To all whom it may concern:

Be it known that I, LAURENCE A. HAWKINS, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Parallel-Feeder Protection, of which the following is a specification.

My invention relates to protective devices for electrical transmission systems employing parallel feeders. In such systems, where a number of feeders are connected in parallel both at the generating and at the receiving end, as is customary, it is extremely desirable to provide automatic means for breaking the circuit of a feeder at both ends when a fault occurs thereon. In case of a fault, such as a ground or a short circuit, if a faulty feeder is cut out only at the generating end a fault current will flow through the remaining feeders to the receiving end and back through the faulty feeder to the ground or short circuit. If simple overload devices are relied upon for breaking the circuits of the feeders, a short-circuit on one feeder may result in opening the circuits of all the feeders, thereby interrupting the service. In order to avoid such interruption, it has been proposed heretofore to provide discriminating devices of the watt-meter type provided with a potential-coil and a current-coil in series with a feeder. Such devices, however, fail in case of a serious short-circuit, since the voltage on the potential-coil may be lowered to a negligible amount. Furthermore, in the case of high-potential lines the expense is greatly increased by employing potential transformers for the protective devices.

The object of my invention is to provide means for cutting out one of a number of parallel feeders whenever a fault occurs upon that feeder and whether the fault-current is large or small. Furthermore, since no potential-transformers are employed in connection with my protective device my invention is particularly applicable to high-tension systems.

My invention will best be understood by reference to the accompanying drawings, in which—

Figure 1 shows diagrammatically an arrangement embodying my invention, and Fig. 2 shows a modification of the same.

In Fig. 1, G represents a generator or other source of energy connected to the station bus-bars 1 2. A B represent two feeders connected in parallel to bus-bar 1 through the circuit-breakers a and b and through the primary winding of a series transformer T. The feeders of opposite polarity I have 60 indicated by a single line C, connected to a bus-bar 2. It will be understood, however, that the feeders of opposite polarity may form a duplication of the feeders A and B. The receiving endings of the feeders A and B are connected in parallel to the receiving bus-bar 3 through the series-transformer T' and circuit-breaker d' and through the series transformer T and circuit-breaker d, respectively. The feeders for the opposite polarity of the system are connected to the receiving bus-bar 3. E represents a relay of the watt-meter type, having two field-windings f' and f'' connected to the secondaries of transformers T' and T, respectively, and a movable winding e, which is connected across the secondary of transformer T by means of the pilot-wire H and an earth connection. The core of movable winding e carries a movable switch-contact I, which is normally held in the position shown by the centering-springs s and which when moved in either direction closes a circuit from the battery or other source of current J through the tripping-coils of one or the other of the circuit-breakers d' and d.

The operation is then as follows: The field-coils f' and f'' of relay E are so connected that they normally oppose each other and produce no flux in the stationary member of the relay. The movable winding e is consequently held in its central position, as shown, by the centering-springs s s. If, however, one of the parallel feeders, such as B, becomes grounded or short-circuited, it will at once be disconnected from bus-bar 1 by the opening of circuit-breaker b. Current will also tend to flow from bus-bar 1 through feeder A to the receiving end and back through feeder B to the fault. A reversal of current will consequently occur in transformer T relative to the current in transformers T and T'. The two field-coils f' and f'' will consequently assist each other in producing a magnetization of the stationary member of relay E, and a movement of winding e will be produced. Switch-contact I
will close the circuit of battery $J$ through the tripping-coil of circuit-breaker $d^2$ and will disconnect feeder $B$ at its receiving end, thereby completely cutting it out of circuit.

5. The circuit of feeder $A$ is not broken, and the service is not interrupted. If, on the other hand, the feeder $A$ is short-circuited, the phase of the flux in the stationary member of feeder $B$ will be in opposition to its phase in the former case when feeder $B$ was short-circuited. Consequently the direction of movement of movable winding $e$ will be reversed, and circuit of battery $J$ will be closed through the tripping-coil of circuit-breaker $d'$. The relay $E$ consequently is discriminating in its action and cuts out the faulty feeder without disturbing the circuit of the healthy feeder. Furthermore, it is always operative under all conditions, since it does not depend upon the potential of the system, but only upon the current in the two feeders and in their connection to the generating bus-bar, and these currents must always exist when a fault exists.

The form of discriminating device may be greatly varied and the connections of the protective circuits greatly altered without varying the mode of operation. Thus in Fig. 2, the currents from the transformers $T'$ and $T''$ are used for tripping the circuit-breakers in stead of employing an auxiliary source of current. Furthermore, the relay is omitted and the transformer secondaries are connected directly to the tripping-coil. The tripping-coils $t$ and $t'$ are connected directly to the secondaries of transformers $T'$ and $T''$, while the tripping-coils $t$ are connected directly to the secondary of transformer $T$. The tripping-coils are so wound or connected that they normally oppose each other.

When the current in either feeder reverses, however, the currents in the tripping-coils of the circuit-breaker for that feeder will help each other and act to disconnect the circuit of the faulty feeder at the receiving end.

Many other forms of discriminating devices may be employed for actuating the circuit-breakers without departing from my invention, which consists in utilizing for securing the differential action the reversal of the current in a feeder relative to the current flowing from the source to the feeders. Moreover, although I have shown my invention applied to a single-phase transmission system employing only two parallel feeders it is evidently applicable to single or poly phase systems embodying any number of parallel feeders. Accordingly I aim in the appended claims to cover all such modifications in the construction and arrangement of parts which do not depart from the spirit and scope of my invention.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In combination, a generating-station, a receiving-station, parallel feeders connecting said stations, series transformers at the receiving-station connected one in each feeder, a series transformer at the generating-station connected between said feeders and the source of energy, and electroresponsive means at the receiving-station energized from said transformers and adapted and arranged to open the circuit of a feeder at its receiving end upon a reversal of current in said feeder relative to the current from the source of energy to said feeders.

2. In combination, a generating-station, a receiving-station, a plurality of feeders connected in parallel at one end to the source of energy and at the other end to the receiving apparatus, a series transformer at the generating-station having its primary connected between said feeders and the source of energy, a second series transformer at the receiving-station having its primary in series with one of said feeders, and an electroresponsive means at the receiving-station connected to the secondary of both transformers and arranged to open the circuit of said feeder upon a reversal of current in said feeder relative to the current from the source of energy to said feeders.

3. In combination, a generating-station, a receiving-station, a plurality of feeders connected in parallel at one end to the source of energy and at the other end to the receiving apparatus, a series transformer having its primary connected between said feeders and the source of energy, and a device at the receiving-station connected to the secondary of said transformer and having a winding energized by the current in a feeder and responsive to a reversal of current in said feeder relative to the current in said secondary and arranged to open the circuit of said feeder at the receiving end.

4. In combination, a generating-station, a receiving-station, a plurality of feeders connected in parallel at one end to the source of energy and at the other end to the receiving apparatus, a series transformer at the generating-station having its primary connected between said feeders and the source of energy, a pilot-wire extending from the secondary of said transformer to the receiving end of said feeders, and a device at the receiving end connected to said pilot-wire and having a winding energized by the current in a feeder and responsive to a reversal of current in said feeder relative to the current in said wire and arranged to open the circuit of said feeder at the receiving end.

5. In combination, a generating-station, a receiving-station, parallel feeders connecting said stations, a winding at the generating-station connected to be energized by the current from the source of energy to said feeders, a second winding at the receiving-station connected therewith and connected to be energized by the current in a feeder, and switch-
ing mechanism comprising an electrora-
quion device at the receiving-station con-
trolled by the joint action of the current in
said windings and arranged to open the cir-
rent at the receiving end upon a
reversal of current therein relative to the
current from the source of energy to the
feeders.
6. In combination, a generating-station, a
receiving-station, parallel feeders connecting
said stations, a series transformer at the
generating-station connected between said
feeders and the source of energy, a second
series transformer at the receiving-station
connected in the receiving end of a feeder, and
an electrora-responsive device at the receiving-
station connected to both transformers and
arranged to open the circuit of the feeder upon
a relative reversal of current in said trans-
formers.
In witness whereof I have hereunto set my
hand this 20th day of May, 1904.
LAURENCE A. HAWKINS.
Witnesses:
Benjamin B. Hull,
Helen Oxford.