Jan. 23, 1962 R. H. ALBRIGHT 3,018,414

INDIVIDUAL ONE-HALF CYCLE INTERRUPTING DEVICE

Filed June 13, 1958 2 Sheets-Sheet 1

FIG. 1

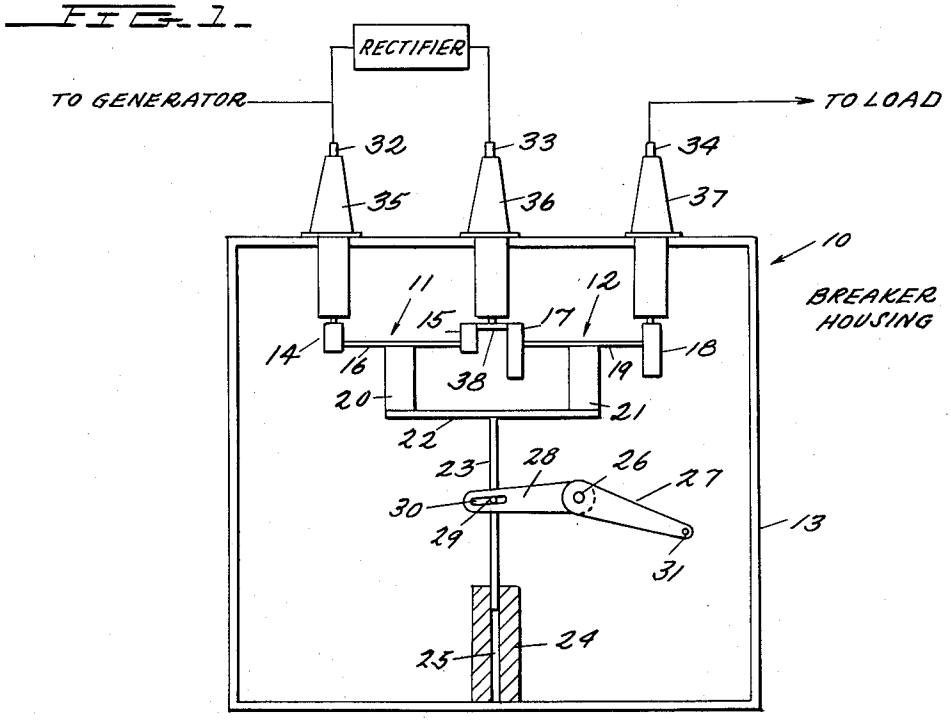


FIG. 2

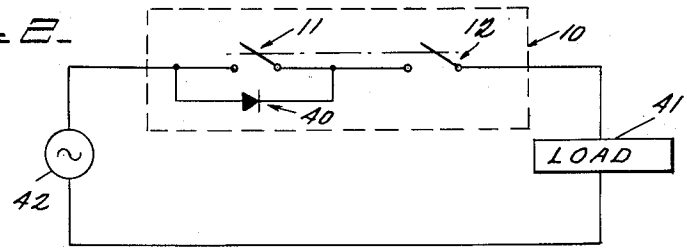
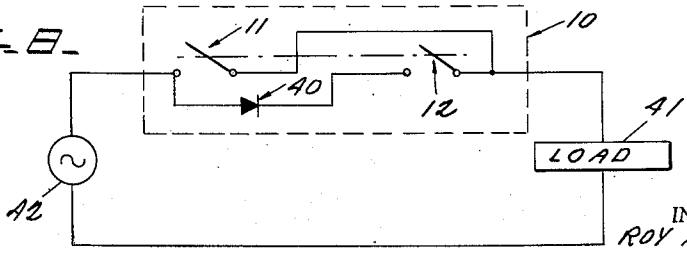


FIG. 3



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FIG. 3.

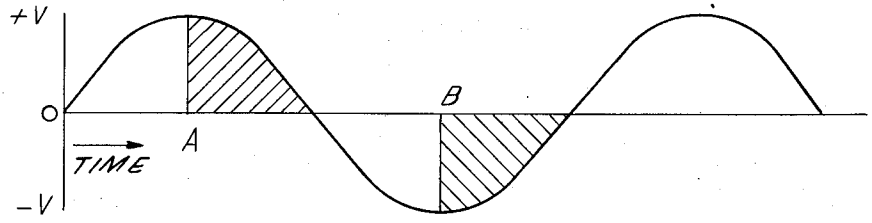


FIG. 4.

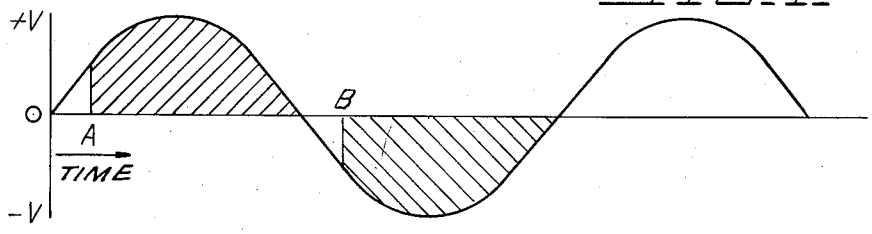


FIG. 5.

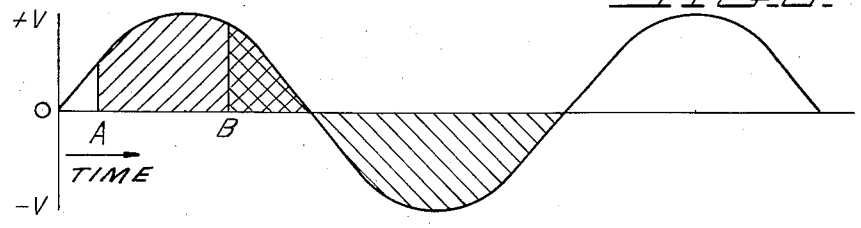


FIG. 6.

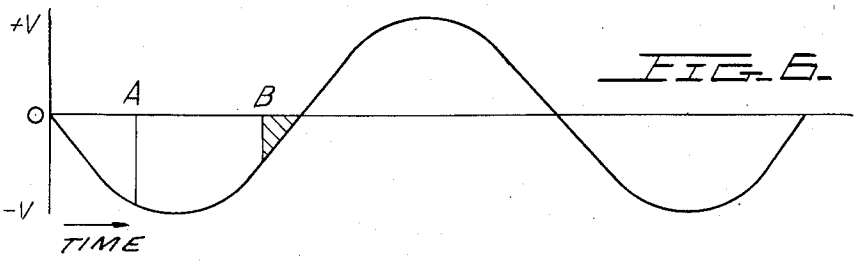
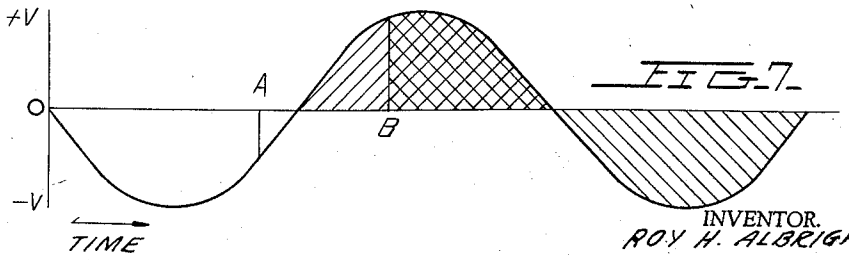


FIG. 7.



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INDIVIDUAL ONE-HALF CYCLE INTERRUPTING DEVICE

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Filed June 13, 1958, Ser. No. 741,757
5 Claims. (Cl. 317—11)

The instant invention generally relates to circuit interrupters and more particularly to an A.C. circuit interrupter having two pairs of cooperating contacts operated in sequence and operatively connected with a rectifier means so that each pair of cooperating contacts is required to interrupt only alternate half-cycles of current.

In the prior art the current flowing between a load and a source of A.C. power has been interrupted by a number of devices such as circuit breakers, horn gap switches, and disconnecting switches with arc chutes or other separate interrupting chambers. These devices have one thing in common in that circuit interruption is made with cooperating contacts. However, no attempt being made to select favorable interrupting conditions.

At the instant of final arc extinction in a circuit breaker a race begins between the rate of increase of dielectric strength in the space between the cooperating contacts and the rate of rise of recovery voltage. Circuit breakers are not capable of causing the dielectric strength to become infinite instantaneously but experience a residual conductivity and corresponding post arc current in the space between the parted contacts since this space is occupied by hot ionized gases.

In the device of the instant invention the arc is split into two sections and each section is subjected to a current zero for one half cycle so that the ionized gases have a prolonged interval of time in which to be cooled and otherwise deionized so that the chances of restrike are minimized once potential reappears across the parted contacts.

Briefly, my device comprises a first and a second pair of cooperating contacts together with a rectification means which is arranged in parallel with the first pair of contacts and in series with the second set of contacts. The first pair of contacts are opened first to interrupt the half cycle of current which the rectification means will not pass. Subsequent to the opening of the first pair of contacts preferably within one quarter to one half cycle thereafter, the second pair of contacts is opened and is effective to interrupt the half cycle of current which is passed by the rectification means.

Thus the half cycles of current which are blocked by the rectifier will flow through the arc of the parallel connected contacts and the half cycles which are passed by the rectifier will flow through the series connected contacts. This will lessen the duty on each set of contacts by providing one half cycle of current zero in each cycle for each pair of contacts.

The rectification means can be of the semiconductor type such as germanium and silicon and can be of a relatively small size as it is not required to carry continuous current. The only current duty will be a relatively high current for only a few cycles during operation of the circuit interrupter. While the circuit interrupter is closed the rectifier is bypassed by the low resistance of the engaged first pair of cooperating contacts paralleling the rectifier.

The prior art has often employed a plurality of rectifiers and a plurality of pairs of contacts in arrangements for short time switching. Each rectifier was arranged in a separate branch of a number of parallel circuits with the opening means for the contacts of one branch being controlled from one of the other branches.

These short time switching arrangements were merely utilized to handle small magnitudes of current. Even though the currents were small, elaborate precautions were included to prevent arcing between the contacts so that contact separation could not take place simultaneously with the occurrence of an overload condition.

Applicant's novel circuit arrangement employs a single rectifier and is utilized to interrupt fault currents of high magnitude by interrupting current flowing between a load and an A.C. source as soon as possible after the occurrence of an overload, without the necessity of waiting for any auxiliary equipment to cycle.

Accordingly, a primary object of the instant invention is to provide a novel improved A.C. circuit breaker, for interrupting high magnitudes of current, in which the duty cycle of the contacts is reduced.

Another object is to provide a circuit interrupter having two pairs of cooperating contacts with each pair being required to interrupt merely alternate half-cycles of current.

Still another object is to provide a circuit breaker for interrupting currents of high magnitude in which a rectifier is connected in parallel with a first set of contacts and in series with a second set of contacts with the first set being opened before the second set.

These as well as other objects of the instant invention shall become readily apparent after reading the following description of the accompanying drawings in which:

FIGURE 1 is a side view, partially sectioned, of a circuit breaker constructed in accordance with the principles of the instant invention.

FIGURE 2 is a schematic diagram illustrating the circuit breaker of FIGURE 1 connected in a circuit.

FIGURES 3–7 are voltage waveforms illustrating the conducting periods through each pair of contacts when the contacts are parted at different portions of the voltage cycle.

FIGURE 8 is a schematic diagram illustrating a modification of the circuit arrangement of FIGURE 2.

Now referring to the figures, circuit breaker **10** comprises a first and a second set of cooperating contacts **11** and **12**, respectively, mounted within enclosure **13** which, if desired, may be oil filled. The first set of contacts **11** comprises two spaced stationary contacts **14**, **15** and a movable blade **16** positioned to bridge the space between contacts **14**, **15** when circuit breaker **10** is closed. Similarly the second set of contacts **12** comprises two spaced stationary contacts **17**, **18** and a movable blade **19** positioned to bridge the space between contacts **17**, **18** when circuit breaker **10** is closed. Even though they have not been illustrated, it is apparent that a suitable arc extinguishing means may be associated with each of the stationary contacts.

Blades **16** and **19** are mounted on insulators **20** and **21**, respectively, which are both carried by cross-member **22** mounted to the upper end of shaft **23**. The lower end of shaft **23** is entered into a vertically extending opening **25** of member **24** mounted to the bottom of enclosure **13**. Shaft **23** may have a non-circular cross-section with opening **25** having a similar cross-section thereby preventing rotation of shaft **23** while it is being raised and lowered.

Jack-shaft **26** extending through a wall of enclosure **13**, has crank arms **27**, **28** keyed thereto. Arm **27** is positioned externally of enclosure **13** and is adapted to be connected to a conventional type actuating mechanism (not shown) for oscillation of arm **27** so that the circuit breaker **10** may be operated to its On and Off positions. The operating mechanism is preferably of the trip free type and should also be responsive to automatically open circuit breaker **10** upon the occurrence of an overload. Arm **28** extends from jack shaft **26** in a direction opposite

to that of arm 27 and engages vertical shaft 23 by means of pin 29 which projects from shaft 23 and is received by elongated slot 30 in arm 28.

Thus by moving the free end 31 of arm 31 upwardly from its position in FIGURE 1, jack shaft 26 will be rotated counterclockwise carrying crank arm 28 with it. Slot 30 also moves counterclockwise about jack shaft 26 as a center causing pin 29 and shaft 23 to be carried downward.

Since contacts 14 and 15 are shorter than contacts 17 and 18 blade 16 will separate from contacts 14, 15 before blade 19 separates from contacts 17, 18. After blade 16 has parted from contacts 14, 15 blade 19 is in sliding engagement with contacts 17, 18 until upon continued downward movement of shaft 23 blade 19 separates from contacts 17, 18. Thus, upon opening of circuit breaker 10 the disengagement of the first set of contacts 11 precedes the disengagement of the second set of contacts 12.

External connections to the stationary contacts 14, 15, 17, 18 are made by means of conducting studs 32—34 which extend through insulating bushings 35—37, respectively while strap 38, having both contacts 15 and 17 secured thereto, is mounted on stud 33.

Circuit breaker 10 also includes a rectifier 40, preferably comprising a semi-conductor, which is connected between studs 32, 33. That is, rectifier 40 is connected in parallel with the first set of contacts 11 and in series with the second set of contacts 12. When circuit breaker 10 is connected in a circuit between a load 41 and source of A.C. power 42 and stud 34 is connected to load 41. Contacts 11 shunt rectifier 40 when circuit breaker 10 is closed so that rectifier 40 is only subjected to short intervals of duty during opening of circuit breaker 10.

Rectifier 40 is connected in the circuit of FIGURE 2 so that it is blocking during the positive half cycles of voltage from source 42 indicated in FIGURES 3–7. In the illustrations of FIGURES 3 and 4 it is assumed that contacts 12 open approximately one half cycle after contacts 11 while in FIGURES 5 and 6 it is assumed that the opening of contacts 12 follows the opening of contacts 11 by approximately one quarter cycle.

The waveforms of FIGURES 3–7 illustrate the voltage delivered by A.C. power source 42. Points designated A and B indicate the points in time of the parting of contacts 11 and 12 respectively. The shading of lines slanting upward from left to right indicate the intervals of arc current between parted contacts 11 while the lines slanting downward from left to right indicate the intervals of arc current between parted contacts 12. The cross latching indicates the intervals during which arc are present at both sets of parted contacts 11 and 12.

In FIGURE 3 circuit breaker 10 is opened in response to a fault or otherwise when the voltage is a positive maximum. Rectifier 40 appears as an open circuit so that an arc is drawn between the first parted contacts 11. This arc persists until the voltage reaches zero approximately one quarter cycle later. Upon reversal of voltage polarity rectifier 40 appears to short the parted contacts 11 thereby maintaining a voltage zero across contacts 11 for one half cycle. During this prolonged interval the combination of contact separation distance and the extended time for deionization of the arc gases builds up the dielectric strength in the gap between parted contacts 11 to prevent restrike when rectifier 40 once again becomes blocking.

When rectifier 40 becomes conducting during the negative half cycle of voltage, all current to load 41 passes through rectifier 40 and contacts 12 in series. At approximately the negative voltage maximum contacts 12 become disengaged drawing an arc therebetween with the arc current passing through rectifier 12.

By the time the voltage reverses polarity to become positive, the gap between parted contacts 11 has become sufficiently deionized to prevent restriking of an arc thereacross. Therefore, any arc current which now might tend to flow between parted contacts 12 is confronted by the essentially infinite impedance of parted contacts 11 in parallel with the blocking rectifier 40 which also presents an extremely high impedance and the arc between parted contacts 12 is extinguished. This condition exists for the next half cycle so that the gap between parted contacts 12 may be sufficiently deionized to prevent restriking when the voltage reaches its next negative half cycle.

Thus each of the sets of contacts 11, 12 will be called upon to interrupt a current which exists for one-half cycle and will then have one-half cycle of current zero before being subjected to another half cycle of current. In the half cycles of current zero the spaces between the parted contacts become sufficiently deionized to prevent restriking when upon voltage reversal in the following half-cycles. In this manner improved rapid arc interruption takes place.

In FIGURE 4 circuit breaker 10 is opened shortly after the voltage begins to rise in the positive direction so that the arc between parted contacts 11 exists for nearly a complete half cycle before the voltage across contacts 11 drops to zero. For the next half cycle rectifier 40 passes current which initially flows through engaged contacts 12 and shortly after the voltage swings negative the current flows through the arc between the parted contacts 12. The later formed arc is extinguished in slightly less than one-half cycle when the voltage reverses to the positive direction since rectifier 40 becomes blocking and the gap between parted contacts 11 is deionized to prevent restriking of the arc.

In FIGURE 5 the operation of circuit breaker 10 is initiated at the same point in the voltage cycle as in FIGURE 4. However, contacts 12 are disengages only one-quarter of a cycle after the disengagement of contacts 11. Thus the arc current between parted contacts 11 will first flow through engaged contacts 12 and upon the parting thereof will flow through the arc drawn therebetween. The arc between parted contacts 11 will continue until rectifier 40 becomes conducting as the voltage polarity reverses to negative. However, the arc between parted contacts 12 will continue until the voltage once again reverses to become positive with the rectifier 40 and parted contacts 11 both now presenting an extremely high impedance. Thus the circuit interruption is complete within less than one cycle.

In FIGURE 6 circuit breaker 10 is opened in the first half of the negative half cycle. At this time rectifier 40 is conducting so that no arc is drawn between contacts 11. In the second half of the negative half cycle contacts 12 are parted drawing an arc whose current passes through rectifier 40. When the voltage swings positive it is highly probable that the impedance of the gap between parted contacts 11 is too high to sustain an arc. Therefore, the arc between parted contacts 12 is extinguished in less than one quarter cycle.

In FIGURE 7 circuit breaker 10 is opened in the second half of the negative half cycle so that contacts 12 part during a positive half cycle. If contacts 11 are parted sufficiently close to the end of the negative half cycle an arc will be drawn therebetween during the positive half cycle with the arc current first passing through closed contacts 12 then through the arc between parted contacts 12. The arc between parted contacts 11 is extinguished in the next negative half cycle and the arc between parted contacts 12 is extinguished in the subsequent positive half cycle.

FIGURE 8 illustrates an alternate circuit arrangement which operates on the same principles as the arrangement of FIGURE 2. In FIGURE 8 rectifier 40 is also in series with contacts 12, however, contacts 11 are connected in parallel with the series combination of rectifier 40 and contacts 12. The sequence of contact operation is the same, that is, opening contacts 11 precedes the opening of contacts 12.

If the circuit breaker is opened on a positive half cycle

an arc is drawn between parted contacts 11. On the next negative half cycle the arc is paralleled by a relatively low impedance of the conducting rectifier 40 connected in series with still closed or only partially opened contacts 12. Thus the arc current between parted contacts 11 will be transferred to flow through rectifier 40 with this current zero continuing during the negative half cycle. The arc between parted contacts 12 extinguishes when the rectifier 40 becomes blocking on the next positive half cycle. By this time the space between parted contacts 11 has been deionized sufficiently to prevent restrike so that interruption is complete.

If the circuit breaker of FIGURE 8 is opened on a negative half cycle no arc is drawn between contacts 11 as they initially part. If contacts 11 are sufficiently parted by the time the positive half cycle begins no arc will be drawn therebetween. Whether or not an arc is drawn between parting contacts 12 then depends upon the opening of contacts 12 during the next positive half cycle and the degree of separation of the contacts 12 during the next negative half cycle.

While the disengagement of contacts 12 has been described as following the disengagement of contacts 11 by one-quarter to one-half cycle, it is to be understood this time interval may vary within limits. Tests with particular types of circuit breakers have indicated that the interval of from one-quarter to one-half cycle is merely best for those particular breakers.

Thus I have provided a novel arrangement for the interruption of high magnitude currents. This arrangement comprises the connection of a rectifier means in parallel with a first set of contacts and in series with a second set of contacts with the first set of contacts being opened before the second set. In this manner each set of contacts is subjected to a long interval of current zero during which a high degree of dionization may take place thereby reducing the arcing time at each set of contacts.

In the foregoing, I have described my invention only in connection with preferred embodiments thereof. Many variations and modifications of the principles of my invention within the scope of the description herein are obvious. Accordingly, I prefer to be bound not by specific disclosure herein but only by the appending claims.

I claim:

1. An A.-C. circuit breaker for controlling the flow of current in an A.-C. circuit; said A.-C. circuit breaker comprising a first pair of cooperating contacts and a second pair of cooperating contacts and a rectifier; said first and second pair of cooperating contacts being movable between an engaged and disengaged position; circuit connections for connecting said rectifier in series with said first pair of cooperating contacts and said A.-C. circuit and for connecting said rectifier in parallel circuit relation with respect to said second pair of cooperating contacts; an operating means for operating said first and second pair of cooperating contacts from their said engaged position to their said disengaged position; said operating means being connected to said first and second pair of cooperating contacts and being operable to first move said second pair of cooperating contacts to their said disengaged position and to thereafter move said first pair of cooperating contacts to their said disengaged position; said rectifier being rated to be capable of conducting the full load current of said A.-C. circuit for at least one-half cycle in series with said first pair of cooperating contacts; at least one of said first or second pair of cooperating contacts conducting the full alternating current of said A.-C. circuit when closed.

2. The device as set forth in claim 1 wherein said second pair of cooperating contacts conducts alternating current when closed; said second pair of cooperating contacts being connected in series with said A.-C. circuit and in parallel with the series connector of said rectifier and said first pair of cooperating contacts.

3. The device as set forth in claim 1 wherein both of said first and second pair of cooperating contacts conduct alternating current; said first and second pairs of cooperating contacts being connected in series with one another and in series with said A.-C. circuit; said rectifier being connected directly across said second pair of cooperating contacts.

4. The device as set forth in claim 1 wherein said first pair of cooperating contacts are moved to their said disengaged position between one-quarter and one-half of a cycle after the movement of said second pair of cooperating contacts to their said disengaged position.

5. The device as set forth in claim 1 wherein said operating means is operated responsive to predetermined fault conditions in said A.-C. circuit.

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