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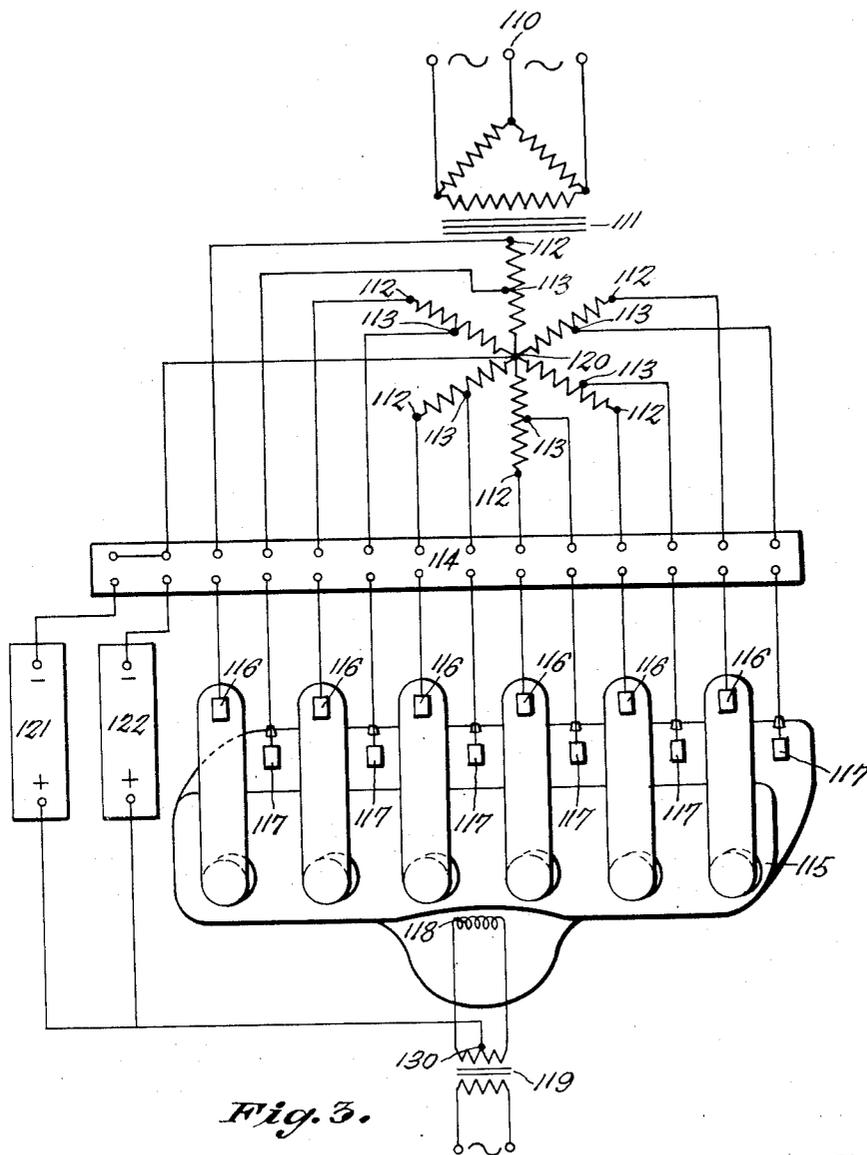


Fig. 3.

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## RECTIFIER TUBE AND CIRCUIT ARRANGEMENT THEREFOR

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My present invention relates to a novel type of rectifier tube and to circuit arrangements therefor.

In various applications it is of great advantage to be able to use a single rectifying tube with a single transformer to provide alternating current of different voltages, without being required to insert resistances or make use of regulating devices to obtain these different voltages from the tube.

My invention is particularly useful for obtaining rectified currents of considerable values, from one ampere up to several hundred amperes, and for voltages of from several hundred volts to several thousand volts, and particularly for rectifying polyphase alternating currents, and I shall describe it in connection with the rectification of such polyphase currents.

The rectifier tubes according to my invention are of the gas-filled, thermionic cathode type, whereby the term "gas-filled" includes fillings of one or more gases or vapors, or a mixture of gases and vapors.

Preferably the tubes of my invention include a vapor in their filling.

In accordance with my invention, as applied to polyphase rectification, I provide in the tube a plurality of sets of anodes, all of which cooperate with a common cathode. The character of the tube is preferably such that one set of anodes supplies with the cathode a rectified current of comparatively low voltage (of the order of a few hundred volts), whereas the other set of anodes supplies with the cathode a rectified current of high voltage (of the order of several thousand volts); proper switching arrangements being provided to selectively operate the cathode with either set of anodes, whereby the tube operates in either case with a high efficiency.

More particularly, I provide a thermionic cathode in a chamber which, in the case of vapor, preferably also serves as a condensation chamber, and in which the pressure is then comparatively high. Within this chamber and in comparatively close proximity to the cathode I place one set of anodes, which, with the cathode, supply the low-voltage, rectified current. The small electrode distance and high pressure thereby insures a high efficiency, and as the voltage is comparatively low there is no danger of back discharge.

The other set of anodes, which supply with the cathode the high-voltage rectified current, I place preferably in separate chambers, and as a rule in arm extensions of the cathode chamber; the

vapor pressure around these anodes being comparatively low. This, together with the long discharge path, protects against back discharge, whereas the comparatively greater internal voltage drop does not markedly reduce the efficiency of the tube because of the higher total value of the output voltage.

If the voltage between the low-voltage anodes and the cathode is sufficiently high as to endanger back discharge, I preferably provide screens around this set of anodes, so as to increase the back discharge. Similarly, if the high voltage is excessively high, screens can also be provided around the high-voltage anodes.

Such tubes, made in accordance with the invention, are operated in specific circuit arrangements, which, as well as details of the tubes of the invention, will be more fully described in connection with the drawings.

I am well aware that it has been proposed to provide in a single tube a plurality of anodes or set of anodes, which are selectively operated. Such prior arrangements have, however, either used anodes which were of the same character and symmetrically arranged with respect to the cathode, or again, comprised two rectifier tubes built into one and operating simultaneously without regard to efficiency of the tubes. Such rectifiers furthermore, only served for very low and medium voltages.

My invention, as stated, makes it possible to rectify in such manner medium and high voltages at large currents, whereby the voltages obtained may differ greatly or only to a small extent from each other; whereas the efficiency remains invariably high.

In order that the invention may be more clearly understood and readily carried into effect, I shall describe same more fully with reference to the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of a circuit arrangement according to the invention;

Fig. 2 is a partly sectionized side view of a rectifier tube made in accordance with the invention, and suitable for use in the circuit arrangement of Figure 1;

Fig. 2a is a partly sectionized view of a portion of the tube shown in Fig. 2;

Fig. 3 is a schematic wiring diagram of a polyphase rectifying device according to the invention.

Referring to Figure 1, the circuit arrangement shown therein is designed for alternately charging two storage batteries 4 and 5 requiring different charging voltages by means of rectified

current. The alternating current is obtained by means of a transformer 2, is rectified by means of a rectifier tube 1, the charging circuits being selectively established by means of a switching device 3 and the currents regulated by rheostats 36 and 37. These devices and the circuits will be more fully described hereafter.

The gas-filled polyphase rectifier tube 1—a suitable type of which is shown in greater detail in Figure 2—has a hermetically-sealed envelope comprising a main chamber 90 and two extending arms 91—91 connected thereto. Within the main chamber 90 and in the upper portion thereof are two anodes 6 and 7, whereas in its lower portion is an incandescible cathode 8; the arms 91—91 contain anodes 9 and 10 respectively.

The transformer 2 has its primary winding 11 connected to a suitable alternating current source 12, and is provided with two secondary windings 13 and 99. The winding 13 has a center tap 14 directly connected through a conductor 38 to the negative sides of the storage batteries 4 and 5. In addition winding 13 has two end taps 15 and 16, and two intermediate taps 17 and 18. Winding 99 supplies the heating current for the incandescible cathode 8 and is provided with a center tap 19, and with two end taps 20 and 21, the latter taps being connected through conductors 22 and 23 respectively to the two ends of the incandescible cathode 8.

The switching device 3 consists of two three-pole, single-throw switches A and B, which are interlocked with an interlocking device 24 in such a manner that only one of the switches A and B can be closed at one time. The switches A and B serve to establish the necessary connections for charging batteries 4 and 5 respectively. The switch A has three arms 25, 26, and 27 having fixed heels 28, 29, and 30, and are rotatable to cooperate in the closed positions of the switches with contacts 31, 32, and 33 respectively.

The heel 28 is permanently connected through lead 34 and rheostat 36 to the positive side of battery 4, whereas the heels 29 and 30 are permanently connected through leads 34 and 35 to the anodes 9 and 10 respectively. Contact 31 is connected through lead 39 to the central tap 19, whereas contacts 32 and 33 are connected through leads 40 and 41 to the end taps 15 and 16 respectively of winding 13.

The switch A thus controls the charging of battery 4 by means of rectified current obtained by the full-wave rectifier formed by anodes 9 and 10 with the cathode 8, the circuit for one phase half-wave being as follows: From end tap 15 through lead 40, switch arm 26, lead 34, anode 9, cathode 8, one of the leads 22 and 23, center tap 19, lead 39, switch arm 25, lead 34, rheostat 36 to positive side of battery 4; the negative side of the battery being permanently connected through lead 38 to the center tap 14 of winding 13. During the other phase, the charging of the battery 4 takes place through the circuit starting from end tap 16 through conductor 41, arm 27, lead 35, anode 10, incandescible cathode 8, and back to the central tap 11 in the same manner as has been described for the first phase.

The switch B, which is used for charging the battery 5, is provided with three contact arms 42, 43, and 44, having heels 45, 46, and 47, respectively, and are movable to engage contacts 48, 49, and 50 respectively. The heel 45 is connected through conductor 51 and rheostat 37 to the positive pole of battery 5, whereas heels 46 and 47 are connected through leads 52 and 53 to

the anodes 6 and 7 respectively. Contact 48 is connected at 54 to lead 39 and thus to center tap 19 of winding 99; whereas contacts 49 and 50 are connected through the leads 55 and 56 to the intermediate taps 17 and 18 respectively.

Thus when the switch B is in the closed position the battery 5 is charged during one phase through the following circuit: From intermediate tap 17 through lead 55, switch arm 43, lead 52, anode 6, cathode 8, one of the leads 22 and 23, center tap 19, lead 39, switch arm 42, lead 51, rheostat 37 to the positive pole of battery 5; the negative pole of battery being permanently connected to the center tap 14 of winding 13. For the other phase the circuit is from intermediate tap 18, lead 56, switch arm 44, lead 53, anode 7, cathode 8, and to the positive pole of battery 5 in a manner similar to the first phase. Thus it will be noted that for the charging of the high-voltage battery 4, a high alternating voltage is applied between the cathode and the high-voltage anodes 9 and 10; whereas for the charging of the lower-voltage battery 5 a smaller alternating voltage is applied between the cathode and the low-voltage anodes 6 and 7. These alternative voltages are for example a thousand volts for the high-voltage anodes and 380 volts for the low voltage anodes. The current may be for example 15 amps. and 3 amps. respectively.

Of course other voltages and currents may be used, lying generally above 500 volts for the high-voltage anodes, for which the blocking voltage may go up to several thousand volts. The voltage applied at the low voltage anodes generally lies under 400 volts and the currents rectified may reach a value of 100 amps. and more.

The rectified tube as shown in greater detail in Figure 2 consists of a vitreous envelope forming a main chamber 60 and having two extending arms 61 and 62 hermetically connected to the main chamber by means of metal rings 63 and 64 respectively. The rings 63 and 64 may be of chromium iron alloy and connected by leads 100—101 to suitable potentials for the purpose of controlling the discharge current or for improving the ignition conditions of the discharge.

The tube is provided with a gaseous filling and if the filling is a vapor, or contains a vapor, the material of the vapor in its non-vaporized form, for example a drop of mercury 102, is provided in the envelope.

Supported from the bottom of the main chamber by means of supply leads 65 and 66 is the incandescible cathode 8', which may be an oxide cathode. The supply leads 65 and 66 are connected to supply conductors 69 and 70 respectively through metal discs 67 and 68 sealed in the bottom of the vitreous envelope.

Supported from the top of the envelope by means of rods 71 are the two anodes 6' and 7'. The rods 71 are electrically connected to suitable terminals through metal discs 75 hermetically sealed in the envelope. Suitable discs for this purpose have been described in U. S. Patent 1,734,809.

Located at the end of the arms 61 and 62 and supported in a manner similar to that of anodes 6' and 7' are the high-voltage anodes 9' and 10' respectively.

If required one or both pairs of anodes may be provided with enclosing screens to increase the blocking voltage. Such screens 83 are shown for the anodes 6' and 7', their construction being fully described in the copending U. S. application Ser. No. 738,758, filed August 6, 1934.

For example if the anodes 6' and 7' are used for voltages up to 100 volts the screens can be omitted, whereas if they are used for voltages of more than 100 volts, screens are preferably provided. Similarly, for voltages of 500 volts anodes 9' and 10' require no screens, whereas for voltages of 1000 volts and more screens are preferably provided.

If desired, there may be also provided in the main chamber 60 and in the vicinity of the cathode 8' (see Fig. 2a), an auxiliary electrode 84, by means of which an auxiliary discharge may be created, the current for this discharge being supplied from a source of direct current (not shown). This discharge set up between the auxiliary electrode 84 and the cathode 8' due to its ionization effect, carries off the electric charges accumulating at the mouth of the arms 61 and 62, and which charges, unless so rendered ineffective, may seriously affect ignition between the cathode and anodes 9' and 10'.

Thus the arrangement according to the invention permits one to obtain rectified currents having widely varying current and voltage values from a polyphase alternating current source by means of a single rectifier tube; the efficiency of the low-voltage rectification thereby being much higher than if the high voltage anodes were used also for the lower voltage.

Furthermore, the low-voltage anodes may be placed within the condensation chamber without requiring any increase in the size of this chamber or of the tube.

Although the embodiment described shows a two phase rectifier, three or six-phase rectification can be achieved in a similar manner. Also more than two sets of anodes may be provided in order to obtain more than two different voltages.

The device illustrated in Figure 3 comprises a transformer 111 which transforms three-phase current supplied by a source 110 into six-phase current. For this purpose transformer 111 is provided with six star-connected secondary windings connected at a star point 120 and each having a terminal 112 and a tap 113. Terminals 112 supply the full secondary voltages of the transformer and taps 113 supply a fraction of these voltages. Terminals 112, taps 113, and the point 120 are connected to a change-over switch 114 indicated by a rectangle.

The device also comprises a six-phase rectifying tube 115 having six high-voltage anodes 116 located in extending arms, and six medium-voltage anodes 117 disposed within the main part of the tube envelope; all the anodes being connected to switch 114.

Tube 115 also has an incandescible cathode 118 disposed near the bottom of the tube and connected to the secondary winding of a heating transformer 119 having a primary winding connected to a suitable source of voltage. Connected with their negative terminals to switch 114 and with their positive terminals to a mid-point 130 on the secondary winding of transformer 119 are two loads 121 and 122.

In a manner similar to Fig. 1, switch 114 has two positions. In one position anodes 116 are connected to terminals 112 and the high-voltage load 121 is in circuit, while taps 113 and load 122 are not in circuit. In the other position, anodes 117 are connected to taps 113 and the medium-voltage load 122 is in circuit, while terminal 112 and load 121 are not connected.

Although I have described my invention in

connection with specific examples and constructions, I do not desire to be limited thereto because obvious modifications will occur to one skilled in the art.

What I claim is:

1. A multi-voltage rectifying tube comprising an envelope having a condensation chamber and extending arms, a gaseous filling and a thermionic cathode within said envelope, a set of high-voltage main anodes disposed within said arms, and a set of medium-voltage anodes disposed within said condensation chamber above the entrance of said arms and nearer the cathode than are the high-voltage anodes, said medium-voltage anodes having at least the current carrying capacity of said high-voltage anodes.

2. In combination, a rectifier tube comprising an envelope having a condensation vessel and extending arms, a gaseous filling and a cathode within said envelope, a set of medium-voltage main anodes disposed in said condensation chamber and above the entrance of said arms, and a set of high-voltage main anodes disposed in said arms and at a comparatively great distance from the cathode, said anodes being adapted to selectively cooperate with said cathode to selectively rectify alternating voltages of greatly differing voltages, and means to selectively apply a medium alternating voltage to said first set of anodes and a high alternating voltage to said second set of anodes.

3. A multi-voltage rectifying tube comprising an envelope having a condensation chamber and extending arms, a thermionic cathode and a gaseous filling comprising a vapor within said envelope, a set of medium-voltage main anodes disposed within said condensation chamber above the entrance of said arms and adapted to provide rectified current at a voltage of several hundred volts, and a set of high-voltage main anodes disposed within said arms at a greater distance from said cathode than are the medium-voltage anodes and adapted to provide rectified current at voltages of several thousand volts, said medium-voltage anodes having at least the current carrying capacity of said high-voltage anodes.

4. A multi-voltage rectifying tube comprising an envelope having a condensation chamber and extending arms, a thermionic cathode and a gaseous filling comprising a vapor disposed within said envelope, a set of high-voltage main anodes disposed within said arms, a set of medium-voltage main anodes disposed within said condensation chamber above the entrance of said arms and nearer the cathode than are the high-voltage anodes, said medium-voltage anodes having at least the current carrying capacity of said high-voltage anodes, and means to increase the blocking voltage of at least one of said sets of anodes.

5. A multi-voltage rectifying tube comprising an envelope having a condensation chamber and an extending arm, a gaseous filling comprising a vapor, the vapor pressure in said arm during operation being considerably less than in said condensation chamber, a thermionic cathode within said chamber, a medium-voltage anode within said chamber above the entrance of said arm and adapted to cooperate with said cathode to provide rectified current of more than one ampere at several hundred volts, and a high-voltage main anode within said arm and at a greater distance from said cathode than is said medium-voltage anode, said high-voltage anode being adapted to cooperate with said cathode to

provide a rectified current of at least one ampere at a voltage from several hundred to several thousand volts.

6. In combination, a rectifier tube comprising an envelope having a condensation chamber and extending arms, a gaseous filling and a cathode within said envelope, a set of medium-voltage anodes disposed in said condensation chamber, and a set of high-voltage main anodes disposed in said arms and at a comparatively large distance from said cathode, said anodes being adapted to selectively cooperate to transform polyphase alternating current of greatly differing voltages into rectified current, a transformer having a primary winding and a polyphase secondary winding having a high-voltage taps and low-voltage taps, a high-voltage load circuit for the high-voltage anodes, a medium-voltage load circuit for the medium-voltage anodes, and switching means to selectively connect the medium-voltage anodes to said low-voltage taps, and the high-voltage anodes to the high-voltage taps.

7. In combination, a rectifier tube comprising an envelope having a condensation chamber and

extending arms, a gas filling and a cathode therein, said filling comprising a vapor, and at least two sets of anodes in said envelope, said anodes being adapted to selectively cooperate with said cathode to transform polyphase alternating current into rectified current, the anodes of one of said sets being disposed in said condensation chamber and the anodes of the second set being disposed in said arms and at a comparatively large distance from said cathode, a transformer having a single-phase primary winding and a split single phase secondary winding, said secondary winding having high-voltage taps and low voltage taps, a high-voltage load circuit for the anodes disposed within the arms, a low-voltage load circuit for the anodes disposed within the condensation chamber, and a switching member adapted to alternately connect said low-voltage taps with the anodes provided in the condensation chamber, and said high-voltage taps with the anodes disposed in the arms.

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