Oct. 2, 1923. 1,469,219

H. H. JOHNSTON ET AL

MOTOR CONTROL SYSTEM

Filed April 18, 1921

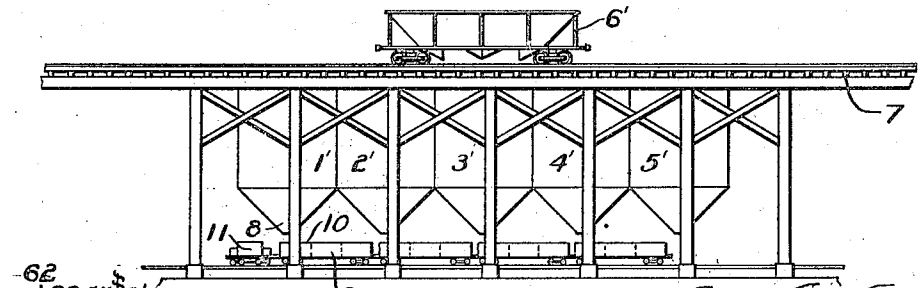


Fig. 1.

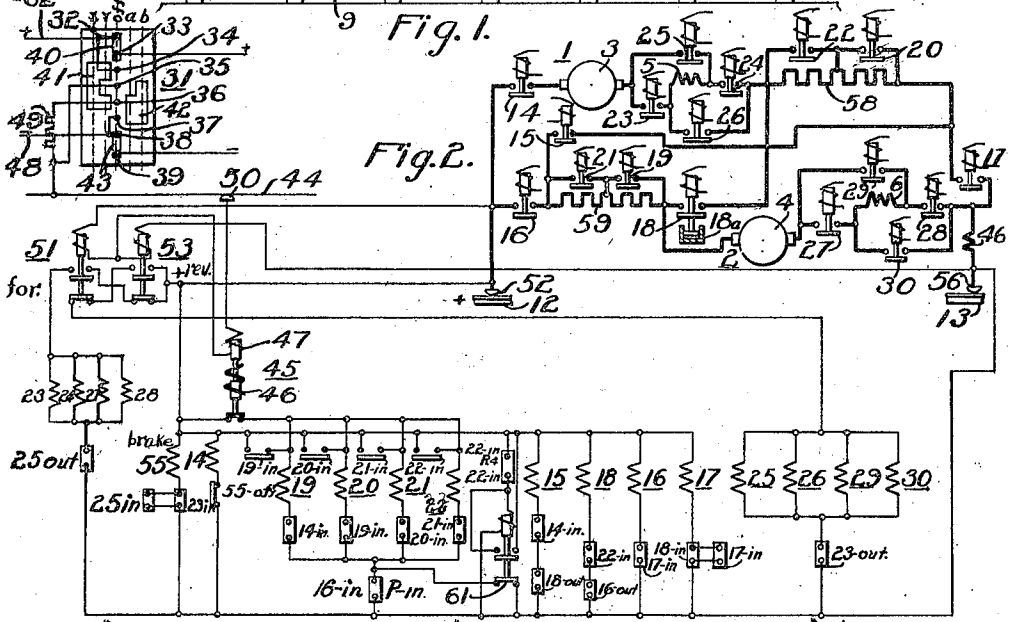


Fig. 2.

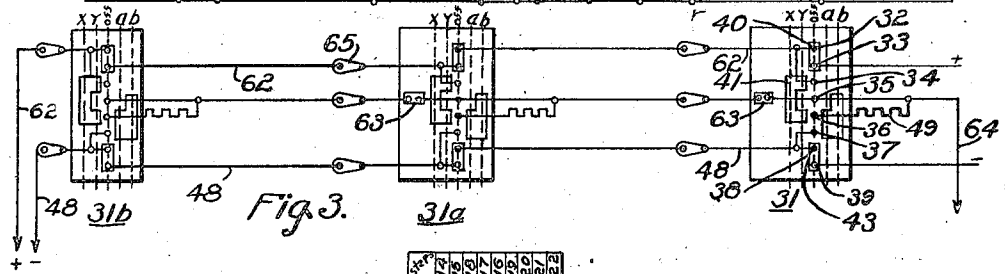


Fig. 3.

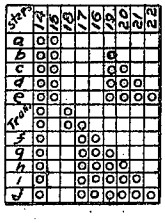


Fig. 4.

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UNITED STATES PATENT OFFICE.

HOWARD H. JOHNSTON, OF EDGEWOOD, AND DONALD C. PEABODY, OF TURTLE CREEK, PENNSYLVANIA, ASSIGNORS TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

MOTOR-CONTROL SYSTEM.

Application filed August 18, 1921. Serial No. 493,214.

To all whom it may concern:

Be it known that we, HOWARD H. JOHNSTON, a citizen of the United States, and a resident of Edgewood, in the county of Allegheny and State of Pennsylvania, and DONALD C. PEABODY, a citizen of the United States, and a resident of Turtle Creek, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Motor-Control Systems, of which the following is a specification.

Our invention relates to motor-control systems and it has particular relation to systems for governing vehicles from points relatively removed therefrom, such for example, as tower control systems for mine and mill locomotives or larry cars.

One object of our invention is to provide a relatively simple and economical control system for governing the speed and direction of operation of an electric vehicle from a station relatively removed therefrom.

Another object of our invention is to provide a control system for governing a plurality of motors whereby both their speed and direction of operation may be governed from a number of relatively distant stations although employing only a single control rail.

Heretofore, various control systems have been proposed for governing the speed of electric vehicles from points relatively removed therefrom, but such control systems have employed more than a single control rail to govern both the speed and direction of operation of the vehicle.

Briefly speaking, our invention consists in providing a control system for governing a plurality of motors that comprises a single wire or control rail which may be energized from either the positive or the negative side of the supply circuit to vary the direction and speed of operation of the motors.

For a better understanding of our invention, reference may be made to the accompanying drawing,

Figure 1 of which is a view, in side elevation, of a plurality of bins and cars for loading and unloading material.

Fig. 2 is a diagrammatic view of the main and the auxiliary control systems of an electric locomotive employed to haul the cars shown in Fig. 1 of the drawing;

Fig. 3 is a diagrammatic view of a plurality of stationary controllers that may be employed in conjunction with the control system illustrated in Fig. 2 of the drawing; and

Fig. 4 is a sequence chart showing the preferred order of closure of the main contactors that are illustrated in Fig. 2.

Referring particularly to Fig. 1 of the drawing, a plurality of bins 1′ to 5′, inclusive, are so constructed that various materials, such as lime, sandstone, ore and coke may be deposited therein from cars 6′, which travel upon an overhead trestle 7.

Each of the bins 1′ to 5′, inclusive, is provided with a chute 8 for directing the material flowing therefrom into a plurality of small larry cars 9, which are provided with compartments 10 for segregating the different materials that are carried by each car.

An electric locomotive or other railway vehicle 11 is employed for hauling the cars 9. The locomotive 11 is provided with a plurality of motors 1 and 2 having armatures 3 and 4, respectively, and corresponding series field-magnet windings 5 and 6. The motors 1 and 2 are energized from the rails 12 and 13 upon which the locomotive 11 operates. A line switch 14, series contactor 15, parallel-connecting contactors 16 and 17, transitional contactor 18 and accelerating contactors 19 to 22, inclusive, are employed to govern the energization and speed of the motors 1 and 2.

A plurality of directional contactors or reversing switches 23 to 26, inclusive, are employed for governing the direction of operation of the motor 1, and contactors 27 to 30, inclusive, are employed for governing the direction of operation of the motor 2.

A controller 31 having an "Off" position, a plurality of forward operating positions a and b and of reverse operating positions y and x, is employed to govern the speed and direction of operation of the motors 1 and 2. The controller 31 is provided with a plurality of control fingers 32 to 39, inclusive, which may be engaged by a plurality of contact segments 40 to 43, inclusive.

A control rail 44 parallels the rails 12 and 13 and may be energized by a circuit through the controller 31 in a manner hereinafter more fully described. A current-limit relay 45, having a current coil 46 and a check or holding coil 47, is employed to govern the closure of the accelerating contactors 19 to 22, inclusive.

The operation of the control system is begun by actuating the controller 31 to either position *a* or position *y*, in accordance with the direction of operation desired by the operator of the vehicle 11. If, for example, the controller 31 is actuated to position *a*, a circuit is established from the negative conductor 48 through control fingers 37 and 36, which are bridged by contact segment 42, control resistor 49, control rail 44, shoe 50, actuating coil 47 of the relay 45 and actuating coil of the forward operating relay 51 to shoe 52, which engages the positively energized rail 12.

The actuating coil of the reverse-operating relay 53 is not energized, as both of its terminals are connected to the negatively energized conductors 13 and 48. The actuating coils of the relays 51 and 53 are so designed that the difference in potential between the rails 12 and 13 is not sufficient to effect the closure of the relays 51 and 53, when the current must traverse both of the actuating coils, which are connected in series relation across the rails 12 and 13. The actuating coil 47 of the relay device 45 is not sufficiently energized to actuate the relay 45 when the resistor 49 is in circuit therewith.

When the forward relay 51 assumes its upper position, a circuit is established from the plus rail 12, through shoe 52, the lower contact member of the reverse relay 53, upper contact member of the forward relay 51, parallel-connected actuating coils of the forward directional contactors 23, 24, 27 and 28, interlock 25-out and shoe 56, to the negatively energized rail 13.

When the forward directional contactors 23, 24, 27 and 28 assume their closed positions, a circuit is established from the positively energized rail 12 through the actuating coil of the magnetic device 55 that governs the brake valve, interlock 23-in and the shoe 56 to the rail 13.

Upon the release of the brakes (not shown), a circuit is established from the positively energized rail 12 through the shoe 52, actuating coil of the line switch 14, brake interlock 55-off and shoe 56 to the negatively energized rail 13.

Upon the closure of the line switch 14, another auxiliary circuit is established from the positively energized rail 12 through the actuating coil of the series contactor 15, interlocks 14-in and 18-out and shoe 56 to the rail 13.

Upon the closure of the line switch 14 and the series contactor 15, a main circuit is established from the positively energized rail 12 through shoe 52, line switch 14, armature 3 of the motor 1, directional contactor 23, series field-magnet winding 5, directional contactor 24, starting resistor 58, series contactor 15, starting resistor 59, armature 4 of the motor 2, forward contactor 27, series field-magnet winding 6, forward contactor 28, current coil 46 of relay 45 and shoe 56 to negatively energized rail 13.

When the above circuit is established, the motors 1 and 2 are connected in series relation with the starting resistors 58 and 59 across the supply circuit.

The motors 1 and 2 are automatically accelerated by means of suitable interlocking and the current-limit relay 45. Upon the closure of the line switch 14, a circuit is established from the rail 12 through contact members of the relay device 45, actuating coil of the contactor 19, interlock 14-in and lower contact member of the transitional relay 61 to the rail 13.

Upon the closure of the accelerating contactor 19, an interlock 19-in is provided for preventing the deenergization of the actuating coil of the contactor 19, upon the current-limit relay 45 assuming its open position. If the current traversing the motors 1 and 2 is sufficiently great to actuate the relay 45 to its open position, further control of the motors 1 and 2 will cease until the relay 45 assumes its lower position.

As soon as this action occurs, a circuit is established from the rail 12 through contact members of the relay device 45, actuating coil of contactor 20, interlock 19-in and lower contact member of the transitional relay 61 to the rail 13. Interlock 20-in is provided for maintaining the actuating coil of the contactor 20 energized upon the opening of the current-limit relay 45. The actuating coils of the contactors 21 and 22 are energized in sequence, in the same manner as the actuating coils of the contactors 19 and 20, to effect closure of the contactors 21 and 22, in accordance with steps *d* and *e* of the sequence chart that is shown in Fig. 4.

After the starting resistors 58 and 59 are completely shunted, the connections of motors 1 and 2 may be changed from series to parallel relation. This change is effected by the actuating coil of the transitional contactor 18 being energized by a circuit that is established from the rail 12 through actuating coil of the contactor 18 and interlocks 22-in and 16-out to the rail 13. The contactor 18 may be equipped with some well known time-element device, such, for example, as a dash pot 18^a to maintain it closed until ground contactor 17 closes. Another circuit is established upon the closure of the accelerating contactor 22 from the rail 12

through interlock 22-in and the actuating coil of the relay device 61 to the rail 13.

The relay device 61 is maintained in its upper position by a holding circuit through the upper contact member of the relay device. When the relay device 61 assumes its upper position, accelerating contactors 19, 20, 21 and 22 are opened. The series contactor 15 has its actuating coil de-energized by the interlock 18-out when the contactor 18 assumes its closed position.

Upon the closure of the contactor 18, a circuit is established from the rail 12 through the actuating coil of ground contactor 17 and interlock 18-in to rail 13. A holding circuit for ground contactor 17 is provided by means of the interlock 17-in. Upon the closure of ground contactor 17, a circuit is established from rail 12 through actuating coil of the contactor 16 and interlock 17-in to the rail 13.

After the closure of the parallel contactor 16, the contactor 18 cannot assume its closed position because of the interlock 16-out.

After the parallel-connected contactors 16 and 17 have closed in accordance with the position *f* of the sequence chart, the motors may be further accelerated by the contactors 19, 20, 21 and 22 closing in sequence, in accordance with positions *g*, *h*, *i*, and *j* of the sequence chart that is shown in Fig. 4. These four contactors have their actuating coils energized by circuits comprising the interlock 16-in.

The motors have now been brought to full speed. If the operator desires to prevent the acceleration of motors 1 and 2 beyond a certain point he may do so by actuating the master controller 31 to position *b*, thereby shunting the auxiliary control resistor 49 to increase the current traversing the actuating coils 47 and 51, as explained below.

The actuating coil of the relay device 47 is designed to lift the relay device 45 to its open position when the auxiliary resistor 49 is shunted. As the accelerating contactors 19, 20, 21 and 22 cannot close so long as the relay device 45 is in its open position, it is apparent that, whenever the actuating coil 47 is sufficiently energized to effect the opening of the relay device 45, further acceleration control of the motors 1 and 2 will cease.

The operation of the motors 1 and 2 in a reverse direction is effected by actuating the controller 31 to position *y* thereby establishing a circuit from the positive conductor 62 through control fingers 34 and 36, which are bridged by contact segment 41, auxiliary control resistor 49, control rail 44, shoe 50 and actuating coil of the reverse directional relay 53 to the negative rail 13.

When the reverse relay 53 assumes its upper position, a circuit is established from rail 12 through upper contact member of reverse directional relay 53 and lower contact member of forward directional relay 51, parallel-connected actuating coils of the contactors 25, 26, 29 and 30, interlock 23-out and shoe 56 to the rail 13.

Upon energization of the actuating coils of the contactors 25, 26, 29 and 30, closure of the contactors is effected and the actuating coil of the magnetic device 55 is energized through a circuit comprising the interlock 25-in to effect release of the brakes (not shown). The line switch 14 is closed upon the brake interlock 55-off assuming its closed position. The acceleration of the motors 1 and 2 may be effected in the same manner as has previously been described for forward operation thereof. Acceleration of the motors 1 and 2 may be stopped by actuating the controller 31 to position *x* thereby shunting the auxiliary resistor 49 to effect opening of the relay device 45, as already set forth.

Referring to Fig. 3 of the drawing, a plurality of similarly constructed controllers 31, 31^a and 31^b, which are mounted in suitable towers, are provided for governing the motors 1 and 2. Interlocks 40 and 43 are provided for de-energizing the positive and the negative conductors 62 and 48, respectively, leading to subsequent controllers, upon any prior controller being actuated from its "Off" position.

Interlock 63 is provided for each of the controllers 31 and 31^a to prevent energization of the neutral conductor 64 by any prior controller in the sequence of operation 31, 31^a and 31^b upon any subsequent controller in that sequence being actuated from its "Off" position. By means of the contact segments 40, 43 and 63, it is apparent that all of the controllers 31, 31^a and 31^b must be in their "Off" position, except the particular controller that is being actuated by the operator, before the control rail 44 can be energized. The interlocks 40, 43 and 63 prevent two of the controllers 31, 31^a and 31^b from concurrently governing the operation of the motors 1 and 2. Hand-operated switches 65 are provided for opening the positive and the negative conductors 62 and 48 and the neutral conductor 64, when the operator desires to render the control system inoperative from any of the controllers.

From the above description, it is apparent that we have provided a control system for a locomotive whereby its speed and direction of operation may be controlled from any one of a number of stationary controllers, although employing but a single control rail. It is also apparent that we have provided means for protecting a control system from injurious effects that might be caused by concurrently actuating two of the stationary controllers.

While we have shown our invention in a preferred form, it is apparent that minor modifications may be made in the arrange-

ment of circuits and apparatus employed without departing from the spirit of our invention. We desire, therefore, to be limited only by the scope of the appended claims.

We claim as our invention:

1. In a control system, the combination with a motor, of means for accelerating said motor, means for reversing the direction of operation of said motor, and means comprising a single conductor for governing both said directional means and the automatic operation of said accelerating means.

2. In a control system, the combination with a motor, of means for reversing said motor, means for accelerating said motor, a plurality of relays for governing said reversing and accelerating means, and means comprising a single conductor associated with said relays for governing said reversing and accelerating means in accordance with the direction and degree of energization of said conductor.

3. In a control system, the combination with a motor, of means for reversing said motor, a plurality of switches for accelerating said motor, and means comprising a single control rail for governing said reversing means and accelerating switches in accordance with the energization of said rail.

4. In a control system, the combination with a motor, of means for reversing said motor and a plurality of switches for accelerating said motor, of two main rails for energizing said motor and means comprising a single auxiliary rail for governing said reversing and said accelerating switches.

5. In a control system, the combination with a motor, of means for reversing said motor, means for automatically accelerating said motor, a relay device for rendering said accelerating means inoperative, and a controller having a single wire connected to said reversing means and said relay device to govern the speed and direction of operation of said motor.

6. In a control system, the combination with a motor, of means comprising two relays having actuating coils for governing the direction of operation of said motor, said relays having their actuating coils connected in series relation, means comprising a relay device, having an actuating coil, for automatically accelerating said motor, said actuating coil having one of its ends connected to adjacent ends of said series-connected actuating coils, and a controller having a conductor connected to said actuating coil.

7. In a control system, the combination with a motor, of a plurality of reversing switches, having actuating coils, for governing the direction of operation of said motor, a forward and a reverse relay for governing the energization of said switches, each of said relays having an actuating coil, means comprising a plurality of switches for automatically accelerating said motor, a relay device for rendering said accelerating means inoperative and means comprising a single conductor for governing the energization of said relay device and the actuating coils of said forward and reverse relays.

8. In a control system, the combination with a plurality of motors, of means for reversing said motors, means for automatically accelerating said motors, means for rendering said accelerating means inoperative, and a single conductor for governing said reversing means and said inoperative-rendering means.

9. In a control system, the combination with a motor and a plurality of stationary controllers relatively removed from said motor, each of said controllers having an "Off" position and a plurality of operating positions, of means for rendering all subsequent controllers electrically inoperative upon a prior controller being actuated from its "Off" position.

10. In a control system, the combination with a motor and a plurality of stationary controllers relatively removed from said motor, each of said controllers having an "Off" position and a plurality of operating positions, of means for rendering all subsequent controllers inoperative upon a prior controller being actuated from its "Off" position, and means at each controller for rendering all controllers inoperative.

In testimony whereof, we have hereunto subscribed our names this 9th day of August, 1921.

HOWARD H. JOHNSTON.
DONALD C. PEABODY.