Nov. 30, 1965 D. J. LESLIE 3,220,356

MODEL TRAIN CONTROL SYSTEM

Filed Dec. 3, 1962 4 Sheets-Sheet 1

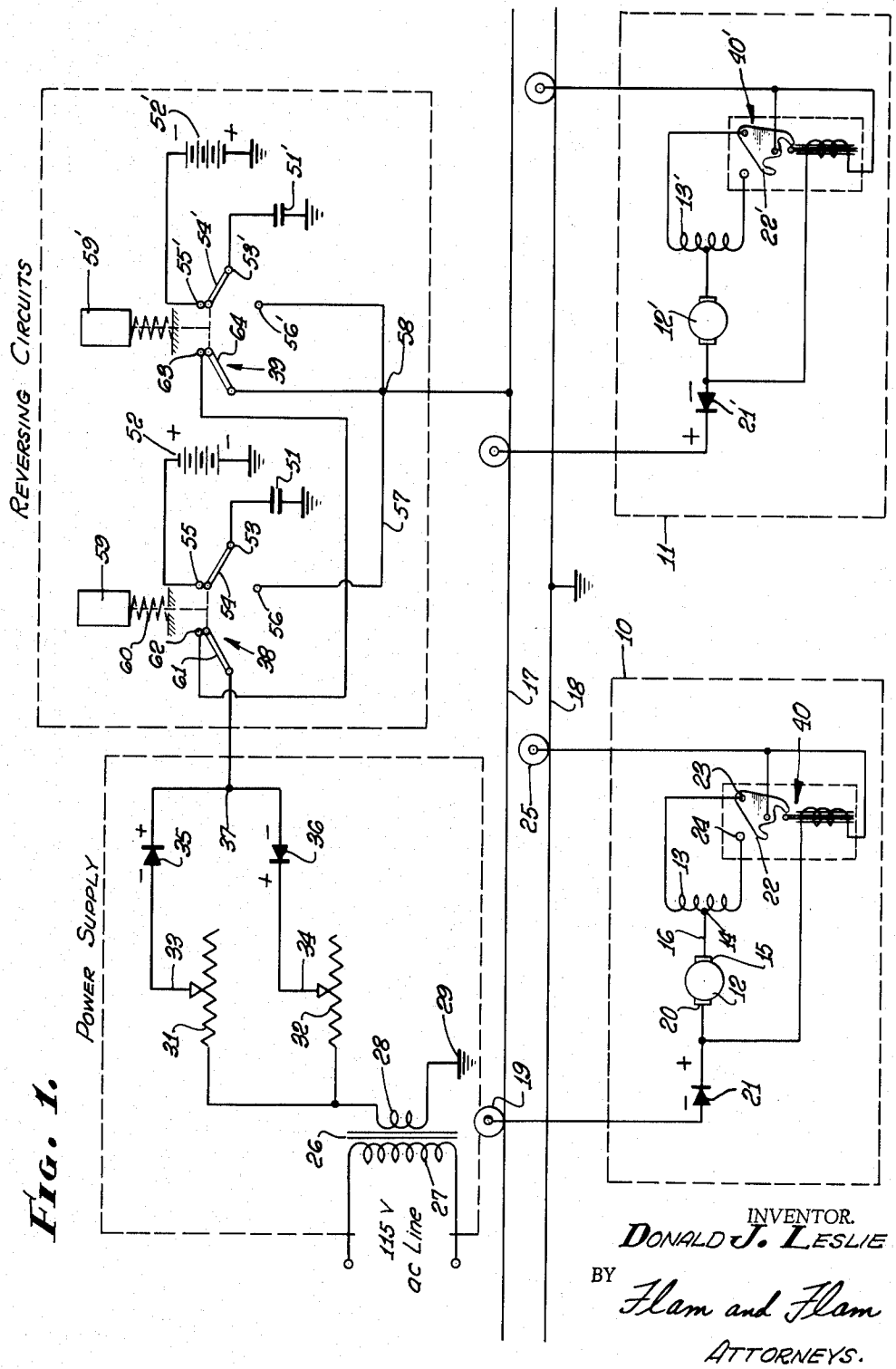


Fig. 1.

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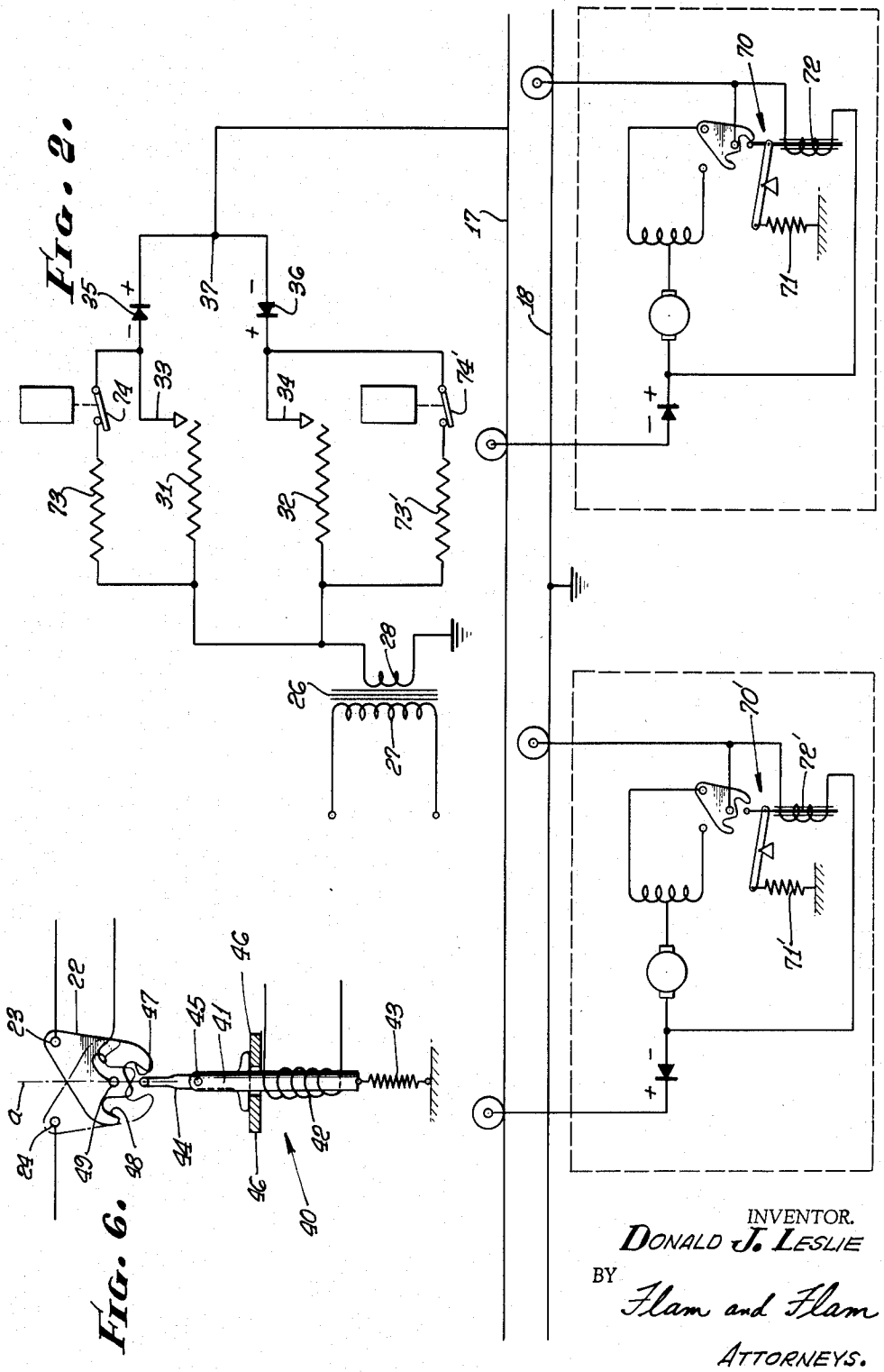


FIG. 2.




FIG. 6.

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MODEL TRAIN CONTROL SYSTEM

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FIG. 3.

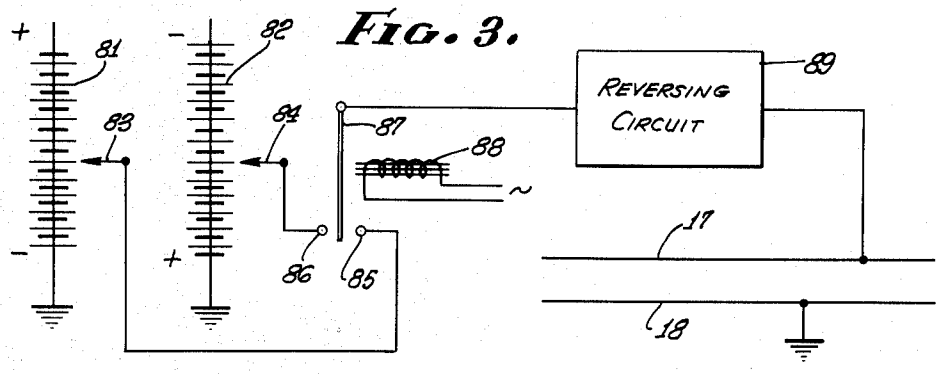



FIG. 4.

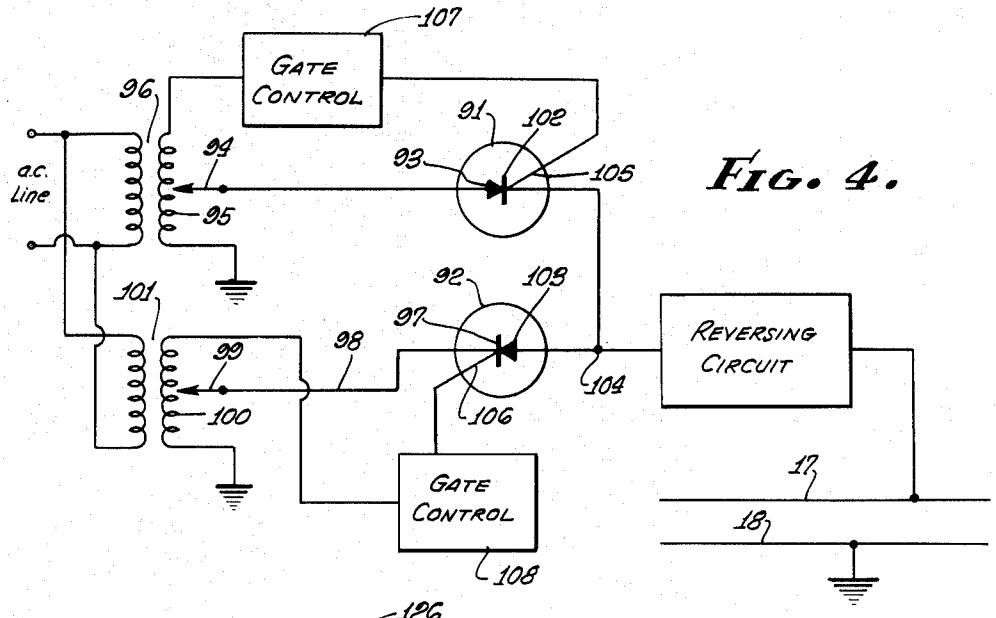
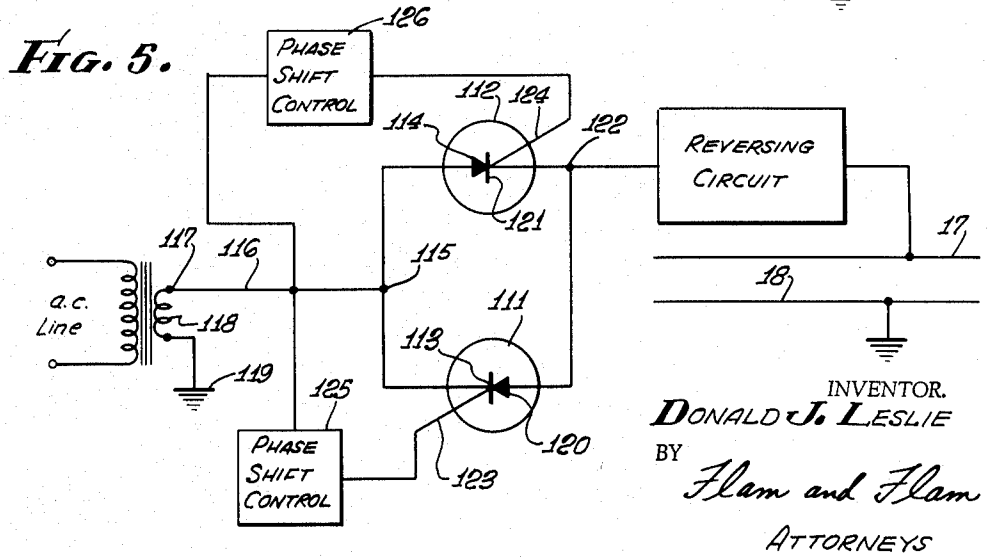



FIG. 5.

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MODEL TRAIN CONTROL SYSTEM

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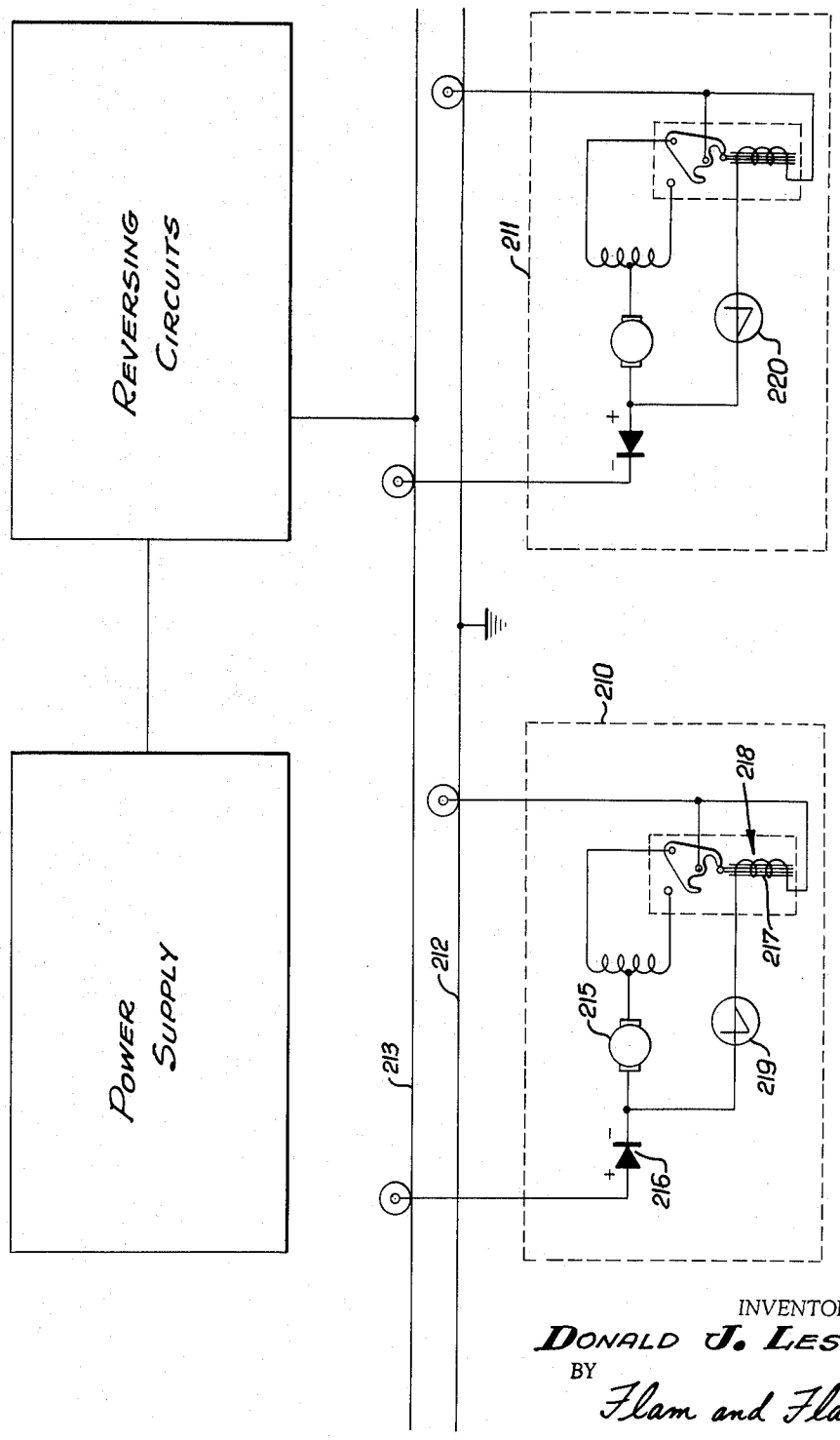


Fig. 7.

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3,220,356

# MODEL TRAIN CONTROL SYSTEM

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Filed Dec. 3, 1962, Ser. No. 242,579
16 Claims. (Cl. 104—151)

This application is a continuation-in-part of my prior application Serial No. 145,349, filed October 16, 1961, now abandoned, and entitled "Model Train Control System." This invention relates to a control system for a plurality of model or toy trains operating on the same track, and particularly to a system wherein each train may be separately controlled as to direction as well as speed.

Patents to Ozanne and Mostek, No. 1,778,465 and 2,754,432 suggest use of (+) and (−) halves of alternating current excitation for use in providing separately adjusted power for two trains operating on the same track. Thus each half of the A.C. supply is rectified and separately controlled. The respective trains are provided with rectifiers so that they respond only to the respective halves of the A.C. supply. An object of this invention is to make it possible to reverse the trains individually as well as to control their speed. Use is made of a relay for switching the field connections or field windings, the relay sensing a critical change in the excitation appropriately to provide the requisite connections.

Another object of this invention is to provide a system of this character that utilizes simple circuit design to accomplish effective non-chatter operation of the reversing relays.

Another object of this invention is to provide improved power supply systems for use in separately controlling opposite phases of an alternating current waveform.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a diagrammatic view of a control system incorporating the present invention;

FIG. 2 is a diagrammatic view of a modified control system incorporating the present invention;

FIGS. 3, 4 and 5 are diagrammatic views illustrating modified excitation control systems for use in the forms of FIG. 1 or FIG 2;

FIG. 6 is a diagrammatic view of a typical relay for use in the present control system; and

FIG. 7 is a diagrammatic view of a system similar to FIG. 1 but showing the incorporation of means for preventing relay chatter.

In FIG. 1 there is diagrammatically illustrated at **10** and **11** power plants of two toy or model locomotives.

The power plant **10** comprises a direct current motor, having an armature **12** and a series field winding **13**. The field winding **13** has a center tap **14** connected to one of the armature terminals **15**, as by the aid of a lead **16**.

The motor is adapted to be excited by one phase of an alternating current supply applied between rails **17** and **18** of the track system. A brush or pick-up wheel **19** forming a part of the toy or model locomotive thus establishes an electrical connection to one of the rails **17**. The pick-up wheel **19** is connected to the other armature



terminal **20** via a unidirectionally conductive device or rectifying diode **21**.

A switch arm **22** connects one of the two end terminals **23** or **24** of the field winding **13** to a second brush or wheel pick-up **25** cooperating with the other track rail **18**.

Either one part or the other of the motor field winding **13** is operative, depending upon which terminal **23** or **24** is operative. The winding parts are so polarized that the direction of motor torque reverses in accordance with the operation of the contacts **23** or **24**.

The power plant for locomotive **11** is identical except that the rectifier **21'** is oppositely arranged whereby the power plant responds to the opposite phase of the alternating current excitation applied to rails **17** and **18**.

The excitation for the rails is provided by a step down transformer **26**, the primary winding **27** of which is cooperable with a commercial power source. The secondary winding **28** is designed to deliver a voltage consistent with the rating of the motor structures for the locomotives.

One terminal of secondary winding is grounded at **29** as is the rail **18**. The other terminal of secondary winding **28** is connected to the rail **17**, thus connected in parallel to the secondary winding **28** are two potentiometer resistors **31** and **32**. Sliders **33** and **34** cooperable with the resistors **31** and **32** connect respectively to two oppositely polarized unidirectionally conductive devices or rectifying diodes **35** and **36**. The diodes **35** and **36** are joined at a terminal **37**. The terminal **37** connects to the rail **17** via two normally closed switches **38** and **39** of a reversing circuit to be hereinafter described.

When the sliders **33** and **34** are at corresponding positions along their respective resistors **31** and **32**, the positive and negative half cycles of the voltage applied to the rail **17** are equal in amplitude. However, the sliders **33** and **34** are separately adjustable and, accordingly, the positive half cycle of the supply may be of quite different amplitude from the negative half cycle of the supply. Since the locomotive power plants **10** and **11** respectively sense the positive and negative half cycles of the supply, the average voltage applied to the motors is determined and the speeds are accordingly separately controlled.

In order to move the switch arm **22**, a latching relay structure **40** is provided, of which the switch arm **22** forms a part. The latching relay requires for its operation a current substantially greater than normally provided by the power supply. Hence, the relay is normally inactive. The manner in which extra current for operating the relay is provided will be hereinafter described.

While any relay of the latching type may be used, the latching relay **40** disclosed herein by way of example in FIG. 6 incorporates an operating push rod **41** movable upwardly along a path or axis *a* in response to a pulse of current applied to the relay coil **42**. A retracting spring **43** pulls the push rod **41** downwardly.

The push rod **41** is pivotally connected to the lower end of a rocker **44** as by the aid of a pin **45**. The rocker **44** has a lower end that engages centering bars **46** on opposite sides of axis *a* under the influence of retracting spring **43**. The centering bars cause the rocker to be aligned with the push rod **41**.

As the rocker **44** moves upwardly along line *a*, its upper end engages one of two contiguous symmetrical recesses **47** or **48** formed on the surface of the switch arm **22** that is opposed to the rocker **44**. The switch arm **22** is pivoted on a pin **49** spaced symmetrically above the recesses **47** and **48** and on the line of movement *a*. When the arm is in one asymmetrical angular position, the recess **47** intersects the line *a*. Thus, as the rocker **44** advances, it enters recess **47** and moves the arm **22** to

the phantom-line position, the rocker pivoting about its pin 45 in the process. When the rocker retracts, it passes easily along the recess 47 without shifting the arm. In the phantom-line position, the opposite recess 48 is now over center, and it will be engaged on the next advancement of the rocker 44. Accordingly, the arm 22 is moved alternately on succeeding pulses applied to relay coil 42.

In order to operate the latching relay 40 and provide an adequate pulse to its coil 42, a reversing circuit is interposed between the rail 17 and the power supply. The reversing circuit includes a capacitor 51 that normally stores a charge derived from a charging battery 52. The charge stored by the capacitor 51 is adequate to operate the coil 42 of the latching relay. In place of the battery 52 and capacitor 51, a small power supply could be substituted, comprising, for example, a diode in series with an A.C. source.

One terminal 53 of capacitor 51 connects to one of two arms 54 of the switch 38 by the aid of which the capacitor receives its charge from the battery or passes its charge to the rail 17. The other terminal of the capacitor is grounded. The switch arm 54 normally engages contact 55 that connects with the positive terminal of the battery 52, but is movable to engage instead a contact 56 connected by a lead 57 to the output terminal 58 of the reversing circuit and thence to rail 17. In order to move the switch arm 54, the switch 38 has an operating button 59 that is normally returned by a spring 60 to a position in which the battery contact 55 is engaged by the arm 54.

The switch 38 also operates to disconnect the power supply when the capacitor 51 is applied to the rail 17. For this purpose, use is made of the second arm 61 of the switch 38. This arm 61 is connected to power supply terminal 37 and normally engages a contact 62 that, in dependence upon switch 39, connects to output terminal 58. Thus, contact 62 of switch 38 connects to a contact 63 normally engaged by an arm 64 of switch 39. The arm 64 is connected to the output terminal 58 of the reversing circuit and to the rail 17.

The positive pulse provided by capacitor 51 on depression of button 59 finds its way via diode 21 to latching relay coil 42 to reverse the locomotive 10. The pulse is blocked by diode 21' and hence only the first locomotive is reversed.

In order to operate the reversing relay 40', a second condenser 51' is provided. This condenser has a terminal 53' normally connected to the negative terminal of a battery 52' via the second arm 54' and contact 55' of switch 39. On depression of button 59', the arm 54' engages contact 56' and a negative pulse is applied to latching relay 40'.

By virtue of the system just described, the direction of movement and the speed of the toy or model locomotives operating on the same track are therefore separately controlled.

In the form illustrated in FIG. 2, a reversing relay 70 is arranged to be operated by a spring 71 when current in the reversing relay coil of 72 drops below a critical value. In this instance, a simpler power supply is provided for achieving this control.

Two potentiometers 31 and 32 have corresponding terminals connected to one side of a secondary winding 28 remote from the ground connection 29, and the back to back rectifying diodes 35 and 36 are provided as before that connect to output terminal 37 and rail 17. A current adequate to hold the coil 72 operative, but inadequate to operate the motor, is provided by a holding circuit including the resistor 73 and a normally closed switch 74, together paralleling the potentiometer resistor 31 and its slider 33. Thus, if the slider 33 is moved to stop or open circuit position, the current on the positive half of the A.C. cycle nevertheless passes to the rail 17 via the holding circuit. This current is adequate to overpower the spring 71. However, by opening the switch 74, when the slider 33 is at a stopped position, the holding current for the latching relay 72 is interrupted, and the spring 71 reverses the motor field.



A similar holding circuit is provided for the opposite or negative half cycle of the supply for use in controlling the latching relay 70 for the other locomotive. Thus, the holding circuit includes the holding resistance 73' and the normally closed switch 74', together paralleling the potentiometer resistor 32 and its slider 34.

In order to improve voltage regulation under varied load conditions, the arrangement of FIG. 3 may be provided. In this example, two batteries 81 and 82 are provided in place of power transformer 26. The batteries have a plurality of series connected cells and voltage taps therebetween, whereby sliders or selector switch arms 83 and 84 may be moved to different voltage positions.

The taps 83 and 84 connect with opposite contacts 85 and 86 of a chopper structure. Thus, an arm 87, vibrated by an A.C. coil 88, alternately engages the contact 85 and 86 to provide an alternating current, the positive and negative halves of which are separately controlled by taps 83 and 84.

The chopper connects with a reversing circuit 89, which in turn connects to the track rails.

In FIG. 4, still another power supply system provides improved regulation. In the present instance, unidirectionally conductive devices 91 and 92 in the form of controlled rectifiers are utilized.

The rectifier 91 has a cathode 93 connected to a slider 94 that cooperates with a secondary winding 95 of a power transformer 96. The controlled rectifier 92 has its anode 97 connected by a lead 98 to a slider 99 cooperable with a secondary winding 100 of a second power transformer 101. The controlled rectifiers 91 and 92 thus provide conduction for the positive and negative halves of the A.C. wave, and the taps 94 and 99 separately control amplitude.

The anode 102 of the rectifier 91 and the cathode 103 of the rectifier 92 are connected together as at 104 to form a common output terminal for the power supply as in the previous forms.

The low internal impedance of the transformers 96 and 101 ensures good voltage regulation for the locomotives connected to the track rails 17 and 18.

In order to prevent a short circuit between the transformer secondary windings 94 and 99 via devices 91 and 92, the gates 105 and 106 of the rectifiers are controlled by circuits 107 and 108. These circuits limit conduction to the corresponding half cycles. The control circuits may be of any suitable design deriving excitation from the transformer secondary windings.

A reversing circuit is interposed between the output terminal 94 and track rails to provide separate direction control.

In the form illustrated in FIG. 5, controlled rectifiers 111 and 112 are connected in back-to-back relationship. Thus, the anode 113 of the rectifier 111 and the cathode 114 of the rectifier 112 are connected to the common terminal 115, which by lead 116 connects one terminal 117 of the transformer secondary winding 118. The other terminal of the winding 118 is grounded, as at 119. The cathode 120 of the device and the anode 121 of the rectifier 112 are connected together at a common output terminal 122.

Cooperable with gate 123 and 124 of the respective rectifiers 111 and 112 are control circuits 125 and 126 used to control the ratio of on-time to off-time whereby energy applied during opposite halves of the A.C. wave form.

In the form illustrated in FIG. 7, locomotives 210 and 211 are illustrated that each cooperate with track conductors 212 and 213. A power supply 214 and reversing circuits shown in block diagram may be the same as illustrated for the form shown in FIG. 1.

The locomotive 210 has a reversible motor 215, a

rectifying diode **216**, a coil **217** of a reversing relay **218**, all similar to the arrangement of FIG. 1. However, serially associated with the relay coil is a device **219** having the characteristic that it conducts only on the application of a critical voltage. This critical voltage by design exceeds any voltage applied to the coil **217** during normal running conditions, but is less than the voltage that can be applied to the coil **217** by the reversing circuits, and via diode **216**. Accordingly, until a pulse is applied for operating the relay coil **217**, no current is permitted to pass to it, and chattering is avoided. This is especially important since the locomotive may be subject to vibrations and the like that might, coupled with chattering of the relay, produce spurious operation.

The device **219** may be a four layer Shockley diode, a Zener diode, or any other device, not necessarily unidirectionally conductive, having the desired critical voltage characteristic.

A similar device **220** is provided for the companion locomotive **211**, and since the device **220** is unidirectionally conductive, its polarity is reversed to conform to the desired direction of current flow.

The inventor claims:

**1.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and in response to a polarized signal transmitted via the corresponding unidirectionally conductive element; and means for separately supplying signals to said conductors of opposite polarities respectively to operate the corresponding reversing relay.

**2.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to a current pulse; means for applying current pulses of opposite polarities to the said conductors for separately reversing said motor.

**3.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to an interruption of current; means normally maintaining holding currents of both polarities for the respective relays; and means for selectively interrupting the said holding currents for separately reversing said motors.

**4.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to a current pulse; a pair of capacitors; switch means for each capacitor and movable to first positions for applying the charge thereof across said conductors, and movable to second positions in which said capacitors are isolated from said conductors; and means operative upon movement of said switches to said second positions for oppositely charging said capacitors.

**5.** The combination as set forth in claim **4**, together with means providing an alternating current the opposite phases of which are separately controlled; and means applying said alternating current to said conductors and dependent upon both said switches being in their said first positions.

**6.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to an interruption of current; first means including a unidirectionally conductive device and a variable impedance for passing current in one direction to said conductors; second means including a unidirectionally conductive device and a variable impedance for passing current in the other direction to said conductors; circuit means parallelling one of said variable impedances to maintain a minimum average current in one direction; circuit means paralleling the other of said variable impedances to maintain a minimum average current in the other direction; each of said circuit means including a make-and-break switch for separately reversing said motors.

**7.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each of said motors having a pair of field windings respectively operable to turn the corresponding motor in opposite directions; each power unit including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses; circuit means, completed by each relay for alternately connecting the corresponding field windings; and means for separately applying pulses of opposite polarities respectively to operate the corresponding relays.

**8.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of batteries having terminals of opposite polarities connected to one of said conductors, each battery having a series of taps between cells thereof whereby voltages of various values can be derived therefrom; a movable arm for each battery; and chopper means for alternately connecting the arms to the other of said conductors.

**9.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for de-

riving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of batteries having terminals of opposite polarities connected to one of said conductors, each battery having a series of taps between cells thereof whereby voltages of various values can be derived therefrom; a movable arm for each battery; chopper means for alternately connecting the arms to the other of said conductors; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by any tap of said batteries; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the chopper means and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**10.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of transformer windings excited from a common source; each winding having sliders operable to derive voltages of various values therefrom; corresponding terminals of said windings being connected to one of said conductors; a first controlled rectifier having its anode connected to the other terminal of one of said windings; a second controlled rectifier having its cathode connected to the other terminal of the other of said windings; the cathode of the first rectifier and the anode of the second rectifier being connected to the other of said conductors; and control circuits for the respective rectifiers limiting conduction to alternate half cycles of the source.

**11.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of transformer windings excited from a common source; each winding having sliders operable to derive voltages of various values therefrom; corresponding terminals of said windings being connected to one of said conductors; a first controlled rectifier having its anode connected to the other terminal of one of said windings; a second controlled rectifier having its cathode connected to the other terminal of the other of said windings; the cathode of the first rectifier and the anode of the second rectifier being connected to the other of said conductors; control circuits for the respective rectifiers limiting conduction to alternate half cycles of the source; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by windings; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the rectifiers and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**12.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of controlled rectifiers connected in back-to-back relationship, the anode of one of the rectifiers and the cathode of the other of the rectifiers being connected to one of said conductors; means applying alternating current excitation between the other of said conductors and the cathode of said one rectifier and between the other of said conductors and the anode of said other rectifier; and means separately controlling the phase angle at which said rectifiers are rendered conductive.

**13.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of controlled rectifiers connected back-to-back relationship, the anode of one of the rectifiers and the cathode of the other of the rectifiers being connected to one of said conductors; means applying alternating current excitation between the other of said conductors and the cathode of said one rectifier and between the other of said conductors and the anode of said other rectifier; means separately controlling the phase angle at which said rectifiers are rendered conductive; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by alternating current excitation applying means; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the rectifiers and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**14.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors; a pair of power units for the vehicle having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and in response to a polarized signal transmitted via the corresponding unidirectionally conductive element; means for separately applying signals to said conductors of opposite polarities respectively to operate the corresponding reversing relay; each of said relays having a core; and means serially associated with the coils for discriminating against the alternating current source for blocking the pulsations thereof from said relay coil while passing the reversing signals, as determined by the corresponding undirectionally conductive elements.

**15.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors; a pair of power units for the vehicles have oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and only in response to a relatively high amplitude polarized pulse transmitted via the corresponding unidirectionally conductive element; each relay having a coil; and means for applying pulses of selected polarity for operating the corresponding reversing relays.

**16.** In a control system for a pair of vehicles both

rectifying diode **216**, a coil **217** of a reversing relay **218**, all similar to the arrangement of FIG. 1. However, serially associated with the relay coil is a device **219** having the characteristic that it conducts only on the application of a critical voltage. This critical voltage by design exceeds any voltage applied to the coil **217** during normal running conditions, but is less than the voltage that can be applied to the coil **217** by the reversing circuits, and via diode **216**. Accordingly, until a pulse is applied for operating the relay coil **217**, no current is permitted to pass to it, and chattering is avoided. This is especially important since the locomotive may be subject to vibrations and the like that might, coupled with chattering of the relay, produce spurious operation.

The device **219** may be a four layer Shockley diode, a Zener diode, or any other device, not necessarily unidirectionally conductive, having the desired critical voltage characteristic.

A similar device **220** is provided for the companion locomotive **211**, and since the device **220** is unidirectionally conductive, its polarity is reversed to conform to the desired direction of current flow.

The inventor claims:

**1.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and in response to a polarized signal transmitted via the corresponding unidirectionally conductive element; and means for separately supplying signals to said conductors of opposite polarities respectively to operate the corresponding reversing relay.

**2.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to a current pulse; means for applying current pulses of opposite polarities to the said conductors for separately reversing said motor.

**3.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to an interruption of current; means normally maintaining holding currents of both polarities for the respective relays; and means for selectively interrupting the said holding currents for separately reversing said motors.

**4.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to a current pulse; a pair of capacitors; switch means for each capacitor and movable to first positions for applying the charge thereof across said conductors, and movable to second positions in which said capacitors are isolated from said conductors; and means operative upon movement of said switches to said second positions for oppositely charging said capacitors.

**5.** The combination as set forth in claim **4**, together with means providing an alternating current the opposite phases of which are separately controlled; and means applying said alternating current to said conductors and dependent upon both said switches being in their said first positions.

**6.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and dependent upon the corresponding unidirectionally conductive element, each relay being operative in response to an interruption of current; first means including a unidirectionally conductive device and a variable impedance for passing current in one direction to said conductors; second means including a unidirectionally conductive device and a variable impedance for passing current in the other direction to said conductors; circuit means parallelling one of said variable impedances to maintain a minimum average current in one direction; circuit means paralleling the other of said variable impedances to maintain a minimum average current in the other direction; each of said circuit means including a make-and-break switch for separately reversing said motors.

**7.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors: a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each of said motors having a pair of field windings respectively operable to turn the corresponding motor in opposite directions; each power unit including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses; circuit means, completed by each relay for alternately connecting the corresponding field windings; and means for separately applying pulses of opposite polarities respectively to operate the corresponding relays.

**8.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of batteries having terminals of opposite polarities connected to one of said conductors, each battery having a series of taps between cells thereof whereby voltages of various values can be derived therefrom; a movable arm for each battery; and chopper means for alternately connecting the arms to the other of said conductors.

**9.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for de-

riving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of batteries having terminals of opposite polarities connected to one of said conductors, each battery having a series of taps between cells thereof whereby voltages of various values can be derived therefrom; a movable arm for each battery; chopper means for alternately connecting the arms to the other of said conductors; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by any tap of said batteries; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the chopper means and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**10.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of transformer windings excited from a common source; each winding having sliders operable to derive voltages of various values therefrom; corresponding terminals of said windings being connected to one of said conductors; a first controlled rectifier having its anode connected to the other terminal of one of said windings; a second controlled rectifier having its cathode connected to the other terminal of the other of said windings; the cathode of the first rectifier and the anode of the second rectifier being connected to the other of said conductors; and control circuits for the respective rectifiers limiting conduction to alternate half cycles of the source.

**11.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of transformer windings excited from a common source; each winding having sliders operable to derive voltages of various values therefrom; corresponding terminals of said windings being connected to one of said conductors; a first controlled rectifier having its anode connected to the other terminal of one of said windings; a second controlled rectifier having its cathode connected to the other terminal of the other of said windings; the cathode of the first rectifier and the anode of the second rectifier being connected to the other of said conductors; control circuits for the respective rectifiers limiting conduction to alternate half cycles of the source; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by windings; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the rectifiers and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**12.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of controlled rectifiers connected in back-to-back relationship, the anode of one of the rectifiers and the cathode of the other of the rectifiers being connected to one of said conductors; means applying alternating current excitation between the other of said conductors and the cathode of said one rectifier and between the other of said conductors and the anode of said other rectifier; and means separately controlling the phase angle at which said rectifiers are rendered conductive.

**13.** In a control system for a pair of toy or model locomotives: a track system including a pair of conductors; a first locomotive power unit having pickup means cooperable with the conductors to derive energy therefrom; a motor for each power unit; circuit means including a unidirectionally conductive element for each motor connecting the motor across the pickup means for deriving energy from said conductors, the unidirectionally conductive means for the respective motors being oppositely polarized; a pair of controlled rectifiers connected back-to-back relationship, the anode of one of the rectifiers and the cathode of the other of the rectifiers being connected to one of said conductors; means applying alternating current excitation between the other of said conductors and the cathode of said one rectifier and between the other of said conductors and the anode of said other rectifier; means separately controlling the phase angle at which said rectifiers are rendered conductive; each power unit further including a relay dependent upon the corresponding unidirectionally conductive element and of the type that moves to contact stations successively upon the application of successive pulses of magnitude larger than provided by alternating current excitation applying means; circuit means completed by each relay for reversing the corresponding motor; and means interposed between the rectifiers and the said other conductor for selectively applying pulses of opposite polarities to said other conductor to reverse the corresponding motors.

**14.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors; a pair of power units for the vehicle having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and in response to a polarized signal transmitted via the corresponding unidirectionally conductive element; means for separately applying signals to said conductors of opposite polarities respectively to operate the corresponding reversing relay; each of said relays having a core; and means serially associated with the coils for discriminating against the alternating current source for blocking the pulsations thereof from said relay coil while passing the reversing signals, as determined by the corresponding undirectionally conductive elements.

**15.** In a control system for a pair of vehicles both deriving energy from a common pair of conductors; a pair of power units for the vehicles have oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and only in response to a relatively high amplitude polarized pulse transmitted via the corresponding unidirectionally conductive element; each relay having a coil; and means for applying pulses of selected polarity for operating the corresponding reversing relays.

**16.** In a control system for a pair of vehicles both

deriving energy from a common pair of conductors; a pair of power units for the vehicles having oppositely polarized unidirectionally conductive elements whereby the units derive excitation from opposite half cycles of an alternating current source applied to said conductors; said power units each including a motor; each power unit including a relay operative to reverse the motor connections and only in response to a relatively high amplitude polarized pulse transmitted via the corresponding unidirectionally conductive element; each relay having a coil; means for applying pulses of selected polarity for obtaining the corresponding reversing relays; and a device serially associated with each relay coil for permitting conduction only upon the application of a critical voltage for preventing chattering of the relays.




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