June 1, 1965 J. W. DAWSON 3,187,285

SPEED CONTROL FOR ELECTRIC TRUCK

Filed April 18, 1961 2 Sheets-Sheet 1

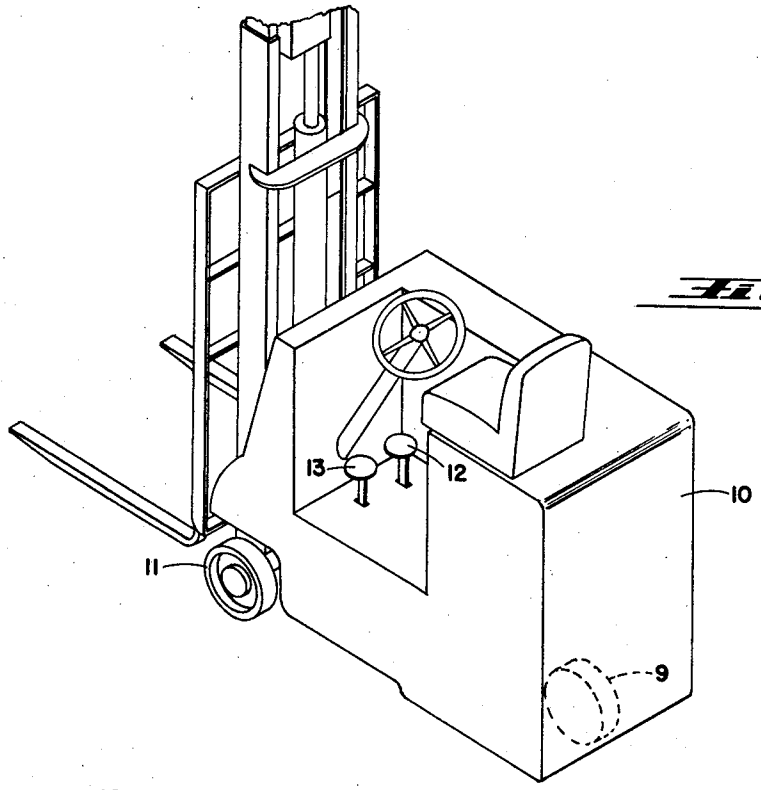



Fig. 1

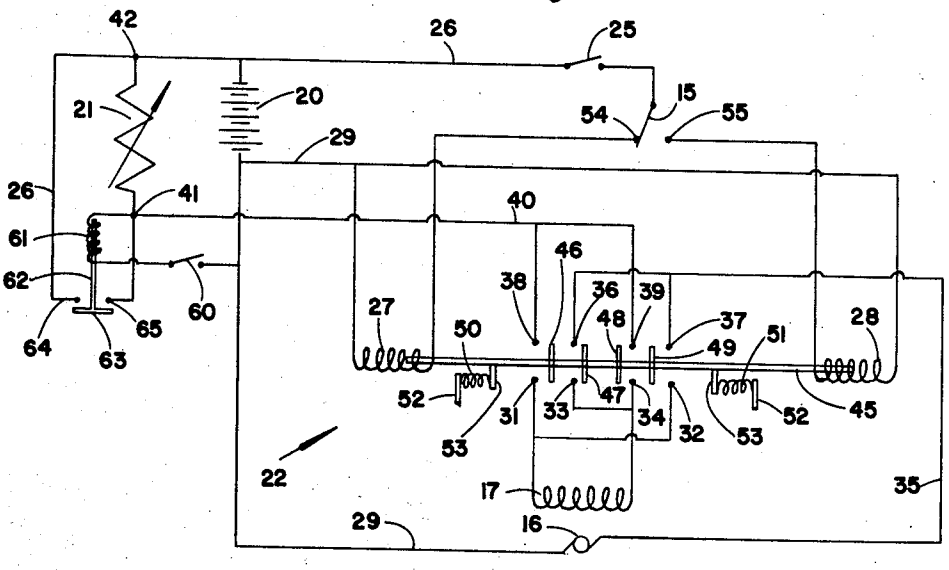



Fig. 2

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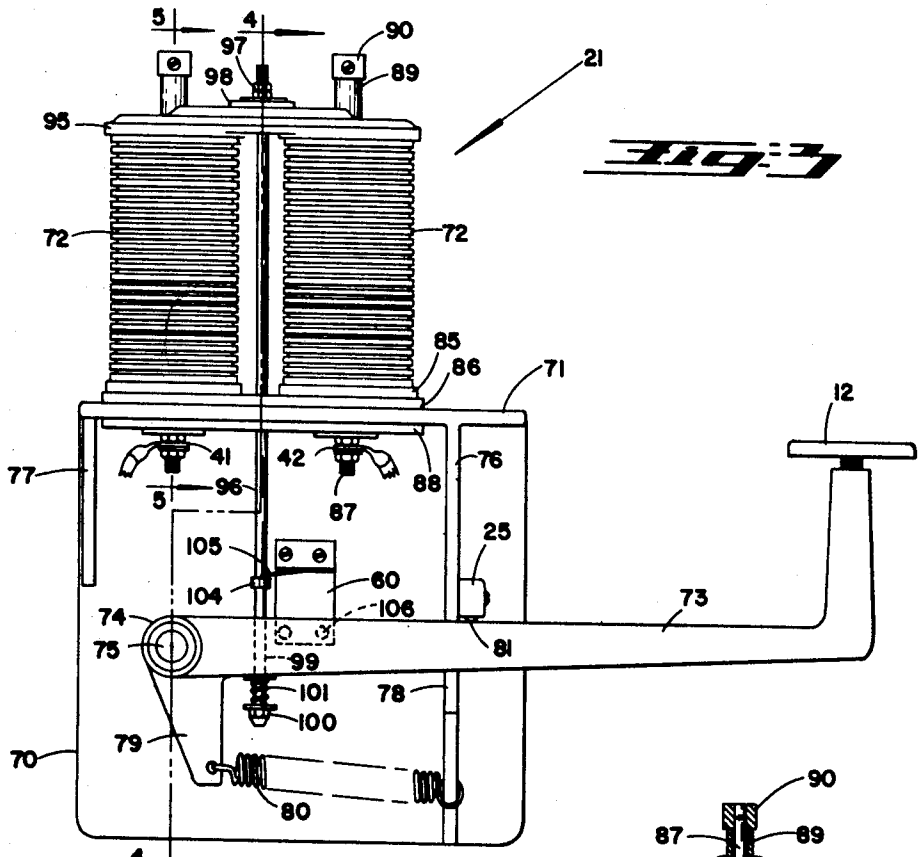



Fig. 3

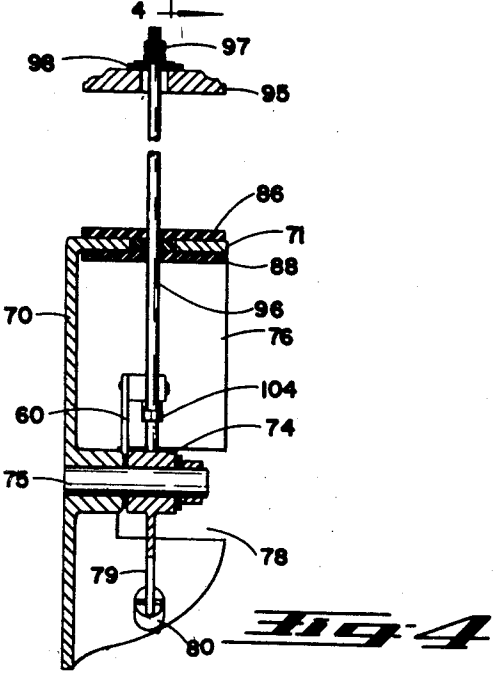



Fig. 4

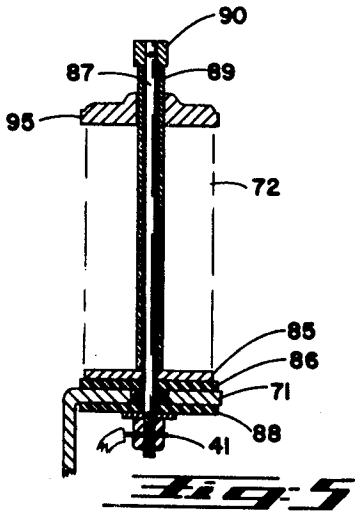



Fig. 5

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United States Patent Office 3,187,285 Patented June 1, 1965



3,187,285

# SPEED CONTROL FOR ELECTRIC TRUCK

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Filed Apr. 18, 1961, Ser. No. 103,835
9 Claims. (Cl. 338—110)

This invention relates to a control system for the drive motor of an electric truck, such as a warehouse fork lift truck and the like.

Small indoor trucks normally spend a large part of their operating time starting and stopping whereby smooth acceleration is of considerable importance to the equipment and operator and often to the load itself. Also, it is necessary for the operator to have very close control of the starting torque and slow running speeds for maneuvering a load back and forth in a restricted space and for spotting a load in a particular place. Electric speed control systems heretofore used for such trucks have been relatively complicated and expensive, contributing to high initial cost as well as excessive maintenance.

Objects of the present invention are, therefore, to provide an improved speed control system for an electric motor; to provide an improved manual control having a novel automatic switching feature; to provide a shunt relay for a speed controlling rheostat which will not operate until a predetermined voltage drop exists across the motor; to provide a compact carbon pile rheostat and accelerator pedal unit; to provide an accelerator pedal control having three ranges of movement for, first, energizing the motor in series with full starting resistance, then gradually reducing said resistance in stepless control and, finally, shunting the resistance out of the motor circuit; and to provide a device of the type described which is relatively simple and inexpensive to manufacture and yet which is rugged and reliable in operation and requires a minimum of maintenance.

The present system comprises a variable resistance carbon pile rheostat equipped with a shunt which is controlled in part manually and in part automatically in response to the voltage drop across the motor. An accelerator pedal is provided having three ranges of movement. The initial movement energizes the drive motor through the full resistance of the rheostat. The second range of movement compresses the rheostat to gradually decrease its resistance and accelerate the motor under normal conditions. In this range of movement the operator has stepless control to vary the speed over a wide range from creep to almost full speed. After the rheostat has been fully compressed, a further range of movement of the accelerator pedal closes a switch to a shunting relay. The relay is made and adjusted so that it will not close the shunting switch until the voltage drop across the motor reaches a predetermined values. Thus, the motor may be accelerated as fast as the operator may desire, or as fast as it can under the particular load condition, as long as the rheostat remains in the circuit but the operator cannot shunt out the rheostat and apply full battery voltage to the motor until the rheostat has first been compressed substantially to its minimum resistance.

The foregoing and other objects and advantages will become apparent and the invention will be better understood with reference to the preferred embodiment illustrated in the accompanying drawings. Various changes may be made, however, in the phyical construction and arrangement of parts and in the control circuit, and all such modifications within the scope of the appended claims are included in the invention.



In the drawings:

FIGURE 1 is a perspective view of a truck containing the present speed control system;

FIGURE 2 is a schematic wiring diagram of the control system;

FIGURE 3 is an elevation view of the rheostat and accelerator pedal unit;

FIGURE 4 is a sectional view taken on the line 4—4 of FIGURE 3; and

FIGURE 5 is a sectional view taken on the line 5—5 of FIGURE 3.

FIGURE 1 shows an industrial truck 10 in which the invention may be used to advantage. This type of truck is ordinarily used in a factory or warehouse where the trips are relatively short and much of the running time is spent in starting, stopping and creeping at low speed to maneuver the load. This particular truck has a pair of front idle wheels 11 and a single rear steering and driving wheel 9. The motion of the truck is controlled primarily by an accelerator pedal 12 and a brake pedal 13. There are also a forward and reverse switch lever, a key switch, and lift and tilt controls for the load fork and mast, not shown.

FIGURE 2 shows the essential components of the electric drive systm. The drive motor is a conventional D.C. series motor having an armature 16 and a field winding 17 energized from a battery 20 under the control of a variable resistance carbon pile rheostat 21 in series circuit with the motor. The direction of rotation of the motor is controlled by a forward-reverse relay 22 which is actuated for forward or reverse drive by the manual switch 15.

Initial downward movement of accelerator pedal 12 starts to compress the carbon pile rheostat 21 and closes starting switch 25. This makes a circuit from one terminal of the battery through wire 26 to one or the other solenoid coils 27, 28 of relay 22, both of these coils being connected with a second battery wire 29.

One terminal of motor field winding 17 is connected to relay contacts 31 and 32, and the other terminal is connected to relay contacts 33 and 34. One armature brush terminal is connected to battery wire 29, and the other armature brush terminal is connected to a wire 35 leading to relay contacts 36 and 37. The two remaining relay contacts 38 and 39 are connected to a wire 40 leading to a terminal 41 of the rheostat. The other terminal 42 of the rheostat is connected with battery wire 26.

The solenoid coils 27 and 28 are arranged in opposition on the opposite ends of a relay armature 45 which carries four insulated contact bars 46, 47, 48 and 49. When the relay is deenergized the armature 45 is held in an open circuit mid-position by a pair of springs 50 and 51. Each spring is compressed between a stationary abutment 52 and a lug 53 on the armature.

Thus, when switch 15 engages contact 54 as shown, the closing of starting switch 25 energizes relay solenoid 27, pulling armature 45 to the left. This causes contact bar 46 to connect the contacts 31 and 38 and causes contact bar 47 to connect the contacts 33 and 36. Motor field winding 17 is thereby placed in series with motor armature 16 and the full resistance of rheostat 21 to start the motor in one direction. If switch arm 15 is moved to engage contact 55, the relay armature 45 will be shifted to the right to complete a similar starting circuit but with the motor field 17 reversed relative to the motor armature 16 whereby the direction of the motor is reversed.

The forward-reverse relay 22 may, if desired, be constructed as two separate relays but in such case they should be mechanically interlocked in some way so that both relays cannot close at the same time in case of sticking or an electrical fault. This mechanical interconnec-

is accomplished in the present instance by using a common armature 45 for both forward and reverse solenoids 27 and 23 and the contact bars for both forward and reverse power circuits.

In a typical small industrial truck installation, the battery 20 is a 24 volt battery. When accelerator pedal 12 is depressed just enough to close the starting switch 25, the rheostat is in its initial stage of compression and most of the voltage drop in the heavy starting current through the stationary motor will occur across the rheostat leaving substantially zero volts drop across the motor. Slight further compression of the rheostat will reduce the voltage drop across the rheostat and increase the voltage across the motor unit, at about six volts across the motor, the motor will start to turn with an ordinary load on a smooth and level floor. Further depression of accelerator pedal 12 compresses the rheostat with greater force to further reduce the voltage drop across the rheostat and increase the voltage applied to the motor. Depressing accelerator pedal 12 to the downward limit of its movement applies a maximum compression to the rheostat and finally closes a switch 60 to complete a circuit through shunt relay solenoid 61. It will be appreciated that even under maximum compression the rheostat still has appreciable resistance whereby full battery potential is not applied to the motor as long as the rheostat remains in series circuit.

One terminal of relay solenoid 61 is connected with rheostat terminal 41 and the other end is connected with battery wire 29 whereby the voltage impressed upon the relay solenoid is equal to the voltage drop across the motor. The relay is made and adjusted so that its armature 62 will not lift until this voltage attains a predetermined value, such as 18 volts in the present instance. With switch 60 closed, a voltage drop of 18 volts across the motor develops sufficient magnetic force in solenoid 61 to lift relay armature 62, causing its contact bar 63 to connect the terminals 64 and 65. This closes the shunting circuit for rheostat 21, placing the motor directly on battery voltage. The motor circuit may now be traced through wire 29, motor armature 16, wire 35, one or the other of contact bars 47 or 49, motor field winding 17 and wire 40, contact bar 63 and wire 26 back to the battery.

Thus, as the accelerator pedal 12 is depressed, the shunting relay cannot close until there is a voltage drop of at least 18 volts across the motor. This requirement assures that the transition to the final accelerating step will be smooth. The fully depressed pedal produces the normal full speed running condition with rheostat 21 shunted out of the power circuit so that there will be no power loss and waste of battery energy in the rheostat.

The rheostat preferably has a minimum resistance under full compression which will produce an 18 volt drop across the motor in stalled condition. This permits the operator to shunt out the rheostat and apply full torque under extreme conditions as in pulling out of a hole or climbing hills. In normal acceleration on a level floor, the motor develops a back E.M.F. which increases the voltage drop across the motor to a somewhat higher value by the time the operator closes switch 60.

In addition to providing the accelerating phase of normal running operation, the middle range of pedal movement also provides stepless control through the rheostat from creep through the medium speed range for backward and forward maneuvering and low and medium speed travel. The present speed control system is, of course, not limited to a low voltage system as described in connection with the preferred embodiment nor is it limited to a battery operated system since it is of rather general application to different voltages and different sources of power in various applications of motor drives.

*Rheostat and pedal unit*

The accelerator pedal 12, rheostat 21 and switches 25 and 60 may conveniently be combined in a unitary mechanism, as shown in FIGURE 3. This unit comprises a vertical base plate 70 having an integral horizontal shelf flange 71 to support two stacks of carbon discs 72. Pedal 12 is mounted on a lever arm 73 having a hub 74 mounted on a stub shaft 75 on base 70. A vertical web flange 76 perpendicular to plate 70 provides additional bracket support for shelf 71. The parts 70, 71 and 76 are preferably made as an integral casting which may also include a second bracket web 77 to support shelf 71. Pedal arm 73 extends through a notch 78 in web 76, the upper and lower edges of the notch serving as stops to limit the pedal movement up and down. A depending ear 79 on the hub end of arm 73 is connected with a pedal return spring 80 which is anchored to web 76.

Switch 25 is mounted on web 76 at the upper end of notch 78. This switch has an actuating button 81 which is engaged by pedal arm 73 in the upper position of the pedal to hold the switch in open circuit position. When arm 73 leaves engagement with button 81, the switch is closed by internal spring action, not shown. Thus, switch 25 itself is made as a normally closed switch but it is normally held in open circuit position by pedal arm 73 under the action of spring 80.

Each stack of carbon discs 72 rests on a bottom metal stack plate 85 on an insulating plate 86. Each stack plate 85 is mechanically and electrically connected with a conductor rod 87, as shown in FIGURE 5. The lower ends of the two rods 87 are threaded to receive nuts whereby they are clamped on shelf 71 and provide the rheostat terminals 41 and 42 in FIGURE 2. These terminals are insulated from shelf 71 by a bottom insulating plate 88. The carbon discs 72 are centrally apertured to receive conductor rods 87 which are insulated through the apertures by glass tubes 89. These tubes are retained on the conductor rods by collars 90 on the upper ends. Rods 87 thereby provide vertical guides rigid with the shelf 71 to hold the carbon discs 72 in alignment during the slight vertical movement incident to compression and relaxation of the discs.

The discs are compressed together by a metal pressure plate 95 which is apertured at its ends to slide over the glass tubes 89 and apertured in its center to receive the pressure rod 96. The upper end of pressure rod 96 is threaded to receive nuts 97 bearing against a washer and insulating plate 98 whereby the pressure rod is insulated from pressure plate 95. The lower end of pressure rod 96 passes through an opening 99 in arm 73 and is threaded to receive a nut 100. The rod is tensioned through a compression spring 101 confined between nut 100 and the lower surface of arm 73.

A collar 104 is adjusted on rod 96 close to the operating finger 105 of switch 60. Switch 60 is biased toward normally open circuit position by an internal spring, not shown. The housing of switch 60 is mounted on arm 73 by means of screws 106 or other suitable means.

When pedal 12 is not depressed it is held against the upper end of notch 78 by spring 80, causing switch 25 to remain in open circuit position. Spring 101 tensions pressure rod 96 in a downward direction holding collar 104 out of actuating engagement with switch 60. Nuts 97 are adjusted to maintain a light pressure on the carbon discs. When pedal 12 is depressed, the initial downward movement of arm 73 causes this arm to leave engagement with switch actuating button 81 allowing switch 25 to close. Motor starting current then flows through the two stacks of carbon discs in series, including terminals 41, 42 and bridging pressure plate 95 which electrically interconnects the top ends of the two stacks. As pedal 12 is depressed farther, the increased compression of the carbon discs reduces the resistance of the rheostat and increases the current to the motor.

When the carbon discs have been compressed to the point where further pressure would not appreciably reduce their electrical resistance, the pedal 12 still has some further downward movement allowed by continued compres-

sion of spring 101. As spring 101 is compressed in this final pedal movement, the relative movement between switch housing 60 and collar 104 causes switch actuating finger 105 to be deflected upward, closing the switch 60. This closes a circuit to the shunting relay 61 as explained in connection with FIGURE 2. Nut 100 is adjusted to obtain the proper spring action in spring 101 for the above described operation of the lost motion connection between pedal arm 73 and pressure rod 96.

Thus, there are three ranges of pedal movement in the rheostat and pedal unit of FIGURE 3 to produce three different functions in the control system of FIGURE 2. The initial movement energizes the motor for starting through the maximum resistance of the rheostat. In the middle range of movement pressure on the carbon discs is manipulated to change the resistance of the rheostat in a progressive or stepless variation for acceleration, low speed travel or maneuvering. Then the final range of movement shunts the remaining minimum resistance of the rheostat out of circuit to connect the motor directly across the battery for high speed travel. When the driver removes his foot from the pedal, switch 25 opens the control circuit to forward-reverse relay 22 and the latter opens the power circuit to the motor.

Having now described my invention and in what manner the same may be used, what I claim as new and desire to protect by Letters Patent is:

1. A speed control unit for an electric motor comprising a base plate, a carbon pile rheostat mounted on said base plate, an accelerator pedal pivotally mounted on said base plate, pressure means for said rheostat having resilient lost motion connection with said pedal, and a shunt control switch for said rheostat operable by relative movement of the parts in said lost motion connection after said rheostat has been fully compressed.

2. A speed control unit for an electric motor comprising a flanged base plate, an accelerator pedal pivotally mounted on said plate for movement parallel with said plate, a carbon pile rheostat mounted perpendicularly on said flange, a pressure rod parallel with said carbon for applying pressure to said rheostat, a resilient lost motion connection between said rod and said pedal, and a shunt control switch for said rheostat actuated by relative movement between said pedal and said rod after said rheostat has been fully compressed.

3. A speed control unit for an electric motor comprising a base plate, a carbon pile rheostat mounted on said base plate, an accelerator pedal pivotally mounted on said base plate, a motor energizing control switch on said base plate actuated by said pedal, a pressure rod having longitudinal movement for applying pressure to said rheostat and having a resilient lost motion connection with said pedal, and a shunt control switch for said rheostat actuated by relative movement between said pedal and said rod after said rheostat has been fully compressed.

4. A speed control unit for an electric motor comprising a base plate, an accelerator pedal pivotally mounted on said base plate, a pair of stacks of apertured carbon discs mounted on said base plate, a stack plate under the bottom disc in each stack, a conductor rod connected with each of said stack plates, terminal means on the lower ends of said rods securing said rods to said base plate, the upper ends of said rods being insulated and extending through the apertures in said discs to support said stacks, a pressure plate bridging the upper ends of said stacks, and a pressure rod extending between said stacks and connected between said pedal and the center of said pressure plate.

5. A speed control unit for an electric motor comprising a base plate having a right angle flange, an accelerator pedal pivotally mounted on said plate beneath said flange, a motor starting control switch on said base plate actuated by said pedal, a pair of stacks of carbon discs mounted on top of said flange, a pair of conductor rods supporting said stacks, said conductor rods extending through said flange and having terminals connected with the lower ends of said stacks, a pressure plate bridging the upper ends of said stacks, a pressure rod connected to said pressure plate and extending between said stacks and through said flange, a lost motion spring connection between said pressure rod and said pedal, a rheostat shunt control switch mounted on said pedal, and means on said pressure rod for actuating said switch by the relative movement in said lost motion connection.

6. A speed control unit for an electric motor comprising an accelerator pedal, a motor starting switch operable by initial movement of said pedal, a carbon pile rheostat, a pressure member for said rheostat, a resilient connection between said pedal and pressure member for compressing said rheostat by further movement of said pedal, and a shunt control switch for said rheostat actuated by movement of said pedal through said resilient connection after said rheostat has been fully compressed.

7. A speed control unit for an electric motor comprising a pedal member having an off position and a range of movement in running positions, a motor starting switch held open by engagement with said pedal member in said off position, said pedal member disengaging and closing said switch when it moves to a running position, a pressure member for said rheostat, a resilient connection between said pedal member and pressure member for compressing said rheostat by movement of said pedal member in said running positions, and a shunt control switch for said rheostat mounted on one of said members and actuated by the other member upon further movement of the pedal member after the rheostat has been fully compressed.

8. A speed control unit for an electric motor comprising an accelerator pedal mounted for downward movement from an off position, a motor starting switch mounted above a part of said pedal and held open by said pedal in said off position, a pressure member for said rheostat having resilient connection with said pedal, downward movement of said pedal causing said pedal to disengage and close said starting switch and compress said rheostat, a shunt control switch for said rheostat mounted on said pedal, and means on said pressure member arranged to close said shunt control switch upon further movement of the pedal after the rheostat has been fully compressed.

9. A speed control unit for an electric motor comprising a base member, an accelerator pedal mounted for relative movement on said member, a pair of elongated insulators mounted in side-by-side upright position on said member, a stack of centrally apertured carbon discs mounted for sliding movement on said insulators, a circuit terminal connected with the bottom disc in each stack, a pressure plate having apertured ends slidable on said insulators and bearing on the top discs in said stacks, said plate constituting a circuit conductor between the top ends of said stacks, and a tension rod connected between said pedal and the center of said pressure plate and insulated from said pressure plate, said rod extending between said stacks and passing slidably through an aperture in said base member.

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