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ELECTRIC CURRENT RECTIFYING SYSTEM

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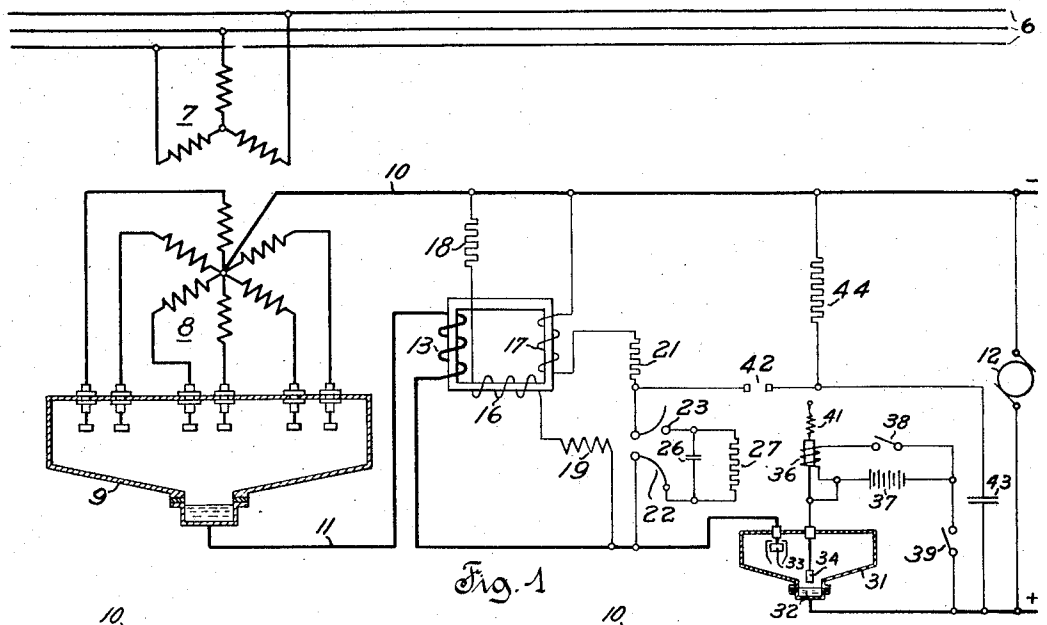


Fig. 1

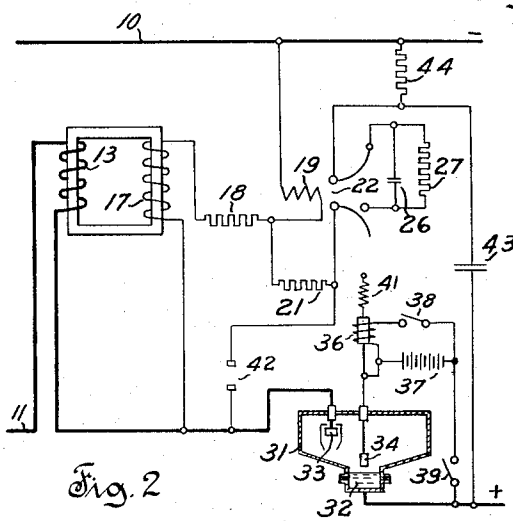


Fig. 2

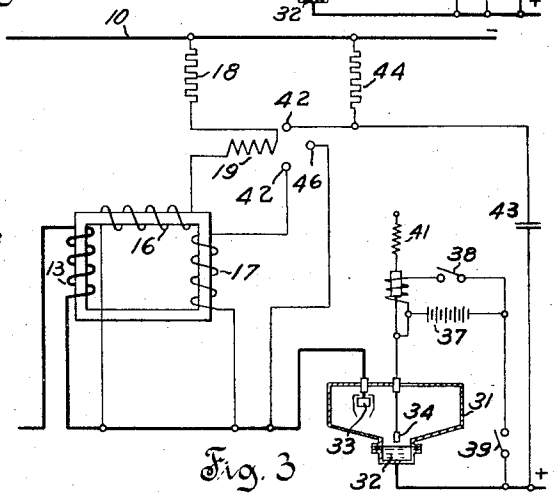


Fig. 3

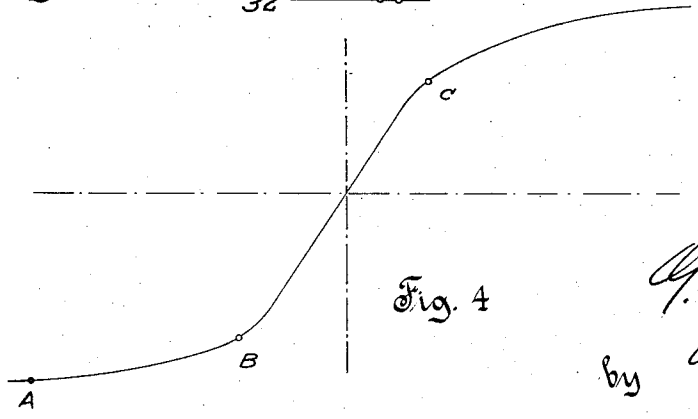


Fig. 4

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ELECTRIC CURRENT RECTIFYING SYSTEM

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4 Claims. (Cl. 175—294)

This invention relates to protective means for high voltage direct current installations and more particularly to means for interrupting the circuit in such installation upon the occurrence of short circuits or other overload disturbances.

It is well known that short circuits or other disturbances in high voltage installations are very destructive and should be limited by interruption of the circuit as rapidly as possible. The use of circuit breakers of the well known movable contact type is impractical for high voltage direct current installations due to the practical impossibility of quenching the arc upon separation of the contacts. A high voltage direct current may, however, be interrupted by quenching the conductive arc within an electric valve. Such arc quenching means may comprise a condenser arranged for connection in parallel with the arc to bypass the arc momentarily or to impress a voltage on the valve in opposition to the normal direction of current flow therethrough. If a spark gap is connected in parallel with the arc to be interrupted and in series with the condenser, the condenser will be connected most quickly upon the occurrence of an overload. The space between the electrodes of the spark gap must be punctured or broken down to cause connection of the condenser and it is preferable to cause such breaking down by means of a transformer, the primary winding of which is energized from the direct current load circuit to be protected against overloading or short circuits. The secondary winding of such transformer must be connected in series with the discharge circuit of the condenser and with the spark gap. Any rapid increase in the current flowing in the direct current load circuit and hence in the primary winding of the transformer will then cause the induction of an additional voltage in the secondary winding, and will therefore cause breaking down of the spark gap and connection of the condenser.

The system above indicated, however, has the disadvantage that the spark gap may break down even upon occurrence of surges within the range of the usual load limits on the circuit just as readily as upon the occurrence of an overload, a short circuit or other disturbance. If the electrodes of the spark gap are widely spaced to avoid such undesired breaking down, the sensitivity of the entire system to overloads or short circuits is very much reduced.

To make a condenser connected in series with a spark gap practically operative for the purpose described, it is necessary that the charging or discharging current of the condenser reach the highest possible peak which requires that the discharge circuit have the lowest possible resistance and practically no inductance. Due to the fact that the secondary winding of the transformer connected with the spark gap is connected with the discharge circuit of the condenser, such winding must be bridged at the moment the spark gap breaks down. Such bridging may be accomplished by a third electrode arranged within the sphere of the arcing of the spark gap. The arc is then, at least partially, brought into contact with the third electrode by means of an electromagnetic coil.

Experience has shown, however, that displacement of an arc by an electromagnetic blast requires a materially greater period of time than is required for the breaking down of a spark gap. Such time difference is especially noticeable if an electric current valve in the direct current circuit is used in parallel with the condenser for overload protection. Due to the high voltage, the electrodes of the spark gap must be widely spaced from each other which results in increasing the time required for movement of the arc to the third electrode. Such increase in the time required for breaking down of the arc gap permits further increase of the overload or short circuit current within the installation. The action of the coil in blowing the arc toward the third electrode cannot be increased too much because of the danger of blowing the arc out before it reaches such electrode.

It is, therefore, among the objects of the present invention to provide means for protecting a high voltage direct current installation by the use of an electric valve of the arcing type therein which is provided with means for securing interruption of such arc upon the occurrence of an overload or short circuit in the installation.

Another object of the present invention is to provide means for protecting a high voltage direct current installation by the use of an electric valve of the arcing type in which a condenser is arranged to be connected in parallel with the arc within the valve for the purpose of quenching such arc upon the occurrence of an overload in the installation.

Another object of the present invention is to provide means for protecting a high voltage direct current system which means employs an electric current valve of the metallic vapor type in which a spark gap and a condenser are connected in series with each other and are arranged to be connected in parallel with the arc in the valve for the purpose of quenching such arc

upon the occurrence of an overload in the system.

Another object of the present invention is to provide means for protecting a high voltage direct current circuit having an electric valve of the metallic vapor type connected therein which valve is arranged to be connected with a spark gap having a potential impressed on the electrodes thereof from a transformer and controlling the discharge of a condenser arranged to be connected in parallel with the arc within the valve for the purpose of quenching such arc upon the occurrence of an overload in the system.

Another object of the present invention is to provide a protective system for a high voltage direct current circuit having an electric valve of the metallic vapor type connected in the circuit in which system a plurality of spark gaps are connected in series with each other in the discharge circuit of a condenser which is arranged to be connected in parallel with the arc within the valve to cause connection of the condenser with a discharge circuit therefor for the purpose of extinguishing such arc.

Another object of the present invention is to provide a protective system for direct current circuits in which a spark gap, arranged to be connected in parallel with an electric valve in the circuit, has a potential impressed on the electrodes thereof from a transformer which is excited in one direction from the direct current circuit to be protected against overloads and is excited in the opposite direction by an additional winding.

Another object of the present invention is to provide a protective system for high voltage direct current circuits having an electric valve connected therein in which system a plurality of spark gaps are connected in series with each other in the discharge circuit of a condenser arranged to be connected in parallel with the arc within the valve and one of the spark gaps is partially bridged upon breaking down thereof by a condenser partially connected in parallel therewith.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing in which:

Fig. 1 diagrammatically illustrates a portion of a high voltage direct current system having an electric current valve of the metallic vapor arcing type connected therein in which the system is provided with means for extinguishing the arc within the valve upon the occurrence of overloads on the system.

Fig. 2 diagrammatically illustrates a modified embodiment of the means connected with a direct current circuit having a metallic vapor valve of the arcing type therein, the means being arranged to extinguish the arc within such valve upon the occurrence of an overload upon the direct current circuit.

Fig. 3 illustrates a further embodiment of the means for accomplishing the purpose set forth above.

Fig. 4 is a curve illustrating the excitation condition of the auxiliary transformer due to the different conditions in the circuit.

Referring more particularly to the drawing by characters of reference, the reference numeral 6 designates an alternating current supply line connected through a transformer comprising the primary and secondary windings 7 and 8 respectively with an electric current rectifier 9 of the well known metallic vapor arcing type. The rectifier supplies direct current to a direct current circuit, the bus bars of which are formed by a conductor 10 connected with the neutral point of the transformer secondary winding 8 and a conductor 11 connected with the cathode of the rectifier 9, both bus bars being connected by a load 12. It is to be understood that the supply line 6, the transformer 7, 8 and the rectifier 9 have been shown merely as a convenient source of high voltage direct current to assure completeness of the disclosure and that any other source might be used without in any way affecting the essence of the invention. The positive current bus bar 11 forms one winding 13 of a transformer having a plurality of other windings 16 and 17 arranged on the same core, the winding 16 magnetizing the core in a direction opposite to the magnetization thereof by winding 13. Winding 16 is connected through a current limiting resistance 18 with the negative direct current bus bar 10 and through a reactance blowout coil 19 with the positive bus bar 11. The winding 17 is connected with the negative bus bar 10 and through a resistance 21 and a horn gap type spark gap 22 with the positive bus bar 11. The horn gap 22 is provided with a third electrode 23 which is arranged between the horns and partially connected in parallel therewith by a condenser 26 and a resistance 27. The coil 19 is so arranged relative to the horn gap electrodes and the third electrode that the arc may be blown to the third electrode due to the magnetization of the coil 19. An electric valve, in the nature of an electric current rectifier and comprising a container 31 for a vaporizable cathode 32 is connected with the positive bus bar 11. The container has an anode 33 extending thereinto, the arc flowing from the anode to the cathode in normal operation connecting the two portions of the positive bus bar 11. The valve is provided with an ignition anode 34 having a solenoid 36 for the operation thereof upon energization from a battery 37. The valve is started by first closing and then opening of switches 38 and 39 which causes contact of the ignition anode with the cathode and the striking of an arc upon separation thereof, responsive to the opening of switch 38, under the action of a spring 41 as is usual in electric current rectifiers. The valve 31 is arranged to be bridged by a parallel circuit including the horn gap 22, a spark gap 42 and a condenser 43. One terminal of the condensers 43 is connected with the negative bus bar 10 through a resistance 44.

During operation, the full direct current flows through the winding 13 of the auxiliary transformer, the core of which is magnetized by winding 16 in a direction opposite to the magnetization thereof by the winding 13. Breaking down of spark gaps 22 and 42 upon the occurrence of surges in the direct current circuit within the range of the normal load current are thus avoided. In normal operation, the full operating voltage of the direct current bus bars 10 and 11 is impressed on the horn gap 22 but no voltage is impressed on the spark gap 42 because of the connections of resistances 44 and 21 thereto with the negative bus bar 10. When an overload or short circuit occurs on the direct current circuit, the rapid change of the current in transformer winding 13 causes breaking down of horn gap 22. When horn gap 22 breaks down, the one electrode of the spark gap 42 is connected with the positive bus bar 11 and spark gap 42 breaks down thus connecting condenser 43 in parallel with valve 31 which causes discharging of condenser 43 through the valve 31 in opposition to the arc

therein thus quenching such arc. The arc across the horns of gap 22 is, however, maintained, even when condenser 43 has discharged and the arc across the spark gap 42 has been interrupted by the residual current from the positive bus bar 11 over resistance 21 and winding 17 to the negative bus bar 10. Such arc is now extinguished by the blowout action of coil 19 which is magnetized by the connection thereof with the positive bus bar 11 and the negative bus bar 10 through transformer winding 16 and resistance 18. The coil 19 also serves as a reactance and prevents the flow of circulating currents of a large value in the winding 17 in cases of short circuit thus reducing the voltage required to break down the spark gaps.

To make quenching an arc between the horns of gap 22 absolutely certain even at high voltages, the arc is partially short circuited by the structure shown in Fig. 1 in which such arc is blown against the third electrode 23 by the coil 19, by the condenser 26 and such portion of the arc is immediately quenched. As soon as a portion of the arc across horn gap 22 is quenched, the direct current circuit is interrupted. Valve 31 must then be reignited to establish an arc between the anode 33 and the cathode 32 to cause reestablishment of the circuit as above described.

The winding 17 connected with the spark gaps 22 and 42 may also be connected with the positive bus bar 11 as shown in Fig. 2 rather than with the negative bus bar as shown in Fig. 1. With connection to the positive bus bar in normal operation, there is no potential impressed on the electrodes of horn gap 22 but the full operating voltage is impressed on spark gap 42 which therefore breaks down before horn gap 22 breaks down upon the increase of the potential in the circuit containing such spark gaps. As shown in Fig. 2, winding 17 may also be used to provide the opposing magnetization of the core of the transformer required to avoid break down of the spark gaps upon the occurrence of surges in the direct current system within normal load limits, thus avoiding the necessity for the use of the additional exciting winding 16. Except for reversal in the order in which the spark gaps break down the operation of the system shown in Fig. 2 is as exactly as described for Fig. 1.

Fig. 3 illustrates a modified embodiment of that portion of the invention relating to the means for extinguishing the arc within the valve in which the winding 17 is short circuited by a third electrode 46 when the spark gap 42 breaks down thus connecting the condenser 43 in parallel with valve 31. The reactance of the winding 17 does not reduce the peak value of the discharge voltage for the condenser because the winding is short circuited by the third electrode. Reactance coil 19 prevents the flow of too great a circulating current which would reduce the voltage required for breaking down of the spark gap. Resistance 18 limits the magnetizing current flowing through the transformer winding 16.

Fig. 4 is a curve illustrating the magnetic excitation of the auxiliary transformer core by windings 13 and 16. In normal operation the core is magnetized to the point B on the curve when the load on the direct current circuit is at the normal full load value. The portion A—B of the curve thus represents the normal full load core excitation. As the direct current load increases, the core is excited to the point C on the curve. The winding 16 is preferably so designed that the magnetization for normal operation is below the point B and that the point B is the lower limit for the magnetization resulting from overloads of such character as would cause extinguishing of the arc within the rectifier.

Although but a few embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In an overload protective system for direct current circuits, an electric valve of the metallic vapor arcing type connected with the circuit, a condenser arranged for connection in parallel with the arc within said valve to extinguish such arc, a discharge circuit for said condenser, a spark gap for connecting said condenser with said discharge circuit upon the impression of potential of predetermined voltage thereon, and a transformer for impressing such voltage on said spark gap as to cause breaking down thereof, said transformer comprising a core, a winding energized by the current flowing in the circuit and magnetizing the core in one direction, a second winding connected with said spark gap, and a third winding energized from the direct current voltage in the circuit.

2. In an overload protective system for a direct current circuit, an electric valve of the metallic vapor arcing type connected with the circuit, a condenser arranged for connection in parallel with the arc within said valve to extinguish such arc, a discharge circuit for said condenser, a spark gap for connecting said condenser with said discharge circuit upon the impression of potential of voltage thereon, and a transformer for impressing such voltage on said spark gap to cause breaking down thereof, said transformer comprising a core, a winding energized by the current flowing in the circuit and magnetizing the core in one direction, a second winding connected with said spark gap and a third winding energized from the voltage in the circuit, the third winding being operative to magnetize the core in addition to and in a direction opposite to the magnetization thereof by the first mentioned winding.

3. In combination with a circuit breaker of the vapor arcing type operable to establish and to interrupt flow of unidirectional current therethrough, of means connected in parallel with said circuit breaker for causing said interruption of flow of current comprising, a condenser, an arc gap connected with said circuit breaker and with said condenser to form a path for discharging the latter through said circuit breaker in a direction to interrupt said flow of current through the latter, an electric circuit including a source of current, a transformer comprising a first winding connected with and operable to impress voltage on said arc gap of such magnitude as to render the latter conductive, a second winding connected with and energized responsive to and in accordance with the voltage of said circuit for inducing in said first winding voltage of one polarity, and a third winding connected with and energized responsive to flow of current in said circuit for inducing in said first winding voltage of polarity opposite to the said one polarity, the said second and third windings being so proportioned as to induce in said first winding voltage of the said

another polarity of such magnitude as to cause discharge thereof across said arc gap to render the latter conductive upon increase of flow of current in the second said excitation winding at a predetermined rate, and means for charging said condenser.

4. In combination with an electric circuit, and a circuit breaker of the vapor arcing type for controlling unidirectional flow of current therethrough in said circuit, of means for rendering said circuit breaker conductive for flow of current therethrough, and means connected in parallel with said circuit breaker for rendering the same non-conductive for said flow of current, the latter means comprising a condenser, an arc gap connected with said circuit and with said condenser to form a path for discharge of the latter through said circuit breaker in a direction to render the latter non-conductive for flow of said current therethrough, means for rendering said arc gap conductive for flow of said condenser discharge current therethrough comprising a transformer having a core, a first winding connected with said arc gap, a second winding connected with and energized responsive to and in accordance with the voltage of said circuit for magnetizing said core in one direction, and a third winding connected with and energized responsive to and in accordance with the magnitude of current flowing in said circuit for magnetizing said core in direction opposite to the said one direction, the said third winding being operable upon occurrence of increase of flow therethrough above a predetermined rate to magnetize said core to such extent as to induce in said first winding voltage of such magnitude as to cause discharge thereof across said arc gap and thus establish said path for discharge of said condenser, and means connecting said circuit with said condenser to charge the latter.

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