May 22, 1956 E. F. MEKELBURG 2,747,046

ACCELERATING MASTER SWITCH

Filed May 25, 1950 4 Sheets-Sheet 1

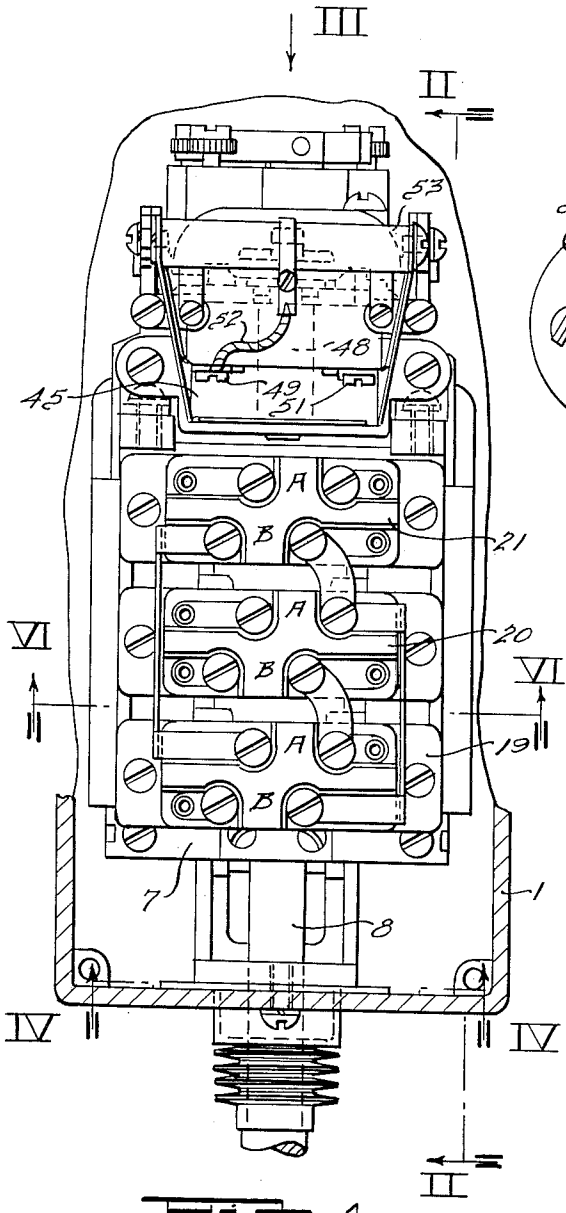


Fig. 1.

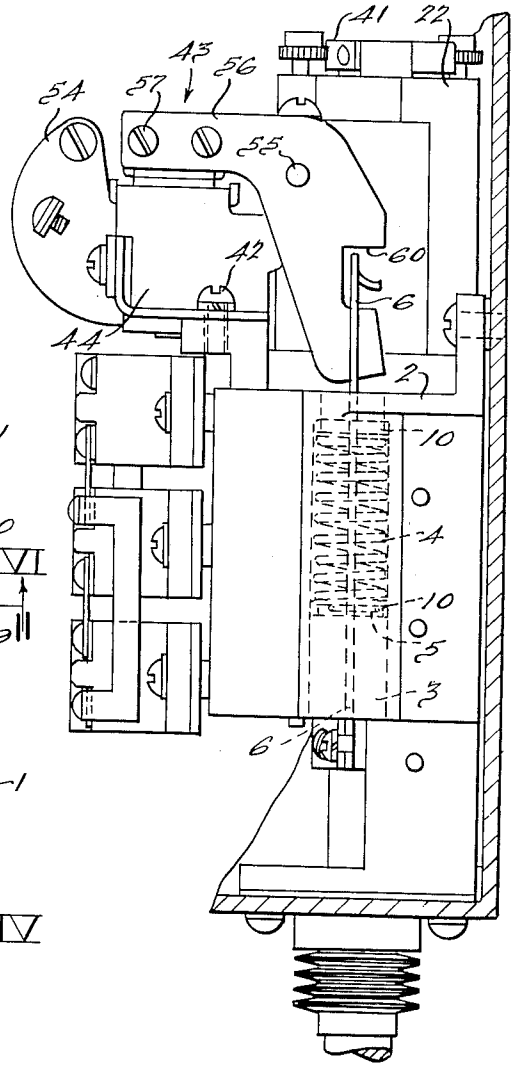


Fig. 2.

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Filed May 25, 1950 4 Sheets-Sheet 2

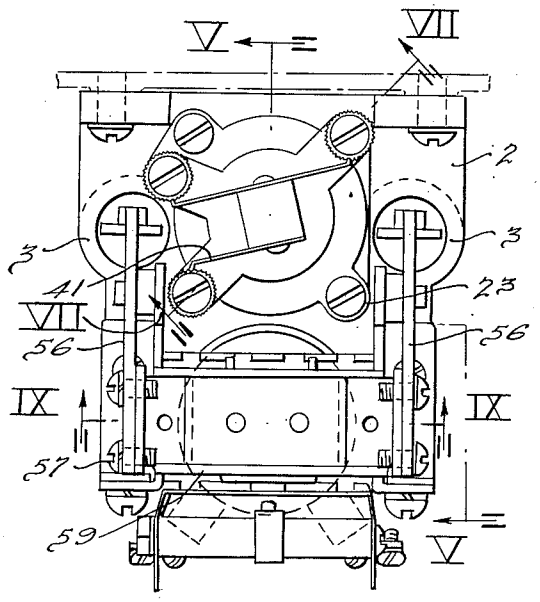


Fig. 3.

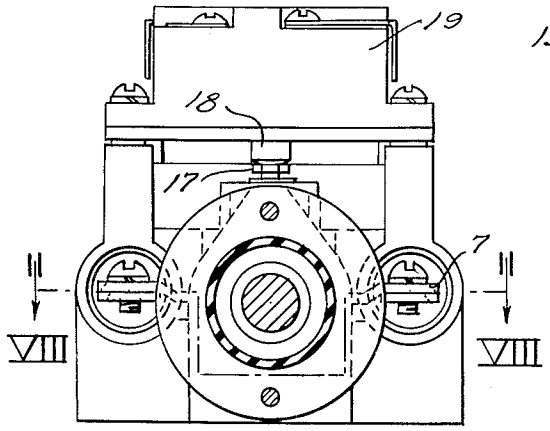


Fig. 4.

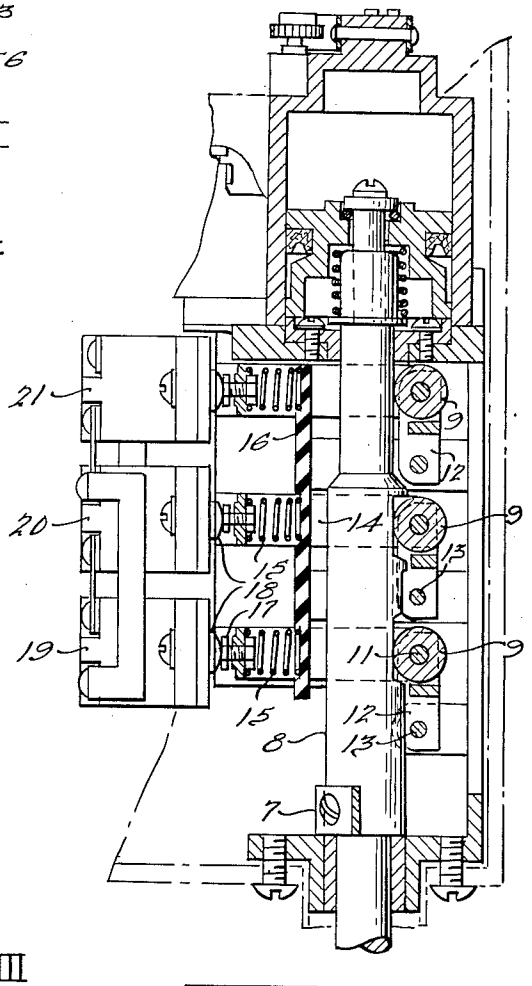


Fig. 5.

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ACCELERATING MASTER SWITCH

Filed May 25, 1950 4 Sheets-Sheet 3

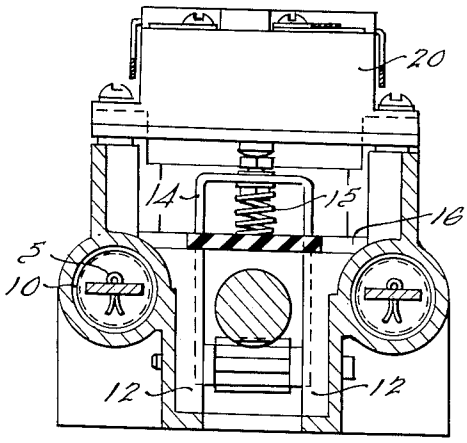


Fig. 5.

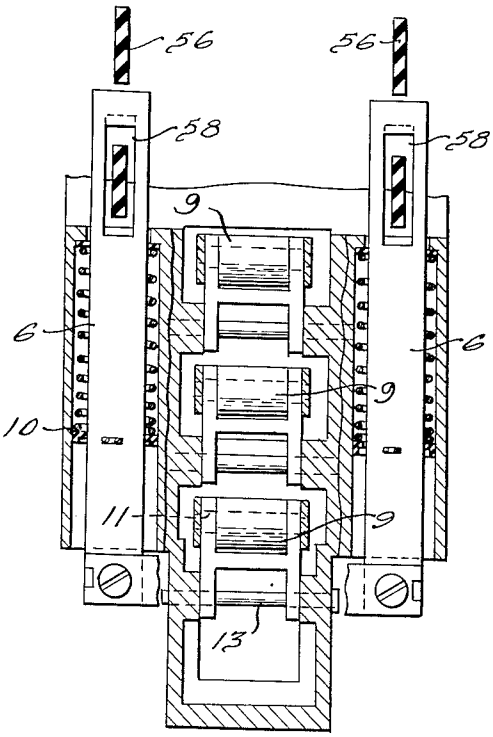


Fig. 8.

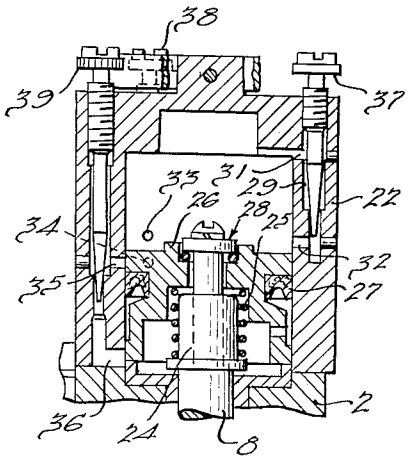


Fig. 7.

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ACCELERATING MASTER SWITCH

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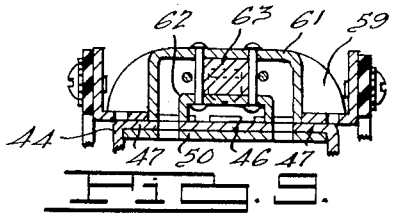


Fig. 9.

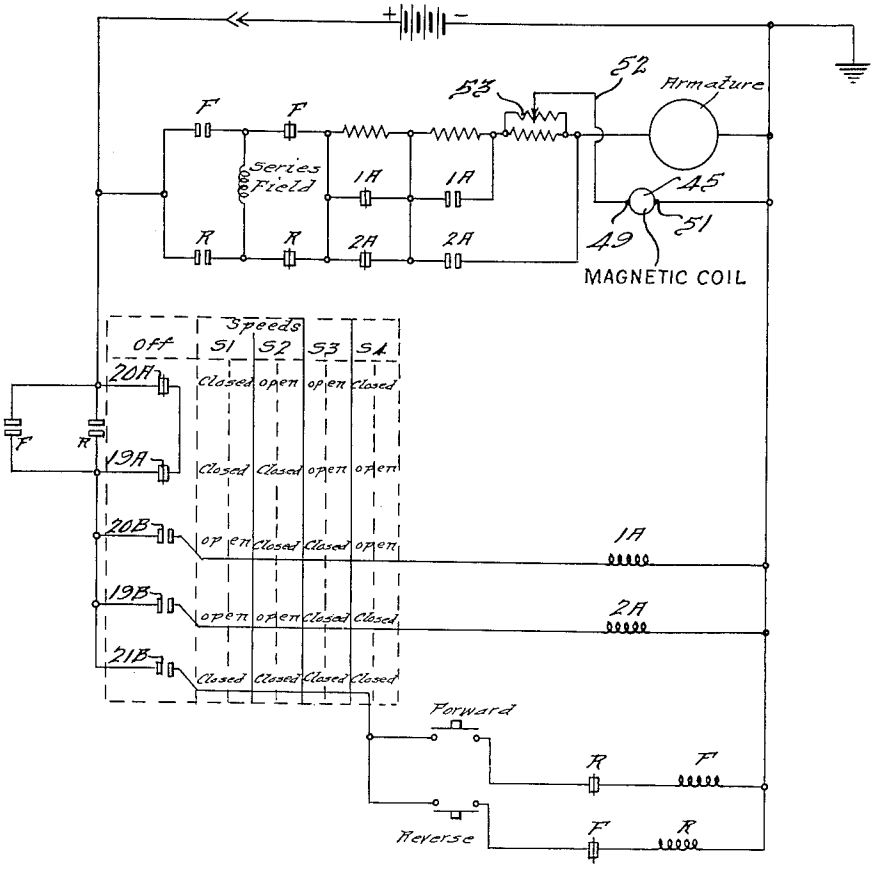


Fig. 10.

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United States Patent Office 2,747,046 Patented May 22, 1956

2,747,046

ACCELERATING MASTER SWITCH

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Application May 25, 1950, Serial No. 164,281

7 Claims. (Cl. 200—98)

This invention relates to an accelerating switch for controlling electric motors, which is particularly useful for controlling the operation of electric trucks.

One object of the present invention is the provision of an accelerating master switch in which a plurality of individual switches are operated by a moving cam, the rate of movement of the cam being determined by a timing mechanism.

Another object of the present invention is the provision of an accelerating master switch in which a movable cam which operates individual switches is rectilinearly movable and which is provided with a timing mechanism which adjustably controls the rate at which the cam may move over varying sections of its travel.

Another object of the present invention is the provision of a switch in accordance with the preceding objects in which movement of the switch operating cam is halted by the operation of a polarized relay until the armature of the electric motor controlled by the accelerating master switch reaches a desired rotating condition.

Another object of the present invention is the provision of an accelerating master switch employing a coil and a permanent magnet which act together to inhibit the accelerating operation until such time as the back E. M. F. in the armature of the associated electric motor has fallen to a desired level.

Another object of the present invention is the provision of an accelerating master switch in accordance with the preceding objects which employs a plurality of individual snap switches operated by a rectilinearly movable cam biased toward the high speed position.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a front elevation of the device of the present invention with part of the enclosure in section and part broken away to show the internal operating members.

Figure 2 is a sectional view along the line II—II of Figure 1.

Figure 3 is a view of the device of the present invention taken from the position III of Figure 1.

Figure 4 is a sectional view along the line IV—IV of Figure 1.

Figure 5 is a sectional view along the line V—V of Figure 3, and in which the cam mechanism has been moved to the opposite extreme from that shown in Figure 1.

Figure 6 is a sectional view along the line VI—VI of Figure 1.

Figure 7 is a detail sectional view along the line VII—VII of Figure 3, in which the movable cam is the same position as that shown in Figure 5.

Figure 8 is a detail sectional view along the line VIII—VIII of Figure 4.

Figure 9 is a detail sectional view along the line IX—IX of Figure 3.

Figure 10 is a diagrammatic representation of a control circuit for an electric motor employing the device of the present invention.

The device of the present invention comprises an outer enclosing box 1 of sectional form and on the back of which there is mounted, as by studs, a metal base assembly 2. The base assembly 2 is provided with a pair of parallel tubular chambers 3 at its opposite sides, in each of which is disposed a strong biasing spring 4, each spring being disposed between two spring keepers 10, the upper of which, from the view shown in Figure 2, abuts against the end of the chamber 3, while the lower spring keeper abuts against a cotter pin 5, which extends through an elongated bar 6, which extends completely through the chamber 3 and projects from both ends thereof. The bars 6 have a rectangular area cut out therefrom which constitute latching openings 58.

Joining the lower ends of the bars 6 is a coupling 7 which is further joined by screws to a cam shaft 8 having a plurality of camming surfaces thereon as shown in Figure 5. Acted upon by these cam surfaces are a plurality of rollers 9 which are mounted upon laterally extending pins 11, the pins joining pairs of arms 12 which project parallel to the cam shaft 8 and are located below it, the arms 12 being pivotally mounted to the base assembly 2 by the pins 13.

Pins 11 serve also to mount generally U-shaped brackets 14 which extend above the cam shaft 8, with springs 15 being provided within each of these U-shaped members 14, the springs 15 acting to bias the bights of the members 14 away from the cam shaft 8. The opposite ends of the springs 15 are mounted upon a supporting member 16, which is mounted upon base assembly 2 above the cam shaft 8.

It will be seen that the springs 15 acting upon the U-shaped members 14 serve to maintain the roller members 9 in contact with the camming surfaces upon the cam shaft 8. It will further be seen that as the cam shaft 8 is rectilinearly moved, the rollers 9 will be moved toward and away from the center of the cam shaft 8 by the camming surfaces thereon to move these bracket members 14 rectilinearly to the left and to the right as viewed in Figure 5.

Each of the bights of the U-shaped brackets 14 is provided with an operating button 17 threaded therein and which in the position in which spring 15 is least stressed, has fully depressed the associated operating button 18 of one of snap switches 19, 20 or 21, the snap switches being mounted upon upstanding projections of the base assembly 2. These snap switches are of the double-throw, double-break type, and have an internal bias acting to press the operating button outward.

The lower end of the cam shaft 8, from the position shown in Figure 1, propects through the cover 1 a substantial distance, that portion of the cam shaft which is outside of the cover 1 being protected by a rubber boot which has a flanged edge serving to protect the interior of the box 1 from the entrance of undesirable particles. The opposite end of the cam shaft 8 projects above the base assembly 2 and extends into a timing cylinder 22 which is illustrated in Figure 7. The cylinder 22 is fixedly mounted by studs 23 to the upper end of the base assembly 2.

Carried by the upper portion of the shaft 8 is a spring guide 24 about which is disposed a coil spring 25 which acts against an inner surface of a piston 26 which fits tightly within the circular interior section of cylinder 22 and is provided with a sealing ring 27 which is disposed about the periphery of piston 26, the piston 26 being mounted to an end of shaft 8 by means of a screw

and sealing washer arrangement generally designated at 28.

As will be seen from an inspection of Figure 7, the walls of the cylinder 22 have relatively thick portions which contain therein elongated passages 29, the outer ends of which are threaded. Each of these passages 29 is communicated with the interior of cylinder 22 by means of two laterally projecting apertures spaced one from the other. In the specific embodiment illustrated, the cylinder 22 has three such elongated passages 29 and, hence, six apertures communicating these passages with the interior of cylinder 22, with these communicating apertures being numbered 31 through 36 inclusive. The apertures 31 through 36 are spaced so that they, together, extend over the entire length of the interior of cylinder 22, with the lower of one pair lying in the same transverse plane as the upper of the next pair. Thus, it will be seen from Figure 7 that aperture 32 lies in the same transverse plane as aperture 33, and aperture 34 lies in the same plane as aperture 35.

In each of the passages 29 is an adjusting screw, these being numbered 37, 38 and 39. These adjusting screws terminate in tapered pins which cooperate with portions of the chambers 29 to limit the free passage of air from one of the transverse apertures to the other cooperating aperture through the associated chamber. Each of these adjusting screws is provided with a knurled head, metallic holding elements 41 being provided at one end of the chamber 22 to cooperate with the knurling of the adjusting screw head to maintain them in any particular desired position, as may be seen in Figure 3.

As will be seen from Figure 2, mounted to upstanding lugs of base assembly 2 by means of studs 42 is a plugging assembly generally designated by means of the numeral 43. This assembly comprises a composite generally U-shaped bracket 44 of magnetic material in which there is mounted a magnet coil 45. The coil 45 surrounds a core of magnetic material 48 fixed at one end by a rivet through the composite bracket 44, the opposite end of core 48 being against a magnetic pole face piece 46 mounted between and in the same plane as the ends 47 of composite bracket 44. The pole piece 46 is mounted on ends 47 of bracket 44 by a nonmagnetic plate 50.

Coil 45 has terminals 49 and 51, and terminal 49 has connected thereto a flexible conductor 52, the other end of which is adjustably and electrically connected to an intermediate point on a resistor 53 which is mounted between the arms of a fiber U-shaped bracket 54. When the device is in circuit, terminal 51 is connected to one terminal of the armature of the electric motor to be controlled, while resistor 53 parallels an accelerating resistor connected to the other terminal of the armature, as may be seen in Figure 10, and serves as a voltage divider.

The bracket 44 has rearwardly extending legs at each side thereof which each support a pivot pin 55. Each pin 55 pivotally mounts a generally L-shaped latch 56. Between one extremity of these latches 56 there is mounted, as by studs 57, an armature assembly which comprises a holding bracket 59 having upper and lower ledges which mount, as shown in Figure 9, two U-shaped pieces of magnetic material 61 and 62 which are separated by and mounted to a strong permanent magnet 63. Near the opposite extremity of each of these latches 56 is a notched portion 60 which is designed to cooperate with the latching openings 58 of rod 6 in a manner subsequently described.

As an example of the use of the device of the present invention, its operation shall be described in a circuit for controlling the traction motor of a battery-operated truck. Such a circuit is illustrated in Figure 10. In this figure, contacts are represented by rectangular boxes, normally closed contacts being represented by showing two of these rectangular boxes in contact with each other, while normally open contacts are represented by two of these rectangular boxes spaced apart. All of the contacts marked "F" are operated by the electromagnetic coil marked "F," the normally open contacts "F" closing upon energization of the coil "F," while the normally closed contacts "F" open upon energization of the coil "F." Similarly, all of the contacts marked "R" are operated by the coil "R." In exactly the same manner, the contacts 1A and 2A are operated by the electromagnetic coils 1A and 2A.

In this Figure 10, the contacts of snap switches 19, 20 and 21 appear diagrammatically within the dotted box superimposed upon the figure, this dotted box including as well a tabular record of the condition of each of the contacts in each of the speed steps accomplished by the device of the present invention, with the speed labeled S4 being the high speed position. The contacts of switch 19 are labelled 19A and 19B, those of switch 20 as 20A and 20B. Only one of the two possible contact positions of switch 21 is used, and is labelled 21B in the diagram.

In the "off" position of the device, cam shaft 8 has been moved to its fully retracted position, that shown in Figures 1 and 2, against the bias of the springs 4 by the foot pedal of the electric truck which is biased by a strong foot pedal spring, the foot pedal being pressed against that part of the cam shaft 8 which projects from the lower end of the device. The spring which operates the foot pedal is, of course, stronger than the biasing springs 4 of the device of the present invention.

When the electric truck which is controlled by the device of the present invention is started from a rest postion, the operator initially closes the direction switch as, for example, in the forward position. Then as the operator depresses the foot pedal against the bias of the foot pedal spring, cam shaft 8 will start to move forward under the influence of the biasing springs 4, until it reaches the first speed position. In this position contacts 21B, which are open in the "off" position of the device, are closed so that an electrical circuit is completed from the supply battery through contacts 20A and 19A, through 21B and the direction selecting switch which is now in the forward position, and through the "Forward" electromagnetic coil indicated by "F" on the diagram of Figure 10. The energization of coil "F" causes the normally open contacts marked "F" to close, and the normally closed contacts marked "F" to open in the usual manner. The electric motor is then connected across the source of energy through the conventional accelerating resistors, the coil 45 being energized by the voltage drop across the armature of the electric motor. The flux caused by the current flow through the coil 45 is in such a direction as to oppose the flux emanating from the permanent magnet 63. The permanent magnet assembly is therefore repulsed by the coil flux so as to rotate the latches 56 in a clockwise direction, from the view of Figure 2, to move the latching toes out of the opening 58 of the rods 6, which then move downwardly under the bias of springs 4 at a rate determined by the timing assembly, the operation of which will be subsequently described.

The back surface of the latching toes of latches 56 then rest upon the transverse end portions of rods 6, which are then movable free of the latches.

As the cam shaft 8, coupled to the rods 6, moves, the camming surfaces operate against the rollers 9 to effect rectilinear movement of the brackets 14. The operating buttons 17, threaded into the brackets 14, either depress the operating buttons 18 of the snap switches or are retracted from the operating buttons of the snap switches to effect the desired operation of the contacts of these switches.

As indicated by the table shown in Figure 10, the cam shaft will operate the switches so that in speed S2 contacts 19A, 20B and 21B are closed. In this speed posi-

tion, the closure of 20B energizes the electromagnetic coil 1A, energization of this coil 1A effecting closure of the normally open contacts labelled 1A, and opening the normally closed contacts labelled 1A thereby cutting out some of the resistance in series with the armature of the electric motor.

Cam shaft 8 continues to move forward at a timed rate, under the influence of the biasing springs 4 to the speed S3 position, operating the push buttons of the snap switches so that 20B, 19B and 21B are closed. It will be readily seen that the closure of contact 19B will effect energization of the electromagnetic coil 2A which operates in a conventional manner to further cut out accelerating resistance in series with the armature of the electric motor.

As the cam shaft moves to the high speed position S4 contacts 20A, 19B and 21B are closed, coil 1A being deenergized, so that all of the resistance in series with the armature is cut out and the motor operates in a conventional manner.

In earlier devices, when the operator desired to reverse the direction in which his electric truck was moving, he would reverse the direction switch and the controlling elements would then operate so as to tend to accelerate the electric motor in the reverse direction in exactly the same way as if the truck had been started from rest. The result of this procedure was that a serious strain would be placed upon the electric motor and the drive elements connecting it to the motor truck. In the device of the present invention a plugging arrangement is employed which limits the torque which may be employed to reverse the direction of motor rotation to that which is obtainable on the first speed position, so that the extreme stress which was experienced with the use of earlier devices is thereby eliminated.

This is accomplished in the following manner: with the direction controlling switch in, for example, the forward position, when the operator opens the "Forward" switch, and closes the "Reverse" switch, the first result is that the electromagnetic coil "F" is deenergized. The contacts controlled by the electromagnetic coil "F" are thereby returned to the positions indicated in Figure 10. It will be observed that before electromagnetic coil "R" can be energized, it is necessary for the operator to permit the device of the present invention to return to the first speed position in which contacts 20A and 19A are closed, as well as contact 21B. This is done by first releasing the foot pedal so that its spring effects movement of cam shaft 8 to the "off" position shown in Figure 1. The latching ends of latches 56 drop through the latching openings 58 in the rods 6 as the openings 58 are moved upwardly.

The operator then again depresses the foot pedal, so that cam shaft 8 moves at a rate determined by the timing assembly, from the "off" position to the first speed position, in which the coil "R" is energized and effects closure of all the normally open contacts marked "R," and effects opening of all the normally closed contacts marked "R." The armature of the electric motor is connected across the battery through the accelerating resistors, and current from the battery will then flow through the series field, but in a direction opposite to that originally used. The armature of the motor, however, is still rotating in the forward direction, and will continue to do so due to inertia, for a short time. During this time in which the armature continues to rotate in the forward direction while current flows through the series field in a direction which tends to rotate the armature in the reverse direction, the counter-E. M. F. in the armature, instead of opposing the supply voltage as is the normal case, will be in the same direction as the supply voltage. This counter-E. M. F. voltage will be greater than the portion of the supply voltage which is across the armature, due to the fact that the greater portion of the supply voltage appears in this speed position across the accelerating resistors. Current will, therefore, flow through the coil 45 in a direction opposite to the direction that current flows through the coil 45 when the counter-E. M. F. opposes the supply voltage. Therefore, the flux emanating from the coil 45 due to this reverse current flow will tend to attract the permanent magnet 63 to keep in the position shown in Figure 2, the latch position 60 of latch 56 thereby holding the rods 6 and preventing them from moving under the bias of springs 4. The cam shaft, which is coupled to the rods 6, can therefore not move out of the speed S1 position. This condition will continue until such time as the armature has decelerated to such a degree that the supply voltage across the armature is high enough to force current to flow through the coil 45 in the normal direction, which is from left to right in Figure 10. When current flow through coil 45 once again is reestablished from the left to the right in Figure 10; that is to say, in the normal direction, the flux emanating from this current once again operates against the flux of the permanent magnet 63 to overcome the sealing effect of the permanent magnet. The rod 6 can therefore rotate the latch 56 about the pins 55 and the cam shaft will move downward toward the high speed position in the usual manner.

It is obvious that other polarizing methods may be utilized, such as employing a pair of electromagnetic coils, or by employing a rectifier to control current flow through coil 45; the particular embodiment shown is, however, more economical.

The device of the present invention will, of course, operate in the same manner should the truck be moving in the reverse direction when the operator desires to obtain a forward motion, the coil 45 permitting movement beyond the first speed position only when the rotation of the armature has been decreased to a desired speed. The particular point at which the holding coil 45 operates to release the latch 56 may be adjusted by moving the connection of the flexible connector 52 to different positions along the resistor 53.

As previously indicated, the cam shaft is moved forward at speeds which are determined by a dashpot timing assembly. The cross section of this assembly is shown in Figure 7. With the device in the "off" position, the position of cam shaft 8 is such that piston 26 abuts against the upper interior surface of the cylinder 22. In this position, the sealing ring 27 which surrounds the plunger 26 is disposed between apertures 31 and 32. As may be seen from Figure 7, cylinder 22 is notched adjacent aperture 31 so that piston 26 does not close aperture 31. When cam shaft 8 starts to move downwardly under the bias of spring 4 and toward the position shown in Figure 7, its rate of movement is controlled by the rate at which air can pass from the underside of piston 26 through aperture 32, chamber 29 and aperture 31 into the upper section of the cylinder 22 above the piston 26. This rate of air flow is controlled by the position of adjusting screw 37. As sealing ring 27 passes aperture 32, it also passes aperture 33 which, as previously indicated, lies on the same transverse plane as aperture 32. The rate of movement of piston 26, and therefore the cam shaft 8, is then controlled by the rate at which air may pass from aperture 34 through the associated chamber 29 and out aperture 33, this rate of air flow being determined by adjusting screw 38. As rubber ring 27 passes aperture 34, it also passes aperture 35 which is coplanar therewith, so that the remainder of the piston travel is controlled by the rate of air flow between aperture 36 and aperture 35.

The setting of adjusting screws 37, 38 and 39 may or may not be such that the piston 26 will move forward, and therefore cam shaft 8 will move forward, at a uniform rate. If the adjusting screws 37, 38 and 39 be set at different positions, the cam shaft 8 will be moved forward by the springs 4 at varying rates depending upon the

particular position of the cam shaft in relation to its length of travel. It will therefore be seen that any desired accelerating characteristic may be obtained by adjustment of the adjusting screws 37, 38 and 39. It is, of course, obvious that other accelerating timing controls may be employed if so desired with the device of the present invention. For example, a dash pot may be employed having but one adjustment feature so that the rate of movement of the cam shaft is uniform over its entire travel. Much greater flexibility is, of course, possible through the use of the embodiment shown where each accelerating step is independently controlled in the same device.

It will therefore be seen that the device of the present invention provides an extremely useful and yet quite inexpensive means of limiting the reversing torque which may be applied to any electric motor operating in one direction to spare the motor and the driving mechanism associated therewith from the severe shock to which it may otherwise be subject. Furthermore, it will readily be seen that this economical torque limiting device is further provided with a timing mechanism which is adjustable so that any desired acceleration may be accomplished so that the electric motor may be maintained at speed steps a period of time which is not dependent upon the length at which the electric motor is kept at other speed steps. In addition, these advantageous features are obtained with simplicity and economy, the device itself also being both rugged and compact.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In a control device, switching means, operating means for said switching means movable to effect switch operation in a predetermined sequence, an airtight enclosure, a piston operating within said enclosure and connected to said operating means for controlling the movement thereof, a plurality of individual pairs of interconnected openings forming inlet and outlet ports with each individual pair constituting a separate rate control means for travel of said piston between the areas of said enclosures as defined by said pairs of openings, said openings being longitudinally spaced along and extending part way through the wall of said enclosure with the upper opening of one pair of openings lying in substantially the same longitudinal position as the lower openings of another of said individual pairs of openings, and means for independently varying the rate of fluid flow through said individual pairs of interconnected openings whereby the rate of movement of said piston is independently variable along the different sections of its travel within said enclosure as defined by said individual pairs of openings.

2. In a control device, switching means, operating means for said switching means movable to effect switch operation in a predetermined sequence, an airtight enclosure, a piston operating within said enclosure and connected to said operating means for controlling the movement thereof, said enclosure having a plurality of chambers in its wall and a pair of apertures associated with each of said chambers extending part way through the walls of said enclosure and each one of said pair of apertures communicating the interior of said enclosure with the associated chamber, each of said pairs of apertures being spaced along a different section of the path of movement of said piston with one aperture of one of said pairs being substantially coplanar with an aperture of another of said pairs, adjustable means for restricting the flow of air through said chambers, said operating means and piston being movable at a rate which depends upon the rate at which air may pass from the portion of said enclosure on one side of said piston to that portion of said enclosure on the other side of said piston through said apertures and plurality of chambers, the rate of movement of said piston being independently variable over different sections of its travel, depending upon the setting of said adjustable means.

3. In a device for controlling the acceleration of an electric motor, switching means, operating means for said switching means movable to effect switch operation in a predetermined sequence, an airtight enclosure, a piston operating within said enclosure and connected to said operating means for controlling the movement thereof, a plurality of individual pairs of interconnected openings forming inlet and outlet ports with each individual pair constituting separate rate control means for travel of said piston between the areas of said enclosure as defined by said pairs of openings, said openings being longitudinally spaced along and extending part way through the wall of said enclosure, a latch for holding said operating means in a desired position, means for maintaining said latch in latching position, means including an electromagnetic coil for overcoming the effect of said last mentioned means to permit said latch to release said operating means whereby said operating means may move to operate said switching means, and means for independently varying the rate of fluid flow through said individual pairs of interconnected openings whereby the rate of movement of said piston is independently variable along different sections of its travel within said enclosure as defined by said individual pairs of openings.

4. In a device for controlling the acceleration of an electric motor, switching means, camming means for operating said switching means in predetermined sequence, biasing means for biasing said camming means toward one position, an airtight enclosure, a piston operating within said enclosure and connected to said camming means for controlling the movement thereof, a plurality of individual pairs of interconnected openings forming inlet and outlet ports with each individual pair constituting a separate rate control means for travel of said piston between the areas of said enclosure as defined by said openings, said openings being longitudinally spaced along and extending part way through the wall of said enclosure, a latch for holding said camming means in a desired position, means for maintaining said latch in latching position, means including an electromagnetic coil for overcoming the effect of said last mentioned means to permit said latch to release said camming means whereby said camming means may move under the influence of said biasing means, and means for independently varying the fluid flow through said individual pairs of interconnected openings whereby the rate of movement of said piston and camming means is independently variable along different sections of travel within said enclosure as defined by said individual pairs of openings.

5. In a control device, a plurality of switching means, said switching means having rectilinearly movable operators biased toward one position, a plurality of generally U-shaped brackets for effecting operation of said switch operators with the bights of said U-shaped brackets being contiguous to said switch operators, an adjusting screw in each of the bights of said U-shaped brackets and aligned with said switch operators for operating said switch operators upon rectilinear movement of said brackets, means biasing said brackets toward said switch operators, a roller connected to the open end of each of said U-shaped brackets, camming means extending through the arms of said U-shaped brackets and having a plurality of camming surfaces thereon engageable with said rollers for effecting rectilinear movement of said rollers and brackets, said comming means being rectilinearly movable in a path perpendicular to the planes of movement of said brackets to effect a predetermined sequence of operation of said switching means.

6. In a control device, switching means, operating means for said switching means movable to effect switch operation in a predetermined sequence, biasing means

urging said operating means toward one position, an airtight enclosure, a piston operating within said enclosure and connected to said operating means for controlling the movement thereof, a plurality of individual pairs of interconnected openings forming inlet and outlet ports within each individual pair constituting a separate rate control means for travel of said piston between the areas of said enclosure as defined by said pairs of openings, said openings being longitudinally spaced along and extending part way through the wall of said enclosure, means for independently varying the rate of fluid flow through said individual pairs of interconnected openings whereby the rate of movement of said piston is independently variable along different sections of its travel within said enclosure as defined by said individual pairs of openings, a latch for holding said operating means in a desired position against the action of said biasing means, a permanent magnet for maintaining said latch in latching position, and means including an electromagnetic coil for overcoming the effect of said permanent magnet to effect the release of said operating means from said latch whereby said operating means may move under the influence of said biasing means to operate said switching means.

7. In a control device, switching means, operating means for said switching means movable to effect switch operation in a predetermined sequence, an airtight enclosure, a piston operating within said enclosure and connected to said operating means for controlling the movement thereof, said enclosure having a plurality of chambers in its wall and a pair of apertures associated with each of said chambers extending part way through the walls of said enclosure and each one of said pair of apertures communicating the interior of said enclosure with the associated chamber, each of said pairs of apertures being spaced along a different section of the path of movement of said piston with one aperture of one of said pairs being substantially coplanar with an aperture of another of said pairs, adjustable means for restricting the flow of air through said chambers, said operating means and piston being movable at a rate which depends upon the rate at which air may pass from the portion

of said enclosure on one side of said piston to that portion of said enclosure on the other side of said piston through said apertures and plurality of chambers, the rate of movement of said piston being independently variable over different sections of its travel, depending upon the setting of said adjustable means, means biasing said operating means toward one position, a latch for holding said operating means in a desired position against the action of said biasing means, a permanent magnet for maintaining said latch in latching position, an electromagnetic coil, terminals on said coil for connection to an electrical circuit, and means mounting said coil adjacent said permanent magnet whereby said coil overcomes the effect of said magnet upon predetermined conditions of energization of said coil so that said latch releases said operating means to effect operation of said switching means.

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