

March 1, 1927.

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1,619,712

INTERMITTENT INDUCTIVE TRAIN CONTROL

Filed April 8, 1925

2 Sheets-Sheet 1

FIG. 1.

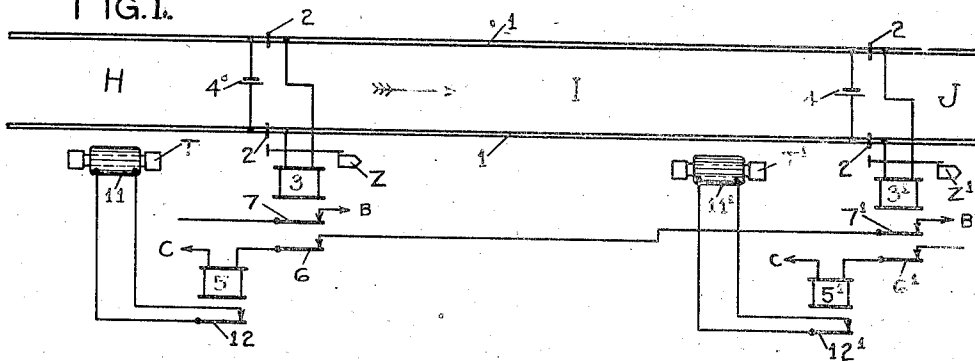


FIG. 2.

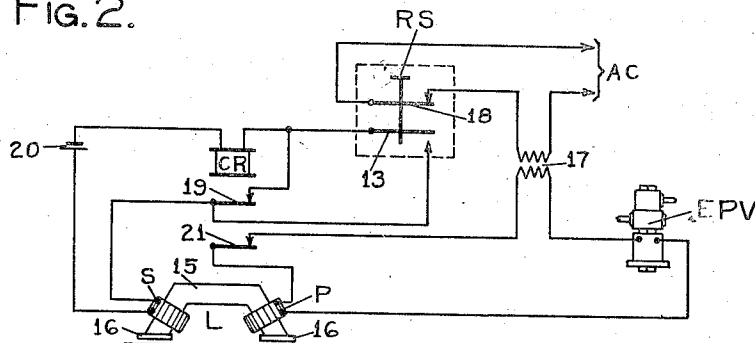
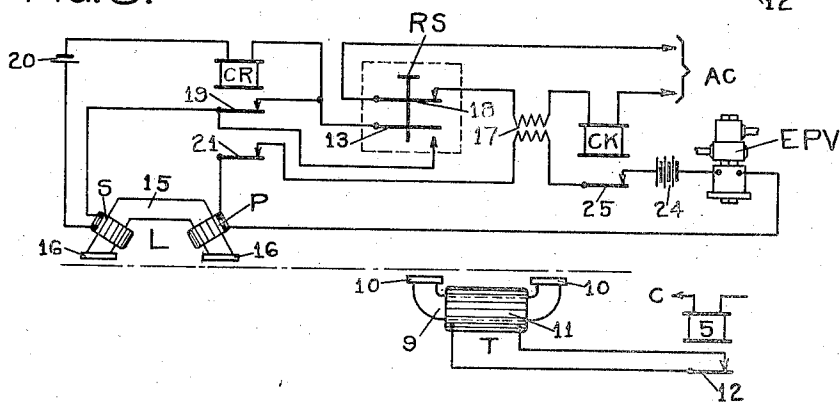


FIG. 3.



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2 Sheets-Sheet 2

FIG. 4.

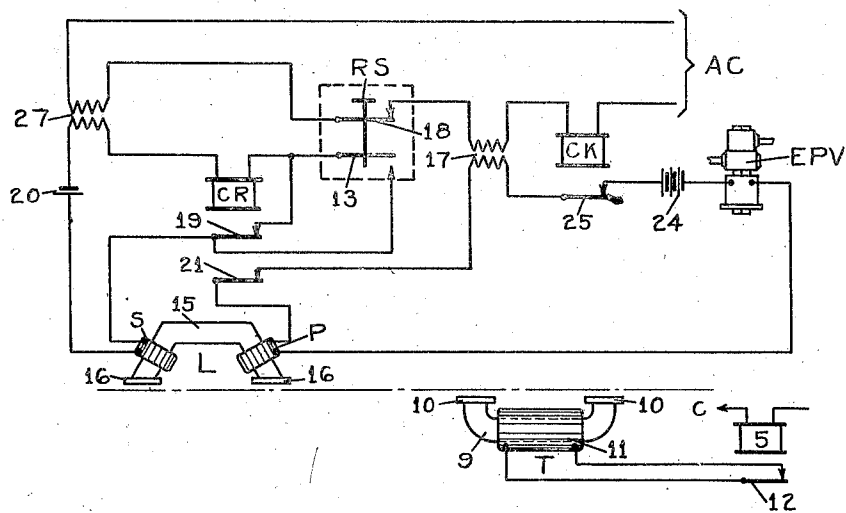
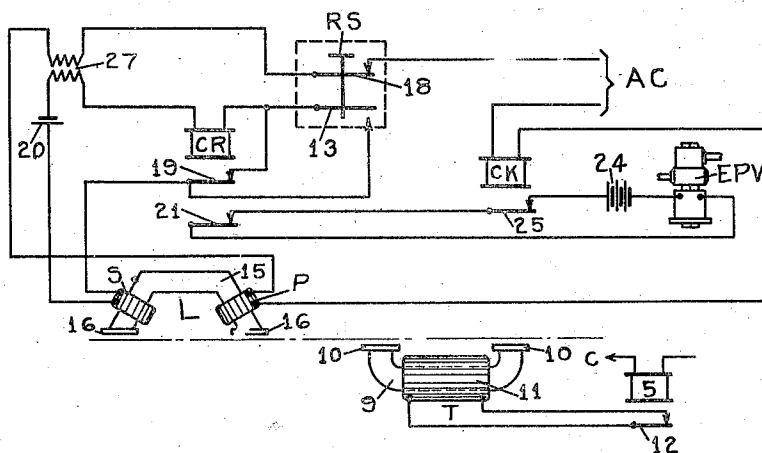


FIG. 5.



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INTERMITTENT INDUCTIVE TRAIN CONTROL.

Application filed April 8, 1925. Serial No. 21,551.

This invention relates to train control systems of the intermittent inductive type, and more particularly to influence communicating means for such systems.

5 In a certain well known system for communicating control influences inductively from the trackway to suitable car-carried apparatus, such influences are communicated by causing the induction of a current in a
10 car-carried coil by the passage of such coil over an inert or non-magnetized magnetic body along the trackway, this flux being derived from a car-carried uni-directional field of flux. In this type of influence communicating
15 apparatus no influence is communicated under favorable traffic conditions ahead, because the inert magnetic body along the trackway has a coil contained thereon which is closed in a circuit of low resistance under
20 such clear traffic conditions. An influence communicating system of this kind has been found to have certain outstanding advantages over certain other systems in that the strength of the control influence is dependent
25 on the speed at which the train is moving. In other words, the strength of the current induced in the car-carried coil of such systems increases as the speed of the vehicle increases, which is desirable for the
30 reason that the time during which an electro-responsive device may respond to such influence decreases as the speed of the train increases, so that the net result is, very effective and pronounced action of such electro-responsive device at all speeds above a
35 certain low speed, which has in practice been found to be about 3 miles per hour, below which it is difficult to transmit such influences.

40 The present invention deals more particularly with systems of the kind just mentioned which are modified by having alternating current impressed in some way so as to either simulate movement of the car or
45 so as to produce response of a relay by reason of the change of impedance due to the presence of a trackway device, or the like; so that the influence communicating means is effective at all speeds from zero up, upon
50 the passage of car-carried apparatus by a trackway device having its coil open-circuited; and the principal objects and purposes of the present invention reside in the provision of apparatus in connection with
55 which alternating current is employed so

that the apparatus is effective to communicate a control influence at all train speeds from zero up.

Other objects, purposes and characteristic features of the invention will appear as the description thereof progresses, and the novel features thereof will be pointed out in the appended claims.

In describing the invention in detail, reference will be made to the accompanying
65 drawings in which:—

Fig. 1 shows a simple form of block signaling system upon which the trackway apparatus of a train control system embodying the present invention is superimposed;

Fig. 2 illustrates a simple form of influence communicating means of the well recognized type heretofore mentioned, which is modified by having alternating current instead of direct current impressed upon the
75 primary or flux producing winding;

Fig. 3 illustrates a system like that shown in Fig. 2 modified by having a pulsating current impressed upon the primary winding instead of an alternating current;

Fig. 4 is a system like that shown in Fig. 3 except that a pulsating current is impressed on the secondary winding instead of an unvarying direct current, that is Fig. 4
85 illustrates a system employing pulsating current on both of the primary and secondary windings; and

Fig. 5 illustrates a system such as shown in Fig. 4 only that it is somewhat modified and has the primary winding energized by
90 alternating current instead of a pulsating current.

Trackway apparatus.—The trackway apparatus adaptable for use with each of the various types of car-carried apparatus illustrated has been shown in Fig. 1 only, and consists of a simple type of block signal system upon which suitable influence transmitting trackway devices are superimposed together with means for controlling the same.
100

Referring to Fig. 1 the track rails 1 are divided by insulating joints 2 into blocks in the usual manner, the block I and the adjacent ends of two other blocks H and J having been shown. Since the various
105 blocks are the same, like parts of each block are designated by like reference characters having distinctive exponents. At the entrance end of the block I is provided a track relay 3, which under normal clear traffic con-
110

ditions of this block is energized by current flowing through the track rails of this block and derived from a track battery 4 at the exit end of this block, the normal direction of traffic being as indicated by the arrow, this circuit thus constituting the usual closed track circuit. Near the entrance end of the block I is provided a line relay 5 which under normal clear traffic conditions of the block I and the block J next in advance is energized through a circuit including the front contact 6 of the track relay 3 and the front contact 7¹ of the track relay 3¹.

Although the influence communicating means embodying the present invention may be applied to train control systems in which cab signals are used and in which wayside signals are not absolutely necessary, it may be used in connection with wayside signals of either the color light or semaphore type, and for convenience semaphore signals Z only have been shown conventionally without illustrating their operating mechanism or control circuits. The apparatus thus far described is that used in practically every modern block signal system.

In addition to this apparatus there is provided at the entrance to the block I a track element T comprising a U-shaped core 9 preferably constructed of laminated magnetic material terminating in enlarged pole pieces 10 and having a coil 11 thereon which is normally closed in a circuit of low resistance through the front contact 12 of the line relay 5. This track element T is preferably located a distance in the rear of the entrance end of the block I, so that it is encountered by a suitable car-carried device of a train before the first axle of the train enters this block, this to avoid the train stopping itself, so to speak, by dropping the track relay of this block.

It is believed unnecessary to consider in detail the movements of trains in the various blocks, it being obvious from the drawing that the track element T has its coil 11 closed in a circuit of preferably low resistance, and is therefore inactive, when the block I at the entrance to which it is placed and the block J next in advance of this block are unoccupied, and that it has its coil open-circuited when either of these blocks is occupied; so that, this trackway device T is inactive under clear traffic conditions ahead and is active under both caution and danger traffic conditions ahead. This control for the trackway device T should be borne in mind in connection with the description of the operation of the various types of car-carried apparatus described hereinafter.

Car-carried apparatus (Fig. 2).—Since the present invention relates particularly to influence communicating means, it is considered unnecessary to show particular means for limiting the speed of the train or

for effecting a brake application regardless of speed, and in order to show a simple system capable of actually controlling a train, an electro-pneumatic device EPV has been illustrated which may be assumed to be a device for effecting an automatic brake application, either by controlling a suitable brake pipe venting device or a brake valve actuator or by initiating a suitable speed restricting mechanism, this device EPV for convenience being shown conventionally.

In the arrangement shown in Fig. 2, the car element L comprises a core 15 of inverted U-shape preferably constructed of laminated magnetic material terminating in downwardly facing pole pieces 16. The leading leg of this core 15 has a primary winding P contained thereon and the trailing leg is provided with a secondary coil S. In the first form of the invention shown the primary coil P is energized by alternating current derived from a transformer 17 which has its primary winding energized from a source of alternating current AC through the front contact 18 of a reset switch RS. In order to assure that this primary coil is properly energized, or rather that de-energization of this coil will effect a brake application, this coil has been connected in series with the train or brake control device EPV, so that, a decrease of the current flow in this primary coil to an unsafe value causes this device to assume its deenergized position. The secondary coil S is connected to a suitable control relay CR through a stick circuit including the front contact 19 of this relay CR, this circuit including a battery 20 of a voltage sufficient to just hold this control relay CR in its energized position. This control relay CR in practice has its movable parts well balanced and pivotally mounted on a vertically disposed axis, so that it is substantially immune to jars and vibration, generally experienced on railway trains.

In each of the modifications shown in this application the operation of the system will be considered under three different conditions as follows:—(1) At very low speeds with the car element passing over an active inductor; (2) when the car element L passes over an active inductor at higher speeds; and (3) when the car element L passes over an inactive inductor.

Operation (Fig. 2).—By looking at Fig. 2 it is obvious that with the various devices in their normal positions, a certain alternating potential is induced in the secondary coil S of the car element L by reason of transformer action acting through the large air gap between pole pieces 16 by reason of the alternating flux of the primary coil. In practice, the potential induced in the secondary coil is insufficient to de-energize the control relay CR even during that part of

the wave of a cycle when this alternating potential opposes the voltage of the battery 20 when this car element is disposed in air.

Let us assume that the car-carried apparatus shown in Fig. 2 is in its normal clear traffic condition as illustrated and that the car element L passes by a track element T at a very low speed of say, between zero and 3 miles per hour. As the car element L comes over the inductor T the air gap between pole pieces 16 is materially reduced so that the car element L together with the track element T constitutes a better and more efficient transformer, whereby a higher voltage is induced in the secondary coil by reason of alternating flux emanating from the leading leg of the car element L, than that induced when this car element is not over an inductor. This higher alternating current voltage induced in the secondary coil S, during that part of a cycle when this voltage is in a direction to oppose that of the battery 20, causes the relay CR to assume its de-energized position, and with this relay once de-energized its front stick contact 19 opens and causes this relay to remain in its de-energized position. De-energization of the relay CR causes opening of the contact 21 thereby de-energizing the device EPV and effecting either a restrictive speed limit or an automatic brake application depending on the particular type of apparatus used.

Proceeding on the assumption that the device EPV is a device which if de-energized effects a venting of the brake pipe and an automatic brake application, the system shown in Fig. 2 illustrates means for again energizing the device EPV after the train has been brought to a stop. In the arrangement shown a suitable reset push button RS has been illustrated, which is so placed on the train that it is only accessible when the train is standing still, that is, is only accessible from the ground. If the engineer alights from the cab and presses the reset push button RS, a pick-up circuit for the control relay CR is completed which is readily traced in the drawings and comprises the stick circuit for this relay CR heretofore considered except that the front contact 19 is shunted by the contact 13 of the reset push button RS. With the control relay CR once energized it remains energized through its stick circuit for reasons heretofore given. In order to prevent the engineer from tying or otherwise permanently holding this reset push button RS in its active depressed position, so that he would not be required to come to a stop to reset the apparatus, this push button is closed in a casing and is provided with another normally closed contact 18 which opens the primary circuit for the transformer 17, and in turn causes de-energiza-

tion of the device EPV, so long as this reset push button RS is in its depressed position. In other words, this reset push button RS is protected against misuse by being so constructed that it must not only be depressed to release the brakes, but must be depressed and again returned to its normal condition and maintained there in order that the brakes may be, and remain, released.

The theory upon which the operation of the system shown in Fig. 2 for higher train speeds is based is substantially the same as that at less than 3 miles per hour just considered, so that, no further description of its operation under adverse traffic conditions ahead need be considered.

Let us now assume that a train equipped with the car-carried apparatus shown in Fig. 2 is in its normal condition and passes by an inactive inductor, that is, an inductor having its coil 11 closed in a circuit of low resistance. As the car element L moves over the inductor T no material increase in the alternating current potential induced in the secondary coil S over that induced when the car element L is at an intermediate point in a block is experienced. This is believed to be due to the bucking action of the short-circuited coil 11, and in spite of the presence of the iron this track element T does not materially decrease the reluctance of the magnetic circuit including the cores 15 and 9. In other words, the transformer action between the primary coil P and the secondary coil S is not materially improved even though the car element L is in inductive communication with the track element T having its coil 11 closed in a circuit of low resistance, so that no influence is communicated from the trackway to the car-carried apparatus under clear traffic conditions. It should be noted that the car-carried as well as the trackway apparatus shown in Fig. 2 is constructed on the closed circuit principle, and that the opening of any circuit makes a change corresponding to adverse traffic conditions.

Structure (Fig. 3).—Fig. 3 illustrates a car-carried circuit arrangement which is identical to that shown in Fig. 2 except that a source of direct current 24 has been connected in series with the secondary coil of the transformer 17, so that the primary coil P is energized by a pulsating uni-directional current instead of alternating current. In practice, the maximum value of the alternating current is preferably less than that of the uni-directional current, so that the net result is a uni-directional current having an alternating wave or ripple superimposed thereon. Since in the arrangement shown in Fig. 3 the device EPV is primarily energized by the battery 24, and since it is desired to check the integrity of the alternating current supply circuit and also to

check the presence of an alternating current potential, a check relay CK connected in the primary energizing circuit for the transformer 17 is provided, which relay has a front contact 25 in the energizing circuit of the device EPV. In other words, failure of the energizing circuit for the control relay CR or failure of the battery 20 causes opening of contact 21 and effects de-energization of the brake control device; further failure of alternating current in the primary winding of the transformer 17 causes dropping of the check relay CK and in turn a de-energization of the device EPV by dropping of the contact 25; and failure of the battery 24 or the integrity of the circuit for the primary coil P causes de-energization of the device EPV; so that the entire car-carried circuit arrangement is constructed on the closed circuit principle.

Operation (Fig. 3).—The operation of the car-carried apparatus shown in Fig. 3 when passing over an active inductor at extremely low speeds of say, less than 3 miles per hour, is substantially the same as that of the system shown in Fig. 2, that is, the control relay CR is de-energized by the induction of a potential in the secondary coil S by reason of an improved transformer coupling between the primary coil P and the secondary coil S, so that the operation under this condition need not be considered specifically.

Let us now assume that a train equipped with the car-carried apparatus shown in Fig. 3 passes by an active track element or inductor T at a comparatively high speed. Under this operating condition it may be presumed that the voltage induced in the secondary coil S by reason of alternating current flowing in the primary coil P although it may be sufficient to operate the control relay CR acts for an insufficient period of time to cause operation of this relay, and that the control relay CR is de-energized mainly by reason of an increase of flux through the secondary coil S due to movement of the vehicle and direct current flowing in the primary coil P derived from the battery 24. In other words, as the car element L approaches the track element T a rapid increase of uni-directional flux in the secondary coil S takes place, this increase of flux, it is believed, is to a large extent due to diversion of flux from leakage paths and to a certain extent due to an increase of the total uni-directional flux passing through the primary coil P. In any event, this increase of flux, uni-directional in character, induces a cycle of potential in the secondary coil S, the first wave of which is in a direction to oppose a voltage of the battery 20, causes de-energization of the control relay CR before the second wave is induced; which relay if once de-energized breaks its own stick circuit by dropping of

contact 19 thus remaining de-energized, and in turn through contact 21 de-energizing the train control device EPV. In other words, in the arrangement shown in Fig. 3, the control relay CR is de-energized by the action of the alternating current flowing in the primary coil P which through transformer action induces a similar voltage in the secondary coil S when the car-carried and trackway devices are in cooperation and this voltage is relied upon at very low train speeds for de-energizing the control relay; whereas the diversion of the uni-directional flux is relied upon to induce a cycle of voltage in the secondary coil S the first wave of which will drop the control relay CR at higher speeds; so that the principle heretofore mentioned for transmitting control influences in accordance with which the strength of the influence is dependent on the speed of the train is taken advantage of at higher speeds, and the variation of flux emanated from the primary coil P due to the alternating current derived from the transformer 17 is taken advantage of at extremely low speeds.

Structure (Fig. 4).—In the discussion of the operation shown in Figs. 2 and 3, it will be remembered that a certain alternating current potential was induced in the secondary coil S at all times, that is, when the car element L was located in air as well as when it was located over an active trackway inductor. In other words, the control relay CR was energized by a small direct current having a small alternating current ripple superimposed thereon due to alternating flux from the primary coil P. The circuit arrangement shown in Fig. 4 is exactly the same as that shown in Fig. 3 except that an additional transformer 27 which has its primary winding connected in series with the primary winding of the transformer 17 has been provided. The secondary winding of this transformer induces a potential in the circuit including the control relay CR which is in a direction to neutralize the voltage ripple induced in the secondary coil S by transformer action from the primary coil P. This transformer 27 is constructed so that its secondary voltage is of the proper value and has the proper phase relation to entirely buck out the ripple heretofore mentioned. The net result is that the control relay CR is energized by a substantially unvarying direct current.

Operation (Fig. 4).—Let us assume that a car equipped with the apparatus shown in Fig. 4 in its normal clear traffic condition as illustrated is moving along the track at an extremely low speed of say, less than 3 miles per hour, bearing of course in mind that the voltage induced in the secondary winding of transformer 27 just neutralizes the voltages induced in the secondary coil S, and passes over a trackway inductor having its coil

open-circuited. As the car element L gets in to registration with the track element T the transformer coupling between the primary coil P and the secondary coil S is materially improved, and further the phase relation of the potential induced in the secondary coil S is shifted to a certain extent whereas the secondary voltage of the compensating transformer 27 is substantially unchanged and is no longer able to neutralize the potential induced in the secondary coil S. A potential is thus induced in the secondary circuit, one wave of each cycle of which is in a direction to oppose the voltage of battery 20, and which wave is of sufficient magnitude to de-energize the control relay CR, which in turn effects the retardation of the train in a manner heretofore explained. Not only is the potential induced in the secondary coil materially increased when the car element L is disposed over an active trackway inductor, but by reason of the decrease of reluctance of the magnetic circuit including this car element L and track inductor T the alternating current flowing in the primary winding of the transformers 17 and 27 is probably materially reduced, so that the voltage induced by the transformer 27 in the circuit including the control relay CR is materially reduced, and is therefore not as effective to neutralize the potential induced in coil S and causes the current change in the control relay CR to be still more pronounced.

The provision of this neutralizing transformer 27 allows the normal direct current to be adjusted nearer to the drop-a-way value for the relay CR, and tests have shown that the arrangement shown in Fig. 4 is more efficient and allows a larger air gap between car-carried and trackway elements to be used than does the arrangement shown in Fig. 3. The operation of the system shown in Fig. 4 at the higher speeds is substantially the same as that shown in Fig. 3 except that the margin of operation is probably materially increased by reason of the transformer 27, which irons out the ripples, so to speak, in the current flowing in the control relay CR, so that, this relay may be adjusted nearer its drop-a-way current and better operation results.

The operation of the apparatus shown in Fig. 4 when passing over an inactive inductor, that is, one having its coils closed in a circuit of low resistance is substantially the same as that of Fig. 3 and needs no further discussion.

Structure (Fig. 5).—In the arrangement of the car-carried apparatus shown in Fig. 5 of the drawings the primary coil P is energized by alternating current only instead of being energized by pulsating current due to an alternating current having a direct current source connected in series therewith as is the case in the arrangement shown in

Fig. 3. Since no direct current is employed in the energization of the primary coil P the device EPV has been shown connected in a separate circuit energized by the battery 24, and the primary coil P is connected directly in series with the primary winding of the transformer 27 and the check relay CK to a source of alternating current AC. In this arrangement the integrity of the alternating current circuit is checked by the check relay CK, the integrity and energization of the secondary circuit is checked by the control relay CR and the failure of the source of current for energizing the device EPV as well as the integrity of this circuit is obviously checked.

Operation (Fig. 5).—The operation of the car-carried system shown in Fig. 5 of the drawings under two conditions, that is, when a car equipped with this apparatus passes an active inductor at very low speeds or when it passes an inactive inductor at high speeds, is substantially the same as that of the system shown in Fig. 4 and no further discussion of this phase of the operation is deemed necessary.

The transmission of a control influence when the car element L of the system shown in Fig. 5 passes an active inductor at high speeds may be said to be dependent on two factors, (1) the rate of change of the reluctance of the magnetic circuit including the car element L and the active track inductor T, which causes an increase of magnetic flux through the secondary coil S for the particular magneto-motive-force existing in the primary leg of this car element, and (2) the increase of flux in the primary leg due to this varying magneto-motive-force. For instance, let us assume that the car element L is approaching a track element T in its active condition and is just about at the point in which these devices are in registration. During this point of travel of the vehicle the reluctance of the magnetic circuit including the car element L decreases very rapidly so that the flux in the secondary coil S, for each unit of magneto-motive-force existing in the primary coil P, increases; also, if the current in the primary coil P is increasing at this time, which it will be during a portion of the time when the reluctance of the magnetic circuit is decreasing, especially if the proper frequency is chosen, the cumulative effect of the decrease of reluctance of the magnetic circuit and the increase in the magneto-motive-force in the primary coil P acts to induce a voltage in the secondary coil S which for a time is in a direction to oppose that of the voltage of the battery 20 thereby causing de-energization of the control relay CR and a restriction in the movement of the train.

Having thus shown and described several embodiments of the invention rather specifi-

cally it is desired to be understood that this has been done for the purpose of disclosing several forms of the invention rather than the scope thereof and the exact structure preferably employed in practice, and that various changes and modifications may be made to adapt the influence communicating means embodying the present invention to the various types of train control systems, such as, semi-automatic or permissive systems, speed control systems and automatic stop systems, without departing from the scope of the invention or the ideas of means underlying the same.

What is desired to be secured by Letters Patent is:—

1. Influence communicating means for automatic train control systems of the intermittent inductive type, comprising a car-carried influence receiving element including a core of laminated magnetic material of general inverted U-shape having a primary coil on one leg and a secondary coil on the other leg, a stick relay, an alternating current source of energy for energizing said primary coil, a direct current source of energy, a secondary circuit including in series said secondary coil, said stick relay and said source of direct current, trackway means for effecting an inductive coupling between said primary and said secondary coil under predetermined traffic conditions ahead, and separate car-carried means for inductively coupling said secondary and said primary circuit.

2. Car-carried apparatus for automatic train control systems comprising: a car element including a core of inverted U-shape having a primary flux producing coil on one leg and a secondary influence receiving coil on the other leg; a control relay; a secondary circuit including said control relay, a battery, said secondary coil and a secondary winding of a transformer in series; a circuit for said primary coil including the primary winding of said transformer and a source of alternating current in series, the various parts being so correlated that the transformer induces a voltage in the secondary circuit substantially equal to and of the proper phase relation to oppose the voltage induced in said secondary coil in response to flux emitted from said primary coil.

3. In an automatic train control system; the combination of car-carried apparatus comprising: a primary circuit including a primary coil having an alternating current potential impressed thereon; a secondary coil; a stick relay; a secondary circuit including said secondary coil, said stick relay and a source of direct current sufficient to maintain said relay in its attracted position in series; and means for inductively coupling the primary circuit and said secondary cir-

cuit so as to neutralize the voltage induced in said secondary coil by said primary coil; and of trackway means which if in its active condition reduces the reluctance between said primary and said secondary coil; whereby the voltage induced in said secondary coil by said trackway means can not be neutralized by said coupling means and de-energization of the stick relay results.

4. In an automatic train control system; the combination with a normally energized brake control device on a railway vehicle which if de-energized applies the brakes of the usual air brake system; a control relay; a check relay; an influence receiving device including a primary and a secondary coil; a source of alternating current; a circuit for energizing said primary coil including in series the winding of said check relay and said source of alternating current; a circuit for said control relay including in series a front contact of said control relay and said secondary coil; and a circuit for said brake control device including in series a front contact of said control relay and a front contact of said check relay.

5. Influence communicating means for automatic train control systems of the intermittent inductive type, comprising; a car-carried influence receiving device including a primary coil and a secondary coil; a stick relay including a front stick contact; a source of alternating current; a primary circuit for energizing said primary coil including said source of alternating current; a source of direct current; a secondary circuit including in series said secondary coil, the winding and front stick contact of said stick relay and said source of direct current; trackway means for effecting an inductive coupling between said primary and said secondary coil under predetermined traffic conditions ahead; and separate car-carried means for inductively coupling said secondary and said primary circuit.

6. Influence communicating means for automatic train control systems of the intermittent inductive type, comprising the combination of car-carried apparatus including a secondary coil connected in series with a stick relay and a source of direct current, a primary flux producing coil energized by alternating current and located in inductive relation with said secondary coil whereby an alternating current potential is induced in said secondary coil by flux emitted from said primary coil, separate means for inducing in the circuit including said secondary coil a counteracting voltage having a phase relation and magnitude to neutralize the alternating current potential induced in said secondary coil by flux emitted from said primary coil; and of trackway means for reducing the reluctance of the magnetic cir-

cuit including said primary and said secondary coils under adverse traffic conditions ahead.

5 7. Influence communicating means for automatic train control systems of the intermittent inductive type, comprising the combination of car-carried apparatus including a secondary coil connected in series with a stick relay and a source of direct current, a
10 primary flux producing coil energized by alternating current and located in inductive relation with said secondary coil whereby an alternating current potential is induced in said secondary coil by flux emitted from said

primary coil, separate means for inducing a counteracting voltage in the circuit including said secondary coil by flux emitted from said primary coil; and of trackway means for reducing the reluctance of the magnetic circuit including said primary and said secondary coils under adverse traffic conditions comprising an unmagnetized core of iron having a coil thereon, which coil is closed in a circuit of low resistance under clear traffic conditions ahead. 25

In testimony whereof I affix my signature.

CHARLES F. ESTWICK.