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TRAIN CONTROL SYSTEM

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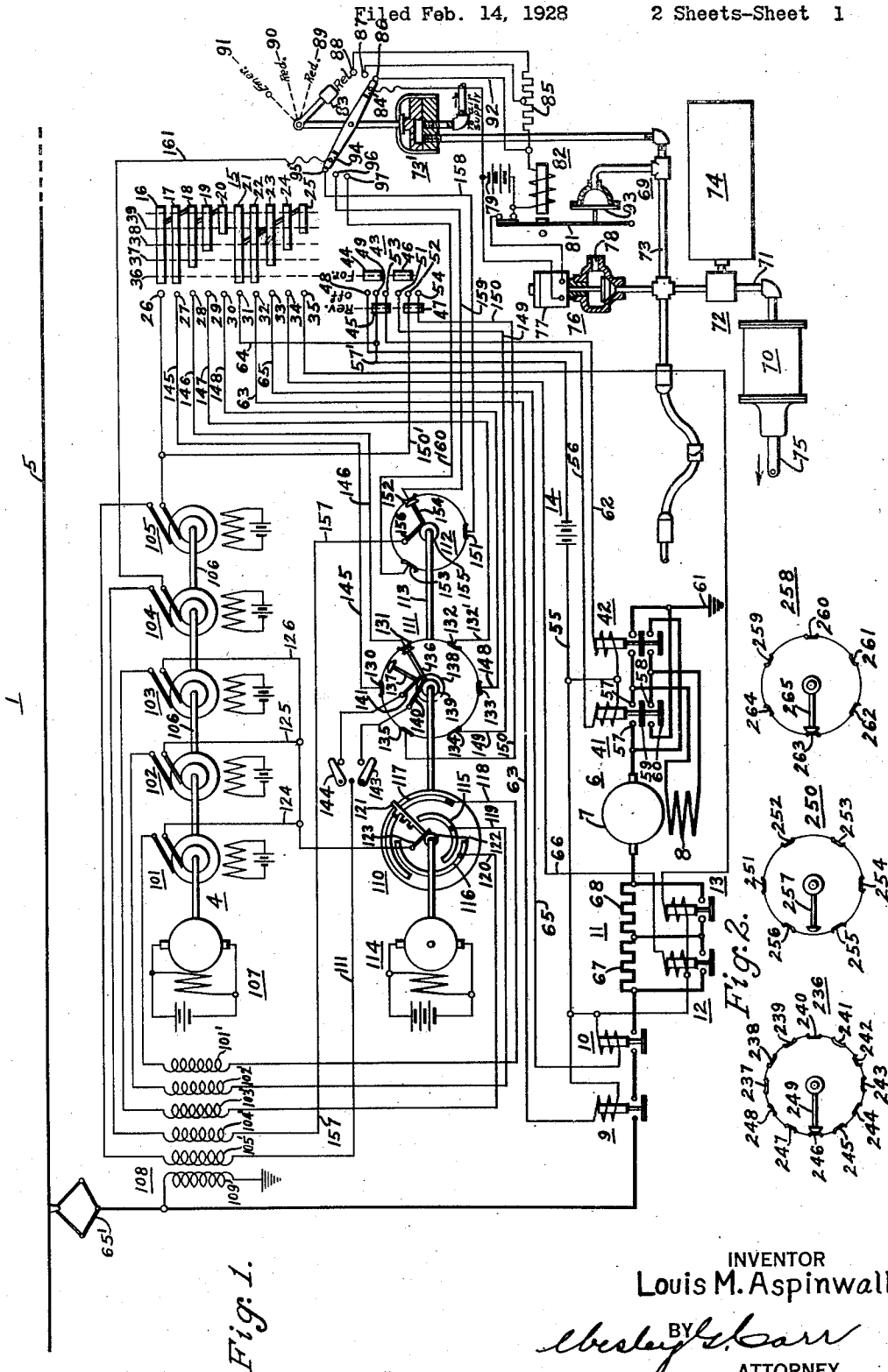


Fig. 1.

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TRAIN-CONTROL SYSTEM

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This invention relates to control systems and particularly to carrier-current control systems for motor vehicles.

The object of the invention, generally stated, is the provision of a control system for electric-energy translating devices that shall be simple and efficient in operation, and easily manufactured and installed.

A more specific object of the invention is to provide for the control of a plurality of locomotives from a selected locomotive where the provision of a train-line conductor is not practical.

A further object of the invention is to provide for transmitting currents of predetermined frequencies from a selected locomotive to other locomotives and utilizing the transmitted currents to operate different control mechanisms which may be made responsive to currents of predetermined frequencies, thereby to effect the operation of the other locomotives in accordance with any requirements.

A still further object of the invention is to provide for the utilization of electric currents of different frequencies to control one locomotive from another.

Another object of the invention is to provide for the utilization of alternating currents of different frequencies to selectively control one or more of a plurality of locomotives from a selected locomotive.

A still further object of the invention is to provide for the synchronous operation of motors located at different points in a train.

And a still further object of the invention is to provide for initiating pneumatic braking on long trains at selected points in the train simultaneously.

Other objects of the invention will, in part, be obvious and will, in part, appear hereinafter.

The invention is disclosed in the embodiment thereof shown in the accompanying drawing and comprises the structural features, the combination of elements and arrangement of parts, that will be exemplified in the structure hereinafter set forth, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature

and objects of the invention, reference may be had to the following description, taken in conjunction with the accompanying drawing, in which

Figure 1 is a diagrammatic view of circuits and apparatus for controlling the operation of a motor vehicle, and sending out currents of different frequencies, arranged in accordance with the invention;

Fig. 2 is a diagrammatic view of a modified form of selector switches embodied in the apparatus of Fig. 1; and

Figs. 3 and 4 are diagrammatic views of circuits and apparatus constructed in accordance with the invention to receive the currents delivered by the apparatus shown in Fig. 1 and to effect the operation of the control apparatus of other locomotives.

In railway transportation systems, it is frequently the practice to provide long freight trains with a plurality of locomotives which are generally located at the front and the rear of the train. In steam practice, each locomotive is provided with an engineer or operator for operating the locomotive. However, in electric-railway transportation systems, multiple-unit locomotives or other motor vehicles may be controlled from one locomotive through a master controller by connecting the control apparatus of each locomotive to the master controller by means of a plurality of train-line conductors.

If it were possible to distribute a number of small locomotives throughout a long freight train and control them from the leading or a selected locomotive, instead of employing one or two units of large capacity at the ends of the train, as at present, a number of practical advantages would be obtained.

Some of these advantages would be reduction in draw bar stresses, both in accelerating and braking; reduction in concentrated weight on the road bed and the use of small light locomotives which could be manufactured cheaply in quantities.

Since it is impracticable, economically, to equip all freight cars with train-line conductors, whereby the control apparatus of each locomotive may be controlled by a mas-

ter controller from a selected locomotive, it is evident that some other form of control must be evolved.

In the present embodiment of the invention, a train-control system is provided whereby unison operation of a plurality of motor vehicles or locomotives 1, 2 and 3 (see Figs. 1, 3 and 4) may be effected without the use of train-line conductors, and from a selected locomotive, which for purposes of illustration, will be the locomotive 1.

In order that the description of the construction and operation of this particular embodiment of the invention, may be simplified, only the locomotive 1 will be illustrated as provided with means for sending currents of different frequencies whereby the operation of any one or both of the locomotives 2 and 3 may be controlled. It is to be understood however, that, in practice, each of the locomotives 1, 2 and 3 may be provided with the same sending and receiving control apparatus in order that any one of them may be utilized as the leading or the selected locomotive. Therefore, in practice, each locomotive will be provided with transmitting and receiving apparatus.

Unison operation of the locomotives may be effected by providing the locomotive 1 with a source 4 of alternating currents of different frequencies and means, to be hereinafter set forth in detail, for delivering these currents to a trolley conductor 5 at predetermined regular intervals, and by providing the locomotives 2 and 3 with apparatus, to be hereinafter set forth in detail, for receiving and distributing the currents to actuate control apparatus on the locomotives 2 and 3.

As shown in Fig. 1 of the drawings, the selected locomotive 1 is provided with a propelling motor 6 of any suitable type. The particular motor illustrated is a series motor having an armature 7 and a field winding 8 that may be connected to the trolley conductor 5, by means of line switches 9 and 10.

As is the usual practice, the motor 6 may be provided with an accelerating resistor 11 that is connected in series with the motor armature when the line switches 9 and 10 have been closed. In order that the resistor 11 may be gradually shunted out of the armature circuit, as the motor speed increases, to obtain a uniform tractive effort from the motor during its accelerating period, resistor short-circuiting switches 12 and 13 may be provided.

The line switches and the resistor-short-circuiting switches may be actuated from a battery 14 or any other suitable source of power and the sequence of operation controlled by a master controller 15. The master controller is provided with two groups of electrically connected contact segments 16 to 20, inclusive, and 21 to 25, inclusive, respectively, the latter group of segments being

utilized for controlling the sequence of operation of the switches 9, 10, 12 and 13. The contact segments 16 to 20, inclusive, may be utilized for controlling other control apparatus to be hereinafter set forth in detail.

As shown, the contact segments 16 to 20, inclusive, are positioned to engage stationary contact fingers 26 to 30, inclusive, and the contact segments 21 to 25, are positioned to engage contact fingers 31 to 35, inclusive, as the master controller 15 is successively set in the positions 36 to 39, inclusive.

While the controller 15 has been shown as comprising two separate groups of contact segments and fingers, it is to be understood that, in practice, one group may suffice.

In order that the motor armature may be rotated in either direction, switches 41 and 42 are provided for controlling the direction of flow of the current through the field winding 8. The switches 41 and 42 may be controlled by an auxiliary or "reverse" drum controller 43 and operated from the battery 14. The controller 43 comprises contact segments 44, 45, 46 and 47, inclusive. The contact segments 44 and 46 of the controller 43 are positioned to bridge the pairs of contact fingers 48 and 49 and 51 and 52, respectively, when the controller 43 is in the "forward" position, and the contact segments 45 and 47 are disposed to bridge the contact fingers 49 and 53 and 52 and 54, respectively, when the controller 43 is in the "reverse" position.

Assuming that it is desired to propel the locomotive 1 in the forward direction, then the auxiliary controller 43 is actuated to the position "forward", in which position the contact fingers 48 and 49 are bridged by the contact segment 44. When the controller is in this position, current flows from the battery 14 through conductor 55, the actuating coil of the switch 41, conductor 56, contact fingers 48 and 49, bridged by contact segment 44, and conductor 57' back to the battery 14. Therefore, the switch 41 is closed and contact fingers 57 and 58 are engaged by contact-bridging members 59 and 60, respectively, whereby the field winding 8 is connected between the armature 7 and ground at 61.

If the locomotive is to be propelled in the reverse direction, then the controller 43 is set in the "reverse" position and current flows from the battery 14 through the operating coil of switch 42, conductor 62, contact fingers 49 and 53 bridged by contact segment 45, and conductor 57 back to the battery. Therefore, the switch 42 is closed and the connections of the field winding 8 between the armature 7 and ground at 61 are reversed with respect to the connections established when the switch 41 is closed.

When the field winding 8 has been connected for the forward propulsion of the locomotive, the master controller 15 is set

in position 37. A circuit is then established that extends from the battery 14 through conductor 55, the actuating coil of switch 9, conductor 63, contact fingers 32 and 31 bridged by contact segments 22 and 21, and conductors 64 and 57 to the battery 14. Another circuit extends from the battery 14, through conductor 55, the actuating coil of the switch 10, conductor 65, contact fingers 33 and 31 bridged by segments 23, 22 and 21, and conductors 64 and 57, to the battery 14.

Therefore, switches 9 and 10 are closed, and the motor circuit is established to extend from the trolley conductor 5, through the pantograph 65', switches 9 and 10, resistor 11, armature winding 7, switch 41 and field winding 8, to ground at 61.

In order to accelerate the motor 6 to its full running speed, the controller 15 is actuated to positions 38 and 39 successively, whereby energizing circuits for the actuating coils of the switches 12 and 13 are established. When the coils have been energized, the switches are closed to short-circuit different sections 67 and 68 of the resistor 11. In this manner, full voltage is supplied to the motor to bring it to its maximum speed.

In order to decelerate the locomotive 1, a pneumatic or air brake system 69 is provided, the master controller being first returned to its "off" position before braking is initiated in the usual manner. The details and construction of the air-brake system 69 is disclosed and claimed in my copending application, Serial No. 167,906, filed February 14, 1927.

In this instance, a brake cylinder 70 is provided for actuating a brake shoe (not shown). The brake cylinder is connected, by a pipe 71, through a triple valve 72, to a brake pipe 73. The triple valve 72 is connected also to an air reservoir 74 that receives its supply of air from the brake pipe 73 which, in turn, may be supplied with air through an engineer's brake valve 73' at a predetermined pressure, from any suitable source of air supply, such as a compressor (not shown).

As is the usual practice in air-brake systems, the application of the brakes may be effected by reducing the air pressure in the brake pipe 73. Upon a reduction in brake-pipe pressure, a piston rod 75 is moved out of the cylinder 70 in the direction indicated by an arrow in Fig. 1.

The reduction in brake-pipe pressure may be effected by an electromagnetically operable valve 76, illustrated partially in section in the drawing. The valve 76 is preferably of the type that is biased towards an open position but which may be held closed by a solenoid 77.

When the brake-pipe pressure is reduced, responsive to an opening of the valve 76,

the triple valve 72 operates to connect the air reservoir to the brake cylinder 70 and to disconnect it from the brake pipe. Assuming that the valve 76 is closed, the brake-pipe pressure increases, causing the triple valve to disconnect the air reservoir 74 from the brake cylinder 70 and to connect it to the brake pipe 73 and, at the same time, permitting air in the brake cylinder 70 to escape to the atmosphere.

In order to maintain the brakes in a released position, the solenoid of the valve 76 must be maintained energized in order that the valve may be closed to prevent discharge of air from the brake pipe 73, through an opening 78 in the valve, to the atmosphere.

The solenoid 77 may be energized from a battery 79 or other source of supply of electrical energy, through a movable switch arm 81, that is held normally in the position shown in Fig. 1 of the drawings, by a solenoid 82. The energization of the solenoid 82 is controlled by a brake handle 83 that is utilized for actuating a switch blade 84 and the valve 73', and a resistor 85. The switch blade is positioned to engage contact fingers 86 to 88, inclusive, as the handle is moved successively from position "release" through positions "89" and "90" respectively.

When the switch handle is in the "release" position, the switch blade 84 engages the contact finger 86, and current flows from the battery 79, through the coil of the solenoid 82, conductor 92, contact finger 86 and the switch blade 84, back to the battery 79. Therefore, the solenoid is energized and at its greatest strength to cause the switch arm 81 to be maintained in the position shown, against the restraining force of a diaphragm 93, which may be directly subjected to the air pressure in the brake pipe 73. It is to be noted also that, when the brake handle 83 is in its "release" position, the valve 73' is set to admit air to the brake pipe 73.

The switch handle 83 may be utilized also for actuating a switch blade 94 that is insulated from the switch blade 84. The switch blade 94 is positioned to engage contact fingers 95 to 97, inclusive, as the handle 83 is moved through positions 89 to 91, inclusive. The purpose of the switch blade 94 and the contact fingers 97 to 95, inclusive, will be set forth in detail hereinafter.

If it is desired to make a light application of the brakes, the air pressure in the train line is reduced a predetermined amount. For purposes of illustration, it may be assumed that the normal air pressure in the brake pipe 73 is 75 pounds per square inch, and that, when the pressure in the brake pipe is reduced to 70 pounds per square inch, a light application of the brakes is made.

In order to effect this reduction in air pressure in the brake pipe, the brake handle 83 is moved to the position 90, in which posi-

tion the switch blade 84 engages contact finger 87, and the engineer's valve 73' operates to cut off the brake pipe 73 from the source of air supply. Therefore, a section of the resistor 85 is included in series-circuit relation with the coil of the solenoid 82 and its magnetic pull is reduced in proportion to the reduction in current in the solenoid winding.

Since the magnetic pull exerted by the solenoid 82 on the arm 81 is reduced, the pressure exerted by the diaphragm 93 against the switch arm is sufficient to open the circuit of the solenoid 77 of the valve 76. When the solenoid 77 is deenergized, the valve 76 opens to permit air from the brake pipe to escape to the atmosphere. The triple valve 72 operates in response to the reduction in air pressure to cause air from the reservoir 74 to be admitted to the brake cylinder 70 at a pressure of approximately 5 pounds per square inch.

However, when the pressure has been reduced to 70 pounds per square inch in the brake pipe, the strength of the solenoid 82 is of such value that the switch arm 81 is actuated to the position shown in the drawings, against the resistance of the diaphragm 93. When the arm 81 is in this position, a circuit is established that extends from the battery through the solenoid 77 and contact fingers 81'—bridged by the arm 81—back to the battery. Therefore, the valve 76 is closed to prevent further escape of air from the brake pipe.

When increased braking is desired, the air-brake handle 83 is actuated to position 90, and current flows from the battery 79, through the solenoid 84, resistor 87, switch blade 86 and contact finger 88, to the battery. Since the magnetic pull of the solenoid has been reduced by reason of the increase in resistance of its circuit, the pressure in the brake pipe is reduced to a lesser value, and the air pressure applied to the brake cylinder is increased correspondingly. So long as the switch blade 84 engages the contact finger 88, this higher pressure will be maintained in the brake cylinder, as stated hereinbefore.

In the event that it may be desirable to reduce the braking effort to the light application, the brake handle 83 may be returned to its release position for a moment, in order to restore the pressure in the brake pipe 73 to normal, and then set in the position 89.

If emergency braking is desired, the handle 83 is set in the "emergency" position. In this position, the solenoid 82 is completely deenergized, also the solenoid 77. Therefore, the valve 76 is opened and the pressure in the brake pipe 73 reduced to atmospheric, wherefore the triple valve 72 is caused to operate to admit air from the reservoir 74

to the brake cylinder at full equalization pressure.

In the interest of simplicity in illustration and description, apparatus for effecting only three steps of air-braking have been shown. However, it is to be understood that any number of steps may be provided.

In order that locomotives 2 and 3 may be controlled in unison with the locomotive 1, and in response to the actuation of the controller 15 to its different positions, the locomotive 1 is provided with a source of power 4 for generating alternating currents of different frequencies, as hereinbefore set forth, and means for delivering impulses of different frequencies to the trolley conductor 5 to be transmitted to responsive control apparatus on the locomotives 2 and 3.

As shown, the source of power 4 comprises alternating-current generators 101 to 105, inclusive, which may be driven through a shaft 106 by a motor 107 of any suitable type. One terminal of each of the generators 101 to 105, inclusive, is connected to a terminal of separate primary transformer winding 101' to 105', inclusive, of a transformer 108 which is also provided with a single secondary winding 109. The secondary winding, as shown, is connected between the pantograph 65 and ground at 61.

While the transformer 108 has been shown as comprising a plurality of primary windings and a single secondary winding, it is to be understood that individual transformers, each having primary and secondary windings, may be utilized, if desired.

In order that the secondary winding 109 of the transformer 108 may be energized to supply the trolley conductor 105 with electrical impulses, a frequency distributor 110 and selector switches 111 and 112 are provided. As shown, the frequency distributor and the selector switches are mounted on a common shaft 113 which may be driven by a motor 114 at a predetermined speed, for example, 120 revolutions per minute.

The frequency distributor is provided with a plurality of arcuate contact segments 115 to 117, inclusive, to which terminals 118 to 120, inclusive, of the respective transformer windings 101' to 103' are connected. The distributor 110 is provided also with a rotatable contact arm 121 having brushes thereon so positioned as to make contact with the segments 115 to 117, inclusive, respectively, when the arm rotates with the shaft 113. The contact arm 121 is provided with a slip ring 122 and a brush 123 which is connected to terminals 124, 125 and 126 of the generators 101 to 103, respectively, whereby the transformer windings 101' to 103' may be successively energized as the arm rotates. As shown in Fig. 1, the contact segments 115 to 117 are of such lengths and so positioned, one with respect to another, that the primary

windings 101' to 103', inclusive, are energized from the generators 101 to 103 in a predetermined order and sequence.

Assuming that the contact arm 121 is in the position shown in Fig. 1 of the drawings and that it is rotating in a clockwise direction, the voltage of generators 101 to 103, inclusive, will be impressed upon the transformer windings 101', 102' and 103' in the following order: Voltage of generator 103, voltages of generators 103 and 102, voltage of generator 102, voltages of generators 102 and 101, voltage of generator 101 and voltages of generators 101 and 103, and so on.

Therefore, since the frequency distributor 110 is driven at a substantially constant speed, the trolley conductor 5 will have the voltages and frequencies of generators 101 to 103 impressed thereon at predetermined regular intervals for energizing electro-responsive devices on locomotives 2 and 3, to be hereinafter set forth in detail.

By means of the rotary selector switches 111 and 112, the generators 104 and 105 are connected to the primary windings 104' and 105', respectively at predetermined regular intervals, and the number of impulses supplied to the windings is controlled by the controller 15.

As shown, the selector switch 111 comprises, in general, a plurality of stationary contact fingers 130 to 135, inclusive, and rotating contact arms 136 and 137 mounted on the shaft 113. The contact arms may be provided with slip rings 138 and 139 and brushes 140 and 141 that may be selectively connected to the winding 104' by switches 143 and 144, respectively.

The contact fingers 130 to 133, inclusive, are connected to the contact fingers 27 to 30, inclusive, of the controller 15 by conductors 145 to 148, inclusive, and contact fingers 135 and 134 are connected by conductors 149 and 150 to contact fingers 47 and 51, respectively, of the reverse drum-controller 43. The contact finger 53 of the controller 43 is connected, by a conductor 150', to one terminal of the generator 105 which is also connected to the contact finger 26 of the controller 15.

When the controller 15 is set in the position 36, the contact fingers 26 and 27 are bridged by contact segments 16 and 17. Therefore, if the switch 143 is closed, the generator 105 is connected to the transformer winding 105' once each revolution of the contact arm 136; that is, each time the contact arm 136 engages the contact finger 130. If the controller 15 is set in the position 39, the contact fingers 130 to 134, inclusive, are connected in circuit with the generator 105 once each revolution of the contact arm 136.

Since there are five contact fingers on the selector switch 11, contact finger 135, being connected only when the reverse drum-controller 43 is in its "reverse" position, the gen-

erator 105 will supply five impulses to the transformer winding 105' per revolution of the contact arm 136. If the switch 144 is closed, the generator 105 will supply 10 impulses of electric current to the winding 105' per revolution of the selector switch.

As one terminal of the generator 105 is connected to contact finger 26 of the controller 15 and contact finger 52 of the controller 43, it will be evident that, if the controller 43 is in its forward position, for example, and the controller 15 is actuated from positions 36 to 40, inclusive, the number of impulses of electric current supplied to the trolley conductor 5 from the generator 105 may be controlled in accordance with the position of the controller 15.

While only six contact fingers and two contact arms have been illustrated as constituting the selector switch 111, it is to be understood that the number of contact arms and fingers will be determined by the number of impulses it is desired to supply to the trolley conductor 5. The impulses supplied by the generator 105 may be utilized by apparatus on locomotives 2 and 3 for controlling their operation in a manner to be hereinafter set forth in detail.

The selector switch 112 is similar to the selector switch 111 and comprises, in general, stationary contact fingers 151, 152 and 153, and a contact arm 154 mounted on the shaft 113. The contact arm 154 is provided with a slip ring 155 and a brush 156 for connecting it to a terminal 157 of the transformer winding 104'.

The contacts segments 151 to 153, inclusive, are connected to the stationary contact fingers 95 to 97, inclusive, of the air-brake controller by conductors 158, 159 and 160, respectively, and the switch blade 94 of the controller is connected by a conductor 161 to one terminal of the generator 104. Therefore, when the switch blade 94 is in the "release" position (see Fig. 1), the generator 104 supplies one electrical impulse to the trolley conductor 5 through the transformer 104' per revolution of the contact arm 154. As the brake handle 83 is set in the respective positions 89 and 90, the number of impulses supplied by the generator 104 to transformer winding 104' and to the trolley conductor 5 do not change because only one of the contact fingers of the brake controller is connected to the generator in any of its controlling positions.

While only one contact arm and three contact fingers have been illustrated, as constituting the switch 112, the number of contact fingers and arms may be varied, depending upon the number of electro-responsive devices to be controlled on locomotives 2 and 3.

Since the locomotives 2 and 3 of Figs. 3 and 4 are substantially identical in construction and operation, only the locomotive 2 and such

apparatus on locomotive 3 as differs from that of the former will be described.

By applying like reference characters to like apparatus in Fig. 4, the description of the operation and the construction of the locomotive 2 will suffice for the description and operation of the locomotive 3.

As shown in Fig. 3, the locomotive 2 is provided with a motor 162 having an armature winding 163 and a series field winding 164 that is adapted to be connected, for energization, to the trolley conductor 5. The motor 162 is provided with line switches 165 and 166, an accelerating resistor 167, resistor short-circuiting switches 168 and 169 and field forwarding and reversing switches 171 and 172, respectively, for connecting the motor to the trolley 5 through a conductor 173 and a pantograph 174.

When the line switches 165 and 166 and the "forward" field-controlling switch 171 are in a circuit-closing position, a circuit is established from the trolley conductor 5 through the pantograph 174, conductor 173, line switches 165 and 166, resistor 167, motor armature 163, contact fingers 175, bridged by contact-bridging member 176, field winding 164 and contact fingers 177—bridged by contact-bridging member 178—to ground at 179.

As the motor accelerates, switches 168 and 169 are closed successively to short circuit the various sections of the resistor 167 in order that full voltage may be applied to the motor in a manner well-known in the art.

The switches 165, 166, 168, 169, 171 and 172 are of a type which close very quickly and open slowly. As switches of this type are well known in the art, a description of their construction will not be given. In Figs. 3 and 4, these switches are illustrated with dash pots 180 attached in order to indicate that they are of this type, but it is not intended to restrict the system in any way to the use of this form of construction. With any suitable form of construction which delays the action of opening, the coils of the switches need be energized only at predetermined intervals to maintain the switches closed. That is, the switches may have a time-delay characteristic such that, if the coils are energized twice per second, the switches will remain closed, but, if the coils are energized less frequently, the switches will be released to an open-circuit position after a predetermined length of time.

The coils of the switches 165 to 172, inclusive, are tuned to be responsive to the current frequency supplied to the trolley by the arm 134 of the selector switch 114 from the generator 105. The means for receiving and distributing these impulses to the coils of the switches will be hereinafter set forth in detail.

Where air-brake systems are employed for decelerating long trains, particularly freight trains, it has been found that the time at

which the brakes are applied varies slightly in different parts of the train when braking is initiated at only one point. This difference of time is frequently sufficient to cause violent stresses in the draft gear and sometimes the breaking of the train into sections, or the wreckage of cars.

With locomotives distributed throughout the train, it is possible, with the air-brake system here disclosed, to initiate braking simultaneously at a number of points, thus insuring more uniform braking action and greatly reducing the stresses at the draw bars.

With this point in view, the locomotives 2 and 3 are provided with air-brake apparatus that is controlled by the brake handle 83 of locomotive 1 whereby the air pressure in the brake pipe 73 on locomotives 2 and 3 may be controlled simultaneously with that in the brake pipe at locomotive 1.

The air-brake apparatus on locomotives 2 and 3 is substantially identical in construction and operation to that of locomotive 1, with the exception that switches 181 to 183, inclusive, are provided for controlling the circuit of the solenoid 82. These switches may be controlled in response to actuation of the air-brake handle 83 of locomotive, in a manner to be hereinafter set forth.

As shown, the switches 181 to 183, inclusive, are provided with dash pots 184 or similar appliances in order that they shall remain in a circuit-closed position for a predetermined length of time after their respective operating coils have been deenergized. The characteristic of the dash pots, as hereinbefore stated, are such that the switches will remain closed, provided the operating coils are energized a predetermined number of times per unit of time, for example, twice per second.

While the switches 181 to 183 have been provided with dash pots in order to delay their return to open-circuit position in response to deenergization of their respective operating coils, it is to be understood that other time-delay switches may be utilized for performing the same operations, if desired. As shown, the switch 181 is normally energized and held in a circuit-closed position when the air-brake handle 83 is in the position shown in Fig. 1 of the drawings.

The operating coils of the switches 181 to 183, inclusive, are tuned to be responsive to electrical impulses of the frequency supplied to the trolley conductor 5 by the generator 104, the particular coils to be energized being controlled by means of the air-brake handle 83 and the selector switch 112.

Since the operation of the air-brake system has been previously described herein, it is believed that further description thereof is unnecessary.

In order that the electrical impulses sup-

plied to the trolley conductor 5 from the generators 101 to 105, inclusive, may be received from the trolley conductor and distributed to the relays of the locomotives 2 and 3, a transformer 185, having primary and secondary windings 186 and 187, and rotary selector switches 188, 188' and 190 are provided.

The selector switch 188 comprises stationary contact fingers 192 to 197, inclusive, and a rotatable contact arm 198 mounted on the shaft 199. The contact arm is provided with a slip ring and a brush for connecting the arm to a bus conductor 200 of the transformer winding 187.

The selector switch 188' (see Fig. 4) is provided with a rotating contact arm 198' that is displaced from the arm 198 of the switch 188 at a predetermined angle and in a counter-clockwise direction. It is to be noted that the arms 198 and 198' occupy the same angular position as the respective arms 136 and 137 of the switch 111. The stationary contact fingers of the switches 188 and 188' occupy the same angular position as corresponding stationary contact fingers of switch 111 and perform the same functions; therefore, the contact fingers of both switches 188 and 188' have been designated by the same reference numerals.

As will be seen by reference to the drawings, one terminal of the respective operating coils of the switches 165 to 172, inclusive, is connected to one of the contact fingers 192 to 197, inclusive, of the selector switch 188 by conductors 201 to 206.

The other terminals of the operating coils of the switches 165 to 172, inclusive, are connected to a common bus conductor 207 which is connected, by a conductor 208, to a bus conductor 209. As shown, the transformer winding 187 is connected across the bus conductors 200 and 209.

In order that the operating coils of the switches 164 to 172 may be responsive only to the currents supplied to the trolley conductor 5 by the generator 105, condensers 210 are provided in circuit with the brushes 198 and 198' of the selector switches 188 and 188'. The capacity of the condensers is such that the circuit comprising the transformer winding 187 and the operating coils of the switches are tuned to the frequency of the currents supplied by the generator 105.

The selector switch 190 of locomotives 2 and 3 is provided with stationary contact fingers 211 to 213, inclusive, and a contact arm 214 mounted on the shaft 199. The contact arm may be connected to the bus 200 of the transformer winding 187 by a slip ring 215 and a brush 216.

As shown, one terminal of each of the operating coils of the switches 181 to 183, inclusive, is connected to the respective contact fingers 211 to 213 by conductors 217, 218 and 219. The other terminals of the operat-

ing coils of these switches are connected to the bus 209 of the transformer winding 187.

In order that the operating coils of the switches 181 to 183 may be responsive only to alternating currents of the frequency generated by the generator 104, a condenser 220 is connected between the brush 216 and the bus 200.

As shown in the drawing, the contact arms 198 and 198' of the selector switches 188 and 188' (see Fig. 3) occupy the same angular positions as the contact arms 136 and 137 of the selector switch 111 (see Fig. 1), and the contact arm 214 of the selector switch 190 (see Figs. 3 and 4) occupy the same angular positions as the contact arm 154 of the selector switch 112 shown in Fig. 1. In order that the contact arms of the selector switches on locomotives 2 and 3 may be caused to rotate in the same angular direction and in synchronism with the contact arms of the selector switches on locomotive 1, the locomotives 2 and 3 are each provided with a synchronous motor 221 for driving the selector switches 188, 188' and 190 in synchronism and in the same angular direction as the selector switches 111 and 112 of locomotive 1. As shown, the synchronous motor 221 is connected to the shaft 199, on which the selector switches are mounted.

The synchronous motor 221 may be provided with a polarized armature 222 and salient poles 223 and 225, inclusive, the poles being provided with field coils 226, 227 and 228, respectively.

In order that the synchronous motor 221 shall operate at synchronous speed with respect to the frequency distributor 113, a rotating electromagnetic field must be provided for causing the polarized armature 222 to rotate at the same speed as the frequency distributor 113 and in the same phase or angular relation therewith. This rotating electromagnetic field may be established by causing the field coils 226 to 228, inclusive, to be energized and deenergized in a predetermined sequence.

In order that the field coils may be energized in a predetermined sequence, switches 229, 230 and 231 are provided. One terminal of the respective operating coils of the switches 229 to 231 is connected to the bus conductor 200 of the transformer winding 187 and the other terminals thereof are connected, through condensers 232, 233 and 234, respectively, to the bus conductor 208 of the transformer winding.

The circuit, comprising the condenser 232, the operating coil of the switch 229 and the transformer winding 187, is tuned to the frequency of the current generated by the generator 101 and is responsive only to that frequency. Similarly, the circuits, comprising the operating coils of the switches 230 and 231 and the condensers 233 and 234, are each tuned to the frequency of the currents gener-

ated by the generators 102 and 103 and are responsive only to their respective frequencies. That is, the operating coil of the switch 230 is responsive only to the current supplied to the trolley conductor 5 by the generator 102, and the operating coil of the switch 231 is responsive only to current of the frequency supplied by the generator 103.

When the operating coil of the switch 229 is energized, the switch is closed and current flows from a battery 235, or other suitable source of supply of electric energy, through the field coil 228 and the switch 229, to the battery.

Likewise, when the switch 230 is closed, the coil 226 of the field pole 223, is connected, for energization, to the battery 235, and, when the switch 231 is closed, the field coil 227 is connected for energization, to the battery 235.

The switches 229 to 231, inclusive, are preferably of the type which open and close quickly in response to the energization and deenergization of their operating coils. Therefore, since the coils of the switches 229 to 231 are responsive to the current supplied by the generators 101 to 103, the switches will open and close in the order in which the voltages of the generators are supplied to them by the frequency-distributor 113, in the manner stated hereinbefore.

Therefore, the field coils 222 to 224, inclusive, will be energized in the following order: field coil 226, field coils 226 and 227, field coil 227, field coils 227 and 228, field coil 228, field coils 228 and 226, and field coil 226, and so on.

Since the field coils are energized and deenergized in a predetermined sequence, it is obvious that a rotating magnetic field will be established which will cause the polarized armature 222 to rotate in synchronism with the field.

When the reverse-drum-controller 43 is set in its "forward" position, the contact fingers 48 and 49 will be bridged by contact segment 44 to establish an energizing circuit for the switch 41. Upon closure of the switch, the field winding 8 of the motor 6 of locomotive 1 is connected between the armature 7 and ground at 61. In this position, the contact fingers 51 and 52 will be bridged by the contact segment 46, whereby the contact finger 134 of the selector switch 111 will be connected successively to the generator 105 when the arms 136 and 137 engage the contact finger 134.

Assuming now that the switches 143 and 144 are closed, two impulses per revolution of the selector switch 111 will be supplied to the trolley conductor 5 per revolution of the contact arms 136 and 137. Since the contact arms 198 and 198' of the selector switches 188 and 188' (see Figs. 2 and 3) are rotated in synchronism with, and in the same angular relation with respect to, the selector switch 111,

the operating coils of the switches 171 of locomotives 2 and 3 will be energized. Therefore, the switches 171 are closed to connect the field windings of the motors connected between the armatures 163 and ground at 179.

When the drum controller 15 is set in the position 37, line switches 9 and 10 of the locomotive 1 will be closed as hereinbefore stated, and contact segments 130 and 131 of the selector switch 111 will be connected in circuit relation with the transformer winding 105' and the generator 105. In this position, contact fingers 26, 27 and 28 are bridged by contact segments 16, 17 and 18. Therefore, with each revolution of the contact arms 136 and 137, four impulses of electric current are supplied from the generator 105 to the trolley conductor 5.

As the contact arms 198 and 198' on locomotives 2 and 3 rotate and engage in succession, contacts 192 and 193 of the selector switches 188 and 188', the impulses supplied by contact arm 136 are distributed to operating coils of line switches 165 and 166 because these arms occupy the same angular positions as the arms 136 and 137 at all times. Therefore, line switches 165 and 166 are closed and a circuit is established from the trolley conductor 5, through the pantograph 174, conductors 173, line switches 165 and 166, resistor 157, and motors 152, to ground at 179.

If the drum controller 15 is set successively in positions 38 and 39, the contact fingers 132 and 133 of selector switch 111 are connected in circuit with the generator 105 and the transformer winding 105'. Therefore, electrical impulses are supplied to the trolley conductor which energize the operating coils of switches 168 and 169 as the contact arms 198 and 198' engage the contact fingers 194 and 195, respectively. When the switches 168 and 169 have been closed, the resistors in circuit with the respective motor armatures are short-circuited so that the motors will have the full voltage between ground and the trolley conductor 5 impressed thereon.

If it is desired that only locomotives 1 and 3 shall be utilized for propelling the train, the switch 143 may be opened, thereby disconnecting the contact arm 136 of the selector switch 111 from the alternating-current generator 105. Since the contact arm 198 of the selector switch 188 of locomotive 2 distributes the impulses supplied by the contact arm 134 to the operating coils 165 to 169 of locomotive 2, it is evident that locomotive 2 will not be energized from the trolley conductor. Therefore, by means of the switches 142 and 143, the number of locomotives utilized in propelling the train may be controlled and selected as desired.

When it is desired to establish air-braking by all of the locomotives, the controller 15 is actuated to its "off" position, as is the usual practice, before the air-brake handle 83 is set

in the successive positions 89 and 90, and, if necessary, the "emergency" position.

When the air-brake handle is set in the position, 89, contact segment 94 engages the contact finger 96, the contact finger 152 of the selector switch 112 is connected in circuit with the generator 104 and the winding 104' each time the contact arm 154 makes contact with the contact finger 152. Since the contact arm 214 of the selector switch 190 rotates in synchronism with the contact arm 154, the operating coils of the switches 182 will be energized once for each revolution of the selector switch 190.

When the switches 182 have been closed, only a portion of each of the resistors 85 is connected in circuit with the solenoids 82. Therefore, a slight reduction in the brake-pipe pressure is effected, as hereinbefore stated. When the air-brake handle 83 is set in the position 90, the operating coil of switch 183 is energized to close the switch. Therefore, the resistors 85 are connected in the circuit with the corresponding solenoids 82 and an increased reduction in air pressure in the brake-pipe 73 is effected.

In Fig. 2 of the drawings modified forms of the selector switches employed on locomotives 1, 2 and 3 are shown. As illustrated, one of the modified selector switches 236 comprises a plurality of stationary contact fingers 237 to 248, inclusive, and a contact arm 249. This switch may be substituted for the switch 111. It is evident that, since the switch 236 has 12 contact fingers and one contact arm, the same number of electrical impulses per revolution of the contact arm 249 may be supplied to the trolley conductor 5, as by the switch 111.

A modified selector switch 250 is shown also which is similar to the switch 188 of locomotive 2 and may be substituted therefor. The switch 250 comprises a plurality of contact fingers 251, to 256, inclusive, and a rotatable contact arm 257. When electrical impulses are supplied to the trolley conductor 5 through contacts 237, 239, 241, 243, 245 and 247 of the switch 236, the impulses are distributed by contact arm 257 as it engages the contacts 251 to 256, inclusive, for the contact arm and the contacts on the latter occupy the same angular position.

A third selector switch 258 shown in Fig. 2, may be substituted for the switch 190 of locomotives 2 and 3. This switch is similar to the switch 250 except that contacts 259 to 264 thereof occupy an angular position intermediate those of the former, while a contact arm 265 of the switch 258 rotates in the same angular position as the switches 236 and 250. Therefore, the electrical impulses that may be supplied by the switch 236 to the trolley conductor 5, as the arm 249 engages, successively, the contacts 238, 240, 242, 244, 246, and 248, are received by the switch

258 as the contact arm 265 thereof engages, successively, the contacts 259 to 264, inclusive.

In order to simplify the drawings and to limit the description, the train-control system has been restricted to a single motor, but it is to be understood that, in practice, two or more motors may be used and that these motors may be operated in any desired manner, such as in series or in parallel, as is well understood in the art.

Since certain changes may be made in the above described construction and different embodiments of the invention may be made without departing from the spirit and the scope thereof, it is desired that only such limitations shall be placed thereon as are imposed by the prior art and the appended claims.

I claim as my invention:

1. In a control system for a plurality of locomotives, each provided with control apparatus, in combination, means for supplying a plurality of separate impulses of currents of different predetermined frequencies, means responsive to preselected impulses of the currents of predetermined frequencies for actuating the control apparatus, and means for preselecting the impulses of currents supplied.

2. In a control system for a plurality of locomotives, each provided with control apparatus, in combination, means for supplying currents of different predetermined frequencies, means responsive to the currents of predetermined frequencies for actuating the control apparatus, and means disposed on a particular locomotive for rendering control apparatus of predetermined locomotives non-responsive to the currents transmitted.

3. In an electric transportation control system for a plurality of locomotives provided with control apparatus, in combination, a trolley conductor, a source of alternating currents of different frequencies, means for supplying intermittent impulses of said currents to the trolley conductor, and means responsive to said impulses of currents of predetermined frequencies for actuating said control apparatus of the different locomotives in unison.

4. In a train-control system, in combination, a trolley conductor, means for supply intermittent impulses of current of different frequencies to the trolley conductor, control apparatus located at different points in the train, and means for actuating the control apparatus responsive to said impulses of predetermined current frequencies.

5. In a train-control system, in combination, a trolley conductor, means for supplying intermittent impulses of current of different frequencies to the trolley conductor, control apparatus located at different points in the train, means for actuating the control

apparatus responsive to said impulses of predetermined current frequencies, and means for selecting the control apparatus to be actuated.

5 6. In a train-control system, in combination, a trolley conductor, means for supplying intermittently current impulses of different frequencies to the trolley conductor, control apparatus located at different points in a train and means for actuating the control apparatus in unison, the said actuating means being responsive to intermittent current impulses of predetermined frequencies.

10 7. In a train-control system, in combination, a trolley conductor, means for supplying a plurality of intermittent impulses of current of different frequencies to the trolley conductor, control apparatus located at different points in the train, means for actuating the control apparatus responsive to predetermined impulses of said predetermined current frequencies, means for selecting the control apparatus to be actuated, and means for actuating the control apparatus in unison responsive to the predetermined impulses of predetermined current frequencies.

15 8. In a train-control system for a plurality of locomotives, a trolley conductor, a leading locomotive and a trailing locomotive, an electrical system for controlling the operation of the leading locomotive, a controller for controlling the electrical system of the leading locomotive, an electrical system on the trailing locomotive for controlling the operation thereof, and means controlled by said controller for transmitting a plurality of electrical impulses of different predetermined current frequencies over the trolley for effecting operation of the trailing locomotive in unison with the leading locomotive.

20 9. In an electric train-control system, in combination, propelling motors located at different points in the train, a trolley conductor for supplying power to the propelling motors, separate control means for the motors located at the different points in the train, means for supplying the trolley conductor with a plurality of intermittent impulses of currents of different frequencies, and means for controlling the operation of the separate control means responsive to certain of said impulses of a predetermined current frequency, whereby operation in unison of the motors may be effected.

25 10. In an electric-transportation control system, in combination, a trolley conductor, a plurality of locomotives provided with electric motors and control apparatus, a controller on one locomotive for connecting its motor to the trolley conductor, means controlled by said controller for supplying the trolley conductor with currents of different predetermined frequencies, and means disposed on the other locomotives responsive to the current of

different frequencies for controlling the operation of the control apparatus therefor.

11. In a train-control system for a plurality of locomotives, each provided with motors and control apparatus for controlling the operation of the motors, said control apparatus being responsive to electric currents of predetermined frequencies, in combination, a trolley conductor, a source of alternating current of a predetermined frequency located on one locomotive, a selector switch for supplying impulses of said current to the trolley conductor at regular and recurring intervals, and a selector switch on each of the other locomotives for receiving said impulses to effect operation of the control apparatus in unison.

12. In a train-control system for a plurality of locomotives, each provided with motors and control apparatus for controlling the operation of the motors, said control apparatus being responsive to electric currents of predetermined frequencies, in combination, a trolley conductor, a source of alternating current of a predetermined frequency located on one locomotive, a selector switch for supplying impulses of said current to the trolley conductor at regular and recurring intervals, and means for rendering the control apparatus of predetermined locomotives non-responsive to the current impulses supplied to the trolley conductor.

13. In a train-control system, in combination, a trolley conductor, a plurality of electric motors located at different points in a train, a source of high frequency current, means for supplying the current to the trolley conductor in a series of recurring impulses, means for controlling the number of impulses supplied, and means responsive to said impulses for controlling the operations of the motors in steps corresponding to the number of impulses supplied.

14. In a train-control system, in combination, a trolley conductor, a plurality of electric motors located at different points in a train line, a source of high frequency current, means for supplying the current to the trolley conductor in a series of recurring impulses, means for controlling the number of impulses supplied, means responsive to said impulses for controlling the operations of the motors in steps corresponding to the number of impulses supplied, and means for selecting the control means to be responsive to the impulses supplied.

15. In a train-control system, in combination, a trolley conductor, a plurality of electric motors located at different points in a train line, a source of high frequency current, means for supplying the current to the trolley conductor in a series of recurring impulses, means for controlling the number of impulses supplied, means responsive to said impulses for controlling the operation of the

motors in steps corresponding to the number of impulses supplied, and means for causing the control means to operate in unison.

16. In a train-control system, in combination, a trolley conductor, a plurality of electric motors, located at different points in a train line, a source of high frequency current, means for supplying the current to the trolley conductor in a series of recurring impulses, means for controlling the number of impulses supplied, means responsive to said impulses for controlling the operation of the motors in steps corresponding to the number of impulses supplied, means responsive to certain of said currents of predetermined frequencies for causing the control means to operate in unison, and means for selecting the control means to be responsive to the impulses supplied to the trolley conductor.

17. In a train-control system, in combination, a trolley conductor, a source of alternating current, means for supplying the current to the trolley conductor in a plurality of separated recurring impulses, means for selecting the number of impulses supplied, a plurality of motor-driven vehicles, control means on each vehicle responsive to said current impulses for connecting the motors to the trolley and for effecting control thereof in steps according to the number of impulses selected and supplied to the trolley conductor.

18. In a train control system, in combination, a plurality of vehicle-propelling motors located at different points in the train, a trolley conductor, a source of alternating current, a selector switch for supplying said current to the trolley conductor in successive recurring impulses, a controller for connecting one of said motors to the trolley conductor and for controlling the number of impulses of current supplied thereto, a selector switch for each of said motors for receiving said impulses, and means responsive to the impulses received for connecting the motors to the trolley conductor and effecting control thereof.

19. In a control system, in combination, a trolley conductor, a source of alternating currents of different predetermined frequencies, control apparatus comprising a plurality of relays responsive to a current of a predetermined frequency, a selector switch for supplying the trolley conductor with said current in recurring impulses, a selector switch for receiving said impulses and causing the relays to be energized in accordance with the relative positions of the supplying and receiving selector switches, means for supplying currents of different frequencies to the trolley conductor, and means responsive to said frequencies for causing the selector switches to operate in synchronism and in a predetermined current supplying and receiving relation to each other.

20. In a train-control system for a plurality of motor vehicles, each provided with motors, control apparatus for the motors and a trolley conductor, in combination, means located on one vehicle for causing unison operation of the motors, a source of alternating currents of different frequencies, said control apparatus being responsive to one of said frequencies, means for supplying a plurality of intermittent impulses of said currents to the trolley conductor, means located on each of the other vehicles for selectively receiving impulses of said currents from the trolley conductors to which the control apparatus is responsive, and means responsive to the other currents of different frequencies for causing synchronous operation of the alternating current supplying and receiving means.

21. In a train-control system, in combination, a trolley conductor, a source of alternating current, means for supplying current to the trolley conductor in a plurality of recurring impulses, means for selecting the number of impulses supplied, a plurality of motor-driven vehicles, control means responsive to said current impulses on each vehicle for connecting the motor to the trolley, and for effecting either acceleration or deceleration of the motors in accordance with the number of impulses selected.

22. In a train-control system, in combination, a trolley conductor, a plurality of propelling motors, an electrical system for controlling each of the propelling motors, a selector switch for controlling each electrical system and means for effecting synchronous operation of the selector switch through the trolley.

23. In a train-control system, in combination, a trolley conductor, a plurality of propelling motors, an electrical system for controlling each of the propelling motors, a selector switch for controlling each electrical system, means for effecting synchronous operation of the selector switch through the trolley, and means for effecting selective control of the selector switches.

24. In a control system, a trolley conductor, a plurality of locomotives, a synchronous motor for each locomotive, and means for effecting synchronous operation of the motors through the trolley conductor from one locomotive.

25. In combination, a plurality of locomotive equipped with electric propelling motors, a trolley conductor, means for connecting said motors to the trolley, accelerating relays for said motors, means disposed on one locomotive for effecting selective operation of the relays on the other locomotive comprising a source of alternating current, means for supplying the current to the trolley conductor and means for selectively energizing said relays from said source of alternating current.

26. In a control system, in combination, a

trolley conductor, a plurality of sources of alternating current of different frequencies, means for successively and at regular intervals connecting said sources of alternating current to said trolley conductor, and means responsive to said alternating currents for producing a rotating electro-magnetic field.

27. In combination, a plurality of locomotives, a trolley conductor, a selector switch on a selected locomotive, means for operating said switch at a predetermined speed, selector switches disposed on each of the other locomotives, means for supplying the trolley conductor with electrical impulses from the selected locomotive, and means responsive to said impulses for causing said selector switches to be operated in synchronism with the selector switch on the selected locomotive.

In testimony whereof, I have hereunto subscribed my name this 10th day of February, 1928.

LOUIS M. ASPINWALL.

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