April 12, 1927. 1,624,118

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AUTOMATIC TRAIN CONTROL

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FIG. 1.

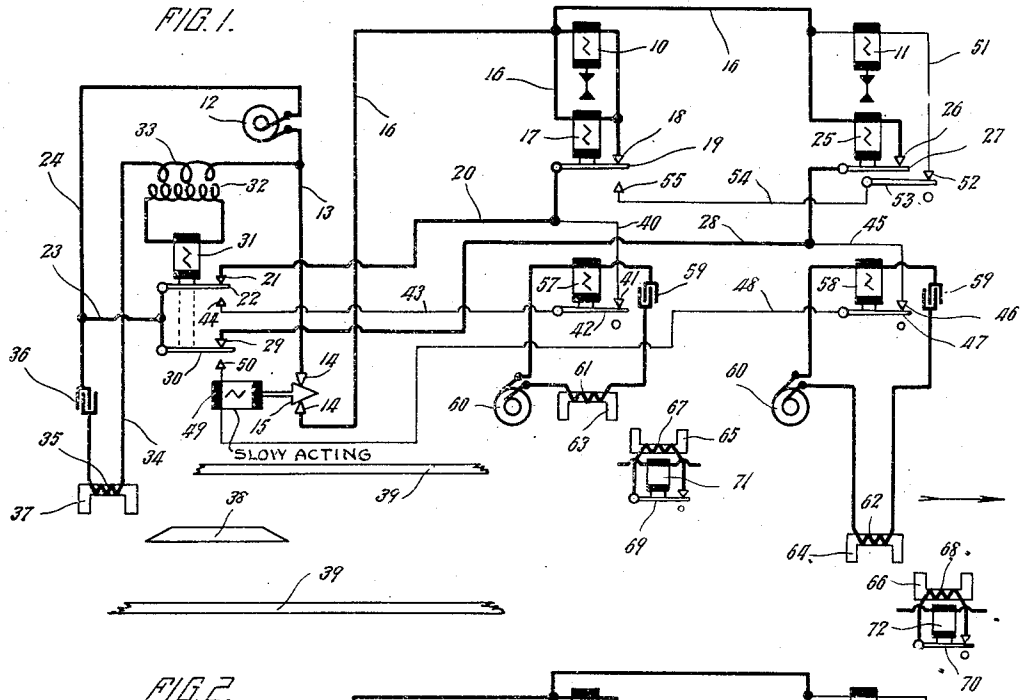
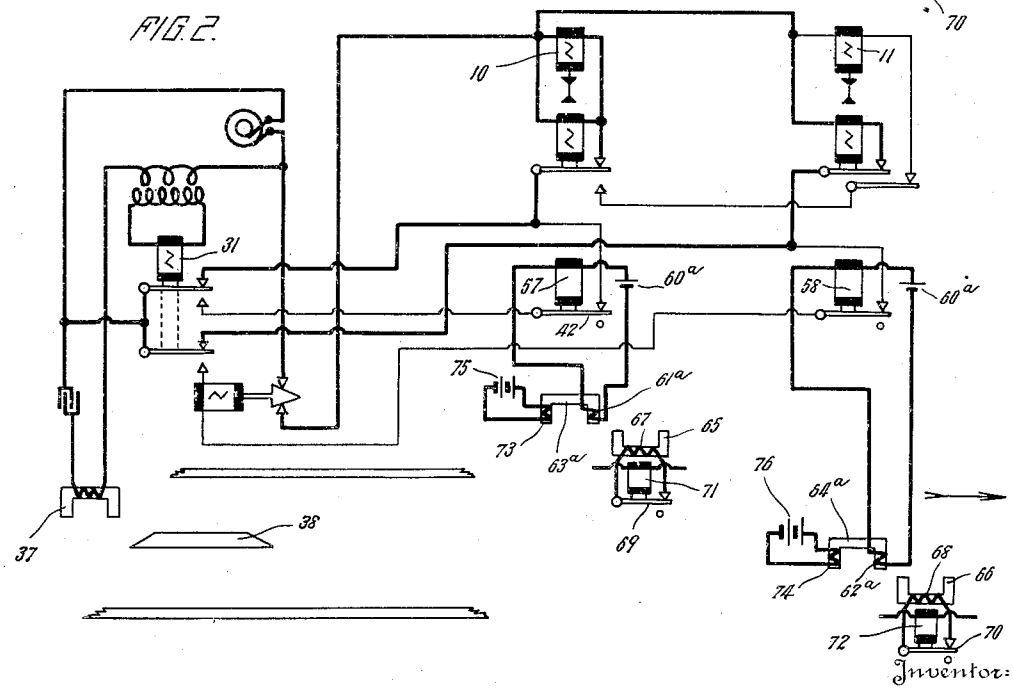


FIG. 2.



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FIG. 3.

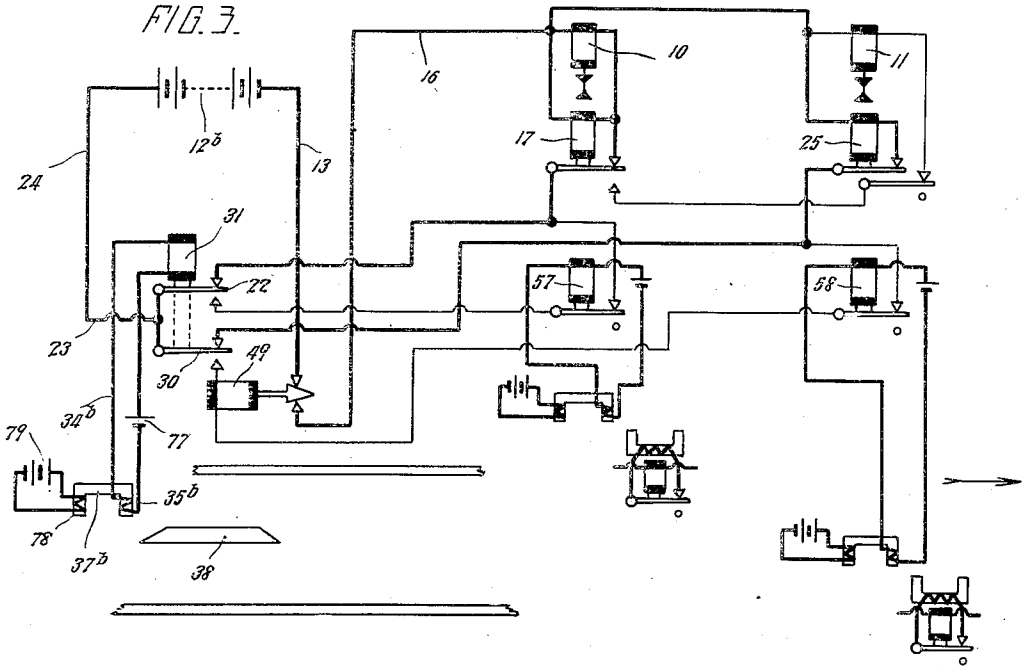
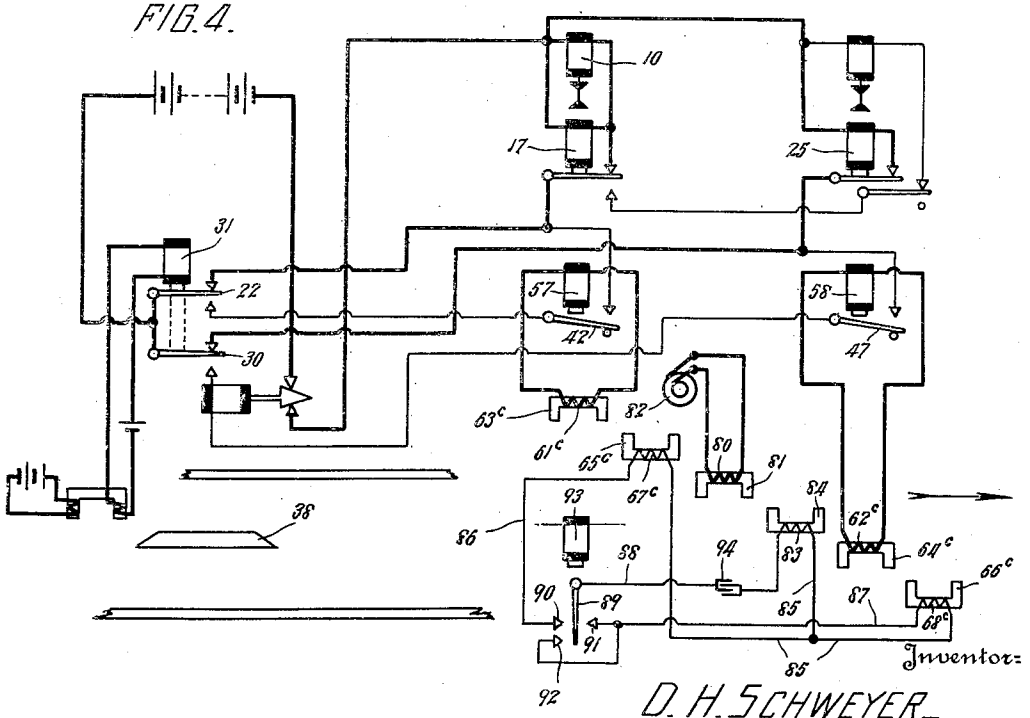


FIG. 4.



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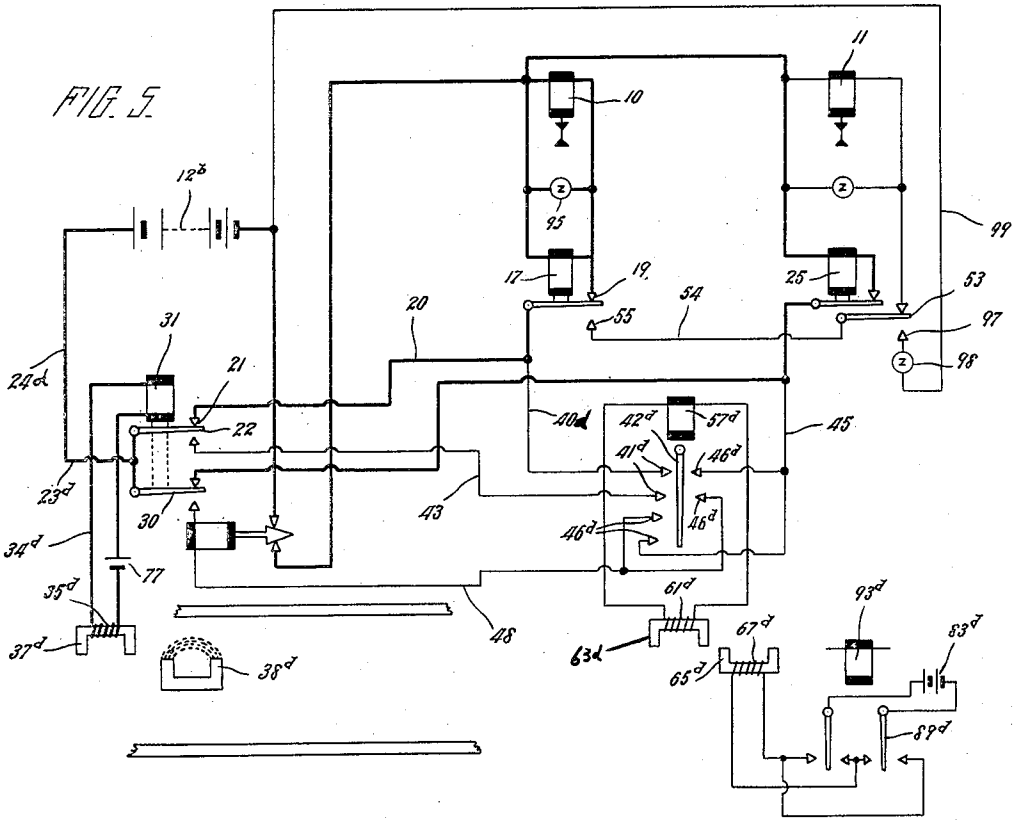
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FIG. 5.



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Patented Apr. 12, 1927. 1,624,118

UNITED STATES PATENT OFFICE.

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AUTOMATIC TRAIN CONTROL.

Application filed April 21, 1925. Serial No. 24,755.

The present invention relates to automatic train control, and aims to provide a novel apparatus wherein the vehicle or car equipment is controlled inductively from control elements on the track, including means for obtaining an initiating action or effect whenever passing a control location, resulting in a danger condition in the vehicle equipment or the retarding or stopping of the vehicle, in combination with other means for nullifying or avoiding said condition to obtain other conditions, such as clear or caution conditions.

It is also an object of the invention to improve the apparatus generally and the several component parts thereof, so that the apparatus will be reliable, practical and efficient in operation, and to place failures on the side of safety.

With the foregoing and other objects in view, which will be apparent as the description proceeds, the invention resides in the construction and arrangement of parts, as hereinafter described and claimed, it being understood that changes can be made within the scope of what is claimed, without departing from the spirit of the invention.

The invention is illustrated in the accompanying drawings, wherein—

Figure 1 is a diagrammatical view of one form of apparatus employing resonant or tuned initiating and nullifying circuits on the vehicle for cooperation with the track elements or inductors.

Fig. 2 is a similar view of a modified form of apparatus using a resonant or tuned initiating circuit and direct current nullifying circuits.

Fig. 3 is a similar view of another modification using direct current circuits for both the initiating and nullifying devices.

Fig. 4 is a diagrammatical view showing the use of a direct current initiating circuit and transformer devices for obtaining the nullifying actions for clear and caution conditions, with the electrical current supplied from the vehicle to the track elements or inductors and reflexed back to the vehicle impulse receivers or inductors.

Fig. 5 is a diagrammatical view of another variation using direct current for the initiating and nullifying actions.

Referring particularly to Fig. 1, the electromagnets or other translating means 10 and 11 control signals or the air brakes, for signalling clear, caution and danger conditions, or for controlling the movement of the train accordingly, as well known in the art. Thus, when the electromagnet 10 is energized clear conditions will exist in the vehicle equipment so that the train may proceed unrestricted; and when the electromagnet 11 is energized with the magnet 10 deenergized then caution conditions will exist, either by a signal or by retarded speed of the train; whereas if both magnets 10 and 11 are deenergized then danger conditions will be in force.

A normal running or clear circuit includes the alternating current generator 12, conductor 13, a pair of contacts 14 and switch 15 bridging them, conductor 16, magnet 10 and an electromagnet 17 connected in parallel with the magnet 10, contact 18, switch 19 normally held closed by the energized magnet 17, conductor 20, contact 21, switch 22, and conductors 23 and 24. Such circuit is a stick circuit because if the circuit is deenergized and the switch 19 dropped to open the circuit, the magnets 10 and 17 will remain deenergized until the switch 19 is closed. The switch 19 may be closed by hand or the switch bridged, to reenergize the magnets 10 and 17, and the switch may be under lock and key so that it can only be closed under proper authority.

Another normal circuit, which is maintained for the establishment of caution conditions as will hereinafter more fully appear, includes the generator 12, conductor 13, contacts 14 and switch 15, conductor 16, electromagnet 25, contact 26, switch 27 normally held closed by the magnet 25, conductor 28, contact 29, switch 30, and conductors 23 and 24. This is also a stick circuit because if the magnet 25 is deenergized to drop the switch 27 the circuit remains open. The switch 27, like the switch 19, may be closed by hand or the switch bridged in any suitable manner for reenergizing the magnets 11 and 25, and the switch may be under lock and key so that it can only be closed under proper authority.

The companion switches 22 and 30 are both under the control of an electromagnet 31 which when energized holds said switches closed, and said switches are released so as to open whenever passing a control location of the track. For this purpose, the magnet

31 is connected in circuit with the secondary winding 32 of a transformer whose primary winding 33 is disposed in a resonant or tuned circuit including the generator 12, primary winding 33, conductor 34, choke coil 35, condenser 36 and conductor 24. The choke coil or winding 35 is mounted on an inverted U-shaped core 37 having an air gap in the magnetic circuit thereof so that the coil 35 provides reactance in the circuit, which is balanced by the capacity or condenser 36, so that when the core 37 is away from an armature 38 on the track, then the energy in the circuit of the winding 33 and coil 35 is at its maximum value, and the magnet 31 is energized to hold the switches 22 and 30 closed, such as when travelling in the block between control locations.

One of the armatures 38 is located or mounted on the track at each control location, such as at a point adjacent to or near the corresponding semaphore of the wayside signal system at the entrance end of a block. Said armature is a body or mass of iron or other magnetic material and is inert. The core 37 of the vehicle-carried inductor passes the armature 38 when the vehicle passes the control location, with a suitable clearance between the core 37 and armature 38, to avoid physical contact between the vehicle and track elements. However, the armature 38 forms a part of the magnetic circuit of the core 37, with short air gaps between the terminals of the core 37 and the armature. This decreases the impedance of the magnetic circuit, and the coil 35 causes a choking or "bucking" action in the initiating circuit, resulting in the detuning of the circuit and the magnet 31 is deenergized sufficiently to release the switches 22 and 30, so that said switches drop open whenever the initiating inductor comprising the coil 35 and core 37 passes an armature 38 on the track. When the inductor has passed the armature 38 the initiating circuit will again become tuned so that the magnet 31 is reenergized to pick up and close the switches 22 and 30. The armature 38 may be located between the rails 39 of the track, or at one side of the track.

It will be observed that when the switches 22 and 30 are opened when passing the armature 38, this will naturally open the normal circuits of the magnets 10, 17 and 25 as hereibefore described. Alternate holding circuits are therefore provided for said magnets in order to keep them energized under clear conditions, and to keep the magnet 25 energized under caution conditions when the magnets 10 and 17 are deenergized.

The alternate holding circuit for the magnets 10 and 17 includes the generator 12, conductor 13, contacts 14 and switch 15, conductor 16, magnets 10 and 17, contact 18, switch 19, conductor 40, contact 41, switch 42, conductor 43, contact 44, switch 22, and conductors 23 and 24. The alternate holding circuit for the magnet 25 includes the generator 12, conductor 13, contacts 14 and switch 15, conductor 16, magnet 25, contact 26, switch 27, conductor 45,. contact 46, switch 47, conductor 48, electromagnet 49, conductor 50, switch 30, and conductors 23 and 24. Both of these holding circuits are normally open at the contacts 44 and 50, respectively, although the switches 42 and 47 are normally closed, and the switches 42 and 47 are under control from the track so that they remain closed under clear conditions, so that both switches 42 and 47 are opened under danger conditions, and so that the switch 42 is opened and the switch 47 closed under caution conditions, when passing the control location.

The electromagnet 49 is a slow acting device controlling the switch 15 for opening said switch after an interval of time, in order to open the circuit between the generator 12 and magnets 10, 11, 17 and 25 should the magnet 49 remain energized through a longer interval than necessary for the normal functioning of the apparatus when passing a control location, as will hereinafter more fully appear.

Under caution conditions, with the switch 19 down in open position, and the magnets 10 and 17 deenergized, the magnet 25 remains energized by being disposed in the circuit hereinbefore described. The magnet 11 is energized, being disposed in the caution circuit including the generator 12, conductor 13, contacts 14 and switch 15, conductor 16, magnet 11, conductor 51, contact 52, switch 53 under the influence of the magnet 25, conductor 54, contact 55, switch 19 in open position, conductor 20, contact 21, switch 22, and conductors 23 and 24. If the magnet 25 becomes deenergized both switches 27 and 53 drop open thereby obtaining danger conditions if the magnets 10 and 17 are also deenergized.

The nullifying or alternate holding circuit switches 42 and 47 are under the control of the respective electromagnets 57 and 58, which are connected in circuit with the generators 60 and the respective choke or reactance coils 61 and 62. A condenser 59 is disposed in each of these nullifying circuits, and the circuits are normally tuned or resonant so that the magnets 57 and 58 are energized to hold the switches 42 and 47 closed. The coils 61 and 62 are wound on the respective cores 63 and 64 which are similar to the core 37, and the capacities or condensers 59 balance the reactances produced by the coils 61 and 62 so that the circuits are normally energized to the highest value to keep the magnets 57 and 58 energized. It will be noted that all of the magnets 10, 11, 17, 25, 31, 49, 57 and 58 are al-

ternating current magnets, and a single alternating current generator will suffice, although separate generators 60 are illustrated to simplify the diagram. The coil 61 and core 63 provide a nullifying inductor for clear conditions, and the coil 62 and core 64 provide a nullifying inductor for caution conditions.

The nullifying inductors carried by the vehicle are controlled, when the initiating inductor 35, 37 passes the armature 38, by control inductors on the track including the cores 65 and 66, having wound thereon the respective coils 67 and 68 whose circuits, which are of low resistance, are opened and closed by the respective switches 69 and 70. The cores 63 and 64 pass simultaneously over the cores 65 and 66, respectively, when the core 37 passes over the armature 38, and the vehicle-carried and track-mounted elements may be located at suitable points for simultaneous cooperation. The switches 69 and 70 may be controlled manually, or may be connected mechanically, pneumatically, electrically or otherwise with the wayside signal system. As shown, the switches 69 and 70 are under the control of electromagnets 71 and 72, respectively which may be located in the wayside signal circuits. Under clear conditions of the track in advance of the control location, both switches 69 and 70 are closed, the electromagnets 71 and 72 or other means being energized or active to hold said switches closed. Under danger traffic conditions in advance both switches 69 and 70 are open, the magnets 71 and 72 being deenergized or the switches released in any other manner. Under caution conditions the switch 69 is open and the switch 70 closed.

Operation.

Clear conditions.—When the track is clear in advance of the control location, both switches 69 and 70 are closed, to close the low resistance circuits of the coils 67 and 68 that neutralize the effects of the cores 65 and 66 on the nullifying inductors of the vehicle. When the core 37 passes the armature 38, the switches 22 and 30 drop open, as hereinbefore described, and the cores 63 and 64 simultaneously pass over the cores 65 and 66, respectively. The effect of the cores 65 and 66 on the corresponding vehicle-carried inductors is neutralized or avoided because of the effect of the coils 67 and 68. Thus, said coils 67 and 68 being in closed circuits will impede the flow of magnetic flux through the cores 65 and 66 from the cores 63 and 64, so that the result is substantially the same as though the cores 65 and 66 were not present when the vehicle-carried inductors pass them. Consequently, the magnets 57 and 58 remain energized. Accordingly, when the switches 22 and 30 drop down, the alternate holding circuits will be closed to maintain the magnets 10, 17 and 25 energized. The circuit of the magnets 10 and 17 being broken at the contact 21, will be completed by way of the conductor 40, contact 41, switch 42, conductor 43 and contact 44, which are in parallel with the conductor 20 and contact 21. The circuit of the magnet 25 being broken at the contact 29 will be completed by the conductor 45, contact 46, switch 47, conductor 48, magnet 49 and contact 50 which are in parallel with the conductor 28 and contact 29. The alternate holding circuits for the magnets 10, 17 and 25 are thus established during the interval when passing the control elements on the track, and the magnets 10, 17 and 25 are sufficiently slow-acting so as to remain energized while the switches 22 and 30 drop away from the contacts 21 and 39 against the contacts 44 and 50, respectively. As soon as the core 37 leaves the armature 38 then the magnet 31 is reenergized to again pick up and close the switches 22 and 30 for restablishing the normal circuits of the magnets 10, 17 and 25. If, for any reason, the magnet 31 fails to pick up the lower switch 30 after an interval of time (several seconds) then the slow-acting magnet 49 remaining energized will open the switch 15, thereby opening both circuits of the magnets 10, 17 and 25, so as to deenergize said magnets and obtain danger conditions. The magnet 49 is therefore a safety device to avoid the energization of the magnets 10, 17 and 25 over the alternate holding circuits after leaving the control location.

Therefore, when the vehicle passes the control location with the switches 69 and 70 closed, the vehicle equipment is maintained in clear condition so that the train can proceed, although the initiating action or effect takes place whenever passing an armature 38, with the circuits of the other track inductors closed.

Danger conditions.—When danger traffic conditions exist in advance of the control location, both switches 69 and 70 are open so that the coils 67 and 68 are not effective. Consequently, when the core 37 passes the armature 38 to open the switches 22 and 30, the cores 63 and 64 simultaneously pass the cores 65 and 66, and said track cores will be effective to influence the choke or reactance coils 61 and 62. This will detune the circuits of said coils 61 and 62, so that the magnets 57 and 58 are deenergized sufficiently to let the switches 42 and 47 drop open. Consequently, the switches 42 and 47 drop open simultaneously with the switches 22 and 30, and the alternate holding circuits for the magnets 10, 17 and 25 cannot be established, and this

results in the magnets 10, 17 and 25 being deenergized. The circuits of said magnets 10, 17 and 25 being stick circuits will remain broken, even though the magnet 31 is reenergized and the switches 20 and 30 again raised after passing the control location. As a result, the magnets 10, 17 and 25 are deenergized, in addition to the normally deenergized magnet 11, so that danger conditions will be enforced.

In order to clear the apparatus for clear conditions, the switches 19 and 27 are either raised manually or by other means, or the magnets 10, 17 and 25 may be energized by bridging the switches 19 and 27 by suitable electrical connections (not shown). The reclosing of the switches 19 and 27 will reestablish the normal circuits so as to reenergize the magnets 10, 17 and 25 and restore clear conditions. The arrangement should be such, however, that the clearing operation may only be done with authority, and the apparatus may be under lock and key to prevent unauthorized clearing of the apparatus when under caution or danger conditions.

Caution conditions.—When the train should proceed under caution conditions after leaving a control location, the switch 69 is open and the switch 70 closed, so that when the vehicle-carried elements pass the track elements the magnet 57 is deenergized while the magnet 58 remains energized, inasmuch as the core 65 is effective to detune the circuit of the magnet 57, while the circuit of the coil 68 being closed will prevent the detuning action in the circuit of the magnet 58. Consequently, when the switches 22 and 30 drop down, the switch 42 also drops down, and the normal and alternate holding circuits of the magnets 10 and 17 are both broken, while the alternate holding circuit of the magnet 25 is closed between the contact 46 and switch 47 and the contact 50 and switch 30, thereby keeping the magnet 25 energized when passing the control location. The caution circuit is now closed including the generator 12, conductor 13, contacts 14 and switch 15, conductor 16, magnet 11, conductor 51, contact 52, switch 53, conductor 54, contact 55, switch 19 in dropped position, conductor 20, contact 21, switch 22 (after core 37 has passed the armature 38), and conductors 23 and 24. The magnet 11 is thus energized, together with the magnet 25, and when the magnet 10 is deenergized by the opening of both of its circuits when passing the control location, caution conditions will then exist in the vehicle equipment. The switches 19 and 27 may be closed by hand, under proper authority or regulations, when the next signal location is being reached, so as to restore clear conditions just prior to passing such signal location. The control of the switches 19 and 27 will be determined by suitable regulations, permitting the engineer to close said switches when an approaching signal location is observed, with the track clear in advance.

The apparatus shown in Fig. 2 is substantially the same as that shown in Fig. 1, and the operation is the same, excepting that the magnets 57 and 58 are controlled in a different manner. Thus, the magnets 57 and 58 are direct current magnets and are connected in circuit with the batteries 60^a and the respective windings or coils 61^a and 62^a on the cores 63^a and 64^a, so that said magnets are normally energized from the batteries 60^a. Other coils or windings 73 and 74 are mounted on the cores 63^a and 64^a, respectively, and are connected in circuit with the corresponding batteries 75 and 76. The two nullifying devices are the same, so that the description of the operation of one will suffice for both. Thus, the magnetic flux created in the core 63^a by the coil 61^a opposes the stronger magnetic flux created in said core by the coil 73, the battery 75 being stronger than the battery 60^a. However, the magnet 57 is energized by the battery 60^a, but when the core 60^a passes the core 65 with the switch 69 open, the core 65 bridges the core 63^a and affords a path of less reluctance for the magnetic flux from the core 63^a. This results in the magnetic flux created by the coil 73 inducing through the registering cores 63^a and 65, a single cycle of alternating current in the coil 61^a, one half cycle opposing the flow of current in the circuit of the coil 61^a from the battery 60^a. As a result, the flow of current in the circuit of the coil 61^a and magnet 57 is neutralized or balanced for an instant, so that the magnet 57 is deenergized to let the switch 42 drop down. However, if the switch 69 is closed then the coil 67 will be effective to impede the flow of magnetic flux through the core 65, and this will prevent the core 65 from being effective, and the magnet 57 will remain energized. The same action takes place when the core 64^a passes the core 66. The magnet 58 is normally energized from the battery 60^a, and if the switch 70 is open then the flow of magnetic flux from the coil 74 will have the counter-effect in the coil 62^a to deenergize the magnet 57, whereas said effect will not take place if the switch 70 is closed to render the coil 58 effective. With the exception of the operation of the nullifying inductors on the vehicle controlling the magnets 57 and 58, the operation is substantially the same as that described in connection with Fig. 1.

Fig. 3 shows the magnets 57 and 58 controlled the same as in Fig. 2, and the magnet 31 is also controlled similarly to the control of the magnets 57 and 58. Furthermore, a battery 12^b or other source of direct cur-

rent may be used in place of the generator 12 so that all magnets may be direct current magnets. The magnet 31 is disposed in the circuit 34^b with the battery 77 and coil or winding 35^b on the core 37^b, so that said magnet is normally energized by the battery 77. A second coil or winding 78 is disposed on the core 37^b and is normally energized by the battery 79 which is of higher voltage than the battery 77, so that the magnetic flux created in the core 37^b by the coil 78 is of higher value than that created in the core by the coil 35^b, the magnetic flux of one coil opposing that of the other. Consequently, when the core 37^b passes the armature 38 the magnetic flux from the core 37^b passing through the armature will result in a single cycle of alternating current being induced in the coil 35^b and one half cycle opposes the normal flow of current in the circuit 34^b, so as to neutralize for an instant the flow of current in the circuit 34^b, so that the magnet 31 is deenergized to let the switches 22 and 30 drop down. The action and results are the same as when the inductor 35, 37 of Figs. 1 and 2 passes the armature, but direct current is used for the control of the magnet 31 as shown in Fig. 3.

Fig. 4 shows the magnet 31 controlled in the same manner as shown in Fig. 3, while the control for the magnets 57 and 58 embodies transformers, as will presently appear. The magnets 57 and 58 are connected in circuits with the respective coils 61^c and 62^c on the cores 63^c and 64^c which cooperate with the respective track cores 65^c and 66^c on which are wound the coils 67^c and 68^c. The vehicle carries an energy transmitter including a coil 80 on a core 81 and energized by the alternating or pulsating current generator 82. A coil 83 is wound on a core 84 on the track, and the cores 81 and 84 register when the other inductors of the vehicle register with the corresponding track elements. There are three transformers each having one part on the vehicle and one part on the track. Thus, the coil 80 is the primary winding of one transformer and the coil 83 the secondary winding thereof, for transmitting inductive energy from the vehicle to the track when the cores 81 and 84 register, the coil 80 and core 81 constituting an energy or impulse transmitter on the vehicle and the coil 83 and core 84 an energy or impulse receiver on the track. The coil 67^c constitutes the primary winding of a second transformer and the coil 61^c the secondary winding of said transformer. The coil 67^c and core 65^c comprise an impulse or energy transmitter on the track, while the coil 61^c and core 63^c constitute an energy or impulse receiver on the vehicle. Similarly, the coil 68^c comprises the primary winding of a transformer of which the coil 62^c is the secondary winding. The coil 68^c and core 66^c comprise an impulse or energy transmitter on the track, while the coil 62^c and core 64^c comprise an energy or impulse receiver on the vehicle. The three pairs of transformer elements or inductors cooperate simultaneously when the initiating inductor passes the armature 38, and the energy received by the coil 83 may be delivered to both coils 67^c and 68^c under clear conditions, or to the coil 68^c only under caution conditions, neither coil 67^c or 68^c receiving energy under danger conditions. The reflexing of energy from the vehicle through the roadside elements back to the vehicle equipment is therefore under trackside control according to traffic conditions. A conductor 85 is connected to one terminal of each of the coils 67^c, 68^c and 83, and the respective conductors 86, 87 and 88 are connected to the other terminals of said coils 67^c, 68^c and 83. The conductor 88 is connected to the switch 89 of a polarized relay 93, the conductor 86 is connected to a contact 90, and the conductor 87 is connected to contacts 91 and 92. The switch 89 is controlled by the electromagnet 93, which may be in the circuit of the wayside signal system whereby, under danger conditions, no current flows in the magnet 93 so that the switch 89 is in intermediate position as shown, while current flows in one direction through the magnet 93 to move the switch 89 against the contacts 90 and 92 under clear conditions, whereas current flows through the magnet 93 in the opposite direction under caution conditions, to move the switch 89 against the contact 91. However, the switch 89 may be controlled manually or by other suitable means.

In the operation of the apparatus shown in Fig. 4, the switches 42 and 47 are normally open, but the alternate holding circuits for the magnets 10, 17 and 25 are the same as for the apparati shown in Figs. 1, 2 and 3. Thus, under clear conditions, when passing the control location, with the switch 89 bearing against the contacts 90 and 92, the magnetic flux created in the core 81 by the coil 80 will pass through the core 84, thereby inducing energy in the coil 83 which is connected in circuit with both coils 67^c and 68^c of the transmitting inductors on the track. One circuit includes the coil 83, conductor 88, switch 89, contact 90, conductor 86, coil 67^c and conductor 85. The other circuit includes the coil 83, conductor 88, switch 89, contact 92, conductor 87, coil 68^c and conductor 85. The common conductor 88 includes a condenser 94 to provide for resonance in both circuits. Both coils 67^c and 68^c are thus energized and the magnetic flux in the cores 65^c and 66^c passes through the cores 63^c and 64^c respectively, of the vehicle elements, so as to induce en-

ergy in the coils 61^c and 62^c. The windings or magnets 57 and 58 are therefore energized to pick up both switches 42 and 47 when the switches 22 and 30 are released by the magnet 31, so that the alternate holding circuits for the magnets 10, 17 and 25 are the same as in Fig. 1, under clear conditions. When the vehicle elements have passed the track elements the magnet 31 is reenergized and the magnets 57 and 58 deenergized so that the switches 22 and 30 are raised while the switches 42 and 47 drop open. Under danger conditions with the switch 89 in intermediate position, both coils 67^c and 68^c are disconnected from the coil 83, so that the coils 61^c and 62^c do not receive energy from the track elements and the magnets 57 and 58 remain deenergized so that the switches 42 and 47 remain open. The alternate holding circuits are therefore not established, and when the switches 22 and 30 drop down the circuits of the magnets 10, 17 and 25 are broken to obtain danger conditions. When the switch 89 is against the contact 91, this connects the coil 68^c with the coil 83, but the circuit of the coil 67^c is open. The circuit of the coils 83 and 68^c includes the coil 83, conductor 88, switch 89, contact 91, conductor 87, coil 68^c and conductor 85. Consequently, when passing the control location, the coil 62^c receives energy from the coil 68^c, so that the magnet 58 is energized to pick up the switch 47, thereby establishing the alternate holding circuit for the magnet 25, while the circuit of the magnets 10 and 16 is broken, to establish caution conditions the same as described in connection with Fig. 1.

The operation will also be the same if the coil 83 is taken to represent an alternating current generator or other source of alternating or pulsating current on the track, without using the coil 80 and core 81 on the vehicle.

Fig. 5 illustrates other variations. Thus, in lieu of the inert armature 38 there is provided a permanent U-shaped or horseshoe magnet 38^d on the track, and the magnet 31 is disposed in a circuit 34^d including the battery 77 and coil 35^d on the core 37^d. The magnet 31 is normally energized by the battery 77, and said battery creates weak magnetic flux in one direction in the core 37^d, while the magnetic flux of the permanent magnet 38^d is in the reverse direction, so that when the core 37^d passes the magnet 38^d in registration therewith, the magnetic flux of the permanent magnet opposes the weaker magnetic flux created by the coil 35^d. The magnetic flux of the permanent magnet passing through the core 37^d in opposition to the normal magnetic flux in said core, will induce a counter or opposing current in the coil 35^d, thereby deenergizing, for an instant, the magnet 31 so that the switches 22 and 30 drop down to obtain the initiating action the same as in the other forms of apparati.

Fig. 5 also shows a variation in the matter of controlling the alternate holding circuits of the magnets 10, 17 and 25. The magnets 57 and 58 are replaced by a single magnet 57^d of a polarized relay having the switch 42^d which is moved in opposite directions when the current through the magnet 57^d flows in opposite directions. The magnet 57^d is normally deenergized so that the switch 42^d is normally in intermediate position. When the switch 42^d moves towad the left it bridges the contacts 41^d to which the conductors 40^d and 43 are connected, and this establishes the alternate holding circuit of the magnets 10 and 17. There are two pairs of contacts 46^d at opposite sides of the switch 42^d, and one contact of each pair is connected to the conductor 45 and the other contact of each pair is connected to the conductor 48, so that when the switch 42^d moves toward either side it will bridge one pair of contacts 46^d so as to connect the conductors 45 and 48 to establish the alternate holding circuit of the magnet 25, the holding circuits of the magnets 10, 17 and 25 being substantially the same as in Fig. 1 excepting for the switches. The magnet 57^d is connected in circuit with a coil 61^d on a core 63^d, and this inductor (61^d and 63^d) takes the place of the two nullifying inductors, and cooperates with a single inductor on the track comprising a core 65^d with a coil 67^d thereon. A reversing switch 89^d connects the coil 67^d with the battery or other source of direct current 83^d, the polarity of the current being reversed when the switch 89^d is reversed, and the circuit being opened when the switch 89^d is in intermediate position. The switch 89^d is part of a polarized relay including the electromagnet 93^d in the wayside signal circuit and the switch 89^d is controlled similarly to the switch 89 of Fig 4. Thus, under danger conditions the magnet 93^d is deenergized and the switch 89^d is in intermediate position so that the coil 67^d is deenergized, and the switch 42^d remains in intermediate position, thereby keeping the alternate holding circuits of the vehicle equipment open when the switches 22 and 30 drop down, so that danger conditions are established. Under clear conditions, the switch 89^d connects the coil 67^d with the battery 83^d for the flow of current in the coil in one direction, and when the core 63^d passes the core 65^d, the magnetic flux in the core 65^d surges through the core 63^d, thereby inducing current in the coil 61^d that will energize the magnet 57^d to throw the switch 42^d toward the left, thereby bridging the contacts 41^d and one pair of contacts 46^d so that both alternate holding circuits are closed, to keep the magnets 10, 17 and 25 energized. Under cau-

tion conditions, the switch 89[d] is moved in the opposite direction so as to reverse the flow of current in the coil 67[d], thereby reversing the flow of magnetic flux, and the current induced in the coil 61[d] flows in the opposite direction so that the magnet 57[d] is energized to throw the switch 42[d] toward the right. This bridges one pair of contacts 46[d] to close the alternate holding circuit of the magnet 25, but the alternate holding circuit of the magnets 10 and 17 is not closed, so that caution conditions are established.

Fig. 5 also illustrates the use of an electric lamp 95 connected in parallel with the magnets 10 and 17 to be lighted during clear conditions, and said lamp may be of white or any other color to indicate clear conditions when lighted. Similarly, an electric lamp 97 is connected in parallel with the magnet 11 to be lighted when said magnet is energized, and said lamp may be of green or other color to indicate caution conditions when lighted. During danger conditions, with the switch 53 down it bears on a contact 97 at the end of a conductor 99 including an electric lamp 98 which may be of red or other color to indicate danger when lighted. The circuit of the lamp 98, under danger conditions, includes the battery 12[b], conductor 99, lamp 98, contact 97, switch 53 in lowermost position, conductor 54, contact 55, switch 19 in lowermost position, conductor 20, contact 21, switch 22 in normal raised position, and conductors 23[d] and 24[d].

Having thus described the invention, what is claimed as new is:—

1. Automatic train control apparatus including a body of magnetic material on the trackway, two inductors on the trackway associated with said body and each including a control coil in an electric circuit, means controlling said circuits for different traffic conditions, and vehicle-carried control means including an inductor affected inductively when passing said body to obtain an initiating effect and one control condition, and including other inductors energized by direct current and cooperable inductively with said trackway inductors whereby when the respective aforesaid circuits are closed the initiating effect is nullified and other controlling conditions are obtained selectively.

2. Automatic train control apparatus including a body of magnetic material on the trackway, two inductors on the trackway associated with said body and each including a control coil in an electric circuit, means controlling said circuits to open the circuits for danger conditions and to close the circuits selectively for clear and caution conditions, and vehicle-carried control means including an inductor affected inductively when passing said body to obtain an initiating effect and danger controlling conditions, and including other inductors energized by direct current and cooperable inductively with the trackway inductors whereby when the respective aforesaid circuits are closed the initiating effect and danger conditions are nullified and clear or caution conditions obtained selectively.

3. Automatic train control apparatus including a body of magnetic material on the trackway, two inductors on the trackway associated with said body and each including a control coil in an electric circuit, means controlling said circuits for different traffic conditions, and vehicle-carried equipment including an inductor affected inductively when passing said body, two other inductors energized by direct current and cooperable inductively with said trackway inductors, a relay controlled by the first-named vehicle-carried inductor, relay means controlled by said two other vehicle-carried inductors, and electrical circuits controlled by said relay and relay means and including controlling devices for obtaining different controlling conditions by the operation of said relay with and without the operation of said relay means.

4. Automatic train control apparatus including a body of magnetic material on the trackway, two inductors on the trackway associated with said body and each including a control coil in an electric circuit, means controlling said circuits for different traffic conditions, and a vehicle equipment including a vehicle-carried inductor affected inductively when passing said body, two other vehicle-carried inductors energized by direct current and cooperable inductively with the trackway inductors, a relay controlled by the first-named vehicle-carried inductor, relays controlled by said two other vehicle-carried inductors, and electrical circuits controlled by said relays and including controlling devices for obtaining danger conditions by the action of the first-named relay and for obtaining clear and caution conditions selectively by the action of the second-named relays.

5. Automatic train control apparatus including a body of magnetic material on the trackway, two inductors on the trackway associated with said body, and each including a control coil in an electric circuit, means controlling said circuits for different traffic conditions, and vehicle carried equipment including a vehicle-carried inductor affected inductively when passing said body and including a coil, two other vehicle-carried inductors energized by direct current and cooperable inductively with said trackway inductors and each including a coil, relays connected in circuits with said coils of the vehicle-carried inductors, and electrical circuits controlled by said relays and including controlling devices for obtaining

different conditions by different inductive effects on the vehicle-carried inductors.

6. Automatic train control apparatus including a normally closed vehicle-carried circuit having a control device, means for breaking said circuit at one point when passing a control location of the track, means controlled from the track for establishing an alternate circuit for said device when the first-named circuit is broken as aforesaid, and means in the second-named circuit operable after a predetermined maintenance of the second-named circuit to render said device inoperative.

7. Automatic train control apparatus including a normally closed vehicle-carried circuit having a control device therein, means for breaking said circuit at one point when the vehicle passes a control location of the track, means controlled from the track for establishing an alternate circuit for said device while the first-named circuit is broken, the two circuits having a common conductor, and slow-acting means in the second-named circuit and arranged to open said conductor.

In testimony whereof I hereunto affix my signature.

DANIEL HERBERT SCHWEYER.