

- [54] MULTI-SHOT RECLOSING RELAY HAVING MEANS FOR REMEMBERING TRIP AND RECLOSURE STATUS IN THE EVENT OF LOSS OF POWER
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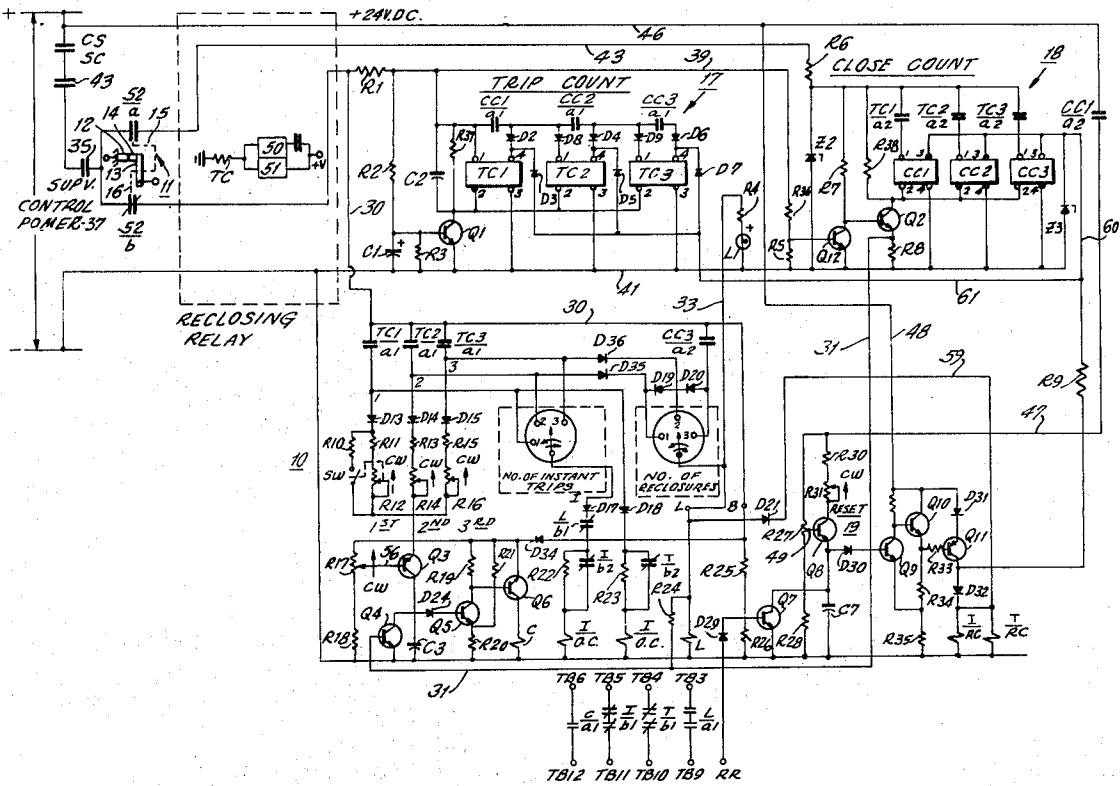
[57] **ABSTRACT**

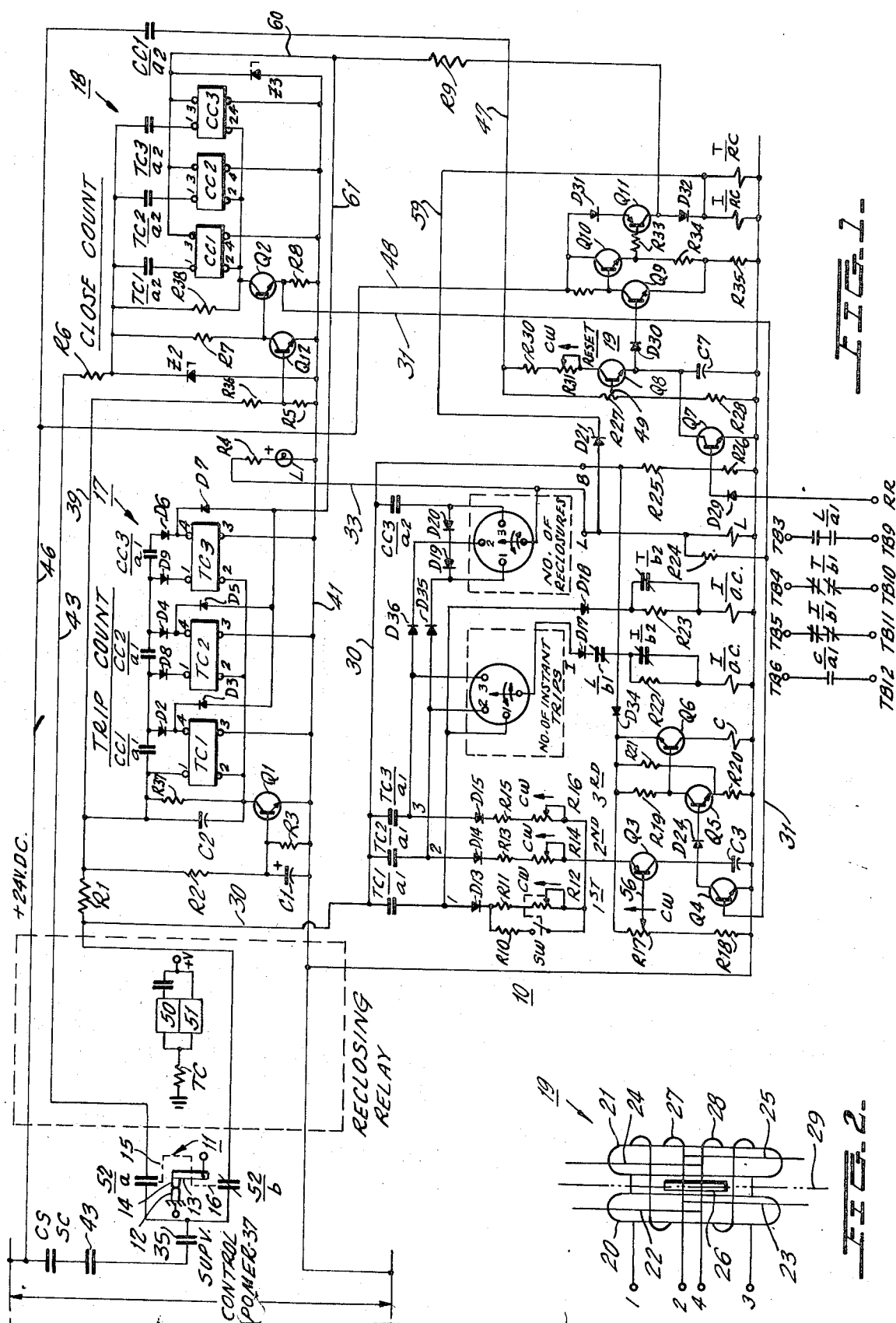
An automatic reclosure employing latching relay structures. The recloser is designed to trip and reclose a selected number of times, dependent upon the particular preset program selected. The latching relay devices are capable of “remembering” the number of tripping operations and reclosure operations which have occurred prior to any loss in power for the system so that this information is retained when power returns to the system.

The automatic reclosure circuitry prevents successive tripping operations from being performed in the absence of intervening reclosure operations and vice versa. In addition thereto, the circuitry is responsive to the state of the circuit breaker being controlled by the recloser system and not to the state of the control power.

- [56] **References Cited**
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14 Claims, 2 Drawing Figures





MULTI-SHOT RECLOSING RELAY HAVING MEANS FOR REMEMBERING TRIP AND RECLOSURE STATUS IN THE EVENT OF LOSS OF POWER

The present invention relates to reclosers and more particularly to a novel automatic recloser system capable of retaining the number of trip and reclosure operations performed prior to loss of control power so that this information is still present upon the return of control power and further provides circuitry which prevents counting of successive trip operations unless and until an intervening reclosure operation has occurred, and vice versa.

SYSTEM APPLICATION

Reclosing relays are used whenever it is desired to automatically reclose a circuit breaker one or more times after it has been tripped by its protective relay. The protective relays are employed to protect power lines which may be subjected to temporary faults caused by lightning or tree branches which may fall on the power lines wherein the lightning surge disappears after a brief interval and wherein the tree branches are caused to burn free leaving the line free. A reclosing relay recloses in the following manner:

RECLOSE TIMING

The reclosing relay is designed to provide for the selection of a desired number of reclosure operations. An adjustable time delay is also provided before each reclosure signal to allow sufficient time for line conditions to stabilize, usually of the order of a few seconds or less.

RESET TIMING

A successful reclosure operation is determined by a preset time delay initiated by the reclosing relay each time the breaker recloses. If the breaker remains closed for this time period, the reclosing relay resets to reinstitute the desired number of reclosures.

LOCKOUT

If, after the preset number of reclosures, the breaker trips before the reset time elapses, the reclosing signal ceases and the relay indicates a lockout condition.

BACKGROUND OF THE INVENTION

Prior art reclosing relays have been constructed employing a synchronous motor which drives a cam shaft usually provided with a plurality of cams. The cams are designed to actuate contacts (either open or closed) in the manner of a drum controller. Reset is obtained by means of a spring and clutch arrangement which disengages the cam shaft mechanism from the motor drive and returns it to its reset position. This complex mechanism, having a large number of moving mechanical components, is not conveniently programmable and is subject to wear and damage through handling and/or use.

Solid state counting circuits have been employed in reclosing relays. However, such circuitry requires adequate buffer circuits to prevent false operation due to the occurrence of transients. In addition thereto, unlike the electro-mechanical relays which are capable of conserving the reclosing program state by virtue of their mechanical position, the relays of the solid state

type will lose this important information with the either brief or indefinite loss of control power. The solid state type of relay is designed for use with batteries and cannot be supplied from control power derived from the a.c. power line which is subject to faults cleared by a reclosing circuit breaker.

BRIEF DESCRIPTION OF THE INVENTION

The present invention is characterized by providing a reclosing relay which, in one preferred embodiment, employs latching reed relays adapted to retain the reclosing program step which it has achieved prior to and during the interruption of control power so as to be capable of continuing from such a "remembered" state when control power is restored.

The reclosing relay of the present invention employs a trip count circuit operated by a circuit breaker auxiliary contact which closes when the breaker opens (i.e., trips). In addition, the relay has a close count circuit operated by a second auxiliary contact provided with the circuit breaker, which contact is adapted to close when the breaker closes.

In addition thereto, the trip count and close count circuits are interlocked in such a manner so that a closure must occur (as indicated by the circuit breaker first auxiliary contact) before a subsequent trip can be counted. Conversely, a trip must occur before a subsequent closure can be counted.

The reclosing relay further includes a reclose timing circuit operated by the trip count circuit and a reset timing circuit operated by the close count circuit to respectively reset these count circuits under appropriate conditions.

The circuit breaker is provided with time and instantaneous overcurrent relays for sensing an overload condition and tripping the circuit breaker either instantaneously or after a predetermined time delay depending upon the state of the reclosure circuit at the time that the overload or overcurrent condition is sensed. The tripping of the circuit breaker causes the circuit breaker first auxiliary contact to apply a signal to the trip count circuit, which signal is stored therein to indicate that one tripping operation has occurred. The trip count circuit establishes a predetermined circuit path in the close count circuit in readiness for the first reclosure operation to be performed. The trip count circuit also establishes a predetermined circuit for determining the interval of time between the trip operation and the first reclosure operation. At this time, since the circuit breaker second auxiliary contact is open, it is not possible to develop a spurious close count until reclosure occurs. Thereafter and upon reclosure, a close count is established whereby the close count circuit conditions a trip count circuit to be capable of "remembering" the second trip operation (if one is necessary) as and when it occurs. In addition thereto, the close count circuit initiates the timing interval of a reset circuit permitting both the close and trip count circuits to be reset to zero if the circuit breaker remains closed after the first or subsequent reclosure operations. The close count circuit, upon storage of a count of reclose operations which is equal to the capacity of the close count circuit, instantaneously goes to lockout to provide an alarm indication and to prevent any further reclosure operation. The close count circuit is further provided with adjustable switch means for adjusting the number of reclosures which may occur before lock-

out. The reset circuit activated by the close count circuit further simultaneously resets the circuit breaker overcurrent relays to their initial condition once a sufficient amount of time has passed for the reset circuit to time out before the occurrence of another trip operation. Also, once the close count circuit reaches the maximum number of reclosures set by its adjustable switch means, the close count circuit automatically causes a trip operation to occur simultaneously with the development of the lockout condition.

BRIEF DESCRIPTION OF THE FIGURES AND OBJECTS

It is, therefore, one object of the present invention to provide a novel reclosing relay capable of being programmed to select a number of trip and/or reclosure operations prior to lockout and to be capable of remembering the number of trips and/or reclosures which have occurred just prior to and during the interruption of power so as to be capable of returning to the same state when control power is resumed.

Another object of the present invention is to provide a novel recloser relay programmable to provide an adjustable number of trip and/or reclosure operations prior to lockout wherein the operation of counting and remembering trips and/or closure operations is dependent only upon the state of the circuit breaker and not the state of the control power.

Still another object of the present invention is to provide a novel reclosure relay programmable to select a desired number of trip and/or closure operations which may occur prior to lockout wherein the trip and close counting devices respectively control reclose and reset timing circuits for respectively controlling the time delay before reclosure and the time delay before reset of the reclosure relay.

Still another object of the present invention is to provide a novel reclose relay programmable to select the number of trip and/or reclosure operations which may occur prior to lockout wherein the trip and close count circuits are interlocked so as to prevent successive trip counts from being developed prior to the occurrence of an intervening close count, and vice versa.

The above as well as other objects of the present invention will become apparent when reading the accompanying description and drawings in which:

FIG. 1 is a schematic diagram showing a reclosure relay designed in accordance with the principles of the present invention.

FIG. 2 is a diagram showing a latching reed relay which may be employed in the trip and close count circuits in the reclosure relay of FIG. 1.

DETAILED DESCRIPTION OF THE FIGURES

FIG. 1 shows a reclosure relay 10 for operating the tripping and reclosure of a circuit breaker 11 which in very simplified fashion, is comprised of a stationary contact 12 and a movable arm 13 carrying a cooperating contact 14 for selective engagement and/or disengagement with stationary contact 12 to establish respectively a closed or open circuit therethrough. Stationary contact 12 is connected into a transmission line to be protected as is movable contact 14. Instantaneous and time overcurrent relays 50 and 51 are typically inductively coupled to the transmission line being protected to respectively provide instantaneous or time delays after the sensing of an overcurrent condition for the

purpose of energizing a circuit breaker trip coil TC connected in common with the outputs of relays 50 and 51. Relay 50 is coupled to power +V through the operation of the switch contacts to be more fully described, relay 51 is directly connected to supply +V.

Let it be assumed that the contacts between +V and instantaneous overcurrent relay 51 are open and that an overcurrent condition is occurring in the line being sensed. Time overcurrent relay 51 will thus sense this condition and after a predetermined time interval will energize trip coil TC to trip the circuit breaker (movable arm 13) to the open or tripped position. Movable arm 13 is coupled to a pair of contacts 52/a and 52/b by mechanical means represented by dotted lines 15 and 16 respectively, in FIG. 1. The operation is such that when the circuit breaker is tripped the mechanical coupling to the above mentioned switches causes contact set 52/b to close when the circuit breaker trips and to cause contact set 52/a to open when the circuit breaker trips. Conversely, contact set 52/a is closed when the circuit breaker is closed and contact set 52/b is open when the circuit breaker is closed. It can clearly be seen that the contact sets 52/a and 52/b are never simultaneously open or closed. If the contact set coupling the instantaneous overcurrent relay to supply +V is closed then, even though both overcurrent relays are enabled, the instantaneous overcurrent relay will "time out" first.

The reclosure relay control 10 of FIG. 1 is comprised of a trip count circuit 17 and a close count circuit 18. Each of these circuits 17 and 18 employ a plurality of two form *a* dual coil latching reed relays. One typical relay 19 which may be employed for this purpose is shown in FIG. 2 and is comprised of first and second glass envelopes 20 and 21 each containing a pair of contacts 22-23 and 24-25, respectively. The inner ends of these contacts are contained within the glass envelopes 20 and 21 and are normally positioned so as to be disengaged, as is shown in FIG. 2. These contacts have a predetermined amount of resiliency and further have a magnetic permeability characteristic which functions in a manner to be more fully described. The envelopes 20 and 21 are separated by a small distance sufficient to position a permanent magnet member 26 which functions in a manner to be more fully described. First and second windings or coils 27 and 28 are wound about the envelopes 20 and 21 in the manner shown.

The operation of the latching relay of 19 of FIG. 2 is as follows:

Let it be assumed that the contact pairs 22-23 and 24-25 are in the open or disengaged position and that a signal is applied across the terminals 1-2 of winding 27. A current flow through winding 27 sets up a magnetic field in the axial direction represented by phantom line 29. The magnetic permeability characteristic of the contacts 22-23 and 24-25 is such as to cause these contacts to move into alignment with the magnetic field generated by energized coil 27 whereby these contacts move to the closed position. Permanent magnet member 26 latches the contacts in the closed position so that the contacts remain in this position even if current is removed from winding 27.

Let it now be assumed that the contacts are in the closed position as a result of the latching operation of permanent magnet member 26. Let it now be assumed that it is desired to move the contact sets to the open

position. To do this a current is applied across terminals 3-4 of winding 28 which encircles both glass envelopes 20 and 21 (as does winding 27). The magnetic field generated by the current passing through winding 28 causes the close contact sets to separate and once separated the contacts are free of the influence of permanent magnet 26 so as to remain in the open (i.e., rest) position.

Let it now be assumed that the contacts are in the open position and that current is applied simultaneously to windings 27 and 28. The magnetic fields generated by coils 27 and 28 tend to counterbalance one another so as to have no effect on the contact sets 22-23 and 24-25 so that they will remain in the open condition. Conversely, if the contact sets are latched in the closed position by permanent magnet 26 and currents are simultaneously applied to windings 27 and 28 the fields generated by these windings cancel one another causing the contact sets 22-23 and 24-25 to remain in the "latched" condition.

The coil 27 having terminals 1-2 will hereinafter be referred to as the "set" coil and the coil 28 having the contact terminals 4-3 will hereinafter be referred to as the "reset" coil.

The sequencing circuit of the recloser is operated by the circuit breaker auxiliary switch sets 52/b and 52/a which are wired in series with enabling contacts such as the breaker control switch CS/SC which functions to open to prevent the breaker from reclosing under control of the recloser when tripped by a manual tripping device (not shown) provided for operator use. The CS/SC contacts close when the above-mentioned manual tripping device operates the breaker to the closed position. The reclosing cutout switch 43, in series with the CS/SC switch, is movable to the open position when it is desired to deactivate the reclosure circuit 10 and which is movable to the close position when it is desired to activate the reclosure relay 10. The supervisory contacts 35 are employed for exerting remote control over the circuit breaker operation, when and if desired.

The sequencing circuit of the relay 10 includes the trip count and close count circuits 17 and 18 each of which contains three trip count reed relays TC1-TC3 and three close count reed relays CC1-CC-3, respectively. The trip count relays are operated by the 52/b contact and the transistor switch Q1 provided the appropriate enabling contacts are made. The sequencing of these reed relays are controlled by close count reed contacts to be more fully described. Each close count relay is operated by a trip count relay contact and the transistor switch Q2. These trip and close count reed contacts (see the contact sets 22-23 and 24-25) establish the interlocking between the trip and close count circuits which function in a manner to be more fully described.

Let it be assumed that time overcurrent relay 51 protects an overload condition and trips circuit breaker 11 after the time delay interval determined by the time overcurrent characteristic of relay 51. The tripping of breaker 11 causes the contact set 52/b to be closed to couple control power 37 through contact sets CS/SC, 43, 35, 52/b, resistor R1 and resistor R2 to the base of transistor Q1. Simultaneously therewith, this established conductive path is coupled through lead 39 and resistor R36 to the base of transistor Q12. Q12 turns on to provide a substantially zero voltage drop across its

emitter and collector electrodes and to prevent base current from being applied to the base of Q2. Hence, Q2 is turned off to prevent operation of the close count circuit. When contact 52/a opens, the 52/b contact closes which also removes control power from the close count circuit, the action of transistor Q12 thereby prevents a close count should the operation of the contacts overlap.

As was set forth hereinabove, control power is applied to the base of transistor Q1. However, the provision of capacitor C1 across the base and emitter of Q1 energizes the base of transistor Q1 only after a time delay in order to override the natural bounce period which may occur during the closure of contact set 52/b. The specific time delay provided is dependent upon the capacitance value chosen for C1.

As a result of the first trip operation, Q1 is energized to develop a current through its collector. This current develops a voltage drop across resistor R37 and thereby applies a current to terminals 1-2 of the trip count latching relay TC1. Contact set CC1/a1 is open at this time so as to prevent the application of power to terminals 4-3 of TC1, as well as preventing the application of control power to any of the remaining trip count latching relays. The energization of the set coil (see coil 27 of FIG. 2) of TC1 closes contacts TC1/a2 which is coupled to the set coil of the latching relay stage CC1 of the close count circuit 18. No further action occurs at this time since Q is maintained in the off condition due to the energization of Q12. Since contact 52/a is open at this time, this acts as a further means for preventing a spurious close count operation.

When the circuit breaker recloses, the 52/b contact opens to deenergize transistor Q12 and the 52/a contact closes to apply voltage to the close count circuit through lead 43, resistor R6 and resistor R7 which is coupled to the base of Q2. The application of base current to Q2 turns Q2 on. The collector current developed at this time generates a voltage drop across resistor R38 which applies current to the set coil terminals 1-2 of close count stage CC1 due to the fact that contact set TC1/a2 was closed during the first trip operation described hereinabove. The energization of the CC1 stage set coil (see winding 27 of FIG. 2) causes its contacts CC1/a1 and CC1/a2 to close. No further action occurs since the trip count circuit is now deenergized due to the fact that contact set 52/b is open when the circuit breaker is in the reclose condition.

When circuit breaker 11 trips a second time, contact 52/b closes and Q12 is energized to bypass space current from Q2 to prevent operation of the close count circuit and thereby prevent the generation of a spurious close count. Contact 52/b also energizes the reset coil of trip count stage TC1 through resistor R1, closed contact CC1/a2, diode D2 and reset coil terminals 4-3 (see reset coil 28 in FIG. 2, for example) to the return line 41 for control power source 37. As a result, contact TC1/a2 in the close count circuit 18 opens. Transistor Q1 turns on after the aforementioned time delay caused by capacitor C1 and simultaneously energizes the set coils of trip count stages TC1 and TC2. As a result, contact TC2/a2 in the close count circuit 18 is closed. Since both coils of TC1 and TC2. As a result, contact TC2/a2 in the close count circuit 18 is closed. Since both coils of TC1 are energized, its contacts remain in the reset (open) state.

When the circuit breaker recloses a second time, Q2 turns on to energize close count stage CC2 (since contact set TC2/a2 is closed and contact set TC1/a2 is open at this time). The energization of stage CC2 causes its contact CC2/a1 in the trip count circuit 17 to be closed. When the circuit breaker trips a third time, TC2 is reset in the same manner as was previously described in connection with stage TC1 and TC3 is set after the delayed turn on of Q1 in the same manner as was previously described for the setting of stage TC2.

Upon the third reclosure operation, CC3 sets (i.e., closes) and the fourth trip resets TC3 to complete the full sequence.

It should be noted that the sequencing set forth hereinabove depends only upon the state of the contacts 52/b and 52/a and not upon the state of the control power and hence no spurious trip or close counts can be developed. Since the reed contacts of the stages TC1-TC3 and CC1-CC3 are all held magnetically (see permanent magnet 26 of FIG. 2), the sequence which may be arrived at any given instant is conserved even during a loss of control power and the system will return to the state of the sequence when control power is restored.

It should be noted that whereas the stages of the trip count 17 and close count 18 circuits are described as utilizing latching reed relay devices, it should be understood that any other type of relay device having a similar latching capability (either mechanical or magnetic) may be employed with equal success.

RESET OPERATION

Upon the occurrence of the first reclose operation, contact CC1/a2 closes to establish an electrical path from control power 37 through lead 46 and lead 47 for energizing the reset timing circuit 19. After a time interval which may be adjustably determined by presetting potentiometer R31 (which cooperates with capacitor C7 in a manner to be more fully described) transistor Q11 is adapted to turn on to energize all of the reset coils of the reclosing relay.

The fixed voltage drops of diode D31 and the base emitter of Q11 must be exceeded in order for Q11 to turn on. Normally, transistor Q10 is maintained on by virtue of base current flowing through lead 46, lead 48 and resistor R32. Hence, Q10 prevents base current from flowing into the base of Q11. At the same time, the Q10 emitter current flows into the voltage divider comprised of resistors R34 and R35 to establish a reference voltage at the emitter of Q9. When the voltage at the base of Q9 exceeds this fixed reference, Q9 will act to divert base current from the base electrode of Q10, allowing for the abrupt turn on of Q11. As a result, a lower emitter reference is established at the emitter of Q9 by virtue of Q11 base current flowing in resistors R33, R34 and R35.

Consequently, the base of Q9 must drop to the lower reference voltage level in order to turn off.

The closure of contact CC1/a2 establishes a reference voltage at the base of Q8 which reference voltage is determined by the positioning of the arm 49 of adjustable resistor R27 and the value of resistor R28. Consequently, the difference between input voltage and this reference voltage appears across resistor R30 and adjustable potentiometer R31. This voltage difference across the preset resistance sets the emitter cur-

rent and hence the collector current of Q8. The constant collector current of Q8 is employed to charge timing capacitor C7 which is determinative of the time in which the voltage across C7 will reach the fixed reference required to turn on Q9. As a result, Q11 turns on to energize all reset coils in the reclosing relay. This occurs by virtue of the fact that the collector of Q11 is coupled through resistor R9 to leads 60 and 61. Lead 60 is coupled in common to all of the reset coils of stages CC1-CC3. Lead 61 is coupled through diodes D3, D5 and D7 to all of the reset coils of the stages TC1-TC3.

When CC1/a2 opens, the voltage across capacitor C7 decays in an exponential fashion. The time required for the capacitor voltage to decay to the turn off reference of Q9 guarantees the pulse length necessary for reset of all of the above mentioned latching relays.

The timing capacitor is totally discharged by transistor switch Q7 each time the circuit breaker trips. Note that the closure of contact 52/b is coupled through lead 30 and resistor R25 to the base of Q7 causing Q7 to conduct and abruptly discharge capacitor C7.

RECLOSING

Each time the circuit breaker 11 is tripped by either of the protective overcurrent relays 50 or 51, the reclose timing circuit is energized by the trip count reed contact TC1/a1, TC2/a1 or TC3/a1. The trip count progresses from one contact to another by the action of the sequencing circuit explained above.

A calibrated reference voltage is set up at the base of transistor Q3 by means of potentiometer R17 through adjustment of its adjustable arm 56. When a trip contact TC1/a1 or TC2/a1 or TC3/a1 closes, the difference between the input voltage and this reference voltage appears across one of the fixed resistors R11, R13 or R15 and one of the preset potentiometers R12, R14 or R16. This voltage and the resistance determines the collector current of transistor Q3. This constant current flows into the timing capacitor C3 when Q3 conducts. Consequently, the voltage of C3 rises in a linear ramp fashion.

The voltage divider formed by resistors R20 and R21 establishes a reference voltage at the emitter of Q5. When the voltage across capacitor C3 exceeds this reference, base current flows and Q5 turns on. The resulting collector current flows in the base of transistor Q6 which turns Q6 on to energize the close relay C. The energization of relay C closes its associated contact C/a1 which is coupled in the close relay circuit provided with circuit breaker 11 (and not shown herein for purposes of simplicity). As a result of the closure of the circuit breaker 11, auxiliary contact 52/b opens. This action deenergizes the trip count circuit and the close relay dropout, due to removal of power from coil C. At the same time, the action of contact set 52/b turns off transistor Q12 to cause turn-on of transistor Q2 as was explained hereinabove. The emitter current of Q2 is coupled through conductor 31 to the base of transistor Q4 to turn Q4 on. This causes abrupt and full discharge of timing capacitor C3 connected across the emitter and collector Q4.

TAP CHANGE BLOCK RELAY (T)

The reclosing relay blocks the action of a tap changing transformer on the first trip of the breaker. The tap changing transformers are devices which are capable of

changing the taps automatically in response to different voltage requirements of the transmission line. It is extremely important to prevent the tap changing upon the occurrence of a tripping operation. This is accomplished by an appropriate contact T/b1 controlled by the magnetically latching auxiliary relay T. On the first trip of the breaker, trip count reed contact TC1/a1 closes to energize the set coil (T/o) of relay T through close contact TC1/a1 and diode D18. This action causes the contacts T/b1 and c) T/b2 to open. Contact set T/b1 is coupled in the tap changer circuit and its opening blocks a tap changing operation. The contact set T/b2 deenergizes the operate coil T/oc. Capacitor C5 allows sufficient follow-through current to guarantee the saturation necessary to latch the T relay. Resistor R23 limits the capacitor discharge current to prevent contact erosion when contact set T/b2 closes upon reset. The T relay is reset by the lockout circuit or the reset circuit.

INSTANTANEOUS BLOCKING

The reclosing relay opens the trip circuit of instantaneous overcurrent relay 50 upon a preselected trip count. This is accomplished by an appropriate contact I/b1 of a magnetically latching auxiliary relay I. The relay and its operation is identical to that of relay T explained above. The I relay is connected to the appropriate trip count reed contact by means of the rotary switch S2 for energizing relay I after a predetermined number of instantaneous trips have occurred. For example, let it be assumed that the switch arm of adjustable switch S2 is coupled to its contact "2." Thus, when contact set TC2/a1 is closed and contact set 52/b is closed (when the circuit breaker is tripped) the current path is established from control power 37 through contact set 52/b, close contact set TC2/a1 contact "2" of switch S2 and its rotary arm through diode D17 and normally close contact set L/b1 through resistor R22 to coil I/o.c. The energization of coil I/o.c. opens its contact set I/b1 to deactivate the instantaneous overcurrent relay 50 and hence placing any subsequent trip operations under the control of the time overcurrent relay 51.

Relay I is reset by the reset circuit 19 or the lockout circuit (to be more fully described). The reset circuit 19 can be seen to provide relay coil I/RC which is the reset coil for the latching relay comprised of coils I/RC and I/O.C. Similarly, the tap change block relay T is comprised of windings T/RC (in the emitter circuit of transistor Q11 of reset circuit 19) and the winding T/O.C.

The lockout circuit is controlled by the switch S1 whose stationary contacts "1" through "3" may be selectively coupled to the associated rotary arm which is manually settable to select a number of reclosures which may occur before lockout (i.e., either one, two or three reclosures before lockout). For example, let it be assumed that the rotary arm of switch S1 is connected to a stationary contact "2." In this instance, when contact set TC3/a1 is closed and contact set 52/b is closed, control power is coupled through contact set TC3/a1, diode D36, stationary contact "2" of switch S1 and its rotary arm to diode D21 and conductor 59 to simultaneously energize coils I/RC and T/RC for resetting these latching relays. Simultaneously therewith, switch S1 energizes coil L which is lockout relay to operate its contact set L/a1 to the close position which

contact set is coupled in the remote circuit to provide a remote indication of lockout.

PRE-SELECTED RECLOSURES

Any number from one to three reclosures can be preselected by means of the adjustable rotary switch S1. This switch allows the lockout line L to be energized by reed contacts TC2/a1, TC3/a1, or CC3/a2, which contact sets are respectively coupled to the stationary contacts "1" through "3" of switch S1. Energizing the lockout line performs the following functions:

1. Lockout line L is coupled through resistor R24 and conductor 31 to the base of Q4 to turn Q4 on, thereby rapidly discharging the voltage across capacitor C3 to zero to prevent reclose timing;

2. the reset coils I/RC and T/RC of relays I and T are respectively energized through diode D21 in line 59 to reset both of these relays;

- 3 the energization of lockout relay L described hereinabove closes its contact set L/a1 to provide a remote indication of lockout; and

4. the rotary arm of switch S1 is coupled through line 33 and resistor R4 to lamp LI to provide a local indication of the lockout condition.

It can clearly be seen from the foregoing description that the present invention provides a novel reclosure relay circuitry for independently maintaining and memorizing the number of trip and close counts which occurred and for remembering these counts even in the case where control power is for either brief or prolonged intervals. Manual adjustment is provided for controlling the number of instantaneous trips and for controlling the number of reclosures prior to lockout. The close and trip count circuits are interlocked in such a manner as to prevent successive close counts or successive trip counts from being developed without the occurrence of a respective intervening trip count or close count so as to prevent any spurious trip or close counts from being developed. The circuitry further provides means for resetting the reclosure status if the system remains closed a predetermined time after a reclosure operation so as to start the reclosure sequence all over again. The time delay between a trip operation and its subsequent closure operation may be adjusted, depending only upon the needs of the user to obtain a variety of different delay times between any trip operation and a subsequent closure operation.

In addition, the system is totally dependent only upon the status of the circuit breaker (i.e., either open or closed) to maintain trip and close and is totally independent of control power.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

What is claimed is:

1. Recloser means for monitoring the status of a circuit breaker movable to a tripped and a closed position and having means for generating mutually exclusive first and second signals representing the occurrence of trip and close operations respectively, said monitoring means comprising:

- trip count means for receiving said first signals to count and store the number of tripping operations which may occur;

close count means for receiving said second signals to count and store the number of closing operations which may occur;

reset means for resetting said close count means after a predetermined time interval;

said close count means including means responsive to at least one of said second signals for activating said reset means;

reclose activating means for generating a reclose activating signal for reclosing the circuit breaker;

variable delay means;

said trip count means including delay means for altering the delay interval of said delay means responsive to the number of trip counts accumulated by said trip count means.

2. The device of claim 1 further comprising lockout means to deactivate said reclose activating means; programmable switch means coupled between said close count means and said lockout means for adjustably controlling the activation of said lockout means dependent upon the number of accumulated close counts.

3. The device of claim 1 wherein said trip count means comprises a plurality of stages of latching relay means, at least one set of cooperating contacts, a set winding for closing said contacts when energized, a reset winding for opening said contacts when energized and a latching device for maintaining said contacts in the state to which they were last operated even during the occurrence of loss of power to the recloser to retain the trip count, thereby enabling said trip count means to resume the sequence of the circuit breaker when power is restored to said recloser means.

4. The device of claim 1 wherein said close count means comprises a plurality of stages of latching relay means, at least one set of cooperating contacts, a set winding for closing said contacts when energized, a reset winding for opening said contacts when energized and a latching device for maintaining said contacts in the state to which they were last operated even during the occurrence of loss of power to the recloser to retain the close count, thereby enabling said trip count means to resume the sequence of the circuit breaker when power is restored to said recloser means.

5. The device of claim 3 wherein said latch device is adapted to prevent said cooperating contacts from changing their state when both set and reset windings are energized substantially simultaneously.

6. The device of claim 1 wherein said trip and close count means are each comprised of "n" stages of latching relay means each having a pair of cooperating contacts, a set winding for closing said contacts when energized, a reset winding for opening said contacts when energized, and a latch device for retaining said contacts in the position to which they were last operated;

the "nth" latching relay cooperating contacts of said trip count means being adapted to couple said second signal to the set winding of the "nth" latching relay stage of said close count means when its set winding is energized by said first signal where $n = 1, 2, 3 \dots$

7. The device of claim 6 wherein the cooperating contacts of the "nth" latching relay stage of said close count means are adapted to couple said first signal to the nth latching relay stage of said trip count means when its set winding is energized by said second signal.

8. The device of claim 3 wherein said latching relays are each further comprised of a second set of cooperating contacts;

said set and reset windings each being adapted to respectively close and open both sets of cooperating contacts when energized;

said latching device being comprised of a permanent magnet positioned adjacent both sets of cooperating contacts to retain the two sets of contacts in the last condition to which they were operated.

9. The device of claim 1 further comprising means responsive to said first signal for preventing operation of said close count means.

10. The device of claim 1 further comprising means responsive to said first signal for activating said trip count means after a predetermined delay.

11. The device of claim 1 wherein said trip count means is comprised of a plurality of stages of latching relays at least equal in number to the number of closing operations which said close count means is capable of counting;

said close count means including means for coupling the stage of said trip count means associated with the count of said close count means.

12. The device of claim 1 wherein said close count means is comprised of a plurality of stages of latching relays at least equal in number to the number of tripping operations which said close count means is capable of counting;

said trip count means including means for coupling the stage of said close count means associated with the count of said trip count means.

13. The device of claim 1 further comprising means for reclosing said circuit breaker after each tripping operation;

variable time delay means responsive to a tripping operation for delaying the operation of said reclosing means;

means coupled to said trip count means for adjusting the delay period of said time delay means dependent upon the count of said trip count means.

14. The device of claim 13 further comprising means responsive to said second signal for deactivating said time delay means and said reclosing means.

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