuit connected in series with the secondary of the transformer, a negative lead for rectified current connected to the rectifier anode, a step-down

transformer arrangement providing a cathode heating circuit, a positive lead for rectified current connected to the filament circuit, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being connected respectively at opposite sides of the reactor in the negative lead.

9. A current rectifying system comprising a source of alternating current, a rectifying device connected to said source, a lead for direct rectified current connected to said device, a return lead for the direct rectified current, a reactor connected in series in the negative lead, and two electrolytic storage devices connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

10. A current rectifying system comprising a source of alternating current, a rectifying device connected to said source, a positive lead for direct rectified current connected to said device, a negative return lead for the direct rectified current, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

11. A current rectifying system comprising line conductors for commercial alternating current, a transformer having its primary winding connected to the line conductors, a rectifying device connected to the secondary of said transformer, a positive lead for direct rectified current connected to said device, a negative lead for direct rectified current connected to said secondary, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

12. A system for modifying electric currents comprising a source of direct current having positive and negative leads, a reactor connected in series in the negative lead, and two electrolytic condensers connected in parallel across said leads and being respectively connected to the negative lead at opposite sides of the reactor.

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