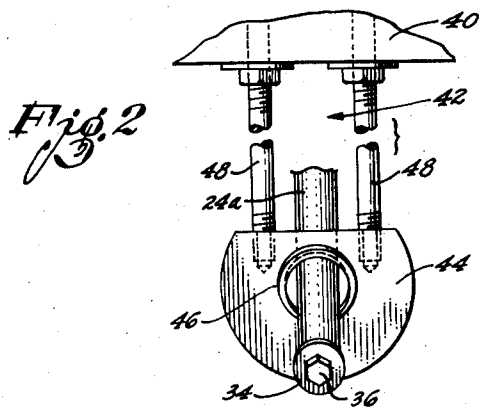
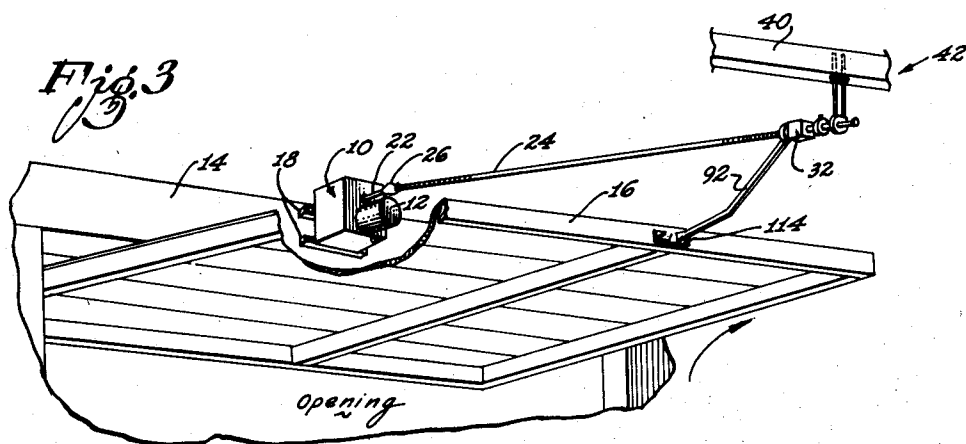
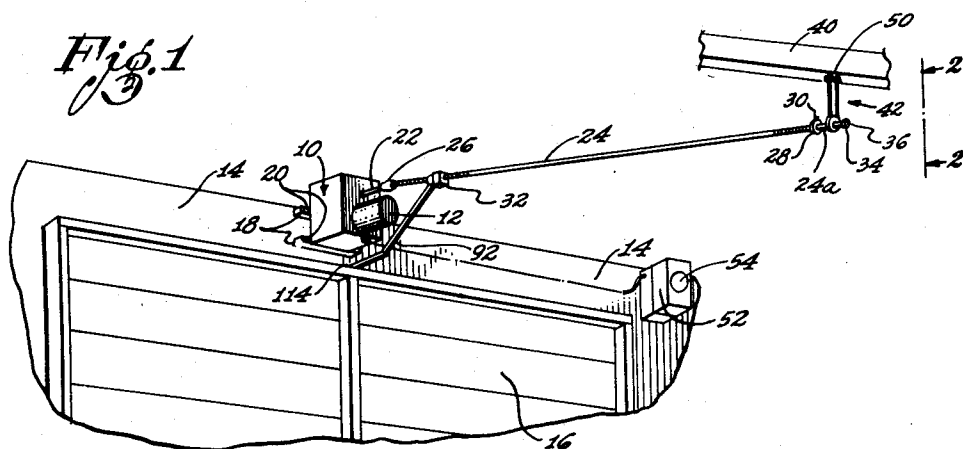


D. R. STUETTIG ET AL
DOOR OPERATING MECHANISM

4 Sheets-Sheet 1

Fig. 1



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2,944,810

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4 Sheets-Sheet 2

Fig. 4

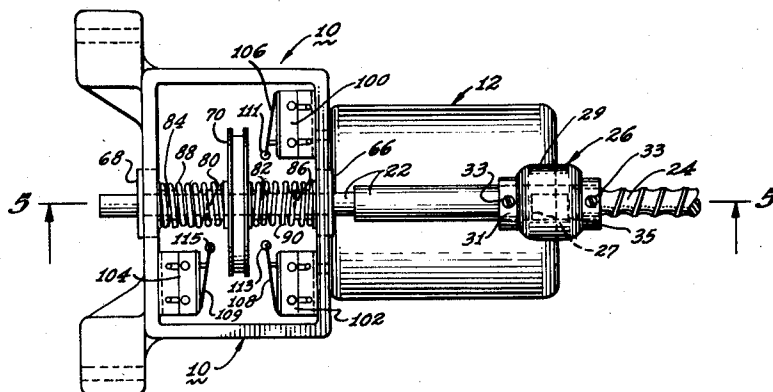
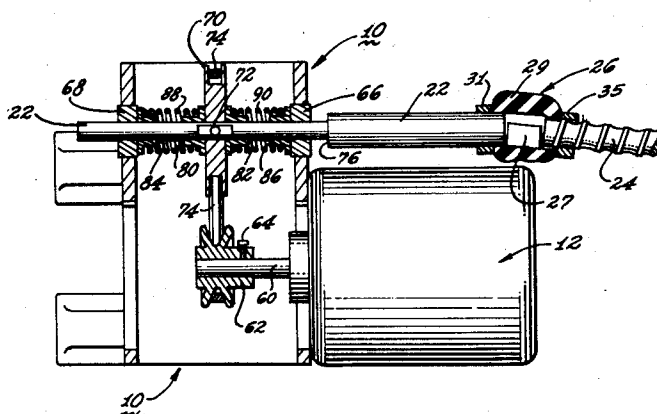


Fig. 5



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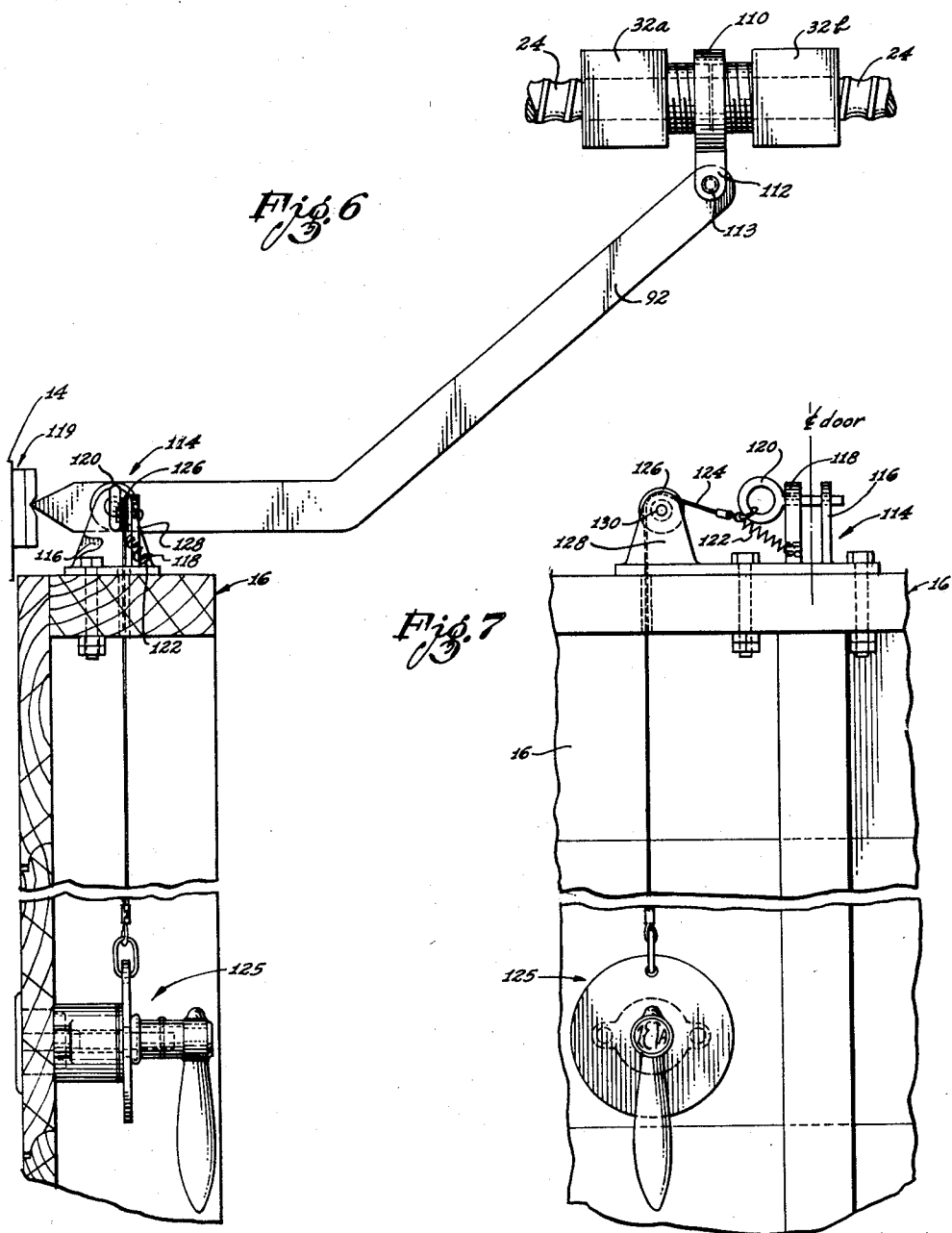
D. R. STUETTIG ET AL

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4 Sheets-Sheet 3



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2,944,810

DOOR OPERATING MECHANISM

Filed Aug. 21, 1958

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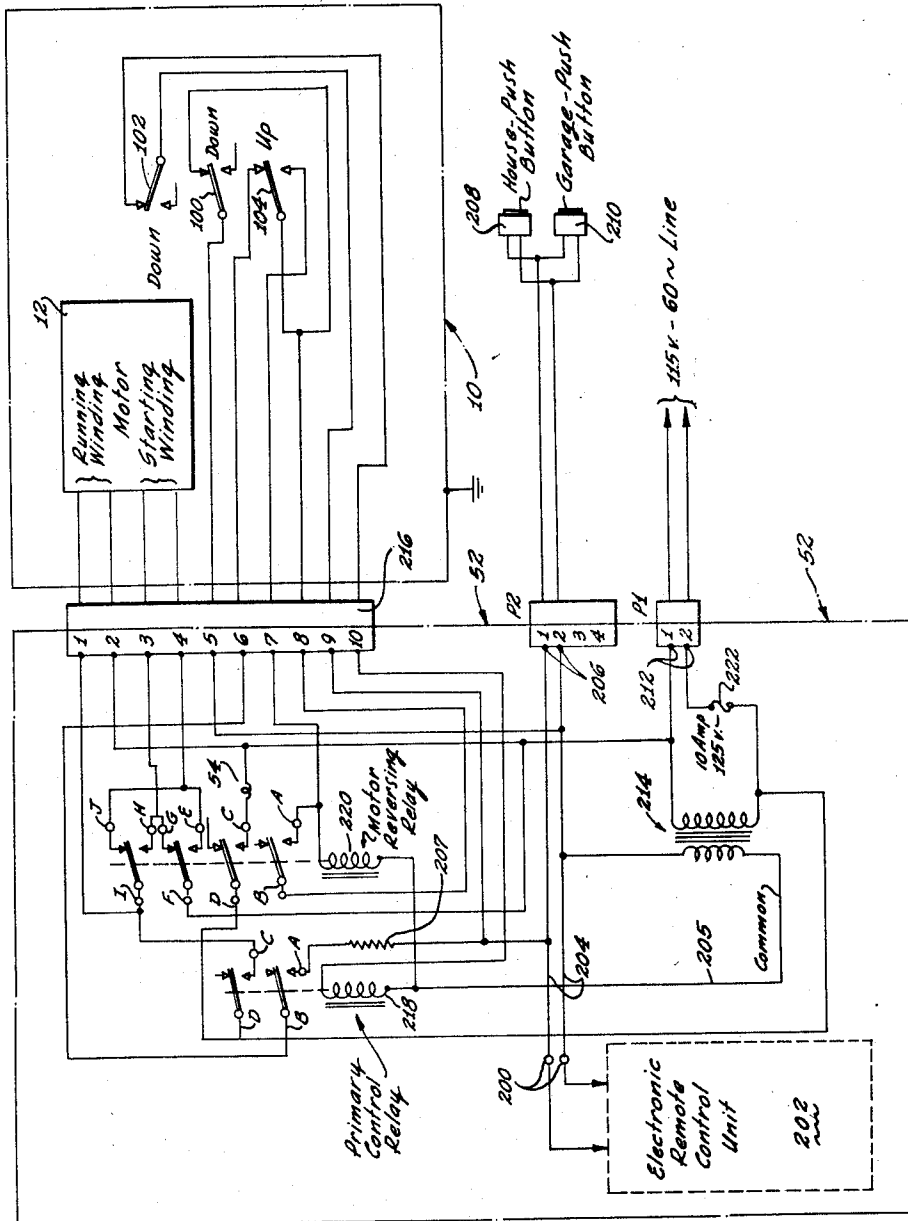


Fig. 8

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2,944,810

DOOR OPERATING MECHANISM

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5 Claims. (Cl. 268—59)

The present invention relates to electrically actuated mechanisms for operating garage doors and the like automatically, either in response to an actuating signal radiated from an automobile or upon the closure of an electric switch situated, for example, in the garage or in the house associated with the garage.

The mechanism of the invention probably finds its greatest utility in conjunction with garage doors for automatically opening and closing such doors upon the receipt of appropriate radiated signals, or upon the actuation of control switches. For that reason, the improved mechanism of the invention will be described in such an environment. It will become apparent as the description proceeds, however, that the improved mechanism of the invention will find utility in any application in which the opening and closing of a closure member is to be electrically controlled.

The most important requirement of the garage door operating mechanisms is, of course, that they be absolutely safe in their operation and incapable of injuring any person using the mechanism or in the vicinity of the door as it is opened or closed, or of damaging any property that might be in the way of the door as it is automatically opened or closed.

The door operating mechanism of the present invention completely fulfills the safety requirement outlined in the preceding paragraph. The mechanism of the invention includes a positive means for immediately arresting the opening or closing motion of the door by the mechanism should the door engage any object tending to impede its opening or closing motion. Therefore, when the mechanism has been actuated to close the door, for example, and should a motor vehicle or other object be inadvertently left in the path of the closing door, or should a child or other person come into the path of the closing door, immediately upon the contact of the door with the object or person, its downward motion is positively stopped. This also applies to anything or anyone impeding the upward motion of the door, when the mechanism of the invention has been actuated to open the door.

A further safety feature of the embodiment of the door operating mechanism of the invention to be described is the provision of a secondary switching mechanism which preserves the downward safety stop feature of the door operating mechanism of the invention despite failure of the control mechanism such as switch failure or relay failure. Normal operation of the door operating mechanism may be restored after the secondary switching mechanism has been actuated only after the malfunction causing primary control circuitry failure has been located and repaired, thus affording an important self-check feature.

Another feature of the improved door operating mechanism of the invention is its high degree of reliability and its capabilities for a long and trouble-free life. This is achieved by the avoidance of complexity in the construction of the mechanism and by the avoidance of any extraneous components. Reliability is also achieved by the

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assignment of the necessary functions of the equipment to a minimum of parts which in themselves are rugged in their composition and extremely simple in their operation.

A belt drive is used, for example, between the electric motor which drives the mechanism and the driven shaft pulley in the embodiment of the invention to be described. The flexibility of the belt drive permits axial misalignments between the motor pulley and the driven shaft pulley without loss of torque, and without creating undue wear.

The belt drive arrangement, referred to above, is extremely advantageous, moreover, for the type of loads exerted on the mechanical driving mechanism in the control of a garage door. Such loads are highly inertial and subject to sudden variations. The use of gears for the same purpose would be impractical, because of the size and strength requirements for such gears to be capable of properly performing under the peculiar load conditions with which the mechanism of the invention is intended to operate.

The door operating mechanism of the invention is also economical and reliable in its electric control circuit, this circuit is extremely simple in its design and straightforward in the composition of its circuitry and associated components. In the embodiment to be described, for example, two relays of known construction are used, and only one of these actually switches motor current. The other is the reversing relay, and it carries motor current. However, the latter relay is timed so that it does not switch motor current, rather, it changes its contacts from one operating condition to the other when no current is flowing through the motor. This means that high switching current contact requirements need be met only in one of the two relays which actually control the operation of the mechanism.

The increased reliability of the door operating mechanism of the invention as compared with the prior art mechanisms of this general type results in longer life of the unit and decreased maintenance costs. Also the likelihood is minimized of access to the motor vehicle in the garage being obstructed due to failure of the mechanism. To render it virtually impossible under any circumstances, even if power failure occurs, for the door operating mechanism to actually obstruct access to the motor vehicle in the garage, the embodiment to be described includes a key-locked release mechanism. This mechanism is operable by key locked handle from the outside of the garage, and it serves completely to disconnect the operating mechanism from the garage door when it is actuated. This enables the garage door to be opened manually when the situation requires it.

The door operating mechanism of the invention also has the advantage of being relatively small in size and relatively easy to install. About 80 percent of the weight of the mechanism may be concentrated, for example, in a housing which supports the drive motor and other drive elements of the assembly. This housing is relatively compact in size, and it is intended to be mounted on the door header portion of the door frame of the garage to be directly over the center of the garage door when the door is closed. This is clearly an ideal position for the unit since it eliminates the need for additional bracing to take up the weight and the thrust forces, such additional bracing being almost universally required by the prior art units.

The above and other features and advantages of the door operating mechanism of the invention will become apparent from a consideration of the following descriptive material in conjunction with the accompanying drawings in which:

Figure 1 is a perspective view of the improved door

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operating mechanism of the invention illustrating the mechanism mounted in place over a garage door, this view showing the drive motor and its associated housing mounted on the header of the door directly over the center of the door, and including a lead screw which extends back from the plane of the door in its closed condition to be rotatably supported at its remote end from a rafter of the garage, and this view showing a nut means which rides on the lead screw and which in this particular view is disposed toward the leading end of the screw, with the nut means being coupled by a pivoted linkage to the top of the door;

Figure 2 is a view substantially on the line 2—2 of Figure 1 to show further details of the means at the remote end of the lead screw for rotatably supporting the lead screw from the rafter of the garage;

Figure 3 is a view similar to the view of Figure 1 but showing the nut means disposed toward the rear end of the lead screw and the garage door in an open condition;

Figure 4 is a top view of the drive motor and associated housing portion of the door operating mechanism of the illustrated embodiment of the invention, with the top being removed from the housing to reveal its internal components;

Figure 5 is a sectional view substantially on the line 5—5 of Figure 4 to show the manner in which the drive motor is coupled to a pulley mounted on a driven shaft, the driven shaft being coupled to the lead screw and in essentially axial alignment with the lead screw;

Figure 6 is a fragmentary view showing the linkage means which couples the mechanism to the garage door and which is pivoted to the top of the garage door and to a nut means which rides on the lead screw described above, the particular nut means illustrated in Figure 6 being slightly modified as compared with the nut means illustrated in the previous figures;

Figure 7 is a fragmentary view of a suitable means for coupling the linkage means of Figure 6 to the garage door, the means of Figure 7 including a releasing mechanism for releasing the door operating mechanism from the garage door, when so desired; and

Figure 8 is a circuit diagram of a suitable electric control for the mechanism illustrated in the other figures.

As shown particularly in Figures 1, 2 and 3, the improved assembly of the invention includes a housing 10 which contains the various drive components of the assembly, as will be described, and which also contains the drive shaft and pulley of a motor 12 which is mounted on the housing. The housing is adapted to be mounted on the header 14 of the doorway of a garage, for example, and it is adapted to be positioned directly over the center of the plane of the garage door 16 when the door is in a closed position. As shown in Figures 1 and 3, the housing 10 may be appropriately mounted on the header 14 by a pair of brackets 18 which are screwed into the header by means of screws such as the screws 20, the housing being fixed to the brackets 18 in any appropriate manner.

A driven shaft 22 extends out of the housing 10 directly over the motor 12, as shown in Figures 1 and 3. The drive shaft of the motor 12 is coupled to the driven shaft 22 in a manner to be explained in detail subsequently. The driven shaft 22 is coupled to an externally threaded elongated rod member, such as a lead screw 24 by means of a suitable resilient universal coupling 26. The resilient universal coupling 26 allows the lead screw 24 to be positioned at a small angle from the horizontal. The lead screw 24 may be one inch in diameter, and it may have four threads to the inch. The lead screw may be composed of steel or aluminum, for example, and it may have a typical length of 72 inches. As shown in Figure 5, the coupling 26 may include a medium hard rubber damper 27 having a typical dimension of .75 inch diameter by 1 inch length.

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The end of the lead screw 24 remote from the housing 10 may be machined to a diameter of, for example, .625 inch. This machined end section is designated as 24a in Figures 1 and 2, and it may have a length of, for example, four inches. A stop collar 28 is mounted on the end of the lead screw 24 adjacent its end section 24a. This collar is bolted to the lead screw by a bolt 30 which extends through the collar and through the lead screw, this bolt assuring a rigid, stable mounting for the collar on the lead screw. The collar 28 forms a limiting stop for a movable recirculating ball bearing nut 32 which is threaded to the lead screw, and which is adapted to move reciprocally and rectilinearly with respect to the longitudinal axis of the lead screw as the lead screw is rotated.

A washer 34 is mounted to the extreme end of the lead screw 24 by means, for example, of a bolt 36 which is threaded into the end of the lead screw. The remote end of the lead screw is rotatably suspended from a rafter 40 of the garage by means of a rear hanger or sling assembly 42 (Figure 2). This rear hanger includes, for example, a bearing member 44 which is best shown in Figure 2 and which includes a tubular nylon insert 46. The bearing member 44 is suspended by means of a pair of screw rods 48, the screw rods extending into a mounting plate 50 which is threaded to receive the rods and which provides for a rigid mounting for the rear hanger.

The machined end portion 24a of the lead screw 24 extends through the nylon insert of the bearing member 44 in rotatable relationship with the bearing. Therefore, the remote end of the lead screw 24a is supported from the rafter without impairing the ability of the lead screw to be rotated. It should be noted at this point that the bulk of the weight of the door operating mechanism is supported in the housing 10, which, in turn, is rigidly mounted on the header 14 of the garage. This precludes any necessity for extra bracing, as is usually required when the actual operating mechanism is supported back in the vicinity of the rear hanger 42.

The electrical controls for the door operating mechanism are housed in a housing 52 (Figure 1). This housing is shown in Figure 1 as being separate from the housing 10 and supported at the corner of the header 14. However, it will become evident as the present description proceeds, that the electrical controls may also be incorporated in the housing 10 to form a single unit. A light 54 may be conveniently included in the housing 52 or on the housing 10, and this light is controlled to be energized whenever the mechanism is operated to open the door. This provides an automatic illumination in the garage whenever the door is open, and the light automatically is turned off when the door is again closed.

Details of the driving assembly for the mechanism are shown in Figures 4 and 5. This driving assembly, as noted above, is housed in the housing 10. The motor 12 is mounted at the bottom of the housing 10, and this motor may conveniently be a quarter-horsepower 1725 r.p.m. induction type motor. The motor has a driven shaft 60 which is mounted in the motor casing in usual motor bearings. The drive shaft 60 extends into the housing 10 and a pulley 62 is mounted at the end of the drive shaft by means, for example, of a set screw 64. The pulley 62 may be a usual 2½ inch V-type belt pulley. The driven shaft 22 is rotatably mounted in the housing 10 in spaced parallel relationship from the drive shaft 60. The driven shaft, for example, may be so mounted in the housing 10 in a pair of bearings 66 and 68 which are mounted in the opposite walls of the housing. A pulley 70 is mounted on the driven shaft 22 in alignment with the pulley 62. The pulley 70 may, for example, be a 4½ inch aluminum pulley. The pulley 70 is affixed to the shaft by appropriate set screws such as the set screw 72. A usual V-type drive belt 74 intercouple the drive pulley 62 with the driven pulley 70.

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As shown in Figure 5, the section of the driven shaft 22 which extends into the housing 10 has a reduced diameter with respect to the diameter of that shaft outside of the housing. The section of reduced diameter forms a shoulder 76 with the section of increased diameter. The driven shaft 22 is rotatably mounted in the bearings 66 and 68, as mentioned above, however, this shaft is also capable of axial movement in the bearings. A pair of thrust bushings 80 and 82 are mounted on opposite sides of the pulley 70 in coaxial relationship with the driven shaft 22. A second pair of thrust bushings 84 and 86 are mounted on the inner sides of the respective bearings 66 and 68 in coaxial relationship with the driven shaft 22. These thrust bushings may be composed of, for example, case hardened steel.

A pair of compression springs 88 and 90 of the coiled type are supported respectively on the bushings 80 and 84 and 82 and 86 in coaxial relationship with the driven shaft 22. These springs are preferably non-linearly wound, and each may have a length of 2.44 inches with an outer diameter of 1.14 inches. Each may include eight coils of No. 6 wire. These compression springs serve to bias the pulley 70 into axial alignment with the drive pulley 62. However, a sufficient axial force exerted on the shaft 22 is capable of overcoming the compression of one of the springs or the other to move the pulley 70 to the left or to the right in Figures 4 and 5. The purpose of the bushings is to provide bearing surfaces for the springs 88 and 90. Spring bearing surfaces are necessary to reduce rotational friction between the springs and the pulley 70 and the housing 10. Pulley displacement is limited during compression of the springs 88 and 90 in either direction by the contact of opposite bushing surfaces, as, for example, the meeting of bushings 80 and 84, or 82 and 86.

As noted above, the universal coupling 26 is shown in somewhat more detail in Figures 4 and 5. This coupling serves to couple the lead screw 24 to the driven shaft 22, and the coupling serves to permit such a coupling with the lead screw being disposed at an angle to the driven shaft 22. This angle, is preferably of the order of 8 to 12 degrees for the "swing-up" type of garage doors, and from -2 to $+2$ degrees for the "roll-up" type of doors. The coupling 26 is composed of a rubber central body 29 which includes the damper 27 referred to above. It also includes annular collars 31 and 35 which are secured to the lead screw 24 and to the driven shaft 22 by means of a plurality of set screws, such as the set screws 33 in Figure 4.

It is clear then that when the motor 12 is energized, the resulting torque exerted on the pulley 62 causes the pulley 70 and the driven shaft 22 to rotate. This causes the lead screw 24 to rotate at the selected angle to the driven shaft 22.

As shown in Figure 1, a linkage 92 is pivotally attached to the nut 32 at one end and in a manner to be described, and is pivotally mounted to the upper edge of the garage door 16 at its other end in a manner also to be described. This linkage couples the ball bearing nut 32 to the bracket assembly 114 attached to the top of the door 16. The resilient universal coupling 26 assists the linkage 92 in exerting force components for the operation of the usual "swing-up" type of overhead garage door, as will be described in more detail subsequently. The "roll-up" type of garage door does not require the disposition of the lead screw 24 at an angle. However, the universal coupling may also be used for the latter type of door to facilitate the coupling of the lead screw 24 with the driven shaft 22. This arrangement is such that when the motor 12 is driven in one direction, the lead screw rotates in a particular direction to cause the nut 32 to move back toward the rear end of the lead screw to open the garage door. Then, when the direction of drive of the motor 12 is reversed, the nut 32 is caused to ride along the lead screw toward its forward end to close the garage door.

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The geometry of the linkage 92 is specifically designed advantageously to lift and close the door in a manner which exerts virtually no lateral or vertical force moments upon the axis of the lead screw 24. This specific design is important for the operation of "swing-up" doors. Swing-up doors of this type do not describe an arc corresponding to a segment of the circumference of a single circle. Rather, the locus of points describing the path taken by the top of the door consists of two arcs, approximating segments of two intersecting circles of different radii.

Considering the movement of a swing-up door in the upward direction, an arc of relatively large radius is described during approximately the first 20° of rotation from the vertical. After the first 20° , an abrupt change in the door path occurs, caused by the raising action of the associated lever components. This latter action results in the movement of the top of the door in approximately an arc of a circle of relatively small radius as compared with the arc of the radius for the first 20° of rotation.

The second arc described by the top of the door is described during the rising phase of the door which occurs during the 60° of rotation following the initial 20° . This second arc continues, although somewhat flattened, for the final 10° of rotation as the top of the door 16 is dropping. The movement described above occurs as the door is moved from its closed condition of Figure 1 to its open condition of Figure 3.

The movement of the nut 32 during the above described opening of the door is essentially horizontal and along the axis of the lead screw 24. For this reason, the linkage 92 is bent in a manner to resolve the transverse movement imparted by the nut into vector components which are in the proper directions to pull the top of the door tangentially to the circular arcs described by the top. Such tangential application of the force is necessary to produce the required vertical rotation of the door by the linkage 92 at the intersecting point of the two arcs.

The linkage 92 is also constructed with a configuration to provide the necessary lift required to raise the top of the door 16 when the door is being pushed down from an up position. The latter situation occurs when it is desired to close the door by the reversed rotation of the lead screw 24 and by the reversed travel of the nut 32.

The linkage 92 does not require a precisely designed configuration when operating doors of the "roll-up" or "horizontal track" type. However, the linkage 92 with a configuration proper for the operation of the swing-up doors can also conveniently be used to operate these latter types, and other types, of doors. Forces required to be coupled through the linkage 92 to the top of the door 16 vary over a wide range. These forces are a maximum at the limiting positions of door travel in the open and closed positions. During door rotational motion from the open to the closed position, or from the closed to the open position, these forces may vary, for example, between 0 and 30 pounds.

An increase in the optional force at the top of the door 16 is created in the event that an obstruction is met by the bottom of the door. Due to the geometry of the lever mechanism associated with the swing-up type of door, a small force at the bottom of the door opposing door movement results in a large force at the top of the door.

The force required at the top of the door to produce rotational movement of the door is, therefore, increased as a result of the obstruction referred to in the preceding paragraph. This increase in force requirements is translated through the linkage 92 to the nut 32 in an opposite direction to the axial movement of the nut 32. This reduces the axial movement of the nut 32 on the lead screw 24 which causes the lead screw to displace the driven shaft 22 axially, the displacement force to the driven shaft being transmitted through the coupling 26.

This movement of the rotating lead screw 24 with respect

to the nut 32 is produced when resistance to movement of the nut is introduced from the door to the nut through the linkage 92. This increased resistance causes the nut 32 virtually to stop. The continued rotation of the lead screw then carries the lead screw through the nut, axially to move the lead screw so as to produce the above described displacement to the driven shaft 22.

The action described in the preceding paragraphs causes the lead screw 24 to move axially against the tension of the springs 88 or 90 in the housing 10 in one direction or the other. The arrangement is such that when an increased door load condition is met during the opening of the door, the driven shaft 22 moves to the left in Figures 4 and 5, and when the garage door load increases while it is being closed, the increased force requirement causes the driven shaft 22 to move to the right in Figures 4 and 5.

As shown in Figure 4, for example, a pair of switches 100 and 102 are mounted inside the housing 10 on one side of the pulley 70, and a switch 104 is mounted inside the housing 10 on the other side of the pulley 70. These switches may be of the type commonly designated "micro-switches." Each of the switches has an actuating arm, which are designated respectively as 106, 108 and 109; and each arm has a roller at its outer extremity, the rollers being designated respectively as 111, 113 and 115. When the driven shaft 22 is moved to the right in Figures 4 and 5, by the garage door load condition increasing as it is being closed, such movement causes the pulley 70 to engage the roller 111 which, in turn, causes the actuating arm 106 to move down and actuate the switch 100. In like manner, movement of the driven shaft 22 to the left in Figure 4, due to an increased load condition on the door as it is being opened, causes the pulley 70 to engage the roller 115 of the actuating arm 109 so as to actuate the switch 104.

The switches 100 and 104 are connected into a relay circuit which interrupts the current applied to the motor 12, and reverses the direction of motor rotation. The relay circuit is to be described in conjunction with Figure 8. By means of the relay circuit, the motor 12 is driven until an obstruction is encountered by the door, or until the door reaches its limiting up position or its limiting down position. For any of the latter conditions, the motor 12 is stopped, as is the up or down movement of the door. Then when the motor is next energized, the motor rotation is reversed which causes the door to move in the opposite direction to the direction it was moving when the obstruction or limiting position was reached.

A third microswitch 102 is mounted on the same side of the housing 10 as the down direction load sensing microswitch 100. The purpose of the switch 102 is to protect the door operating mechanism of the invention, preserve the safety stop feature of the mechanism, and to indicate malfunction in the event of a failure in the relay circuit.

During normal running conditions, the microswitch 102 is not operated because of its position in the housing 10. By placement and adjustment, the microswitch 102 is located in a manner which causes its roller 113 to be behind the plane of the roller 111 of the "down" sensing microswitch 100. Consequently, under normal operation, the pulley 70 engages the roller 111 of the actuating arm 106 to actuate the switch 100 and stop the motor 12, before the pulley 70 is shifted by the lead screw 24 to a position in which it can engage the roller 113 of the switch 102.

Actuation of the switch 102 causes a switching action to occur in the relay circuit of Figure 8, as will be described in conjunction with Figure 8, and this switching action de-energizes the motor 12 regardless of all other conditions of the relay circuit. Actuation of the switch 102 in the door downward limiting position renders all switching circuits ineffective to initiate powered door movement until the lead screw 24 is rotated manually.

This assures that the mechanism will be held in an ineffective condition until an acknowledgement of the fault has been made and the fault has been corrected.

The coupling between the lead screw 24 and the nut 32 is such that although rotation of the lead screw causes the nut to move rectilinearly with respect to the lead screw, the nut itself is incapable of producing rotation of the lead screw. Therefore, whenever the motor 12 is de-energized, and regardless of the position of the nut 32 on the lead screw, such de-energizing of the motor causes the lead screw to be immediately stopped and locked at that position. This precludes any possibility of the garage door falling to a closed position, should the operating mechanism be de-energized while the door is partially or fully opened.

Locking of the nut 32 on the lead screw 24, with forces exerted at the bottom of the door being ineffective in causing rotation of the lead screw also provides an important feature of the invention. That feature is the locking of the door securely against unauthorized entry to the garage when the door is in the down position. A manually operated, locked disconnect, to be described in conjunction with Figure 7 is the only means of circumventing this locking action, apart from energizing the motor 12 through the control circuit.

Further details of the linkage 92 and the way in which it is pivotally mounted to the nut of the operating mechanism and to the top of the garage door 16 is shown in Figure 6. As shown in that figure, the linkage has a pair of sections which are disposed at an angle to one another. These sections may, for example, be 11.25 inches and 10.50 inches long respectively, with the longer section being coupled to the nut assembly. Also, the angle between the sections may be of the order of 50-56 degrees. A slightly modified nut means is illustrated in the showing of Figure 6, this nut means using a pair of ball nuts 32a and 32b mounted in back-to-back relationship and threaded into a threaded annular yoke 110. These ball nuts may be of a usual known type. The ball nuts use, for example, alternate balls of nylon and steel, each having a diameter of $\frac{5}{32}$ of an inch.

The threaded annular yoke 110 may be an aluminum casting, and it includes a clevis fitting 112 extending downwardly from its main body portion. The brackets of this clevis fitting are spaced in parallel relationship, and they are adapted to receive the end of the linkage 92. Nylon isolation bushings may be inserted in holes located in each bracket of the clevis fitting 112, and a suitable bolt 113 may extend through the brackets through the bushings and through the upper end of the linkage 92 to pivotally support the linkage in the yoke 110. As in the previous embodiment, rotation of the lead screw 24 causes the nut means 32a, 32b and the yoke 110 freely to move in a reciprocal manner with respect to the lead screw. However, any linear force on the yoke 110 is incapable of moving the nut means along the lead screw, or of rotating the lead screw 24, when the drive motor is de-energized.

The other end of the linkage 92 is pivotally mounted in a bracket 114 (Figures 6 and 7) which is supported on the top of the garage door 16 as an integral part of the disconnect mechanism referred to above. The bracket 114 includes a pair of spaced parallel flanges 116 and 118, and the lower end of the linkage 92 extends through these flanges to be pivotally supported on a pin 120. The pin 120 extends through the flanges 116 and 118, and through the end of the linkage 92. The pin is in the form of an eye-bolt, and it is extractable from the flange 118. A spring 122 is secured to a cable 124 and to the flange 118, the cable being fastened to the eye of the pin 120. The spring serves to resiliently hold the pin 120 in place so that the lower end of the linkage 92 may be pivotally connected to the bracket 114.

The cable 124 extends over a pulley 126 which may be mounted on a suitable mount 128 which, in turn, is

supported on the base of the disconnect mechanism. The pulley 126 is rotatably mounted on the mount 128 by a pin 130, and the cable extends down through a hole in the base of the disconnect mechanism and down the inner side of the garage door 16. It is apparent, that whenever a sufficient tension is placed on the cable 124 to overcome the tension of the spring 122, that the pin 120 is withdrawn from the flange 118 so that the linkage 92 is disengaged, and the door 16 may be manually opened. This serves as a convenient means for disconnecting the mechanism from the garage door in the event of a power failure or malfunction so that access to the motor vehicle will not be obstructed. The lower end of the cable 124 is secured to a usual type of center lock overhead garage door handle assembly 125. The lock handle assembly 125 is key-operated from the outside of the door, and upon the operation of the lock by the proper key, sufficient tension is exerted on the cable 124 by manually rotating the exterior handle of the assembly 125 to withdraw the pin 120 and to free the door from the door operating mechanism.

When the door 16 is in the down position, the end of the linkage 92 is caused to engage a jamb plate 119 which is mounted on the header 14. The purpose of this arrangement is to facilitate the disengagement of the linkage 92 from the disconnect mechanism.

The jamb plate offers a resistance to the force exerted by the spring 90 through the driven shaft 22, the lead screw 24 and the linkage 92 when the spring 90 is compressed when the door is in the downward limiting position. The downward limiting position is in fact determined by the contact of the pointed end of the linkage 92 and the header jamb plate 119. This contact of the linkage 92 with the plate 119 relieves the pin 120 from receiving the jamming force created by the compression of the spring 90. This permits sufficient looseness of the pin 120 to enable it to be withdrawn with relative ease through the linkage 92 and from the flange 118.

In addition, the jamming of the linkage 92 into the jamb plate 119 holds the linkage in a constrained position independent of the door. This allows the door to be operated manually without interference by the linkage 92. This arrangement also facilitates manual door operation by maintaining a fixed alignment between the linkage 92 and the disconnect assembly when the door is down to facilitate the insertion of the pin 120 when powered operation is desired.

Suitable electrical circuitry for operating the door operating mechanism described is shown in Figure 8. This circuitry includes a pair of input terminals 200 which are adapted to be connected to a relay included in an electronic remote control unit 202, and which operates in response to the proper radiated signal from a device included in the motor vehicle. Suitable electronic equipment is known which will respond to the radiated signal from the motor vehicle to close a pair of relay contacts in the unit 202, and it is believed unnecessary to describe such a mechanism in detail in the present specification, since such mechanism forms no part of the present invention. The terminals 200 are connected to a pair of leads 204 which are also connected to a pair of input terminals 206. The latter input terminals connect with usual push-button switches, such as the switches 208 and 210. One of these switches may be positioned in the house to permit the garage door to be automatically opened, for example, from inside the house. The other may be positioned in the garage to permit a similar control of the opening and closing of the door to be carried out inside the garage.

The unit also includes a pair of input terminals 212 which are adapted to be connected to the usual 115 volt 60 cycle power line available for domestic use. An earth ground is provided by connection from the housing 52 and 10 frames to the electrical conduit.

The input terminals 212 are connected to the primary

of a transformer 214 through a fuse 222. The secondary of the transformer is connected to a common lead 205 and to one of the leads 204. This lead is also connected to a terminal designated 5 on a connecting block 216. The other one of the leads 204 is connected through a 22 ohm resistor 207 to a normally open fixed contact A of a relay 218. The contact A has an armature B associated with it, and this armature is connected to a terminal 6 on the connector 216. The relay 218 is the primary control relay, and it also has a second normally open fixed contact C. This second fixed contact is connected to a terminal designated 1 on the connector 216. One terminal of the primary of the transformer 214 is connected to the armature D of the relay 218 associated with the normally open contact C. The other terminal of the primary of the transformer 214 is connected to an armature F of a motor reversing relay 220, and this latter terminal is also connected to the illuminating lamp 54 (referred to previously) and to a terminal 2 of the connector 216.

The connector 216 has a terminal 10 which connects with one side of the energizing winding of the relay 218, the other side of this winding being connected to the common lead 205. The connector 216 also has a terminal 9 which is connected to the switched side of the leads 204. The connector has a terminal 8 which is connected to an armature B associated with a normally open contact A of the motor reversing relay 220. This latter contact A is connected to a terminal 7 of the connector 216 and to one side of the energizing winding of the relay 220.

The lamp 54 is connected to a normally open contact C of the relay 220, and the armature D associated with that contact is connected to the armature D of the relay 218. The connector 216 has a terminal 4 which is connected to a normally open contact E of the relay 220 and to a normally closed contact J of that relay. The connector 216 has a terminal 3 which is connected to a normally closed contact G and to a normally open contact H of the relay 220. The relay 220 has an armature F associated with the contacts E and G and which is connected to the other terminal of the primary of the transformer 214, as mentioned above. The relay 220 also has an armature I which is associated with the contacts J and H, and this latter armature is connected to the terminal 1 of the connector 216. The connector 216 serves to connect the housing 52 of Figures 1 and 3 with the actuator housing 10 in those figures. The terminals 1 and 2 of connector 216 connect with the running winding of the motor 12, and the terminals 3 and 4 connect with the starting winding of the motor.

The terminal 5 of the connector strip 216 connects with the armature of the microswitch 100, and this armature is normally closed with a fixed contact which, in turn, is connected to the terminal 8 of the connector. The terminal 6 of the connector strip is connected to a normally closed contact of the microswitch 104, and the armature of microswitch 104 is also connected to the terminal 8 of the connector strip 216. The microswitch 104 also has a normally open contact which is connected to the terminal 7 of the connector strip 216. The terminal 9 of the connector strip 216 is connected to the armature of the microswitch 102, and switch 102 has a normally closed contact which is connected to the terminal 10.

It will be observed as the description proceeds, that the microswitches 100 and 104 are used not only to sense an obstruction in the path of the door as it is opened and closed, but also to serve as reversing switches when the door reaches its fully opened condition or its fully closed condition. Under the latter circumstances, when the door reaches either one of its limiting conditions, the actuation of the microswitches 100 or 104 conditions the circuitry so that the next time it is operated, it will actuate the door for movement in an opposite direction from the previous actuation.

Assume now that garage door is closed. When the

door is in its closed position, the switch 100 will be actuated open and the switch 104 will be in its illustrated position with its armature engaging the upper fixed contact. Now, under these conditions, the motor reversing relay 220 is not energized because the armature of the microswitch 104 does not contact the lower contact. The relay 218 also is not energized because an energizing circuit to its coil has not been made.

Assume now that a signal is received to operate the relay 202, or that either the push-button 208 or 210 has been operated, also assume that the over-ride microswitch 102 is closed. When such switches or relays are operated, an energizing circuit to the relay 218 is completed from the secondary of the transformer 214 so that the primary control relay 218 is energized. A holding circuit for the relay is established through its contacts B and A, through the resistor 207, and through the normally closed contact of the microswitch 104. The contacts D and C of the relay 218 now close so that terminal 1 of the connector 216 is connected to one side of the primary of the transformer 214 and terminal 2 of the connector strip is connected to the other side to energize the running winding of the motor 12. This also connects the terminal 4 of the connector strip 216 to the same side of the primary as the terminal 1 of the connector, and the terminal 3 of the connector is connected to the other side of the primary. These connections supply electrical current to the motor 12 in a manner to cause the motor to turn in a direction so that the garage door may be opened.

It will be noted that the relay 220 does not switch currents to the motor, since it is previously established in its de-energized condition before the control relay 218 is energized. This also applies on the reverse operation where the relay 220 is energized after current is removed from the motor by action of the relay 218, which is caused to be faster than the pull in of relay 220 by resistor 207.

Assume that the door starts its upward movement under the control of the operating mechanism described previously. The switch 100 now closes with its upper contact to provide an auxiliary energizing circuit to the coil of the relay 218 through its hold contacts B and A and through the upper fixed contact of the microswitch 104. This permits the door to continue its upward motion, even after the contacts of the relay 202 have been opened, or after the push-buttons 208 or 210 have been released. Assume now that the door meets with an obstruction on its upward motion. Such an obstruction causes the sequence of mechanical operations described previously, which move the armature of the switch 104 from its top contact to its lower contact in Figure 8. This immediately breaks the energizing current to the relay 218 and the door stops. The door is held stopped with the armature of the switch 104 engaging its lower contact so that the motor reversing relay 220 is now energized. The next time that the push-buttons 208 or 210, or the relay 202 is closed, the action is reversed with relay 220 latched in an energized position until unlatched by opening of the holding circuit through switch 100 when the door meets an obstruction or the downward limiting position.

The microswitch 104 also can be used when the obstruction met by the door is the stop which is intended to limit its upward motion. Such a limit to the upward motion of the door causes the switch 104 to be actuated so that the door mechanism is in a condition to close the door the next time the relay contacts 202 are closed, or the next time the push-button switches 208 or 210 are actuated. The lamp 54 is also illuminated by energization of the relay 220.

In like manner, when the door reaches its lowermost position, or meets an obstruction on the way down, the switch 100 opens to immediately de-energize the control relay 218 and to reverse the condition of the reversing relay 220 at a discrete time displacement. This latter

microswitch also serves not only as a safety feature in the event that an obstruction is met, but also serves as a limiting switch for when the door is fully closed.

It should be again noted that whenever the mechanism is de-energized, the door is positively locked at whatever position it is in when the de-activation of the mechanism occurs. The lead screw 24 provides a positive lock against any movement of the door until the lead screw again is rotated. This, as mentioned above, not only provides a safety feature in which the door is immediately stopped upon meeting an object, but also provides a burglar-proof arrangement by which the door cannot be opened when it is in a closed condition.

Upon failure of the equipment to operate on the down position when an obstruction is met which should normally open the switch 100, the over-ride switch 102 then operates, as discussed above, and this opens the circuit to the primary control relay 218. The circuit cannot be closed until a manual means is resorted to to move the door away from the jammed condition so that normal operation can be restored. This provides a safety feature, as explained, in which the mechanism of the door is held in a condition in which it cannot be operated until appropriate steps are taken to remove the fault and again to restore normal operation of the door.

The invention provides, therefore, a new and improved door operating mechanism which is relatively inexpensive in that it utilizes a minimum of component parts. Of paramount importance is the fact that the door operating mechanism of the invention is completely safe and includes positive means for immediately stopping the operation of the door should any object be encountered in the path of the door as it is being opened or closed. Also, the embodiment of the invention described above includes an over-riding feature which serves immediately to de-activate the equipment upon a fault occurring in the control system. The mechanism of the invention is also advantageous in that the major portion of the weight is concentrated in the actuator housing which may be conveniently mounted on the header of the garage door so as to preclude the necessity for any additional bracing in the garage.

We claim:

1. An opening and closing mechanism for a garage door, and the like, the door being disposed in a vertical plane when closed and supported to be moved upwardly to a horizontal plane when opened, the mechanism including: a hanger assembly adapted to be mounted in a position displaced rearwardly from the plane of the door in its closed position and disposed substantially in the plane of the door in its open position, a housing adapted to be mounted in the plane of the door in its closed position and over the door, a drive motor supported on the housing and including a drive shaft, a driven shaft rotatably supported on the housing for limited axial movement and disposed in spaced parallel relationship with said drive shaft, an externally threaded elongated drive screw rotatably mounted at one end in said hanger assembly for limited axial movement with respect thereto, a resilient member for coupling the driven shaft to the other end of the drive screw to enable rotational motion to be imparted to the drive screw through the driven shaft, the drive screw being supported by the hanger assembly and by the resilient coupling member in a position extending essentially perpendicular to the plane of the door in its closed position and in essentially axial alignment with the driven shaft, a first pulley mounted in the housing on the drive shaft, a second pulley mounted in the housing on the driven shaft, a belt drive member in the housing intercoupling the first and second pulleys for imparting rotational motion from the motor to the drive screw, a pair of compression coil springs positioned in the housing in coaxial relationship with the driven shaft on opposite sides of the second pulley, electric switching means adapted to be actuated upon axial move-

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ment of the driven shaft against the compression of at least one of said coil springs, a threaded yoke member mounted on the drive screw in threaded relationship therewith for axial movement with respect to the drive screw upon rotation of the drive screw, and a linkage arm having one of its ends pivotally fastened to the yoke member and having its other end adapted to be pivotally fastened to the top of the door to control the opening and closing of the door upon the axial movement of the yoke member and any obstruction to the movement of the door producing axial movement of the lead screw and of the driven shaft coupled thereto against the compression of one or the other of said coil springs to actuate said electric switching means.

2. The combination defined in claim 1 in which said linkage arm has a particular V-shaped configuration to cause the forces exerted by the linkage on the door in the opening of the door to be essentially tangential to the arcs described by the top of the door during such opening.

3. The combination defined in claim 1 and which includes a pair of bearings mounted on the housing to support the driven shaft, a first pair of thrust bushings mounted on opposite sides of the second pulley in coaxial relationship with the driven shaft, a second pair of thrust bushings mounted on respective ones of the bearings in coaxial relationship with the driven shaft and spaced from corresponding ones of the bushings of the first pair, said bushings serving as a support for said coil springs and providing bearing surfaces for the springs and said bushings further serving to limit the axial movement of said driven shaft with respect to the housing.

4. The combination defined in claim 1 in which said switching means includes a first electric switch and a second electric switch mounted on the housing, said first

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switch having an actuating arm positioned to be operated by said second pulley upon the axial movement of the driven shaft in a first direction with respect to the housing, and the second switch having an actuating arm positioned to be operated by said second pulley upon the axial movement of the driven shaft in a second direction with respect to the housing.

5. The combination defined in claim 1 in which said switching means includes a first electric switch and a second electric switch mounted on the housing, said first switch having an actuating arm positioned to be operated by said second pulley upon the axial movement of the driven shaft in a first direction with respect to the housing to a particular position due to the door meeting an obstruction during its closing operation, said second switch having an actuating arm positioned to be operated by said second pulley upon the axial movement of the driven shaft in the opposite direction with respect to the housing and due to the door meeting an obstruction during its opening operation, and switching means including a third electric switch mounted on the housing and having an actuating arm adapted to be operated by said pulley upon the axial movement of said driven shaft in said first direction beyond said particular position.

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