

Oct. 2, 1928.

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1,686,434

INTERMITTENT INDUCTIVE TRAIN CONTROL

Filed April 16, 1925

2 Sheets-Sheet 1

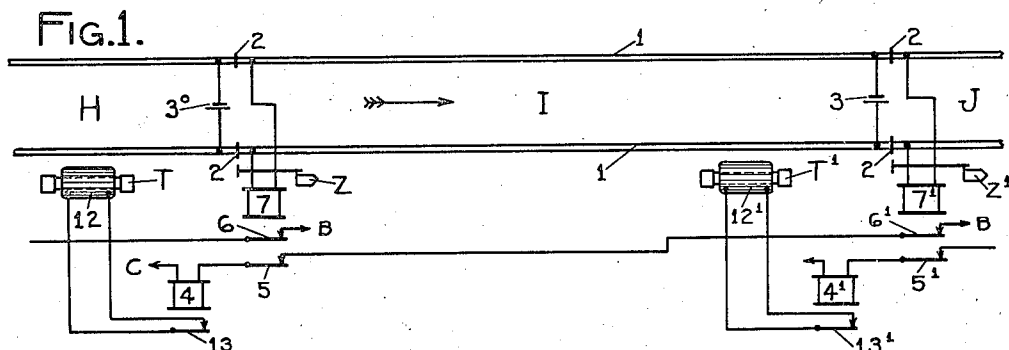
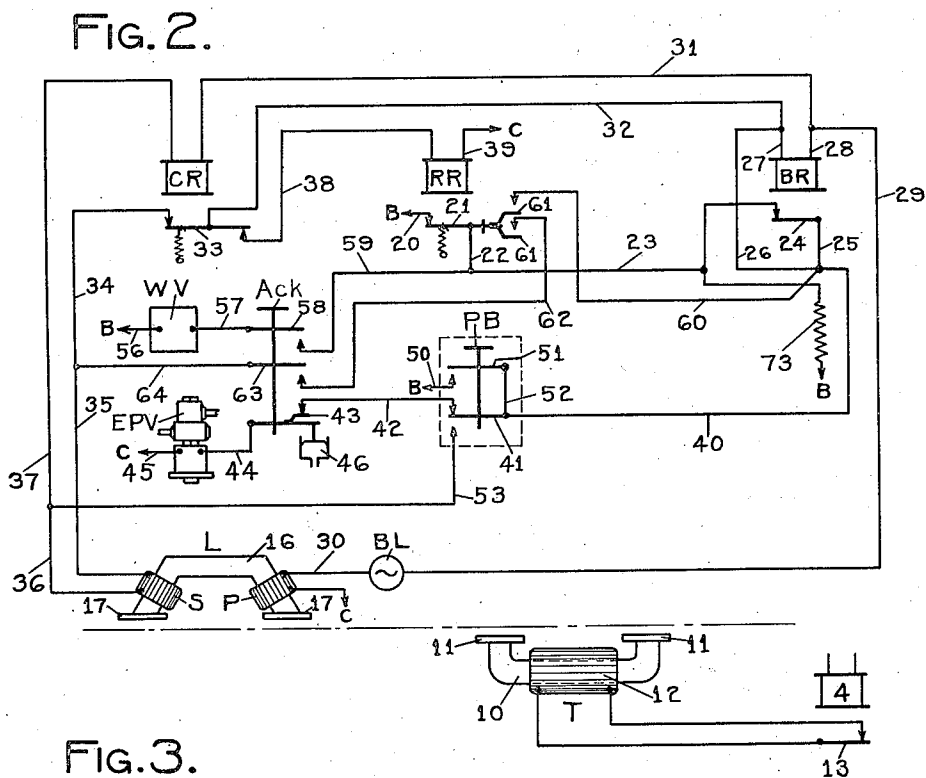
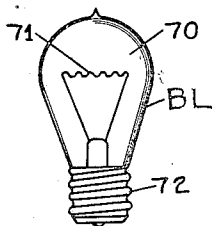


FIG. 3.



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2 Sheets-Sheet 2

FIG. 4.

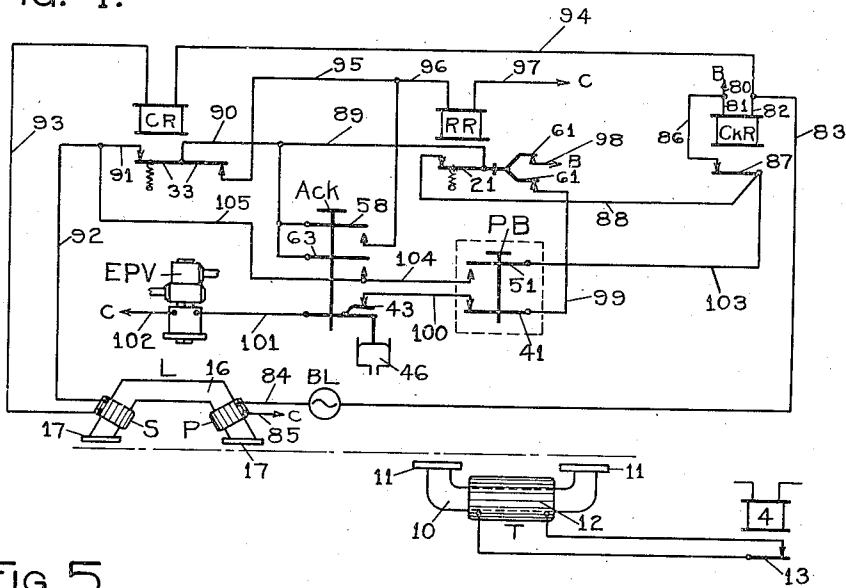
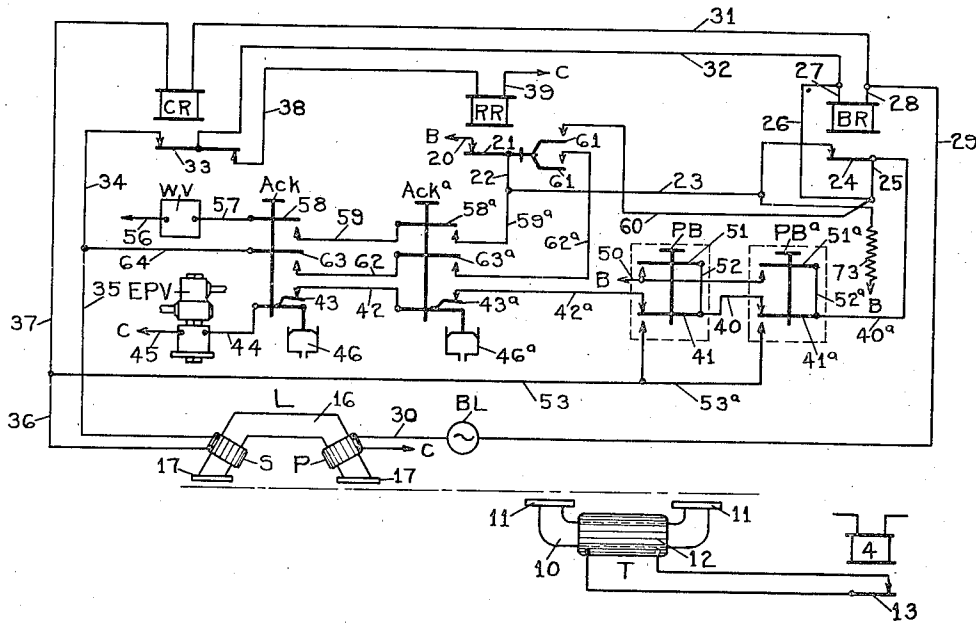


FIG. 5.



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INTERMITTENT INDUCTIVE TRAIN CONTROL.

Application filed April 16, 1925. Serial No. 23,572.

This invention relates to automatic train control systems of the intermittent inductive type.

In a certain well recognized train control system control influences are transmitted from the trackway to suitable car-carried apparatus from suitable inert trackway devices governed in accordance with traffic conditions ahead. Generally speaking, the principle of transmitting control influences by this system consists in diverting flux through an influence receiving coil under danger traffic conditions by the action of an unmagnetized or inert body of magnetic material along the trackway which is ineffective to transmit such control influence when a coil surrounding said body is closed in a circuit of low resistance. An influence communicating means of this kind has certain desirable features, the principal one of which is that no trackway energy of any kind is required. Another advantage experienced in this system is that the rate of diversion or change of flux in the car-carried influence receiving coil and in turn the voltage induced in said coil by such change of flux increases with the speed of the train so that suitable electro-responsive devices may be operated by such influence at extremely high speeds as well as at the lower speeds, in spite of the fact that the time during which influences may be communicated decreases as the speed increases. Obviously, in a system of this kind an influence cannot be communicated while the car-carried device is moving over a trackway device at an extremely low speed, this because a certain rate of movement is necessary to effect the necessary rate of diversion of flux; also, a certain limit of sensitiveness of the car-carried apparatus is necessary, so that the car-carried apparatus does not respond when it moves by a trackway device which has its coil closed in a circuit of low resistance; and since the sensitiveness of the car-carried apparatus heretofore proposed is not the same for all conditions, this varying with the voltage of the battery used in connection with the car-carried apparatus, the outside temperature, and the like, it is proposed in accordance with the present invention to provide a current regulating device or ballast lamp which regulates the flow of current to the car-carried apparatus, so to speak, regardless of certain variation in battery voltage and variations in the resistance of the various circuits due to temperature changes,

so that the car-carried apparatus may be designed to work properly from extremely low speeds and up to extremely high speeds, operation at speeds of 90 miles per hour having been obtained.

Other objects and purposes of the present invention reside in the provision of a system including suitable manually operable acknowledging means whereby the engineer's vigilance may be manifested and suitable manually operable reset means.

Other objects, purposes and characteristic features of the invention will appear as the description progresses.

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

Fig. 1 illustrates conventionally and in a diagrammatic manner a very simple type of railway block signaling system upon which the trackway apparatus of an embodiment of the present invention is superimposed;

Fig. 2 shows diagrammatically the car-carried apparatus in which the various devices are shown conventionally together with a side elevation of a trackway device and the manner in which this device cooperates with the car-carried influence receiving element;

Fig. 3 shows the current regulating device or ballast lamp mentioned; and

Figs. 4 and 5 show modified forms of the invention.

Trackway apparatus.—Referring to Fig. 1 of the drawings, the reference character 1 designates track rails divided by insulating joints 2 into blocks, the block I and the adjacent ends of two other blocks H and J being shown. Since the various blocks are the same, like parts of each block are designated by like reference characters having distinctive exponents.

In the particular arrangement shown the entrance end of the block I is provided with the usual track relay 7, which under normal clear traffic conditions of this block is maintained energized by the usual track battery 3 through a circuit including the rails of the block I in series, thus constituting the usual closed track circuit. At the entrance end of the block I is also located a line relay 4 which under clear traffic conditions of the blocks I and J is maintained energized by a circuit including contact 5 of the track relay 7 and contact 6¹ of the track relay 7¹. The reference character B represents a terminal of a

suitable source of energy such as a battery having its other terminal connected to a suitable common return wire C. The present invention is preferably used in connection with
 5 wayside signals of any of the various well known types, such as, color light or semaphore signals and for convenience semaphore signals Z only have been shown without illustrating their well known operating mechanism and control circuits.

The apparatus thus far described comprises that necessary for wayside signal control purposes; in addition to this apparatus there is provided a trackway influence communicating element or inductor T which comprises a U-shaped core 10 terminating in enlarged pole pieces 11 and having a coil 12
 15 thereon which coil is normally closed in a circuit of low resistance by a front contact 13 of the line relay 4. This track element T is preferably located on the right hand side of the track the normal direction of traffic being as indicated by the arrow, and has its pole pieces located a few inches above the top
 20 of the rails, so that this track element has an influence communicating advantage over that of other magnetic bodies along the track, such as diverging switch rails, crossing rails, and the like.

By looking at the trackway apparatus shown in Fig. 1, it is obvious that the coil 12 of the track element T is closed in a circuit of low resistance when both the block at the entrance end to which it is placed and the
 25 block next in advance thereof are unoccupied, and that it is open-circuited, thereby causing the track element to assume its active condition, when either of these blocks is occupied, that is, is active under either caution or danger traffic conditions ahead; and for this reason, it is believed unnecessary to consider
 30 movements of trains in the various blocks.

Structure (Fig. 2).—Since many of the elements of the car-carried apparatus are well known in the art of railway signaling they will be only briefly mentioned, after which the car-carried circuit arrangement and operating features of the system will be considered. The car-carried apparatus includes a
 35 control relay CR, a repeater relay RR and a brake control relay BR. These relays are constructed so as to be immune to jars and vibration, quick acting and responsive to very slight changes in current flowing in their
 40 windings.

This car-carried apparatus includes a suitable electrically operated audible signal conveniently called a whistle valve WV, and also includes an electro-pneumatic valve EPV
 45 which may control a suitable pneumatically operated brake pipe venting device which if operated retards the movement of the train or the EPV may control a pneumatically operated brake valve actuator, as desired.
 50 This device EPV representing suitable means

to effect an automatic brake application of any degree or character desired upon the deenergization of a circuit, this conventional representation is considered sufficient since the present invention is not directed to any particular type of brake control apparatus.

The car-carried influence receiving apparatus comprises an influence receiving element L including an inverted U-shaped core 16 of laminated magnetic material terminating in enlarged pole pieces 17 spaced to properly cooperate with the pole pieces 11 of the trackway or inductor element T. This core 16 is provided with a primary or flux producing coil P and a secondary or influence receiving coil S.

In previous influence communicating systems of the type to which the present invention is particularly directed, changes of battery voltage and changes in the resistance of the various devices due to changes in temperature made it necessary to sacrifice sensitivity of the car-carried apparatus in order to avoid the transmission of control influences when passing by inductors in their clear traffic condition, that is, having their coils closed in a circuit of low resistance. In the present invention a current regulating device or ballast lamp BL is employed to compensate for these variable factors.

This current regulating device or ballast lamp BL has been more clearly shown in Fig. 3 of the drawings, and comprises an evacuated sealed globe 70 filled with nitrogen similar to that used in incandescent lamps in which a ballast unit 71 of resistance wire having an extremely high temperature coefficient of resistance is contained; this ballast unit as it heats up causes its resistance to rise very rapidly as compared with the resistance change in the rest of the circuit when the current is increased. On account of the construction of this lamp and also on account of the manner in which it is housed in practice, the unit 71 itself being not exposed to the outside temperature, if the current flowing therein decreases slightly for some reason or other, the temperature of this unit and its ohmic resistance drops, causing the current to again increase practically to its normal value. In other words the ballast lamp BL consists of a ballast unit contained in a vacuum or inert gas so that very little heat radiation and no oxidation takes place and in which a change of temperature due to a change of current flowing therein causes the resistance of this unit to change abruptly and in this way causes it to be self adjusting, and causes it to automatically regulate the flow of current in the circuit in which it is contained. This ballast lamp BL is provided with the usual lamp base 72 which in practice is screwed into a lamp socket of the usual construction. This ballast lamp is so located in the circuit arrangement as to affect those circuits in which the

degree of energization is very important. The main wire including this ballast lamp BL is included in the circuit containing the primary coil P and the brake control relay BR in series which circuit may be traced as follows:—beginning at the terminal B of a suitable source of energy, wire 20, front contact 21, of the repeater relay RR, wires 22 and 23, front contact 24 of the brake control relay BR, wires 25, 26 and 27, winding of the brake control relay BR, wires 28 and 29, ballast lamp BL, wire 30, primary coil P back to the common return wire C connected to the other end of said source of energy. The provision of this ballast lamp BL, which is preferably so located as not to be affected by outside temperature, causes the current flowing in this circuit to be substantially constant regardless of ordinary variations in battery voltage and changes of the resistance of this circuit due to temperature changes, contact resistances and the like.

In order that the current flowing in the control relay CR, which relay is connected in series with the secondary winding S, may vary with the slight changes in the current in the primary coil P, the potential for supplying current to this control relay CR is the resistance drop across the brake control relay BR. In other words, the control relay CR and secondary coil S are connected in series with each other and in multiple with the brake control relay BR through the following circuit:—beginning at one side of the winding of the brake control relay BR, wires 27 and 32, front contact 33 of the control relay CR, wires 34 and 35, secondary coil S of the car element L, wires 36 and 37, winding of the control relay CR, wires 31 and 28 back to the other terminal of the brake control relay BR. The various constants are so chosen that the potential across this brake control relay BR is sufficient to hold the control relay CR energized to a predetermined degree just enough to keep this relay from dropping under most unfavorable conditions of battery voltage and temperature, when traffic conditions are clear.

With the control relay CR energized the repeater relay RR is energized through the following circuit:—beginning at the terminal B, wire 20, front contact 21 of the repeater relay RR, wires 22 and 23, front contact 24 of the brake control relay BR, wires 25, 26 and 32, front contact 33 of the control relay CR, wire 38, winding of the repeater relay RR, wire 39, back to the common return wire C. It is thus noted that the repeater relay RR is connected in a stick circuit including its own front contact 21, and that this stick circuit also includes a front contact 33 of the control relay CR. It should also be noted, that the brake control relay BR and the primary coil P which are connected in series include the front contact 24 of this brake controlling

relay BR, so that this relay BR is also connected in a stick circuit and similarly, the control relay CR is connected in a stick circuit including its front contact 33.

With these relays energized an energizing circuit for the brake control device EPV is closed which may be traced as follows:—beginning at the terminal B, wire 20, front contact 21 of the repeater relay RR, wires 22 and 23, front contact 24 of the brake control relay BR, wires 25 and 40, front contact 41 of the reset push button PB, wire 42, slow releasing contact 43 of the acknowledging push button Ack, wire 44, winding of the device EPV, wire 45 back to common return wire C. The front contact 43 of the acknowledging device Ack is slow releasing because it is retarded by the dash pot 46, this dash pot being provided to permit the acknowledging push button Ack to be depressed for a predetermined period of time without opening the energizing circuit for the brake control device EPV.

Operation (Fig. 2).—As heretofore mentioned, the present system is one of the permissive or semi-automatic type, that is, a system in which an automatic brake application is initiated if the engineer fails to manifest his vigilance when passing an active control point, this being assumed to be sufficient to effect stoppage of the train when the engineer is dead, incapacitated or is not attending to his duties for any other reason. In order to clearly understand the operation of the system, the transmission of a control influence when the engineer does not manifest his vigilance will first be taken up, after which it will be shown how the engineer can avoid an automatic brake application by depressing the acknowledging push button Ack at the time he is passing an active trackway inductor, and what takes place when an inactive inductor is passed.

Let us assume that a train equipped with the car-carried apparatus shown in Fig. 2 passes by an inductor having its coil open-circuited because traffic conditions ahead are dangerous. As the car-carried element L gets into communication with the trackway element T the reluctance of the magnetic circuit including the primary coil P and the secondary coil S materially decreases so that a rapid increase of flux through the secondary coil S takes place. This increase of flux, it is believed, is mainly due to a diversion of flux from leakage paths and, possibly to a certain extent, is due to an increase of the total flux passing through the primary coil P. This increase of flux through the secondary coil S induces a voltage in this coil which voltage is in a direction opposite to that of the resistance drop due to the energizing current flowing through the brake control relay BR, so that the current in the control relay CR is reduced. This reduction

in the current in the control relay CR is sufficient to cause it to assume its retracted position if the speed of the train is above a certain low value, more particularly discussed hereinafter. Momentary de-energization of the control relay CR causes it to drop its front contact 33 thereby interrupting the energizing circuit for this relay so that this relay continues to assume its de-energized position. As the car-element recedes from the track element a voltage is induced in the coil S in the opposite direction for obvious reasons, but this voltage has no effect because the stick circuit for the relay CR is open.

With the contact 33 in its retracted position the repeater relay RR is de-energized. With the repeater relay RR de-energized the energizing circuit for the brake control relay BR and the device EPV are broken so that these devices assume their de-energized positions and an automatic brake application, which brings the train to a stop, results. After the train has been brought to a stop by such a brake application the engineer, after alighting from the cab, may restore the apparatus to normal by depressing the reset push button PB which is contained in a casing as shown by the dotted rectangle, and is only accessible from the ground.

If now, the engineer depresses the push button PB a pick-up circuit for the brake control relay BR is closed as follows:—beginning at the terminal B, wire 50, back contact 51 of the reset push button PB, wires 52, 40, 26 and 27, brake control relay BR, wires 28 and 29, ballast lamp BL, wire 30, primary coil P back to common return wire C. Also, with this push button PB depressed a pick-up circuit for the control relay CR is completed as follows:—beginning at the terminal B, wire 50, back contact 51 of the push button PB, wire 52, back contact 41 of the push button PB, wires 53 and 37, winding of the control relay CR, wires 31 and 29, ballast lamp BL, wire 30, primary coil P back to the common return wire C. With the control relay CR again picked up the repeater relay RR assumes its energized position for obvious reasons, and since the brake control relay BR is again energized its stick circuit is completed through contact 21 of the repeater relay RR so that all relays as well as the device EPV again assume their energized positions and permit the train to proceed. This circuit for picking up the relay RR comprises:—B, resistance 73, contacts 24, wires 25, 26 and 32, contacts 33, wire 38, relay RR, wire 39, to common return wire C.

Let us now assume that the train with its car-carried apparatus in its normal condition passes by an active trackway inductor at a time when the engineer is vigilant and manifests his wakefulness by operating the acknowledging push button Ack. With the acknowledging push button Ack depressed,

potential is applied to the winding of the stick brake control relay BR and its stick contact 24 through the whistle valve WV, so that this brake control relay BR remains energized regardless of the de-energization of the control relay CR and the repeater relay RR. This partial circuit for the brake control relay BR includes wire 56, winding of the whistle valve WV, wire 57, back contact 58 of the acknowledging push button Ack, wires 59 and 23. It should however be noted that during acknowledgement (Ack depressed) and with relay RR also energized practically no current will flow through winding of whistle valve WV, because it is shunted by the contact 21 of relay RR. In any event the small current that may flow is insufficient to operate and sound the whistle valve WV. As an influence is received by the secondary coil S upon passage of the car element L by the trackway inductor T, for reasons heretofore given, this control relay CR assumes its de-energized position and de-energizes the repeater relay RR. With the repeater relay RR in its de-energized position the brake control relay BR has its current fed through the whistle valve WV, so that an audible signal is given so long as the repeater relay RR is de-energized, the current flowing through the whistle valve WV however, being sufficient to maintain the brake control relay BR and in turn the device EPV energized. With the repeater relay RR in its de-energized position a pick-up circuit for the control relay CR is completed which may be traced as follows:—beginning at the terminal B of a suitable battery, wire 56, whistle valve WV, wire 57, back contact 58 of the acknowledging push button Ack, wires 59 and 23, front contact 24 of the brake control relay BR, wires 25 and 60, back contacts 61 of the repeater relay RR, wire 62, back contact 63 of the acknowledging push button Ack, wires 64 and 35, secondary coil S, wires 36 and 37, winding of the control relay CR, wires 31 and 29, ballast lamp BL, wire 30, primary coil P, back to the common return wire C. With the control relay CR again picked up the repeater relay RR is picked up thereby closing a shunt around the whistle valve WV, so that, the whistle is no longer sounded, and the stick circuit for the brake control relay BR is again completed and the engineer may release the acknowledging push button Ack, it being of course assumed that the trackway device has been passed over by this time. It is of course understood that the control relay would not have assumed its energized position upon completion of its pick up circuit had there still been an appreciable voltage induced in the secondary coil S due to an increase of flux, but that it will pick up when the trackway device has been passed over. It should be noted that the

front contact 43 of the acknowledging push button Ack is not under ordinary operating conditions allowed sufficient time to open and de-energize the valve EPV, the dash pot 46 being constructed to allow sufficient time for the engineer to manifest his vigilance, but so as not to permit the engineer to maliciously fasten down the acknowledging push button Ack and thereby defeat the purpose of the train control system. In this connection, it should also be noted that the reset push button PB is protected against misuse by the front contact 41, that is, this contact 41 de-energizes the EPV so long as the push button PB is depressed; this is, however, not harmful because the push button PB is only required to be operated while the train is standing still and if the device EPV is de-energized at this time no particular harm is done.

We have thus far in connection with the operation of the system considered the train passing an active inductor when no acknowledgment is made by the engineer, resulting in an automatic brake application, and have considered passing an inductor when such acknowledgment is made which results in an audible signal and no automatic brake application. The audible signal given in this way serves two important functions. In the first place the momentary sounding of the whistle informs the engineer that he has passed the active control point, and that he may now release the acknowledging push button Ack and thereby avoid an application by the eventual opening of the slow releasing contact 43 of this acknowledging device. In the second place, the sounding of the warning whistle informs the engineer that his train control apparatus works properly so that he may report accordingly at the end of his run.

Let us now consider what takes place when the car-carried apparatus passes an inactive inductor, that is, an inductor having its coil closed in a circuit of low resistance. As the car element L passes upon a trackway inductor having its coil in a closed circuit of low resistance no rapid increase of flux through the secondary coil S takes place. This, it is believed, is due to the bucking action of the coil 12, that is, a slight increase of flux through the track element or inductor T causes an appreciable current to be set up in the closed circuited coil 12 which current is in a direction to oppose the flux producing it. This slight increase of flux through the track element T allows a similar increase of flux through the secondary coil S, but this slight increase of flux through the secondary coil S is insufficient to induce the necessary voltage to de-energize the control relay CR. As the car element recedes from the track element T the flux passing through the secondary coil S again decreases without any mate-

rial effect on the car-carried apparatus, so that the passage of the car-carried apparatus by an inactive track-way inductor produces no effect on the control relay CR and therefore does not transmit a control influence. 70

It will be noted that a limited amount of current can flow, at least for a time, through the relay BR, the primary coil P and the device EPV even if contacts 21 are open, this slight amount of current being derived from the terminal B of the battery through the discharge resistance 73 and the front contact 24 of the relay BR. This resistance is employed to prevent excessive arcing at the contacts 21 when the relay RR is de-energized and does not allow the flow of sufficient current to maintain the relay BR up, so that the dropping of its contact 24 completely de-energizes the device EPV. In other words, the current for energizing the primary coil P and the device EPV is cut off in two steps, so to speak, that is, is first reduced and then entirely cut off through the medium of contacts 21 and 24 and discharge resistance 73.

Let us now consider how the margins of operation of the present system have been improved over previous systems of the same general type by the addition of the ballast or regulating lamp BL. In previous systems it was necessary to keep the current in the control relay at a higher margin above drop away, or it was necessary to keep the current in the primary winding lower than is now necessary, this, in order to avoid the transmission of a control influence in passing over an inactive or closed circuited inductor under conditions when the current in the control relay is a trifle low, either because of an increase in the resistance of the circuit or because of a decrease of the voltage of the source of supply for energizing this circuit. That is, in the present system by reason of the provision of the ballast lamp, which maintains substantially a constant flow of current in the primary coil P, the relays CR, RR and BR regardless of ordinary changes in temperature and battery voltages function properly and always the same, and by the addition of this ballast resistance it has been possible to adjust the various currents so near their critical value that the system functions when the car-carried apparatus passes by an active open circuited inductor at extremely low speeds. Successful operation of the present system under most adverse conditions and changes of battery voltages and outside temperature has been obtained at all speeds between about one-half mile per hour and the highest speed obtainable by a locomotive, whereas in previous systems it was necessary to adjust the currents in the various car-carried circuits to a value making the apparatus less sensitive so as to avoid false operation under adverse conditions of voltages and circuit resistances, and by such adjustment it 130

was possible to transmit control influences only between train speeds of about 3 miles per hour and said highest speed.

The ballast lamp BL thus affords a peculiar function in a system of the kind described. Systems of this general character have previously been used without this current regulating device or ballast lamp BL and in those systems operation could not be obtained below three miles per hour. This was true because the car-carried apparatus could not be adjusted extremely sensitively because if this were done it would respond when passing over a clear inductor at a time possibly when the battery voltage on the car was above the average or possibly because extremely cold weather existed and the resistance of the circuits were below the average value. By the employment of the ballast lamp BL it has been made possible to adjust the various constants of the car-carried apparatus so that operation has been obtained from speeds of $\frac{1}{2}$ mile per hour up to said highest speed under all conditions of ordinary changes in battery potential, changes of temperature, contact resistances and the like. In other words, the provision of the ballast lamp BL has enabled the inherently changeable factors of the system to be made practically constant so that the operating margin of the system has been materially increased, that is, the minimum speed at which control influences could ordinarily be transmitted has been reduced.

Structure (Fig. 4).—In Fig. 4 has been shown a modified form of the present invention in which a ballast lamp BL is used in series with the circuit including the primary coil P, but wherein the primary coil P is not deenergized each time that an automatic brake application occurs. In the arrangement shown, a check relay CkR is employed instead of the brake control relay BR which is contained in a somewhat different circuit arrangement so that this check relay CkR is not automatically controlled at all, but merely serves to check the presence of a predetermined amount of current flow in the primary coil P. In this circuit arrangement the circuit for energizing the primary coil P may be traced as follows:—beginning at the terminal B of a battery, wires 80 and 81, winding of the check relay CkR, wires 82 and 83, ballast lamp BL, wire 84, primary coil P, wire 85 back to common return wire C connected to the other terminal of such battery. With a flow of current in the circuit just traced, a potential drop exists across the check relay CkR which potential is used for energizing the control relay CR connected in series with the secondary coil S in a circuit very similar to that for energizing the control relay CR in Fig. 2. This circuit may be traced as follows:—beginning at the terminal B, wire 80 also connected to one

terminal of the check relay CkR, wire 86, front contact 87 of the check relay CkR, wire 88, front contact 21 of the repeater relay RR, wires 89 and 90, front contact 33 of the control relay CR, wires 91 and 92, secondary coil S, wire 93, winding of the control relay CR, wire 94 leading to the other terminal of the check relay CkR. The repeater relay RR is energized through the following circuit:—beginning at the terminal B, wires 80 and 86, front contact 87 of the check relay CkR, wire 88, front contact 21 of the repeater relay RR, wires 89 and 90, front contact 33 of the control relay CR, wires 95 and 96, winding of the repeater relay RR, wire 97 to the common return wire C.

With the repeater relay RR energized an energizing circuit for the device EPV is closed which may be traced as follows:—beginning at the terminal B of a suitable source of energy, wire 98, front contacts 61 of the repeater relay RR, wire 99, normally closed contact 41 of the reset push button PB, wire 100, normally closed slow released contact 43 of the acknowledging device Ack, wire 101, winding of the device EPV, wire 102 to a common return wire C connected to the other terminal of such source.

Operation (Fig. 4).—In considering the operation of the system shown in Fig. 4, let us first consider a train equipped with the car-carried apparatus shown in this figure assuming it to be in its normal condition as illustrated and passing by a trackway device which is in its active stopping condition, that is, having its coil 12 open-circuited. As the train passes by this trackway inductor T a potential is induced in the secondary coil S of the car element L which is in a direction to oppose a potential drop due to the current flowing in the winding of the check relay CkR and is of a magnitude sufficient to deenergize the control relay CR for reasons given in connection with the system shown in Fig. 2. With the control relay CR once dropped its energizing circuit is broken by reason of opening of its stick contact 33, whereby the repeater relay RR is also deenergized. With the repeater relay RR in its de-energized position, the stick circuit for the control relay CR is broken at another point, so that, even if the engineer depresses the acknowledging button Ack he can not again pick up the control relay CR. This means that acknowledgement, as more clearly pointed out hereinafter, must take place during the reception of a control influence, that is, must anticipate and precede and not follow the reception of such influence. Also, with the repeater relay RR in its retracted position, the energizing circuit for the device EPV is broken at front contacts 61 of this repeater relay RR, whereby the train is brought to a stop in a manner as already explained in connection with the embodiment

of the invention shown in Fig. 2 of the drawings. It should, however, be noted that the primary coil P has not been de-energized; this coil P still receives energy through the winding of the check relay CkR. In other words, the device EPV has been automatically operated without breaking the heavy energizing current for the primary coil P, so that, the current actually interrupted by the repeater relay RR is only that required for energizing the device EPV and the discharge resistance 73 is not required.

On the other hand, the integrity of the circuit including the primary coil P is checked by the check relay CkR, so that, interruption of this circuit or depreciation of the source of energy for energizing it is automatically detected by dropping of this relay; further, weakening of the field of flux produced by the primary coil P which would tend to weaken the impulse transmitted to the control relay CR is compensated for by a corresponding reduction of the potential applied to this control relay, this because the potential impressed upon the control relay CR is directly proportional to the amount of current flowing in the primary coil P, so that a correspondingly weaker impulse is necessary to de-energize the control relay CR when the current for energizing the primary coil is reduced.

After the train has been brought to a stop by reason of the automatic brake application for reasons just given, the train may again proceed if the engineer alights to the ground and depresses the reset push button PB, which is mounted in a casing as indicated by the dotted rectangle and is only accessible from the ground. Depression of this push button PB closes a pick-up circuit for the control relay CR including the potential drop due to the current flowing in the winding of the check relay CkR, which may be traced as follows:—beginning at the wire 86 connected to one side of the check relay CkR, front contact 87 of this check relay CkR, wire 103, normally open contact 51 of the push button PB, wires 104, 105 and 92, secondary coil S, wire 93, winding of the control relay CR, wire 94, to the other terminal of the check relay CR. Completion of this pick-up circuit causes the control relay CR to assume its energized position and again complete its normally closed stick circuit, because the potential impressed across relay CkR is also impressed across the circuit portion including the coil S and the relay CR in series. As soon as this occurs and the engineer continues to depress the push button PB an energizing circuit for picking up the repeater relay RR is closed which is the same as the pick-up circuit for the control relay CR just traced up to wire 105 from whence it comprises wire 91, front contact 33 of the control relay CR, wires 95 and 96, winding of the repeater relay RR, wire 97 to

common return wire C. With the repeater relay RR, again picked up and stuck up through its stick contact 21 the energizing circuit for the device EPV heretofore traced is again closed, whereupon the brakes may be released by the engineer and the train may again proceed until it is restricted at another control point. It should be noted that while the push button PB is depressed to pick up the control relay CR, and in turn the repeater relay RR, the energizing circuit for the device EPV is broken at another point, namely at the normally closed contact 41 of the push button PB. This breaking of the circuit for the device EPV is provided for, so that, the engineer can not permanently tie down or otherwise fasten the push button PB in its active position, and thereby defeat the purpose of the train control system by providing a continuously effective reset. In other words, the push button PB must be returned to normal before the device EPV is again energized and the brakes can be released.

Let us now assume that the train in question with its car-carried devices in their normal condition passes by an active track element T, and that the engineer is vigilant and manifests such vigilance by depressing the acknowledging push button Ack. With the acknowledging push button Ack depressed, two shunting contacts 58 and 63 are closed. The contact 58 through a partial circuit readily traced in the drawing shunts the right-hand side of front contact 33 of the control relay CR for preventing the repeater relay RR dropping in response to momentary dropping of the control relay CR, and the contact 63 through a partial circuit readily traced shunts the lefthand portion of contact 33 of the control relay CR, so that this control relay CR is connected non-stick so long as the acknowledging push button Ack is depressed. If now the car element L passes over the track element T in its active condition while the acknowledging push button Ack is depressed by the engineer the control relay CR is momentarily de-energized. This momentary de-energization of the control relay has no effect upon the repeater relay RR, because this repeater relay RR is held up by the acknowledging push button Ack, by the depression of which the engineer has avoided an automatic brake application. In this connection, it should be noted that the time during which an acknowledgment may be made must be limited by reason of opening of normally closed slow releasing contacts 43 of the acknowledging push button Ack for reasons given in connection with Fig. 2.

The functioning of the car-carried apparatus in the modification shown in Fig. 4 when passing over an inactive closed circuited trackway inductor is the same as that of the system heretofore described, that is, insufficient voltage is induced in the secondary coil

S to effect the control relay CR and therefore no operation results for reasons already mentioned.

Structure and operation (Fig. 5).—In certain classes of railway trains it is considered expedient in intermittent train control systems of the type shown in Fig. 2 to require both the engineer and the fireman to acknowledge the fact that they are passing an active trackway device, this, to guard against the possibility that the engineer might fall dead or become incapacitated after having made an acknowledgement in which event the train might be wrecked. In the present system it would be the duty of the fireman to take charge of the train, the fireman, of course, now being aware of having passed an active trackway device because he has acknowledged such passage. In other words, it would be impossible for the engineer to enter caution or danger territory without the cooperation and the aid of the fireman, because only one of two acknowledging devices are operable at one time by the same man.

As heretofore mentioned, it is necessary for the engineer or fireman to alight from the train each time that an automatic brake application occurs in order to again release the brakes after coming to a stop. This reset push button PB is preferably located along the side of the tender or beneath the same and is accessible only by a man walking along the side of the train. In practice, it has been experienced that at certain places, and especially on high trestles and bridges, it is possible to alight from one side of the engine only, and in accordance with the present invention it is proposed to provide a reset push button on each side of the tender so that if it is only possible to alight from one side of the train, a reset push button is still accessible.

The car-carried apparatus shown in Fig. 5 is intended to provide this feature and is identical to that shown in Fig. 2 except that two acknowledging buttons Ack and Ack^a are used instead of one as shown in Fig. 2. It should be noted that the two acknowledging push buttons shown have all of their normally open corresponding contacts connected in series, this being done so that both of these acknowledging push buttons must be depressed before such acknowledgement is effective; whereas in the case of the push buttons PB the normally open corresponding contacts are connected in multiple so that the operation of either of these push buttons produces the desired effect. Further, it should be noted that the normally closed contacts of both the acknowledging and reset push buttons are connected in series so that all of these devices are protected against misuse as more clearly heretofore set forth.

The arrangement shown in Fig. 5 thus requires the cooperation of the engineer and fireman before an active control point may be

passed without the imposition of an automatic brake application, so that, the engineer can not enter dangerous territory without the consent and knowledge of the fireman, which in turn will cause the fireman to observe whether the engineer is properly controlling the train and whether he is capable of so controlling it. Also, in this embodiment of the invention, a properly protected reset device has been provided to be accessible by alighting from either side of the engine, this in order to permit a reset device to be operated regardless of the direction of movement of the train over bridges, viaducts, and the like even though such bridges and viaducts have provision for walking along one side of the train only.

Having thus shown and described several specific embodiments of the invention, and having described them rather specifically, it is desired to be understood that this has been done for the purpose of disclosing the invention rather than illustrating its scope or the exact circuit arrangements preferably employed in practice, and that various changes and modifications may be made to adapt the invention to the various systems encountered in practice without departing from the spirit of the invention or the idea of means underlying the same.

What I claim is:—

1. In an automatic train control system; the combination of an electro-responsive device which if in its retracted position restricts the movement of the train; a source of energy; a ballast lamp; a circuit including said device, said source and said lamp in series; and an inductive influence communicating means located in inductive relation with the trackway for changing the flow of current in said circuit.

2. A train control system comprising, an inductive influence communicating device for communicating influences from the trackway to the vehicle inductively, a source of current, a circuit including said device and said source in series, and means included in said circuit for compensating for changes of flow of current in said circuit due to changes in the potential of said source or changes in temperature.

3. Car-carried apparatus for automatic train control systems comprising; an electro-responsive device which if de-energized restricts the movement of the train, a source of energy; a ballast device; and a circuit including said electro-responsive device, said source and said ballast device in series; said ballast device being constructed to compensate by changing the voltage impressed upon said electro-responsive device for changes in the flow of current in said circuit due to changes in temperature and battery voltage.

4. Car-carried apparatus for automatic train control systems comprising, an in-

fluence receiving car element consisting of an inverted U-shaped core of magnetic material having a primary flux producing coil on one leg and a secondary influence receiving coil on the other leg, and a circuit for energizing said primary coil including a source of energy and a self-adjusting current regulating device in series.

5. Car-carried apparatus for automatic train control systems comprising, an influence receiving car element consisting of an inverted U-shaped core of magnetic material having a primary flux producing coil on one leg and a secondary influence receiving coil on the other leg, a control relay, an electro-responsive device, an automatic current regulating device, and a circuit including in series said primary coil, a source of current and said current regulating device, said electro-responsive device having connected in multiple therewith said control relay and said secondary coil connected in series, whereby said regulating device directly regulates the flow of current in said primary coil and in said control relay, and a change in the flow of current in said primary coil changes the potential applied to said control relay.

6. An automatic train control system comprising; an inductive influence communicating device; a source of current; a self-adjusting current regulating device; and a circuit including said influence communicating device, said regulating device and said source of current in series; said regulating device consisting of a resistance unit having a high temperature co-efficient of resistance housed so that heat is not readily radiated therefrom.

7. In an automatic train control system, the combination of a train retarding device, an electro-responsive means, a circuit for energizing said retarding device including a front contact of said electro-responsive means, a circuit for energizing said electro-responsive means including a front contact of said retarding device, and a ballast lamp in a circuit portion common to both of said circuits.

8. Car-carried apparatus for automatic train control systems comprising, a control relay, a repeater relay, a train retarding device, a push button, a circuit for energizing said train retarding device including a front contact of said repeater relay, a stick circuit for energizing said control relay including a front contact of said train retarding device, a circuit for energizing said repeater relay including a front contact of said control relay, and a pick up circuit for said control relay including a back contact of said repeater relay and a normally open contact of said push button, and means for independently energizing said train retarding device when said push button is depressed.

9. Car-carried apparatus for automatic train control systems comprising, a control relay, a repeater relay, a train retarding device, a circuit for energizing said train retarding device including a front contact of said repeater relay, a stick circuit for energizing said control relay including a front contact of said train retarding device, a circuit for energizing said repeater relay including a front contact of said control relay, and means which if depressed independently energizes said train retarding device and closes a pick up circuit for said control relay while said repeater relay is in its de-energized position.

10. Car-carried apparatus for automatic train control systems comprising, a control relay, a repeater relay, a train retarding device, a circuit for energizing said train retarding device including a front contact of said repeater relay, a stick circuit for energizing said control relay including a front contact of said train retarding device, a circuit for energizing said repeater relay including a front contact of said control relay, and means effective if depressed for independently energizing said train retarding device through a circuit including an audible signal and for completing a pick up circuit for said control relay while said repeater relay is de-energized.

11. Car-carried apparatus for automatic train control systems comprising, an electro-pneumatic valve which if de-energized effects venting of the brake pipe of the usual air brake system, inductive influence communicating means consisting of a secondary coil and a primary coil energized by a circuit having an external resistance therein, a control relay, a repeater relay, a circuit for energizing said repeater relay including a source of energy and front contacts of said control relay and said repeater relay connected in series, a circuit for energizing said control relay including said secondary coil and the front contacts of said control relay and said repeater relay in series and bridged across said resistance, a circuit controlled by said repeater relay for energizing said electro-pneumatic valve, and manually operable means for bridging the front contacts of said control relay and said repeater relay.

12. Car-carried apparatus for automatic train control systems comprising, an influence receiving car element consisting of an inverted U-shaped core of magnetic material having a primary flux producing coil on one leg and a secondary influence receiving coil on the other leg, a circuit for energizing said primary coil including a source of energy and a self-adjusting current regulating device in series, and means effective to apply the brakes of the train if said circuit is broken.

13. In an automatic train control system, the combination with a normally energized

electrically operable brake control mechanism of the type which if momentarily de-energized will remain de-energized until restored by some other means, and manually operable devices accessible only from the ground for restoring said brake control mechanism, said manually operated devices each alone being capable of restoring said mechanism and being located on opposite sides of the train so that the engineer may alight at the side of the train at which a manually operable device is most readily accessible to restore said mechanism to normal.

14. In an automatic train control system, the combination of a normally energized electrically operable means for applying the brakes of the type which if momentarily de-energized will remain de-energized until restored by some other means and having a pick-up and a stick circuit, and two manually operable reset devices located on opposite sides of the train and located so as to be accessible only by a man standing on the ground each comprising, a normally open contact which if closed completes a pick-up circuit for said brake applying means and having a normally closed contact which if broken effects an automatic brake application.

15. Car-carried apparatus for automatic train control systems comprising, an influence receiving car element consisting of an inverted U-shaped core of magnetic material having a primary flux producing coil on one leg and a secondary influence receiving coil on the other leg, a circuit for energizing said primary coil including a source of energy, an electro-responsive device and a self-adjusting current regulating device in series, and a circuit for energizing said secondary influence receiving coil in which the current is derived from the voltage drop over said electro-responsive device.

16. Car-carried apparatus for automatic

train control systems of the intermittent inductive type; the combination with an inductive influence communicating means including an influence receiving coil; a normally energized control stick relay, repeater stick relay and train retarding stick relay; an energizing circuit for said influence receiving coil including the winding of said control relay in series therewith and including contacts of said control relay, contacts of a repeater relay and contacts of said train retarding relay in series all of which contacts are closed when said respective relays are energized; an energizing stick circuit for said repeater including normally closed contacts of said control relay and normally closed contacts of said train retarding relay, and an energizing circuit for said train retarding relay including its own normally closed contact and a normally closed contact of said repeater relay.

17. A train control system comprising, an inductive influence communicating device for communicating influence from the trackway to the vehicle inductively, and including a primary flux producing and a secondary influence receiving coil; a unit of comparatively low electrical resistance connected in series with said flux producing coil; a control relay having a front stick contact connected in series with its winding; a source of current; a circuit for energizing said flux producing coil including, said unit, said source of current and means for compensating for flow of current in said circuit due to changes in the potential of said source; and a circuit for energizing said control relay including in series said receiving coil, said unit, said control relay and its front contact all in series and receiving its energy from the potential drop across said low resistance unit.

In testimony whereof I affix my signature.

CHARLES S. BUSHNELL.