

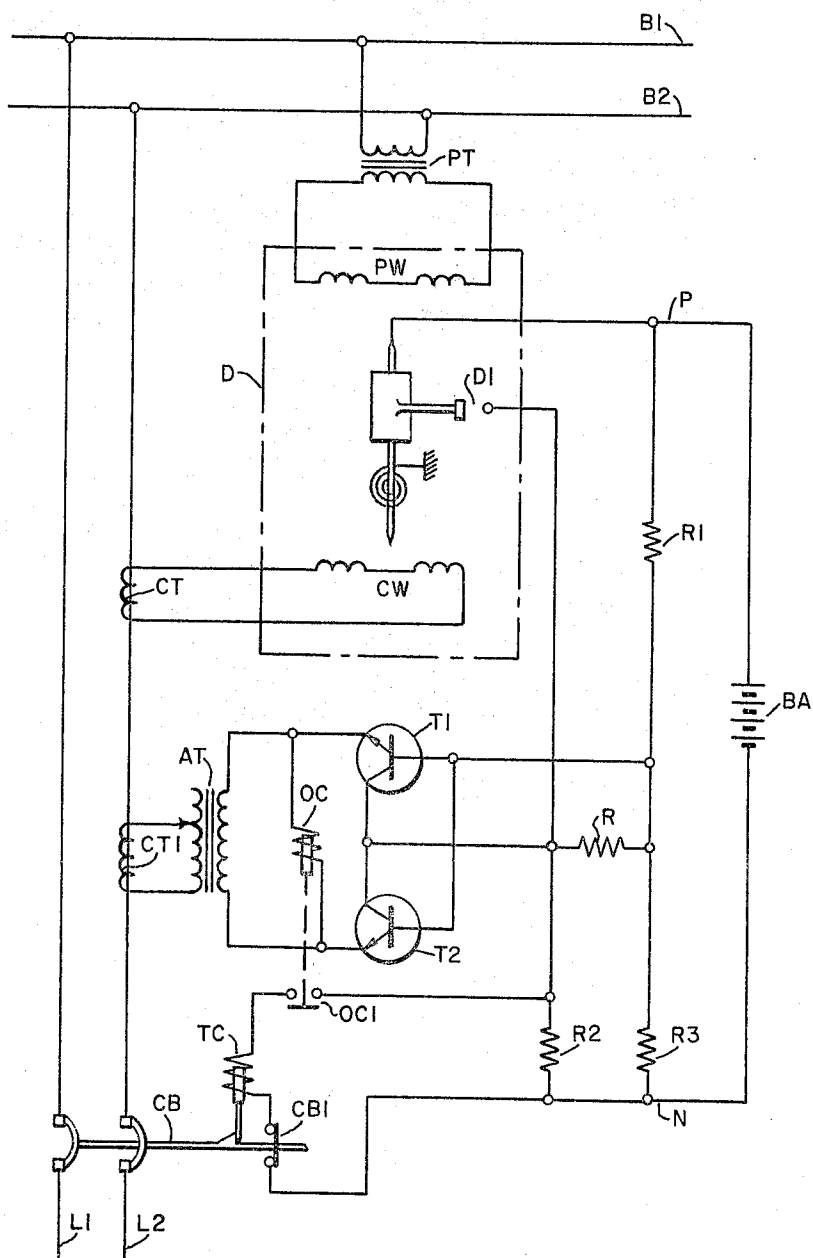
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DIRECTIONAL OVERCURRENT RELAYS

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WITNESSES

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3,278,804

DIRECTIONAL OVERCURRENT RELAYS

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This invention relates to protective arrangements for electric systems and it has particular relation to directional overcurrent relays suitable for incorporation in such protective arrangements.

In protective arrangements for electric systems, it has been conventional practice to employ a first relay for controlling the operation of a second relay. For example, in a high-speed directional overcurrent relay assembly operation of a directional relay has been employed for controlling the effectiveness of an overcurrent relay. Because of the requirements of the overcurrent relay, the contacts of the directional relay were required to handle substantial current.

In accordance with the invention a controlled electronic switch preferably a transistor switch is interposed between the directional relay and the overcurrent relay. This facilitates the selection of a small and compact overcurrent relay design. Furthermore, the directional relay contacts handle small currents and the relay may be designed for optimum sensitivity.

In a preferred embodiment of the invention the same set of contacts of the directional relay not only controls the effectiveness of the overcurrent relay but also is located directly in the energizing circuit of apparatus controlled by the relay assembly.

In a preferred embodiment of the invention a pair of transistors are arranged as an alternating current switch. When the directional relay is in its non-tripping condition the transistors are biased to a closed condition in order to shunt the overcurrent relay thus making the overcurrent relay ineffective. When the directional relay is in its tripping condition, the transistors are biased to their open condition thus opening the shunt across the overcurrent relay to place the overcurrent relay in effective condition.

It is therefore an object of the invention to provide an improved relay assembly wherein an electronic switch controls the effectiveness of a relay.

It is another object of the invention to provide a protective relay assembly wherein a directional relay controls an overcurrent relay through a controlled electronic switch.

Other objects of the invention will be apparent from the following description taken in conjunction with the accompanying drawings in which a single figure represents a schematic view of an electric system embodying the invention.

In the drawing an electric system to be protected is associated with a suitable source of power. The system may be a single-phase or a polyphase alternating current system. For exemplary purposes, it will be assumed that the electric system is a transmission line having line conductors L1 and L2 arranged for single-phase alternating current operation at a power frequency such as sixty cycles per second. The line conductors L1 and L2 are connected through a circuit breaker CB for energization from a suitable source represented by bus conductors B1 and B2. The circuit breaker CB has a trip coil TC which may be energized to trip the circuit breaker and an auxiliary switch CB1 which is closed when the circuit breaker is in closed position and which is open when the circuit breaker is in open position. The circuit breaker CB is illustrated in the drawing in its closed position.

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Tripping of the circuit breaker CB is supervised by a directional relay D having a set of contacts D1. The contacts D1 are open when the flow of power in the transmission line is in a non-tripping direction as from the transmission line to the bus. The contacts are closed when the flow of power is in a tripping direction as from the bus to the transmission line through the circuit breaker CB.

The contacts D1 may be operated by any suitable structure. As shown in the drawing, potential windings PW are provided for the directional relay which are energized in accordance with the voltage across the bus conductors B1 and B2 through a potential transformer PT. In addition, the directional relay D has current windings CW which are energized in accordance with line currents supplied to the transmission line. Such energization is effected through a current transformer CT. Desirably the directional relay D may have the construction shown in the Marieni Patent 2,949,515 which issued Aug. 16, 1960.

The directional relay D is employed for supervising the effectiveness of an overcurrent relay OC having contacts OC1. The overcurrent relay may be of a simple solenoid type having an operating coil connected for energization across a secondary winding of a transformer AT. The transformer AT has an adjustable primary winding which is connected for energization through a current transformer CT1 in accordance with line currents supplied to the transmission line. The value of line current for which the overcurrent relay picks up may be adjusted by adjustment of the number of effective turns in the primary winding of the transformer AT. Preferably, the transformer AT has a saturable magnetic core which is designed to saturate for large values of line current in order to protect the overcurrent relay operating coil and associated equipment from the application thereto of excessive voltages.

The effectiveness of the overcurrent relay is controlled by a controllable switch which preferably is of the electronic type as illustrated.

In the preferred embodiment of the drawing the electronic switch includes two transistors T1, T2 which conveniently may be of the n-p-n type. The emitters of the two transistors are connected respectively to the terminals of the operating coil of the overcurrent relay OC. The collectors of the two transistors are connected to each other. The bases of the transistors T1 and T2 are also connected to each other. It will be noted that a resistor R is connected between the two collectors and the two bases of the transistors. The polarity of the voltage across the resistor R determines the condition of the switch represented by the two transistors.

If the polarity of the voltage across the resistor R is such that the base of each of the transistors is maintained positive relative to the associated collector the transistors are turned on and establish a shunt across the operating coil of the overcurrent relay OC. This maintains the overcurrent relay in an ineffective condition, wherein the contacts OC1 are open. If the polarity of the voltage across the resistor R is reversed the transistors T1 and T2 turn off to remove the shunt from the operating coil of the relay OC. The relay now is energized in accordance with current flowing in the transmission line and if this current is above the pickup value for which the relay is set the relay operates to close its contacts OC1.

The polarity of the voltage across the resistor R is determined by a network connected between the positive terminal P and the negative terminal N of a source of direct current such as battery BA. This network includes two resistors R1 and R3 which are connected in series across the battery BA. The right-hand terminal of the resistor R is connected to a point intermediate the

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two resistors R1 and R3. The contacts D1 of the directional relay D and a resistor R2 also are connected in series across the battery BA. The left-hand terminal of the resistor R is connected to a point intermediate the contacts D1 and the resistor R2. The resistors R1, R2 and R3 and the contacts D1 may be considered to be the four arms of a bridge. The battery BA is connected across one diagonal of the bridge whereas the resistor R is connected across the other diagonal of the bridge. When the contacts D1 are open the arm of the bridge represented by such contacts may be said to have infinite resistance. When the contacts D1 are closed the arm may be said to have substantially zero resistance.

By inspection of the drawing, it will be noted that when the contacts D1 are open the battery BA supplies current to the resistor R in such a direction that the right-hand terminal of the resistor R is positive relative to the left-hand terminal of the resistor R. This polarity turns on the transistors T1 and T2 to establish a shunt across the coil of the overcurrent relay OC. When the contacts D1 are closed the polarity of the voltage across the resistor R reverses to maintain the collectors of the two transistors positive with respect to their associated bases. This turns the transistors off to render the overcurrent relay OC effective.

The trip coil TC of the circuit breaker CB is connected across the resistor R2 through the contacts OC1 of the overcurrent relay OC and through the auxiliary switch CB1 of the circuit breaker. If the contacts OC1 and the auxiliary switch CB1 are closed while the contacts D1 are open, current can be supplied to the trip coil TC through the resistors R and R1. The parameters are such that this current is insufficient to trip the circuit breaker CB. However, if the contacts D1 and OC1 and the auxiliary switch CB1 are all closed a tripping circuit for the circuit breaker may be traced from the positive terminal P of the battery through the contacts D1, the contacts OC1, the trip coil TC, and the auxiliary switch CB1 to the negative terminal N of the battery. The flow of current through this circuit results in a tripping operation of the circuit breaker CB.

The operation of the system now will be reviewed briefly. It will be assumed first that the circuit breaker CB is closed and that power is flowing through the circuit breaker in a non-tripping direction. Under such circumstances, the contacts D1 of the directional relay D are open. The voltage across the resistor R has a polarity which turns on the transistors T1 and T2 to establish a shunt across the overcurrent relay OC and this relay therefore remains dropped out.

If the flow of power through the circuit breakers CB reverses and is in the tripping direction, the directional relay D closes its contacts D1. Inasmuch as the directional relay D is required to control only small current by means of its contacts D1, the directional relay D may be designed for optimum sensitivity. The closure of the contacts D1 result in a reversal in the polarity of the voltage across the resistor R and the voltage now turns off the transistors T1 and T2 to interrupt the shunt across the overcurrent relay OC. This places the overcurrent relay OC in effective condition and its operating coil receives a current which is dependent on line current flowing in the transmission line. If a fault occurs on the transmission line the line current increases to a value in excess of the pickup value for which the overcurrent relay OC is set. The overcurrent relay OC thereupon picks up to close its contacts OC1. Inasmuch as the contacts D1 and OC1 and the auxiliary switch CB1 are all closed, a substantial current flows from the battery BA through the tripping coil TC to trip the circuit breaker CB.

The use of transistors in a switching mode is discussed in an article by R. L. Bright, entitled "Junction Transistors Used As Switches" which appeared in the transactions of the American Institute of Electrical Engineers,

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New York City, part I, March 1955, page 111. A further discussion will be found in the R. L. Bright Patent 2,962,603 which issued Nov. 29, 1960.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications falling within the spirit and scope of the invention are possible.

We claim as our invention:

1. In a protective arrangement for an electric system, a directional relay including a first switch operable into closed and open conditions dependent on the direction of the energization applied to the directional relay, an overcurrent relay including a second switch operable into closed and open conditions dependent on the magnitude of the energization of the overcurrent relay, a source of energy, an energy-controlled switch dependent on the polarity of its energization for controlling the operability of the overcurrent relay and control means effective with the first switch in a first condition for energizing the controlled switch from said source with a first polarity for rendering the overcurrent relay inoperative, said control means including means effective with the first switch in a second condition for energizing the controlled switch from said source with a second polarity for rendering the overcurrent relay operative.

2. In a protective arrangement for an electric system, a directional relay including a first switch operable into closed and open conditions dependent on the direction of the energization applied to the directional relay, an overcurrent relay including a second switch operable into closed and open conditions dependent on the magnitude of the energization of the overcurrent relay, a source of energy, an energy-controlled switch dependent on the polarity of its energization for controlling the operability of the overcurrent relay and control means effective with the first switch in a first condition for energizing the controlled switch from said source with a first polarity for rendering the overcurrent relay inoperative, said control means including means effective with the first switch in a second condition for energizing the controlled switch from said source with a second polarity for rendering the overcurrent relay operative, and an output circuit for supplying energy from said source through the first and second switches in series.

3. In a protective arrangement for an electric system, a directional relay including a first switch operable into closed and open conditions dependent on the direction of the energization applied to the directional relay, an overcurrent relay including energizable input means and a second switch operable into closed and open conditions dependent on the magnitude of the energization of the overcurrent relay, a source of energy, an energy-controlled switch dependent on the polarity of its energization for controlling the operability of the overcurrent relay and control means effective with the first switch in a first condition for energizing the controlled switch from said source with a first polarity for rendering the overcurrent relay inoperative, said control means including means effective with the first switch in a second condition for energizing the controlled switch from said source with a second polarity for rendering the overcurrent relay operative, said controlled switch comprising a pair of transistors having their collector-emitter circuits connected back-to-back across the energizable input means of the overcurrent relay, said transistors having input control circuits connected in parallel for energization from said source under the control of said control means, whereby for said first polarity of energization of the controlled switch the collector-emitter circuits of the transistors constitute a shunt across the energizable input means of the overcurrent relay, and whereby for said second polarity of energization of the polarized switch the collector-emitter circuits of the transistors are substantially cut off.

4. In a protective arrangement for an electric system, an overcurrent relay having energizable input means, a

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directional relay including a first switch operable into closed and open conditions dependent on the directions of the energization to which the relay is designed to respond, a source of direct electric energy, first and second terminals, control means including said switch and a network connecting the terminals to the source to establish a first polarity across the terminals when the switch is open, said control means in response to closure of said switch modifying the voltage distribution in the network to establish a second polarity across the terminals, a pair of transistors, each having a collector electrode, an emitter electrode and a base, means connecting the bases of the transistors to the first terminal, means connecting a similar one of the electrodes of each of the transistors to the second terminal and the remaining electrode of each of the transistors respectively to the terminals of the energizable input means, said first polarity of voltage placing said transistors substantially in cut-off condition and said second polarity of voltage placing said transistors substantially in saturated condition.

5. In a protective arrangement for an alternating electric system having a line section and a circuit breaker for controlling the connection of the line section to another portion of the electric system, said circuit breaker having tripping terminals effective when energized for tripping the circuit breaker, a directional relay including a first switch operable into closed and open conditions dependent on the direction of the energy flow through said circuit breaker, an overcurrent relay including energizable input means and a second switch operable into open and closed conditions dependent on the magnitude of current flowing through the circuit breaker, a source of direct current, polarized means responsive to the polarity of a voltage applied thereto for controlling the operability of the overcurrent relay, a network for applying to the polarized means from said source a voltage having a first polarity for rendering the overcurrent relay inoperative, said network being responsive to closure of the first switch for modifying the current distribution in said network to render the overcurrent relay operative, and means connecting the tripping terminals for energization from said source through said first and second switches in series.

6. In a protective arrangement for an alternating electric system having a line section and a circuit breaker for

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controlling the connection of the line section to another portion of the electric system, said circuit breaker having tripping terminals effective when energized for tripping the circuit breaker, a directional relay including a first switch operable into closed and open conditions dependent on the directions of the energy flow through said circuit breaker, an overcurrent relay including energizable input means and a second switch operable into open and closed conditions dependent on the magnitude of current flowing through the circuit breaker, a source of direct current, energy-controlled means responsive to the polarity of a voltage applied thereto for controlling the operability of the overcurrent relay, a network for applying to the controlled means from said source a voltage having a first polarity for rendering the overcurrent relay inoperative, said network being responsive to closure of the first switch for modifying the current distribution in said network to render the overcurrent relay operative, and means connecting the tripping terminals for energization from said source through said first and second switches in series, said network having four arms connected in a bridge, one of said arms comprising the first switch, said source being connected across a first diagonal of said bridge, and said polarized means comprising a pair of transistors each having an emitter, a collector and a base, means connecting the base-collector circuits of these transistors in parallel across a second diagonal of the bridge, and means connecting the base-emitter circuits of the transistors back-to-back in series across the energizable input means of the overcurrent relay.

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