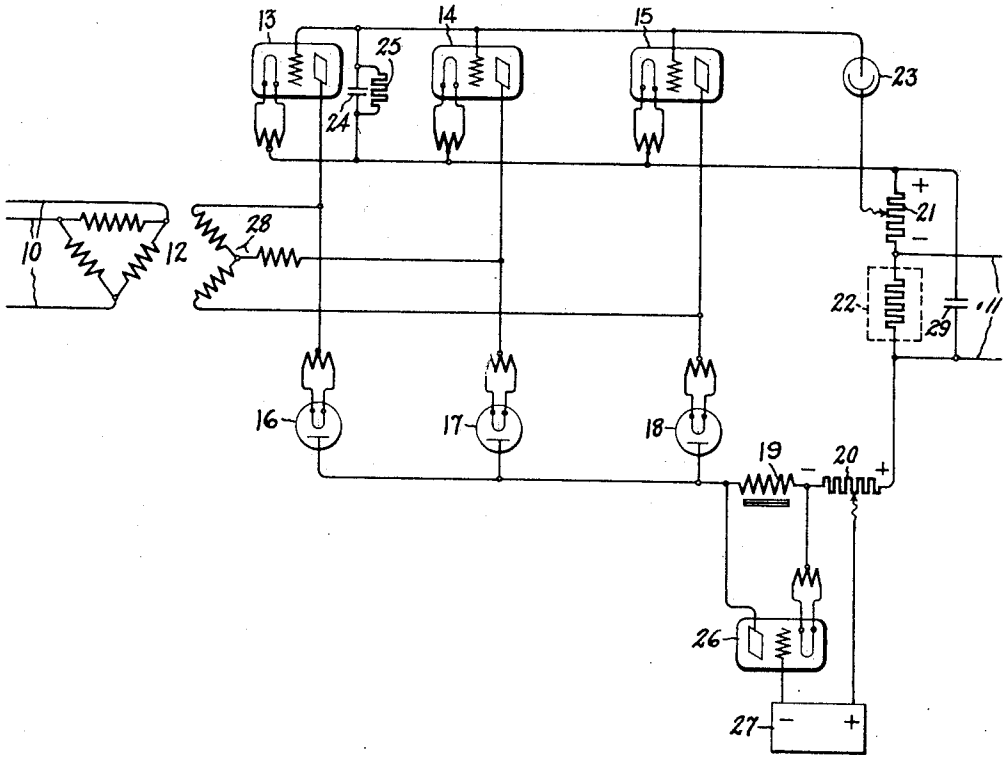
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RECTIFICATION OF ALTERNATING CURRENT

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RECTIFICATION OF ALTERNATING CURRENT

Application filed August 21, 1929. Serial No. 387,524.

My invention relates to the rectification of alternating current, and has for its principal object the provision of an improved alternating current rectifying system and method of operation whereby both the rectifying apparatus and the load circuit devices are protected from injury due to short circuits or other electrical disturbances.

Various types of apparatus have been utilized for transmitting electrical power between alternating current and direct current circuits. It has been found advantageous to include in these apparatus electric valves of any of the several types well known in the art. Discontinuous control electric valves, such, for example, as valves of the vapor electric discharge type have been found particularly suitable for operation in power circuits because of the relatively large amount of power which may be handled at moderate operating voltages. By the term discontinuous control electric valves, I refer to valves provided with an anode, a cathode, and a control grid and in which the starting of current in the valve is determined by the potential on its control grid but in which the current in the valve can be interrupted only by reducing its anode potential below the critical value, which may be of the order of 15 or 20 volts. It has been found that valves of this type are usually incapable of limiting the current which they transmit to a value which prevents injury or destruction of the valves themselves or the load devices which are energized from the circuit in which they are connected.

It is an object of my invention to provide an improved apparatus including discontinuous control electric valves for transmitting energy between direct and alternating circuits in which the current through the valves will be interrupted upon the occurrence of predetermined abnormal conditions.

It is a further object of my invention to provide an improved apparatus including electric valves for transmitting energy between direct and alternating circuits in which the current through the valves will be interrupted upon the occurrence of a predetermined current in the direct current circuit and in which this interruption will be maintained for a predetermined interval.

In accordance with my invention the occurrence of destructive current in the electric valves is prevented by an improved arrangement whereby a negative voltage is applied to the control grids of electric valves when the load current has reached a predetermined value and whereby the anode voltage is controlled in such a way as to insure that the anode current is interrupted by the grid when it is subjected to this negative voltage.

My invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

The drawing is a circuit diagram of a rectifying system wherein my invention has been embodied.

This system includes alternating current supply terminals 10 and direct current terminals 11 between which electrical power is transmitted through a transformer 12, a plurality of discontinuous control electric valves 13, 14, 15, 16, 17 and 18, a smoothing reactor 19, a resistor 20 and a resistor 21. It will be observed that the valve 13 is connected to the load circuit in series with the valve 16, that the valve 14 is likewise connected in series with the valve 17 and that the valve 15 is similarly connected with the valve 18. The direct current load is indicated at 22 which is intended to represent any device which utilizes direct current in its operation. A smoothing condenser 29 is connected in shunt to the load circuit and the resistor 21.

The electric valves 13 to 18 inclusive are each provided with an anode and a cathode and are preferably of the discontinuous control type. The valves 13, 14 and 15 are each provided with a grid which is connected to its cathode through the bias resistor 21 and a voltage responsive device 23 which may be a glow tube or other device operable to apply potential to the grids when the voltage produced in the resistor 21 exceeds a predetermined value. Also connected between the cathodes of the valves 13, 14 and 15 and their

grids is a condenser 24 and an impedance element or grid leak 25.

During the operation of the system the direct current load may be increased or short circuited. In either case when the potential drop across the grid bias resistor 21 exceeds the break down voltage of the device 23, the valves 13, 14 and 15 are biased to cut off and the direct current is interrupted. In the absence of the grid leak resistance 25, the current would be interrupted indefinitely. The function of this resistor is to allow the charge to leak off the condenser and to permit the current to be reestablished. When this occurs current will be supplied to the direct current circuit for one-third of a cycle and will again be interrupted if the direct current load is still short circuited. If the short circuit or overload has been removed by the time the charge leaks over the condenser 24, the normal operating condition will be resumed.

The use of the smoothing reactor 19 involves an additional complication in the protection of the rectifier and the direct current load. As previously indicated the valves 13 to 15 are of a type in which the grid is capable of preventing the starting of current between the cathode and anode, but is incapable of interrupting the current after it has been started.

When the rectifier is overloaded or the direct current circuit is short circuited, a very high rate of change in the current of the smoothing reactor 19 occurs. This produces a comparatively high voltage between the terminals of this reactor, and this voltage is added to the anode voltage of the particular valve which happens to be transmitting current at that instant. This reactor voltage will, if it is large enough, hold a potential which is always positive on the anode circuit of the valve and which will prevent the anode current from reaching zero. If this occurs, the grid is ineffective to produce cut-off and the current is not interrupted. It is therefore, necessary to provide some means whereby the induced voltage of the smoothing reactor 19 may be controlled when the current changes suddenly.

This result is produced by including a valve 26 which is similar in its operation to the valves 13 to 15, and which is arranged to have potential applied to its grid through the resistor 20 and a bias rectifier 27. With this arrangement the valve 26 transmits no current during the normal operation of the system. When the direct current load becomes abnormal however, the negative voltage applied to the grid of the valve 26 through the bias rectifier 27 is neutralized by the opposed voltage produced in the resistor 20, and the load current is shunted through the valve 26, thus permitting the anode current of the valves 13, 14 and 15 to be interrupted by the grids of these valves.

It will be readily understood by those skilled in the art that current is transmitted from the secondary winding 28 of the transformer 12 to the direct current load circuit successively through the valves 13, 14 and 15, and is returned from the load circuit to the secondary winding of the transformer 12 successively through the valves 16, 17 and 18. The improved rectifying system has the advantages that the current is filtered and maintained substantially constant by means of the smoothing reactor 19 and the smoothing condenser 29 which is connected in shunt to the direct current load circuit, and that interruption of the current by the grids of the valves 13, 14 and 15 is insured under all conditions of operation regardless of the voltage produced at the terminals of the smoothing reactor when the magnitude of the direct current is suddenly changed.

As will be apparent, the valve 26 and its grid control circuit may be replaced by a glow tube or other voltage responsive device where the load current is sufficiently small to permit the use of such a device.

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

1. The combination of alternating and direct current terminals, means including a discontinuous control electric valve connected between said terminals and provided with a grid for controlling the current transmitted between its cathode and anode, means responsive to the current of said direct current terminals for producing a negative bias voltage, and a voltage responsive device operable to apply said negative bias voltage to said grids when it exceeds a predetermined value.

2. The combination of alternating and direct current circuits, means connected between said circuits including a discontinuous control electric valve of the vapor electric type provided with a grid for controlling the current transmitted between its cathode and anode, means connected in series with said direct current terminals for producing a negative bias voltage, and a voltage responsive device operable to apply said voltage to said grid when the current of said direct current circuit exceeds a predetermined value.

3. The combination of alternating and direct current circuits, means connected between said circuits including a reactor and a discontinuous control electric valve of the vapor electric type provided with a grid for controlling the current transmitted between its cathode and anode, means connected in series with said direct current terminals for producing a negative bias voltage, a voltage responsive device operable to apply said voltage to said grid when the load current of said direct current circuit exceeds a predetermined value, and means connected in shunt to said reactor and arranged to bypass said

load current when it changes in magnitude at a predetermined rate.

4. The combination of alternating and direct current circuits, means connected between said circuits including a reactor and a discontinuous control electric valve of the vapor electric type provided with a grid for controlling the current transmitted between its cathode and anode, means connected in series with said direct current terminals for producing a negative bias voltage, a voltage responsive device operable to apply said voltage to said grid when the current of said direct current circuit exceeds a predetermined value, and means including an asymmetric conductor connected in shunt to said reactor and arranged to bypass said load current when it changes at a predetermined rate.

5. The combination of alternating and direct current circuits, means connected between said circuits including a discontinuous control electric valve provided with a grid arranged to control the current between its cathode and anode, means for applying to said grid a negative bias voltage dependent on the magnitude of the current of said direct current circuit, a smoothing reactor connected in series with said direct current circuit, and a discontinuous control electric valve connected in shunt to said reactor and operable to transmit the load of said direct current when the potential drop between the terminals of said reactor exceeds a predetermined value.

6. The combination of alternating and direct current circuits, means connected between said circuits including a discontinuous control electric valve provided with a grid arranged to control the current between its cathode and anode, means for applying to said grid a negative bias voltage dependent on the magnitude of the current of said direct current circuit, a smoothing reactor connected in series with said direct current circuit, a discontinuous control electric valve connected in shunt to said reactor and operable to transmit the load of said direct current when the potential drop between the terminals of said reactor exceeds a predetermined value and a second discontinuous control electric valve connected in series with said first mentioned valve.

7. The combination of alternating and direct current circuits, means connected between said circuits including a discontinuous control electric valve provided with a control grid, means responsive to the current of said direct current circuit for producing a negative bias voltage, means operable to apply said negative bias voltage to said grid when it exceeds a predetermined value and means associated with said last mentioned means for dissipating said negative bias only after a predetermined interval.

8. The combination of alternating and direct current circuits, means connected between said circuits including a discontinuous control electric valve provided with a control grid, a resistor in said direct current circuit for producing a negative bias voltage in accordance with the current flowing therein, voltage responsive means for connecting said negative bias voltage between the cathode and grid of said valve to render said valve non-conducting, and a second circuit interconnecting said cathode and grid including a condenser shunted by a resistor to restore the conductivity of said valve after a predetermined interval.

In witness whereof, I have hereunto set my hand this 20th day of August, 1929.

RAYMOND H. WILLIAMSON.