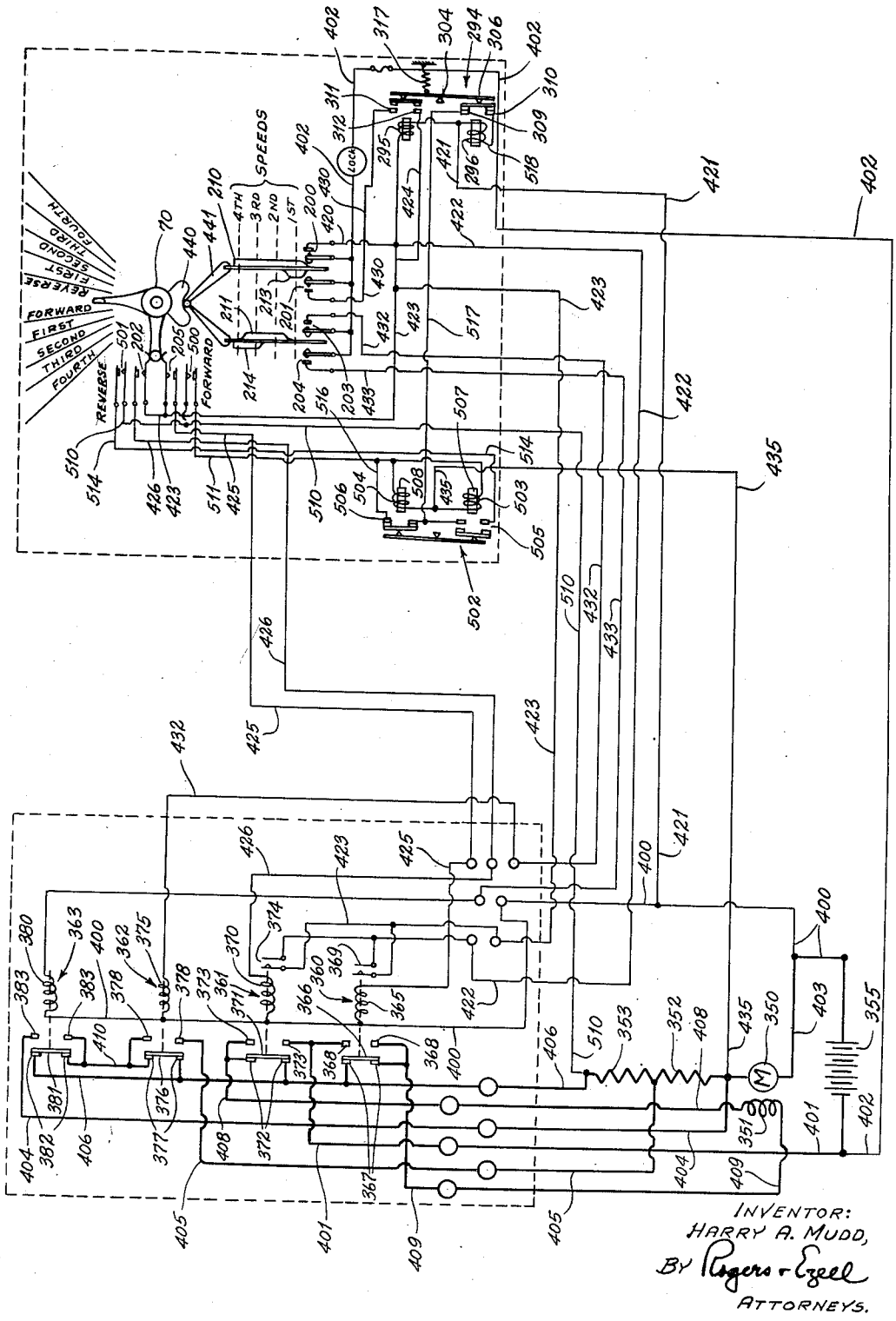
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H. A. MUDD

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TRUCK CONTROL WITH MEMORY RELAY

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INVENTOR:
HARRY A. MUDD,
BY Rogers & Egan
ATTORNEYS.

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TRUCK CONTROL WITH MEMORY RELAY

Harry A. Mudd, Maplewood, Mo., assignor to McQuay-Norris Manufacturing Company, St. Louis, Mo., a corporation of Delaware

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The present invention relates to a control such as those used for controlling the speeds of trucks that are driven by electric motors. Specifically, the present invention is an improvement over the truck control shown in the application of Lawrence M. Persons, Serial No. 41,695, filed July 30, 1948, for Multi-Speed Truck Control, and assigned to the assignee of the present application.

In a multi-speed truck control providing several rates of speed for both forward and reverse direction of travel, the problem exists that, when the control is suddenly shifted from a high speed operation in one direction to the position in which it is to obtain high speed operation in the other direction, there may be a sudden overload on the driving motor, attempting to make the motor reverse itself against the momentum of the truck. It has heretofore been proposed to control this by the effects of dynamic braking. For instance, in some controls sudden reversal of the control lever energizes a dynamic braking circuit that will hold until the motor substantially stops, which dynamic braking circuit includes hold-out relays that prevent energization of the circuits to drive the motor in the opposite direction until the truck has stopped its initial movement, and then only after the controller is once again neutralized and reset for drive in the new direction. The difficulty with such controls is that they fail to accommodate a condition where the operator, driving the truck in one direction, first reverses the controller, but then changes his mind and returns the controller to a driving position in the initial direction. Present controls, such as suggested have the characteristic that once the controller has been reversed from its initial direction they block out for any drive in either direction until the truck is actually substantially stopped. Therefore, it is impossible to return the drive to the initial direction without substantially stopping the truck, even though a return in the initial direction does not overload the truck motor.

It is an object of the present invention to overcome this deficiency in former controls by having means that prevent a reversing energization of the motor until it has substantially stopped movement in its initial direction, but which does not interfere with instant reenergization of the motor for further drive in its intial direction. In one sense of the invention, it is an object to provide a delaying means that will delay a reversing energization of the drive motor until it has slowed down sufficiently to avoid overload, but which will

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not delay any repeat energization of the motor in its initial direction.

It is a further object to combine the foregoing functions with dynamic braking so as to prevent the control mechanism from responding to a reversing shift of the operating member until the dynamic braking has caused the truck substantially to stop; but which does not interfere with the immediate reenergization of the motor in response to a return of the operating control member to a high speed position in its initial direction.

Another aspect of the objects of the invention is to provide a control for a motor driven, reversible truck that will provide dynamic braking whenever the operating control is moved from a driving position in either direction down to neutral, and which, when the operating control is moved from a driving position in one direction to a reversing driving position, will provide dynamic braking and will prevent reversing energization of the motor until the truck has substantially stopped, but which will eliminate dynamic braking and will provide immediate reenergization of the motor if the operating control, after such neutralization, is again returned to a driving position in its original direction.

In particular, this control has a controlling relay that must be closed to enable the truck motor to become energized at all when the controller is moved from neutral position to a driving position for operating the motor in either direction, and it has means interconnected with the dynamic braking circuit that prevents closure of this relay when the controller is moved from a driving position in one direction to a reversing driving position, but which does not so act when the controller is moved to neutral and back to a driving position in its initial direction.

As this control is basically similar to the previously mentioned Persons' control, I have here illustrated it following in practically all cases the reference numbers shown in that previous application, adding thereto the ones necessary to illustrate the improvements herein disclosed.

The drawing is a diagrammatic showing of the control.

Referring to the diagrammatic view, there is a truck drive motor **350** that is shown as series wound, it having a field winding **351** and a divided resistance **352** and **353** in series with the rotor. This motor **350** is a reversible direct current motor that is operated from a battery **355**. It is reversed by reversing the direction of current through its field winding and its speed is regu-

lated by varying the amount of resistance put in series with its armature. This latter involves the selected use of both, either, or neither of the two resistances 352 and 353.

There are two primary solenoid control switches 360 and 361 that act as criss-cross interlocking switches to determine the direction of current flow through the field winding 351 and hence the direction of rotation of the drive motor 350. The solenoid switch 360 is energized to produce forward rotation of the motor 350, whereas the solenoid switch 361 is energized to produce reverse rotation.

There are two additional solenoid switches 362 and 363 that control the speeds of the driving motor and, as it will appear, provide four speeds in each of the chosen directions.

The winding connections for the motor include a positive battery line 400 and a negative battery line 401. The positive battery line is connected by a lead 403 to one side of the motor armature. The other side of the armature of the motor 350 is connected directly into one end of the resistance 352 and is also connected by a line 404 to one of the contacts 383 of the speed control solenoid switch 363.

The other end of the resistance 352 is connected by a line 405 that leads to one of the contacts 378 of the other speed control solenoid switch 362. As is evident, the contacts 383 of the solenoid 363 are closed when the coil 380 of that solenoid is energized. Similarly, the two contacts 378 of the speed control solenoid switch 362 are closed when the coil 375 thereof is energized. In the released position of the solenoid switch 363, its two contacts 382 are closed by its armature 381. In the released position of the solenoid 362, its two contacts 377 are closed by its armature 376.

The upper end of the resistance 353 connected into the rotor of the drive motor 350 is connected to a wire 406. This wire 406 connects to the outside ones of the released contacts 377 and 382 of the two speed control solenoid switches 362 and 363. The two inside ones of the contacts 377 and 382, as well as the two inside ones of the energized contacts 378 and 383, are all connected together by a connection 410.

As illustrated, the directional control solenoid switches 360 and 361 have both released and energized switch contacts. The solenoid 360 has a coil 365 that, when deenergized, releases an armature 366 to close the contacts 367. When the coil 365 of the solenoid 360 is energized, its armature 366 closes together the two contacts 368.

In similar fashion, the directional control solenoid 361 has an armature 371 controlled by a coil 370. When the coil 370 is deenergized, the armature 371 closes together two contacts 372. When the coil 370 is energized, it closes together two contacts 373.

It will be observed that the two adjacent contacts 367 and 372 are both connected to the previously mentioned line 406. The two adjacent ones of the contacts 368 and 373 of the solenoids 360 and 361 are connected together and are joined to a wire 401 which is the negative lead of the battery 355.

The upper end of the field coil 351 is connected by a wire 408 that leads to both of the two upper outer ones of the contacts 372 and 373 of the solenoid 361. The lower end of the field winding 351 is connected to a wire 409 that leads to both of the two outer ones of the contacts 367 and 368 of the solenoid switch 360.

The coil 365 of the solenoid switch 360, when energized, closes a switch 369. Similarly, when the coil 370 of the solenoid switch 369 is energized, it closes a switch 374.

The direction of movement and the speed of movement of the drive motor 350, as already stated, are controlled by the four solenoid switches. These solenoid switches are, in turn, controlled by a control mechanism that has a main control handle that is manually operated. The major part of this section of the present control is shown at the right of the schematic drawing.

The control 70 is preferably one that is manually operated in the manner shown in the Persons' application previously referred to. For diagrammatic purposes, it is shown as being mounted for rocking movement on a shaft and as having a double cam 440. When the arm 70 is rocked in either direction from its neutral position illustrated, one or the other sides of the cam 440 will cause a cam follower device 441 to be moved. In the actuation of the control, the cam follower mechanism 441 is moved down to actuate a group of sequence switches that obtain movement of the truck motor 350 and increase its speed. When the controller 70 is returned, the follower mechanism 441 moves upwardly, reduces the speed of the motor 350, and finally can neutralize it or stop it.

The cam follower mechanism 441 has four cams on it illustrated at 210, 213, 211, and 214, reading from right to left in the drawing. These cam devices 210, 213, 211 and 214 actuate four switches 200, 201, 203 and 204, respectively. It will be seen that the cam 210 closes the switch 200 upon movement of the arm 70 in either direction from neutral, and maintains the switch 200 closed whenever the arm 70 is out of its neutral position. The cam 213 closes the switch 201 only when the arm 70 is in its first speed position. The cam 211 closes the switch 203 when the arm 70 is moved to its second speed position, holds the switch 203 closed when the cam is continued into its third speed position, but then reopens it when the arm 70 is moved to its fourth speed position. The cam member 214 closes the switch 204 only when the arm 70 is moved to its third speed position and maintains the switch 204 closed as the arm 70 is moved into its fourth speed position.

The controller 70 also actuates a forward and reverse switch arrangement that is illustrated to the left of the controller 70 in the diagrammatic view. There is a pair of mechanically coupled forward switches 205 and 500 that are closed only when the controller 70 is moved as far counterclockwise as the position marked "Forward" in the drawing. There is also a pair of mechanically coupled reverse switches 202 and 501 that are closed only when the controller 70 is moved as far as the position marked "Reverse" in the drawing. It will be noticed that these switches are actuated before the controller 70 closes any speed-regulating switches. When the arm 70 is in its neutral position, all of the four switches are open.

The control also includes a blocker relay 294 having an actuating rocking lever or armature 306 that is pivoted at 304. Adjacent one end of the armature 306 are two contacts 309 and 310, and adjacent its other end are two contacts 311 and 312. This armature 306 is normally spring urged to the position shown, closing the contacts 309 and 310 together, by a spring 317. The re-

lay 294 has two coils 295 and 296. The coil 295 will draw the armature 306 into position such that its armature 306 closes the contacts 311 and 312. The coil 296 is a bucking coil that opposes the operation of the coil 295, or, as illustrated in the diagram, it is a coil that holds the armature 306 in position wherein it closes the contacts 309 and 310 and holds the contacts 311 and 312 open. When the coil 296 is fully energized, the coil 295, even when it also is energized, cannot shift the armature 306.

There is also what is called a memory relay illustrated at 502 in the diagram. This relay includes an armature that is rockable to close either of two switches 505 or 506 and to open the other. There are two coils 503 and 504. The coil 503 will draw the armature in position to close the switch 505, whereas the coil 504 will draw the armature to close the switch 506. The coils 503 and 504 are mounted about permanent magnet cores, there being such a core 507 associated with the coil 503, and a core 508 associated with the coil 504. Each core is of inadequate strength to tip the armature from either position to the other, but each will hold the armature in either operated position after it has been displaced into such position by suitable energization of the corresponding one of the two coils 503 and 504.

The secondary parts of the control are interconnected with the primary control. The negative side of the battery has a line 402 that leads to each of the four switches 200, 201, 203 and 204. The switch 200 is also connected by a line 420 that leads in one branch through the blocking relay coil 295, the other side of which is connected to a line 421 that leads to the line 400 on the positive side of the battery. The line 420 from the switch 200 in another branch is connected by a line 422 that, in turn, is connected to one side of each of the two solenoid operated holding switches 369 and 374. The other side of both of these switches is connected by a line 423 that leads back to the secondary part of the control, and thence one branch of the line 423 is connected into one side of each of the forward and reverse switches 205 and 202. Another branch from the line 423 is shown at 424 and leads to the contact 312 of the blocker relay 294. The switch 201 of the speed regulating group is connected by a line 430 to the other terminal 311 of this blocker relay switch.

The other cam operated switch 203 is connected by a line 432 that leads into the coil 375 of the solenoid 362. The other side of this coil is connected to the line 400 on the positive side of the battery.

The switch 204 is connected by a line 433 that leads to one side of the coil 380 of the solenoid 363, the other side of which is also connected to the line 400 on the positive side of the battery.

The other side of the forward switch 205 is connected by a line 425 that leads to one side of the coil 365 of the solenoid 360, the other side of which is connected to the line 400. The other side of the reverse switch 202 is connected by a line 426 that leads to one side of the coil 370 of the solenoid 361, the other side of which coil is connected to the line 400.

The upper end of the resistor 353 in series with the armature winding of the motor 350 is connected by a line 510 that, in turn, is connected to one side of each of the forward and reverse switches 500 and 501. The other side of the switch 500 is connected by a line 511 that leads

to one end of the coil 503 of the memory relay, and also includes a branch 516 that leads to the switch 506 of the memory relay. In similar fashion, the reverse switch 501 is connected by a line 514 that is connected to one side of the memory relay coil 504 and is also connected to one side of the switch 505 of the memory relay. The other sides of the two coils 503 and 504 are connected by a line 435 that leads back to the lower side of the resistance 352. The other sides of the two switches 505 and 506 are connected by a wire 517 that leads to the terminal 309 of the blocker relay. The other side 310 of this switch of the blocker relay is connected by a wire 518 into one end of the coil 296. The other side of this coil is connected to the wire 421 that leads back to the wire 400 on the positive side of the battery.

Operation

When the control is completely at rest, its components occupy the positions indicated in the drawing. The motor 350 is entirely inactive and its field winding 351 short-circuited upon itself. The various truck controlling solenoids 360—363 are in their released positions. The holding switches 369 and 374 are open. The main control handle 70 is in its neutral position so that the switches 200, 201, 203 and 204 are entirely open and the switches 202 and 205, which are the directional control switches, are also open, as are their related switches 500 and 501. The blocking relay armature 306 is operated by the spring 317 to the position shown with the contacts 311—312 open and the contacts 309—310 closed. The memory relay 502 may be in the position shown, but its actual position will depend upon the direction of travel of the truck when it was previously operated before the stop. It is retained in its position by the action of the near end of its armature to one of the magnetic cores 507 and 508.

If the operator desires to move the truck forward, he first moves the handle 70 counterclockwise, as, for example, to the first speed position. In this operation, the handle first passes the position marked "Forward" and in so doing it closes the switches 205 and 500 while leaving the switches 202 and 501 open. The movement of the arm 70 to the first speed position, by the action of the cam 440 upon the arm 441, causes the switches 200 and 201 to be closed subsequently to closure of the directional switch 205 and the memory relay control switch 500.

When the switches aforesaid are closed, circuits are established from the battery 355. The negative lines 401 and 402 are constantly connected to the negative side of the battery. The line 402 leads to the secondary side of the control and to the several switches 200, 201, 203 and 204. With the switch 200 closed, the circuit from the negative line 402 passes through that switch, thence through the line 420, the coil 295, the line 421 and the positive line 400 of the battery to the positive side of the battery. This action energizes the coil 295 and draws the armature 306 of the holding switch against the spring 317 to close the contacts 311 and 312 and to open the contacts 309 and 310.

When the blocking relay closes the contacts 311 and 312, a circuit from the negative line 402 then flows through the now closed switch 201, the line 430, the contacts 311 and 312, the line 424, the line 423, the directional switch 205, the line 425, the coil 365 of the forward solenoid switch 360,

and the line 400 back to the positive side of the battery.

When the coil 365 is energized, it draws its armature 366 to open the contacts 367 and to close the contacts 368 of this directional solenoid relay 360. Also it closes the switch 369.

When the switch 369 is closed a circuit shunting the switch 201 is established, this circuit being dependent only on continued energization of the coil 365 of the relay 360 and closure of the switches 200 and 205. It renders the continued energization of the relay 360 independent of the switch 201 and independent of the position of the armature 306 of the blocking relay. Stated differently, and, as will appear, it requires operation of the control through first speed position when the direction of travel is reversed.

When the directional relay 360 is so operated, the drive motor 350 is caused to move in a forward direction at a first low speed. Its primary circuit is as follows, beginning with the negative side of the battery: The line 401, the contacts 368 through the contact 366, the line 409, field winding 351, the line 408, the contacts 372 through the contact 371, the line 406, the resistances 353 and 352 in series, the rotor of the motor 350, the line 403 and the line 400 to the positive side of the battery. In this, the direction of flow of current through the field winding 351 is upwardly in the drawing. The entire resistance 353—352 being in series, the motor 350 operates at only a a low speed.

The resistance drop across the resistor combination 353—352 is also applied across one of the coils of the memory relay 502. Starting at the upper end of the resistor 353, there is a circuit beginning with the line 510 that extends to the switch 500 that is part of the directional switch combination operated by the controller handle 70. From the switch 500, the circuit continues through the line 511 and the coil 503 of the memory relay. This is a high resistance coil. The circuit continues through the line 435 that extends back to the bottom of the resistor 352. The foregoing resistance drop is suffcient to cause the coil 503 to pull the armature over to close contacts 505 and open the contacts 506. As soon as the armature has thus shifted, the coil 503 may be deenergized and the permanent magnet core 507 within the coil 503 will hold the armature in the position described. No circuit combinations of the switches 505 and 506 are affected at this time.

If the handle 70 is moved to its second speed position, the switch 200 will remain closed. The switch 201 is opened, but this has no effect because of the previously mentioned holding circuit through the switch 369 of the directional solenoid 360. The switch 203 will be closed by the cam 211 when the second speed position is obtained.

Closure of the switch 203 establishes a circuit from the negative line 402 through the switch 203, the line 432 to the coil 375 of the solenoid switch 362, and thence to the positive line 400 leading to the battery. Energization of the coil 362 shifts its armature to open the contacts 377 and to close the contacts 378. This will be found to shunt out the resistance 353. The motor circuit is then from the line 401, the contacts 368, the line 409, the field winding 351, the line 408, the contacts 372, the line 406, the contacts 382, the line 410, the contacts 378, the line 405 to the top of the resistance 352, thence through that resistance and the motor 350 to the line 400 in the positive side of the battery. The shunting of the resistance 353 causes the speed of the motor 350 to increase so that the truck or other vehicle can move faster.

If the operator moves the handle 70 to the third speed position, the switches 200 and 203 remain closed and the switch 204 is also closed. Closure of the switch 204 completes the circuit from the negative side of the battery through the line 402 through the switch 204, the line 433, the coil 380 of the solenoid switch 363, and the line 400 to the other side of the battery. When the coil 380 is energized concurrently with the energization of the coil 375 of the solenoid switch 362, the resistance 352 is shunted out and the resistance 353 alone is left in the motor circuit. The motor circuit then is as follows: From the negative side of the battery, the line 401, the contacts 368, the line 409, field winding 351, the line 408, the contacts 372, the line 406 to the upper end of the resistance 353, the line 405 from the lower end of the resistance 353, the contacts 378, the line 410, the contacts 383, the line 404 through the rotor of the motor 350 and the lines 403 and 400 to the other side of the battery. As illustrated, the resistance 353 is less than the resistance 352 so that the speed of the motor increases.

If the operator moves the handle 70 to the fourth speed forward position, this action will maintain the switches 200 and 204 closed but will open the switch 203. As the switch 203 directly controls the coil 375 of the solenoid switch 362, its being open will deenergize the coil 375 and permit the armature 376 to shift from the contacts 378 back to the contacts 377. Otherwise, the various switches remain as before. However, this change completely shunts out both resistances 352 and 353 from the motor circuit which becomes as follows: from the negative side of the battery through the line 401 to the contacts 368, the line 409, field winding 351, the line 408, the contacts 372, the line 406, the contacts 377, the line 410, the contacts 383, the line 404, the armature of the motor 350, and the lines 403 and 400 to the positive side of the battery. The drive motor 350, therefore, operates at maximum speed.

If the handle 70 of the control is moved downward to a lower position, it will cause the truck to reduce speed. If the handle is returned all the way to the neutral position, the motor 350 will be disconnected from the battery. However, dynamic braking will be effective to cause the truck to slow down and ultimately to stop. As aforesaid, the field winding 351 is short-circuited upon itself by the release of all of the solenoid switches 360–363, and, when the handle 70 is returned to neutral, the solenoid switches are thus released to the positions illustrated. The circuit through the field winding 351 can be traced from it through the line 408, the contacts 372, the line 406, the contacts 367, and the line 409 back to the other end of the field winding.

With the truck geared to the motor 350, the motor will be driven and will act as a generator. A circuit for dynamic braking can be established as soon as the blocking relay 294 is released. That is to say, as soon as the coil 295 becomes deenergized by neutralization of the handle 70, the spring 317 will swing the blocking relay over to the position wherein it closes the contacts 309 and 310. Thereupon, a dynamic braking circuit is established from the top of the motor 350 through the line 435, the coil 504, the line 514, the previously closed contacts 505, the line 517, the contacts 309 and 310, the line 518, the block-

ing coil 296, the line 421, and the lines 400 and 403 back to the motor. The current thus supplied to the coil 504 during dynamic braking is insufficient to overcome the permanent magnet in the coil 503 so that the memory relay is not shifted by the dynamic braking operation.

In order to operate the truck in a reverse direction, the handle 70 is moved clockwise in the drawing, as, for example, to the first speed reverse position. In so doing, it passes through the position indicated "Reverse" and at such time closes the switch combination 202—501.

The cam action on the cam follower arm 441 and the switches 200, 201, 203 and 204 is identical for the several speeds in reverse that it is for the corresponding speeds in the forward direction. The switch 202, however, closed in place of the switch 205, energizes the solenoid switch 361 instead of the solenoid 360, so that in the reverse position the circuit combinations for the several speeds are identical as in the forward direction, except that the flow of current through the field winding 351 is in the opposite direction. Also, the switch 501 energizes the memory relay in the opposite direction.

To illustrate, for the first speed in reverse, the movement of the lever 70 closes the switches 202 and 501 and also closes the switches 200 and 201. Closure of the switch 200 establishes the circuit from the negative line 402 through the switch 200, the line 420, the coil 295, and the lines 421 and 400 to the battery to energize the coil 295 and operate the blocking relay as previously. Similarly, the closure of the switch 201 initially establishes a circuit from the negative line 402 through the switch 201, the line 430, the contacts 311 and 312, the line 424, the line 423, the reverse switch 202, the line 426, the coil 370 of the solenoid switch 361 and the line 400 back to the positive side of the battery. This energizes the solenoid 361, draws its armature 371 to close the contacts 373 and open the contacts 372, and it also closes the holding switch 374. When the switch 374 is closed, the foregoing circuit to the coil 370 is held as before through the switch 200 to the line 422, the switch 374, the line 423, the switch 202, the line 426 to the coil 370 and the return battery line 400, thus shunting the blocking relay.

The primary circuit to the drive motor 350 now extends from the negative side of the battery through the line 401, the contacts 373, the line 408, downward through the field coil 351, thence through the line 409, the contacts 367, the line 406 through the two resistors 353 and 352, the motor 350 and the lines 403 and 400 back to the positive side of the battery.

As before, the resistance drop across the two resistors 352 and 353 is then placed onto the memory relay. This circuit is from the top of the resistor 353 through the line 510, the switch 501, the line 514, the memory relay energizing coil 504, the line 435 to the bottom of the resistor 352. This will energize the coil 504 and cause it to pull the armature of the memory relay over to the position shown wherein it closes the contacts 506 and opens the contacts 505. The permanent magnet in the memory relay will be sufficient to hold the armature in the position indicated until the coil 503 is subsequently similarly energized.

It is not necessary to trace the several reverse speed positions because they are the counterparts of the forward speed positions, save only

that the solenoid 361 is energized in place of the solenoid 360.

If from one of the reverse speed positions, the operator returns the handle abruptly to neutral, dynamic braking will result. All of the truck solenoid switches will be released, and the several cam operated switches on the control handle mechanism will be opened. The blocking relay will return to the position shown. The memory relay 502 will hold the position shown because the deenergization of the coil 504 merely leaves the memory relay under the control of the permanent magnet 508 associated with the coil 504. When the truck overrides the motor 350 with the control lever 70 in its neutral position, the dynamic braking circuit will be the counterpart of that obtained in the forward travel. It starts from the top of the motor 350, extends through the line 435 to the coil 503, thence by way of the lines 511 and 516 through the closed switch 506, the line 517 through the released blocking relay, and thence by way of the line 518, the coil 296, the line 421 and the line 400 to the bottom of the motor.

The dynamic braking circuit includes the coil 503, which is a high resistance coil, in series with the relatively low resistance plugging coil 296. The high resistance of the coil 503 prevents the plugging coil 296 from holding the blocking relay against an energization of the coil 295. If the handle 70 is moved from the reverse side to the forward side, the first action in displacement in the forward direction is a closure of the switches 205 and 500. As soon as the switch 500 is closed, a different dynamic braking circuit is energized, which substitutes the low resistances 352 and 353 in series with the plugging coil 296 in place of the coil 503. This circuit is as follows: From the motor 350 through the resistors 352 and 353, the line 510, the switch 500, the line 511, the line 516, the switch 506, the line 517, the contacts 309, 310, the line 518, the coil 296, the line 421 and the lines 400 and 403 back to the motor. The low resistance of this circuit produces sufficient energization of the coil 296 to hold the armature of the blocking relay in the position shown, and to prevent the closure of the contacts 311 and 312, regardless of subsequent energization of the coil 295, until the motor slows down. Thus, when the truck has been running in the reverse direction, and the handle is suddenly thrown over to the forward direction, there is an immediate blocking of the control so that the motor 350 cannot be energized in the forward direction until it has slowed down and substantially stopped. This also produces dynamic braking.

If the handle 70 from a reverse position is neutralized and then returned to the reverse direction, the plugging relay coil 296 will not be energized through the last named circuit. The dynamic braking circuit will continue as originally by way of the line 435, the coil 503, the lines 511 and 516, the switch 506, the line 517, the switch 310, the line 518, the coil 296, the lines 421, 400 and 403, back to the motor. However, a reclosure of the reverse switch 501 will not energize the parallel dynamic braking circuit that energizes the plugging coil 296 sufficiently to hold the blocker relay in its open position illustrated. The former circuit which began with the resistors 352, 353, and when through the line 510 now passes through the closed switch 501 and the line 514 back to the memory relay.

Owing to the initial energization of the memory relay to the position shown when the arm 70 was first moved to the reverse direction, the switch 505 will remain open, thus breaking the alternative or parallel circuit that adequately energizes the plugging relay coil 296 to prevent a pull-in by subsequent energization of the coil 295. Hence, the return or repeat movement of the arm 70 in the reverse direction to one of its four speed positions will at once reenergize the coil 295 and that coil will have power enough to pull the blocking relay to the position closing the contacts 311 and 312. The memory relay acts in direct counterpart when the control has been in a high speed reverse position and is shifted to a forward position.

Thus it may be seen that the memory relay will actually block out any attempt to reverse the potential applied to the motor 350 when the operating handle 70 is moved from a high speed position in one direction to a position in the other direction until the motor has slowed down sufficiently to stop generating enough current to energize the blocking relay coil 296 sufficiently to hold the blocking relay open; but the memory relay, having previously been positioned, will not act to prevent a shift of the blocking relay when the handle 70 is moved to neutral and is thereafter returned to a speed position in the same direction as previously occupied.

It may be noted that, if the operating handle is moved from a high speed position in one direction across neutral to a speed position in the other direction, dynamic braking will be obtained, and also the control will be blocked out to prevent reverse energization of the motor; but that, if the handle is then returned to a speed position in its initial direction before the truck has stopped moving, the blocking is ineffective and energization of the motor for such initial direction of travel will obtain. Also, dynamic braking follows when the handle is only neutralized, but blocking does not occur.

Another feature of the truck control is that, when the direction of the control handle 70 is suddenly reversed from one direction to a high speed position in the other direction, the motor cannot be energized for such high speed operation in the opposite direction even after dynamic braking has caused the motor to stop. The operator must take the control through a first speed operation in the other direction before he can obtain higher speed operations in such direction.

The foregoing comes about because the control requires an initial closure of the switch 201 whenever the handle 70 is moved from neutral position, as a prerequisite to the energization of either the solenoid switch 360 or the solenoid switch 361. If, during operation of the motor in one direction, the handle is crossed over to a second, third, or fourth speed position in the opposite direction, the blocking operation of the coil 296 will be effective to prevent closure of the blocking relay contacts 311 and 312 until the motor has substantially stopped. Hence the starting circuit for energization of either solenoid coil 365 or 370 is not closed, even when the manual switch 201 is momentarily closed during displacement of the handle 70 to a second or higher speed position. The switch 201, though momentarily closed, is reopened as the handle is moved on to a second, third or fourth speed position. Subsequent release of the blocker coil 296 when the dynamic braking and blocking effect is over does not proceed to a shifting of the relay 294 because the coil 295 is not in circuit when the switch 201 is opened. The operator must then return the control handle 70 to the first speed position before he can obtain any operation in the opposite direction. This avoids an overload of the motor. It will be noted that this effect is not true when the handle 70 is returned to operation in its initial direction. The neutralizing of the handle does not produce the blocking effect, so that a return in the initial direction will enable the coil 295 to be energized whenever the switch 201 is closed and an upper speed position will result in an upper speed energization of the motor 350.

It may be noted that the foregoing effect may also be combined with the arrangement in the Persons' application, in which the blocking relay mechanically prevents movement of the switches above first speed position in a reversing direction.

The truck can still be plugged back and forth between first speed forward and first speed reverse without being blocked because the amount of current passed through the blocking coil 296 when the truck is moving only as fast as the first speed positions provide is not enough to block out the action of the coil 295 in closing the blocker relay 294 to establish energization of one of the two solenoids 360 and 371. The plugging operation is required because in maneuvering a truck in narrow spaces it is frequently necessary to move quickly in opposite directions for very short distances.

It will be seen that this truck control provides the mechanism whereby the objectives set forth in the preceding specification are obtained.

In the claims to follow, the terms "forward" and "reverse" are employed merely to distinguish the two opposite directions of movement of the motor, and without being intended to mean movement "frontward" and "backward" with respect to the normal front of the object operated by the motor, or the clockwise or counterclockwise direction of rotation of the motor shaft.

What is claimed is:

1. In a control for a reversible electric motor, control means movable to forward, neutral, and reverse positions, circuits operated by the control means in its forward and reverse positions to produce forward and reverse energization of the motor, the control means opening said circuits when in neutral position; means to prevent the reverse circuit from being operated when the control means is moved to reverse position during operation of the motor in forward direction, means to disestablish the preventing means when the control means is returned to forward position during continued forward operation of the motor, whereby the control means may reclose the forward circuit, forward and reverse dynamic braking circuits energized by operation of the motor as a generator; said dynamic brake circuit including switch means movable to close either forward or reverse dynamic brake circuit contacts, preset means operable upon energization of the forward motor circuit to operate said switch means into closing position in the reverse dynamic brake circuit, and into opening position with respect to the forward dynamic brake circuit and operated by energization of the reverse motor circuit to operate said switch means into closing position in the forward dynamic braking circuit and into opening position with respect to the reverse dynamic braking circuit; means operable by displacement of the control means

from one directional position to the other to close the opposite dynamic brake circuit through the preset means; and means in said dynamic braking circuits to prevent energization of the motor circuits during energization of the dynamic brake circuit, and additional dynamic brake circuit means closed when the control means is moved to neutral position.

2. In a control for a reversible electric motor, control means operable to forward, reverse, and neutral positions, a forward motor energizing circuit operated by operation of the control means to forward position, a reverse motor energizing circuit operated by operation of the control means to reverse position, the control means being adapted to open said circuits when it is in neutral position; a dynamic braking circuit including means to prevent closure of the forward or reverse motor circuits when the motor is operating as a generator, said dynamic brake circuit including two branches for connection with the motor to be energized by the motor running as a generator, comprising a reverse branch adapted to be established through the control means in reverse position and a forward branch adapted to be established through the control means in forward position, and preset means to close the reverse dynamic brake circuit branch and open the forward dynamic braking circuit branch when the forward motor circuit is energized, and means to close the forward dynamic brake circuit branch and open the reverse dynamic brake circuit branch when the reverse motor circuit is closed, whereby the means to prevent closure of the motor circuits is effective when the control means is displaced during operation of the motor in one direction, to a position to produce operation of the motor in the other direction, but is ineffective to prevent reenergization of a motor circuit to operate the motor in its initial direction.

3. In a control for a reversible electric motor, control means operable to forward, reverse, and neutral positions, a forward motor energizing circuit operated by operation of the control means to forward position, a reverse motor energizing circuit operated by operation of the control means to reverse position, the control means being adapted to open said circuits when it is in neutral position; a dynamic braking circuit including means to prevent closure of the forward or reverse motor circuits when the motor is operating as a generator, said dynamic brake circuit including two branches comprising a reverse branch adapted to be established through the control means in reverse position and a forward branch adapted to be established through the control means in forward position, and preset means to close the reverse dynamic brake circuit branch and open the forward dynamic braking circuit branch when the forward motor circuit is energized, means to close the forward dynamic brake circuit branch and open the reverse dynamic brake circuit branch when the reverse motor circuit is closed, whereby the means to prevent closure of the motor circuits is effective when the control means is displaced during operation of the motor in one direction, to a position to produce operation of the motor in the other direction, but is ineffective to prevent reenergization of a motor circuit to operate the motor in its initial direction, and additional dynamic braking circuit means operable when the control means is moved to neutral position and the motor is operated as a generator.

4. In a control for a reversible electric motor, control means operable to forward, reverse, and neutral positions, a forward motor energizing circuit operated by operation of the control means to forward position, a reverse motor energizing circuit operated by operation of the control means to reverse position, the control means being adapted to open said circuits when it is in neutral position; a dynamic braking circuit including means to prevent closure of the forward or reverse motor circuits when the motor is operating as a generator, said dynamic brake circuit including two branches comprising a reverse branch adapted to be established through the control means in reverse position and a forward branch adapted to be established through the control means in forward position, and preset means to close the reverse dynamic brake circuit branch and open the forward dynamic braking circuit branch when the forward motor circuit is energized, means to close the forward dynamic brake circuit branch and open the reverse dynamic brake circuit branch when the reverse motor circuit is closed, whereby the means to prevent closure of the motor circuits is effective when the control means is displaced during operation of the motor in one direction, to a position to produce operation of the motor in the other direction, but is ineffective to prevent reenergization of a motor circuit to operate the motor in its initial direction, said preset means including relay mechanism having a coil in each motor circuit and switch means in each dynamic brake circuit branch, the forward relay coil when energized, closing the switch means in the reverse dynamic brake branch, and vice versa, and holding means to maintain each relay switch closed, once its coil is energized, until the other coil is energized.

5. In a control for a reversible electric motor, control means operable to forward, reverse, and neutral positions, a forward motor energizing circuit operated by operation of the control means to forward position, a reverse motor energizing circuit operated by operation of the control means to reverse position, the control means being adapted to open said circuits when it is in neutral position; a dynamic braking circuit including means to prevent closure of the forward or reverse motor circuits when the motor is operating as a generator, said dynamic brake circuit including two branches comprising a reverse branch adapted to be established through the control means in reverse position and a forward branch adapted to be established through the control means in forward position, and preset means to close the reverse dynamic brake circuit branch and open the forward dynamic braking circuit branch when the forward motor circuit is energized, means to close the forward dynamic brake circuit branch and open the reverse dynamic brake circuit branch when the reverse motor circuit is closed, whereby the means to prevent closure of the motor circuits is effective when the control means is displaced during operation of the motor in one direction to a position to produce operation of the motor in the other direction, but is ineffective to prevent reenergization of a motor circuit to operate the motor in its initial direction, said preset means including relay mechanism having a coil in each motor circuit and switch means in each dynamic brake circuit branch, the forward relay coil when energized, closing the switch means in the reverse dynamic brake branch, and vice versa, and

holding means to maintain each relay switch closed, once its coil is energized, until the other coil is energized, said holding means comprising a permanent magnet associated with each coil.

6. In a control for a reversible electric motor, control means operable to forward, reverse, and neutral positions, a forward motor energizing circuit operated by operation of the control means to forward position, a reverse motor energizing circuit operated by operation of the control means to reverse position, the control means being adapted to open said circuits when it is in neutral position; a dynamic braking circuit including means to prevent closure of the forward or reverse motor circuits when the motor is operating as a generator, said dynamic brake circuit including two branches comprising a reverse branch adapted to be established through the control means in reverse position and a forward branch adapted to be established through the control means in forward position, and preset means to close the reverse dynamic brake circuit branch and open the forward dynamic braking circuit branch when the forward motor circuit is energized, means to close the forward dynamic brake circuit branch and open the reverse dynamic brake circuit branch when the reverse motor circuit is closed, whereby the means to prevent closure of the motor circuits is effective when the control means is displaced during operation of the motor in one direction to a position to produce operation of the motor in the other direction, but is ineffective to prevent reenergization of a motor circuit to operate the motor in its initial direction, said control means being operable to a plurality of forward speed positions, and there being a plurality of forward speed circuits corresponding to said positions, and means to prevent energization of the motor for a higher speed operation when the control means is placed in a higher speed position and the blocking means is effective, even after the blocking means is released by decay of dynamic braking.

7. In a control for a reversible electric motor; a forward and a reverse solenoid switch for controlling the direction of the motor, each having a coil, and each having a holding switch energized upon energization of its coil; a displaceable member operable from neutral oppositely to a plurality of forward and reverse positions, a plurality of speed switches open when the member is in neutral position but successively closed by the member in accordance with its displacement from neutral, a pair of forward directional switches and a pair of reverse directional switches, all being open when the displaceable member is in neutral position and each pair being closed by movement of the displaceable member from neutral toward, but prior to, speed positions thereof in its respective directions, a memory relay comprising a pair of coils and switch means, the switch means being operated to close one set of contacts and open the other upon predetermined energization of each of its coils, and having means to retain the switch means in each such position until predetermined energization of the other coil; a blocking relay including main coil means and blocking coil means, and a switch closing a main set of contacts when the main coil is energized, closing a blocking set of contacts when the main coil is released, and the blocking coil being adapted to prevent closure of the main contacts by the main coil when the blocking coil is energized by predetermined current; a circuit to energize the main blocking relay coil including a first speed switch operated by movement of the displaceable member to a first speed position; an energizing circuit for one of the solenoid switch coils including a second speed switch operated by the displaceable member in first speed position, the main blocking relay contact set, and one of the directional switches corresponding to the direction of movement of the displaceable member; a holding circuit branch for the aforesaid solenoid coil including the first speed switch, the holding switch of the solenoid, and the directional switch; a circuit energized by voltage drop in the motor circuit, including the other of the pair of directional switches, and one of the memory relay coils to energize said latter coil and close its switch means; a plurality of different speed circuits operated by movement of the displaceable member beyond its first speed position, and such movement of the member being adapted to open the second-named speed switch; a dynamic braking circuit from the motor operable by movement of the displaceable member from an operating speed position in one direction to a speed position in the opposite direction, including the second directional switch in such opposite direction, the memory relay switch closed as aforesaid, the blocking relay released contacts, and the blocking coil, said dynamic braking circuit energizing the blocking coil to prevent closure of the main blocking relay contacts so long as the motor generates a predetermined current and the dynamic braking circuit is closed as aforesaid.

8. In a control for a reversible electric motor; a forward and a reverse solenoid switch for controlling the direction of the motor, each having a coil, and each having a holding switch energized upon energization of its coil; a displaceable member operable from neutral oppositely to a plurality of forward and reverse positions, a plurality of speed switches open when the member is in neutral position but successively closed by the member in accordance with its displacement from neutral, a pair of forward directional switches and a pair of reverse directional switches, all being open when the displaceable member is in neutral position and each pair being closed by movement of the displaceable member from neutral toward, but prior to, speed positions thereof in its respective directions; a memory relay comprising a pair of coils and switch means, the switch means being operated to close one set of contacts and open the other upon predetermined energization of each of its coils, and having means to retain the switch means in each such position until predetermined energization of the other coil; a blocking relay including main coil means and blocking coil means, and a switch closing a main set of contacts when the main coil is energized, closing a blocking set of contacts when the main coil is released, and the blocking coil being adapted to prevent closure of the main contacts by the main coil when the blocking coil is energized by predetermined current; a circuit to energize the main blocking relay coil including a first speed switch operated by movement of the displaceable member to a first speed position; an energizing circuit for one of the solenoid switch coils including a second speed switch operated by the displaceable member in first speed position, the main blocking relay contact set, and one of the directional switches corresponding to the direction of movement of the displaceable

member; a holding circuit branch for the aforesaid solenoid coil including the first speed switch, the holding switch of the solenoid, and the directional switch; a circuit energized by voltage drop in the motor circuit, including the other of the pair of directional switches, and one of the memory relay coils to energize said latter coil and close its switch means; a plurality of different speed circuits operated by movement of the displaceable member beyond its first speed position, and such movement of the member being adapted to open the second-named speed switch; a dynamic braking circuit from the motor operable by movement of the displaceable member from an operating speed position in one direction to a speed position in the opposite direction, including the second directional switch in such opposite direction, the memory relay switch closed as aforesaid, the blocking relay released contacts, and the blocking coil, said dynamic braking circuit energizing the blocking coil to prevent closure of the main blocking relay contacts so long as the motor generates a predetermined current and the dynamic braking circuit is closed as aforesaid, and an additional dynamic braking circuit including one memory relay coil, the opposite memory relay switch, the release contacts of the blocking relay, and the blocking relay coil; said memory relay coils having sufficient impedance to prevent enough current from flowing through the blocking coil to enable it to block action of its main coil.

9. In a control mechanism for a reversible electric motor, control means movable to forward, neutral, and reverse positions, a forward and a reverse circuit branch adapted to be selectively closed by said control means for establishing forward and reverse motions of the motor and adapted to be opened when the control means is moved to neutral; a dynamic braking circuit branch for the motor wherein the motor is adapted to operate as a generator, switch means operable to close the dynamic braking circuit branch upon movement of the control means to neutral, and additional means including a blocking coil and a relay switch, the switch being biased upon energization of the coil toward a position to maintain the reverse circuit branch open; and circuit branch means operable upon movement of the control means to reverse position during operation of the motor as a generator to energize the coil by the potential so generated by the motor to prevent closure of the reverse circuit.

10. The combination of claim 9, wherein the first mentioned dynamic braking circuit branch also includes the coil of the additional means, but comprises a high resistance circuit branch delimiting energization of the coil sufficiently to hold its switch; and the second mentioned circuit branch means comprises a low resistance branch connected to shunt said high resistance of the first branch to enable the coil to be energized sufficiently to hold its switch to maintain the reverse circuit deenergized.

11. The combination of claim 9, wherein the relay switch of the additional means is in the forward and the reverse circuit branches and has a main coil energizable by operation of the control means for closing it in the said circuit branches, and wherein the dynamic brake switch means is operatively connected with the switch of the additional means so that (1) the main relay coil acts to close the relay switch of the additional means and to open the dynamic brake switch means, and (2) the relay coil of the additional means acts to hold the relay switch of the additional means open and to close the dynamic brake switch means.

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