Jan. 17, 1939. E. L. HARDER ET AL 2,144,493

PILOT PROTECTIVE SYSTEM

Filed Nov. 13, 1936 2 Sheets-Sheet 1

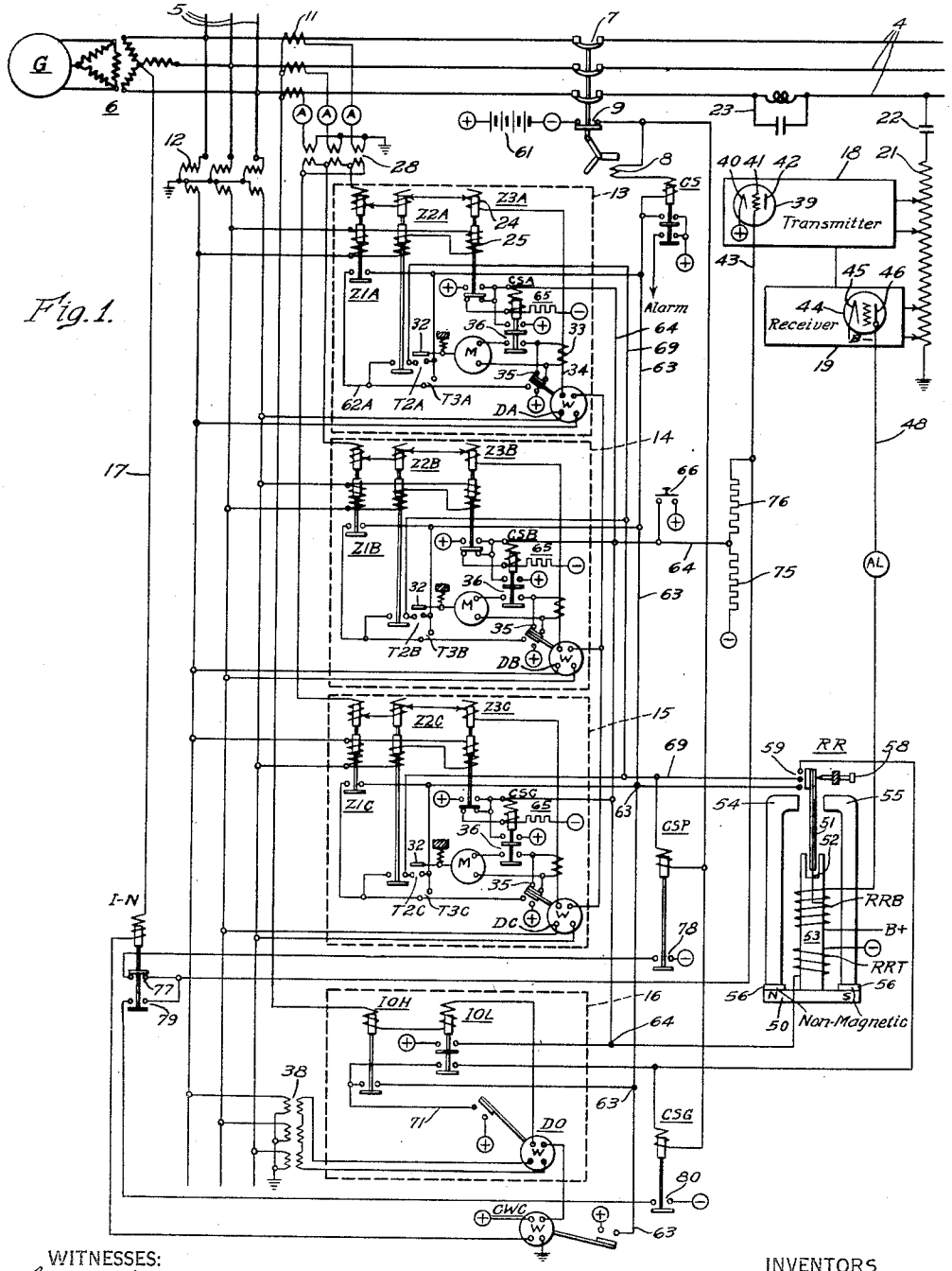

Fig. 1.

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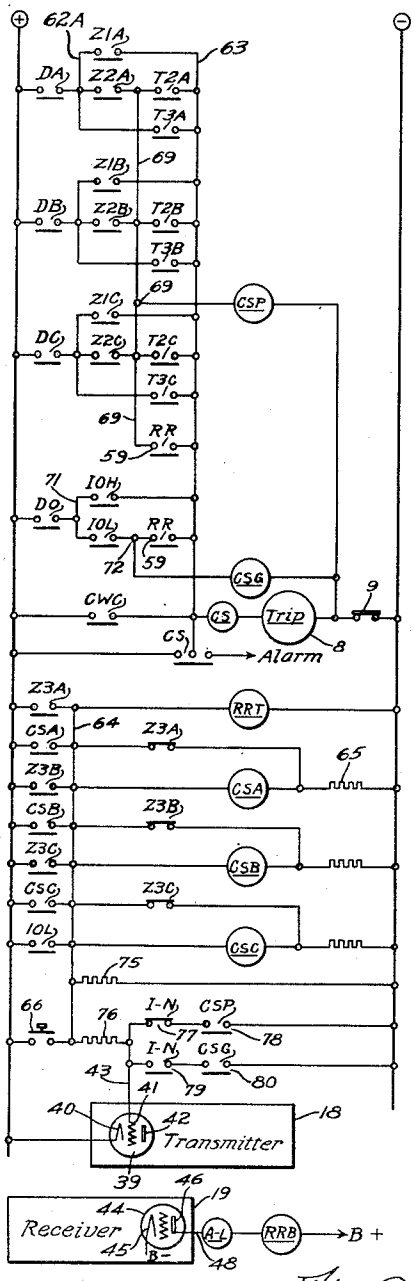

Fig. 2.

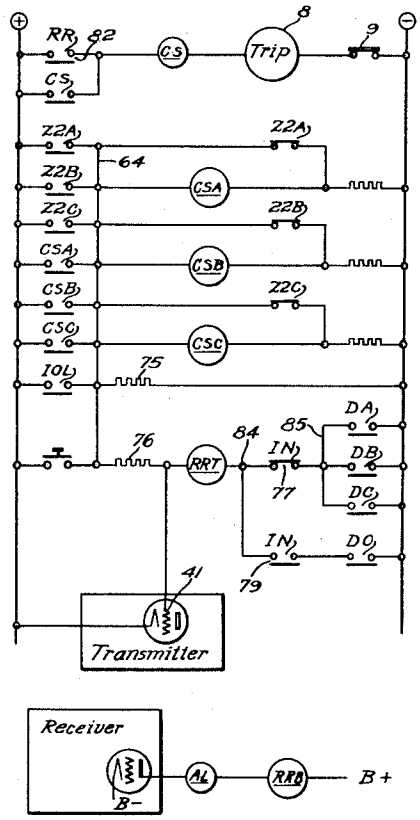

Fig. 3.

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PILOT PROTECTIVE SYSTEM

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Application November 13, 1936, Serial No. 110,660

55 Claims. (Cl. 175—294)

Our invention relates to systems for protecting electric transmission lines and the like against faults, and it has particular relation to such systems utilizing pilot communicating channels such as pilot wires or carrier current whereby signals may be transmitted from one end to the other of the protected line-section.

One of the important objects of our invention is to provide a pilot protective system utilizing a two-position receiver-relay for receiving and responding to signal currents transmitted from the other end of the protected line-section, the characteristic feature of this two-position receiver-relay being that it has continuously operating biasing means tending to move the relay to its open position, and in addition to the biasing means, the relay has two normally deenergized electro-responsive means. One of said electro-responsive means is energized from a local battery source, under the control of suitable fault-detectors, so as to develop an operating force sufficient to overcome the biasing force and to actuate the relay with a sufficient speed of operation, usually about 0.3 cycle. The other of said electro-responsive means is energized in response to the receipt of a predetermined signal current transmitted either locally or at the other end of the protected line-section, so as to develop a restraining force assisting the biasing force in holding the relay in its normal open position, and strong enough so that these two forces combined will hold the relay open, or block its operation, even when the electro-responsive operating force is in effect. The signal current may be a superimposed carrier current or other pilot-channel current which is preferably placed on the pilot channel in response to fault-detectors, and removed or blocked from the pilot channel in response to an internal direction of power-frequency current-flow into the protected line-section at each end, a separate signal-current transmitter being utilized at each end and being controlled in response to the line-conditions at its own end of the protected line-section.

A further object of our invention is to provide a novel transmitter-controlling system utilizing only grid-control contacts for starting and blocking the oscillations of a carrier-current transmitter of the oscillator-tube type, thereby securing the advantage of utilizing make-contacts which can be paralleled and used in common with other circuits. By "make" contacts we mean contacts which are normally open and which are closed or made in response to predetermined line conditions.

A further object of our invention is to utilize the same contact for both starting the carrier-current transmitter and energizing the tripping coil of our two-position receiver-relay.

A further object of our invention is to utilize a pilot protective system in which the carrier currents or other signal currents are of the intermittent type in the sense that they are not normally transmitted, but when predetermined fault conditions are indicated, the carrier-current transmission is quickly initiated, and subsequently the carrier-current transmission is stopped in response to an internal directional indication, a feature of our invention being that there is a small but significant slight delay in the stopping of carrier-current which is once initiated, said delay being of the order of a small fraction of a cycle and being of advantage in coordinating the various relay-movements when there is an external fault at a time when there is an internal load.

By "carrier current" we mean pilot-channel current of any kind. By "external" we mean, accompanied by a current flowing out of the protected line-section; and by "internal" we mean, accompanied by a current flowing into the protected line-section.

Without proper coordination of the various relay-movements, any internal load-current which is flowing at the time of an external fault tends to cause the directional elements to indicate an internal fault as soon as the external fault is cleared, or even partially cleared, thus creating the possibility of stopping the carrier-current transmission before the non-directional fault-responsive relays on the protected line-section can return to normal position as a result of the cessation of external fault conditions.

A further object of our invention is to provide ground-preference means in a protective system for polyphase lines, in which the zero-phase-sequence line-voltage, specifically a zero-phase-sequence voltage-response obtained by a transformer-neutral current, is utilized to energize the ground-preference relay, thereby avoiding the faulty operation of the ground-preference relay on residual current due to non-simultaneous breaker-pole opening during phase-fault conditions, as would be the case if the ground-preference relay were energized from residual current, as heretofore, rather than being operated from residual voltage as in the preferred form of our invention.

A further object of our invention is to provide a ground-directional means which utilizes a

ground-fault detector as well as a ground-current directional element.

A further object of our invention is to provide a three-step ground-fault relaying equipment in connection with carrier-current protection for providing a first step in instantaneous response to overcurrent and direction, a second step in response to overcurrent and direction with carrier control, and a third step comprising a timed directional ground back-up relay.

A further object of our invention is to provide a plurality of single-phase directionally responsive elements having their contact-circuits controlled by single-phase fault-detectors, in a protective system for a polyphase line, for controlling the blocking of carrier, thereby avoiding certain difficulties which have been experienced, in protective systems utilizing a single three-phase directional element for responding to line-to-line faults in any one of the three phases.

A further object of our invention is to utilize a two-position polarized receiver relay in an intermittent-carrier protective system.

With the foregoing and other objects in view, our invention consists in the circuits, apparatus, systems, combinations and methods hereinafter described and claimed, and illustrated in the accompanying drawings, wherein

Figure 1 is a diagrammatic view of circuits and apparatus embodying our invention in one preferred form of embodiment,

Fig. 2 is a so-called "across the line" diagram of the direct-current connections of the relaying system shown in Fig. 1, and

Fig. 3 is a view similar to Fig. 2, illustrating a modification.

As shown in Fig. 1, our invention is illustrated as being applied to the protection of one end of a protected-line-section 4 of a three-phase transmission line, only one end of the protected section being illustrated, as the other end may be similar thereto, in its relaying equipment. The protected line-section 4 is connected to a bus 5 at the illustrated relaying station, and the bus 5 is usually provided with a plurality of power transformers 6 which are connected to preferably synchronous motors or generators such as the generator G in Fig. 1. It will be understood that other circuits or lines, similar to line-section 4, will in general be connected to the station bus 5, the simplest possible connections being illustrated for the sake of clearness.

Each end of the protected line-section 4 is provided with a line-sectionalizing circuit-interrupter 7 which may be an oil circuit-breaker provided with a trip-coil 8 and having auxiliary contacts 9 which are closed when the circuit interrupter or breaker is closed.

Our protective system, for controlling the tripping of the circuit breaker 7, utilizes both line-frequency relays and a carrier-current system or other pilot-channel system for transmitting, and responding to relaying signals to and from the other end of the protected line-section.

The line-frequency relays are illustrated as being energized from a group of line-current transformers 11 and potential transformers 12, and are arranged essentially in four panels 13, 14, 15 and 16, the first three of which are phase-to-phase relays and the last of which is composed of ground protective relays. In addition, according to our invention, we utilize a special ground-preference relay marked I—N, which is simply an overcurrent relay arranged to be responsive to the neutral connection 17 of the power transformer 6, so as to obtain a response which is more reliable than the zero-phase-sequence-current response of previous ground-preference protective means, because of the possibility of the different poles of the three-phase breakers opening at different moments of time, as previously intimated. It will be understood that the power-transformer neutral-connection 17 is made between ground and the neutral point of a Y-connected transformer-winding which is connected to the bus 5.

The carrier-current equipment for the end of the line-section illustrated in Fig. 1 comprises a carrier-current transmitter 18 and a carrier-current receiver 19, both tuned to the same high or carrier-current frequency, and both coupled to the protected line-section by means of a coupling transformer 21 and a coupling capacitor 22. In addition, it is necessary to provide a resonant carrier-frequency choke coil or wave-trap 23 in the line-wire to which the carrier is coupled, as indicated; and it is necessary to have a receiver-relay, marked RR, which responds to the receipt of suitable carrier-currents or signals.

The phase-fault line-frequency relaying equipments 13, 14 and 15 are all alike, except that they are connected to be responsive to different phases of the transmission line, as indicated by the distinguishing letters A, B and C in the symbols designating the various relay-elements, so that a description of the relay elements comprising the group 13 will suffice also for the other groups 14 and 15.

The relay panel 13 utilizes three so-called "instantaneous" impedance relays which are set to respond to different distances or zones known as zones 1, 2 and 3, as indicated by the symbols Z1A, Z2A and Z3A, the letter A indicating the phase in which the relay is connected. The balance point of the first impedance element Z1A is necessarily within the length of the protected line-section, and is as close to the far end of the same as it is possible to make it without running the risk of a response to any fault conditions which are further than the far end of the protected line-section. The second impedance element Z2A has its balance point somewhere beyond the far end of the protected line-section and usually, but not necessarily, in the next section beyond. The third impedance element Z3A is much more sensitive, being set to respond to faults which are still more remote. Each of these impedance elements is provided with a current-responsive actuating coil 24 tending to actuate the relay, and a voltage-responsive restraining coil 25 tending to restrain the operation of the relay.

These impedance relays Z1A, Z2A and Z3A are shown as having their current coils 24 energized in response to the difference between the line current in two of the phases of the protected section 4, this difference being obtained by means of auxiliary current-transformers 28. The voltage coils 25 of the impedance relays are energized by the phase-to-phase line-voltages in the same phases to which the current coils respond, the voltage potential being supplied by the potential transformer 12.

The relay panel 13 also comprises a so-called "instantaneous" directional element DA which is designated schematically as a wattmeter indicated by the letter W; a timing element which is designated schematically as a motor M, having a movable arm 32 which makes the successive contacts T2A and T3A for cooperating with the

second- and third-zone impedance elements Z2A and Z3A respectively; also an auxiliary relay or contactor-switch CSA.

The current-coil of the directional element DA is necessarily energized in response to the same current which activates the second-zone impedance element Z2A, this being necessary in order to prevent faulty operation of our relaying equipment, as will subsequently be explained.

The timer motor M is energized by means of an auxiliary current-transformer 33 which is connected in series with the current conductor 34 which carries the current for the current coils of this relay panel. In a preferred form of embodiment, the current-transformer 33 is normally short-circuited by means of back-contacts 35 on the directional element DA. The timer motor M is connected to the current-transformer 33 by means of one of two sets of front or "make" contacts 36 of the auxiliary relay CSA. Thus the timing motor M is energized only when the auxiliary relay CSA is energized and when, at the same time, the directional element DA is actuated. The directional element is connected so as to respond only when there is a line-frequency current-flow in an "internal" direction, that is from the bus 5 into the protected line-section 4.

The ground-relay panel 16 comprises two so-called "instantaneous" ground-overcurrent relays IOH and IOL which are energized from the neutral of the line-current transformers 11. These relays are of different sensitivities, the first one being a high-current relay, as indicated by the letter H, and the second one being a more sensitive, low-current relay, as indicated by the letter L.

The ground-relay panel 16 also comprises a so-called "instantaneous" ground directional element DO which is illustrated as being a wattmeter designated by the letter W, the voltage coil of the wattmeter being energized with zero-phase-sequence voltage derived from a set of auxiliary potential transformers 38. The connections for the directional element DO are such that this relay element responds only when the direction of the ground current is such as to indicate that the ground fault is on the same side of the bus 5 as the protected line-section 4.

In addition to the ground panel 16, we have also provided a sensitive but slow power-directional ground-relay CWC which is indicated symbolically as a wattmeter element designated W. This element is of the induction type, which requires a definite time for its movement, as distinguished from the substantially instantaneous directional elements DA, DB, DC and DO. Like the other directional elements, it responds only to internal faults, that is, to faults which are accompanied by current-flow in such direction as to indicate that the fault is on the same side of the bus 5 as the protected line-section 4. The CWC ground-directional relay compares the directions of the neutral current of the line-current transformer 11 and the neutral current of the neutral-ground connection 17 of the power-transformer 6.

The carrier-current transmitter 18 is illustrated as being of a type having a master-oscillator tube 39 which is shown as being a triode comprising a cathode 40, a grid 41, and a plate or anode 42. The oscillator-tube 39 is of such a type that the oscillations are blocked when a predetermined negative bias is applied to the grid 41 through the grid-control circuit 43, the cathode 40 being permanently connected to the positive station-battery terminal (+).

Our receiver 18 is illustrated as comprising, inter alia, a receiver tube 44, having a cathode 45 which is connected to the negative terminal B(−) of the "B" battery, and having a plate 46 which is connected to the plate circuit or output circuit 48 of the receiver.

Our receiver-relay RR is of special construction, an improved form of which is described and claimed in an application of B. E. Lenehan and A. W. Rogers, Serial No. 114,964, filed December 9, 1936. Some of the most essential features of the receiver-relay are indicated in Fig. 1 of our drawings, from which it will be seen that the relay is of the polarized type, having a permanent magnet 50 at its base. The relay has a movable armature 51 of laminated soft iron, which is pivoted by means of a spring 52 which is connected to a central core 53 extending from the mid-point of the permanent magnet 50. Two special pole-pieces 54 and 55 are provided, for carrying the magnetic flux from the terminals of the permanent magnet 50 to the front and back sides, respectively, of the armature 51, the pole-pieces 54 and 55 being preferably slightly separated, magnetically, from the ends of the permanent magnet 50, by means of shims or spacers 56 of brass or other non-magnetic material.

The central core 53 of the receiver-relay RR is provided with two coils, namely a trip coil marked RRT and a blocking coil marked RRB. The trip coil RRT is adapted to be energized in such direction as to produce an operating force tending to move the armature 51 away from its back-stop 58, so as to make a set of electrical contacts at 59. The blocking coil RRB is more powerful than the tripping coil RRT, as indicated by its greater number of turns, and it is designed to be energized in such direction that it will tend to hold the armature back against its back-stop 58. In addition to these two forces, the receiver relay also has a continuously operative biasing torque which is provided, partly by the spring pivotal connection 52, and partly by an off-center mounting of the movable armature 51 between the faces of the two pole-pieces 54 and 55, so that the armature is normally a little bit nearer to the back pole-piece 55, thereby developing a magnetic force tending to hold the armature 51 against its back-stop 58 as a result of the magnetism of the permanent magnet 50.

The operating connections of the various parts of our system are shown in both Figs. 1 and 2, and may perhaps best be followed with reference to Fig. 2, although the connections may be traced in either figure. The station battery is indicated only in Fig. 1, near the circuit-breaker 7, where it is designated by the numeral 61. It is provided with a positive terminal (+) and a negative terminal (−), and it is indicated in Fig. 2 only by means of its two terminals (+) and (−) respectively.

Starting at the top of Fig. 2, it will be noted that the directional element DA is provided with a make contact which establishes a partial circuit from the positive terminal (+) to a phase directional bus 62A. Connected to the phase directional bus 62A is one terminal of a make contact carried by the first impedance element Z1A, the other terminal of which is connected to a tripping bus 63. Following down along the tripping bus 63, in Fig. 2, it will be noted that this bus is connected, through the operating coil

of a contactor switch CS, to the trip-coil 8 of the circuit breaker, and thence, through the auxiliary circuit-breaker contact 9, to the negative bus (—). The contactor switch CS is utilized for the purpose of providing a sealing-in or holding circuit for the tripping bus 63, being provided with make contacts for connecting the tripping bus to the positive terminal (+) and also for sounding an alarm, if desired.

Before proceeding further with the next contacts shown at the top of Fig. 2, it is necessary to refer further down in the figure, where it is seen that the operating coil of the auxiliary relay CSA is connected between a so-called carrier-starting bus 64 and the negative terminal (—), through a resistor 65.

The carrier-starting bus 64 is energized from the positive terminal (+) by means of the closure of normally open or "make" contacts of any one of the three third-zone phase-fault impedance-elements Z3A, Z3B or Z3C, or of the low-current, ground-current relay IOL, or of a test push-button 66. If the carrier-starting bus 64 is energized by the response of any one of the three third-zone impedance-elements Z3A, Z3B or Z3C, the impedance-element contacts which initially energize this bus will be immediately by-passed by a make-contact of the corresponding auxiliary contactor-switch or relay CSA, CSB or CSC as the case may be. The operating coil of the CSA relay (for example) is normally shunted by a closed back-contact of the Z3A relay, so that this CSA relay cannot operate unless its particular associated Z3A relay responds to faults on the transmission system.

Referring, now, to Fig. 1, it will be seen that the CSA relay, through its make-contacts 36, controls the energization of the timer motor M which is associated with the timer contacts T2A and T3A. The starting of the timer motor M is dependent, also, upon a response of the internal directional element DA, which response is necessary in order to remove the short-circuit at the back contacts 35 of the directional element. It will be seen, therefore, that, as soon as the third impedance element Z3A and the directional element DA respond, the auxiliary relay CSA is energized, starting the timer motor M which, in predetermined times, first closes its timer contact T2A, and, later on, its timer contact T3A.

Referring again to the top portion of the across-the-line diagram in Fig. 2, it will be seen that there is a second energizing circuit for the tripping bus 63 from the phase directional bus 62A through the front contact of the second impedance element Z2A and thence through the timer contact T2A. The purpose of this energizing circuit is to provide for what is known as sequential tripping in the event that the carrier-current system is not utilized or is out of operation; that is, if there is a fault on the protected line-section very close to the far end of the line-section, so that the first impedance element Z1A will not respond, the fault will not be cleared at the relaying station under consideration until the elapse of a certain time determined by the T2A contact, which will provide ample time for the fault to be cleared by the instantaneous tripping element Z1A at the beginning of the next adjacent line-section (not shown) if it should be that the fault were just beyond the end of the line-section 4 rather than just before the end of the line-section 4. Meanwhile, the fault is instantaneously cleared at the far end of the protected line-section by the Z1A tripping contact at that end, thereby resulting in the sequential tripping of the fault, first at the end which is closest to the fault, and second at the end where the fault is so far away that the first-zone impedance relay element cannot discriminate between faults lying in the very extreme end of the line-section and faults occurring in the beginning of the next adjacent line-section beyond the section which is being protected.

The partial tripping circuits which may be traced through the directional and impedance contacts DA and Z2A in each of the three single-phase, phase-fault-responsive relaying elements, that is, including the partial tripping circuits provided by the make contacts of DB, Z2B, and DC, Z2C, are bussed together by means of a phase-fault bus 69 which is thus energized whenever there is a phase-to-phase fault across any two of the line conductors of the line-section 4, close enough to energize the second impedance element of the corresponding line-frequency phase-relays, if, at the same time, the fault current is in the "internal" direction, so as to pick up the corresponding directional element DA, DB or DC in that particular phase.

As is previously known in carrier-current protective systems, and as shown in Figs. 1 and 2, we utilize make-contacts 59 of our receiver-relay RR to directly connect the phase-fault bus 69 with the tripping bus 63 under the control of carrier, so that the carrier-current protection may be utilized to discriminate between the faults which are just beyond the end of the protected line-section and faults which are just within the end of the protected line-section, so as to eliminate the timing element provided by the T2 timing contacts in the three phase-relaying panels.

Fig. 2 also shows a back-up energizing circuit for the tripping bus 63 through the long-time contacts T3A which eventually complete a circuit directly from the phase directional bus 62A to the tripping bus 63, thus providing back-up protection in the event that the fault is not properly cleared by relays at other stations which are closer to the fault, before the elapse of the time-setting of the T3A contacts.

It will be understood that the foregoing description which is mainly directed to the line-frequency phase-fault relay-panel 13 is equally applicable to the other two phase-panels 14 and 15, with a change of subscript to designate the B or C phases rather than the A phase.

Our ground-fault protection which we have shown in our drawings is unique in providing three-step protection corresponding approximately to the three-step phase-fault protection, except that impedance elements are not utilized in our three-step ground-fault protective means.

Our first two steps of ground-fault protection, as most readily seen in Fig. 2, utilize the instantaneous ground-directional relay DO to energize a ground directional bus 71.

Our first ground-fault protection is an instantaneous response obtained by an actuation of the insensitive, high-current, ground-overcurrent relay IOH, the make-contact of which joins the ground directional bus 71 with the tripping bus 63, resulting in the instantaneous energization of the trip-coil 8 of the circuit-breaker. The overcurrent setting of the relay IOH is so high that it will not pick up for any ground faults further away than the end of the protected line-section, so that instantaneous ground-fault pro-

tection is thus provided without the necessity for interlocking with carrier-current control.

Our second ground-fault protective circuit utilizes the sensitive low-setting ground-overcurrent relay IOL which closes a partial circuit from the ground directional bus 71 to an intermediate bus 72 and thence on through the receiver-relay contacts 59 to the tripping bus 63. The low-current ground relay IOL is so sensitive that it will respond to faults beyond the end of the protected line-section so that it requires the assistance of the carrier-current response in order to discriminate between ground faults within the protected section and ground faults beyond the same.

The third step of our ground-fault protection is provided by means of a slow ground-fault power-directional relay CWC of the induction type which is utilized for ground back-up protection. This relay closes its make-contact only after a definite time-delay which is sufficient for the ground fault to be cleared at other relaying stations which are nearer to the fault if said other relaying stations are operating properly. This timed directional ground back-up relay CWC makes a direct connection from the positive bus (+) to the tripping bus 63.

Our various control-means for our carrier-current transmitter 18 involve several novel features which are shown in the bottom portion of Fig. 2. The grid 41 of the oscillator-tube 39 is normally connected to the negative bus (—) through two serially connected resistors 75 and 76 the mid-point of which is connected to the carrier-control bus 64. Thus the resistor 75 is connected between the bus 64 and the negative terminal (—), and the resistor 76 is connected between the bus 64 and the grid 41. It will be noted that the carrier-control bus 64 is normally deenergized, so that a negative potential is normally applied to the grid 41 through the two resistors 75 and 76, thus blocking the oscillations of the oscillator-tube 39 of the transmitter.

A second feature of our transmitter-control means involves the utilization of two auxiliary relays or contactor-switches marked CSP and CSG, the letters P and G indicating respectively phase-fault response and ground-fault response. As shown in the top half of Fig. 2, the operating coils of these relays CSP and CSG are energized respectively from the auxiliary buses 69 and 72. Thus, the CSP relay is energized whenever any second-zone impedance-element such as at 62A, is actuated, if, at the same time, the corresponding internal directional element, in this case DA, is also actuated; and the CSG relay is energized whenever the sensitive or low-setting ground-overcurrent relay IOL is actuated, if, at the same time, the internal ground-fault directional element DO is actuated.

We utilize the auxiliary relays CSP and CSG in the control of our carrier-current transmission, but we interlock this control, particularly the CSP control, with our novel ground-preference relay I—N, previously described. The carrier-controlling circuits utilizing this ground-preference interlock are best shown in the lower portion of Fig. 2 wherein it will be seen that we provide two additional connections between the transmitter grid 41 and the negative bus (—), in addition to the connection which is afforded by the resistors 75 and 76.

As shown in Fig. 2, the grid 41 is directly connected to the negative bus (—) through a normally closed back-contact 77 of the ground-preference relay I—N, and a normally open make-contact 78 of the CSP relay. A second connection is made from the grid 41 to the negative bus (—) through the normally open front-contact 79 of the ground-preference relay I—N, and the normally open make-contact 80 of the CSG relay.

The tripping coil RRT of our receiver relay RR is controlled from the carrier-controlling bus 64. In the embodiment of our invention shown in Fig. 2, this tripping or operating coil RRT of the receiver relay is directly connected between the carrier-controlling bus 64 and the negative battery terminal (—).

The blocking or restraining coil RRB of our carrier-current-receiver relay RR is energized directly from the output circuit 48 of the receiver element 19, being connected between the receiver plate 46 and the positive terminal B+ of the "B" battery of the receiver. As shown in the drawings, the actuating coil AL of an alarm is also connected in this circuit for the purpose of facilitating the testing of the carrier-current circuits by means of the pushbutton 66.

The operation of our system shown in Figs. 1 and 2 is as follows.

Normally, the carrier-current transmission is blocked by the application of negative bias to the grid 41 through the resistance-circuit 75—76. Thus, our carrier-current system belongs to the class or type known as the intermittent carrier system. Normally, also, our receiver relay RR not only has its trip-circuit contacts 59 open, but also has both of its coils RRT and RRB deenergized. So far as we know, ours is the first intermittent-carrier protective system having a receiver-relay which is biased at all times toward its open position. Previous intermittent-carrier systems have utilized receiver-relays which are biased toward their closed or tripping positions, and various means have been utilized for opening the receiver-relays, or holding them open, against their biasing forces, either throughout the normal fault-free operation of the transmission line, or at least upon the occurrence of a fault and in time to block tripping in a sound line-section.

When a fault occurs on the protected line-section sufficiently close to the relaying station to actuate one of the first-zone impedance elements, such as Z1A, or to actuate the insensitive ground overcurrent element IOH, the tripping bus 63 will be directly energized without the intervention of carrier, as previously explained, by reason of the operation of the directional elements, such as DA or DO, at the same time as the impedance element, such as Z1A, or the ground overcurrent element IOH, according as the fault is a phase-to-phase fault or a ground fault, as will be readily understood. The tripping circuit 63 thus energizes the trip-coil 8, causing an opening operation of the circuit-breaker 7 which, in turn, opens its auxiliary switch 9 and breaks the tripping circuit, including the circuits of the operating coils of the CSP and CSG relays.

Whenever any kind of fault occurs on the transmission line, whether it is near or remote, provided that it is within the operating range of our relays, the carrier-controlling bus 64 will be connected to the positive terminal (+) by the actuation of one or more of the relays Z3A, Z3B, Z3C and IOL, and this action will occur instantaneously, and independently of the direction of the fault-current. The energization of the carrier-controlling bus 64 simultaneously performs two carrier-current functions: it in-

stantly energizes the receiver-relay operating coil RRT, and it instantly removes the negative grid-restraint from the transmitter-oscillator 38 by causing the grid 41 to be connected to the positive bus (+) through the resistor 76. The transmitter 18 immediately begins its transmission of carrier-current without any detectable delay, thus instantly energizing the receiver-relay blocking coil RRB at both ends of the protected line-section.

Our novel two-position polarized receiver relay RR is so adjusted, as by the screw adjustment of the back-stop 58, or other means for controlling the biasing force, and by the proper choice of the ampere-turns on the two coils RRT and RRB, that when the received carrier-currents are the weakest which they will ever be, the ampere-turns on the holding, restraining or blocking coil RRB, assisted by the constant restraining biasing force of the receiver relay, will be sufficient to overpower the actuating force of the operating or tripping coil RRT, so that the receiver-relay RR will not respond as long as the receiver 19 is receiving at least as much as its aforesaid minimum or weakest carrier-current.

In general, it is possible to make the instantaneous fault-detectors, such as Z3A, Z3B, Z3C and IOL, quicker in their action than the instantaneous directional elements DA, DB, DC or DO, because a reliable directional response requires an integration of comparative current condition, or comparative current and voltage conditions, over an appreciable portion of the line-frequency cycle, in order to properly determine the phase-relations between the compared alternating quantities. There are times, also, near the balance-points of the directional elements, when the directional torque is just barely able to move the movable member of the directional element, thus making the response of the directional element relatively sluggish under these conditions. For all of the foregoing reasons, therefore, we prefer to initiate carrier-current transmission, and to initiate the energization of the receiver-relay tripping coil RRT, in response to instantaneous fault-detectors, without waiting for a directional indication as to whether the current-flow is into or out of the protected line-section.

Whenever a phase-fault occurs on the internal-direction side of the bus 5, in either the first zone or the second zone of the impedance elements, one of the second-zone impedance elements Z2A, Z2B or Z2C, as the case may be, will respond, thus energizing the auxiliary phase bus 69 and instantly energizing the CSP relay. The CSP relay thus affords a means for providing an extra contact 78 without the necessity for providing additional contacts on either the phase directional elements or the impedance elements.

As soon as the CSP contact 78 closes, assuming that there is no ground-fault on the transmission system, the transmitter grid 41 will be directly connected to the negative bus (—), thus blocking or stopping carrier-current transmission regardless of whether the carrier-controlling bus 64 is open or not. This action, in general, may be made to occur within one cycle of the line frequency, after the occurrence of the fault, so that it will be seen that the carrier current will be quickly interrupted at each relaying station where there is a phase-fault indication accompanied by internal power-direction. If this internal phase-fault directional response of the CSP relay is obtained at both ends of the protected line-section, the carrier current will be altogether removed from this line-section, and the receiver-relay blocking-coils RRB at both ends of the line-section will be deenergized, thereby permitting the tripping coils RRT to actuate the receiver-relays to tripping position, at both ends of the protected line-section, thus closing the receiver-relay tripping contacts 59 and by-passing the timer contacts T2A, T2B and T2C, so that instantaneous tripping is obtained at both ends of the protected line-section.

In case there should be a ground-fault on the transmission system, it is necessary for the ground-preference relay I—N to be constructed so that it will be quicker in its operation than the time required to operate the CSP relay. At least the ground-preference relay I—N must be able to open its back-contacts 77 within the time required to close the contacts which are necessary to energize the operating coil of the CSP relay, plus the fraction of a cycle required for the CSP relay to close its contacts 78 after its operating coil has been energized. These precautions are necessary because occasionally, as under heavy load-conditions, the ground currents plus the load currents may be sufficient to operate the second impedance element and the directional element in one phase of the phase relays, and if the load is internal, that is, if the load-current is flowing into the protected line-section at the relaying station, the phase directional element, such as DA, might register an internal direction even for a ground-fault accompanied by an external direction of the ground-current.

Whenever a ground-fault occurs within the zone of response of the high-current ground-relay IOH, or even beyond this point and within the zone of operation of the low-current ground-relay IOL, if the ground-fault is accompanied by an internal ground-direction, the auxiliary ground bus 72 wil be energized, thus energizing the CSG relay, causing it to pick up its contact 80, thus directly connecting the transmitter grid 41 to the negative bus, instantly blocking transmission. It will be understood that, under these conditions, the ground-preference relay I—N will also operate to close its contact 79 which is in series with the CSG contact 80. If the ground-fault direction is internal at both ends of the protected line-section, carrier will thus be removed from the line-section and the receiver-relay blocking coils RRB will be deenergized at both ends, permitting instantaneous tripping of the circuit breakers so as to clear the fault.

It is important to consider the various operating times of the several relay-elements of our system. The various instantaneous fault-detector elements are made to operate in the minimum possible time, and also to drop out, after the termination of the fault-conditions, in the minimum possible time.

The receiver-relay should be designed so that the operating force of the operating coil RRT, minus the restraining force of the biasing means of the realy, is sufficient to acuate the receiver-relay to closed position within a reasonable time such as 0.3 cycle of the power-line frequency. In general, at the present time, it is not necessary to make the operating time of the receiver-relay any less than about 0.3 cycle; and if it is not necessary to make this relay any quicker in its operation, it is desirable not to do so, because the operating time of 0.3 cycle is useful in coordinating the various times of operation of

the various relay-elements, and it also helps to define what is meant by "substantially simultaneously", or what is meant by "energizing the restraining coil RRB before energizing the operating coil RRT of the receiver-relay." These expressions must take into account the time of operation of the receiver-relay, the idea being that the blocking coil must become effectively energized at least before the receiver relay has moved very far in its up-stroke, and in time to make sure that the movable element 51 of the receiver relay shall not touch its make-contacts 59 when it is intended that the operation of the receiver relay shall be blocked.

The times of operation of the CSP and CSG relays are made quite small, so as not to occupy too much of the total relaying time, which is usually desired to be less than 1 cycle, but the operation of these relays need not be too quick, particularly the dropping-out time of the relays. This dropping-out time of the CSP relay or of the CSG relay is useful in preventing the premature restoration of carrier-current transmission in the case of power-reversals encountered during the clearing of faults, as it is well known, now, that there is a tendency for the power-direction to suddenly change from an external direction to an internal direction while some fault-current still remains on the line, or before the fault-detectors have had time or a chance to return to non-responsive positions, during the clearing of some fault-conditions on some transmission systems. In other words, after the initial determination of whether the fault-conditions are accompanied by an internal or external current-flow at any relaying station, it is advantageous to slightly delay any alteration of that initial indication, and the CSP and CSG relays aid in this function.

The auxiliary contactor-switches or relays CSA, CSB and CSC, which are utilized principally for controlling the operation of the timers M of the various phase-relay aggregates 13, 14 and 15, also introduce a slight time-delay in the discontinuance of carrier after the occurrence of an external-fault indication. It will be understood that the initiation of carrier in response to fault-detectors, accompanied by a non-operation of the internal directional elements, is the equivalent of a positive, definite, external-fault indication. If there should be an external fault under internal power-flow conditions, that is, when the load-current is flowing into the protected line-section at the relaying station, it sometimes happens that the arc is interrupted in the circuit-breaker in the pole or phase which is carrying the fault-current quicker than in the other poles or phases, so that the extremely sensitive third-zone impedance elements may all open their contacts very quickly, thus tending to quickly interrupt the carrier-current transmission. In order to prevent a faulty tripping-operation in a sound section, it is necessary to make sure that the first- and second-zone impedance-elements shall open their contacts before the power-directional elements may close their contacts in response to the internally flowing load-currents. Under such circumstances, the auxiliary relays CSA, CSB and CSC are useful, at least in the case of the second-zone impedance-elements (which are the most troublesome in such cases), in preventing the closure of the receiver-relay contacts 59 before the second-zone impedance-elements have had a chance to open their contacts.

It will be noted that the effect of the auxiliary relays CSA, CSB and CSC is initially to close a by-pass circuit, by reason of their make-contacts, around the sensitive fault-detector contacts which initially energized the carrier-controlling bus 64. These make-contacts of the relays CSA, CSB and CSC thus seal themselves in, and help to make a more positive make-contact than the light contacts of the sensitive phase-fault impedance-elements Z3A, Z3B or Z3C. It will be understood that only the particular auxiliary relay or relays, CSA, CSB or CSC, in the affected phase or phases, will respond, because the operating coils of these auxiliary relays are normally short-circuited by the back-contacts of the associated third-zone impedance-elements Z3A, Z3B and Z3C, respectively. Thus the auxiliary relay which corresponds to the impedance relay in the phase in which the fault occurs will be the only auxiliary relay to respond, the other auxiliary relays having their operating coils short-circuited.

At the termination of the phase-fault conditions, the third-zone impedance-relay drops out, first opening its front-contacts, but this operation produces no effect on the carrier-controlling bus 64 because said front-contacts are by-passed by the front-contacts of the corresponding auxiliary relay CSA, CSB or CSC as the case may be. When the third-zone impedance element drops all the way out, it finally closes its back-contacts, thereby short-circuiting the operating coil of its corresponding auxiliary relay CSA, CSB or CSC as the case may be, and thereafter causing said auxiliary relay to begin to drop out, with a definite time of action which, although only a small part of a cycle, is nevertheless useful in coordinating the relay-responses, by slightly delaying the opening of the make-contacts of said auxiliary relay CSA, CSB or CSC, as the case may be.

It can be shown that the currents circulating in the wires of a three-phase system during fault-conditions are exactly the superposition of two sets of quantities: (1) the load-currents flowing prior to the fault, and (2) the currents which would flow were all the electromotive forces of the network set equal to zero and the voltage at the point of fault prior to the fault applied alone in the fault path.

This will show that, in the case of a wire-to-wire fault on a balanced three-phase system, the current in the third wire is identically what it was, prior to the fault.

When single-phase fault-detector elements are connected in series with single-phase directional elements to provide a tripping combination, or to provide a directional combination, the association of an impedance element of a phase carrying phase-to-phase fault-current or delta current, with a directional element of a phase carrying only load-current or star current, may result in the combination being either closed or open during fault-conditions, depending upon the direction of the load-current prior to the fault.

This has not caused trouble with distance relaying because of two reasons. (1) For a BC fault, with the A phase carrying load, the conventional arrangement is generally to utilize star current A on the directional element (30-degree connection) and delta current BA on the correspondng impedance element for said phase A. This BA impedance element or fault-detector does not generally respond for a BC fault, because the BA voltage does not collapse suffi-

ciently, and hence a faulty relay-operation is so infrequent, for relays set as distance relays, that star directional and delta impedance current-connections have been standard for years. Where other connections have been used the reason has been to obtain a 60° connection (delta) rather than 30°, because the line-impedance angle was such as to give better directional torques with this connection.

(2) The third-zone impedance elements Z3 which have been set for far faults have heretofore been time-delayed, and hence the faults, if external, have been cleared before the expiration of this time-delay. With carrier-current control, it is the second-zone impedance element Z2 which is set for far faults at times. If this Z2 element responds in phase A, for a BC fault, when the load-current direction is internal, it stops carrier, and instantaneous tripping thus occurs, even though the fault may be external.

With carrier-current relaying, the distance-setting of the second-zone impedance elements Z2 may be many section-lengths, in order to secure a high speed of operation for faults within the protected line-section; carrier-current supervision, rather than distance-settings, being relied upon for selectivity. The voltage-collapse of the BA phase, in the event of a BC fault, is enough to operate the Z2 fault detectors so set. It is an important novel feature of our invention, therefore, to energize the current coils of each of the phase-directional relays DA, DB and DC from the same current-phases as their associated second-zone impedance elements Z2A, Z2B and Z2C, respectively, in view of the fact that these pairs of elements provide a carrier-supervised tripping circuit through the tripping contact 59 of the receiver-relay.

It is obvious that various changes may be made in the precise form of embodiment of our invention, other features being added, on occasion, and some of our protective features or refinements being omited, also, when considerations of simplicity or economy so dictate or when the conditions of any particular transmission system are such as to require a change or to make certain safeguards necessary or unnecessary, as the case may be.

As an illustration of a way in which our invention may be embodied without utilizing the precise arrangement shown in Fig. 2, we have shown our invention in Fig. 3 in a somewhat simpler system in which we do not provide for any protective operation except that which is provided under the control, or with the cooperation of carrier.

In the system shown in Fig. 3, the trip-coil 8 is energized whenever the receiver-relay RR responds to close its normally open make-contact, which is indicated by the numeral 82 in Fig. 3. This tripping operation is performed without any line-frequency relay-contacts in the tripping circuit. Only a single impedance-element is utilized in each phase of the phase-fault-responsive relays, said impedance-element being designated Z2A, Z2B and Z2C in Fig. 3, and only one ground overcurrent relay IOL is utilized in Fig. 3. These phase and ground relays energize the carrier-controlling bus 64 in a manner similar to that which was described for Fig. 2.

In Fig. 3, the resistor 75 is utilized as in Fig. 2, being connected between the carrier-controlling bus 64 and the negative terminal or bus (—), but the receiver-relay tripping coil RRT is utilized as part of the resistance 76 which is connected between the carrier-controlling bus 64 and the negative terminal (—) under the control of the directional elements DA, DB, DC and DO and the ground-preference element I—N. That is, the resistor 76 is connected, as before, between the transmitter grid 41 and the carrier-controlling bus 64, but the receiver-relay trip coil RRT is connected in series between the grid 41 and an auxiliary bus 84 from which a plurality of different paths are provided to connect the same to the negative bus (—).

One path from the auxiliary bus 84 to the negative bus (—) is through the back-contact 77 of the ground-preference relay I—N and thence to another auxiliary bus 85, and from this point over to the negative bus (—) there are three parallel paths through the make-contacts of the three instantaneous phase-directional elements DA, DB and DC.

Another connecting path from the auxiliary bus 84 to the negative bus (—) is through the front contact 79 of the ground-preference relay I—N and through the front-contact of the instantaneous ground-directional element DO.

In other respects, the system which we have shown in Fig. 3 is very similar to that which we have described and explained in connection with Figs. 1 and 2.

While we have illustrated our invention in two forms of embodiment which are at present preferred by us, it is obvious that many changes in details of execution may be made without departing from some of the broader principles of our invention. We desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language and the prior art.

We claim as our invention:

1. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising a transmitter means at the other end of the line-section capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, fault-responsive and directionally responsive relaying means at said other end for responding to transmission-line conditions at said other end, means at said other end of the line-section for utilizing a response of said relaying means in the control of said transmitter means, normally inactive circuit-interrupter operating means at the first-mentioned end including a receiver relay having an operating tripping condition and an inoperative normal condition, means normally operative to bias said receiver relay towards its inoperative normal condition, normally ineffective electric-current trip-condition means tending, when effectively energized, to cause the actuation of said receiver relay to its tripping condition, electric-current blocking means tending, when effectively energized and with the help of said biasing means, to overpower said trip-condition means and to restrain said receiver relay in its inoperative normal condition, means for effectively energizing said trip-condition means, including means responsive to faults on the transmission line, and means for effectively energizing said blocking means, including means responsive to an effective received signal-current.

2. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising normally ineffective transmitter means

at the other end of the line-section for transmitting a signal-current from its end to the first-mentioned end of the line-section, means at said other end responsive to faults accompanied by current-flow direction out of the protected line-section at that end for causing the effective operation of said transmitter means during a time when the circuit-interrupter operation should be blocked, normally inactive circuit-interrupter operating means at the first-mentioned end including a receiver relay having an operating tripping condition and an inoperative normal condition, means normally operative to bias said receiver relay towards its inoperative normal condition, normally inactive electric-current trip-condition means tending, when effectively energized, to cause the actuation of said receiver relay to its tripping condition, normally inactive electric-current blocking means tending, when effectively energized and with the help of said biasing means, to overpower said trip-condition means and to restrain said receiver relay in its inoperative normal condition, means for effectively energizing said trip-condition means, including means responsive to faults on the transmission line, and means for effectively energizing said blocking means, including means responsive to an effective received signal-current.

3. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising normally ineffective transmitter means at the other end of the line-section for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means at said other end including means responsive to faults on the transmission line, normally inactive transmitter-stopping means at said other end including means responsive to fault-currents flowing into the line-section at that end, normally inactive circuit-interrupter operating means at the first-mentioned end including a receiver relay having an operating tripping condition and an inoperative normal condition, means normally operative to bias said receiver relay toward its inoperative normal condition, normally inactive electric-current trip-condition means tending, when effectively energized, to cause the actuation of said receiver relay to its tripping condition, normally inactive stronger electric-current blocking means tending, when effectively energized and with the help of said biasing means, to overpower said trip-condition means and to restrain said receiver relay in its inoperative normal condition, means for effectively energizing said trip-condition means, including means responsive to faults on the transmission line, and means for effectively energizing said blocking means, including means responsive to an effective received signal-current.

4. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, normally inactive transmitter means for transmitting a signal-current from its end to the other end of the line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, fault-responsive means operative, in the absence of other inhibitions, to remove an impediment against the effective operation of said transmitter means and to remove an impediment against the effective operation of said trip-condition means, said fault-responsive means being responsive by an operative change in its condition as a result of faults on the transmission line, and directionally responsive means operative, in the absence of other inhibitions, to interpose an impediment against the effective operation of the transmitter means and independently of the signal-current to remove an impediment against the effective operation of said trip-condition means, said directionally responsive means being responsive by an operative change in its condition as a result of current-flow direction into the protected line-section.

5. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, normally inactive circuit-interrupter operating means including a receiver relay having an operating tripping condition and an inoperative normal condition, means normally operative to bias said receiver relay toward its inoperative normal condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, fault-responsive means for closing a break in a common portion of two partial circuits operative, when made, and in the absence of other inhibitions, to remove an impediment against the effective operation of said transmitter means and to remove an impediment against the effective operation of said trip-condition means, said fault-responsive means being responsive to faults on the transmission line, and directionally responsive means operative, in the absence of other inhibitions, to interpose an impediment against the effective operation of the transmitter means, said directionally responsive means being responsive by an operative change in its condition as a result of current-flow into the protected line-section.

6. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, normally inactive circuit interrupter operating means including a receiver relay having an operating tripping condition and an inoperative normal condition, means normally operative to bias said receiver relay toward its inoperative normal condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, fault-responsive means operative, in the absence of other inhibitions, to remove an impediment against the effective operation of said transmitter means and to remove an impediment against the effective operation of said trip-condition means, said fault-responsive means being responsive by an oper-

ative change in its condition as a result of faults on the transmission line, and directionally responsive means for closing a break in a common portion of two partial circuits operative, when made, to stop the transmitter means and further operative, when made, and in the absence of other inhibitions, to remove an inpediment against the effective operation of said trip-condition means, said directionally responsive means being responsive to current-flow direction into the protected line-section.

7. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, fault-responsive means for closing a break in a common portion of two partial circuits operative, when made, and in the absence of other inhibitions, to remove an impediment against the effective operation of said transmitter means and to remove an impediment against the effective operation of said trip-condition means, said fault-responsive means being responsive to faults on the transmission line, and directionally responsive means operative, in the absence of other inhibitions, to interpose an impediment against the effective operation of the transmitter means, said directionally responsive means being responsive by an operative change in its condition as a result of current-flow into the protected line-section.

8. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising; at each end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, fault-responsive means operative, in the absence of other inhibitions, to remove an impediment against the effective operation of said transmitter means and to remove an impediment against the effective operation of said trip-condition means, said fault-responsive means being responsive by an operative change in its condition as a result of faults on the transmission line, and directionally responsive means for closing a break in a common portion of two partial circuits operative, when made, to stop the transmitter means and further operative, when made, and in the absence of other inhibitions, to remove an impediment against the effective operation of said trip-condition means, said directionally responsive means being responsive to current-flow direction into the protected line-section.

9. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising, in combination, a local source of direct-current energy at the other end of the line-section, a normally ineffective transmitter means at said other end of the line-section for transmitting a signal-current from its end to the first-mentioned end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, transmitter-controlling circuit-connections at said other end including resistance means for normally connecting said controlling tube-circuit to said local source in a predetermined manner whereby the effective operation of the transmitter means is blocked, fault-detector means at said other end for closing a first normally open contact which is so associated with the resistance means of said transmitter-controlling circuit-connections and said local source as to cause said controlling tube-circuit to cease blocking the effective operation of said transmitter means when said first normally open contact is closed, said fault-detector means being operative in response to faults on the transmission line, directional means at said other end for closing a second normally open contact which is so associated with the resistance means of said transmitter-controlling circuit-connections and said local source as to again cause said controlling tube-circuit to block the effective operation of said transmitter means when said second normally open contact is closed, even though said first normally open contact is also closed, said directional means being operative in response to current-flow direction into the protected line-section at that end, normally inactive circuit-interrupter operating means at the first-mentioned end of the line-section including a receiver relay having a tripping condition and a non-tripping condition, and means at said first-mentioned end responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

10. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, transmitter-controlling circuit-connections including resistance means for normally connecting said controlling tube-circuit to said local source in a predetermined manner whereby the effective operation of the transmitter means is blocked, fault-detector means for closing a first normally open contact which is so associated with said transmitter-controlling circuit-connections and said local source as to cause said controlling tube-circuit to cease blocking the effective operation of said transmitter means when said first normally open contact is closed, said fault-detector means being operative in response to faults on the transmission line, directional means for closing a second normally open contact which is so associated with said transmitter-controlling circuit-connections and said local source as to again cause said controlling tube-circuit to block the effective operation of said transmitter means when said second normally open contact is closed, even though said first normally open contact is

also closed, said directional means being operative in response to current-flow direction into the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive to the same fault-detector-responsive circuit-closing contact-member which removes the blocking of the transmitter means for also energizing said trip-condition means from said local source in such manner as to be effective to cause said receiver relay to change to its tripping condition in the absence of said blocking action.

11. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, transmitter-controlling circuit-connections including resistance means for normally connecting said controlling tube-circuit to said local source in a predetermined manner whereby the effective operation of the transmitter means is blocked, fault-detector means for closing a first normally open contact which is so associated with said transmitter-controlling circuit-connections and said local source as to cause said controlling tube-circuit to cease blocking the effective operation of said transmitter means when said first normally open contact is closed, said fault-detector means being operative in response to faults on the transmission line, directional means for closing a second normally open contact which is so associated with said transmitter-controlling circuit-connections and said local source as to again cause said controlling tube-circuit to block the effective operation of said transmitter means when said second normally open contact is closed, even though said first normally open contact is also closed, said directional means being operative in response to current-flow direction into the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to an effective received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive to the simultaneous closure of the aforesaid fault-detector-responsive circuit-closing contact-member and the aforesaid directionally responsive circuit-closing contact-member for also energizing said trip-condition means from said local source when said contacts are closed, said energization of the trip-condition means being effective to cause said receiver relay to change to its tripping condition in the absence of said blocking action.

12. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, in combination, an auxiliary source of direct-current energy, a normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, means for connecting one terminal of the controlling tube-circuit to one terminal of the local source, means including two serially connected resistance devices for connecting the second terminal of the controlling tube-circuit to the second terminal of the local source, the polarities being such that the effective operation of the transmitter means is blocked under these circumstances, a transmitter-controlling bus connected to an intermediate point between the two serially connected resistance devices, fault-detector means for closing a circuit-break between the first-mentioned terminal of the local source and said transmitter-controlling bus in response to faults on the transmission line, whereby the transmitter means is caused to transmit an effective signal-current, directional means for closing a bypassing circuit-break around said two serially connected resistance devices in response to a current-flow direction into the protected line-section, whereby the transmitter means is again caused to block the transmission of an effective signal-current even though said fault-detector-responsive circuit-break means is closed, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

13. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, means for connecting one terminal of the controlling tube-circuit to one terminal of the local source, means including two serially connected resistance devices for connecting the second terminal of the controlling tube-circuit to the second terminal of the local source, the polarities being such that the effective operation of the transmitter means is blocked under these circumstances, a transmitter-controlling bus connected to an intermediate point between the two serially connected resistance devices, fault-detector means for closing a circuit-break between the first-mentioned terminal of the local source and said transmitter-controlling bus in response to faults on the transmission line, whereby the transmitter means is caused to transmit an effective signal-current, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, means connected between the transmitter-controlling bus and said second terminal of the local source for rendering said trip-condition means effective in the absence of said blocking action, and directional means for closing a

bypassing circuit-break around said two serially connected resistance devices in response to a current-flow direction into the protected line-section, whereby the transmitter means is again caused to block the transmission of an effective signal-current even though said fault-detector-responsive circuit-break means is closed.

14. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal-current from its end to the other end of the line-section, said transmitter means including an oscillator tube having a main tube-circuit and a controlling tube-circuit, means for connecting one terminal of the controlling tube-circuit to one terminal of the local source, means including two serially connected resistance devices for connecting the second terminal of the controlling tube-circuit to the second terminal of the local source, the polarities being such that the effective operation of the transmitter means is blocked under these circumstances, a transmitter-controlling bus connected to an intermediate point between the two serially connected resistance devices, fault-detector means for closing a circuit-break between the first-mentioned terminal of the local source and said transmitter-controlling bus in response to faults on the transmission line, whereby the transmitter means is caused to transmit an effective signal-current, directional means for closing a bypassing circuit-break between said second terminal of the controlling tube-circuit and said second terminal of the local source in response to a current-flow direction into the protected line-section, whereby the transmitter means is again caused to block the transmission of an effective signal-current even though said fault-detector-responsive circuit-break means is closed, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means included in the circuit-connections from said transmitter-controlling bus through said directionally responsive bypassing circuit-break device to said second terminal of the local source for rendering said trip-condition means effective.

15. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising, in combination, a local source of direct-current energy at the other end of the line-section, a normally ineffective transmitter means at said other end of the line-section for transmitting a signal current from its end to the first-mentioned end of the line-section, said transmitter means including an oscillator tube having at least two main electrodes and a grid electrode, means for normally permanently connecting one of said main electrodes to one of the terminals of the local source, a transmitter-controlling bus, a first resistance means normally permanently connected between said transmitter-controlling bus and the second terminal of the local source, a second resistance means, a first normally open contact member between said transmitter-controlling bus and said first-mentioned terminal of said local source, a second normally open contact member in series with said second resistance means in a circuit connection between said transmitter-controlling bus and said second terminal of the local source, means for normally permanently connecting said grid electrode to said transmitter-controlling bus through at least a part of said second resistance means, the polarities and resistances being such that, when said first and second contact members are both open, the effective operation of said transmitter means is blocked, and when said first contact member is closed and said second contact member is open the blocking of the transmitter means is removed, and when both of said contact members are closed the effective operation of the transmitter means is again blocked, means responsive to different transmission-line conditions at said other end of the line-section for actuating said first and second contact members, normally inactive circuit-interrupter operating means at the first-mentioned end of the line-section including a receiver relay having a tripping condition and a non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

16. Protective relay equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal current from its end to the other end of the line-section, said transmitter means including an oscillator tube having at least two main electrodes and a grid electrode, means for normally permanently connecting one of said main electrodes to one of the terminals of the local source, a transmitter-controlling bus, a first resistance means normally permanently connected between said transmitter-controlling bus and the second terminal of the local source, a second resistance means, a first normally open contact member between said transmitter-controlling bus and said first-mentioned terminal of said local source, a second normally open contact member in series with said second resistance means in a circuit connection between said transmitter-controlling bus and said second terminal of the local source, means for normally permanently connecting said grid electrode to said transmitter-controlling bus through at least a part of said second resistance means, the polarities and resistances being such that, when said first and second contact members are both open, the effective operation of said transmitter means is blocked, and when said first contact member is closed and said second contact member is open the blocking of the transmitter means is removed, and when both of said contact members are closed the effective operation of the transmitter means is again blocked, means responsive to different transmission-line conditions for actuating said first and second contact members, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, one of said resistance means being at least partially comprised of receiver-relay-initiating means for causing said receiver relay to change to its trip-

ping condition in the absence of said blocking action.

17. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a transmission-line section, comprising, at each end of the line-section being protected, in combination with a local source of direct-current energy, a normally ineffective transmitter means for transmitting a signal current from its end to the other end of the line-section, said transmitter means including an oscillator tube having at least two main electrodes and a grid electrode, means for normally permanently connecting one of said main electrodes to one of the terminals of the local source, a transmitter-controlling bus, a first resistance means normally permanently connected between said transmitter-controlling bus and the second terminal of the local source, a second resistance means, a first normally open contact member between said transmitter-controlling bus and said first-mentioned terminal of said local source, a second normally open contact member in series with said second resistance means in a circuit connection between said transmitter-controlling bus and said second terminal of the local source, means for normally permanently connecting said grid electrode to said transmitter-controlling bus through at least a part of said second resistance means, the polarities and resistances being such that, when said first and second contact members are both open, the effective operation of said transmitter means is blocked, and when said first contact member is closed and said second contact member is open the blocking of the transmitter means is removed, and when both of said contact members are closed the effective operation of the transmitter means is again blocked, means responsive to different transmission-line conditions for actuating said first and second contact members, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, said second resistance means being at least partially comprised of receiver-relay-initiating means for causing said receiver relay to change to its tripping condition in the absence of said blocking action.

18. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a transmission-line section, comprising normally ineffective transmitter means at the other end of the line-section for transmitting a signal-current from its end to the first-mentioned end of the line-section, means at said other end of the line-section responsive in a predetermined manner to faults on the transmission line for quickly initiating the effective operation of said transmitter means, directional means at said other end of the line-section responsive to current-flow direction into the protected line-section for quickly actuating a circuit-make-and-break contact-device, said directional-means-operated contact-device being of such nature as to restore itself to its initial condition only after a slight delay after the cessation of said current-flow direction into the protected line-section, circuit-connection means at said other end of the line-section for utilizing the actuation of said directional-means-operated contact-device for blocking the effective operation of said transmitter means, normally inactive circuit-interrupter operating means at the first-mentioned end of the line-section including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

19. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising a transmitter means at the other end of the line-section capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, a plurality of combined fault-responsive and directional single-phase relaying means at said other end of the line-section, each responsive essentially to the concurrence of a fault-condition in its particular phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, means at said other end of the line-section whereby the response of said single-phase relaying means in any phase will be effective in the control of said transmitter means, normally inactive circuit-interrupter operating means at the first-mentioned end of the line-section including a receiver relay having a tripping condition and a normal non-tripping condition, and means for controlling said receiver relay in response to received signal-current.

20. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising, at each end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the other end of the line-section, a tripping bus adapted, when energized, to effect a circuit-interrupter opening-operation, a normally open-circuit receiver relay adapted, when changed to a closed-circuit condition, to operate in the energization of said tripping bus, a circuit-make-and-break means, a plurality of combined fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, means whereby the response of said single-phase relaying means in any phase will effect a quick actuation of said circuit-make-and-break means, means responsive to received signal-current for blocking the change to the closed-circuit condition of said receiver relay, and means for blocking the effective operation of said transmitter means, including means responsive to the operation of said circuit-make-and-break means.

21. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising normally ineffective transmitter means at the other end of the line-section for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means at said other end of the line-section including means responsive in a predetermined manner to faults on the transmission line, nor-

mally inactive transmitter-stopping means at said other end of the line-section including a circuit-controlling means, a plurality of combined fault-responsive and directional single-phase relaying means at said other end of the line-section, each responsive essentially to the concurrence of a fault-condition in its particular phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, means at said other end of the line-section whereby the response of said single-phase relaying means in any phase will effect a quick actuation of said circuit-controlling means and whereby a subsequent failure of response of all of said single-phase relaying means will cause a return of said circuit-controlling means to its initial condition only after a slight delay, circuit-connection means for utilizing the actuation of said circuit-controlling means for blocking the effective operation of said transmitter means, and normally inactive circuit-interrupter operating means at the first-mentioned end of the line-section including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

22. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a plurality of combined phase-fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular line-to-line phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, phase-fault means whereby the response of said single-phase-fault relaying means in any phase will effect a quick actuation of said phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, a combined ground-fault-responsive and ground-fault-directional means for effecting a quick actuation of said ground-fault-responsive circuit-controlling means essentially upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

23. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a plurality of combined phase-fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular line-to-line phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, phase-fault means whereby the response of said single-phase-fault relaying means in any phase will effect a quick actuation of said phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, a combined ground-fault-responsive and ground-fault-directional means for effecting a quick-actuation of said ground-fault-responsive circuit-controlling means essentially upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-detector means and the operation of said ground fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

24. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive in a predetermined manner to faults on the transmission line, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a plurality of combined phase-fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular line-to-line phase of the trans-

mission line and a current-flow direction into the protected line-section in that particular phase, phase-fault means whereby the response of said single-phase phase-fault relaying means in any phase will effect a quick actuation of said phase-fault-responsive circuit-controlling means and whereby a subsequent failure of response of all of said single-phase phase-fault relaying means will cause a return of said phase-fault-responsive circuit-controlling means to its initial condition only after a slight delay, a ground-fault-responsive circuit-controlling means, a combined ground-fault-responsive and ground-fault-directional means for effecting a quick actuation of said ground-fault-responsive circuit-controlling means essentially upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, said ground-fault-responsive circuit-controlling means being of such nature as to return to its initial position only after a slight delay after the cessation of the circumstances which caused its operation, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and at the first mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

25. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive in a predetermined manner to faults on the transmission line, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a plurality of combined phase-fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular line-to-line phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, phase-fault means whereby the response of said single-phase phase-fault relaying means in any phase will effect a quick actuation of said phase-fault-responsive circuit-controlling means and whereby a subsequent failure of response of all of said single-phase phase-fault relaying means will cause a return of said phase-fault-responsive circuit-controlling means to its initial condition only after a slight delay, a ground-fault-responsive circuit-controlling means, a combined ground-fault-responsive and ground-fault-directional means for effecting a quick actuation of said ground-fault-responsive circuit-controlling means essentially upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, said ground-fault-responsive circuit-controlling means being of such nature as to return to its initial position only after a slight delay after the cessation of the circumstances which caused its operation, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-detector means and the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

26. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means in the control of said circuit-interrupter means, and circuit-connection means for utilizing the operation of said ground-fault relaying means in the control of said circuit-interrupter means.

27. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, ground-fault relaying means including means responsive to a predetermined zero-phase-

sequence line-current component, ground-preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means in the control of said circuit-interrupter means, and circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means in the control of said circuit-interrupter means.

28. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means in the control of said circuit-interrupter means, and circuit-connection means for utilizing the operation of said ground-fault relaying means in the control of said circuit-interrupter means.

29. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means in the control of said circuit-interrupter means, and circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means in the control of said circuit-interrupter means.

30. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

31. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

32. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the effec-

tive response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit connection means for utilizing the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

33. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

34. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

35. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means responsive to a predetermined zero-phase-sequence line-voltage component more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

36. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow

in said neutral connection more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

37. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, normally inactive transmitter-stopping means including phase-fault relaying means and ground-fault relaying means, said phase-fault relaying means including means responsive to line-conditions indicative of a predetermined phase fault on the transmission line, said ground-fault relaying means including means responsive to a predetermined zero-phase-sequence line-current component, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the effective response of said phase-fault relaying means, circuit-connection means for utilizing the non-operation of said ground-preference relaying means and the operation of said phase-fault relaying means for blocking the effective operation of said transmitter means, circuit-connection means for utilizing the operation of said ground-preference relaying means and the operation of said ground-fault relaying means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

38. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station, ground-preference relaying means including means responsive to a zero-phase-sequence voltage of the transmission line more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said received relay to its tripping condition.

39. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station, ground-preference relaying means including means responsive to a zero-phase-sequence voltage of the transmission line more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

40. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-

operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

41. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station, ground-preference relaying means including means for providing a grounded neutral connection to the transmission line and means responding to predetermined current-flow in said neutral connection more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-preference means and the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

42. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, phase-fault-directional means for effecting a quick actuation of said phase-fault-responsive circuit-controlling means upon the occurrence of a phase-fault condition on the transmission line accompanied by a phase-fault current-flow direction into the protected line-section, ground-fault-directional means for effecting a quick actuation of said ground-fault-responsive circuit-controlling means upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

43. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitting-stopping means including a phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, phase-fault-directional means for effecting a quick actuation of said phase-fault-responsive circuit-controlling means upon the occurrence of a phase-fault condition on the transmission line accompanied by a phase-fault current-flow direction into the protected line-section, ground-fault-directional means for effecting a quick actuation of said ground-fault-responsive circuit-controlling means upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-detector means and the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

44. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the

protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station; ground-preference relaying means for responding to the presence of a ground-fault on the transmission line more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

45. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive to faults on the transmission line, phase-fault-directional means for responding to an internal direction of line-to-line fault-currents into the protected line-section, ground-fault-directional means for responding to an internal direction of ground-fault currents flowing in the transmission line in a direction indicative of the presence of a ground-fault on the protected-line-section side of the relaying station, ground-preference relaying means for responding to the presence of a ground-fault on the transmission line more quickly than the response of said phase-fault directional means, circuit-connection means for utilizing the non-operation of said ground-preference means and the operation of said phase-fault directional means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-preference means and the operation of said ground-fault directional means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, and means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition.

46. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive in a predetermined manner to faults on the transmission line, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, phase-fault-directional means for effecting a quick actuation of said phase-fault-responsive circuit-controlling means upon the occurrence of a phase-fault condition on the transmission line accompanied by a phase-fault current-flow direction into the protected line-section and for effecting a subsequent return of said phase-fault-responsive circuit-controlling means to its initial condition only after a slight delay after the cessation of the circumstances which caused its operation, ground-fault-directional means for effecting a quick closure of said ground-fault-responsive circuit-controlling means upon the occurrence of a ground-fault condition on the transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, said ground-fault-responsive circuit-controlling means being of such nature as to return to its initial condition only after a slight delay after the cessation of the circumstances which caused its operation, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the nonoperation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

47. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at one end of a polyphase transmission-line section, comprising, at the other end of the line-section being protected, normally ineffective transmitter means for transmitting a signal-current from its end to the first-mentioned end of the line-section, normally inactive transmitter-starting means including means responsive in a predetermined manner to faults on the transmission line, normally inactive transmitter-stopping means including a phase-fault-responsive circuit-controlling means, a ground-fault-responsive circuit-controlling means, phase-fault-directional means for effecting a quick actuation of said phase-fault-responsive circuit-controlling means upon the occurrence of a phase-fault condition on the transmission line accompanied by a phase-fault current-flow direction into the protected line-section and for effecting a subsequent return of said phase-fault-responsive circuit-controlling means to its initial condition only after a slight delay after the cessation of the circumstances which caused its operation, ground-fault-directional means for effecting a quick closure of said ground-fault-responsive circuit-controlling means upon the occurrence of a ground-fault condition on the

transmission line accompanied by a ground current-flow direction indicative of a location of the ground fault on the protected-line-section side of the relaying station, said ground-fault-responsive circuit-controlling means being of such nature as to return to its initial condition only after a slight delay after the cessation of the circumstances which caused its operation, ground-detector means for responding to the presence of a ground fault on the transmission line more quickly than the response of said phase-fault-responsive circuit-controlling means, circuit-connection means for utilizing the non-operation of said ground-detector means and the operation of said phase-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and circuit-connection means for utilizing the operation of said ground-detector means and the operation of said ground-fault-responsive circuit-controlling means for blocking the effective operation of said transmitter means, and, at the first-mentioned end of the protected line-section, normally inactive circuit-interrupter operating means including a receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current for blocking the change of said receiver relay to its tripping condition, and means responsive in a predetermined manner to faults on the transmission line for rendering said trip-condition means effective in the absence of said blocking action.

48. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means for a polyphase transmission-line section, comprising, at each end of the line-section being protected, a transmitter means capable of transmitting a signal-current from its end to the other end of the line-section, a directional-fault-responsive bus, a tripping bus adapted, when energized, to effect a circuit-interrupter opening-operation, a timer operative, when sufficiently actuated, to connect said tripping bus to said directional-fault-responsive bus, a normally open-circuit receiver relay adapted, when changed to a closed-circuit condition, to operate in the energization of said tripping bus, a plurality of combined fault-responsive and directional single-phase relaying means, each responsive essentially to the concurrence of a fault-condition in its particular phase of the transmission line and a current-flow direction into the protected line-section in that particular phase, means whereby the response of said single-phase relaying means in any phase will effect a quick energization of said directional-fault-responsive bus, means for actuating said timer only upon the occurrence of predetermined fault-conditions on the transmission line, normally ineffective trip-condition means tending, when effectively operative, to cause said receiver relay to change to its closed-circuit condition, means responsive to received signal-current for blocking the change to the closed-circuit condition of said receiver relay, and means for utilizing the energization of said directional-fault-responsive bus for blocking the effective operation of said transmitter means.

49. Protective relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at a predetermined end of a transmission-line section, comprising distance-relay means including tripping contacts for operating said circuit-interrupter means in response to both near and remote faults accompanied by current-flow direction into the protected line-section, the distance-relay operation of the tripping contacts being substantially instantaneous for near faults and delayed for more remote faults, in combination with a normally ineffective transmitter means at the other end of the protected line-section for transmitting a signal-current to said predetermined end of the line-section, means at said other end for initiating the effective operation of the transmitter means in response to fault conditions at least including conditions indicative that the fault is outside of the protected line-section, means at said other end for insuring the blocking of the effective operation of the transmitter means in response to fault conditions indicative that the fault may be within the protected line-section, a receiver relay at said predetermined end of the protected line-section, said receiver relay having a tripping condition and a normal non-tripping condition, normally ineffective trip-condition means at said predetermined end tending, when effectively operative, to cause said receiver relay to change to its tripping condition, means responsive to received signal-current at said predetermined end for blocking the change of said receiver relay to its tripping condition, means at said predetermined end responsive to fault conditions at least including conditions indicative that the fault may be within the protected line-section for putting said trip-condition means in a condition which is effective to cause said receiver relay to change to its tripping condition in the absence of said blocking action, and means at said predetermined end for utilizing the tripping condition of said receiver relay to substantially eliminate the time-delay element of said tripping contacts for faults within the protected line-section.

50. Protective ground-fault-responsive relaying equipment for effecting a control of line-sectionalizing circuit-interrupter means at a predetermined end of a polyphase transmission-line section, comprising a transmitter means disposed at the other end of the protected line-section and capable of giving a predetermined signal to the predetermined end of the line-section, transmitter-controlling means at said other end for causing said transmitter means to give said predetermined signal, said transmitter-controlling means including means responsive to a predetermined zero-phase-sequence current flowing in a predetermined direction in the transmission line at said other end of the protected line-section, a receiver relay at said predetermined end of the protected line-section for responding to said predetermined signal, a substantially instantaneous signal-free circuit-interrupter actuating-means at said predetermined end for effecting a circuit-interrupter operation, said substantially instantaneous signal-free circuit-interrupter actuating-means including means responsive to a predetermined excessive zero-phase-sequence current in the transmission line at said predetermined end, a substantially instantaneous signal-responsive circuit-interrupter actuating-means at said predetermined end for effecting a circuit-interrupter operation, said substantially instantaneous signal-responsive circuit-interrupter actuating-means including means responsive to the condition of said receiver relay and means responsive to zero-phase-sequence current conditions in the transmission line at said predetermined end, and

a time-delay circuit-interrupter actuating-means at said predetermined end for effecting a circuit-interrupter operation after a time-delay, said time-delay circuit-interrupter actuating-means including means responsive to the direction of a zero-phase-sequence electrical quantity in the transmission line at said predetermined end.

51. The invention as defined in claim 1, characterized by the fact that said receiver relay is a polarized relay.

52. Relaying equipment for an alternating-current transmission-line, including a signal-current pilot-channel between the ends of a line-section to be protected, and further including, at each of said ends, a circuit-interrupter means and trip-circuit means for actuating said circuit-interrupter means, including a fault-detector relaying means and a directional relaying means both responsive to the same kinds of faults on the transmission-line, a normally non-transmitting signal-current transmitter, means responsive to a response of said fault-detector relaying means for initiating the operation of said signal-current transmitter, means responsive to a response of said directional relaying means for nullifying the transmitter-controlling action of said fault-detector relaying means, a signal-current receiver, and a receiver-relay arranged for controlling said trip-circuit means, means for restraining said receiver-relay in a non-tripping condition during normal fault-free operating conditions of the transmission line, means responsive to a receipt of sufficient signal-current by said receiver for blocking a change of said receiver-relay to its tripping condition, and means responsive to some fault-response for causing said receiver-relay to change to its tripping condition in the absence of said blocking action, characterized by said directional relaying means comprising a sensitive directional element and a fault-detector element, and connections whereby both of said elements must respond before said directional relaying means will indicate a response.

53. The invention as defined in claim 52, characterized by said fault-detector element being less sensitive than said fault-detector relaying means.

54. Protective relaying equipment for a polyphase transmission-line, including a signal-current pilot-channel between the ends of a line-section to be protected, and further including, at each of said ends, a circuit-interrupter means and trip-circuit means for actuating said circuit-interrupter means, including a phase-fault directional relaying means, a signal-current receiver, and a signal-current transmitter, characterized by transmitter-stopping means responsive to said directional relaying means, the phase-fault directional relaying means comprising a plurality of pairs of single-phase elements connected in different phases, one of said elements of each pair being a sensitive directional element and the other being a fault-detector element, both responsive to the same currents derived from the line, and connections whereby both of the elements of some pair must respond before the corresponding directional relaying means will indicate a response.

55. The invention as defined in claim 54, characterized by said trip-circuit means also including a phase-fault-detector relaying means which is more sensitive than the fault-detector element of said phase-fault directional relaying means, the signal-current transmitter being in a non-transmitting condition during normal fault-free operating conditions of the transmission-line, means responsive to a response of said phase-fault-detector relaying means for initiating the operation of said signal-current transmitter, and a receiver-relay jointly controlled by some fault-responsive means and said signal-current receiver, said receiver-relay including means for causing it to be in a non-tripping condition during normal fault-free line-conditions.

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