ABSTRACT

A door operator for a vehicle wherein resilient means couples the drive arm to the door to control the force applied by the door operator throughout the door closing cycle. The operator is compact and mountable in the side wall of the vehicle above the floor and includes an independent locking system, together with an emergency opening assembly.

12 Claims, 11 Drawing Figures
ELECTRICAL DOOR OPERATOR

This invention relates in general to a door operator for opening and closing door panels on a public passenger vehicle, and more particularly to an electrically powered door operator for use in rail type passenger vehicles, and still more particularly to an electric door operator for use in public conveyances such as rapid transit and railway cars where rigorous safety features must be incorporated for the protection of the users during entry, egress or emergency situations.

With the advent of new rail car designs and the constant efforts to improve passenger safety, there has been a need for improved door operators used to open and close door panels on such vehicles. While it has been proposed to mount a door operator vertically in the side wall of a car as in U. S. Pat. No. 3,537,403, door operators have generally been mounted on the floor of the vehicle, such as under a seat, as illustrated in U. S. Pat. No. 3,104,098. It can readily be appreciated that vertically mounting a door operator in a side wall of a car brings the operator to a level where it may be more easily serviced. However, heretofore known door operators mountable in the side wall of a car have not been able to overcome many of the difficulties inherent in door operator construction, nor have previous inwall door operators been capable of driving the door panel alongside the operator within a movable position. Further, the problem of passenger safety relative to the application of a driving force to the door has not been satisfactorily solved.

The door operator of the present invention obviates the above difficulties in providing a compact assembly mountable in a side wall of a car which permits movement of a door panel alongside the assembly and which provides better force control on the door when it is being moved to closed position during the closing cycle. This enhances passenger safety and avoids hazardous problems developing pursuant to a passenger obstructing movement of the door to closed position. Additionally, the door operator includes an independent door locking device which operates independent of the door operator, thereby additionally enhancing the safety of passengers in the event that the connection between the door operator and door becomes broken. An interlock is provided on the locking device sensing when the door is in completely closed position and otherwise prohibiting the energization of the traction motors to the car. An indicator light is also associated with the locking device to indicate when the door is in completely closed position. In order that the door may be opened when the door operator malfunctions, an emergency device may be manually operated to unlock the door and condition it so that it may be pushed open by hand.

It is therefore an important object of the present invention to provide a door operator that will give programmed force control mechanically on the door panel during the closing cycle in such a way that the maximum door closing force can be limited as desired.

It is another object of the present invention to provide an improved door operator for a passenger vehicle that is compact in nature and capable of being mounted within a side wall pocket of the vehicle above the floor and adjacent to the door opening and which provides greater passenger safety.

Another object of this invention is in the provision of a door operator having a coupling assembly between the drive arm and the door panel which coacts with the door operator to control the force applied to the panel during the closing cycle, thereby enhancing passenger safety.

A further object of this invention is in the provision of a door operator having a unique operator drive arm assembly which applies a substantially constant force to the door panel during the entire closing cycle.

A still further object of this invention is in the provision of a door operator including a locking device that is independently operable relative to the door operator motor and gear box assembly to enhance the safety of passengers in the event that there is a failure of the connection between the door operator drive arm and the door panel.

Another object of this invention is in the provision of a door operator capable of providing better force control conditions during the closing cycle together with a pushback feature.

Still another object of the invention is in the provision of a door operator including a secondary lock with a door pushback feature.

Other objects, features and advantages of the invention will be apparent from the following detailed description, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a fragmentary perspective view of the inside compartment of a vehicle to illustrate the inwall installation of door operators according to the present invention;

FIG. 2 is a fragmentary elevational view of the interior of a vehicle utilizing a door operator according to the invention and illustrating the movement of a door panel relative to the door operator, together with the amount of travel incurred by the drive arm of an operator as it travels between open and closed positions;

FIG. 3 is a fragmentary top view of a door and pocket arrangement to illustrate the relationship between a door panel and the operator according to the invention as the door moves between open and closed positions;

FIG. 4 is a vertical end elevational view of a door panel and operator arrangement according to the invention to illustrate the manner in which the door panel is capable of moving alongside the operator and is capable of utilizing the common pocket compartment formed in the side wall of the vehicle;

FIG. 5 is a greatly enlarged front elevational view of the door operator according to the invention as it would be viewed looking from the inside of the vehicle and illustrating the positions of movable parts when the door panel is in closed and locked position;

FIG. 6 is an end elevational view of the door operator of FIG. 5 looking in the direction of the motor and locking device and also illustrating the parts in position when the door panel is in closed and locked relationship to the door opening of the vehicle;

FIG. 7 is a rear view of the door operator taken from the opposite side relative to FIG. 5 and illustrating the parts when the door panel is in closed position;

FIG. 8 is an enlarged front elevational view of the locking device illustrating the lock pawl in released position and the lock cam rotated with the fork to allow the door panel to move toward open position;
FIG. 9 is a generally schematic force analysis diagram for the door closing cycle of the drive arm to illustrate the forces applied to the door panel at the various positions throughout the door closing cycle.

FIG. 10 is an electrical schematic diagram of the control circuitry for the door operator; and FIG. 11 is a partially fragmentary elevational view of a modification where the pushback feature of the door is provided by a structure mounted on the door panel, wherein the door panel and associated components in solid illustrate the closed position while the parts shown in phantom depict open and intermediate positions and indicate the general forces applied during the closing cycle.

Referring now to the drawings and particularly to FIGS. 1 to 4, the door operator of the invention, generally designated by the numeral 20, is illustrated as being mounted in the side wall 21 of a vehicle 22 for controlling the opening and closing of door panels in a door opening 23 formed in the side wall 22. While biparting door panels 24 and 25 are illustrated in FIG. 1 to close the door opening 23, it will be appreciated that each door panel is opened and closed by a single door operator 20. Accordingly, the door operator of the invention is intended to open and close a single door whether it be associated in a biparting arrangement as illustrated or otherwise. As illustrated, the door operator is mounted in a vertical manner above the floor 26 of the vehicle in a side wall pocket 27 that not only accepts the door when it moves to open position but also receives the door operator 20. The pocket is essentially defined by an inner wall 28 and an outer wall 29, together with opposed side walls 30, the innermost side wall of which includes a slot for the door to move through when moving between open and closed positions. An access panel 31 is provided for the inner wall 28 which may be removed to provide suitable access to the operator when servicing or adjusting same.

The door operator 20, as more particularly seen in detail in FIGS. 5 to 8, includes an upstanding mounting plate or panel 35 which is suitably secured by brackets or otherwise to the vehicle body and which has mounted thereon all of the components of the door operator and therefore may easily be removed as a unit for servicing and/or replacement. Mounted on the front side of the plate 35, this side being the one viewed in FIG. 5, is a reversible high-torque motor 36 and gear box 37 as an assembly which includes an output shaft 38 that extends substantially perpendicular to the mounting plate 35 and carries a drive arm 39 on the back side of the mounting plate, which is the side viewed in FIG. 7.

At the outer free end of the drive arm 39 in the embodiment shown in FIGS. 5 to 7, in order to provide a pushback feature for the door panel, a stub shaft 40 pivotally carries a pushback lever 41 that is restrained for limited movement as defined by a stop pin 42 extending from the drive arm into a notch or slot 43 formed in the lever. The lever 41 includes a drive extension 44 extending downwardly as viewed in FIG. 5 and on the terminal end of which is rotatably mounted a drive roller 45 and an extension portion 46 extending upwardly having one end of a coil spring 47 attached thereto. The other end of the coil spring is attached to an arm 48 which is secured to the drive arm that extends at just less than 90° with respect to the drive arm adjacent the output shaft 38. The coil spring 47 functions to continually urge the lever 41 to the positions shown in FIG. 5 where the stop pin 42 abuts against the edge 43a of the notch 43. Pressure applied to the drive roller 45 in excess of the force exerted by the spring 47 will cause the pivoting of the lever 41 in a clockwise direction and to the position where the stop pin 42 may abut against the edge 43b of the notch 43 if the force is sufficient, except when the drive arm is positioned such that the pivot axes of the lever and roller pass through a horizontal plane at which time the drive arm and lever are effectively solid.

The roller 45 engages in a slide bracket assembly 55 suitably attached to the trailing edge of the door 24 and therefore parallel to the vertical axis of the door wherein movement of the drive arm 39 in a counterclockwise direction, as viewed in FIG. 5, will cause movement of the door leftward and alongside of or overlapping the door operator as it moves to open position, assuming that the door locking device is in unlocked condition.

Accordingly, it can be seen that the lever 41 defines a pushback feature for the door panel in the event that it meets an obstruction or is restrained from closing during the closing cycle. Referring to FIG. 9, which illustrates a schematic force analysis diagram illustrating the drive arm in open and closed positions 56 and 57 and intermediate positions 58 and 59, at the intermediate position 58 the pivot axes of the lever and the roller are aligned in a horizontal plane and effectively render the drive arm and lever solid as force applied to or by the door will be applied directly through these pivot axes. From the position 58 through position 59 and to the closed position 57, the torque arm on the lever increases, thereby making it more flexible when a force is applied to the door panel by an obstruction on the front edge thereof. Movement of the drive arm between position 58 and position 57 takes place during the last half of the door closing cycle where the lever becomes more flexible. It should also be appreciated that during the beginning of the last half of the closing cycle, the torque arm on the lever is less and therefore the lever becomes less flexible. However, in the first half of the closing cycle, the torque arm of the drive arm is greater and therefore any force due to an obstruction on the front edge of the door panel exerts greater torque against the motor and prevents the door from closing. Accordingly, it can be seen that the combination of the pushback feature and its mutual reaction with respect to the door panel position provides a safer door operation.

The locking device of the door operator, generally indicated by the numeral 60, includes a fork 61 arranged on the backside of the mounting plate carried on a shaft 62 pivotally mounted in the mounting plate and which has mounted thereon at the front side of the mounting plate a lock cam 63. The fork includes an upwardly opening rectangular slot 64 coacting with a lock pin 65 that is carried on a bracket 66 which in turn is mounted on the slide bracket assembly 55 of the door panel. When the door panel is in closed position, the lock pin 65 will generally abut against the forward edge 64a of the slot 64, and when sufficient force is applied against the leading edge of the door to drive it toward open position against the force of the spring 47 to cause it to yield, the pin can move to the trailing edge 64b of the slot 64 before being stopped against further movement. Accordingly, the fork 61 functions to lock the
The lock cam 63 includes a notch 70 at its upper edge for receiving a tongue 71 of a lock pawl or locking bar 72. The locking pawl 72 is pivotally mounted on a stub shaft 73 carried on the locking device bracket 74 and continually resiliently biased in a clockwise direction by means of a spring 75. When the fork 61 is tilted in the clockwise direction as viewed in FIG. 7 and counterclockwise direction as viewed in FIG. 5, the tongue of the locking pawl will ride on the edge 76 of the lock cam 63 as shown in FIG. 8. In order to move the lock pawl to its up position and release the lock cam and fork, a solenoid 78 having a plunger 79 is energized to drive the locking pawl in a counterclockwise direction. The solenoid 78 is mounted on the bracket 74, as seen particularly in FIGS. 5 and 8. While the fork 61 and lock cam 63 will move by gravity in a counterclockwise direction upon being released by the lock pawl 72, a coil spring 80 is provided to additionally urge the fork to open position when it is released.

Should an emergency situation arise where it would be desired to open the door and when the usual switching operation would not work, an emergency device is provided on the door operator which can be reached by opening and removing the access panel on the side wall. This emergency device includes a handle 90 pivotally mounted on a shaft 91 and held in the position shown in FIG. 5 by means of a coil spring 92 and which carries the cam member 93. The cam member 93 which rotates with the lever 90 includes a cam surface 93a that engages the rear end 93b of the solenoid plunger 79 when the handle is rotated in a clockwise direction and drives the plunger toward the right as viewed in FIG. 5 to raise the locking pawl 72 and unlock the fork 61. Following the unlocking of the locking pawl, an emergency switch 94 is actuated when the track 95 on the emergency handle 90 is moved out of the path of the switch to energize the operator motor for an opening cycle in the event that power is available to the operator. This would thereby open the door.

If power is not available to the operator, through a lost motion connection, the emergency handle 90, having a pin 96 extending from the cam 93, engages and drives a lever 97, pivotally mounted on the stub shaft 91 to rotate it in a clockwise direction and drive the operator arm 39 in a counterclockwise direction to unlock the overcenter locking arrangement and permit opening of the door by the application of force to the door. The lever 97 includes a drive pin 98 mounted on the free end and extending through an opening 99 formed in the mounting plate 35 and which engages the lower end of the arm 48 that extends below the output shaft 38, and which when force is applied thereto causes the drive arm 39 to rotate in a counterclockwise direction. The lever 97, as shown in FIG. 5, is held in the position shown, where the pin 98 abuts against the back end of the opening 99 by means of the spring 92 which applies a force to the lever through the emergency handle, the cam 93 and the pin 96 which engages the lever 97.

In the operation of the door operator, with some reference to the electrical schematic diagram of FIG. 10, power is always supplied to the line 110 and when an open signal is applied to the motor control relay line 111 simultaneously with an unlock signal applied to the unlock line 112, the sequence causes the locking solenoid 78 to be energized which lifts the lock pawl or locking bar 72 to allow the lock cam and fork to rotate out of the path of the lock pin on the door panel. Additionally, the locking pawl actuates indicator light switch 113 to energize a door indicator light located at the conductor's control panel indicating the door panel is in unlocked position and interlock switch 114 which opens the traction motor circuit by opening contacts 114a and completes the circuit to the solenoid 115 of the motor control relay of energizing same by closing contacts 114b. Energizing the motor control relay swings the contact arm 115a and 115b thereof to the positions shown in dotted lines to apply power to the motor and causes it to drive the door operator arm through the opening cycle to move the door panel to open position.

As the operator drive arm commences movement to the open door position, the switch cam 116 on output shaft 38 first actuates the closing limit switch 117 to close contacts 117a and condition same for the closing cycle, and after about 110° of drive arm movement actuates switch 118 which de-energizes the locking solenoid by opening contacts 118a, thereby allowing the locking bar 72 to move to a relaxed position where it is held on the cam edge 76 as shown in FIG. 8. At the same time the open cushion resistor 119 is connected across the armature 120 of the motor by closing contacts 118b to provide dynamic braking to the motor and cushion the final portion of the opening cycle of the door and prevent slamming. The motor field 121 is in series with the armature 120. After the operator drive arm has moved through about 145°, the switch cam 116 actuates the open limit switch 122 to de-energize the operator motor by opening contacts 122a and allow coating of the operator to the fully opened position at about 150° of drive arm movement.

A close signal from the train conductor removes the voltage signal from the motor control relay and unlock lines to de-energize the motor control relay and allow the contact arms 115a and 115b to return to their original position, shown in solid lines in FIG. 10, which causes the operator motor to be energized for driving the operator drive arm through the closing cycle to close the door panel. Since the closing resistor 123 is in series with the armature and motor field, the speed of the motor is reduced during the closing cycle. When the operator drive arm reaches the position just slightly past overcenter, the switch cam actuates the closing limit switch 117 to de-energize the motor and allow the operator to coast to the final resting position where the door is closed and locked in closed position by the drive arm. As the door moves to the closed position, the lock pin 65 engages the fork 64 to rotate it and the lock cam to the position where the lock pawl 72 will drop into the notch on the lock cam 63 and lock the fork in locking position relative to the lock pin.

In the event that the door need be opened in an emergency situation, the emergency lever is operated by swinging it upwardly in a clockwise direction. The cam on the emergency handle first manually drives the locking the emergency handle first manually drives the locking solenoid plunger to pivot the lock pawl and allow the lock cam and fork to rotate to open position, at which time it will actuate switches 113 and 114 to close contacts 114b and open contacts 114a. When the cam on the emergency lever is in this position, it as-
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sures that the lock pawl has been raised to unlock the door, and then the switch track 95 moves to a position to allow actuation of the emergency switch 94 to move the contacts arm 94a to the dotted position which will apply power through line 110 to the motor control relay 115 in the event that power is available and cause opening of the door by actuation of the motor control relay as above explained. In the event that no power is available on line 110, the emergency lever, through a lost motion connection, drives lever 97 which engages the operator drive arm to rotate the drive arm past overcenter relationship in the open direction so that further pressure against the door will permit opening of same by swinging the drive arm in a counterclockwise direction.

A cutout switch 125 shown in normal position in FIG. 9 can be moved to cutout position when it is desired to take any door operator out of the train line circuit.

A modification of the resilient coupling arrangement between the operator drive arm and the door panel is illustrated in FIG. 11. This modification differs in that the resilient pushback feature is incorporated in structure mounted directly to the door instead of in the linkage arrangement with the drive arm and in particular, where the drive arm is solid with a roller on its free end engaging in a slide assembly that is resiliently mounted on the door panel. The dynamics of this embodiment are identical to the dynamics in the embodiment of FIG. 5.

Referring to FIG. 11, the output shaft of the operator is identified by the numeral 130 on which the drive arm 131 is mounted for movement through a plane parallel to the path of movement of the door panel 132. A roller 133 is mounted on the outer free end of the drive arm 131 for sliding engagement in a slide 134 of the slide bracket assembly 135 mounted on the trailing edge of the door panel 132. The upper end of the slide 134 is pivotally mounted on a pin 136 carried by a bracket 137 that is in turn secured to an elongated mounting bar 138.

Extending from the lower end of the slide is a guide member 139 coacting with a guide pin 140 that is carried on the upper end of a bracket assembly 141, the latter of which is secured to the lower end of the mounting bar 138. Accordingly, the guide pin 140 prevents movement of the slide laterally of the plane of the door panel while permitting movement of the slide toward and away from the door panel but restricted from movement away from the panel beyond the stop 142 carried on the end of the guide pin 140. A compression spring assembly 143 is connected at one end to the bracket assembly 141 and at the other end to the guide member 139 of the slide to resiliently bias the lower end of the slide in a direction away from the door panel and normally against the guide pin stop 142. When a force is applied to the door panel which exceeds the force applied to the slide through the drive arm of the operator and the force generated by the compression spring assembly 143, the spring assembly will yield and the lower end of the slide 134 will swing inward toward the door panel. A stop 144 extends from the upper bracket assembly 137 to limit the pivotal movement of the slide 134.

The drive arm of the operator and the slide bracket assembly attached to the door panel 132 are illustrated in FIG. 11 in solid lines in the positions taken when the door panel is in closed position and the drive arm is in overcenter locked position relative to the slide, and where no force is being applied to the door to actuate the door pushback feature. In the event that a sufficient force were applied to the door to overcome the force of the spring compression assembly 143, the lower end of the slide 134 would be in a position closer to the trailing edge of the door panel. The door panel open position and the two intermediate door panel positions are depicted in phantom where the position 145 defines the door panel open position and the positions 146 and 147 define the intermediate positions. At the intermediate position 145, the roller 133 of the drive arm is positioned in the slide just below the pivot pin 136. Therefore, the flexibility of the coupling is at the minimum.

As the drive arm moves from position 146 through 147 and to closed position, the action of the slide 134 becomes more flexible and this is during the last half of the closing cycle, and here, the torque arm of the slide is the greatest. Accordingly, the coupling of this embodiment between the drive arm and the door panel is essentially the same as the coupling in the embodiment of FIG. 5 wherein the combination of the pushback feature and its mutual reaction with respect to the door panel position provides a safer door operation.

The emergency device for actuating the door operator operates in the same way as the emergency device disclosed and described in connection with the embodiment of FIG. 5 but is slightly differently constructed. The emergency handle 148 swings on a pivot shaft 149 to drive a cam 150 which operates the plunger solenoid 151 of the locking solenoid 152 and the emergency switch 153. A compression spring assembly 154 through a toggle action normally maintains the emergency handle 148 in the position shown but allows the handle to be driven in a clockwise direction to a second position for first driving the plunger in the direction to unlock the locking bar and secondly to actuate the switch 153 and finally to drive an arm 155 having a pin 156 extending from its end so that the pin engages an extension 157 connected to the output shaft 130 to drive the drive arm past overcenter relationship so that the door may be pushed to open position. Accordingly, this arrangement works essentially the same as that already described in connection with the embodiment of FIG. 5.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

The invention is hereby claimed as follows:

1. In a vehicle having a door opening and a door selectively movable between open and closed positions relative to said door opening, a door operator for driving said door between said open and closed positions arranged so that the door is driven along one side of the operator when it is moved to open position, said door operator including an upstanding mounting plate, a reversible motor and gear box assembly mounted on the plate, said gear box having an output shaft extending substantially perpendicular to the mounting plate and in a substantially horizontal position, a drive arm mounted on the output shaft adapted to move in a plane extending substantially parallel to the mounting plate and substantially parallel to the door, means coupling the drive arm to the door including a slide assembly mounted on the trailing edge of the door and a rol-
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1. The locking device for a sliding door including in the slide assembly and mounted on the drive arm, the drive arm being on the side of the plate opposite to the side mounting the motor and gear box, said coupling means also including resilient means for controlling the force applied to the door through the drive arm.

2. The combination as defined in claim 1, wherein said coupling means includes an arm pivotally mounted on the drive arm movable indefinitely between first and second positions and resiliently biased normally to the first position, said roller being mounted on one end of the arm such that when the door is in fully closed position the roller will be in an overcenter locking position relative to the output shaft of the gear box.

3. The combination as defined in claim 1, wherein the coupling means includes the roller being mounted on the end of the drive arm and the slide bracket assembly mounted to the door edge with one end carried on a pivot and the other end resiliently biased to a first position but movable infinitely to a second position upon the exertion of a predetermined force on the door.

4. The combination as defined in claim 1, and a locking device mounted on the mounting plate coacting with a locking element on the door to positively lock the door in closed position and to sense the closed position of the door.

5. The combination as defined in claim 4, wherein said locking device includes means that permits a limited pushback action for the door when the device is in locked position.

6. The combination as defined in claim 4, and including an emergency handle mounted on the mounting plate coacting with the locking device and the operator drive arm to open the door in the event that the locking device does not unlock and in the event that no power is available to the operator.

7. In a vehicle having a floor, a ceiling, side and end walls and a door opening in a side wall with a slidable door selectively movable between open and closed positions relative to said door opening, said side wall having inner and outer panels wherein the door is movable between said panels when moving to open position, a door operator for driving said door between said open and closed positions and being mounted above the floor and within the side wall between the inner and outer panels adjacent to the door opening wherein the door moves alongside the operator when moving to open position, said door operator including a mounting plate, a reversible motor and gear box assembly mounted on said mounting plate, an output shaft extending from the gear box substantially perpendicular to the mounting plate and in a substantially horizontal position, a drive arm secured to the output shaft and movable in a plane extending perpendicular to the drive shaft and substantially parallel to the mounting plate, coupling means between the drive arm and the door including a roller element on the drive arm and a slide bracket element on the trailing edge of the door, one of said elements being resiliently biased so that the force applied by the drive arm is controlled within a predetermined range during closing of the door, said drive arm being on the side of the mounting plate opposite to the motor and gear box.

8. The combination as defined in claim 7, wherein the roller element on the drive arm is resiliently biased to yield in the event an abnormal force is encountered by the leading edge of the door.

9. The combination as defined in claim 7, wherein the slide bracket element on the door is resiliently biased to yield in the event an abnormal force is encountered by the leading edge of the door.

10. The combination as defined in claim 7, wherein a locking device mounted on the mounting plate coacting with a locking element on the door to positively lock the door in closed position and to sense the closed position of the door.

11. The combination as defined in claim 10, wherein said locking device includes means that permits a limited pushback action for the door when the device is in locked position.

12. The combination as defined in claim 10, and including an emergency handle mounted on the mounting plate coacting with the locking device and the operator drive arm to open the door in the event that the locking device does not unlock and in the event that no power is available to the operator.