No. 856,465. PATENTED JUNE 11, 1907.

L. A. HAWKINS.

BLOCK SIGNAL SYSTEM.

APPLICATION FILED DEC. 3, 1906.

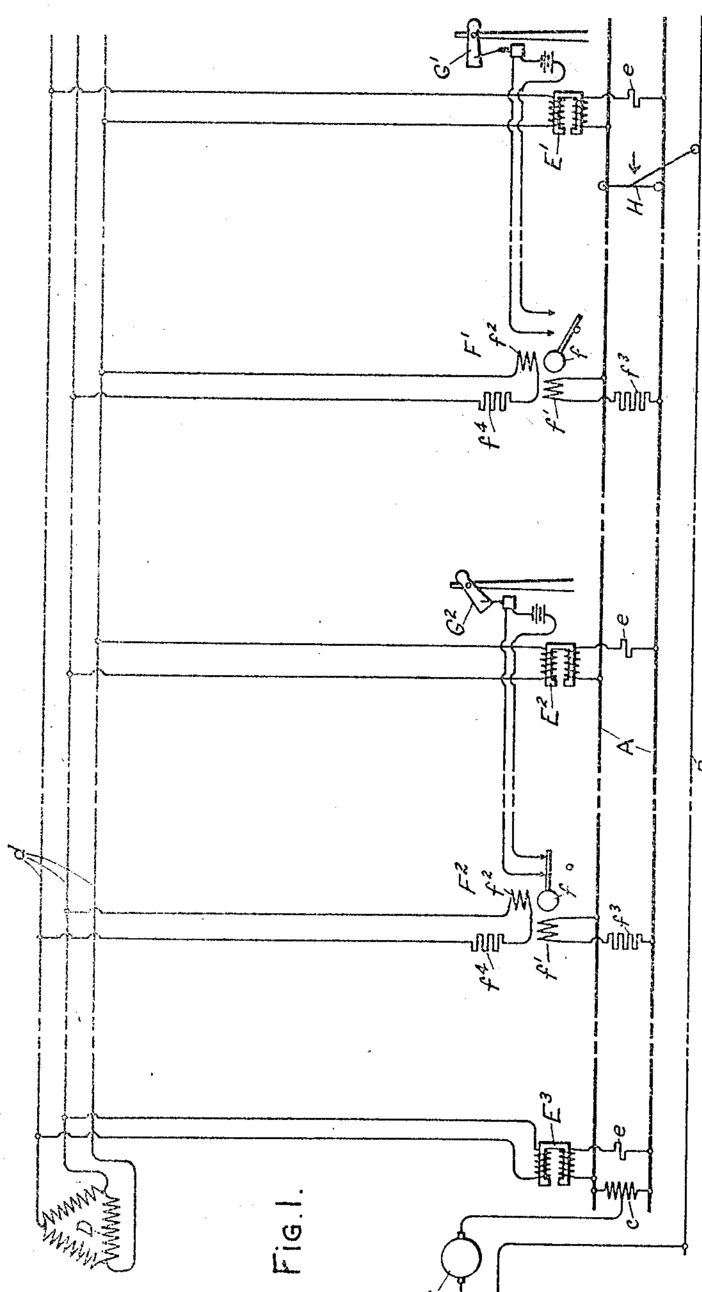

Fig.1.

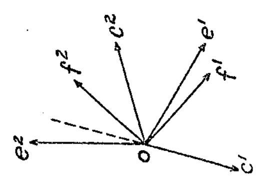

Fig.2.

Witnesses:

Irving E. Steers.

J. Ellis Glen.

Inventor

Laurence A. Hawkins,

by Albert G. Davis

Att'y

UNITED STATES PATENT OFFICE.

LAURENCE A. HAWKINS, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

BLOCK-SIGNAL SYSTEM.

No. 856,465. Specification of Letters Patent. Patented June 11, 1907.

Application filed December 3, 1906. Serial No. 346,034.

To all whom it may concern:

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

My invention consists in an improvement in the system described in an application, Serial No. 335,209, filed by E. F. Bliss, September 19, 1906, assigned to the General Electric Company. In that application was described a block signal system for electrically-operated roads having both rails conductively continuous for all currents in which sources of alternating-current were connected across the track-rails at intervals, adjacent sources being of different phase, with track relays connected across the rails in pairs at points between the sources, one relay of each pair being arranged to drop its armature upon the failure of one of the two adjacent sources. For this purpose, each relay is provided with two coöperating windings, one connected across the track-rails, and consequently supplied with the resultant current delivered by the two adjacent sources, while the other winding is supplied independently of the rails with a current which, in a relay of the induction type, corresponds in phase to that of one of the adjacent sources. With this arrangement, upon the failure of either source, the torque of one relay falls to zero, while the torque of the other relay remains normal. By connecting the contacts of the two relays in series, the signal controlled by them is put at danger by the failure of either source.

My invention consists in arranging a single relay so as to take the place of the pair of relays described in the former application.

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

Figure 1 shows diagrammatically a block signal system arranged in accordance with my invention; and Fig. 2 is an explanatory diagram.

In Fig. 1, A represents the track-rails, which may be conductively continuous for all currents throughout their length. B represents the third-rail, or other conductor of power-current, which is connected to one terminal of the power-generator C; the other terminal of which is connected to the track-rails through the differential choke-coil *c*. This generator may produce direct-current or low-frequency alternating-current.

D represents a three-phase high-frequency generator, which supplies the signal-current for the rail-circuits through the transmission-lines *d*, extending along the track.

E^1, E^2, etc., represent transformers, the primaries of which are connected to the transmission-lines *d*, and the secondaries of which are connected across the track rails. It will be seen that adjacent transformers are connected to different phases of the transmission-lines *d*. Small resistances *e* may be inserted in series with the secondaries of the transformers to reduce the flow of power-current through the transformer windings if the track bonding becomes defective.

F^1 and F^2 represent relays each having two coöperating windings; one connected across the track-rails, and the other supplied with alternating-current independently of the rails.

In the drawing I have shown relays of the well-known induction type each comprising a short-circuited secondary *f* carrying the relay contact, and two primary windings f^1 and f^2, the first of which is connected across the rails through a resistance f^3 to reduce the flow of power-current through the winding, while the other is connected directly to the line-wires *d* or otherwise supplied with current independently of the rails.

It will be seen that the relay winding f^1 is traversed by current which is the resultant of the currents supplied to the rails by the two adjacent transformers. The phase of the current through winding f^2 is adjusted so that it is ninety degrees out of phase with the current in the winding f^1. Any suitable phase-adjusting device, as, for instance, the non-inductive resistance f^4, may be utilized in the circuit of the winding f^2 to supply the desired adjustment. As long as the track between two adjacent transformers is clear, the relay connected to the track between them will consequently have a phase-displacement of ninety degrees of the currents in the windings, thereby producing an effective torque, so as to maintain its contact closed. This is shown in the case of relay F^2, controlling the signal G^2. If, however, one of the transformers is cut off from the relay by a broken rail, or is short-circuited by a train, as shown at H in the drawing, the relay torque will fall to fifty per cent. of its normal value, or less, if the presence of the train at H reduces the amount of current supplied to the winding f^1 by the transformer E^2. By adjusting the relay so that it will drop its armature when the torque falls to fifty per cent. of normal, the relay F^1 will have dropped its armature when the train passes the transformer E^1; thereby putting the signal at danger indicating that the block is occupied.

The phase relations of the currents in the relay windings, and the effect of short-circuiting one adjacent transformer will be readily understood by an inspection of Fig. 2, in which $o\,e^1$ represents the voltage impressed on the rails by the transformer E^1, and $o\,e^2$, 120 degrees out of phase with $o\,e'$, the voltage impressed on the rails by the transformer E^2.

$o\,c^1$ represents the currents in the rails, due to the voltage $o\,e^1$. This current lags behind the voltage by a large angle due to the high inductance of the rail-circuit with the high frequency that is preferably employed for the system. Similarly, $o\,c^2$, 120 degrees out of phase with $o\,c'$, represents the current in the rails due to the voltage $o\,e^2$.

$o\,f^1$, 60 degrees out of phase with both $o\,c'$ and $o\,c^2$, consequently represents the resultant current which flows through the track winding of the relay.

$o\,f^2$ represents the current which is supplied to the second winding of the relay, displaced ninety degrees from $o\,f^1$.

The torque produced in a relay of the induction type, is proportional to the product of the currents in the two windings multiplied by the sine of the phase-angle between them, which is normally ninety degrees, as shown in Fig. 2.

Now, if either transformer fails, one of the component currents, as for instance, $o\,c^1$ will disappear, and the current through the track winding of the relay will consequently be the current supplied by the other transformer, $o\,c^2$. The torque of the relay remains proportional to the product of the currents multiplied by the sine of the phase-angle between them. The amounts of the currents have remained unchanged, but the phase-angle has shifted from ninety degrees to thirty, and since the sine of ninety degrees is 1, and the sine of 30 degrees is $\frac{1}{2}$, the relay torque has fallen to one half its normal value. If a train short-circuiting one transformer somewhat reduces the current supplied to the track winding of the relay by the other transformer, the relay torque will fall to less than fifty per cent. of normal. Consequently, by adjusting the relay so as to drop its armature at fifty per cent. of normal torque, the relay will at all times put the signal at danger upon the failure of either adjacent transformer, whether because of a broken rail or because of the presence of a train in the block.

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

1. In combination with an electric railway having both rails conductively continuous for all currents, sources of alternating-current connected across the rails at intervals, adjacent sources being of different phase, and signal-controlling relays connected singly across the rails between the sources, each relay being responsive to control a signal only when supplied with current from both adjacent sources.

2. In combination with an electric railway having both rails conductively continuous for all currents, sources of alternating-current connected across the rails at intervals, adjacent sources being of different phase, and signal-controlling relays connected singly across the rails between the sources, each relay having two coöperating windings, one connected across the track-rails and the other supplied independently of the rails with alternating-current of proper phase for effectively operating the relay only when the track winding is traversed by a current corresponding in phase to the resultant current delivered by the two adjacent sources.

3. In combination with an electric railway having both rails conductively continuous for all currents, sources of alternating-current connected across the rails at intervals, adjacent sources being of different phase, and signal-controlling relays connected singly across the rails between the sources, each relay comprising a short-circuited secondary member and two primary windings, one connected across the track-rails and the other supplied independently of the rails with current substantially ninety degrees out of phase with the resultant current delivered by the two adjacent sources.

In witness whereof, I have hereunto set my hand this 30th day of November, 1906.

LAURENCE A. HAWKINS.

Witnesses:

BENJAMIN B. HULL,

MARGARET E. WOOLLEY.