

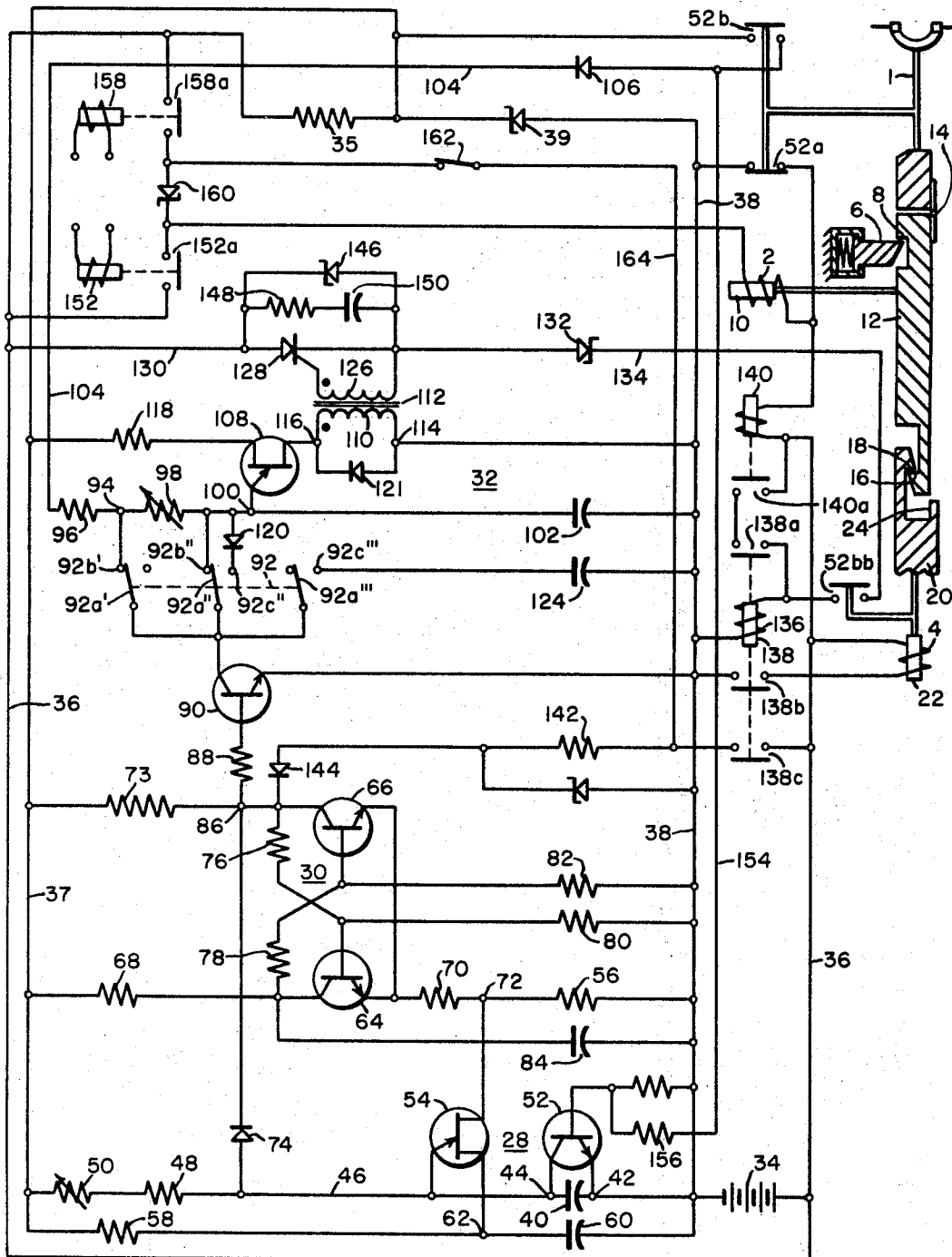
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RECLOSING RELAY APPARATUS

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WITNESSES

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3,388,296

RECLOSING RELAY APPARATUS

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In prior art relaying apparatus for controlling circuit breakers of the reclosing type, it has been customary to reclose the relay a predetermined number of times in the hope that each time the relay is closed the fault will have cleared. In the majority of instances such faults of an ephemeral nature will tend to clear themselves. In some instances, however, a fault is not of this type. Usually when the faults are not of the self-clearing type, the fault current is of high magnitude and the breaker or other current circuit interrupting device is operated with a minimum delay interval. It is the purpose of this invention to utilize this characteristic to provide for preventing subsequent reclosures of the breaker when the fault is not self-clearing.

It is an object of this invention to provide an improved relaying apparatus for controlling reclosing relays wherein the breaker will not reclose if the relay trips out upon an initial reclosure in a very short time interval such time interval as might indicate the existence of a permanent fault.

A further object of this invention is to provide a relay which embodies a timer having a timing interval so related to the timing interval of the fault responsive device that the breaker will remain open and not reclose after the first reclosing when the fault current is such that the fault responsive device operates in a time interval less than a minimum predetermined time interval.

Other objects of this invention will be apparent from the description, the hereinafter appended claims and the drawings in which the sole figure is a schematic representation of a relaying system for controlling a circuit breaker and embodying the invention.

Referring to the drawings by characters of reference numeral 1 represents a circuit breaker of the reclosing type which embodies a trip coil 2 which when energized will cause the circuit breaker to open the circuit controlled thereby and a closing coil motor 4 which, when energized, will actuate the circuit breaker 1 to reclose the circuit controlled thereby.

The circuit breaker including the trip coil 2 and closing motor 4 can take any of various forms. As diagrammatically shown in the sole figure of the drawing it comprises a slidable latch 6 which, is engaged by a shoulder 8 to holding the circuit breaker 1 in its circuit closed position. Upon energization of the trip coil 2 its armature 10 moves into the trip coil 2 and rotates a rockable portion 12 about a hinge 14. This moves the shoulder 8 out of engagement with the latch 6 and the breaker contact carrying portion moves downwardly and opens the circuit controlled thereby. This rocking movement of the rockable portion 12 disengages the latch 16 from the downwardly facing shoulder 18 and the lower portion 20 moves downwardly. As will be discussed below opening of the breaker 1 opens its contacts 52a. This de-energizes the trip coil 2 and so the latch rockable portion 12 swings back into a position in which the latch 16 again underlies the shoulder 18. The breaker 1 is moved to a closed position by energization of the closing motor.

The closing motor 4 may be of any usual construction and is shown schematically as a solenoid coil having a core 22. When the coil is energized, the core 22 is moved upwardly locking the rockable portion 12 in engagement with the lower portion 20; the flange 24 on the lower por-

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tion locking the portion 12 against outward movement. The circuit breaker elements move upwardly to close the circuit controlled thereby and passes beyond the slidable latch 6 which thereupon slides outwardly into the illustrated position to hold the circuit breaker in its circuit closed position.

With the breaker in closed position and the closing motor 4 deenergized, the shoulder 18 seats on the latch 16 and holds the lower portion 20 substantially in the position shown with the switch elements 52bb, carried by the lower portion 20, held in open circuit position. The switch 52bb is held open until the trip coil is energized to release when the switch 52bb moves to its closed circuit position. Similarly, the switch 52a is in its closed position when the circuit breaker is closed and the switch 52b is in its open circuit. Conversely when the circuit breaker is open the switch 52a will be open and the switch 52b will be closed.

The relay 26 comprises a timer 28, a flip-flop or switching network 30 and an initiating circuit 32. Electrical energy for operating the relay 26 may be supplied from any suitable direct current source and is diagrammatically illustrated as a battery 34. The positive terminal of the battery 34 is connected by a positive bus 36 through a resistor 35 to a regulated bus 37. The voltage of the regulated bus is controlled by a Zener diode 39 connected between the regulated bus and a negative bus to which the negative terminal of the battery 34 is connected.

The timer 28 comprises an energy storage device 40, a unijunction transistor 54 and a bias voltage producing resistor 56. The storage device 40 may take the form of a capacitor 40 having terminals 42 and 44. The terminal 42 is connected to the negative bus 38 and the terminal 44 is connected by bus 46 and resistors 48 and 50 to the regulated bus 37. The emitter of the unijunction transistor 54 is connected to the capacitor terminal 44. One of the bases of the unijunction transistor 54 is connected to the bus 38 through the resistor 56 and the other base thereof is connected through a resistor 58 to the regulated bus 37. A capacitor 60 may be connected between the bus 38 and the common connection 62 of the unijunction transistor 54 and the resistor 58, for stabilizing the potential of the common connection 62 and thereby the critical potential to which the capacitor 40 must be charged to cause the unijunction transistor 54 to conduct. A transistor 52 has its emitter and collector connected to the terminals 42 and 44 respectively, and is rendered conducting, as described, below to establish an initial discharged condition of the capacitor 40. The timing functions of the timer 28 is initiated by the rendering of the transistor 52 non-conducting whereupon charging current flows to the capacitor 40 at a rate determined primarily by the resistance afforded of the resistors 48 and 50. When a critical charge accumulates in the capacitor 40, the magnitude of the potential of the terminal 44 will reach a critical value and the unijunction transistor 54 will conduct and the capacitor 40 will discharge through the resistor 56.

The flip-flop or switching network 30 comprises a pair of transistors 64 and 66 which are interconnected so that in its stable conditions only a single one therein will conduct at any one time. With the illustrated arrangement the conductive condition of the transistors is altered by rendering the transistor 64 conducting and non-conducting. More specifically, the transistor 64 has its collector connected through a resistor 68 to the regulated bus 37 and its emitter thereof connected through a resistor 70, the common connection 72 and resistor 56 to the negative bus 38. The transistor 66 has its collector connected to an output terminal 86. This terminal 86 is connected to regulated bus 37 through a resistor 73 and through a diode

74 and the resistors 48 and 50. The emitter of transistor 66 is connected to the emitter of the transistor 64 and this common emitter connection is connected to the negative bus 38 through the resistors 70 and 56. The base of the transistor 64 is connected to the common point of a pair of voltage dividing resistors 76 and 80 which are series connected between the collector of the transistor 66 and the negative bus 38. The base of the transistor 66 is connected to the common point of a pair of voltage dividing resistors 78 and 82 which are series connected between the collector of the transistor 64 and the negative bus 38. A voltage stabilizing capacitor 84 is connected in shunt with the series connected resistors 78 and 82 to insure that the flip-flop 30 will always come on with the transistor 64 conducting and the transistor 66 non-conducting. The flip-flop switch 30 is provided with an output terminal 86 located between the collector of the transistor 66 and the diode 74. This terminal 86 is connected to the base of a switching transistor 90 through a resistor 88. With this arrangement, the transistor 90 is normally maintained non-conducting by the normally conducting transistor 66.

The collector of the transistor 90 is connected to the three switch arms 92a', 92a'' and 92a''' of a three pole switch 92 having contacts 92b', 92b'' and 92b''' . With the switch 92 in the illustrated position the arms 92a' and 92a'' are in engagement with the contacts 92b' and 92b'' respectively and the arm 92a''' is disengaged from the contact 92c''' . The contact 92b' is connected to the common terminal 94 of a pair of resistors 96 and 98 and the contact 92b'' is connected to the common terminal 100 of the resistor 98 and a capacitor 102. The contact 92c''' is connected to one terminal of a capacitor 124; the other terminal of which is connected to the negative bus 38. In the illustrated position of the switch 92, the resistor 98 is shorted and the capacitor 124 is disconnected whereby the resistor 98 and capacitor 124 are effectively isolated from the circuit. In the other position of the switch 90 the arm 92a' is open circuited, the arm 92a'' is connected to contact 92c'' and the arm 92a''' is connected to contact 92c''' . A blocking diode 120 connects the contact 92c'' to the common connection 100. The free terminal of the resistor 96 is connected by a conductor 104, a diode 106 and the switch 52b to the regulated bus 37. A unijunction transistor 108 has its emitter connected to the common connection 100 and one of the bases connected to the negative bus 38 through the primary winding 110 of a pulsing transformer 112. A free wheeling diode 121 is connected across the terminals 114 and 116 of the primary winding 110. The upper base of the unijunction transistor 108 is connected to the positive bus 37 through a resistor 118.

The secondary winding 126 of the transformer 112 is connected between the gate and cathode of a thyristor 128; the anode of which is connected by a conductor 130 to the positive bus 36 and the cathode of which is connected through a Zener diode 132, conductor 134, switch 52bb, and the control winding 136 of a relay 138 to the negative bus 38. When the capacitor 102 reaches a critical charge it will cause the unijunction transistor 108 to conduct whereby the capacitor will discharge through the primary winding 110 of the transformer 112. This discharge pulses the thyristor 128 into conduction to energize the winding 136 of the relay 138.

When so energized, the relay 138 closes its normally open contacts 138a, 138b and 138c. Closure of the contacts 138a establishes a circuit which shunts the switch 52bb through the contacts 140a or relay 140 (relay 140 being deenergized at this time) whereby the relay 138 will be maintained conducting even though the breaker switch 55bb opens. The relay 140 will remain deenergized until the closure of the breaker switch 52a which closes an obvious energizing circuit for the relay 140 between the buses 36 and 38.

Closure of the contacts 138b of the relay 138 completes an obvious energizing circuit for the closing motor 4 which

is thereupon energized to move the breaker 1 to its closed position.

Closure of the contacts 138c completes a control circuit from the positive bus 36 through a resistor 142, a diode 144 and the resistor 76 to the base of the transistor 64 to pulse this transistor 64 into conduction. Conduction of the transistor 64 renders the then conducting transistor 66 non-conducting to interrupt the pulsing network and place the operation of the timer 28 under control of the breaker contacts 52b as will be described in greater detail below. The conductions of the thyristor 128 will be interrupted during closure of the breaker when the contacts 52bb open. Transient voltages across the thyristor are limited by the Zener diode 146. The resistor 148 and capacitor 150 aid in the turn on of the thyristor 128.

It is believed that the remainder of the details of construction may best be understood from a description of operation of the apparatus which follows: Assuming the apparatus is in the illustrated condition in which the breaker 1 is closed and the transistor 66 is conducting. Upon the occurrence of a fault in the circuit protected by the apparatus, the relay 152 will be energized (through a suitable circuit not illustrated) whereby its contacts 152a will close and establish a circuit therethrough from the positive bus 36 through the trip coil 2 and the now closed contacts 52a to the negative bus 38. Upon energization of the trip coil 2, the armature 10 will engage and rock the rockable portion 12 about its hinge 14 to disengage the shoulder 8 from the latch 6 and the shoulder 18 from the latch 16. Thus disengaged, the breaker 1 moves to its open position. When the breaker reaches its open position, the switch 52b thereof closes and establishes two circuits. One of these circuits extends from the regulated bus 37 through the diode 106, conductor 104, resistor 96 and capacitor 102 to the negative bus 38. The capacitor 102 thereupon charges. The magnitude of the resistor 96 is small so that the capacitor reaches its intended charge almost immediately. The other circuit extends from the bus 37 through a conductor 154 and a resistor 156 to the base of the transistor 52 whereby the transistor 52 is rendered conducting to insure that the capacitor 40 is maintained in a discharged condition after having been discharged through a circuit which extends through diode 74 and transistor 66.

When the charge on the capacitor 102 reaches its predetermined critical charge, the unijunction transistor 108 conducts to discharge the capacitor 102 through transformer 112. This discharge fires the thyristor 128 which completes an energizing circuit for the relay 138 through the now closed switch 52bb. The relay 138 thereupon closes its contacts 138a, 138b and 138c. Closure of the contacts 138a establishes a holding circuit for the relay 138 as above described. Closure of the contacts 138b establishes an energizing circuit for the closing motor 4 which thereupon proceeds to move the breaker 1 to its circuit closed position. Closure of the contacts 138c actuates the flip-flop network 30 to render the transistor 64 conducting and a transistor 66 blocked. Blocking of the transistor 66 causes transistor 90 to conduct and interrupts further pulsing of the transformer 112.

Shortly after the energization of the closing motor 4, the breaker 1 will have moved sufficiently toward closed position to open the switch 52bb which terminates the conducting period of the thyristor 128. This interruption is without effect on the relay 138 because of the holding circuit established through the contacts 138a and 140a. This same movement of the breaker 1 toward closed position opens the switch 52b which interrupts the circuits between the bus 37 and the conductors 104 and 154. The opening of the circuit to the conductor 104 is without effect since at this time further charging of the capacitor 102 has been terminated by the conduction of the transistor 90. The deenergization of the conductor 154 removes the base drive of the transistor 52 which becomes non-conducting to initiate the time out interval of the timer 28.

Assuming the value of the resistance of resistors 48 and 50 and of the capacity of the capacitor 40 is such that the fault response relay 152 remains deenergized for at least three timing intervals of the timer 28, the capacitor 40 will accumulate its predetermined critical charge. This charge raises the potential of the bus 46 to the critical minimum potential required to render the unijunction transistor 54 conducting. Conductions of the transistor 54 discharges the capacitor 40 through the resistor 56 whereupon the potential of the common connection 72 is raised sufficiently to elevate the potential of the emitter of the transistor 64 above the potential of its base and this transistor becomes non-conducting. When the transistor 64 becomes non-conducting, the transistor 66 reconducts and establishes a shunting circuit about the capacitor 40 which terminates further operation of the timer 28. Conduction of transistor 66 also establishes a shunting circuit to interrupt further conduction of the transistor 90 to render the initiating circuit responsive to the switch 52b.

When the breaker 1 reaches its fully closed position, the switch 52a closes and energizes the relay 140 which opens its contacts 140a to interrupt the holding circuit of the relay 138. If the fault has disappeared and the fault responsive relay 152 is not further energized the apparatus will remain in this condition. If the fault remains but the magnitude of the fault current is low and the reoperation of the relay 152 occurs after time out of the timer 28 a repeat operation will occur as described above.

If the fault does not clear and the fault current is greater than a predetermined magnitude the fault responsive relay 152 will be actuated and reclose its contacts 152a prior to the timing out of the timer 28. In such an event, the flip-flop switch 30 will not have been actuated to render transistor 66 conducting (the transistor 64 will still be conducting). Under these conditions the transistor 90 will still be conducting and the initiating circuit 32 will be ineffective to fire the thyristor 128 to close the circuit breaker 1. The circuit breaker 1 will remain in the "tripped-out" position until closed by other means (not shown).

With the switch 92 in the position as shown, there is little if any time interval between the opening of the breaker 1 and the energization of the closing motor 4 to reclose the breaker. If such a time interval is desired, the switch 92 is placed in its other position to which the capacitor 124, resistor 98 and diode 120 are connected into the circuit. The capacitor 124 is charged through the resistors 96 and 98 and is of sufficient magnitude to provide a time delay of the initiation of operation of the initiating circuit 32.

If it is desired to utilize the circuit breaker 1 for back-up protection of another protecting network and to provide this backup protection in a manner which prevents reclosure of the relay 1, a second fault responsive or backup protection relay 153 may be provided. Such a relay will be actuated through circuitry not shown but well known in the art to energize the relay 153 in the event of the failure of the normal fault responsive apparatus.

The relay 153 is provided with contacts 158a which connect the bus 36 through a Zener diode 160 to the trip coil 2 whereby the breaker 1 is actuated to open position as a consequence of the energization of the relay 153. The contacts 158a also complete a circuit for actuating the flip-flop switch 30. This circuit extends from bus 36 through contacts 158a, 162, a conductor 164, the resistor 142, diode 144 and resistor 76 to the base of the transistor 64. The closure of the contacts 158a therefore trips the switch 30 to render transistor 90 conducting. As described above this prevents the firing of the thyristor 128 and the energization of the closing motor 4. The transistor 66 cannot be rendered conducting until the timer 28 times out and since the breaker 1 is open and

its contacts 52b are closed the transistor 52 will be maintained conducting to prevent the timer 28 from timing out. If reclosing operation is desired despite the operation of the breaker 1 for back-up protection, the switch 162 may be opened and the breaker 1 will be reclosed as described above.

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.

What is claimed and is desired to be secured by U.S. Letters Patent is as follows:

1. In an apparatus for controlling the energization of the opening and closing elements of a reclosing type of circuit controller, a timer having a set condition and a timed-out condition and timing means for determining the time interval required by the timer to change its condition from its said set condition to its said timed-out condition, a control means having first and second operating conditions, an initiation circuit, actuating means, means connecting said actuating means to said initiating circuit and to said timing means whereby a change in energization of said actuating means initiates the operation of said initiating circuit and places said timer into said set condition, means connecting said timing means to said control means whereby said timing means is actuated to time out its said time interval upon the actuation of said control means to its said first condition, and means connecting said control means to said initiating circuit whereby said control means is actuated to its said first condition as a consequence of the operation of said initiating circuit, and means actuated by said timing means as a consequence of the timing out of said time interval for actuating said control means to its said second condition.

2. The combination of claim 1 in which there is provided means connecting said contact means to said initiating means whereby said initiating means is rendered ineffective when said control means is in a condition other than said second condition.

3. The combination of claim 1 in which there is provided a controlled mechanism, said mechanism having first and second operating conditions, said mechanism having a first circuit controlling device actuated into a first condition when said mechanism is in its said first condition and into a second condition when said mechanism is in its said second condition, means connecting said actuating means to said circuit controlling device, said circuit controlling device when in said first condition being effective to cause said change in energization of said actuating means.

4. A control apparatus, an energy storage device, a charging circuit for said device including means for controlling the rate at which energy is accumulated by said device, a flip-flop circuit having first and second operating conditions and first and second control connections, said first and second control connections being effective when energized to actuate said flip-flop circuit into its said first and second operating conditions respectively, an operation initiating circuit having first and second operating conditions and first and second control connections, said initiating circuit being rendered effective solely when both of its said control connections are in first operating conditions, a first control circuit including a first switch connected to said first control connection of said initiating circuit and effective when said switch is in a first position to render said first control connection of said initiating circuit in its said first operating condition, a second control circuit connecting said flip-flop to said second control connection and effective solely when said flip-flop is in its said first condition to render said second control connection of said initiating circuit in its said first condition, means connect-

ing said storage device to said first connection of said flip-flop whereby said flip-flop is actuated to its said first operating condition as a consequence of the accumulation of a predetermined quantity of energy by said storage device, a setting circuit connected to said storage device and effective to establish a predetermined minimum magnitude of accumulated energy in said storage device, a control circuit, means connected to said setting circuit and including said first switch for rendering said setting circuit effective when said first switch is in its said first position, control means connecting said charging circuit to said flip-flop, said just-named control means being effective solely when said flip-flop is in its said second condition to render said charging circuit effective to supply energy to said storage device.

5. The combination of claim 4 in which said setting circuit includes an electric valve connected in shunt with said storage device and in which said means which connects said storage device to said first connection includes a voltage sensitive breakover device.

6. The combination of claim 5 in which there is provided a circuit breaker having first and second and third sets of contacts and a trip device and a closing device, said breaker being actuated by said closing device to a circuit close position and by said trip device to a circuit open position, said first set of contacts being closed when said breaker is in its said closed position and said second and third sets of contacts being closed when said breaker is in its said open position, said first switch including said second set of contacts, means connecting said initiating circuit to said closing device and including said third set of said contacts.

7. The combination of claim 6 in which said means which connects said initiating circuit to said closing device includes a discontinuous contact type electric valve, said valve being effective upon being rendered conducting to continue conducting until current flow therethrough is externally interrupted, and network means including said first set of contacts for externally interrupting current flow through said discontinuous control type electric valve.

8. In a controlling network, a pair of buses, a first circuit connected between said buses and including a first resistor and a first capacitor connected in series, a plurality

of electric valves, each said valve having a main circuit and a control circuit for controlling at least the initiation of current flow through its said main circuit, means connecting said main circuit of a first of said valves in shunt with said capacitor, a second circuit connected between said buses and including said main circuit of a second of said valves and a second resistor in series, a third circuit connected between said buses and including said main circuit of a third of said valves and said second resistors, a breakover device, a fourth circuit connected in shunt with said breakover device and including said breakover device and said second resistor, a diode, a fifth circuit connected in shunt with said capacitor and including said diode and said main circuit of said third valve, an initiating circuit including said main circuit of a fourth of said valves, said initiating circuit being operable solely when said main circuit of said fourth valve is non-conductive, means connecting said control circuit of said second valve to said main circuit of said third valve and said control circuit of said third valve to said main circuit of said second valve whereby the rendering conductive of said main circuit of one of said second and said third valves renders said main circuit of the other thereof non-conductive, and means connecting said control circuit of said fourth valve to said main circuit of said third valve.

9. The combination of claim 8 in which there is provided a control device having a set of contacts, an operating assembly for actuating said control device having a set of contacts, circuit means actuated by said set of contacts of said control device and connected to said control circuit of said first valve and to said main circuit of said fourth valve, circuit means actuated by said set of contacts of said operating assembly and connected to said contact circuit of said second valve.

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