C. P. STEINMETZ.

ALTERNATING CURRENT RECTIFIER.

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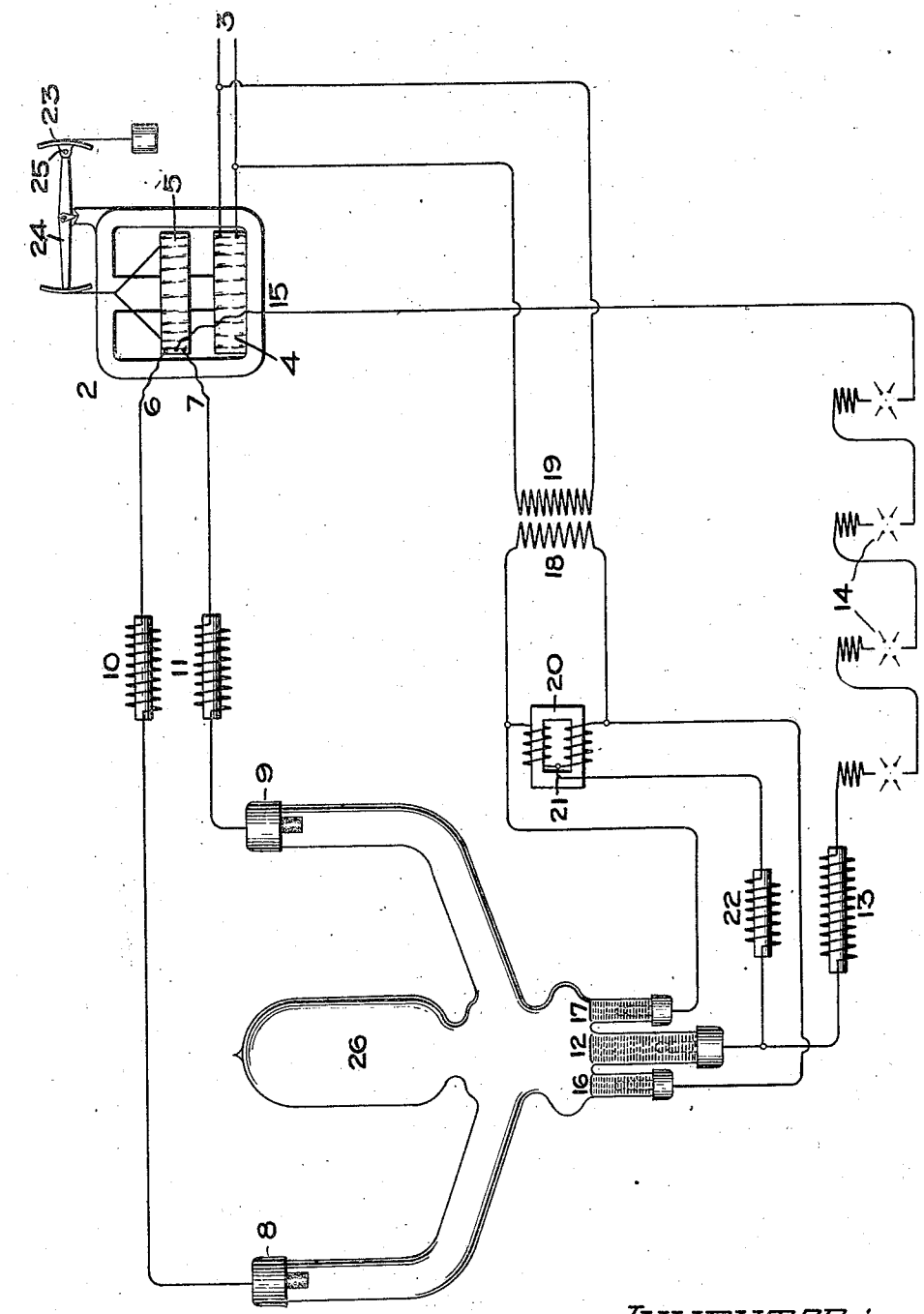
1,037,558.

Patented Sept. 3, 1912.



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ALTERNATING-CURRENT RECTIFIER.

1,037,558. Specification of Letters Patent. Patented Sept. 3, 1912.

Original application filed May 23, 1905, Serial No. 261,868. Divided and this application filed November 21, 1910. Serial No. 593,304.

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Alternating-Current Rectifiers, (division of my application, Serial No. 261,868, filed May 23, 1905,) of which the following is a specification.

This invention relates to a system of electrical distribution in which alternating current is rectified to produce a unidirectional current applicable to series circuits requiring substantially constant current.

The invention also relates to the forms of apparatus whereby this result is obtained.

In carrying out my invention I make use of the peculiar property of a mercury or similar arc, whereby current is permitted to pass freely through the arc in one direction but is prevented from flowing in the opposite direction.

The details of my invention will be better understood by reference to the following description taken in connection with the drawing forming part of this specification which represents diagrammatically my improved system of electrical distribution.

Referring to the drawing, the mercury rectifier 1 is connected through a transformer 2 to the source of constant potential 3. This transformer 2 is in some respects similar to the ordinary tub transformer for converting constant potential alternating current into constant current, but differs in some particulars, which are hereinafter pointed out. The transformer comprises a primary coil 4 and a floating secondary coil 5, the terminals 6 and 7 of which are connected, respectively, to the anodes 8 and 9 of the mercury rectifier through reactance devices 10 and 11. The mercury cathode 12 of the rectifier is connected through a reactance 13 to a series circuit containing a plurality of translating devices 14, such for instance, as mercury lamps, magnetite, or other arc lamps. The other end of this consumption circuit is connected to a tap 15 from the center of the secondary 5. The rectifier is also provided with two auxiliary electrodes 16 and 17 separated from the cathode 12, but located near enough thereto so that when the rectifier is shaken or tipped slightly, a small quantity of mercury will flow from these auxiliary electrodes to the cathode or vice versa, to establish a starting arc in the lower end of the rectifier for the purpose hereinafter pointed out. These electrodes 16 and 17 are supplied with current from the low potential secondary 18 of a transformer, the primary 19 of which is connected to the constant potential source 3. A reactance device 20 is connected directly across the terminals of the secondary 18 and is provided with a tap 21 from which a conductor leads to a reactance 22 and then to the cathode 12. These auxiliary anodes 16 and 17, together with their co-relating transformer and reactances, operate to render the space within the rectifier conductive, for current from the transformer secondary 5 in a manner hereinafter described more in detail.

The operation of the mercury arc rectifier is based on the phenomenon of the electric arc by virtue of which current is conducted through the arc in one direction but is prevented from flowing freely in the opposite direction, so as to pass only unidirectional currents.

In an electrical arc, current is carried across the gap between the terminals by a bridge of conducting vapor consisting of material, projected and constantly replenished by a high velocity blast issuing from the cathode. The arc, therefore, must be continuous at the cathode, though it may be shifted from anode to anode. Any interruption of the cathode blast puts out the arc by interrupting the supply of conducting vapor. With an alternating impressed E. M. F. the arc, if established, will go out at the end of the half wave, or if a cathode blast is maintained continuously by a second arc, only alternate half-waves can pass, namely, those for which that terminal is negative from which the continuous blast issues. The arc, with an alternating impressed voltage, consequently rectifies the current, and the voltage range of rectification is very great.

The rectifier requires some means for maintaining the cathode blast at 12 for the current in the first half wave goes down to zero at the zero value of its electromotive force before the current of the next half wave is started by its electromotive force.

It is therefore necessary to maintain the current of the first half wave beyond the zero value of its propelling impressed electromotive force until the current of the next half wave has started, that is, to overlap the currents of the successive half-waves. This is done by inserting reactances 10 and 11 into the leads from the transformer 2. The effect of these reactances is that the current of the first half wave continues to flow beyond the zero of its impressed electromotive force, or in other words, until the electromotive force has died out and reversed and the current of the next half wave has been started, thus the two half waves of the current overlap and each half wave lasts for more than half a period, or for more than 180 degrees. By this means a rectifier becomes self-exciting as each half wave by overlapping within the next, maintains the cathode blast until the next half wave is started.

A high reactance 13 is inserted into the direct current circuit which consumes the excess voltage when the rectified voltage is above line voltage, and supplies line voltage during the period of zero rectified voltage.

In addition to these features the drawing shows a means contemplated by me for starting the first discharge through the mercury rectifier. This starting means comprises the two auxiliary electrodes 16 and 17 which are supplied with current from the secondary 18 of a transformer, and comprises also an arrangement of reactance devices 20, 22, whereby these two auxiliary electrodes 16 and 17 may alternately pass current to the main cathode 12, and furthermore may maintain an overlapping phase relation of these successive current waves so that the cathode 12 is at all times energized or excited by current from these auxiliary electrodes. After the rectifier has once been started the auxiliary electrodes may be cut out of circuit entirely and the rectifier will maintain itself in a conductive condition because of the effect produced by the reactances 10 and 11 in the manner previously discussed, but on the other hand, the continuous use of the auxiliary electrodes 16 and 17 requires the expenditure of only a small quantity of energy and has the advantage that if the consumption circuit is accidentally opened or is subjected to marked fluctuations from any cause the auxiliary exciting means serves to bridge over these disturbances and prevents the rectifier from being extinguished.

The rectifier itself embodies certain features which I consider of importance. As the conditions for successful operation to produce constant current are somewhat different from those which exist when the rectifier is operated on constant potential circuits, I find it advantageous to inclose each of the anodes 8 and 9 in a separate tube having a bend, the anode being located beyond said bend, as indicated in the drawing. I also find it advantageous to use as a cathode an amalgam of a refractory metal such, for instance, as gold or silver. Such a refractory metal has no appreciable vapor tension at the temperature of the mercury arc, and so does not take part in the conduction of current between the electrodes. The presence of such a metal reduces the vapor tension of the mercury and so makes the rectifier run cooler and thereby renders the rectifying arc less liable to "strike back". By the expression "strike back" I mean the action which takes place when a mercury arc reverses so that a carbon electrode becomes momentarily a cathode. Such an action produces a short circuit through the rectifier between carbon electrodes and by the disintegration of the carbon is likely to ruin the tube.

I find it desirable to use a higher magnetic density in the transformer than is ordinarily employed in constant current transformers of the tub type, and furthermore I find it desirable to so adjust the angular relation between the weight supporting arc 23 and the lever arm 24 that the transformer will deliver from its secondary a current which tends to decrease slightly in quantity as the voltage across the consumption circuit decreases. This adjustment is rendered desirable because of the fact that the overlapping of the current curves caused by the reactances 10 and 11 increases with a decrease of load and tends to make the rectified current increase when the number of translating devices in the series circuit decreases. This adjustment of the transformer may be easily effected by shifting the weight supporting arc 23 about a pivoted connection 25 in the manner well known to persons skilled in the art. An exact compounding may thus be effected so that the current through the translating devices is substantially constant under all conditions of load.

The specific form of mercury rectifier shown is well adapted for use on high potential circuits, as it will readily stand a pressure of many thousand volts between anodes without causing an arc to strike between them. Each anode is carried in the top of a comparatively narrow chamber which is separated by a considerable distance from the mercury cathode and furthermore is shielded from the direct cathode blast by a bend in the walls of the chamber as clearly shown in Fig. 1. By making these chambers small a relatively high temperature is produced in and around the anodes, thus preventing the condensation of mercury at these points and so decreasing the liability of arcing between anodes. A mer-

cury condensation chamber 26 is located directly above the mercury cathode 12 and serves to receive the direct cathode blast and to relieve the anode chambers of excessive vapor pressure.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. The combination with a source of electrical potential which periodically and regularly reverses in sign, of a vapor electric apparatus having electrodes connected with said source, said apparatus having electrodes functionating as anodes, and also having a cathode consisting of an amalgam of a refractory metal.

2. The combination with a source of alternating potential, of a vapor electric apparatus comprising an evacuated chamber, anodes and a cathode consisting of an amalgam of a metal having a negligible vapor tension at the operating temperature of said apparatus, and conductors for connecting said anode and cathode to said source of potential.

3. The combination of a source of alternating electromotive force, a vapor electric apparatus comprising an evacuated chamber inclosing a plurality of electrodes, at least one of which consists of silver-amalgam, a condensing chamber in proximity to said amalgam electrode, and means for connecting said source to said electrodes.

In witness whereof, I have hereunto set my hand this 19th day of November, 1910.

CHARLES P. STEINMETZ.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.