Aug. 12, 1947. M. A. SCHEG ET AL 2,425,570

SWITCH SYSTEM TO PREVENT ARCING OF CONTACTS

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FIG. 1.

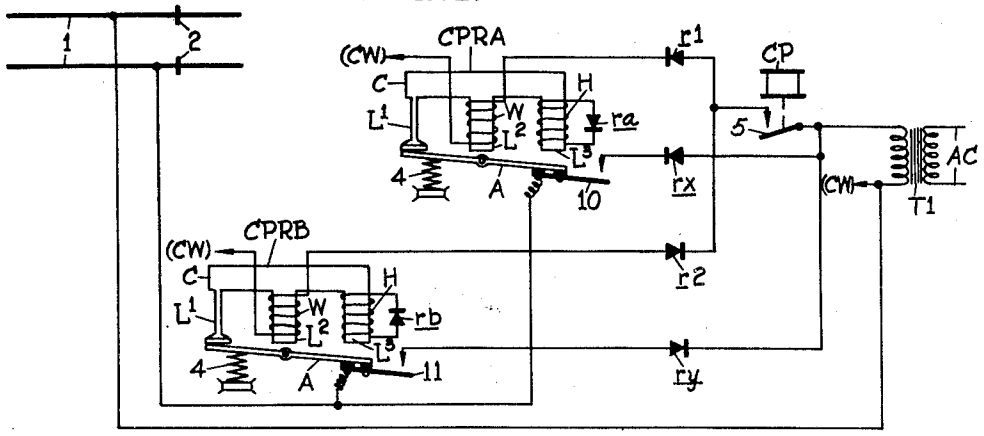
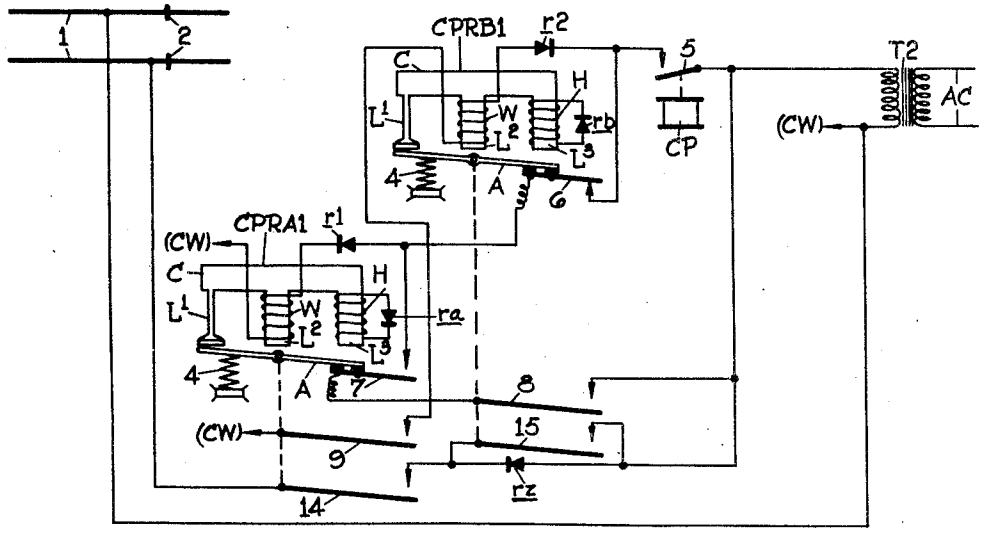


FIG. 2.



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SWITCH SYSTEM TO PREVENT ARCING OF CONTACTS

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8 Claims. (Cl. 175—294)

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This invention relates to circuit controlling apparatus and more particularly to apparatus controlled by and for controlling an alternating current circuit.

The problem of preventing or at least reducing sparking upon the closure and opening of circuits has always been present and more particularly becomes a problem where the energy for operating the contacts is small. Also, where high voltage is employed the contacts may be immersed in oil but this is not practical for low voltage circuits by reason of the contact resistance involved. This is particularly true where contacts engage each other with comparatively small contact pressures.

In view of the foregoing and other important considerations it is proposed in accordance with the present invention, which is applicable to alternating current circuits only, to employ electro-responsive circuit controlling means which closes contacts during particular portions of an alternating current cycle irrespective of the time of application of current to such electro-responsive means with respect to a cycle of such alternating current, and to so organize these contacts in a circuit structure that current cannot flow therethrough at the instant of closure or opening thereof by reason of the relative polarity of the current at the particular time of closure or opening thereof.

Stating this more specifically it is proposed to empoly two separate contacts one of which is closed during one half-wave of an alternating current cycle and the other of which is closed during the other half-wave of an alternating current cycle and to employ one or more rectifiers in combination with these contacts so that a circuit for passing current of one polarity is closed and opened during one-half of an alternating current cycle and a branch circuit is closed and opened during the other half of such alternating current cycle. In accordance with one form of the present invention it is proposed to employ a control circuit which includes two branches in each of which there is an oppositely poled rectifier each rectifier of which has included in series therewith a contact of the special electro-responsive means which will only be closed or opened when this rectifier blocks the flow of current as a result of which no sparking should occur because the contacts are made and broken at a time when no current flows therethrough.

In accordance with another form of the present invention it is proposed to employ a single rectifier and to close a circuit through the medium of one of the contacts of the special electro-responsive device at a time when such rectifier blocks the flow of current and to then shunt out this rectifier at a time when such rectifier passes the flow of current as a result of which no sparking should occur at the contacts because there is no current flowing when the first contact is closed or opened and current is bi-passed around the second contact by the rectifier at the time this second contact is either closed or opened.

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Other objects, purposes and characteristic features of the present invention will be in part pointed out hereinafter in the specification and will in part be obvious from the accompanying drawings, in which:

Fig. 1 illustrates one form of the present invention; and

Fig. 2 illustrates an improved form of the present invention.

The present invention employs relays or electro-responsive devices of very specific and special construction two forms of which have been fully described in the prior application of Scheg and Wall, Ser. No. 462,964, filed October 22, 1942, to which attention is directed for a more detailed description of this electro-responsive device.

The particular electro-responsive device such as relay CPRA shown in Fig. 1 of the drawings and described in detail in said prior Scheg and Wall application consists of a magnetizable core C of soft iron having three depending legs L^1, L^2 and L^3 of which the leg L^1 is of comparatively small cross-section. Just below and adjacent to the leg L^2 is a fixed pivot for pivotally supporting an armature A, which armature is biased by a spring 4 to engage the leg L^1 and which armature A upon being actuated to its active position will have its other end engage the leg L^3 and close contact 10.

On the middle leg L^2 of the core C is provided a winding W which winding is connected in series with a rectifier *r1* through the medium of a control contact 5 of a control relay CP and a circuit including the common return connection CW to a source of alternating current, herein shown as the secondary winding of the transformer T1 having its primary winding connected to an alternating current source AC. The leg L^3 is provided with a bucking winding H which is short-circuited for current of one polarity through the medium of the rectifier *ra*.

Stating the operation briefly, closure of the contact 5 of the control relay CP causes the winding W of the relay CPRA to be energized by

pulsating current of positive polarity as a result of which the leg L^1 will be completely saturated before the first complete pulse of current of positive polarity has passed. This causes the larger part of the magnetic flux to pass through the leg L^3 and causes snap actuation of the armature A to its actuated position. By reason of the lag of the current in winding W and the resulting lag in flux the armature A will not start to move until the voltage wave of positive polarity has entirely passed. Furthermore, in spite of the fast movement of the armature a certain amount of time is necessary for the armature to move from its normal position to its actuated position, so that actual closure of front contact 10 of relay CPRA does not take place until the "off" period of the pulsating current is well under way. In other words, the relay CPRA shown in Fig. 1 is constructed to begin its actuation during a substantial full pulse of positive polarity of alternating current and to close its contact 10 during a wave of negative polarity of the alternating current.

Since the winding W of the relay CPRA is energized by pulsating current, derived through the medium of the rectifier *r1*, suitable means must be provided to prevent chattering of the armature A during "off" periods of the current and for this purpose the bucking winding H on the leg L^3 has been provided. In order to prevent this bucking coil H from bucking the building up of flux in the leg L^3, this bucking coil H has included in series therewith a rectifier *ra* which allows current to flow only due to voltage induced in this coil upon a decrease in flux originally created therein by the winding W by current derived through rectifier *r1*. In accordance with the present invention, and also the invention of said prior application, it is proposed to cause this bucking coil H not only to prevent the dropping of the armature A between two successive pulses of pulsating current but to also hold the armature A still slightly longer in its actuated position so as not to drop to its non-actuated position until during the second "off" period of the pulsating current following deenergization of the winding W. Since the proper functioning of the special relay involves periods of delay the relay must of course be designed and constructed in accordance with the frequency of the alternating current which it is to control and which controls such relay and in accordance with the present invention it is assumed that the alternating current to be employed is of a frequency of 60 cycles per second. In other words, the relay CPRA shown in Fig. 1 is constructed to close its contact 10 during the first pulse of negative polarity following the first full pulse of positive polarity applied to its winding and so as to open this contact 10 during the second wave of negative polarity following the last full pulse of positive polarity applied to its winding.

The relay CPRA1 shown in Fig. 2 is of exactly the same construction as the relay CPRA shown in Fig. 1 and therefore requires no further description.

The relay CPRB shown in Fig. 1 is of exactly the same construction as that of the relay CPRA except that its winding W includes a rectifier *r2* in series therewith which is poled in the opposite direction from that of the rectifier *r1* included in series with the winding W of the relay CPRA, and further differs from the relay CPRA by having the rectifier *rb* poled in the opposite direction from that of the rectifier *ra* included in the bucking coil H of the relay CPRA. The relay

CPRB1 of Fig. 2 is of exactly the same construction as is the relay CPRB of Fig. 1.

In both Figs. 1 and 2 the relays CPRA and CPRB are used for controlling the application of energy to a track circuit of a track section including track rails 1 insulated from an adjacent track section by insulating joints 2. It should, however, be understood that the invention is not limited to the application of current to a track circuit but may be used to control any load circuit to which alternating current is to be applied and removed. It is desired to point out that the relay CP heretofore referred to as a control relay may be energized and deenergized intermittently to characterize a code and may therefore constitute a code repeating relay if a code type track circuit is involved.

Fig. 1 structure and operation.—Referring to Fig. 1 it will be observed that the contact 5 of the control relay CP when closed applies energy from the secondary winding of the transformer T1 to the windings W of both of the relays CPRA and CPRB and that by reason of the rectifiers *r1* and *r2* respectively included in series with these relays the relay CPRA is energized by pulsing current of positive polarity whereas the relay CPRB is energized by pulsing current of negative polarity. It is of course understood that the pulses of the first pulsating current each occur during one-half of the alternating current cycle whereas the pulses of the other pulsating current each occur during the other half of the alternating current cycle. In view of the construction of these relays as heretofore described the relay CPRA will close its front contact 10 during the first negative pulse of the alternating current whereas the relay CPRB will close its contact 11 during the first positive pulse of the alternating current after closure of the contact 5. It will be observed that the two contacts 10 and 11 of these relays are connected in multiple through branch circuit portions which include rectifiers *rx* and *ry* respectively. It will be observed that the rectifier *rx* permits the flow of current of positive polarity whereas the rectifier *ry* permits the flow of current of negative polarity. Since, as already explained, the contact 10 closes or opens during a negative pulse of the alternating current only and since the rectifier *rx* blocks the flow of this current no sparking will occur at the contact 10 when this contact is either opened or closed.

Similarly, since the contact 11 of the relay CPRB can close or open only during a positive pulse of the alternating current cycle and since the rectifier *ry* blocks the flow of current of positive polarity no current can flow through contact 11 during the instant of its closure or opening. From this consideration it should become apparent that no sparking at either of the contacts 10 or 11 can occur during either closure or opening of these contacts. It should further be observed that with both of the contacts 10 and 11 closed alternating current flows comparatively freely from the secondary winding of the transformer T1.

It will readily be understood from the foregoing discussion that the relays CPRA and CPRB will always be picked up and dropped in sequence and that this sequence depends upon at what point in the cycle of the alternating current the front contact 5 of the control relay CP is closed. That is, if the first full pulse of pulsating current applied to the relays is a pulse of positive polarity the picking up of the relay CPRA will pre-

cede that of the picking up of the relay CPRB, and vice versa. What has been said as to the sequential picking up of the relays CPRA and CPRB of Fig. 1 is likewise true of the sequential dropping of these relays in response to opening of the contact 5 of the relay CP. It will be observed that a certain amount of resistance is imposed by the rectifiers *rx* and *ry* in multiple in the Fig. 1 structure, thereby causing heating of these rectifiers. It would be much more desirable to have one of the contacts 10 or 11 close the load circuit through a rectifier and to then have the other contact shunt out this rectifier, and such a construction is shown in Fig. 2 of the drawings.

Fig. 2 structure and operation.—In the modified form of the invention illustrated in Fig. 2 the relays CPRA1 and CPRB1 are of the same construction as are the correspondingly designated relays of Fig. 1 but in this Fig. 2 structure the circuits are so organized that upon closing of the front contact 5 of the relay CP the relays CPRA1 will always be picked up ahead of the relay CPRB1 irrespective of the particular instant in a cycle of alternating current that this contact 5 is closed. The circuit organization is furthermore such that upon opening of the contact 5 the relay CPRB1 is always the first one of these two relays to drop irrespective of the particular instant in a time cycle of the alternating current that contact 5 is opened. This picking up of the relays CPRA1 and CPRB1 in sequence in one order and the dropping of these relays in the inverse order irrespective of the instant of closure or opening of the contact 5 of the relay CP with respect to the cycle of the alternating current is accomplished through the medium of pick-up and stick circuits for the relay CPRA1 presently to be described. By this construction, causing these relays to pick up in one order and drop in the reverse order, it is possible to have the first relay to pick up to close a load circuit through a rectifier and to then have the second relay to pick up and shunt this rectifier, and to cause the opening of the circuit by first unshunting the rectifier and to thereafter open the circuit in which it is included.

Referring to Fig. 2 it will be observed that the relay CPRA1 is provided with a pick-up circuit including the front contact 5 of the control relay CP and the back contact 6 of the relay CPRB1, and that with the relay CPRA1 once picked up it is stuck up through a stick or holding circuit including its own stick contact 7 and the front contact 8 of the relay CPRB1 as soon as this latter relay has assumed its energized position. It will also be seen that the picking up of the relay CPRA1 in response to closure of the front contact 5 of the control relay CP results in the closure of an energizing circuit for relay CPRB1 which includes both this contact 5 of the control relay CP and the front contact 9 of the relay CPRA1. This pick-up and this stick circuit each include the common return wire CW. In other words, the circuit structure for these relays CPRA1 and CPRB1 is such that upon closure of the front contact 5 of control relay CP an energizing circuit for the relay CPRA1 only is closed and that this relay CPRA1 upon picking up will close an energizing circuit for the relay CPRB1 which will result in closing a stick circuit not including the contact 5, from which it is apparent that these relays will always pick up in the order CPRA1 followed by CPRB1. It is also readily seen that with these relays both

assuming their energizing position the opening of the contact 5 will directly break the energizing circuit for the relay CPRB1 but that the relay CPRA1 will remain energized through a stick circuit not including the front contact 5 of the relay CP. The stick circuit for relay CPRA1 will therefore not be broken until the relay CPRB1 has assumed its deenergized position. From this it is readily apparent that these relays will drop in the order CPRB1 followed by CPRA1. In other words, these relays CPRB1 and CPRA1 are always picked up in the order CPRA1 followed by CPRB1 whereas they are always dropped in the order CPRB1 followed by CPRA1. This particular sequence in the picking up of the relays CPRA1 and CPRB1 and the dropping of these relays in the reverse order is important because of the contacts 14 and 15 of these relays included in the load circuit.

It will be observed that the picking up of the relay CPRA1 may through the medium of its front contact 14 connect the secondary winding of the transformer T2 to the track circuit through the medium of the rectifier *rz* and that this rectifier *rz* may thereafter be shunted out by closure of the front contact 15 of relay CPRB1. As heretofore pointed out the contact 14 of the relay CPRA1 closes only during a negative wave of the alternating current. It is readily understood that the closure of this contact 14 will occur at the time the rectifier *rz* blocks the flow of current. After the contact has once closed pulsating current may flow to the track circuit.

It will also be remembered that the front contact 15 of the relay CPRB1 which closes later than contact 14 will close only during a positive wave of the alternating current. This contact 15 therefore always closes during a positive wave of the alternating current and therefore only closes when current is free to flow through the rectifier *rz* so that the potential difference across the terminals of this rectifier *rz* is extremely low and cannot cause sparking at the contact 15.

It will also be remembered from the foregoing consideration that the contact 15 of the relay CPRB1 always opens prior to the opening of the contact 14 of the relay CPRA1 and that this contact 15 only opens when current of positive polarity flows from the upper terminal of the secondary winding of the transformer T2 to the track circuit. Since the rectifier *rz* allows the free flow of this current of positive polarity the potential drop across this rectifier *rz* is very low and no sparking at the contact 15 upon opening of this contact will occur and that the opening of the contact 14 of the relay CPRA1 can only occur when the upper terminal of the secondary winding of the transformer T2 is negative at which time flow of current in the load circuit is blocked by the rectifier *rz* so that no sparking at the front contact 14 will occur upon opening of this contact.

The applicants have thus shown and described several embodiments of the present invention in one form of which an alternating current load circuit is closed through oppositely poled rectifiers included in multiple branches of this load circuit and in the other form of which a rectifier is temporarily included in the load circuit and it is desired to be understood that the invention is not limited to these embodiments and that various changes, modifications and additions may be made in practicing the invention without departing from the scope of the inven-

tion so long as these changes, modifications and additions come within the scope of the appended claims.

What we claim as new is:

1. Apparatus for respectively closing and opening an alternating current load circuit wholly automatically by said apparatus in a manner to prevent sparking comprising, means including an asymmetric unit for closing a load circuit through such asymmetric unit at that part of a cycle of said alternating current when current flows in a direction so that the resistance imposed by said unit is a maximum and for thereafter wholly automatically closing a by-pass partial circuit around said unit at that part of a cycle of said alternating current when such current flows in a direction so that the resistance imposed by said unit is a minimum, means including said means for opening said alternating current load circuit by inserting said asymmetric unit in said load circuit by removing such by-pass partial circuit at that part of a cycle of said alternating current when current flows in a direction so that the resistance imposed by said unit is a minimum and which then opens the said load circuit including said unit at that part of a cycle of said alternating current when current flows in a direction so that the resistance imposed by said unit is a maximum, and means for controlling both of said means by alternating current from the same alternating current source as that from which said load circuit is supplied.

2. Electro-responsive contact controlling means for controlling alternating current circuits comprising, a first polarity responsive relay controlled from an alternating current source and constructed to be slow acting and close and open a front contact when alternating current flowing from said source is of a polarity to flow in a particular direction irrespective of the time of closure or opening respectively of the control circuit for said relay, a second polarity responsive relay controlled from said alternating current source and constructed to be slow acting and close and open its front contact when alternating current flowing from said source is of the opposite polarity and irrespective of the time of closure or opening respectively of its control circuit, rectifying means, and a load circuit controlled by said two contacts and said rectifying means and by alternating current from the same source by controlling two circuit portions in multiple one including one of said contacts and the other including the other contact, said contacts being closed in sequence and at times when current flow due to said rectifying means in such portions is a minimum.

3. Electro-responsive apparatus for controlling an alternating current circuit, the combination with a source of alternating current, a first polarity responsive relay means controlled by current from said source and constructed to when energized from said source or deenergized irrespective of the time of energization or deenergization thereof with respect to a cycle of such current to close and open respectively a front contact thereof when the potential of said source is of a particular polarity, a second polarity responsive relay means controlled by current from said source and constructed to when energized from said source or deenergized irrespective of the time of energization or deenergization thereof with respect to a cycle of such current to close and open respectively a front contact thereof when the potential of said source is of the reverse polarity, and means including rectifying means and said contacts for controlling a load circuit by current from said source by controlling two circuit branches in multiple one during a plus half and the other during a minus half of a cycle of such alternating current each branch being closed at that time of an alternating current cycle when the current in such branch is a minimum.

4. Electro-responsive apparatus for controlling an alternating current controlled circuit, the combination with a source of alternating current, a first relay controlled by current from said source including relay retarding means to cause it when energized from said source or deenergized irrespective of the time of energization or deenergization thereof with respect to a cycle of such current to close and open respectively a front contact thereof when the potential of said source is of a particular polarity, a second relay controlled by current from said source including relay retarding means to cause it when energized from said source or deenergized irrespective of the time of energization or deenergization thereof with respect to a cycle of such current to close and open respectively a front contact thereof when the potential of said source is of the reverse polarity, a controlled circuit having two branch paths in multiple one of which includes a rectifier the flow of current wherein is controlled by one of said front contacts and the other branch of which includes the other of said front contacts, whereby upon energization of said relays the controlled circuit is first closed by one contact through a rectifier while such rectifier is blocking the flow of the initial current and such rectifier is then by-passed by the other contact while said rectifier passes current and upon deenergization of said relays the controlled circuit is first partially opened by opening such by-pass at a time when such rectifier is passing current and is then fully opened by opening the branch including said rectifier at a time when such rectifier is blocking current.

5. Apparatus for closing an alternating current load circuit in a manner to prevent sparking comprising, a first means for closing a load circuit through an asymmetric resistance unit at that part of a cycle of alternating current when the asymmetric resistance unit restricts the flow of current therethrough, other means for thereafter closing a shunt solely around said asymmetric resistance unit at that part of a cycle of the alternating current when the asymmetric unit is allowing the substantial free flow of such current, and means for controlling said first means and said other means by alternating current from the same source as that from which said load circuit is supplied.

6. Apparatus for opening an alternating current load circuit in a manner to prevent sparking comprising, means for inserting an asymmetric resistance unit in said load circuit by removing a by-pass circuit portion from immediately around such asymmetric resistance unit at that part of a cycle of said alternating current when the asymmetric resistance unit allows the substantial free flow of current therethrough, other means for thereafter opening the load circuit including said asymmetric resistance unit at that part of a cycle of said alternating current when the asymmetric unit is restricting the flow of such current, and means for controlling both of said means by alternating current from the same source as that from which said load circuit is supplied.

7. Apparatus for closing a circuit for the flow of alternating current with reduced sparking comprising, a first polarity responsive relay constructed to be actuated rapidly the instant the magnetism in its core structure has built up to a predetermined value in a particular direction, a second polarity responsive relay constructed to be actuated rapidly the instant the magnetism in its core structure has built up to a predetermined value in the opposite polarity direction, means for at times applying alternating current from such source to said relays to cause them to assume an actuated position in succession, said relays by reason of their polarity responsive character being operated sequentially time spaced substantially a half cycle of said alternating current in a manner such that one relay closes its contact when current from said source flows in one direction and such that the other relay closes its contact when current from said source flows in the opposite direction, an energizing circuit for said second relay including a contact closed only when said first relay assumes an actuated position, a load circuit including a front contact of said first relay and an asymmetric unit in series therewith poled to restrict the flow of current when the front contact of said first relay is first closed and a front contact of said second relay in multiple with said asymmetric unit.

8. Apparatus for closing a circuit for the flow of alternating current with reduced sparking comprising, a first relay constructed to be actuated rapidly the instant the magnetism in its core structure has built up to a predetermined value and including an asymmetric unit in series with its winding, a second polarity responsive relay constructed to be actuated rapidly the instant the magnetism in its core structure has built up to a predetermined value and including an oppositely poled asymmetric unit in series with its winding, means for at times applying alternating current from such source to said relays to cause them to assume an actuated position in succession, said relays and their associated asymmetric units by reason of their polarity responsive character being operated sequentially time spaced substantially a half cycle of said alternating current in a manner such that one relay closes its front contact when current from said source flows in one direction and such that the other relay closes its front contact when current from said source flows in the opposite direction, an energizing circuit for said second relay including a contact closed only when said first relay assumes an actuated position, a load circuit including a front contact of said first relay and an asymmetric unit in series therewith poled to restrict the flow of current when the front contact of said first relay is first closed and a front contact of said second relay in multiple with said last mentioned asymmetric unit.

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