

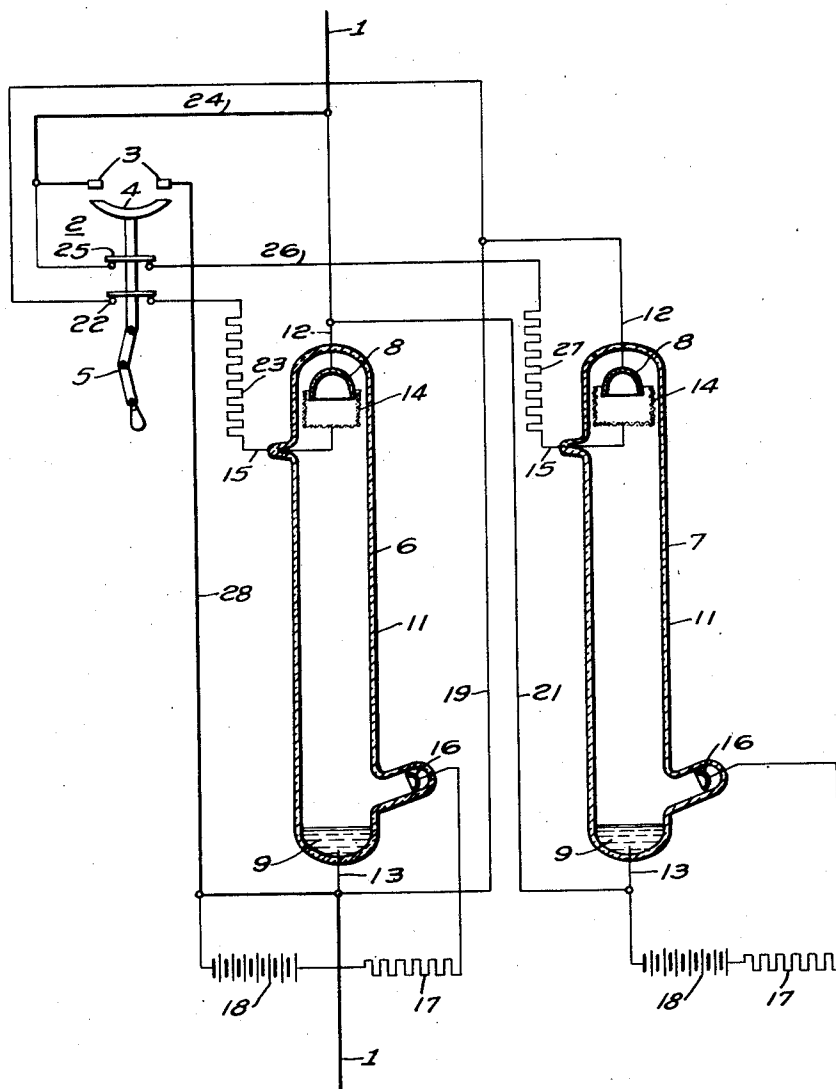
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CIRCUIT BREAKER

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## UNITED STATES PATENT OFFICE

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## CIRCUIT BREAKER

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My invention relates to circuit-interrupting systems and particularly to such systems wherein circuit interruption is accomplished through the medium of two asymmetric valves.

One object of my invention is to provide a system of the above-mentioned type wherein two rectifiers are oppositely connected in parallel relation to a circuit interrupter that shall interrupt the circuit without the arcing that usually accompanies such operation.

Another object of my invention is to provide a system of the above-mentioned type for interrupting an electrical circuit that shall require no other mechanical interrupting means than that associated directly with the main circuit interrupter.

A further object of my invention is to provide a circuit-interrupting system with two asymmetric valves that shall embody, in themselves, means for rendering a path through the valves impervious to the flow of current, under predetermined relative conditions in the system, to effect a complete interruption of the circuit.

Heretofore, in circuit-interrupting systems wherein valves were employed to aid in the interruption of the main system, mechanical or chemical means were usually relied upon to render the valves non-conducting. Such construction usually extended the time necessary to complete circuit interruption and was often unreliable, because of the auxiliary switching equipment that was operated independently of the operation of the main circuit interrupter. This construction had the additional disadvantage of causing a heavy current arc to be drawn at the contacts that had a deleterious effect thereupon and likewise produced objectionable electrical transients in the power system.

In practicing my invention, I avoid the additional mechanical structure above described and the arcing at the contact members by taking advantage of the inhibitory effect to current flow that is produced in an ionized current path by a screen upon which a rapid recombination of the ions takes place under certain predetermined conditions.

My invention will better be understood by

referring to the following description, taken in conjunction with the accompanying drawing, the single figure of which is a diagrammatic illustration of a circuit-interrupting system embodying my invention.

My system comprises, in general, an electrical transmission line 1 having therein a circuit interrupter 2 which comprises a pair of stationary contact members 3, a cooperating movable bridging member 4 and an actuating mechanism 5 for controlling the operation of the bridging member 4. The circuit interrupter 2 may be of any conventional type, as this specific structure forms no part of the present invention.

In parallel-circuit relation to the circuit interrupter 2, are placed a pair of oppositely-disposed mercury rectifiers 6 and 7 of conventional design, each comprising an anode 8 and mercury pool or cathode 9 that are sealed within an evacuated tube 11. Conductors 12 and 13 are respectively attached to the anode 8 and the cathode 9 and extend through the walls of the tube 11.

A grid 14 is provided adjacent to the anode 8 located in the path of current flow between the anode 8 and the cathode 9. A conductor 15 extends through the wall of the tube 11 to constitute a conducting path to the grid 14. The purpose and the operation of the grid will be described more fully hereinafter.

A starting electrode 16 is provided adjacent to the mercury pool 9 and is connected, through a resistor 17, to a source of energy 18, herein shown as a battery, but it is to be understood that any other source of energy known to be suitable may be employed. As current flows through the path between the electrodes of a rectifier only when the mercury pool 9 is a negative electrode, the proper connection to the source of energy 18 must be made.

To start a thermionic emission in each of the rectifiers 6 and 7, the cathode thereof must first be heated, which is accomplished by tilting the tube 11 to close the circuit between the mercury pool 9 and the starting electrode 16. When the tube 11 is returned to its normal position, which is that illustrated in the drawing, an ionized path will be established

between the starting electrode 16 and the mercury pool 9, and current from the battery 18 will continue to flow through the resistor 17 and the ionized path, keeping the cathode 9 alive. When the cathode 9 is alive, current may pass through the space between the anode 8 and the cathode 9 when the circuit interrupter 2 is moved to open position. This circuit for keeping the mercury pool alive to maintain the main path through the tube available for current flow will be known hereinafter as the "keep alive circuit."

It has been the practice in the past, when interrupting a current flow through a pair of rectifiers 6 and 7, to insert switches in the respective keep alive circuits thereof to interrupt the latter circuits for rendering the paths between the anodes and the cathodes of the rectifiers impervious to the flow of current during the subsequent one-half cycle thereof. With such an arrangement, the successful operation of the system depended upon a mechanical structure that was subject to failures and also upon the natural recombination of the ions in the path between the anode 8 and the cathode 9.

In practicing my invention, I avoid the necessity of additional apparatus exterior of the tube 11 by employing the grid 14 adjacent to the anode 8, and obtain the additional advantage, besides that of rendering the path impervious to the flow of current, of quickly raising the voltage gradient between the anode 8 and the mercury pool 9 to a value considerably greater than that resulting in the same length of time when a natural recombination of the ions takes place after the current flowing through the rectifier has passed to zero value.

A low-pressure region is provided about the anode 8 during the period when the current flowing therethrough has passed to zero value in the course of its alternating cycle which insulates the anode from a further passage of current on a succeeding similarly directed one-half cycle of the alternating wave.

The grid 14, which may be a metal plate, wires or screen, causes a diffusion of the ions of the current path to the surface thereof, resulting in a sheath of low ion density to be formed, in a manner similar to that disclosed by Dr. J. Slepian in his copending application, Serial No. 54,930, filed September 8, 1925, and assigned to the assignee of the present invention.

So long as the density of ionization of the path between the anode 8 and the mercury pool 9 remains large, the effect of the grid is slight. If, however, the current is interrupted momentarily then, due to recombination, the density of ionization rapidly decreases and the sheath about the surfaces increases in thickness until a point is reached when a continuous space charge

sheath forms thereover that greatly increases the voltage required to restrike a path across the electrodes. When a negative voltage is applied to the grid 14 this sheath may be made to grow to almost any size to thereby raise the restriking voltage, although not influencing the path when the current is flowing.

Accordingly, the rectifiers 6 and 7, besides being oppositely disposed in the main circuit, are so otherwise associated therewith that a negative potential is provided to the respective grids 14 when a negative potential is applied to the mercury pool of the respective rectifiers 6 and 7.

As shown in the drawing, the conductors 12 and 13 of the rectifier 6 are directly connected in the line 1 in parallel relation to the circuit interrupter 2. In a similar manner, the conductors 12 and 13 of the rectifier 7 are connected, through the conductors 19 and 21, respectively, to the line 1 in parallel relation to the rectifier 6 but having the anode 8 and the cathode 9 thereof oppositely disposed in the said line. In such an arrangement, the rectifiers 6 and 7 are so associated in the line 1 that, when the mercury pool of one rectifier is subjected to a negative potential, the mercury pool of the other rectifier is subjected to a positive potential.

The conductor 19 from the line 1 on the lower side of the rectifier 6 is connected through a switch 22 in the circuit interrupter 2 and is closed when the circuit interrupter 2 is in open-circuit position. A resistor 23 is connected between the switch 22 and the conductor 15 of the rectifier 6 and is of the non-inductive type and of high resistance to reduce the current effective at the grid 14 to a very low value to thereby ensure that a relationship of anode and cathode is not established between the anode 8 and the grid 14. Similarly, a circuit 26 is provided from the main line 1 through a switch 25 of the circuit interrupter 2 that operates in conjunction with the switch 22 to be closed when the circuit interrupter 2 is in open-circuit position. The circuit 26 is connected to a resistor 27 which has the same characteristics as those above noted of the resistor 23. The other end of the resistor 27 is connected, by the conductor 15, to the grid 14 of the rectifier 7.

The operation of my circuit-interrupting system will now be described. Assume the circuit interrupter 2 to be in closed-circuit position with the bridging member 4 in engagement with the contact members 3 and the keep alive circuit of the rectifiers 6 and 7 operative to establish an ionized path between the starting electrodes 16 and the mercury pool 9. Current will then flow from the line 1 through the conductor 24 through the circuit interrupter 2 and through the conductor 28 and continue onward in the line 1.

When the circuit interrupter is opened, the current of the line 1 will be immediately transferred to the pair of rectifiers 6 and 7 without having an arc established between the contact members 3 and the bridging member 4 thereof. The sparking that may occur at the contact would only be that caused by the drop in potential therethrough of approximately 15 volts, which is the drop across the rectifiers 6 and 7. The current will then pass through the line 1 and through either of the rectifiers 6 and 7, depending upon the direction of flow of current in the line 1 at the time of the opening of the circuit interrupter.

If we assume this current to be positive, it will flow through the rectifier 6 and will be prevented from flowing through the rectifier 7 because of the positive potential at the mercury pool 9 thereof. When the direction of flow of current changes, in the course of its alternating cycle, current will then flow through the rectifier 7 and will be prevented from flowing through the rectifier 6 because the mercury pool 9 thereof is now provided with a positive potential.

When the circuit interrupter 2 reaches the open position and the possibility of arcing between the members 3 and 4 is terminated, the switches 22 and 25 close and connect the grids 14 with the respective cathodes or mercury pools 9. Thereafter, as negative potential builds up at the mercury pool 9 of one of the rectifiers at the beginning of each half-cycle, it simultaneously builds up at the grid of that rectifier, so that, beginning with the half-cycle following closing of the switches 22 and 25, the path between the anode 8 and the mercury pool 9 of each rectifier is rendered impervious to the flow of current.

Thus, it will be seen that the current flowing in the line 1 is interrupted by rectifiers 6 and 7 in such manner that little or no disturbances will be present in the main system. This I accomplish without the necessity of cutting off the keep-alive circuit, as has been the practice in the past, so that my system will, at all times, be in condition for immediate operation by the mere closure of the circuit interrupter 1, which may be accomplished by remote means. Heretofore, it has always been necessary to first start the keep-alive circuit after each operation of the circuit interrupter.

It will thus be seen that I have provided a circuit-interrupting system wherein the current of a circuit is opened without establishing an arc at the contact members thereof or setting up transients in the main circuit, as has usually been the case in circuit-interrupter operations in the past. This I accomplish by providing a pair of asymmetric valves oppositely disposed in parallel relation with the circuit interrupter of the main circuit that has means associated there-

with other than that for severing the keep-alive circuit for rendering the current path through the valves impervious to current flow.

While I have illustrated but one embodiment of my invention, it will be apparent to those skilled in the art that various changes, modifications, substitutions, additions and omissions may be made in the apparatus illustrated without departing from the spirit and scope of my invention, as set forth in the appended claims.

I claim as my invention:

1. In an alternating-current circuit, the combination with a circuit interrupter therefor, of two rectifiers oppositely disposed in parallel circuit relation to each other and to said circuit interrupter, a "keep-alive circuit" for said rectifiers, a grid disposed in the current path through each rectifier and means responsive to the open position of said circuit interrupter for rendering said grid negative to interrupt the flow of current after said circuit interrupter is opened.

2. In an alternating-current circuit, the combination with a circuit interrupter therefor, of two rectifiers oppositely disposed in parallel-circuit relation to each other and to said circuit interrupter, a "keep-alive circuit" for said rectifiers, a grid disposed in the current path through each rectifier, a cathode for each rectifier, and a circuit connected to said grids in such manner as to apply a negative potential thereto when a negative potential is applied to the cathode of said rectifier, and means controlled by the circuit-interrupter for closing said last-mentioned circuit after the circuit-interrupter is opened.

3. In an alternating-current circuit, the combination with a circuit interrupter therefor, of two rectifiers oppositely disposed in parallel-circuit relation to each other and to said circuit interrupter, a "keep-alive circuit" for said rectifiers, a grid disposed in the current path through each rectifier, means responsive to the open position of said circuit interrupter for applying a negative potential to said grid, and a resistor in circuit with said grid to limit the current thereto.

4. In an alternating-current circuit, a circuit interrupter through which the current in said circuit normally flows when said interrupter is closed, a pair of asymmetric cells oppositely disposed in parallel-circuit relation to each other and to said circuit interrupter so that the current through said circuit flows through said cells only when said circuit interrupter is open, each of said cells having a cathode and a grid, means keeping said cathode in condition to conduct current, and means rendered operative in response to the circuit-interrupter reaching opened position for energizing said grids to interrupt the

flow of current through said cells while said cathode is in conducting condition.

5 The combination with a circuit-interrupter for an alternating-current circuit, of  
two rectifiers oppositely connected in parallel-circuit relation with each other and  
with said circuit interrupter, a "keep-alive"  
circuit for each rectifier, a grid disposed in  
the current path through each rectifier, and  
10 means responsive to the open position of the  
circuit interrupter for applying a negative  
potential to each grid to render the rectifier  
impervious to the flow of current.

In testimony whereof, I have hereunto  
15 subscribed my name this 2nd day of August  
1929.

RAY P. JACKSON.

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