

March 19, 1929.

T. E. CLARK ET AL

1,706,022

CONTROL SYSTEM FOR RAILWAY TRAINS

Filed Jan. 3, 1927

3 Sheets-Sheet 1

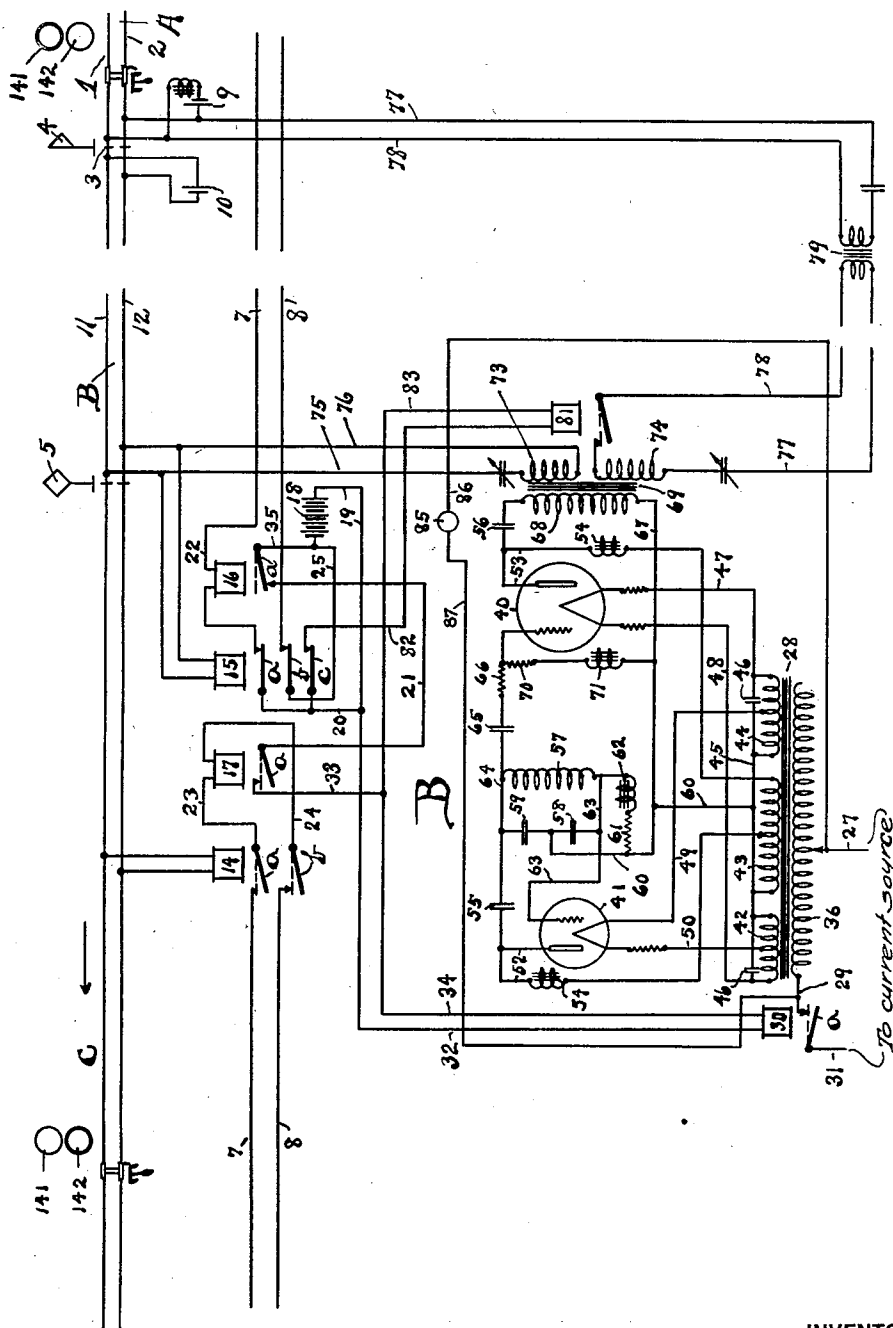


Fig. 1.

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3 Sheets-Sheet 2

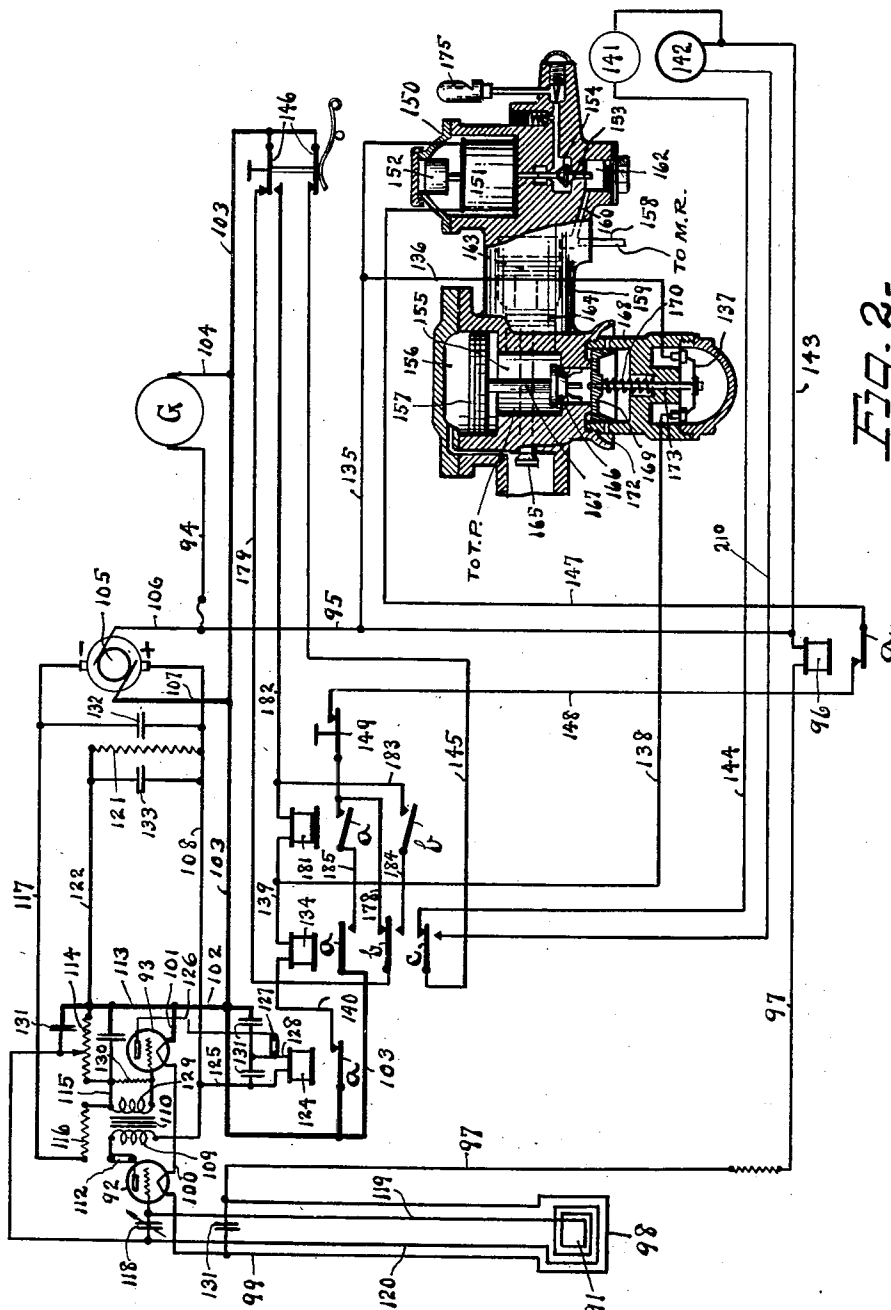


Fig. 2-

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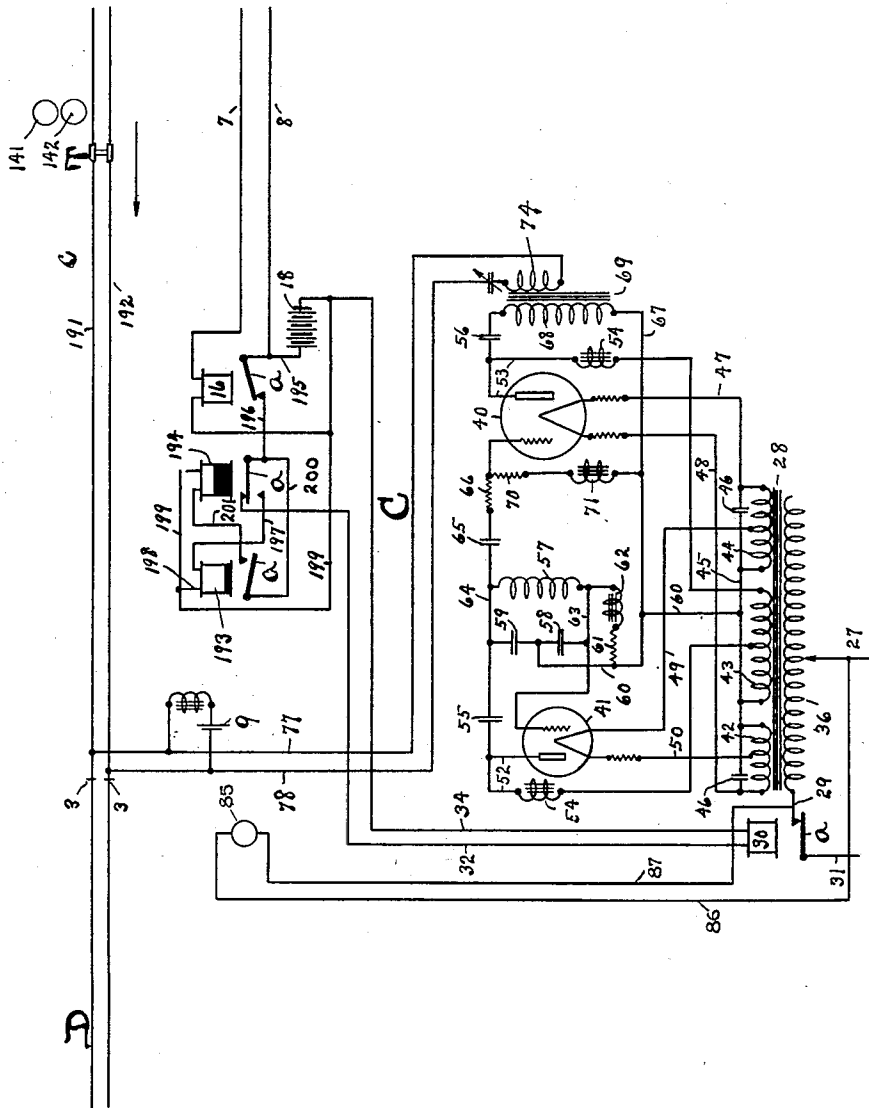


Fig. 3.

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CONTROL SYSTEM FOR RAILWAY TRAINS.

Application filed January 3, 1927. Serial No. 158,527.

This invention relates to control systems for railway trains traveling over tracks divided into blocks, whereby radio-frequency current may be impressed upon the track rails of such blocks as may be occupied when the block in advance is unoccupied, in order that electromagnetic force or flux may be picked up from adjacent the rails by a receptor coil mounted on the locomotive, or other controlled vehicle, which is provided with proper instrumentalities for controlling the air-brakes, so that the operation of the vehicle may be governed by such radio-frequency current; and its object is to provide transmission instrumentalities which will continuously impress a current of predetermined frequency upon the rails of the controlled block when the block in advance is unoccupied and will interruptedly impress such current upon the last block of controlled track so that proper instrumentalities on the vehicle may respond thereto and the automatic brake-control mechanism may be rendered inoperative.

The present invention is embodied in the system illustrated in the accompanying drawings in which:—

Fig. 1 is a diagram of a railway trackway installation adapted to impress radio-frequency current upon the rails of the track;

Fig. 2 is a diagram of a vehicle installation adapted to respond to the electro-magnetic flux impressed upon the rails by the installation shown in Fig. 1;

Fig. 3 is a diagram of a trackway installation designed to be connected to the last section of controlled track.

The present instrumentalities are comparatively simple and are designed for railways where substantial protection is desired at a minimum of expense. The usual three-block scheme of control is employed, that is, one signal on the locomotive, preferably a green lamp which may be termed the "clear" signal, indicates two blocks in advance unoccupied, another signal preferably a red lamp which may be termed the "danger" signal, indicates that the block in advance is occupied, and a forestalling key on the locomotive is operable to prevent the normal automatic application of the air brakes when the locomotive enters a block next in the rear of an occupied block. These two signals are used to indicate by alternate flashing that the locomotive is passing from controlled to non-controlled track, an installation being connected to the exit end of the controlled track to impress the current to which the locomotive instrumentalities respond upon the rails at short intervals of time so long as the rails to which it is connected are occupied.

The rails in Fig. 1 are shown divided into cut-sections by insulations 3, preferably at points about one-half mile apart, and these points may be indicated by the half mile markers 4 and mile markers 5. Two cut-sections constitute a block and a train-control station is located at the exit end of each block. Both cut-sections of each block receive the same radio-frequency current, the presence or absence of such current depending upon the occupancy of that block and on the occupancy of the next block ahead.

The instrumentalities embodying the present invention are designed to impress a current of predetermined wave length and frequency upon the rails of a block when the block in advance is unoccupied and to remain idle so as to impress no such current when the block in advance is occupied, so that a train entering a block next in the rear of an occupied block will detect no current in the rails. An open switch or broken rail in a block has the same effect as an occupying train upon the instrumentalities connected to the block next in the rear. The locomotives to be operated upon such controlled tracks are provided with means to pick up by induction electro-magnetic flux or force from the energized rails and to utilize such force to affect instrumentalities to control the operation of the air brakes and signals on such locomotives, and while any desired type of locomotive installation may be employed, Fig. 2 of the drawings shows one which is peculiarly adapted for the present purpose.

A transmission or control station is connected to the rails at the exit end of each block of controlled track, and the delivery or non-delivery of train-control current to the rails of each block is controlled in the first instance by current received over the wires 7 and 8 from the next station in advance, and in the second instance, by the occupancy of the block of the station itself, no control station being active or operative unless the block to which it is connected is occupied. A track battery 9 is connected to

the rails 1 and 2 at the exit end of the entrance cut-section A and a track battery 10 is connected to the entrance ends of the rails 11 and 12 of the other cut section B of the same block. Current from battery 9 normally energizes track relay 14 of the next station in the rear, while track relay 15 of the control station of any block is energized by the battery 10 of that block. Each of these track relays is short circuited when the cut-section to which it is connected is occupied.

The only movable parts of the installation shown in Fig. 1, and which will be termed station B, are the armatures of the several relays and will be designated by letters together with the reference numerals of their relays. If sections A and B were unoccupied, current would flow from battery 9 connected to rails 1 and 2 of section A to track relay 14 of the next station in the rear and cause its armatures *a* and *b* to close that end of the circuit to the adjacent relay 17. Current would then flow from battery 18 of station B over wires 19 and 20, armature 15^a, wire 22, relay 16, wire 7, armature 14^a of the next station in the rear, wire 23, relay 17, wire 24, armature 14^b, wire 8 to station B, armature 15^b and wire 25. This is the normal condition of the wayside circuit. When a locomotive enters cut-section A, it short circuits relay 14 at the station next in the rear and causes the circuit of wires 7 and 8 leading to station B to be opened, causing relay 16 of station B to become de-energized and further resulting in the dropping of armature 16^a and in the closing of the supply circuit for the generator of high frequency currents at station B.

When the train leaves section A, the circuit of wires 7 and 8 closes behind it but as it enters section B, it short circuits track relay 15 of station B which drops its armatures, thus opening the above described circuits so that control relay 16 cannot again be energized until the train leaves section B. Relay 17 at any station is therefore de-energized so long as either of the next two cut-sections in advance is occupied; track relay 15 is de-energized so long as the cut-section to which it is connected is occupied; and control relay 16 is de-energized so long as either of the cut-sections of the block in the rear is occupied.

A. C. current preferably of 110 volts, is supplied to the station from any suitable source by the line wire 27 adjustably connecting to the primary winding 36 of a transformer 28, and wire 29, armature *a* of relay 30 and line wire 31 connect the other end of this winding 36 to the current source. Relay 30 receives current from the battery 18 over wires 19 and 32 and connects to the other side of the battery by wires 34 and 33, armature 17^a (when the block in advance is unoccupied) wire 21, armature 16^a and wire 35,

so that so long as control relay 16 is de-energized A. C. current will flow to winding 36.

No current flows to the winding 36 of any station so long as the block to which the station belongs, is unoccupied, that is, so long as its control relay 16 is energized, nor so long as the block in advance is occupied.

Each station embodies two electron tubes, the oscillations of the output tube 40 being controlled by those of the master tube 41. As the construction of these tubes is well known, the details need not be described. The main transformer has three secondary windings 42, 43 and 44, and the current for the filament of tube 40 traverses the circuit including winding 42, connector 45 extending between the blocking condensers 46, winding 44 and wire 47, and back over wire 48. The current for the filament tube 41 traverses the right-end portion of winding 42, connector 45, left-end portion of winding 44, wire 49 and back over wire 50.

The plate current of tube 41 travels from the filament of this tube to the plate and thence over wire 52 to a tap on winding 43, while the plate current of tube 40 travels from the filament of that tube to the plate and thence over wire 53 to the end of winding 43. Choke coils 54 are inserted in these wires 52 and 53 to block the radio-frequency oscillations and force them through the condensers 55 and 56 as will be explained later on.

The oscillatory circuit which generates the train control currents is governed by an inductance 57 and condensers 58 and 59, between which the wire 60 attaches and this wire extends to the connector 45. A grid leak 61 and choke 62 connect wire 60 to wire 63 which terminates in the grid of the tube 41, and also connect to one end of the inductance 57 and to the condenser 58. The other end of the inductance 57 and the condenser 59 connect to the wire 64 which extends between the condenser 55 and a grid condenser 65 and thence through grid leak 66 to the grid of tube 40. It will thus be seen that the grid and plate of tube 41 are connected to the ends of the inductance 57 and condensers 58 and 59 whereby the tube 41 is caused to produce oscillations of a predetermined frequency, this being governed by the inductance 57 and the capacity of the condensers 58 and 59.

The plate output of tube 41 being impressed upon the grid of tube 40, the oscillations of tube 40 are governed by the plate output of tube 41, and therefore the plate output of this tube 40 is always of the same frequency as that of tube 41, and this is unaffected by any connections or conductors which may be attached to the plate circuit of tube 40. The plate output of tube 40 passes through condenser 56 to primary 68 of the output transformer 69 and thence over wire 67 to wire 60

terminating in conductor 45. The grid of tube 40 is properly biased through a leak 70 and choke 71 connecting to wire 67. Practical tests have demonstrated the advisability of using a tube 40 of fifty watts rating and a tube 41 of seven and one-half watts rating.

The output transformer 69 has two secondary output windings 73 and 74, the former connecting to the rails 11 and 12 of cut-section B by means of wires 75 and 76 and the latter to rails 1 and 2 of cut-section A by means of wires 77 and 78. As these wires 77 and 78 extend to the exit end of cut-section A, the step-down transformer 79 may be connected into these wires near such exit end of the rails 1 and 2 so that high-potential current of low amperage may be received from secondary winding 74 and be transformed to low potential and greater amperage at cut-section A, thus permitting the use of small wayside wires.

As stated before, the transformer 69 becomes operative as soon as cut-section A is occupied (providing the next block in advance is unoccupied) and this continues until both sections A and B are cleared. As soon as cut-section B is occupied there is no necessity of impressing current on rails 1 and 2 of section A, and a relay 81 is therefore installed to open and close the circuit between the winding 74 and these rails, the circuit to this relay being from battery 18 over wires 19 and 20; armature 15^a, wire 82 to relay 81 and over wires 83 and 33, armature 17^a, wire 21, armature 16^a and wire 35 to the battery. The connection of wire 83 to wire 33 instead of to wire 35 directly is to avoid energizing relay 81 when section A is unoccupied.

The locomotive installation intended to be controlled by track stations of the character above described embodies a green lamp which indicates proper current in the rails and a red lamp to indicate an absence of such current. But a failure of a track station will also result in the red lamp receiving current so that the locomotive crew could not determine whether the track in advance is occupied or whether the track station is inoperative. We therefore provide a signal lamp 85 at each station which lamp receives current whenever the block of said station is occupied and relay 30 is energized, such current passing over a circuit consisting of wires 27 and 86, lamp 85, wires 87 and 29, armature 30^a and wire 31.

While any desired instrumentalities may be installed on the locomotive, we prefer the simple mechanism illustrated in Fig. 2 of the drawings.

A receptor coil 91 and the circuit connected thereto are designed to develop potential by reason of the electro-magnetic flux or force at the rails of the controlled track received from the transformer 69. A receptor electron tube 92 and an operating tube 93 are connected into this circuit, and this operating

tube controls the opening and closing of electric circuits and the operation of the relays therein to govern the automatic operation of the air brakes of the locomotive or other vehicle equipped with the present installation.

The receptor coil 91 is preferably mounted on the leading truck of the locomotive near the rails so as to pass through the field of greatest electro-magnetic flux around the rails, and the filament circuits of the said tubes include a loop which extends down to and around the receptor coil so that, should the coil be torn from its mounting, the filament circuit will be broken.

The filaments of these tubes are energized by current from current source G, usually the headlight generator of the locomotive, and the current passes over wires 94 and 95, relay 96, wire 97, loop 98, wire 99, filament of tube 92, wire 100, filament of tube 93, wires 101, 102, 103 and 104. The plate current for both tubes is derived from a transformer or dynamotor 105 which is energized by current from the generator G over wires 94—106 and 107—103—104. The wire 108 extends from this dynamotor to the primary winding 109 of the transformer 110, and the plate of tube 92 connects to this winding by means of a switch 112 which is there inserted to permit testing. The filaments of both tubes are connected to the dynamotor by means of wires 100, 101 and 113, resistance 114, wire 115, resistance 116 and wire 117.

The receptor coil 91 connects to the adjustable condenser 118 by means of the wires 119 and 120. The wire 119 connects to the grid of the electron tube 92, while the wire 120 adjustably connects to the resistance 114 which connects to the negative end of the resistance 121 by means of wire 122. As the current in this receptor coil circuit is usually weak, the two electron tubes are made use of. If the current in the receptor coil circuit were sufficiently strong, the tube 93 might be dispensed with.

In order that the several instrumentalities of this installation may move to neutral or "danger" position should any breakage or failure occur, provisions are so made that the control relay 124 will function only when proper electro-magnetic conditions exist in the track rails and in the receptor circuit.

The resistance 121 connects to the positive side of the dynamotor by means of wire 108 and is of much greater resistance than that of resistances 114 and 116 combined. It therefore so influences resistance 114 that this may be considered as an extension of the negative end of resistance 121 in relation to the filaments. The plate of tube 92 connects to positive wire 108 as above described and the plate of tube 93 connects to this wire 108 by means of wire 125, control relay 124, wire 128, test switch 127 and wire 126, so that these plates are therefore positive relative to the

filaments of the tubes which connect to the negative wire 117 as above described.

The negative bias of potential is impressed upon the grid of tube 92 by reason of the wire 120 engaging the resistance 114 on the negative side of the filament connection 113, the circuit to this grid being over this wire 120, receptor coil 91 and wire 119. The electromagnetic flux around the track rail builds up an alternating potential in the receptor circuit which alternates at the frequency to which this receptor is tuned. This alternating potential acts on the grid of tube 92 to cause it to be first less negative and then more negative and this action causes the current in the plate circuit to increase and decrease in unison with the frequency impressed on the grid circuit. So long as direct current passes from filament to plate in tube 92, no current is induced in the secondary winding 129 of transformer 110, but when a potential is induced on the receptor circuit, it changes the bias on the grid of tube 92 so that the current passing from filament to plate of such tube is increased and decreased, resulting in an alternating current being induced in the secondary winding 129.

Negative bias is also present in the grid of tube 93, this bias being derived from the connection 115 between the resistances 114 and 116. So long as this bias continues constant in tube 93, its plate current is somewhat obstructed, but whenever the current in the plate circuit of tube 92 is varied, induced alternating current is set up in the secondary winding 129, the positive half thereof reducing the negative bias of the grid of tube 93, so that current may flow in the plate circuit of that tube and energize relay 124.

The usual grid leak 130 is connected into the grid circuit of tube 93, so that, if the secondary winding 129 burns out, the negative bias of potential of the grid of tube 93 is not affected thereby. Condensers 131 are positioned wherever necessary to by-pass and confine the radio-frequency currents to their proper circuits. A by-pass condenser 132 bridges across between the main positive wire 108 and the main negative wire 117 and a condenser 133 shunts the resistance 121.

When the receptor coil 91 intercepts electromagnetic flux of proper frequency, current in the circuit of the plate of tube 93 energizes relay 124, but when no such flux is intercepted this relay is de-energized and its armature drops. Fig. 2 shows the several armatures of the installation for "clear" track conditions.

Control relay 124, when energized, closes the circuit to relay 134 from positive wire 95 over wires 135 and 136, pneumatically controlled switch 137 (to be explained later) wires 138 and 139, relay 134, wire 140 and armature 124^a to negative wire 103.

Two electric signal lamps 141 and 142 are

mounted on the locomotive, being preferably green and red respectively, to indicate "clear" or "danger", and these lamps have a common wire 143 connecting to the wire 95. From lamp 141 the circuit is over wire 144, armature 134^a, wire 145 and lower part of forestalling key 146 to wire 103. This lamp therefore receives current only when relay 134 is energized.

An electro-pneumatic valve 150, of well known construction and commonly known as an E. P. valve, is adapted to cause reduction of the air pressure within the brake system and within the casing of this valve is a magnet 151 adapted to draw down its armature 152 from which a stem 153 extends down to the valve 154, which is normally held in its seat while the magnet is energized. The construction and operation of this E. P. valve and the parts controlled thereby are fully described in application Serial Number 153,258 filed by William L. Coop and Charles B. Stone on December 8, 1926, but the connection between that construction and the present system will be described briefly.

When a train is to be moved under "clear" conditions, at which time the E. P. valve is energized, the engineer swings the handle of his train valve to permit air to fill the train pipe and cause the release of the train pipe and release the brakes. This causes a slow accumulation of pressure within the chamber 155, which is connected to the train pipe, and in the upper part of the cylinder 156 above the piston 157. This train pipe pressure is less than the pressure within the main reservoir to which the pipe 158 connects, from which pipe 158 air flows into the cylinder 159 and through passage 160 into chamber 162. The pistons 163 and 164 in this cylinder connect to valve 165. The piston 157 in cylinder 156 is connected to valve 166 by stem 167, this valve 166 being normally closed, and a second cylinder 168 contains a piston 169 normally held up by a spring 170. The cylinder 168 is provided with openings 172 which are opened when the piston 169 is forced down. The stem 173 on the piston 169 is connected to the switch member 137 which normally bridges the wires 136 and 138. The E. P. valve connects directly to wire 135. Its return circuit normally consists of wire 147, armature 96^a, wire 148, key 149, wire 178, armature 134^b, wire 179 and key 146 to wire 103.

Whenever relay 134 is de-energized, armature 134^b falls and opens the normal circuit to the E. P. valve. When the magnet 151 of the E. P. valve is de-energized, air pressure in the chamber 162 lifts the valve 154 and permits air to flow from the cylinder 159 to the whistle 175 faster than the pipe 160 can replace it. The sound of the whistle indicates the de-energization of the E. P. valve. The now greater pressure in chamber 155 forces piston 164 to the right in Fig. 2, cutting off the connec-

tion between the train pipe and cylinder 156 and permitting the air therein to escape. This reduction of pressure above the piston 157 is slow, permitting the forestalling key 146 to be operated after the whistle 175 sounds, but finally the pressure in chamber 155 lifts the piston 157 and the valve 166 and then rushes down into cylinder 168, forcing down piston 169 below the holes 172 and thus relieving the train pipe pressure and causing the application of the brakes. This downward movement of piston 169 causes switch 137 to open the circuit to relay 134 which causes the circuit to the E. P. valve to also open at armature 134^b. The switch 137 remains open until the train pipe pressure falls so low that the spring 170 can move the piston 169 up against such pressure, but before this, the brakes will have been applied.

But should the forestalling key 146 be actuated as soon as the whistle sounds and before the piston 157 rises and the switch 137 opens, which may be from five to ten seconds, an auxiliary circuit to the E. P. valve is closed thereby, consisting of wires 94, 95, 135 and 136, switch 137, wires 138 and 139, slow acting relay 181, wire 182, key 146 and wires 103 and 104. But this cannot be done if the relay 181 has been de-energized by the opening of switch 137 until after the brakes have been applied and switch 137 again closed. Energized relay 181 attracts its armatures and holds them by reason of the current which is passing over this auxiliary circuit. When key 146 is returned to normal position, a stick circuit for this relay is closed consisting of the above described circuit to this relay and thence over wires 182 and 183, attracted armature 181^b, wire 184, dropped armature 134^b, wire 179 and key 146 to wire 103. At the same time an auxiliary circuit for the E. P. valve is closed over wire 147, armature 96^a, wire 148, key 149, attracted armature 181^a, wire 185 and dropped armature 134^a to wire 103.

When relay 134 is de-energized, the circuit for lamp 141 is opened by armature 134^c and the return wire 186 of red lamp 142 is connected by this armature to wire 145. The key 149 may be mounted at the front end of the locomotive so that it may be moved to open all the circuits by an inspector standing on the ground to test the brakes.

When relay 134 is de-energized, its armature *c* falls and closes the circuit for lamp 142 over wire 210, armature 134^c, wire 145, and key 146 to wire 103. This circuit is opened when the forestalling key is actuated. When the locomotive enters non-controlled trackway, this key must be actuated and left in actuated position to close the circuit between wires 182 and 103 which prevents the application of the brakes until relay 134 is again energized which is indicated by whistle 175 after which the key must be at once moved to normal position.

In Fig. 3 we have shown an installation here termed station C, connected to the rails 191 and 192 of the last controlled section, this installation being adapted to intermittently impress upon these rails radio-frequency current of the same wave length as the station shown in Fig. 1. The transformer 28, the electron tubes 40 and 41 and the parts connected thereto which correspond to those of station B shown in Fig. 1 are designated with the same reference characters and have the same functions. The output transformer 69 of station C has only one secondary winding 74 as the rails 191 and 192 constitute one section and the track battery 9 energizes the relay 14 of the next station in the rear when this last controlled section is unoccupied. Fig. 3 shows this section occupied by a train T, and the relay 16 of this rail section C is therefore de-energized. When block C is unoccupied current flows from battery 18^c over wires 195 and 8, armature 14^b at station B, wire 24, relay 17, wire 23, armature 14^a, wire 7, relay 16 at station C and thence to battery 18^c, armature 16^a at station C being attracted to open the circuit to relay 194. But when block C is occupied, the circuit just described is opened by armatures 14^a and 14^b at station B. When the circuit to relay 194 is opened, its armature drops and closes the circuit over wire 195, armature 16^a, wire 196, armature 194^a, wire 197, relay 193 and wire 199. Energized relay 193 then closes the circuit consisting of wire 200, armature 193^a, wire 201, relay 194, and wire 199, which energizes relay 194 and causes it to attract its armature and open the circuit to relay 193 and again open the circuit to relay 194.

While the armatures of the slow-action relays 193 and 194 are in the positions shown, current flows from battery 18 of station C over wire 195, armature 16^a, wire 196, armature 194^a, wire 32, relay 30, wire 34, to the battery, relay 30 being energized and causing its armature to connect wires 31 and 29 which results in the radio-frequency current passing to the rails of section C over wires 77 and 78.

But the circuit to relay 194 has just been broken and after a few seconds, this relay becomes de-energized and again drops its armature, opening the circuit to relay 30 which causes the transmission of this radio-frequency current to stop. Current now flows from wire 196 over armature 194^a, wire 197, relay 193, and wires 198 and 199 to the battery, relay 193 being energized thereby and attracting its armature to close the new circuit for relay 194 consisting of wires 195, armature 16^a, wires 196 and 200, armature 193^a, wire 201, relay 194, and wire 199 back to the battery. When relay 194 again becomes energized, the time required depending upon its construction, it will again attract its armature *a* and again break the circuit which carries current to

relay 193. This relay 193 is sufficiently slow to hold its armature during the time required for armature 194^a to move from one of its positions to the other, while relay 194 is constructed to hold its magnetism during the length of time desired for impressing radio-frequency current on the rails of section C.

The lamps 141 and 142 on the locomotive will therefore flash while the vehicle travels section C and notify the engineer that he is passing out of controlled territory. These time intervals are too short to permit the application of the brakes through the opening of valve 166. As soon as the flashing of the lamps stops and the whistle 175 sounds, which occurs when the locomotive enters non-controlled section D, the engineer actuates his key 146 and the locomotive proceeds as if no automatic brake-control mechanism were installed until the receptor coil 91 again picks up proper current.

Should the engineer tie down the key 146 while relays 124 and 134 are de-energized, the automatic brake control would be inoperative, current flowing over wires 94, 95, 135, and 136, switch 137, wires 138 and 139, relay 181, wire 182, depressed key 146, and wires 103 and 104. Energized relay 181 closes the circuit for the E. P. valve over wires 94, 95, 135, winding 151, wire 147, armature 96^a, wire 148, key 149, armature 181^a, wire 185 dropped armature 134^a, and wires 103 and 104. But this circuit to the E. P. valve is opened when relay 134 is energized so that should the key be tied down, the train would be brought to a stop as soon as the receptor coil picks up current.

We claim:—

1. In a control system for railway trains, a track divided in part into blocks, a source of current, means connected to each block for transforming said current into radio-frequency current of a predetermined wave length and to impress the same on the rails of such block, and means responsive to the presence of a train in one of the blocks to

cause such radio-frequency current to be conducted to such block intermittently.

2. In a control system for railway trains, a track divided in part into blocks, a source of current, means connected to each block for transforming said current into radio-frequency current of a predetermined wave length and to impress the same on the rails of such block, and means responsive to the presence of a train on the rails of one of such blocks to cause the transformer connected thereto to operate intermittently.

3. In a control system for railway trains, a track divided into blocks, a radio-frequency current generator connected to the exit end of each block, two control relays adjacent each generator and current sources for said relays, one of said relays being adapted when energized to hold open the supply circuit for the generator and the other adapted when de-energized to hold open said circuit, said first named relay being short circuited by a vehicle occupying the block to which the generator is connected and the second relay being short circuited when the block next in advance is occupied.

4. In a control system for railway trains, a track divided into blocks, a radio-frequency current generator connected to the exit end of each block, two control relays adjacent each generator and current sources for said relays, one of said relays being adapted when energized to hold open the supply circuit for the generator and the other adapted when de-energized to hold open said circuit, said first named relay being short circuited by a vehicle occupying the block to which the generator is connected and the second relay being short circuited when the block next in advance is occupied, and an electric signal and circuits connecting it to the current supply of the transformer and receiving current therefrom simultaneously with the transformer.

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