

[72] Inventors Nathaniel D. Tenebaum
Plainfield;
Walter A. Elmore, Millington, N.J.
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[73] Assignee Westinghouse Electric Corporation
Pittsburgh, Pa.
a corporation of Pennsylvania

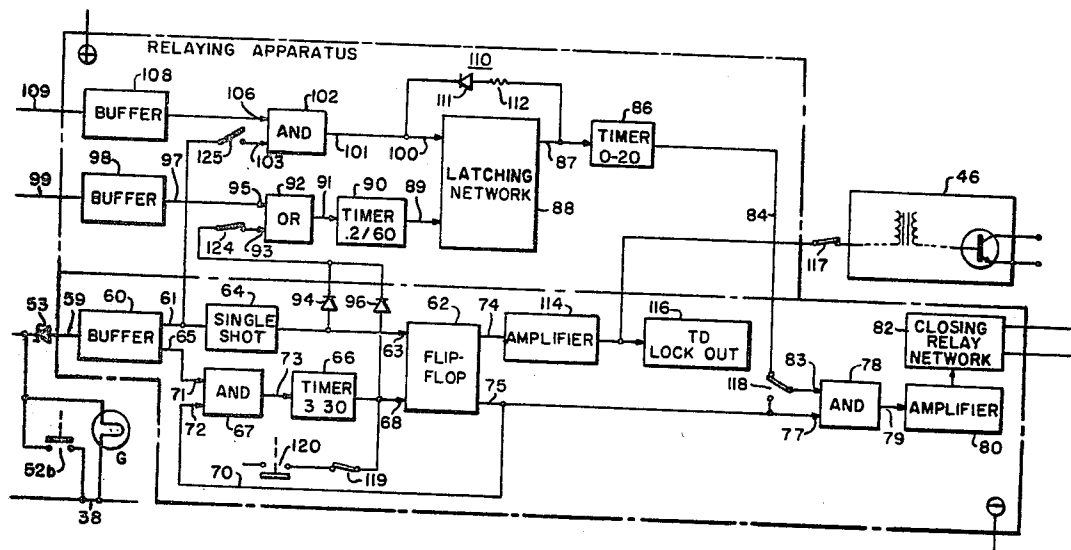
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Primary Examiner—James D. Trammell
Attorneys—A. T. Stratton, C. L. Freedman and J. L. Stoughton

[54] **BREAKER RECLOSING AND LOCKOUT RELAY**
26 Claims, 6 Drawing Figs.
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317/33, 317/36, 317/142
[51] Int. Cl. H02h 3/08,
H01h 47/18
[50] Field of Search 317/22, 33,
36, 142

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ABSTRACT: A reclosing solid state relaying network which eliminates the necessity for the usual 52x breaker contact (a contact that closes during the closing movement of a power circuit breaker) and utilizes an existing 52b contact (which is a contact closed solely when the breaker is in wide open condition) associated with the usual green lamp used to indicate an open circuit condition of the breaker thereby eliminating the cost of the additional wiring from the switch yard to the control house and enabling the use of breakers having no 52x contact. The solid state relaying network may be arranged to control the operation of a single breaker or in its more complete form arranged to control a plurality of breakers in a "breaker-and-a-half or ring bus arrangement" to lockout upon the second reclosure of a breaker into a faulted power line thereby eliminating further breaker reclosures upon a faulted line as occurred in prior art systems.



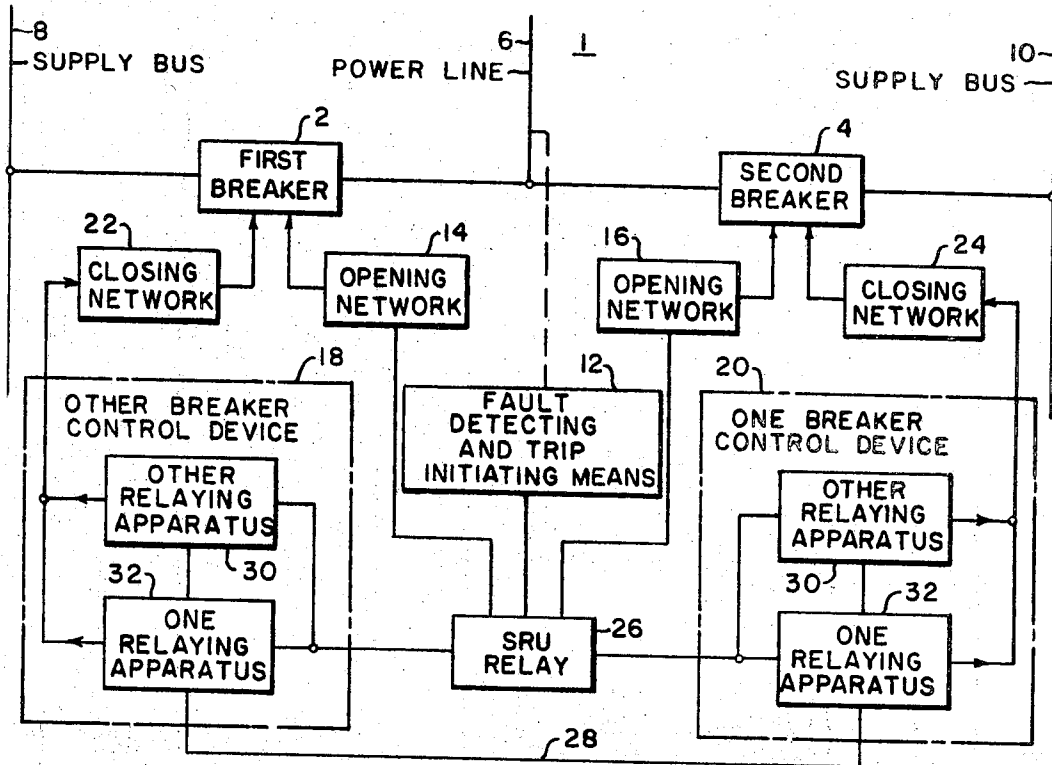


Fig. 1

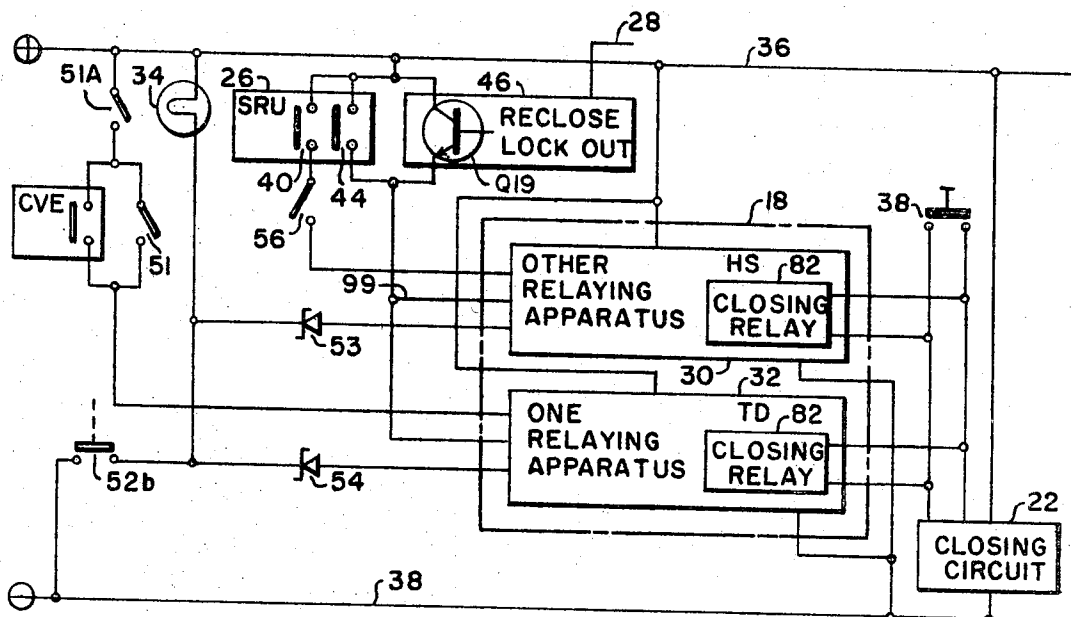
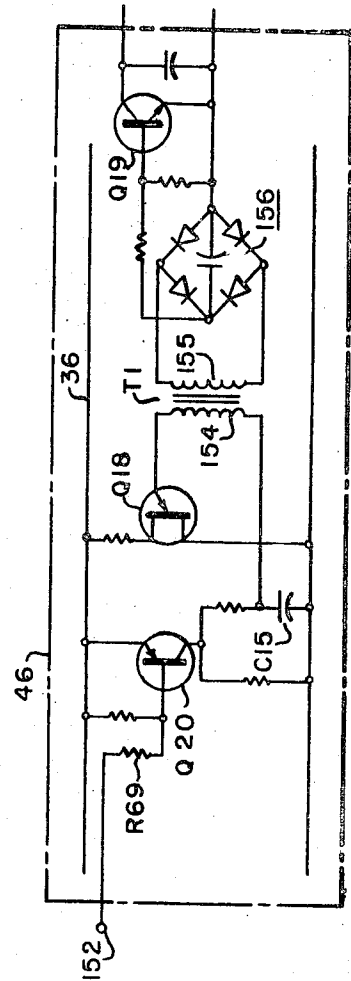
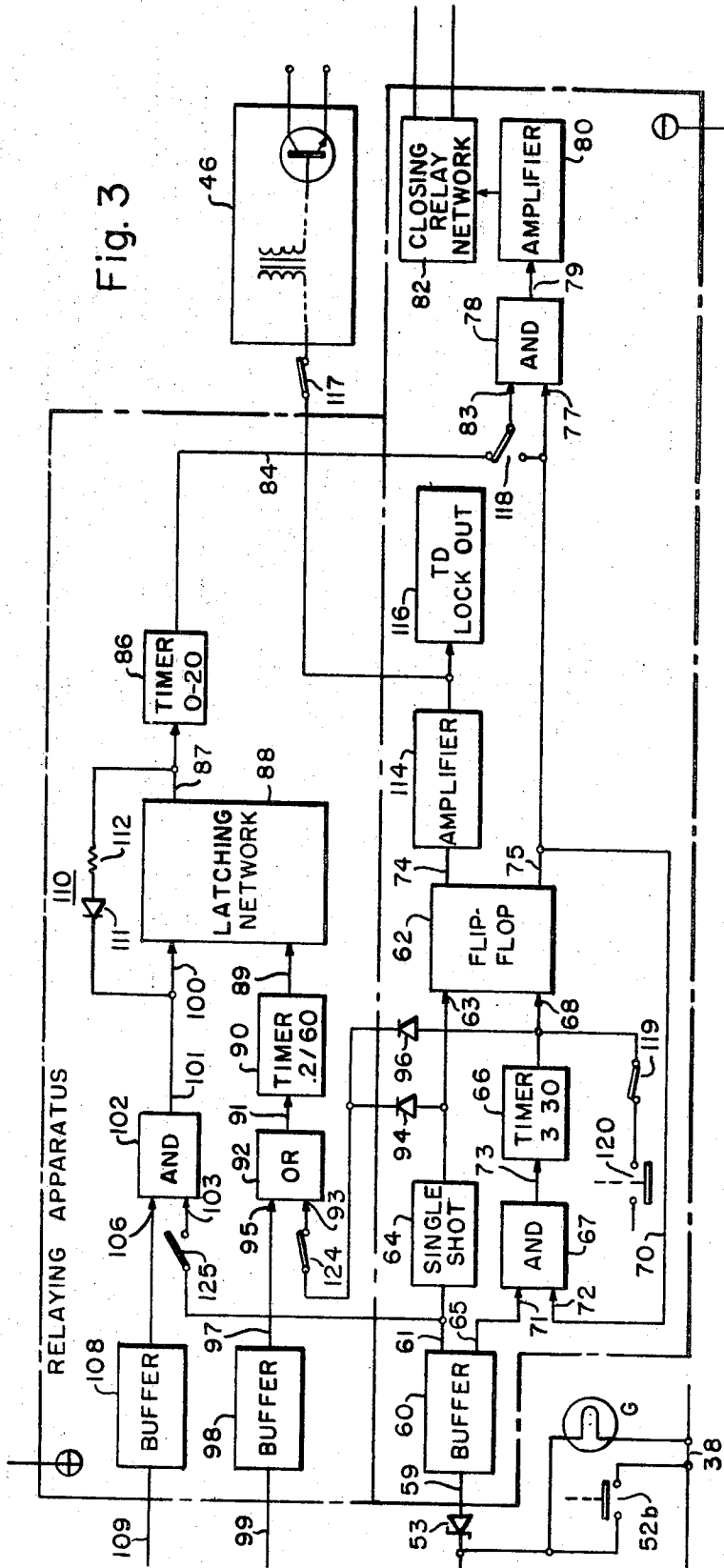


Fig. 2

INVENTORS
Walter A. Elmore and
Nathaniel D. Tenenbaum
BY *John L. Stoughton*
ATTORNEY



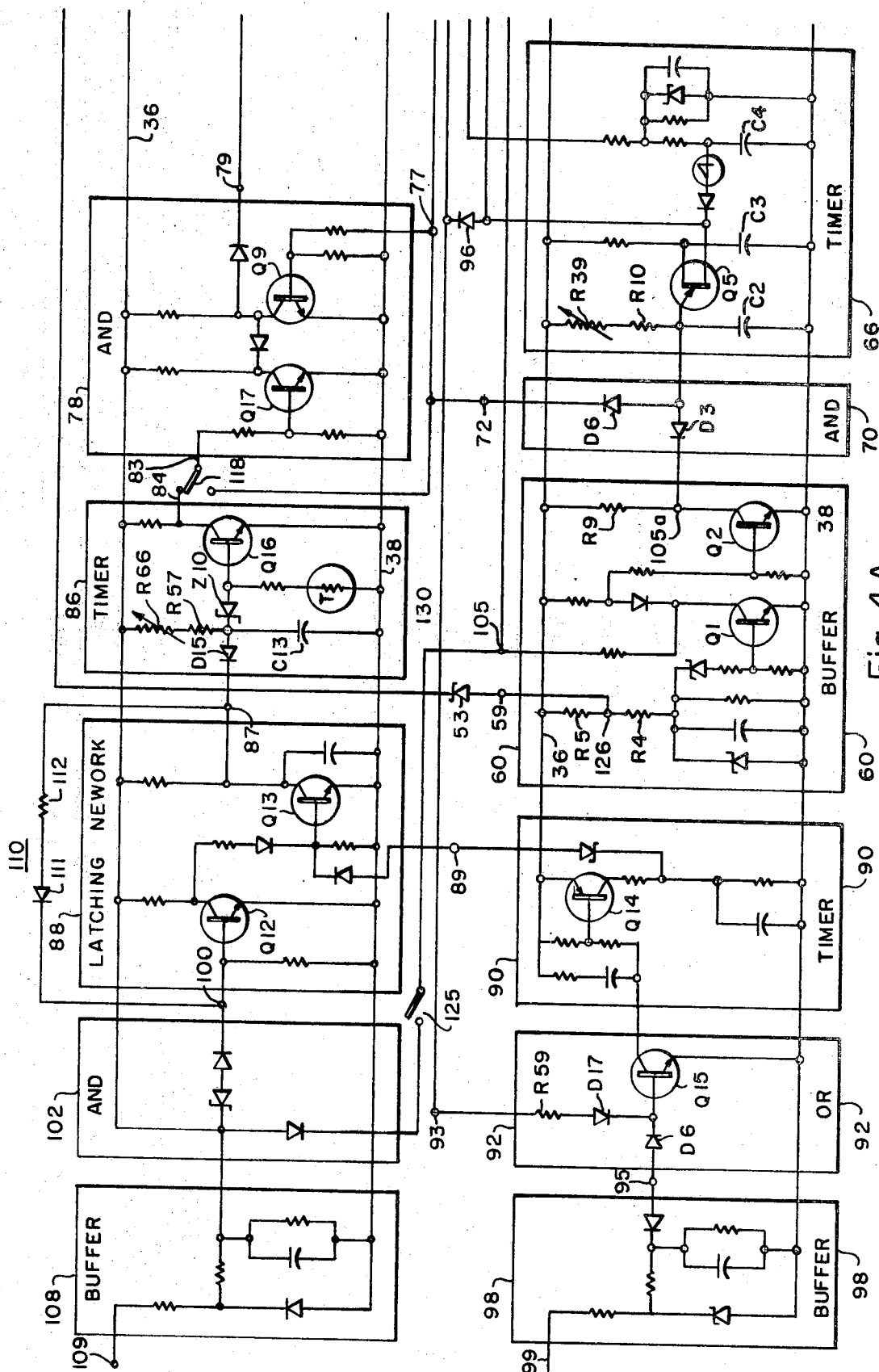


Fig. 4A

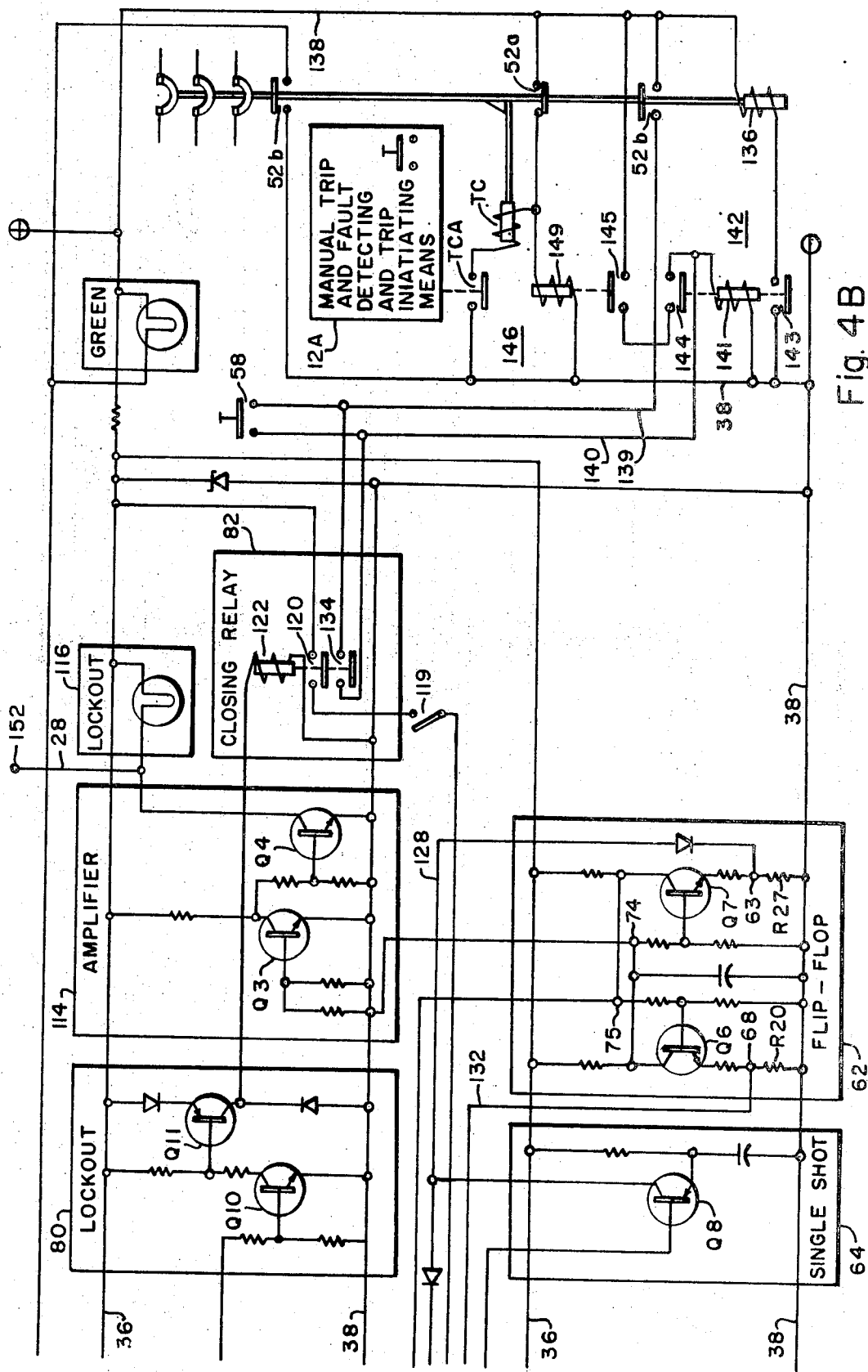


Fig. 4B

BREAKER RECLOSING AND LOCKOUT RELAY

SUMMARY OF THE INVENTION

An object of this invention is to provide a breaker reclosing relay or control device wherein a 52b contact is utilized to perform the same operation as is performed by a 52x contact.

A further object of this invention is to provide such a relay which may be operated from the existing green lamp control without the necessity of installing further wiring from the switch yard to the control house.

Another object of this invention is to provide a relaying arrangement for breakers connected in a breaker-and-a-half or ring bus arrangement to minimize the number of unsuccessful reclosures and thereby reduce wear and tear on the breakers.

A still further object of the invention is to provide a relay for controlling a pair of breakers which energize a power line from a pair of sources which will provide a high speed reclosure of one breaker and a time delayed reclosure of the second breaker and wherein if the second breaker closure is unsuccessful it will lockout further closures of both breakers.

Other objects of this invention will be apparent from the specification, the hereinafter appended claims, and the drawings in which:

FIG. 1 is a block diagram illustrating the invention when used in connection with a breaker-and-a-half or ring bus arrangement;

FIG. 2 is a block diagram illustrating, in somewhat greater detail the breaker control device of FIG. 1 and its interconnections with a breaker reclosing apparatus;

FIG. 3 is a block diagram showing in a greater detail one of the relaying apparatuses illustrated in the block diagram of FIG. 2;

FIGS. 4A and 4B collectively illustrate schematically circuitry which may be utilized in the blocks illustrated in FIG. 3; and

FIG. 5 schematically shows circuitry which may be actually one breaker conduct device to lock out the other breaker device in the event that the said one breaker device recloses its breaker on a faulted power line.

Referring to the drawings by characters of reference, the numeral 1 represents a breaker control system for controlling first and second circuit breakers 2 and 4 which connect a power line 6 to a pair of supply buses 8 and 10 respectively. A fault detecting and trip initiating means 12 is operatively connected to be responsive to the operating condition of the power line 6 and operates through an SRU relay 26 in response to a fault in the line 6 to actuate a pair of breaker opening networks 14 and 16 which open the breakers 2 and 4 respectively. The SRU relay 26 also actuates a pair of breaker control devices 18 and 20 to reclose the breakers 2 and 4 respectively.

The fault detecting and trip initiating means 12 may take any desired form and may be what is known as a "phase comparison" fault detecting system as for example that illustrated in Altfather, U.S. Pat. No. 3,295,019 or the "direction comparison" relaying system as illustrated in Rockefeller, U.S. Pat. No. 3,337,774 or the "distance relay" apparatus illustrated in Calhoun, U.S. Pat. No. 3,339,115 or a combination of such protective systems.

In most instances, faults on a power line are of a short duration and will almost immediately clear upon deenergization of the power line when the breakers open. It is therefore desirable to attempt the reclosure of the breaker almost immediately to reduce a malfunction of the power network and to eliminate as far as possible the interruption of power to the consumer.

In the apparatus illustrated in FIG. 1, the breakers 2 and 4 are reclosed by means of the breaker control devices 18 and 20 which actuate the reclosing network 22 and 24, respectively of the breakers 2 and 4. In this form of the invention, the SRU relay 26 when actuated by the fault detecting and trip initiating means 12 actuates the control device 18 for a high-speed reclosure of the first breaker 2 and the control device

20 for a time delayed closure of the breaker 4. If the closure of the breaker 2 is successful (the fault has disappeared from the power line 6) the reclosure of the second breaker 4 by the breaker control device 20 will reestablish energization of the power line 6 from both buses 8 and 10. If however, the closure of the breaker 2 was unsuccessful (the fault still exists) the breaker 2 will immediately be reopened and disconnect the line 6 from bus 8. Subsequently to the unsuccessful reclosure of the breaker 2, as determined by the time delay of the control device 20, the second breaker 4 will close to connect the power line 6 to the bus 10. If this closure of the breaker 4 is successful, the control device 18 subsequently will reclose the breaker 2 to reconnect the power line 6 to the bus 8. If, however, the closure of the breaker 4 was unsuccessful (the fault still existed on the power line 6) the breaker 4 will immediately be reopened and a blocking signal will be transmitted through the interconnection 28 and a lockout control device 29 to lock out a further reclosing operation of the control device 18 and no further reclosure of the breakers 2 and 4 by the devices 18 and 20. Thereafter the breakers 2 and 4 must be reclosed manually by the switch 58 or by other apparatus not illustrated or otherwise involved in this invention.

If the power line 6 is connected to a single supply bus through a single breaker as for example the line 4 to bus 8 by means of the single breaker 2 and the power line 6 faults, the fault detecting and initiating means 12 responds to the fault to actuate the SRU relay 26 in the opening of the breaker 2. The SRU relay 26, also actuates the other relaying apparatus 30 of the control device 18 for a high-speed reclosure of the breaker 2. If the fault has disappeared, the breaker 2 will remain closed and the control device 18 will reset itself as will be described below. If however, the fault had not cleared, the breaker 2 will reopen. After a desired time interval, the one relaying apparatus 32 of the breaker control device 18 will subsequently close the breaker 2. If this second reclosure is successful, the fault has disappeared, the breaker 2 remains reclosed and the breaker control device 18 will reset itself. If however the second reclosure is unsuccessful, the fault has not disappeared, the breaker control device 18 will lockout and no further reclosing of the breaker 2 by the control device 18 will occur. Any subsequent closure of the breaker 2 must be by a manual reclosure or by other apparatus not embodied in this invention as shown herein.

The SRU relay, per se, does not form a part of this invention. It is relay manufactured and sold by Westinghouse Electric Corporation, the assignee of this invention, under the type designations SRU and includes a set of normally open contacts 40 which close substantially simultaneously with the actuation of the fault detecting means 12 to trip the breaker and a set of normally open contacts 42 which close under certain fault or breaker conditions for which reclosing of the breaker is not desired.

Each breaker control device is identical and comprises a pair of relaying apparatuses 30 and 32 which cooperate together under a control of the SRU relay 26 and the usual 52b contacts of the breaker with which the particular breaker control device is associated. The 52bb contacts are contacts associated with the circuit breaker and are closed solely when the circuit breaker is in its fully open condition. These contacts are normally associated with a so-called green lamp 34 which is energized to indicate an open breaker condition. The lamp 34 is connected between positive and negative direct current power supplying buses 36 and 38 through the 52b contacts. It will be apparent from the foregoing that whenever the breaker is in its open circuit condition, the green light 34 will be illuminated. The pair of normally open contacts 40 of the SRU relay 26 are closed substantially simultaneously with the tripping operation of the means 12 as it initiates an opening operation of the breaker. This results in a high-speed or rapid reclosing of the closing of the relay closing circuit 22 and consequently the closing of the breaker 2. SRU relay 26 provided with the normally open contacts 44 of this relay 26 are actuated through suitable mechanism, not illustrated, to their

closed conditions and lock out the associated control device 18 or 20 and prevent any reclosing operation of the associated relaying apparatus 30 and 32. The SRU relay 26 is actuated to close its contacts 44 when the breaker should not be reclosed.

The reclosing lockout or circuit controlling network 46 is provided with a pair of normally open contacts 48 which may take the form of the normally nonconducting transistor Q19 of FIG. 5. The contacts 48 are connected in parallel with the normally open contacts 44 of the SRU relay 26 and which if closed will, like the contacts 42, prevent further breaker closing actuation of the relaying apparatus 30 and 32. The reclosed lockout network 46 is more completely disclosed in FIG. 5.

Under some reclosing conditions it may be desirable to compare the phase of any energization of the power line 6 with respect to the phase of one or both of the supply buses 8 and 10 as for example, a time delayed operation of the relaying apparatus 32 to insure that phase of the voltage in the power line 6 and of one or both of the buses 8 and 10 is within proper limits. If the phase difference is too great, the CVE relay which includes switch 50 will not close and thereby prevent the breaker closing operation of the relaying apparatus 32. If the CVE relay is not used or its operation is not desired it may be rendered ineffective by the closure of a suitable shunting switch 51. If the high speed reclosing is not desired, a switch 56 may be opened and if the time delayed reclosing by the relaying apparatus 32 is not desired, the switch 51A may be left in its open circuit condition as will be more fully described below.

When the circuit breaker opens, the contacts 52b thereof close and connect the anode terminal of the Zener diodes 53 and 54 to the negative bus 38 to reset the relay apparatuses 30 and 32 as will become more apparent below.

The relaying apparatuses 30 and 32 are somewhat more completely shown in the block diagram of FIG. 3 and still more completely shown in FIGS. 4A and 4B. The contacts 52b and Zener diode 53 control the connection of the input connection 59 of a buffer network or signal producing circuit 60 to the negative bus 38. The output connection 61 of the network 60 is connected to a first input connection 63 of a flip-flop or bistable network 62 through a monostable network or single shot pulser 64. The output connection 65 of the network 60 and through connections 71 and 73 of an AND network 76 a first timer 66 to a second input connection 68 of the flip-flop 62. The flip-flop 62 has a pair of output connections 74 and 75. The output connection 74 is connected by a conductor 76 to the input connection 72 of the AND circuit 70. The output connection 75 is also connected to one input connection 77 of an AND circuit 78 which has its output connection 79 connected through an amplifier 80 to control the energization of a closing relay network 82. The other input connection 83 of the AND circuit 76 is connected by a conductor 84 to the output connection 85 of a timer 86. The timer 86 is normally maintained in its reset or initial condition by means of the signal applied to its input connection from the output connection 87 of a latching network or second control network 88. The latching network 88 is unlatched by a signal applied to its input connection 89 from the timer 90 and latched by a signal applied to its input connection 100.

The timer 90 is connected to an output connection 91 of an OR circuit 92. The input connection 93 of the OR circuit 92 is connected through a diode 94 to the output of the single shot pulser 64 and also through a diode 96 to the output of the timer 66. The other input connection 95 of the OR circuit 92 is connected to the output connection 97 of a circuit controlling means or buffer network 98, whereby the latching network may be unlatched by a signal applied to the OR circuit 92 either through the buffer 98 or from the signals derived from the single shot pulser 64 of the timer 66. The timer 90 provides a first time delay between the energization of its input by the OR network 92 and a second time delay upon the deenergization of the network 92. This prevents false unlatching of the network 88. Suitable times for the first and

second delays are 0.2 and 10.0 milliseconds, respectively. When unlatched, the latching network 88 resets timer 86 and holds it in its reset condition in which it is prevented from timing out and from supplying a conductive signal to the input connection 83 of the AND network 78. Latching of the network 88 is obtained when a latching signal is applied to its input connection 100 in the absence of an unlatching signal at the connection 89. For this purpose the input connection 100 is connected to the output connection 101 of an AND circuit 102. The AND circuit 102 has one input connection 103 connected by conductor 104 to the output connection 61 of the buffer 60. The other input connection 106 of the AND circuit 102 is connected to the control device or buffer 108 which has its input connection 109 connected to the positive bus 36 through the normally open contacts 40 of the SRU relay 26. The latching network 88 includes the feedback circuit 110 having the illustrated diode 111 and resistor 112.

The output connection 74 of the flip-flop 72 is connected by an amplifier 114 to a lockout indicating network 116 and the reclose lockout network 46. As will be further described below, the flip-flop is normally maintained in its condition in which the terminal 74 is in a condition to maintain the lamp 113 in the lockout indication network deenergized and the switch 48 in open circuit. Manually operable switch 117 may be opened to disconnect the reclose lockout network 46 if its function is not desired.

If reclosing of the circuit breaker is desired without the utilization of a separate closing signal such as that desired from the SRU relay, the portions of the diagrams of FIG. 3 above the dash line may be rendered ineffective by the switches 118, 119, 124 and 125 whereby a single breaker reclosure is initiated solely by the closure of the 52b contacts. When the manually operable single-pole double-throw switch is moved from its illustrated position in which the input connection 83 of the AND network 78 is connected to the output of the timer 86 into its other position in which the input connection 83 of the AND circuit 78 is energized from the output connection 75 of the flip-flop 62 in parallel with the connection 77, the AND operation of the AND network 78 is effectively removed. Opening of the manual switch 119 disconnects the connection 68 of the flip-flop 62 to the positive bus 36 through the normally open contacts 120 of the closing relay 122 forming part of the closing relay network 82. Opening of the switches 124 removes the operation of the OR circuit 92 by means of signals derived through diodes 94 and 96. Opening of the manual switch 125 prevents the application of a signal to the input connections 103 of the AND circuit 102.

It is believed that the remainder of the details of construction of the relaying apparatus may best be understood by a description of the operation thereof and with more particular reference to FIGS. 4A and 4B. In FIG. 4B the manual trip and fault detecting and initiating means encompasses the breaker opening function of the means 12, the SRU relay 26, and network 14.

With the circuit breaker closed and the breaker control system timed out and in its normal state, the transistors Q1, Q3, Q7, Q8, Q13 and Q17 are provided with base drive and transistors Q2, Q4, Q5, Q6, Q9, Q10, Q12, Q14, Q15, Q16, Q18 and Q19 are held nonconducting. The maintenance of Q11 in its nonconducting state holds the relay 122 deenergized in which its contacts 120 and 134 are open. Likewise, breaker contacts 52b will be open and contacts 52a will be closed, relay 142 is deenergized holding its contacts 143 and 144 open, and relay 146 is deenergized with its contacts 145 closed. The circuit through trip coil TC is interrupted by the trip contacts TCA.

When the circuit breaker trips upon closure of the contacts TCA in response to a fault, the breaker opens its power controlling contacts and its contacts 52a and closes its contacts 52b. Closure of contacts 52b connects the anode of the diode 53 and will be connected to the negative bus 38 and the input terminal 59 of the buffer 98 will connect the common connection 126 of the resistors R4 and R5 to the negative bus 38

through a low impedance path. This interrupts the base drive current to transistor Q1 which becomes nonconductive. When Q1 is nonconductive base drive is supplied to transistor Q2 which thereupon conducts without effect except to insure that the time 66 is reset to its initial condition. The rendering of the transistor Q1 nonconductive interrupts the flow of base drive current to the transistor Q8 rendering it nonconductive to permit the charging of the capacitor C7 of the single-shot pulse 64.

Operation of the trip network 12 closed the contacts 40 (FIG. 2) and provided a positive potential at the input connection 109 of the buffer 108. At this time the transistor Q1 is blocked and a positive potential is supplied from the output terminal 61 of the buffer 60 to the other input connection 103. The AND circuit 102 then supplies a latching signal to the input connection 100 of the latching network 88. Under the conditions set forth the transistor Q14 of the timer 90 is not conducting and no unlatching signal is supplied to the connection 89. The latching signal at connection 100 causes the transistor Q12 to conduct to interrupt the base current to transistor Q13 which thereupon blocks. This results in a positive signal at the output connection 87 which interrupts the discharge circuit of the timing capacitor C13 which thereupon commences to charge to measure the timing interval of timer 86. When the transistor Q13 blocks and the connection 87 becomes positive, the feedback circuit 110 becomes effective to keep the transistor Q12 conducting independently of the output signal supplied by the AND network 102.

When the timer 86 times out, transistor Q16 conducts, the potential of the conductor 84 becomes substantially that of the negative bus 38 to terminate further conduction of the transistor Q17 of the AND network 78. When Q17 blocks, the potential of the output connection 79 rises and base current flows to render conductive transistor Q10 of the amplifier 80. Transistor Q10 when conducting causes base drive current to flow in transistor Q11 which thereupon conducts to energize the relay 122 which closes its contacts 120 and 134.

Closure of the contacts 134 cannot complete a circuit for energization of the closing coil 136 unless the breaker is fully open. When the 52b contacts are closed, closure of the contacts 134 completes a circuit from the positive bus 138 through the now closed contacts 52b, conductor 139, contacts 134, conductor 140, winding 141 of relay 142 to the negative bus 38 thereby energizing the relay 142. When energized, the relay 142 closes its contacts 143 and 144. Closure of the contacts 143 completes the energizing circuit of the closing coil 136 to close the breaker. Closure of the back contacts 144 completes a holding circuit for the relay 142 in shunt with the contacts 52b and 134 through the contacts 145 of the relay 146. When the breaker closes, the contacts 52a close energizing relay 146 which opens its contacts 145 to interrupt the holding circuit for the relay 142 which thereupon opens its contacts to deenergize the closing coil 136.

When the 52b contacts open, the connection of the input connection 59 to the negative bus 38 is interrupted whereby the transistor reconducts to render transistor Q2 blocked to place a back bias on diode D3 of the AND network 70 and to render the transistor Q8 conducting to permit a pulse output from the single shot pulse 64 due to the discharge of the capacitor C7 thereof through the emitter-collector circuit of transistor Q8.

The discharge pulse of the capacitor C8 is applied to the input terminal 63 of the flip-flop 62 and to the input connection 93 of the OR network 92. The pulse applied connection 93 renders the transistor Q15 conducting to initiate the on timing functions of the timer 90 which after a 0.2 millisecond delay renders Q14 conducting to supply a pulse to the unlatching connection 89 to render transistor Q13 conducting and unlatch the network 88. When unlatched, transistor Q12 blocks, transistor Q13 continues to conduct and maintain a discharge path for the capacitor C13 of the timer 86 whereby it is placed in its reset or ready condition, in which the transistor Q17 returns to its conductive condition preventing

the AND network 78 from maintaining the transistors Q10 and Q11 conducting to terminate energization of the relay 122.

The flip-flop 62 comprises a pair of transistors Q6 and Q7 interconnected so that only one thereof can conduct at any one time and the rendering of the one thereof which is not conducting into a conductive state renders the formerly conducting one thereof nonconducting. Under nonfault operating conditions, the transistor Q7 of the flip-flop 62 will normally be conducting while the transistor Q6 will normally be in a block condition. Therefore under normal nonfault operating conditions of the relaying apparatus the output connection 75 thereof will be at substantially the potential of the negative bus 38 to supply a negative signal to the input connection 77 of the AND network 78 whereby the transistor Q9 thereof remains nonconducting. The output terminal 73 is maintained substantially at the potential of the positive bus 36 to provide base current for the transistor Q3 of the amplifier 114. When the transistor Q3 conducts, the transistor Q4 is deprived of base drive current and the transistor Q4 remains nonconducting and the amber light of the lockout network 116 remains dark. The negative potential maintained at output connection 75 also maintains a discharge circuit for capacitor C2 of the timer 66, the diode D6 and the normally conducting transistor Q7. When the capacitor C7 discharged and supplied a pulse to the input connection 63, the potential across the resistor R27 increased and raised the potential of the emitter sufficiently to render transistor Q7 blocked resulting in the conduction of transistor Q6 and the rendering of connection 74 negative and connection 75 positive.

The positive potential now existing at the output terminal 74 is applied to the input connection 72 of the AND circuit to block the diode D6 thereof. Since as explained above the diode D3 is now also reverse biased, the capacitor C2 begins to charge through the potentiometer R39 and resistor R10. As the capacitor C2 charges, the potential increases at a desired rate to determine the timing interval of the timer 66. When the charge in the capacitor C2 reaches a desired quantity a critical potential, the unijunction transistor Q5 conducts and the capacitor C2 discharges through a circuit which extends from the capacitor C2 through the unijunction transistor Q5, the output terminal of timer 66, and conductor 132 to the input terminal 68 of the flip-flop 62. This discharge is through the resistor R20 and raises the potential of the emitter of the transistor Q6 sufficiently to block the transistor Q6 whereby the transistor Q7 becomes conducting. Reconduction of the transistor unblocks the diode D6 to provide a discharge path for capacitor C2 and terminate further operation of the timer 66 which is not reset to its initial condition ready for a subsequent timing operation.

If however, the breaker reopened before the end of the timing interval of the timer 66, the contacts 52b reclose and terminate further conduction of the transistor Q1. When the transistor Q1 terminates conduction with the flip-flop 62 maintaining output terminal 75 positive the AND circuit 78 cannot be actuated to energize the network 82 because of the maintenance of the transistor Q9 conductive by the positive potential at the connection 75. It will be understood that when the transistor Q9 conducts it maintains the potential of the output connection 79 of the AND network 78 substantially at the potential of the negative bus 38 to prevent the conduction of the transistors Q10 and Q11. As long as these transistors remain blocked the relay 122 of the network 82 remains deenergized with the contacts 134 thereof open and preventing energization of the closing coil 136 of the circuit breaker.

It will be appreciated that as long as the breaker remains open, the contacts 52b will remain closed. As long as the contacts 52b remain closed the transistor Q1 will remain blocked and transistor Q2 conducting to prevent charging of the capacitor C2 which is necessary to reset the flip-flop 62. Unless flip-flop 62 resets the relay 122 of the network 82 it cannot be energized and the circuit breaker remains in its locked-out condition as far as closure by the relaying apparatus 30 is concerned.

A single control device 18 was used and the manual switch 52 was open and no further operation of the circuit hereby would occur. If however, the switch 52 was closed, a subsequent reclosure operation of the breaker would occur, at the end of the time interval as determined by the setting of the timer 86 of the relaying apparatus 32. Normally the timer 86 of the apparatus 32 is set to time out a sufficient time after the timing out of the timer 86 of the apparatus 30 to provide an interval in which a temporary fault condition could reasonably be expected to clear itself. For this reason the relay network 30 in FIG. 2 includes the designation HS and the network 32 includes the designation TD.

With the arrangement of FIG. 1 in which breakers 2 and 4 are both utilized, the timer 86 of the apparatus 30 of the device 18 is set for a very short or HS time interval in which the breaker 2 almost immediately recloses on the assumption that the fault is such that it will have disappeared in the HS time interval. The timer 86 of the apparatus 32 of the device 20 is set for an interval greater than the timer 86 of the apparatus 32 of the device 18 so that if the fault had not cleared when the breaker 2 reclosed, the next attempt would be a reclosure of the breaker 4 by the apparatus 32 of the device 30. If this closure of the breaker 4 were successful, the fault had cleared, then subsequently the first breaker 2 would be closed upon the timing out of the timer 86 of the apparatus 32 of the device 18 restoring the energizing connection for the line 6.

Subsequently to the closure of the breaker 2, the apparatus 30 of the device 18 will reset itself. This is because the closure of the breaker 2 by the apparatus 32 of the device 18 results in the opening of the contacts 52b of breaker 2 to actuate the associated apparatus 30 to permit its timer 66 to time out and reset the flip-flop to its normal condition. When so reset and with the reset condition of the apparatus 32 of the device 30, the system reverts to its normal conditions.

In the event the reclosure of the breaker 4 was not successful, the flip-flop of the apparatus 32 of the device 20 would be maintained in its condition in which the output connection 74 thereof was positive preventing energizing of the closing relay 122 of the network 82 and with the contacts 52b holding the transistor Q2 conducting to prevent the timing out of the timer 66 which is a prerequisite to the return of the flip-flop to its initial condition in which the relay 122 may become energized to close its contacts 134.

With the flip-flop in this condition (transistor Q7 blocked and Q6 conducting) transistor Q3 will remain blocked, transistor Q4 will conduct and the amber lockout light of the lockout indicating network will light. Further, the conducting condition of transistor Q4 will maintain the output terminal 152 at substantially that of the negative bus 38. This terminal as indicated by the like numbered terminal in FIG. 5 is connected through a resistor R69 to the base of transistor Q20. Base drive current therefore flows in transistors Q20 of the isolation or circuit controlling network 46. When so energized the transistor permits charging current to flow to the capacitor C15 which periodically discharges through the unijunction transistor Q18 to pulsating energize the primary winding 154 of the transformer T1.

With the winding 154 so energized a voltage will be induced in the secondary winding 155 which is rectified in the fullwave rectifying network 156. The resultant rectified voltage causes a base drive current to flow in transistor Q19 to render its emitter-collector circuit conducting. As indicated in FIGS. 1 and 2, the network 46 controlled by the apparatus 32 of the device 30 has its transistor Q19 connected so that, when conductive, the emitter-collector circuit supplies a positive signal to the input terminal 99 of the apparatuses 30 and 32 of the device 18.

As will be apparent from FIG. 2, the transistor Q19 and contacts 44 are connected in parallel with each other so that the conduction of transistor Q19 or closure of the contacts 44 connect the positive bus 36 to both terminals 99 of the device 18. When the input connection 99 of the buffer 98 is energized, the buffer 98 provides an output signal to the input con-

nection 95 of the OR circuit 92. This signal will establish a base current drive current to transistor Q15. When conducting, transistor 15 causes base drive current to flow in the transistor Q14 of the timer 90. Upon conduction, the transistor Q14 maintains the potential of the timer output terminal of the timer elevated above that of the negative bus 38 whereby a base drive current is supplied through the input terminal 89 of the latching network 88 to unlatch the network by causing the transistor Q13 to conduct. Conduction of the transistor Q13 by the timer 90 is independent of any signal applied to the latching terminal 100. When transistor Q13 conducts the timer 86 is prevented from timing out and supplying a signal to the AND circuit 78. In the absence of this signal to the AND circuit 78, the transistor Q17 thereof remains conducting preventing conduction of the transistors Q10 and Q11 of the amplifier 80 and consequently energization of the relay 122 of the closing network 82 of the circuit breaker closing motor 136.

As indicated above, if a single reclosure of a breaker is desired without the use of initiating contacts, the switch 118 is positioned to connect the input connections 83 to the input connection 77 and thereby effectively eliminate the "and" effect of the network 78. Only the elements below the dash line are necessary since the closure of the contacts 52bb initiates the closing actions. If the reclosure is successful the timer 66 will reset the flip-flop 62. If the closure is unsuccessful the timer will not time-out and the flip-flop 62 will remain in the condition to which it was actuated by the single shot pulses 64 and a second reclosure of the breaker is prevented.

Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. In a relaying apparatus for reclosing a circuit breaker, a signal producing circuit, a single shot pulser connected to said signal producing circuit and operable to provide an output signal at its output connection solely for a desired time period subsequent to actuation of said signal producing circuit, a first AND network having a pair of inputs and an output, a first timer, a flip-flop having a pair of input connections and a first output connection, first circuit means connecting one of said input connections of said flip-flop to said output connection of said pulser, second circuit means connecting the other of said input connections of said flip-flop through said timer to said output of said AND network, a breaker closing relay, third circuit means connecting said output connection of said flip-flop to said relay and to one of said input connections of said AND network, and a fourth circuit means connecting the other input connection of said AND network to the contacts of said relay for actuation thereby.

2. The combination of claim 1 in which there is provided a second AND network having first and second input connections and an output connection, said third circuit means includes said first inputs and output connections of said second AND network, third and fourth timers, a latching network having latching and unlatching connections and an output connection, fifth circuit means connecting said second input connection of said second AND network to said output connection of said latching network and including said third timer, sixth circuit means connecting said unlatching connection of said latching network to at least one of said single-shot pulses and said first timer, said sixth circuit including said fourth timer, a first control device, and seventh circuit means connecting said first control device to said latching connection.

3. The combination of claim 2 in which there is provided a third AND network having first and second input connections and an output connection, said seventh circuit including said first input and said output connections of said third AND network, and an eighth circuit means connecting said contacts to said second input connection of said third AND network.

4. The combination of claim 2 in which there is provided an OR network having first and second input connections and an output connection, said sixth circuit including said first input and said output connections of said OR network, and circuit-controlling means connected to said second input connections of said OR network.

5. The combination of claim 4 in which the timing interval of said third timer is less than the timing interval of said first timer.

6. A breaker control device resulting from the combination of two relaying apparatuses as set forth in claim 5 and in which said signal producing circuits are connected together for common actuation by contacts actuated by said breaker, in which both of said circuit-controlling means are connected for actuation by a common circuit and said first control device are separately controlled, in which said flip-flop of one of said two relaying apparatuses is provided with a second output connection, in which there is provided a circuit-controlling network, and in which a tenth circuit means connects said circuit controlling network to said second output connection of said flip-flop of said one of said two apparatuses.

7. The combination of two breaker control devices as set forth in claim 6 and in which said circuit-controlling network of one of said two breaker control devices is connected to control said common circuit of the other of said two breaker control devices.

8. The combination of claim 7 in which there is included first and second breakers controlling the connection of a power line to a pair of electrically energized supply buses, fault detecting means associated with said power line and with both of said breakers, said fault detector being effective upon the occurrence of a fault on said power line to trip both of said breakers to disconnect said power line from both of said buses, circuit means connecting each of said breaker closing relays of said other of said two breaker control devices to one of said breakers, and circuit means connecting said breaker closing relay associated with said one of said two relaying apparatuses of said one of said two breaker control devices to the other of said breakers, the time interval of said third timer of said one of said two relaying apparatuses of said one of said two breaker control devices being less than the time interval of said third timer of said one of said two relaying apparatuses of said other of said two breaker control devices.

9. In a relaying apparatus for reclosing a circuit breaker, first switching means actuated as a function of the operating conditions of said breaker, a first bistable network having first and second stable operating conditions, a first circuit connecting said first switching means to said bistable network and effective as a consequence of the actuation of said breaker out of its fully opened condition to actuate said bistable network from its said first to its said second condition, a circuit breaker closing network connected between said breaker and said bistable network and effective to actuate said breaker to a closed position solely when said bistable network is in its said first condition, a second circuit connected between said first switching means and said bistable network of said second circuit including a first timer effective to time out a desired interval as a consequence of being actuated from a reset condition as a result of the actuation of said breaker in a closing direction, said timer being effective upon timing out to actuate said bistable network from its said second to its said first condition, said bistable network when in its said second condition being effective to prevent closure of said breaker by said breaker closing network.

10. The combination of claim 9 in which said first switching means comprises contacts held in closed position when said breaker is in its open circuit condition.

11. The combination of claim 9 including a third circuit connecting said bistable network to said timer and effective when said bistable network is in its said first condition to place said timer in its said reset condition.

12. The combination of claim 11 in which said second circuit is effective to initiate the timing by said timer solely subsequent to the actuation of said bistable network into its said second condition.

13. The combination of claim 12 in which said timer acts to time out said desired interval solely when said breaker is out of its fully open condition.

14. The combination of claim 9 in which said first circuit includes a monostable network, said monostable network being characterized by the fact that it normally remains in a first condition and may be actuated into a second condition solely for a given time interval after which said monostable network will return to and remain in its said first condition irrespective of the time interval that said monostable network remains actuated, said monostable network being actuated into said second condition solely as a consequence of the actuation of said breaker in said closing direction.

15. The combination of claim 13 in which said first circuit includes a monostable network, said monostable network being characterized by the fact that it normally remains in a first condition and may be actuated into a second condition solely for a given time interval after which said monostable network will return to and remain in its said first condition irrespective of the time interval that said monostable network remains actuated, said monostable network being actuated into its said second condition solely as a consequence of the actuation of said breaker in said closing direction.

16. The combination of claim 9 in which said breaker closing network includes a first control network having a blocking and an unblocking condition, said control network being effective when in its said blocking condition to prevent closure of said breaker by said bistable network, said control network being effective when in its said unblocking condition to permit closure of said breaker by said bistable network, and third circuit means for actuating said control network into its said conditions.

17. The combination of claim 16 in which said control network includes a second timer effective to time out a desired interval as a consequence of being actuated from a reset condition as a result of the actuation of said control network, said control network further including means normally maintaining said second timer in its said reset condition, said second timer being effective to place said control network in its said unblocking condition solely subsequent to the timing out of said desired interval.

18. The combination of claim 17 in which said means which normally maintains said second timer in its said reset condition is connected to said second circuit and is actuated thereby to maintain said second timer in its said reset condition as a consequence of the actuation of said second circuit by said breaker.

19. The combination of claim 18 in which said means which normally maintains said second timer in its said reset condition includes a second control network having a blocking condition in which said second timer is prevented from timing out its said desired interval and having an unblocking condition to permit said second timer to time out its said desired interval, and means normally maintaining said second control network in its said blocking condition and which is actuable to place said second control network in its said unblocking condition.

20. The combination of claim 19 which includes locking means associated with said second control network and operable to maintain said second control network in its said unblocking condition subsequent to actuation thereof by said normally maintaining means irrespective of the actuation of said normally maintaining means.

21. The combination of claim 20 in which said means which normally maintains said second timer in its said reset condition includes a third timer and effective to delay the actuation of the timing out of said desired interval by said second timer as a consequence of the actuation thereof from said second circuit, said third timer further being effective to delay the interruption of the timing out of its said desired interval as a consequence of the actuation thereof from said second circuit.

22 The combination of claim 21 in which said third timer is located between said second circuit and said second control network.

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23. The combination of claim 22 in which additional control means is coupled to said third timer, said additional control means being effective to prevent the operation of said third timer to place said second control network in condition to initiate the timing out of said second timer into a condition to place said first control network in its said unblocking condition.

24. The combination of claim 9 in which there is provided a circuit-controlling network connected to said bistable network, said circuit-controlling network including circuit-con-

trolling means actuatable between a first and a second circuit controlling condition as a consequence of the change in said condition of said bistable network.

25. The combination of claim 24 in which said circuit-controlling network includes means conductively isolating said circuit controlling means from the portion of said circuit-controlling network which is connected to said bistable network.

26. The combination of claim 25 in which said isolating means includes a transformer.

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