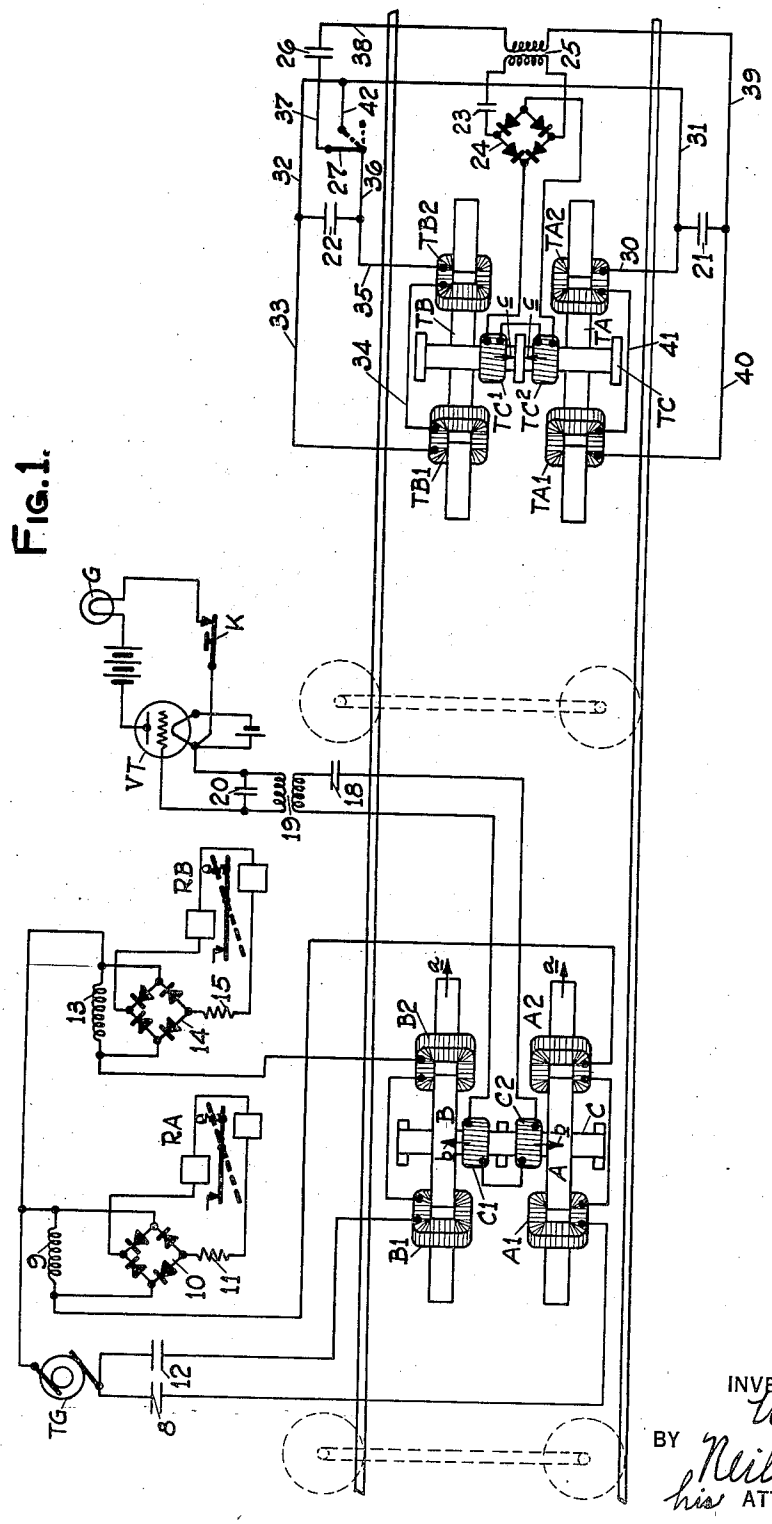
Feb. 22, 1938. W. H. REICHARD 2,109,154

INTERMITTENT INDUCTIVE TRAIN CONTROL SYSTEM

Filed March 23, 1936 5 Sheets-Sheet 1

FIG. 1.



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INTERMITTENT INDUCTIVE TRAIN CONTROL SYSTEM

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FIG. 2.

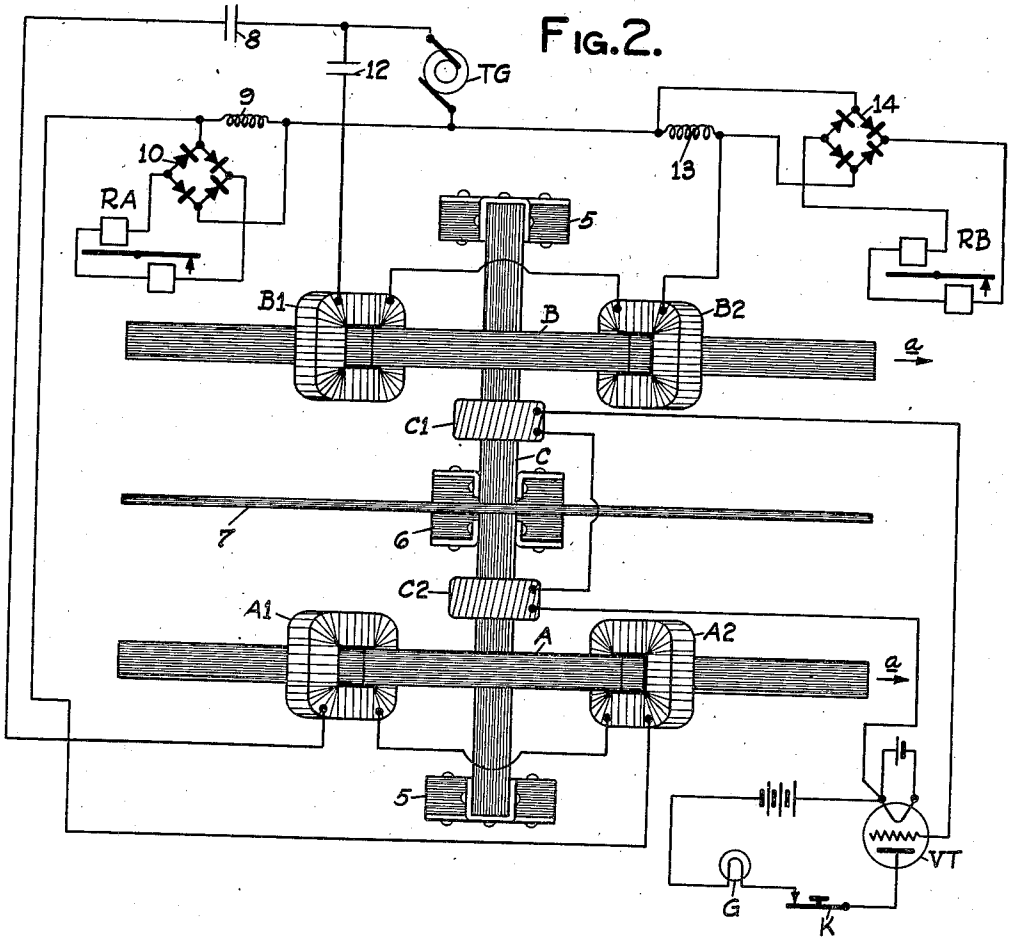
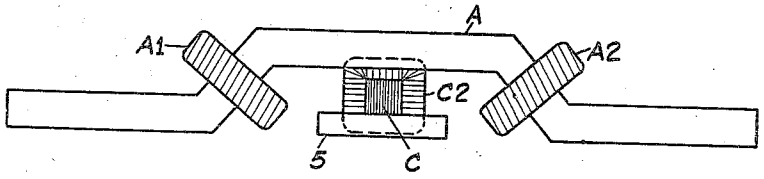


FIG. 3.



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INTERMITTENT INDUCTIVE TRAIN CONTROL SYSTEM

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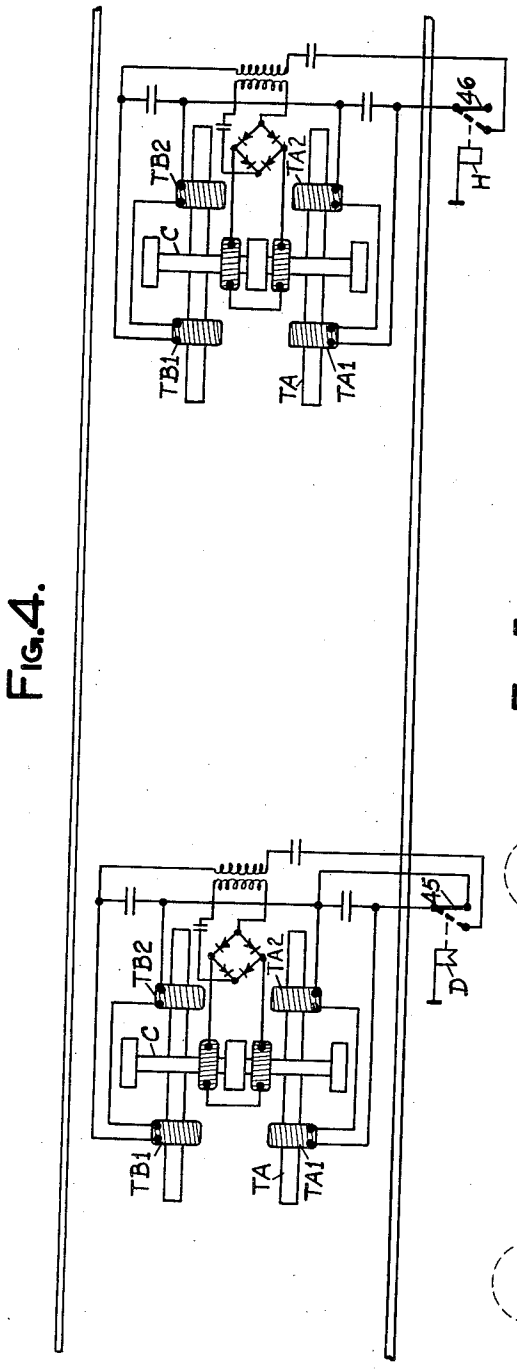


FIG. 4.

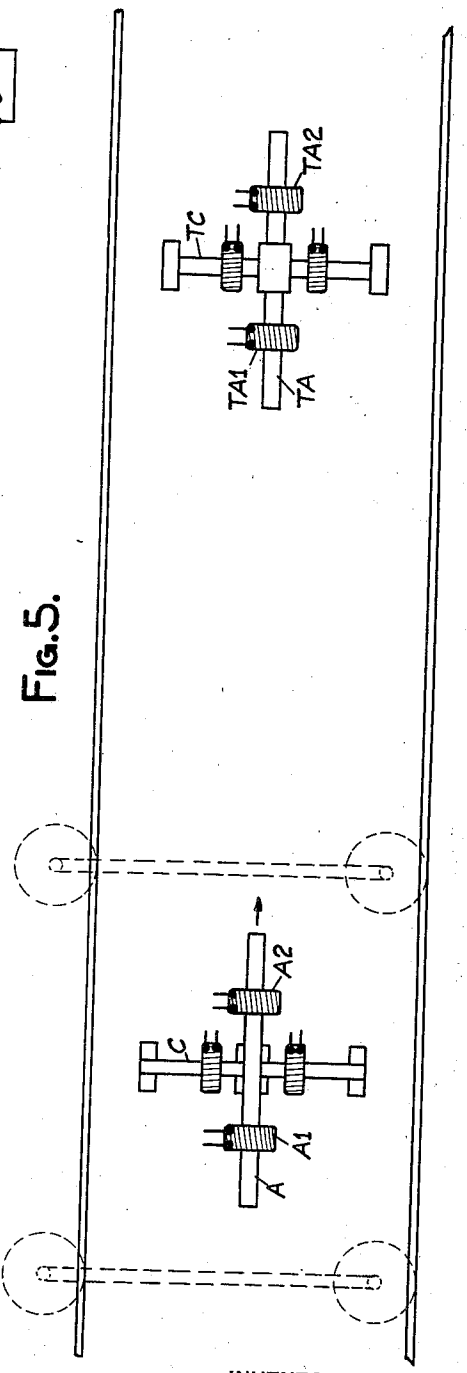


FIG. 5.

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INTERMITTENT INDUCTIVE TRAIN CONTROL SYSTEM

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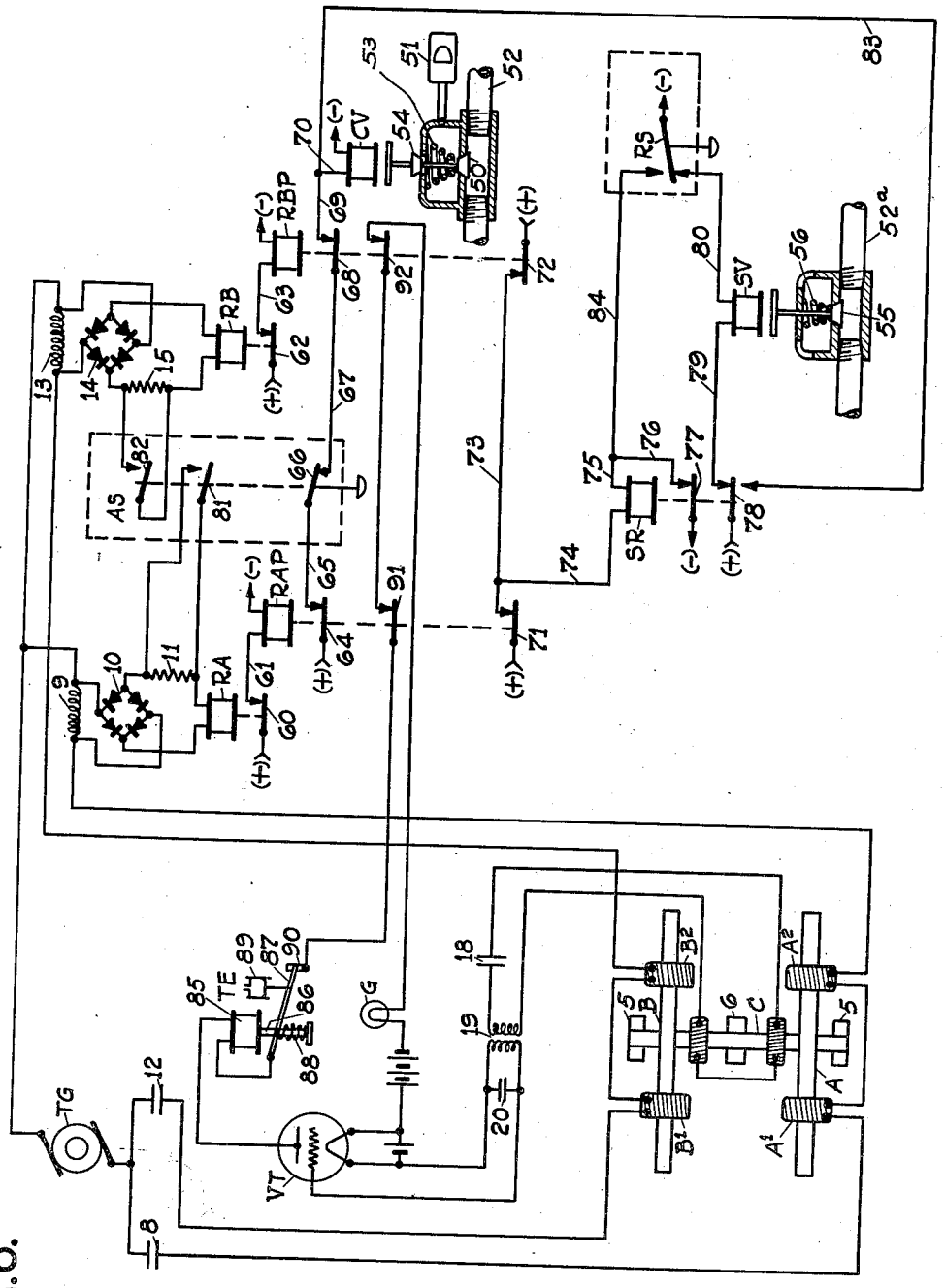


FIG. 6.

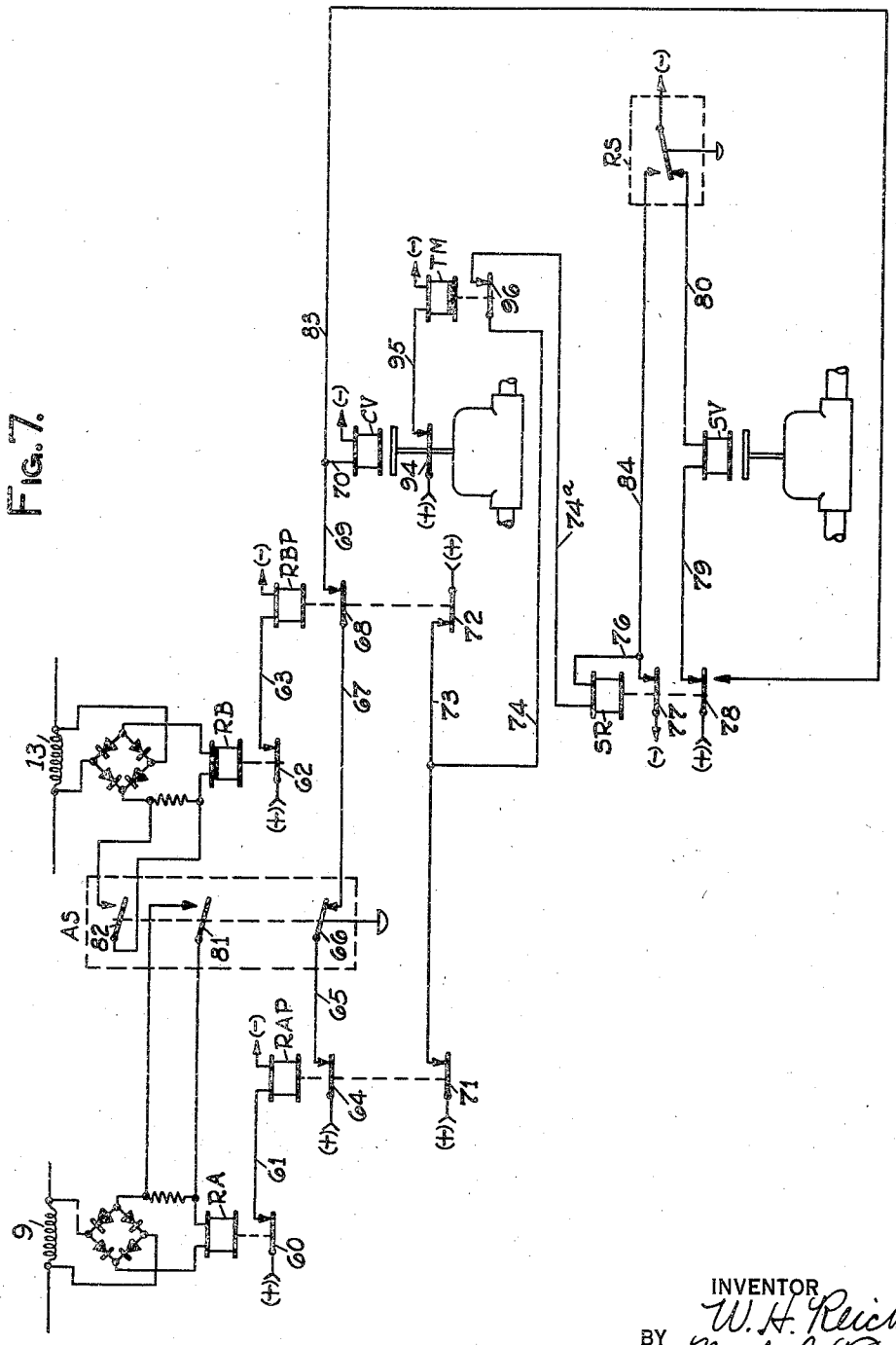
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Fig. 7.



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2,109,154

UNITED STATES PATENT OFFICE

2,109,154

INTERMITTENT INDUCTIVE TRAIN CONTROL SYSTEM

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Application March 23, 1936, Serial No. 70,259

28 Claims. (Cl. 246—63)

This invention relates to automatic train control systems for railroads, and more particularly to an intermittent inductive system of the inert track element type which provides a distinctive indication of clear, in addition to a caution and stop control.

The general underlying purpose or object of this invention is to obtain, in a safe and efficient manner, a distinctive indication of clear, as well as restrictive indications or controls of caution or stop, or neither, at the same or different track locations, by the intermittent inductive co-operation of a receiver carried on a railway vehicle and inductors located on the track, which comprise simple magnetic cores and coils energized only from a source of alternating current on the vehicle, and which provide an organization in which the receiver on the vehicle will not be adversely influenced by extraneous magnetic fields or masses of iron along the track, and in which transmission of the indications or controls is effective, without changing circuit connections or the like, for movement of the vehicle in either direction past the inductor location, or with either end of the vehicle ahead.

Generally stated, and without attempting to define the exact nature and scope of the invention, the receiver on the vehicle comprises a laminated magnetic core, having coils thereon in a resonant circuit energized from a source of alternating current on a vehicle of a relatively high frequency, together with a suitable quick-acting electro-responsive means responsive to the intensity of current in this circuit. The track inductor comprises a similar laminated magnetic core with which the receiver core is magnetically coupled as the vehicle passes the inductor location; and the track inductor core is provided with coils and circuits to control its effect upon the receiver, such that the electro-responsive means may be effectively de-energized or maintained energized to provide for the transmission of a restrictive indication or control when desired, in accordance with traffic conditions, or the indications of an associated wayside signal. In the preferred form of the invention, two such cores in the receiver and in the track inductor are employed to act independently to transmit distinctive indications or controls of caution and stop at the same or different inductor locations. The receiver also comprises an additional laminated magnetic core, disposed so as to have the minimum of magnetic coupling with the other receiver core or cores, and having coils thereon connected to a suitable quick-acting electro-responsive means to register an indication of clear; and the track inductor comprises a similar additional laminated core with coils thereon so disposed as to be magnetically coupled with the additional core of the receiver as the vehicle passes an inductor location. Under clear conditions, when a circuit on the trackway is closed, energy is transferred from the receiver to the track inductor through the same core or cores and coils producing the caution or stop control; and this energy is then reflected back from the additional core and coils of the inductor to the additional core and coils of the receiver, such reflected energization actuating the clear electro-responsive means.

Various other characteristic features, attributes and advantages of the organization of parts and circuits constituting the invention will be in part apparent, and in part pointed out, as the description progresses.

In the accompanying drawings, which illustrate certain specific embodiments of the invention which are, of course, susceptible of variation and modification in accordance with the results desired, Fig. 1 is a diagrammatic representation of the parts and circuits constituting the vehicle equipment and trackway equipment, these parts and circuits being shown in the manner to facilitate an understanding of the invention, rather than to show the particular construction and arrangement of parts preferably employed in practice; Figs. 2 and 3 are plan and side views respectively of the preferred construction of the car-carried receiver; Fig. 4 illustrates one particular arrangement of track inductors and their control circuits for home and distant signals; Fig. 5 illustrates a modification of the receiver and inductor; and Figs. 6 and 7 illustrate two different specific arrangements of parts and circuits for utilizing the caution and stop controls for safeguarding train operations.

Referring to Figs. 1, 2 and 3, the inductive device carried on the locomotive or car, and conveniently termed a receiver in the particular organization shown comprises two spaced magnetic cores A and B, laminated in accordance with the usual practice, and disposed parallel to the trackway. These cores A and B preferably have the general shape and proportions shown in Figs. 2 and 3. Each of these cores A and B has thereon two coils A1, A2, and B1, B2 of the usual construction. The receiver also comprises a transverse laminated magnetic core C, with two coils C1 and C2 thereon. This transverse core C is disposed at right angles to the cores A and B, so

as to have the minimum magnetic coupling with said cores A and B. Laminated pole pieces 5, extending parallel with the track and with their lower faces substantially in the same plane as the lower faces of the ends of cores A and B, are preferably attached in a suitable manner, as by clamps and bolts to the ends of this transverse core C. The transverse core C also is preferably provided with a middle pole piece 6, likewise extending longitudinally of the track parallel with the track A and B, and approximately twice the cross section of the end pole pieces 5. The receiver, as shown in Fig. 2, may also include a middle narrow longitudinal stabilizing core 7 of laminations, which is useful under certain conditions as a flux stabilizer, but may be omitted.

These cores A, B and C of the receiver are in practice rigidly supported and housed in a suitable non-magnetic casing (not shown), which is adjustably hung from a wheel truck or the body of the locomotive or car at a height to provide the desired clearance over the track rails at switch points and crossings and other bodies between the tracks, and at such a height as to provide a suitable working air-gap with the track inductor. In one typical arrangement, the receiver is supported with the lower faces of its cores approximately 5 inches above the level of the top of the track rails. The receiver is also preferably disposed symmetrically on the center line of the car, although it may be otherwise located on the car where space and clearance permit.

Referring to Figs. 1 and 2, the coils A1 and A2 of the longitudinal core A of the receiver are connected in series in a circuit including a condenser 8, an impedance 9, and a suitable source of alternating current, such as a steam turbo-generator TG, preferably of a relatively high frequency such as 360 cycles per second. The coils A1 and A2 are so wound and connected as to produce magnetic lines of force or flux through the core A in the same direction. The condenser 8 is adjusted or selected so that the circuit is substantially resonant at the normal frequency, when the receiver is not over the track inductor.

The terminals of the impedance 9 are connected to the input terminals of a suitable double wave rectifier 10, shown conventionally, and preferably of the metallic or copper-oxide type; and the output terminals of this rectifier 10 are connected to a direct current electro-responsive device in the form of a relay RA, preferably with a series resistance 11 for the purpose to be explained later.

The coils B1 and B2 of the other longitudinal core B of the receiver are connected in a similar manner in a resonant circuit including a condenser 12 and impedance 13, and the same source of current TG, and control the energization of the similar relay RB through a double-wave rectifier 14 and resistance 15.

The coils A1, A2 and the coils B1, B2 on the two longitudinal cores A and B are so wound and connected as to produce magnetic lines of force or flux in the same direction in the two cores A and B, as indicated by the arrows *a* for a given instant.

The relays RA and RB are each preferably a two coil structure with an armature pivoted at its center of mass, so as to be substantially immune to all jar and vibration, the biasing force to actuate the armature to its retracted position upon de-energization of its windings being provided by a suitable spring. Each relay RA and RB is preferably so constructed or adjusted that, upon movement of its armature to its retracted position, the normal energizing current will not be sufficient to attract the armature again. In other words, the relay has locking or stick characteristics when de-energized due to its inherent magnetic construction, this being considered preferable to an electrical stick relay, which may be used as desired, because it makes the operating characteristics of the relay more suitable for a quick response to a momentary change in its energizing current.

The coils C1, C2, on the transverse core C of the receiver are arranged to supply voltage to a normally de-energized and inactive quick-acting device for giving a clear indication. On account of the relatively small energy change occurring upon transmission of the clear indication, and the rapid response necessary at high speeds of train movement, this clear responsive device preferably comprises an electronic tube of the mercury vapor or gas filled type, which is rendered conductive, or fired so to speak, by an increase in its grid potential above a critical value, this tube also having the operating feature characteristic of its type that, once conductive or fired by an increase in grid potential, remains in that condition even after the grid potential is restored to normal, until the tube is restored to its non-conductive condition by interrupting its plate circuit or the like. Electronic tubes of the type contemplated are well known in the art; and one form well adapted for use in this invention is commonly known as a positive grid controlled "Thyraton".

In the preferred arrangement shown in Fig. 1, the coils C1, C2 are connected in series with a condenser 18 to the primary of a small coupling transformer 19, this primary circuit being tuned for a frequency double the frequency of the turbo-generator TG. The secondary of the transformer 19, tuned by a condenser 20 for maximum terminal voltage at this double frequency is connected to the grid circuit of the tube VT. As shown, the heating element or filament of this tube is supplied with current from a battery; and the plate circuit of this tube is energized from another battery. If desired current derived from the turbo-generator TG through rectifiers, with such a transformer as necessary to change the voltage, may be employed instead of these batteries, a condenser across the rectifier being preferably employed to maintain an effective potential on the plate of the tube at all instants.

In the arrangement illustrated in Fig. 1 as typical of the invention, an electrical lamp G of the usual type is included in the plate circuit of the tube VT, so as to be lighted to display a proceed indication when the tube is fired. A suitable hand switch or key K is provided to open the plate circuit of the tube manually, and extinguish the lamp G, such manual manipulation being an act of recognition or acknowledgment of the clear indication. In this connection, a suitable time element device may be employed, as later described, to extinguish the lamp G automatically after a time interval.

The track inductor comprises the same general organization of longitudinal cores TA and TB, a transverse core TC, and coils TA1, TA2, coils TB1, TB2, and coils TC1 and TC2 as the receiver; and for convenience in manufacture the same laminations may be employed to construct the receiver and track inductor. The cores and coils of the track inductor are rigidly supported in a suitable housing of non-magnetic material, preferably with ramped ends to deflect

dragging equipment; and on electrified railroads employing a central contact rail, the inductor housing may be supported on insulators, and may be equipped with a wear resisting surface to cooperate with the contact shoe of the car or locomotive. These, and various other details of construction preferably employed in practice, have not been specifically illustrated.

The coils TA1 and TA2 on the longitudinal core TA of the track inductor are connected in series to a control circuit. In the preferred arrangement, these coils are connected to the terminal of a stop condenser 21. The coils TB1, TB2 on the other longitudinal core TB of the track inductor are similarly connected to a stop condenser 22. The coils TC1 and TC2 of the transverse core TC of the track inductor are connected in series to a circuit for transmitting the clear indication.

In the preferred arrangement for transmission of a clear indication, which involves use of a frequency double the frequency of the vehicle-carried source TG, these coils TC1 and TC2 are connected to the terminals of a double-wave rectifier 24, preferably of the metallic or copper-oxide type, the other terminals of which are connected in series with a condenser 23 to the secondary of a transformer 25. The primary of this transformer 25 is adapted to be connected in series with a clear condenser 26 to the coils TA1, TA2, TB1 and TB2, under the control of contacts for governing the character of indication to be transmitted, such that the coils TC1 and TC2 are energized under clear conditions, at double the frequency of the vehicle-carried source, by energy transmitted from the car to the track, in a manner to be explained more in detail later. In the simplified arrangement shown in Fig. 1, the contacts governing the condition of the track inductor are shown in the form of a movable switch arm 27, movable to any one of three different positions.

With this explanation of a general organization and arrangement of parts and circuits constituting the invention, consideration may now be given to the contemplated operation of the system.

Under normal conditions, while the vehicle is traveling between inductor locations, the parts and circuits on the vehicle are as shown in Fig. 1. The coils A1, A2, and B1, B2 are energized with alternating current in circuits tuned to resonance by the condensers 8 and 12, so that a maximum current flows through these coils.

The drop of potential across the impedances 9 and 13 supply voltage to the rectifiers 10 and 14, which in turn supply unidirectional current to energize the relays RA and RB.

Due to the transverse arrangement of the core C of the receiver, there is no direct magnetic coupling between this core and the longitudinal cores A and B. Also, the coils C1 and C2 are so wound with the same number of turns and connected in series on the core C that, if energized, they tend to produce fluxes in opposite directions as indicated by the arrows *b*. Thus, magnetic lines of force passing through these coils C1 and C2 in the same direction induce opposing voltages. Consequently, any leakage fluxes from the cores A and B tend to produce opposing voltages in the coils C1 and C2. The net result is that there is substantially no normal voltage in the coils C1 and C2.

In the preferred embodiment of the invention illustrated, the receiver core A, co-operating with the inductor core TA, acts to control the energization of the relay RA independently of the control of the relay RB by the co-operation of the other receiver core B and inductor core TB. As already noted, the magnetic flux produced in the longitudinal receiver cores A and B by their coils is in the same relative direction as indicated by the arrows *a* for a given instant; and the parts are so designed and proportioned that these fluxes are substantially equal. The transverse spacing of the longitudinal receiver cores A and B is made several times the normal working air-gap between the receiver cores and inductor cores, the spacing in one typical arrangement being about 11 inches for a working air gap of 3 inches. The magnetic independence between the longitudinal receiving cores A and B is further assured by the longitudinal stabilizing middle core 7 shown in Fig. 2. In short, the two pairs of longitudinal receiver and inductor cores comprise independently acting and duplicate indication or control transmitting instrumentalities; and since the operation of each of these duplicate units is the same, a discussion of one will suffice for both.

According to the contemplated operation, when the longitudinal core of the receiver comes over its co-operating track core TA, with the coils TA1 and TA2 thereon on open circuit, or connected to a stop condenser of proper capacity, the current normally flowing in the receiver coils A1, A2 is greatly reduced, and the relay RA is effectively de-energized to release its armature. There seems to be several electrical and magnetic phenomena involved in thus producing such reduction in the normal energizing current for the receiver coils A1 and A2, so that it is difficult to attribute the results obtained to any one simple action.

According to one theory of operation, the receiver circuit through the coils A1, A2 is substantially resonant under normal conditions when the receiver is not over the track inductor; but when the receiver core A is magnetically coupled to the inductor core TA, the resonant condition of the receiver circuit is destroyed, and losses are reflected into this circuit, so that there is a large change in the normal current. Among other things, the presence of the inductor core TA may be considered as changing the magnetic reluctance of the receiver core A, and hence the inductive reactance of the receiver coils A1 and A2, thereby disturbing the critical resonant condition of the receiver circuit and reducing the current therein. The presence of the inductor core TA also seems to have the effect of reflecting additional losses into the receiver circuit, likewise tending to reduce the current intensity in this circuit.

In this connection, it is apparent that the more sharply this receiver circuit is tuned, the greater will be the decrease in current for a given change in the inductive reactance in this circuit. The magnetic characteristics of the iron and thickness of the laminations of the receiver core, the efficiency of the tuning condenser, and the proportions of the coils on this core are chosen so that the receiver circuit as a whole has relatively small effective resistance losses and may be tuned sharply, with due regard to its stability for the small variations in the frequency of the turbo-generator that must be expected in practice.

It is found that this range of current change produced by the track inductor core TA is ma-

terially increased by connecting the coils TA1, TA2 on this inductor core to a stop condenser 21 of the proper capacity, apparently because the current which then circulates in the coils TA1, TA2, and the magnetic flux associated with such circulating current, has a reaction on the receiver core and coils, perhaps due to its time phase relation, which reduces the current in the receiver circuit more effectively than if the inductor coils are on open circuit. Accordingly, such a stop condenser 21 of the proper capacity, permanently connected across the inductor coils, is preferably employed so as to obtain a wider range of current change than the inductor core alone would give, even though the inductor core without such stop condenser connected to its coils causes a reduction in the normal energizing current of the relay amply sufficient to release its armature.

The proportions of the parts, the frequency employed, and other conditions of course modify in some degree the operation and the results obtained; and it should be understood that the foregoing is merely a theoretical explanation of the phenomena to which the results obtained in practice are attributed. As an indication of the effectiveness of the type of inductive control provided by this invention, it may be stated that, with a typical arrangement of parts and a frequency of about 360 cycles per second, a normal current in the order of two amperes may be reduced to substantially zero with an air-gap of about 3 inches between the receiver and inductor.

When it is desired to render the inductor core TA ineffective to cause such de-energization of the relay RA, the coils TA1, TA2 of the inductor are preferably short-circuited, although a similar non-effective condition of the inductor core may be obtained by connecting these coils to a condenser of suitable large capacity, or to a condenser and reactance in series. Under these conditions, when the core A of the receiver passes over the core TA of the inductor, the disturbance of the resonant condition and the reflection of energy losses is small, and there is only a small change in the normal current through the receiver coils A1, A2, something in the order of 10 per cent. The operating characteristics of the relay RA are readily chosen, so that this relatively small reduction of current is not sufficient to cause this relay to release its armature.

This non-effective condition of the inductor core, produced by short-circuiting the coils TA1, TA2 on this core, is attributed, among other things, to the choking effect of the circulating current in these coils, which tends to reduce the magnetic flux of the receiver core passing through the inductor core, and thus reducing its influence upon the receiver circuit. There may be other contributing factors to be considered in a precise theoretical analysis of the operation; but the general effect is that short-circuiting the coils TA1, TA2 on the track inductor core TA render it ineffective to cause de-energization of the relay RA.

Thus, in accordance with this invention, the relay RA is not deenergized effectively, during the passage of the receiver, if the coils TA1, TA2 on the inductor core are short-circuited; but if these coils are on open circuit or connected to a stop condenser 21, there is a great change in the normal energizing current for the relay RA, and it is effectively deenergized to release its armature. In short, by controlling the circuit connections of the coils of the track inductor, without using any source of current on the track, the relay RA on the vehicle may be maintained energized, or may be de-energized upon passing over the track inductor, thereby providing for the transmission of a restrictive indication or control under unfavorable traffic conditions, as may be required.

The same plan and theory of operation for relay RA applies to the relay RB; and either one, or both, or neither of distinctive restrictive indications may be produced on a railway vehicle at an inductor location. In one typical arrangement, considered more in detail later, it is contemplated that a caution condition is obtained when either one of the relays RA or RB is de-energized, and a stop control when both of these relays are simultaneously de-energized.

Considering now the operation of the system of transmitting an indication of clear, the inductor coils TA1, TA2 and TB1 and TB2 are connected together in series with the clear condenser 26 under clear conditions. Thus, if the switch 27 is in the clear position shown, a circuit for current to circulate through the coils TA1, TA2 and TB1 and TB2 in series may be traced from one terminal of coil TA2, wires 30, 31, 32, 33, coil TB1, wire 34, coil TB2, wires 35 and 36, switch 27 in clear position shown, wire 37, clear condenser 26, wire 38, primary of transformer 25, wires 39 and 40, coil TA1, wire 41, back to coil TA2.

In this connection, it should be understood that the coils TA1, TA2, and TB1, TB2 are so wound on the respective inductor cores TA and TB and so connected that the voltages induced in these coils by the alternating flux produced in said cores by induction from the cores A and B of the receiver, will be in the same direction or cumulative. In other words, when the receiver cores A and B come over the inductor cores TA and TB, the magnetic fluxes in the cores A and B in the same direction as indicated by arrows *a*, pass through the coils TA1, TA2, TB1 and TB2 and induce voltages therein, and these several coils of the inductor are so wound and connected that these voltages add together.

The current thus produced in the primary of the transformer 25 induces a voltage in the secondary which supplies current through a double wave rectifier 24 to the coils TC1 and TC2 on the transverse core TC of the track inductor, preferably with a series condenser 23 to obtain the maximum circulating current.

Since the voltages induced in the coils TA1, TA2, TB1 and TB2 are ordinarily relatively high in an organization of parts in accordance with this invention, the transformer 25 is used to reduce this voltage to fit the voltage limitations of the rectifier 24, assuming the use of rectifiers of the metallic or copper-oxide type. Due to this double-wave rectifier 24, voltage pulses in the same direction are applied to the coils TC1, TC2 at double the frequency of the voltages which are induced in the inductor coils from the receiver.

While the receiver is passing over the inductor, the transverse core C of the receiver is magnetically coupled with the transverse core TC of the inductor; and the current circulating in the inductor coils TC1, TC2 produces opposing fluxes in opposite directions as indicated by the arrows *c* for a given instant, which pass through the coils C1, C2 of the receiver in opposite directions, indicated by the arrows *b* for the same instant, and thereby induce therein cumulative voltages. The pole pieces 5 and 7 on the transverse cores C and TC of the receiver and in-

ductor aid in prolonging the duration of this transfer of energy.

The voltage thus induced in the receiver coils C1 and C2 produces a circulating current through the primary of the transformer 19, the condenser 18 being provided to make this circulating current a maximum at the double frequency; and the current in this primary in turn induces a voltage in the secondary, which is tuned for the double frequency by the condenser 20, so as to have the maximum terminal voltage. This terminal voltage is applied to the grid of the tube VT and makes this grid sufficiently positive with respect to its filament or heating element that the tube is rendered conductive, and current flows in the plate circuit to light the lamp G. This tube has a structural arrangement of elements, or is otherwise so designed, that it maintains this flow of plate current even after the voltage applied to the grid has ceased. The hand switch or push button K, located within convenient reach of the engineman or driver, is operated by him to open the plate circuit to extinguish the lamp G.

The clear indication provided by this invention is intended to convey information to the engineman or driver that he has passed a signal indicating clear, this being particularly useful in case of dense fog or other unfavorable weather conditions where the engineman may not be able to see the signal clearly. The purpose of the caution and stop control or indications is to inform the engineman that he has passed a caution or stop signal, and also to enforce such acknowledgment or automatic control of the brakes of the train as may be desired.

It is a fundamental principle in automatic train control that as far as practicable the apparatus and circuits should be so organized and arranged that a broken wire, failure of a source of energy, or the like, should be on the side of safety. In the case of restrictive indications or controls, such as caution or a stop, it is desirable to provide circuits and devices which are normally energized, and which are de-energized to produce the desired effect, so that any broken wire, failure of energy or contacts, or the like, will cause a condition on the side of safety, and will not show proceed condition which may not be true.

This principle, sometimes called the normally closed circuit principle, is carried out in this invention. Relays RA and RB are normally energized, and if the turbo-generator fails, or a wire breaks, the relay RA or RB is de-energized. Since the circuit for energizing each relay RA or RB is tuned to resonance, a break-down of the tuning condenser, or a short circuit of one or both of the coils on the receiver, will destroy the resonant condition of the circuit and cause de-energization of the relay.

Also, the desired restrictive indication is produced by the magnetic qualities of the inert cores of the track inductor; and no reliance is placed upon any supply of current on the trackway or continuity of a circuit, or a permanent condition of a magnet to produce the caution or stop control.

In this connection, it should be understood that the stop condenser, which is preferably employed for reasons already stated, is not relied upon to produce the caution or stop control; and if this circuit should be broken, the inherent magnetic qualities of the inductor cores cause a sufficient reduction in the normal energizing current for the relays RA or RB to assure retraction of their armatures for all ordinary operating conditions. The stop condenser gives an additional range of control which it is considered desirable to use.

The non-restrictive indication at an inductor location is produced by closing a circuit of low resistance around the inductor coils; and any break or contact failure in this circuit is a failure on the side of safety, since a restrictive indication is transmitted in the event of such failures.

In the case of a clear indication, however, it is desirable to utilize an organization of normally de-energized circuits and normally inactive devices, such that a broken wire, failure of energy, or the like, will not cause an improper clear indication, but rather prevent the transmission of such a clear indication. In other words, an indication of clear should not be obtained unless the circuits and all the parts are functioning properly. Thus, the tube VT is arranged to require the application of voltage to light the lamp; and the circuit through the coils C1 and C2 of the receiver is normally de-energized, and receives its energy at inductor locations only by inductive transfer of energy from the track. Such transfer of energy will occur only if the circuits on the track are functioning properly.

In this connection, the transformer 25, rectifier 24, and the electrical connections described, are employed to double the frequency; and the clear indication receiving circuit, including the transformer 19 and condensers 18 and 20, is tuned so as to be responsive only to such double frequency. This avoids the chance of an improper clear indication by transfer of energy from the car alone, and requires co-operation with track devices. This arrangement for employing double frequency for a clear indication is considered to be an important feature of the invention.

Also, the clear indication transmitting coils TC1, TC2 on the track inductor are so wound that they create opposing fluxes which at a given instant, when the receiver is passing over the track inductor, may be considered as projecting upward from the middle of the transverse track core TC into the middle of the receiver transverse core C, and then sidewise in opposite directions through the clear indication receiving coils C1, C2.

This particular direction of flux through the receiver coils C1, C2 is necessary to induce cumulative voltages. This arrangement makes the clear indication coils C1, C2 of the receiver immune to extraneous flux fields that might be encountered along the railroad track, since the lines of force from such extraneous fields would cut both coils in the same direction, and the voltages induced thereby would counter-act each other. Thus, the magnetic fields of power conductors or magnetized bodies along the track will not cause an improper indication of clear.

Since the restrictive indications are produced by magnetic qualities of the inert inductor cores, the receiver is susceptible in a degree to the influence of extraneous magnetic bodies along the track between the track rails, such as covers for signal or switch point operating apparatus, water pans, and the like. Such extraneous magnetic bodies are ordinarily at such a distance below the receiver, as compared with the inductor, that their influence on the receiver is not significant. Also, on account of the relatively high frequency employed, such extraneous iron masses along the track do not affect the receiver as much as the

laminated inductor cores; and even when acting through the same air-gap such as the inductor cores, such extraneous magnetic bodies fail to produce a sufficient reduction in the normal relay energizing current to release their armatures. This, of course, is a matter of degree; and in some instances it may be desirable to reduce further the effect of such extraneous magnetic bodies by employing a shield of a copper plate or the like, which due to the effect of eddy current losses renders such extraneous magnetic bodies substantially ineffective to influence the receiver.

From the foregoing explanation, it can be seen that a clear, caution, or stop control or indication may be transmitted at any inductor location by properly governing the control circuits for the inductor. If it is desired to provide for all of these controls or indications of clear, caution or stop at the same inductor location, the control circuits are organized and arranged to be controlled by contacting means, equivalent to the switch **27** as shown in Fig. 1. If this switch **27** is in the position shown, the coils on the longitudinal cores TA and TB of the inductor are connected to the coils on the transverse core TC, to provide for a clear indication. If the switch **27** is in its intermediate position, the coils **TB1**, **TB2** of the inductor core TB are short-circuited by the wires **33**, **32**, **42**, **36** and **35**, while the coils TA1 and TA2 are closed through the stop condenser **21**. Thus, the longitudinal core TB of the inductor is rendered ineffective to de-energize relay RB, while the inductor core TA is effective to de-energize relay RA. This corresponds to caution conditions. If the switch is in the lower open position, the coils on the longitudinal inductor cores TA and TB are both connected to their stop condensers **21** and **22**; and both relays RA and RB are de-energized, corresponding to a stop control.

It should be noted that the desired caution control, obtained by de-energization of one of the relays RA or RB, and the stop control, obtained by the simultaneous deenergization of both of these relays RA and RB, will be obtained when the locomotive or car is travelling in either direction over the track inductor, with either end leading, without any change in the circuit connections either on the car or on the track. In other words, the receiver and inductor are symmetrical; and no change or adjustment has to be made to provide for operation of the locomotive or motor car with either end leading, or for train movements in either direction.

Where it is desired to have a caution or a clear indication only at one inductor location, and a stop control or clear indication at another inductor location, such as for a typical home and distance arrangement of signals, the inductor control circuits are arranged as shown in Fig. 4. At the distant signal D, a circuit controller **45** operated directly by the signal, or an equivalent contact of a distant relay, acts under clear conditions to provide a circuit to connect the coils on the longitudinal inductor cores TA and TB with the coils on the transverse inductor core C; and if the distant signal indicates caution, this circuit controller establishes a short circuit for the pair of coils on one of the longitudinal cores, such as the coils TA1, TA2, while the coils on the other longitudinal coil are connected to the stop condenser, in a manner which will be apparent from the drawings. At the home signal location, a circuit controller **46** operated by the home signal, or by home relay, acts to connect the coils on both of the longitudinal inductor cores to the coils of the transverse core, when the home signal is clear, and to connect the coils on both of these cores to their stopping condensers when the home signal indicates stop.

It will be apparent that other arrangements of control circuits may be provided for governing the controlling condition of the track inductor for the same or different locations, and still carry out the principles and mode of operation of the invention.

Fig. 5 illustrates a variation or modification of the invention in which the receiver has only one longitudinal core A, and the track inductor a corresponding core TA, so that only one restrictive indication or control of either stop or caution, as desired, is obtained at an inductor location, in conjunction with a clear indication transmitted by reflecting energy from the receiver to the track inductor and back to the receiver through the medium of the transverse cores C and TC and their coils, in the manner explained.

Other modifications and variations in the arrangement and positioning of the receiver cores on the vehicle may be employed. For example, in the organization illustrated, the transverse core C is disposed near the middle of the longitudinal cores A and B; but this transverse core may be carried at a suitable distance, either ahead or behind the longitudinal cores, and the inductor cores may be disposed in a corresponding relationship. Such an arrangement more distinctly segregates the transverse core C magnetically from the longitudinal cores A and B, and assures that any energization of the transverse core must come from the track. If desired, two such transverse cores may be provided to co-operate with an inductor for movement of the vehicle in either direction, or with either end leading.

Also, it should be understood that the relative spacing, shape, and proportions of the receiver and inductor cores shown is merely illustrative, and that various other structural organizations may be employed without departing from the invention. For example, the longitudinal cores may be spaced farther apart than shown, and the transverse core C located at a higher plane, if it is desired to provide clearance over water pans or similar objects in the middle of the track.

Having explained how the system of this invention acts to transmit caution, or stop controls or indications from the trackway to a moving vehicle, consideration may now be given to the manner in which these controls may be utilized to provide for the desired safety of train operation. One arrangement of the car apparatus and circuits for this purpose is illustrated in Fig. 6.

Referring to Fig. 6, it is contemplated that the caution control will cause a partial application of the brakes, accompanied by an audible warning signal which continues until acknowledged by the engineman or manual operation of a restoring switch or button; and that the stop control will result in a full or emergency application of the brakes, continued until the train is stopped, and the apparatus restored by a reset device, preferably accessible only from the ground.

This scheme of partial or full automatic brake control, while applicable to various types of air brake equipment, is illustrated as applied to a system of the so-called vacuum type, in which the brakes are applied by admitting atmospheric air into a brake pipe or its connection. In this form shown, a caution electro-pneumatic valve CV of suitable construction, acts when de-energized to open a valve **50** to allow atmospheric air

to pass through a suitable air whistle 51 or equivalent audible signalling device, into the brake pipe or a connection 52 at such a restricted rate as to cause the desired partial application of the brakes. The valve 50 is biased to open by a suitable spring 53, when the winding of the electro-pneumatic valve CV is de-energized, aided by the atmospheric pressure on said valve 50. Another valve 54, closed when valve 50 opens, is preferably provided to avoid leakage around the stem of valve 50 and assure passage of air through the whistle 51. Another similar electro-pneumatic valve SV when de-energized, opens a valve 55, biased by a spring 56, to establish an opening into a similar connection 52a to the brake pipe to cause a quick or emergency application of the brakes.

In addition to these electro-pneumatic valves CV, SV and the relays RA and RB, directly responsive to the caution and stop indication, repeater relay RAP and RBP, a stop stick relay SR, an acknowledging device AS, and reset switch RS are employed, with contacts and circuit connections so organized as to obtain the desired operation. These contacts and circuit connections are more conveniently considered in describing the operation. The circuits are illustrated in a simplified and diagrammatic form, with the connections to terminals of a suitable supply of current, preferably direct current, indicated by the symbols (+) and (—).

Under normal conditions, while the vehicle is travelling between inductor locations under clear conditions as shown in Fig. 6, the repeater relay RAP is energized by a circuit readily traced from (+), front contact 60 of relay RA, wire 61, relay RAP to (—). The repeater relay RBP is energized by a similar circuit from (+) through front contact 62 of relay RB, wire 63, relay RBP, to (—).

With the relays RAP and RBP thus energized, the caution electro-pneumatic valve CV is maintained energized by a circuit from (+), front contact 64 of RAP, wire 65, normally closed contact 66 of the acknowledging switch AS, wire 67, front contact 68 of RBP, wires 69 and 70, winding of valve CV, to (—).

The stop stick relay SR is energized by a stick circuit from (+) through a front contact 71 of the relay RAP, in multiple with a front contact 72 of the relay RBP, wires 73 and 74, relay SR, wires 75 and 76, front contact 77 of relay SR to (—).

With the relay SR energized and the reset switch RS in its normal position shown, the stop electro-pneumatic valve SV is energized by a circuit readily traced from (+), front contact 78 of relay SR, wires 79, magnet winding of valve SV, wire 80, and switch RS in the normal position to (—).

Assume now that the vehicle passes a track inductor in the caution condition, i. e. with one or the other of its longitudinal cores TA and TB effective to cause de-energization of the relay RA or RB. Such de-energization of the relay RA, or the relay RB, de-energizes relay RAP or RBP, as the case may be, and breaks at their front contacts 64 or 68 the energizing circuit for the caution valve CV, thereby sounding the whistle 51 and making a partial application of the brakes. This condition continues until the engineman operates the acknowledging or restoring switch AS located within his convenient reach.

This operation of the acknowledging switch AS closes contacts 80 and 81 to establish a shunt circuit around the resistances 11 and 15 in the energizing circuits for relays RA and RB, so that whichever relay has released its armature may again attract its armature, due to the increased current, normal current conditions in the alternating current circuit having in the meantime been established by movement of the receiver beyond the influence of the inductor.

When the acknowledging switch AS is thus manually operated to restore the relay RA or RB, as the case may be, this switch must be returned to the normal position to close contact 66, in order to energize the caution valve CV. Consequently, the switch AS cannot be moved or kept in the restoring position and prevent operation of the caution valve CV. This acknowledging switch AS may be of any suitable construction and is enclosed in a suitable sealed or locked case, indicated by dash lines, with a suitable knob or operating handle projecting outside of the case. This switch is preferably provided with a spring, not shown, for returning it to the normal position, although it may be operated manually to both positions.

If now the vehicle passes a track inductor in its stop position, i. e. with both the inductor cores TA and TB effective, both relays RA and RB are simultaneously de-energized, and in turn their repeater relays RAP and RBP, so that the stick circuit for the stop relay SR is broken by the concurrent opening of the front contacts 71 and 72 of the repeater relays RAP and RBP. The de-energization of the stop relay SR breaks the energizing circuit for a stop valve SV, which causes a full or emergency application of the brakes.

This simultaneous de-energization of relays RAP and RBP opens the energizing circuit for the caution valve CV; and in order that this valve CV may not be operated as well as the stop valve SV, a supplemental circuit to hold up the valve CV is preferably provided, so that when relay SR drops, it closes an energizing circuit for the valve CV from (+), through back contact 78 of relay SR, wires 83 and 70, valve CV, to (—).

When a stop control has been thus transmitted, the acknowledging switch AS has to be operated by the engineman to restore the relays RA and RB; but the stick stop relay SR is not energized until the reset switch RS is also operated. This reset switch RS is preferably accessible only from the ground, or otherwise so constructed that it cannot be operated until the train has been brought to a stop, or the stop brake application has been maintained for a sufficient time. Operation of the reset switch RS closes a pick-up circuit for the stop relay SR over wire 84; and this switch must then be returned to its normal position to permit energization of the stop valve SV.

In the arrangement shown in this Fig. 6, the clear indication is transmitted in the same way already described to render the tube VT conductive to allow current to flow in its plate circuit; but in this embodiment of the invention, a time element device TE is provided to automatically open this plate circuit after a time and automatically restore the tube to its normal condition to extinguish the lamp G. In the simplified form illustrated, this time element device TE comprises a solenoid winding 85, having a core 86, which drives a contact member through a compressible spring 88. The movement of the contact 87 is retarded by a suitable dash pot 89, so that this contact member maintains engagement with a stationary contact for the desired time interval after energization of the solenoid

85. When the tube VT responds to the clear indication impulse and current flows in its plate circuit to light the lamp G, the solenoid 85 is energized at the same time and attracts its core 86, stressing the spring 88, and initiating the retarded upward movement of the contact member 87. After the desired time interval for which the device is built or adjusted, the contact member 87 is raised by the coil 85 under the retarding influence of the dash-pot 89 far enough to separate from the stationary contact 90, whereupon the plate circuit is broken, the tube VT is restored to normal, and the solenoid 85 is de-energized to cause the contact member 87 to drop to its lower normal position under its own weight, supplemented by a spring, if desired, ready for the next operation.

In the arrangement of Fig. 6, the plate circuit of the tube VT also includes, in addition to the lamp G and the contacts of the time element device TE, front contacts 91 and 92 of the repeater relays RAP and RBP, so that the lamp G is not lighted, or at least is very quickly extinguished, when either relay RAP or RBP, or both, responds to a caution or stop control. This is a supplemental and optional feature, which is considered desirable to assure that no misleading indication of clear shall be given under either caution or stop conditions, and even though the system is otherwise organized, as already explained, such that clear indication is not communicated except under clear conditions.

Another organization of relays and circuits for utilizing the caution and stop control is illustrated in Fig. 7, which incorporates the additional feature that the engineman or driver must acknowledge the caution control by timely operation of the acknowledging switch AS, otherwise the stop valve is operated to bring the train to a stop. In other words, if the engineman is dead, incapacitated, or inattentive to his duties, and fails to operate the acknowledging switch AS within a limited time after a caution control is received, and thus fails to manifest that he is aware of the existence of danger and assumes responsibility for the safe control of the train, then a full or emergency application of the brakes automatically occurs.

This modification of Fig. 7 adds to the same parts and circuits of Fig. 6 a timing device, which is initiated upon de-energization of the caution valve CV, and opens the stick circuit for the stop relay SR after a time delay, unless the relays RA and RB are restored, and the caution valve CV again energized, by timely operation of the acknowledging switch AS. In the simplified arrangement illustrated, this timing device is shown in the form of a slow-release relay TM, which is energized by the circuit from (+), through a normally closed contact 94 operated by the caution valve CV, wire 95, relay TM to (−), and which is provided with a dash-pot or other well-known means to delay the opening of its front contact 96 for a desired time interval after de-energization of its winding. The contact 96 of this timing relay TM is included in the wire 74 of the stick circuit for the stop relay SR.

With the organization as shown in Fig. 7, when a caution control is received and the caution valve CV is deenergized, in the manner already explained, the timing relay TM is also de-energized. If the engineman is alive and alert, and promptly operates manually the acknowledging switch AS over and back to restore the relay RA or RB, as the case may be, and reenergize the valve CV, the timing relay TM is again energized before sufficient time, such as 10 seconds, has elapsed for the contact 96 of the relay TM to open and break the stick circuit for the stop relay SR. If, however, the relay SR is de-energized, the resultant brake application cannot be released until the reset switch RS is operated. This brake application is in the nature of a penalty to induce the engineman to be alert; and the manual act of the engineman in operating the acknowledging switch AS is a definite acknowledgment or recognition of the existence of danger conditions and assures that the engineman is in full possession of his faculties and may be relied upon to take charge of the control of the train.

From the foregoing explanation, in connection with the drawings, it can be seen that a simple and efficient system of intermittent inductive train control may be constructed in accordance with this invention, which satisfies the requirements and conditions for practical operation, and which has the various important features and advantages pointed out.

Having now particularly described and ascertained the nature of my invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In an intermittent inductive train control system, vehicle equipment comprising, a control coil in a normally resonant circuit normally energized with alternating current, normally energized relay means responsive to a decrease in the normal current in said circuit, a normally de-energized clear indication receiving coil having the minimum of magnetic coupling with said coil in said circuit; and trackway means effective in one controlling condition to influence said control coil on the vehicle inductively to cause effective de-energization of said relay means, and in another clear controlling condition to receive energy inductively from said resonant circuit and induce a momentary voltage pulse in said clear indication coil and without de-energization of said relay means.

2. An intermittent inductive train control system for railroads comprising, normally energized relay means on a vehicle for a restrictive control, a normally de-energized and inactive electro-responsive device on the vehicle for a clear indication, a receiver on the vehicle energized from a source of alternating current on the vehicle of relatively high frequency, and an inductor on the track magnetically coupled with said receiver during movement of the vehicle past the inductor location, said inductor in one stopping condition causing de-energization of said relay means without affecting said electro-responsive device, and in another distinctive clear condition causing momentary energization of said electro-responsive device without de-energization of said relay means by energy derived wholly from said source on the vehicle.

3. An intermittent inductive train control system for railroads comprising, a receiver having separate magnetic cores with coils thereon, said cores being disposed substantially at right angles to have the minimum magnetic coupling, the coil on one of said cores being included in a normally resonant circuit energized from a source of alternating current on the vehicle of a relatively high frequency, relay means on the vehicle responsive to a decrease of current in said circuit, a normally de-energized clear indication electro-responsive device responsive to a

momentary voltage pulse in the coil of the other core of said receiver, and a track inductor having cores with coils thereon magnetically coupled respectively with the cores of the receiver during movement of the vehicle by the inductor location, said track inductor being changeable in its condition to cause de-energization of said relay means under adverse traffic conditions and to induce a momentary voltage pulse in the coil controlling the clear indication electro-responsive device under clear traffic conditions by energy derived wholly from the source of the vehicle, and without causing de-energization of said relay means.

4. In an intermittent inductive train control system of the character described, a receiver on a vehicle having a magnetic core with a coil thereon in a normally resonant circuit energized from a source of alternating current on the vehicle, normally energized relay means responsive to a reduction in the current in said coil, normally de-energized clear indication receiving means on the vehicle, a track inductor core magnetically coupled with the core of the receiver during movement of the vehicle by the inductor location and tending to disturb the resonance of said circuit to cause effective de-energization of said relay means, said inductor core having a coil thereon in which voltage is induced by the magnetization of the receiver core, and means connected to said inductor coil only under clear traffic conditions for inductively actuating said clear indication receiving means by energy derived wholly from the source on the vehicle and without de-energization of said relay means.

5. An intermittent inductive train control system for railroads comprising, a receiver on a vehicle having separate coils with their axes at right angles to have minimum magnetic coupling, a track inductor having coils corresponding to those of the receiver and magnetically coupled therewith during movement of the receiver by the track inductor, a source of alternating current on the vehicle for energizing one of the coils of the receiver, and a circuit closed only under clear traffic conditions for connecting together the coils of the inductor, whereby energy from said source is inductively transmitted from the receiver to the inductor and back to the receiver to produce a clear indication.

6. Apparatus for inductively transmitting indications from the track to a moving vehicle comprising, in combination with a normally energized restrictive indication device and a normally de-energized clear indication device both on the vehicle, of a receiver on the vehicle and an inductor on the track co-operable inductively to cause either de-energization of said normally energized restrictive indication device or the energization of said normally de-energized clear indication device by energy derived wholly from a source of alternating current on the vehicle, said conductor comprising separate coils with their axes at right angles, and control means for connecting said coils in series or for connecting one of said coils to a stop condenser.

7. Apparatus for transmitting distinctive caution or stop controls inductively from the trackway to a moving vehicle comprising, a receiver on the vehicle having duplicate magnetic cores with coils thereon in separate normally resonant circuits energized from a source of alternating current on the vehicle of a relatively high frequency, relay means associated with each of said circuits and independently responsive to the reduction in the current in its circuit, an inductor on the track having cores and coils corresponding with its said receiver and magnetically coupled therewith during movement of the vehicle by said inductor, and means for rendering said duplicate inductor cores effective or non-effective in their influence upon the corresponding receiver core to cause de-energization of only one, or both, or neither of said relay means.

8. An intermittent inductive train control system comprising, in combination with vehicle equipment having a normally resonant circuit energized from a source of alternating current on the vehicle and a normally de-energized clear indication receiving circuit, of trackway means inductively energized from said resonant circuit and effective only if a clear indication circuit on the trackway is closed for momentarily energizing said clear indication circuit during movement of the vehicle by said trackway means without materially disturbing the resonance of said circuit.

9. An intermittent inductive train control system comprising, apparatus on a vehicle including spaced parallel magnetic cores disposed longitudinally of the vehicle symmetrically on opposite sides of its center line, a transverse magnetic core disposed substantially at right angles to said longitudinal cores, coils on said longitudinal cores including in separate normally resonant circuits energized from a source of alternating current on the vehicle, normally energized relay means separately controlled by each of said circuits, normally inactive clear indication receiving means responsive to the magnetization of said transverse core, and trackway means co-operating inductively with said cores on the vehicle and effective dependent upon its controlling condition to cause de-energization of one or the other or both of said relay means or magnetization of said transverse core by energy derived wholly from said source on the vehicle without de-energization of either of said relay means.

10. Apparatus for inductively transmitting a clear indication from the trackway to a moving vehicle comprising, in combination with a source of alternating current on a vehicle, of clear indication receiving means including a magnetic core having spaced normally de-energized coil thereon wound and connected in series such that cumulative voltages are induced therein only by magnetic flux through said coils in opposite directions at the same instant, and trackway means effective only when a clear circuit is closed and deriving its energy inductively from said source on the vehicle alone for creating flux fields to induce cumulative voltages in said coils.

11. A system of intermittent inductive train control comprising, a receiver on a vehicle and an inductor on the track having counterpart cores and coils of the same relative dimensions and disposition, said receiver and inductor each including a core extending longitudinally of the track and symmetrically with respect to the center line of the track, and a transverse core disposed at right angles with respect to the longitudinal core, whereby the inductive co-operation between said receiver and track inductor is the same for either direction of movement of the vehicle with either end leading.

12. A receiver for intermittent inductive train control systems adapted to be carried on a vehicle and comprising, two spaced parallel lami-

nated cores extending longitudinally of the vehicle and symmetrical with respect to its center line, a transverse core disposed at right angles to said longitudinal cores near their middle, coils on said longitudinal cores included in separate normal resonant circuits energized from a source of alternating current on the vehicle of a relatively high frequency, and spaced coils on said transverse core wound and connected in series so that cumulative voltages are induced therein only by magnetic flux through said coils in opposite directions at the same instant.

13. A receiver for intermittent inductive train control systems comprising, a laminated magnetic core, two spaced clear indication receiving coils on said core, which are so wound and connected as to produce cumulative voltages in response only to magnetic flux through said coils in opposite directions at the same instant.

14. Vehicle equipment for intermittent inductive train control systems comprising, two spaced parallel laminated magnetic cores disposed longitudinally of the vehicle and symmetrically with respect to its center line, a transverse laminated magnetic core disposed at right angles to said longitudinal cores near the middle, two coils on each of said cores, a source of alternating current on the vehicle of a relatively high frequency, the coils on the longitudinal cores being included in separate normally resonant circuits energized from said source, relay means associated with each of said circuits and independently responsive to a decrease in normal current in its own circuit, normally de-energized and inactive clear indication receiving means responsive to a momentary voltage pulse in the coils of the transverse core, said coils on the transverse core being wound and connected so that cumulative voltages are induced therein only by magnetic flux through said coils in opposite directions at the same instant.

15. A track inductor for intermittent inductive train control systems comprising, two cores positioned to have a minimum of magnetic coupling, coils on said cores, and control means operable to at times connect all of said coils in series with each other and with a clear condenser, and at other times to connect in series the coils on one of said cores alone while open circuiting the coils on the other core, and a stop condenser connected across the last said coils.

16. A track inductor for intermittent inductive train control systems comprising, two spaced laminated magnetic coils disposed longitudinally of the track and symmetrically on opposite sides of the center line of the track, a transverse core disposed at right angles to its longitudinal cores, coils on said cores, the coils on the transverse core being spaced and wound and connected in series to create fluxes in opposite directions at the same instant, and controllable means for at times connecting all of said coils in series with each other and a clear condenser.

17. A train control system comprising, in combination with a source of alternating current on a vehicle of a relatively high frequency, a receiver having a normally de-energized clear indication coil, quick-acting electro-responsive means connected to said coil and responsive only to a frequency double the frequency of said source, and means partly on the vehicle and partly on the track and effective only when a clear circuit on the track is closed for producing in said coil a voltage pulse of double frequency derived wholly from said source on the vehicle.

18. An intermittent inductive train control system comprising, a source of alternating current on a vehicle, coils on the vehicle energized from said source, a normally de-energized clear indication receiving circuit on the vehicle requiring energization to indicate clear, and trackway inductor means positioned for receiving energy from said energized coils on the vehicle for inducing a voltage pulse in said clear indication receiving circuit of a frequency different from that of said source, and only if a clear circuit on the track is closed.

19. An intermittent inductive system of the character described, a source of alternating current on a vehicle of relatively high frequency, a receiver on the vehicle having coils in a normally resonant circuit energized from said source, said receiver including a normally de-energized clear indication receiving means responsive only to a frequency double that of said source, and trackway means inductively energized by said coil in said resonant circuit and effective only if a clear circuit is closed to induce a voltage of double frequency in said clear indication receiving means during movement of the receiver by said trackway means and without materially disturbing the resonance of said circuit.

20. An inductor for intermittent train control systems comprising two magnetic cores disposed to have a minimum of magnetic coupling with each other, coils on said cores, a clear indication circuit connecting the coils on one core in series through a double wave rectifier, and means connecting the output side of the rectifier in series with the coils on the other core whereby alternating current of a given frequency induced in the coils of said one core will produce current of double frequency in the coils of the other core.

21. An intermittent inductive train control system for railroads comprising, in combination with a source of alternating current on a vehicle of a relatively high frequency, a normally de-energized clearing indication receiving circuit, an electronic tube connected to said receiving circuit and rendered conductive by a momentary voltage pulse, said tube once rendered conductive remaining in that state after cessation of the voltage pulse until restored to normal, and trackway means from said source on the vehicle for inducing a voltage pulse in said clear indication receiving circuit only if a clear circuit on the track is closed.

22. In a system of intermittent inductive train control, apparatus for transmitting clear indication from the track to the moving vehicle comprising, in combination with a source of alternating current on the vehicle, clear indication receiving circuit on the vehicle, a receiver on the vehicle and the inductor on the track co-operable only if a clear circuit on the track is closed to induce a momentary voltage pulse in said clear indication receiving circuit by energy derived wholly from said source, an electronic tube coupled to said receiving circuit and rendered conductive only when its grid voltage is increased above a critical value, said tube remaining conductive after such voltage pulse has ceased until restored, indication means governed by said tube, and means for restoring said tube to its normal condition.

23. In a system of intermittent inductive train control, in combination with a receiving circuit in which a momentary voltage pulse is induced

from the trackway, an electronic tube coupled with said circuit rendered conductive only if its grid voltage is increased above a critical value, said tube when once rendered conductive remaining in that state after the voltage pulse has ceased until restored, indication means governed by said tube, and means for automatically restoring said tube to its normal condition after a predetermined time following each operation.

24. Apparatus for inductively transmitting a clear indication from a trackway to a moving vehicle comprising, in combination with a source of alternating current on the vehicle, a normally de-energized clear indication receiving coil on the vehicle, means including an electronic tube responsive to a voltage pulse in said coil only if of a frequency double the frequency of said source, and trackway means effective only if a clear circuit is closed for inducing a voltage pulse in said coil of said double frequency by energy derived wholly from the source on the vehicle.

25. A system of automatic train control comprising, separate relay means on the vehicle, a receiver on the vehicle and a track inductor cooperable to inductively cause de-energization of one or both of said relay means dependent upon the controlling condition of said track inductor, a caution control device on the vehicle actuated upon de-energization of either one of said relay means, and a stop control device actuated only upon simultaneous de-energization of both said relay means.

26. A system of automatic train control comprising, separate relay means on a vehicle, a receiver on a vehicle and a track inductor including duplicate magnetic cores and coils co-operable to cause de-energization of one or both of said relay means dependent upon the condition of the track inductor, a caution control device on the device actuated upon de-energization of either one of said relay means, a stop control device actuated only upon simultaneous de-energization of both of said relay means, said relay means when once operated remaining in that state until restored, a manually operable switch for restoring said relay means, and a separate manually reset switch for restoring said stop control device.

27. A system of automatic train control comprising, separate relay means on the vehicle, a receiver on the vehicle and a track inductor cooperable to inductively cause deenergization of one or both of said relay means dependent upon the controlling condition of said track inductor, a caution control device on the vehicle actuated upon deenergization of either one of said relay means, a stop control device actuated only upon simultaneous deenergization of both said relay means, and means for automatically applying the brakes to one extent upon actuation of the caution device, and to a different extent upon the actuation of the stop device.

28. An intermittent inductive train control system comprising a source of alternating current on a vehicle, coils on the vehicle energized from said source, a normally deenergized clear indication receiving circuit on the vehicle requiring energization to indicate clear, and trackway inductor means positioned for receiving energy from said energized coils on the vehicle for inducing voltage in said clear indication receiving circuit of a frequency different from that of said source, and only if a clear circuit on the track is closed.

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