Dec. 21, 1965 R. D. HOUK 3,224,493

DOOR AND CONTROL SYSTEM THEREFOR

Filed April 30, 1962 4 Sheets-Sheet 1

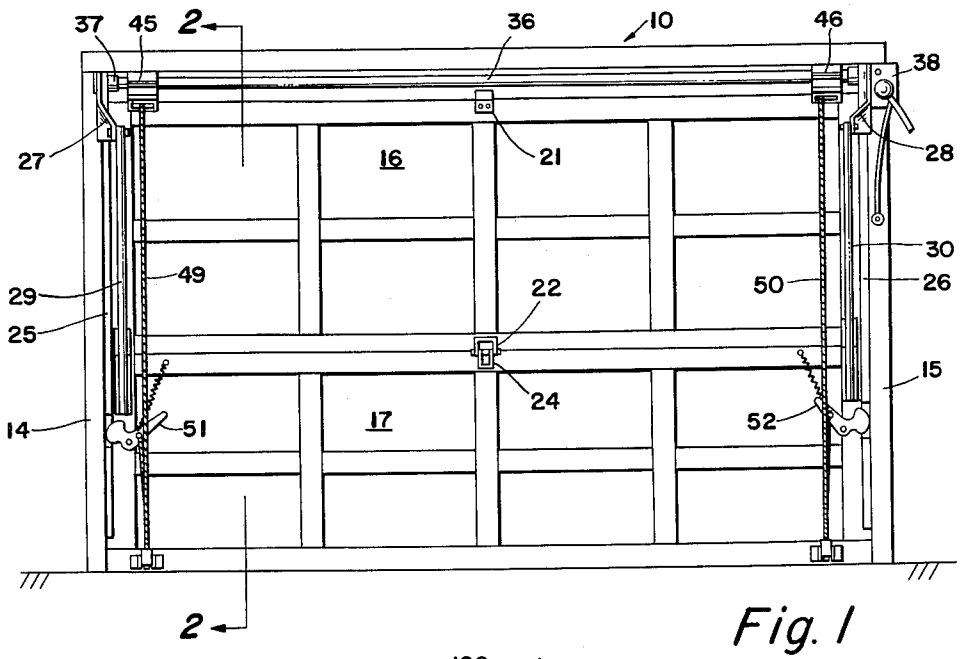


Fig. 1

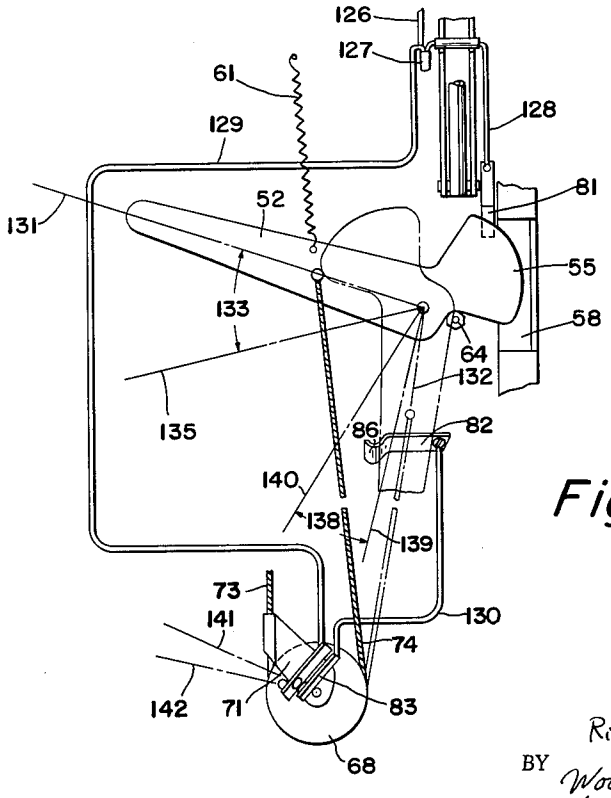


Fig. 7

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DOOR AND CONTROL SYSTEM THEREFOR

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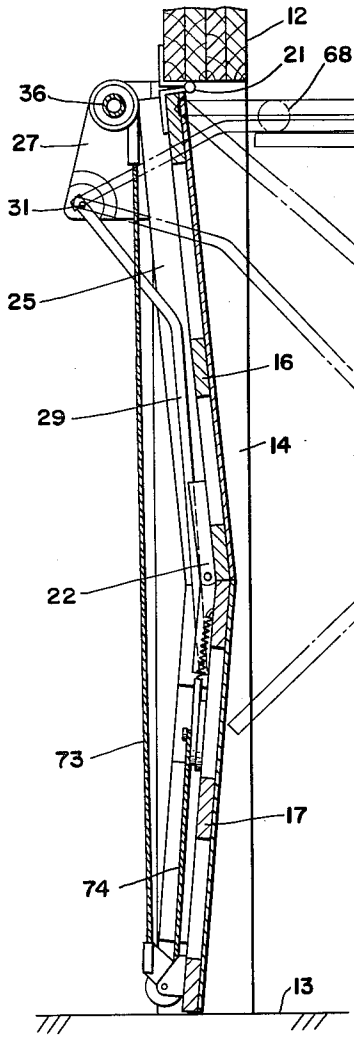


Fig. 2

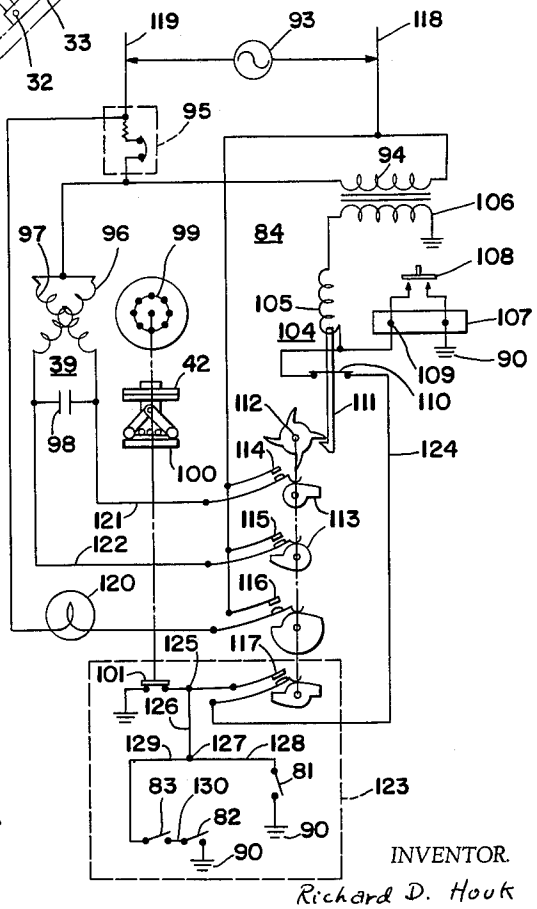


Fig. 6

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DOOR AND CONTROL SYSTEM THEREFOR

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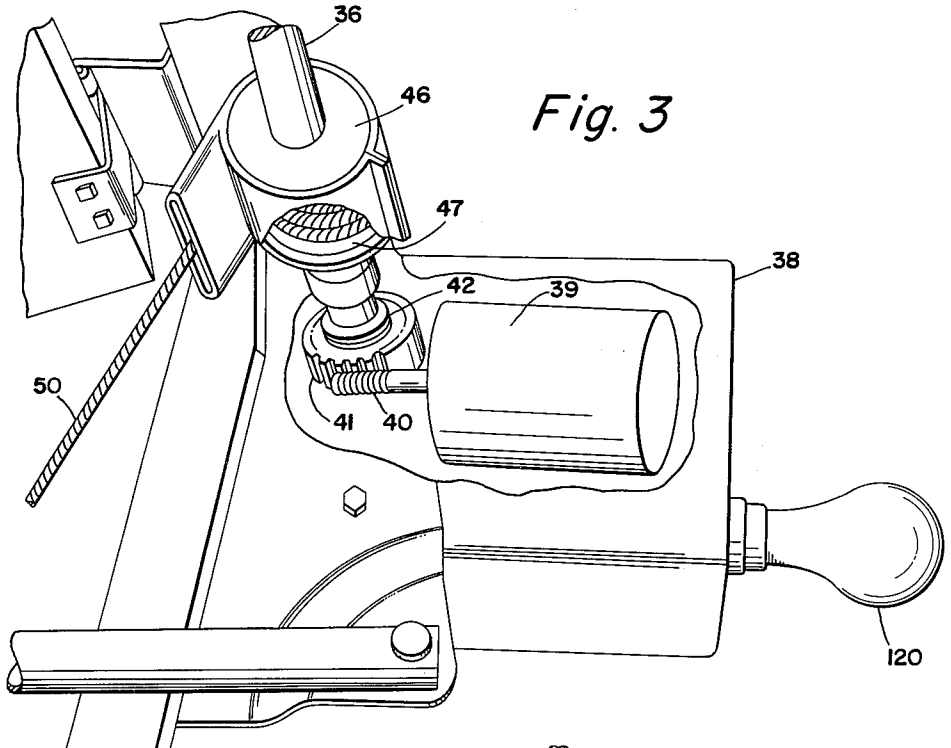


Fig. 3

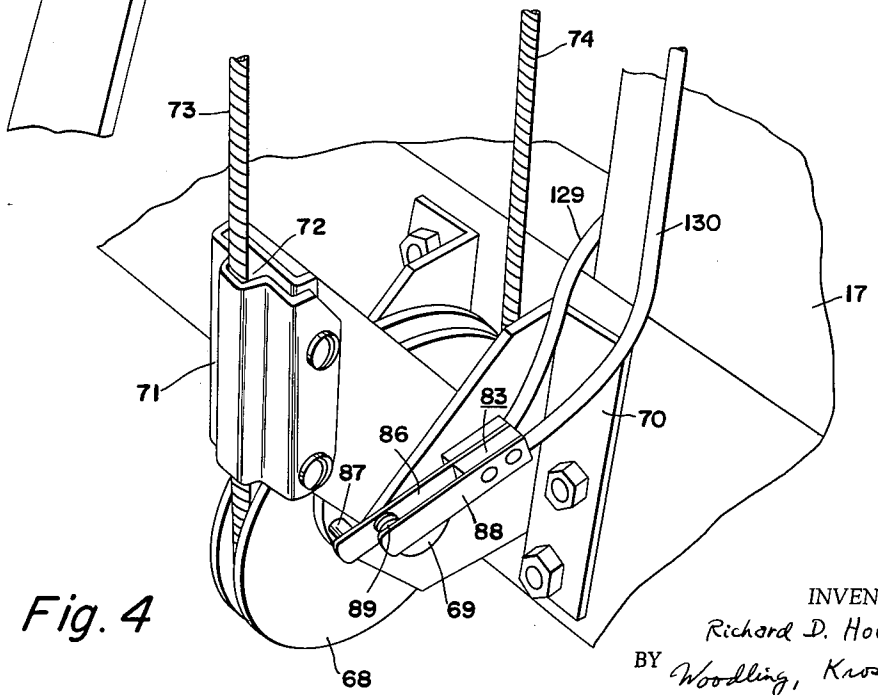


Fig. 4

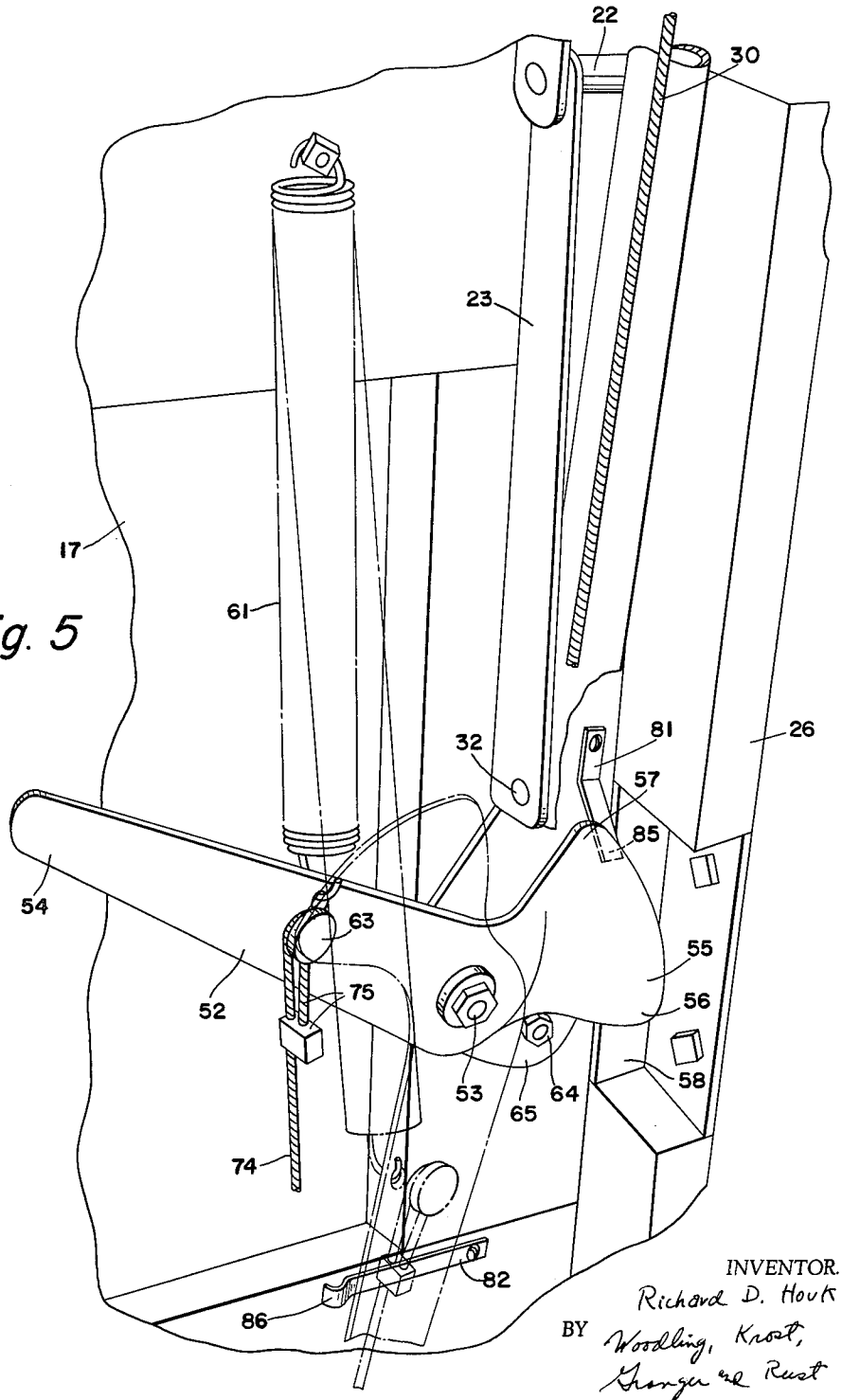
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Fig. 5



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3,224,493

DOOR AND CONTROL SYSTEM THEREFOR

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Filed Apr. 30, 1962, Ser. No. 190,877
12 Claims. (Cl. 160—189)

The invention relates in general to doors having control systems and more particularly, to an upward acting door such as a garage door with a motor connected to move the door in an upward direction, plus a control system to control the actuation of the motor and thus control the operation of the door.

Doors such as garage doors have been devised with upward opening movements and where these doors are moved by an electric motor or other power means, suitable controls for the power means are desirable. In upward acting garage doors it is necessary to at least start and stop the motor, with starting being under control of a person and the stopping at least being effected when the door reaches the fully open or the fully closed position. Many garage door operators have not had satisfactory safety controls to control the movement of the door should the door meet an obstruction to movement and various other control systems have failed to provide a safe operation for doors.

Accordingly, an object of the present invention is to provide a safe door control system.

Another object of the invention is to provide a door and control system therefor in which a simple and reliable control circuit is achieved constantly under control by a person.

Another object of the present invention is to provide an upward acting door with a door control system wherein the door may be stopped by any of three different means in the downward closing direction.

Another object of the invention is to provide two different limit switches actuable by linkage of an upward acting door with one limit switch overriding the control effected by the second limit switch.

Another object of the invention is to provide an upward acting door with a control system controlled by movement of a latch latching the door.

Another object of the invention is to provide an upward acting door with a control system wherein three limit switches are used, two actuated by a latch mechanism and a third limit switch capable of overriding the control of the second limit switch.

Another object of the invention is to provide a control system for a door moved by a flexible cable with control effected by the position of a cable sheave guard on a sheave around which the cable passes.

Another object of the invention is to provide a door control system with a limit switch controlled by position of a latch and capable of being overridden by a second limit switch controlled by position of the door.

Another object of the invention is to provide a control system for a door pulled open by a flexible cable wherein the control system is sensitive to tension on the cable.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is an inside elevational view of a door embodying the invention;

FIGURE 2 is an enlarged sectional view on line 2—2 of FIGURE 1;

FIGURE 3 is a perspective view of the motor and operator in the upper right corner of FIGURE 1;

FIGURE 4 is a perspective view of the cable sheave in the lower right corner of FIGURE 1;

FIGURE 5 is a perspective view of the cable latch and switch construction in the right center of FIGURE 1;

FIGURE 6 is a schematic electrical diagram of the control system; and,

FIGURE 7 is a diagrammatic illustration of the latch lever and limit switches.

The invention relates generally to a door **10** which in this embodiment has been illustrated as a garage door. The door **10** is used in connection with a door frame having a header **12**, a lower wall or floor **13**, and side jamb members **14** and **15**. The door **10** includes generally an upper panel **16** and a lower panel **17**. The upper panel **16** is swingably mounted relative to the door frame as by a first hinge means **21**. Second hinge means **22** hinges together the upper and lower panels **16** and **17**. The first hinge means **21** hinges the upper part of the upper panel **16** to the header **12** and the second hinge means **22** hinges the upper part of the lower panel to the lower part of the upper panel **16**. The second hinge means **22** includes side hinges **23** and where the door is wide, one or more intermediate hinges **24**. Door stops **25** and **26** are mounted on the side jambs **14** and **15**, respectively, and maintain the door panels **16** and **17** in a slightly outwardly bent position to break the toggle effectively established by the first and second hinge means **21** and **22** and the upper and lower panels **16** and **17**. First and second jamb brackets **27** and **28**, respectively, are mounted at the top of the respective side jambs **14** and **15** up against the bottom of the header **12**. The jamb brackets carry first and second control arms **29** and **30**, respectively. First and second pivot means **31** and **32**, respectively, are used on each control arm. The first pivot means **31** pivotally connects one end of each control arm to the respective jamb bracket. The second pivot means **32** pivotally connects the other end of the respective control arm to the door **10**. As shown, this second pivot means **32** is connected to the lower panel **17**. The second pivot means **32** of the control arms are connected at the side hinges **23** on a lower extension **33** thereof to positively position the distance between the second pivot means **32** and the second hinge means **22**. The jamb brackets are mounted directly against the underside of the header **12** and this positively positions the first pivot means **31** relative to the first hinge means **21**, thus the first hinge means **21** and the first pivot means **31**, plus the control arms **29** and **30** constitute support and control means for movement of the door **10**.

The jamb brackets **27** and **28** support a torque tube or rotatable member **36** for rotation on an axis generally parallel to the first hinge means **21**. A bearing **37** supports one end of the torque tube **36** and a motor actuator **38** supports the other end. The bearing **37** and motor actuator **38** are interchangeable on jamb brackets **27** and **28**. Motor actuator **38** includes an electric motor **39** driving a worm **40** and a worm wheel **41**. The worm wheel drives through a friction clutch **42** to the torque tube **36**. The worm **40** and worm wheel **41** provide irreversible power direction means from the motor to the torque tube **36**.

Depending upon the width of the door **10**, one or more cable drums may be used. The door illustrated uses two such cable drums **45** and **46**. Each cable drum may be fixed to the torque tube **36** and has spiral grooves **47** therein to receive a flexible cable. Flexible cables **49** and **50** are provided for the respective drums **45** and **46**. The motor **39** is thus capable of rotating the torque tube **36** to wind the cables **49** and **50** on the respective cable drums to exert a lifting force to open the door **10**.

First and second cam lock levers or latch levers **51** and **52** are provided on each side of the door **10**. These latch

levers are movable links connected to the door and are positioned near the second hinge means **22** and are shown as being on the lower panel **17**. The levers **51** and **52** are right and left hand but otherwise are identical. FIGURE 5 illustrates the latch lever **52** and it will be understood that the latch lever **51** has a reversed construction. The latch lever **52** is pivoted on a pivot axis **53** fixed relative to the lower panel **17**. The lever **52** has an actuator end **54** and a cam lock portion **55** which is skewed or has about a one inch lead of a leading edge **56** relative to a trailing edge **57** thereof. This cam lock portion **55** cooperates with a latch plate **58** fixed on the side jamb **15**. The approximately one inch lead of the leading edge **56** provides a camming action to positively bring the door closed against the door stops **25** and **26**.

A return spring **61** is a tension spring having one end fixed to the lower panel **17** and the other end fixed at a point **63** on the latch lever **52**. This return spring urges the latch lever **52** to a first limit position relative to the door panel **17** as established by a stop **64**. This stop **64** may be provided by a bolt or lag screw fastening a plate **65** to the lower panel **17**. This plate **65** is an extension of the side hinge **23** and also mounts the pivot **53** for the latch lever **52**.

A cable sheave **68** is journalled on an axle **69** carried in a bracket **70** fixed near the bottom of the lower panel **17**. A cable sheave guard **71** is also pivoted on the axle **69** and has an opening **72** through which the respective cable passes. Each flexible cable has first and second runs **73** and **74**, respectively, and the first run of cable **73** extends downwardly from the respective cable drum through the cable sheave guard **71** and around the respective sheave **68**. The second run of cable **74** extends upwardly from the respective sheave **68** to the respective latch lever **51** or **52**. This second run of cable is fixed to the latch lever in a convenient manner as by wrapping around the pivot **63** and being fixed by a cable clamp **75**.

A second limit position is provided for the latch lever **52** and this is with the latch lever moved through an arc of about 100 degrees by pull on the cable which pulls downwardly on the second run **74** against the urge of the return spring **61**. This second limit position of tthe lever **52** is thus determined by alignment of the pivot **53**, the pivot **63** and the second run **74** going to the sheave **68**. The cam lock portion **55** is positioned so that the first portion of about 30 or 40 degrees of the approximately 100 degree arc of movement of the lever **52** is that which unlocks or unlatches the door **10** and then as the cables are wound on the cable drums and become taut, the latch levers **51** and **52** swing to their downward or second limit position and then a lifting force is exerted on the lower panel. This lifting force is exerted essentially at the lower edge of this lower panel **17** and the control arms together with the first hinge means **21** and the first pivot means **31** establish controlled quadrilateral movement of the door panels **16** and **17**. During this door opening movement, the upper panel **16** swings upwardly and outwardly to a generally horizontal position and the lower panel **17** swings approximately 180 degrees relative to the upper panel **16** to fold and collapse upwardly substantially against the upper panel **16**.

First, second and third limit switches **81**, **82** and **83** are provided in a control circuit **84**. The first limit switch **81** is a leaf spring insulatively mounted on the lower panel **17** outboard of the side hinge **23**. The outer tip **85** of this leaf spring blade is adapted to be contacted by the inner face of the cam lock portion **55** of the latch lever **52**. This first limit switch **81** is closed in the first limit position shown in full lines in FIGURE 5. The control circuit **84** is a grounded or single conductor system and, hence, the electrical contact is made between the leaf spring blade **81** and the cam lock portion **55** which is grounded through the plate **65** and control arm **30** and jamb bracket **28** to the case of the motor actuator **38**.

The second limit switch **82** has another leaf spring blade insulatedly mounted on the lower panel **17**. This blade has an outer end **86** which is adapted to be engaged by the under face of the latch lever **52** as it swings near the second limit position. This second limit switch is also a normally open switch and is actuated closed by contact with the latch lever **52** in a range of about 10 to about 40 degrees spaced from the second limit position of the latch lever **52**.

The third limit switch **83** is insulatedly mounted on the bracket **70** of the cable sheave **68**. This third limit switch **83** has a spring blade **86** carrying an insulated projection **87** adapted for actuation by movement of the cable sheave guard **71**. The third limit switch **83** also includes a second leaf spring **88** carrying a contact **89** adapted to be electrically closed relative to the spring blade **86** when the cable sheave guard **71** actuates the projection **87**. In the position of the cable sheave guard **71**, shown in FIGURE 4, the third limit switch **83** is not actuated closed and is a normally open switch. Upon pivotal movement of the cable sheave guard **71**, about 5 or 10 degrees in the counter-clockwise direction, however, the third limit switch **83** is actuated closed. This will be with the first and second cable runs **73** and **74** diverging about 5 or 10 degrees. This third limit switch **83** remains closed for all further counter-clockwise movements of the cable sheave guard **71**.

The control circuit **84** is energized from a suitable voltage source such as an alternating voltage source **93**. A control transformer **94** is energized through an overload protector **95**. The electric motor **39** is also energized through this overload protector **95** and has first and second windings **96** and **97**, respectively. This motor is a reversible capacitor induction motor having a capacitor **98**. The motor **39** has a rotor **99** which drives through the friction clutch **42** to a centrifugal mechanism **100**. A torque switch **101** is driven from the centrifugal mechanism **100** to be opened upon acceleration of the motor to about one-half speed.

The control circuit **84** also includes a ratchet relay **104** having a relay coil **105** energizable from a secondary **106** of the control transformer **94**. One end of the secondary **106** is grounded for a grounded or single conductor control system and the other end of the relay coil **105** is connected to a terminal **109** on a terminal board **107**. A push button switch **108** is connected across the terminals of the terminal board **107** to ground **90** to establish energization of the relay coil **105**. This push button switch may be a manual switch such as an ordinary door bell push button operating on the low voltage secondary **106**, for example 24 volts. Also, this push button switch **108** may be representative of a radio controlled switch closed by actuation of a radio transmitter in an automobile for remote operation of the door **10**.

A relay armature position switch **110** is a normally closed switch connected to be actuated to the open position by energization of the relay coil **105** and, hence, actuation of the relay armature. The relay armature **111** actuates a ratchet **112** to rotate a plurality of cams **113** and, accordingly, actuate a series of relay contacts **114** to **117**, inclusive, in a predetermined sequence. The relay contacts **114** to **117** are normally open contacts and are shown in the open position in FIGURE 6 which corresponds to the door closed position of the door **10**. Conductor **118** of the voltage source **93** is connected to each of the contacts **114** to **116**. Conductor **119** of the voltage source **93** is connected through a lamp **120** to the contacts **116**. This lamp **120** may be mounted on the motor actuator **38** to illuminate the interior of the garage or other structure for which the door **10** is a closure. A conductor **121** connects motor winding **97** to the other side of contacts **114** and the conductor **122** connects the motor winding **96** to the other side of relay contacts **115**.

The relay contacts **114–116** are power contacts to control energization to the motor **39** and lamp **120** and relay contacts **117** are control contacts forming part of a con-

trol circuit **123**. A conductor **124** is connected from the relay armature position switch **110** through the relay contacts **117** to a terminal **125**. The torque switch **101** is connected between terminal **125** and ground. A conductor **126** leads from terminal **125** to a junction **127** from which a conductor **128** leads to the first limit switch **81**. Another conductor **129** leads from the junction **127** to the third limit switch **83** actuated by the cable sheave guard **71**. A conductor **130** is connected from the other side of this third limit switch **83** to the second limit switch **82**. The other side of the second limit switch **82** is connected to ground **90**.

As viewed in FIGURES 5 and 7, the latch lever **52** has a first limit position **131** as shown in solid lines in FIGURES 5 and 7 and has a second limit position **132** as shown in dotted lines in FIGURES 5 and 7. The first limit position **131** of this latch lever **52** is caused by the urging of the return spring **61** urging this latch lever **52** against the stop **64**. As stated above, the first limit switch **81** is closed with the latch lever **52** at the first limit position **131**. This first limit switch **81** is actuated to a closed position by grounding the leaf blade of this switch against the cam lock portion **55** of the latch lever and this grounding occurs generally through an arc **133**. The arc **133** is a range of actuation of this first limit switch **81** as established by the radial lines **131** and **135**. The radial line **135** is in the order of 40 to 50 degrees from this first limit position **131**.

The second limit switch **82** is also actuated to a closed position by being grounded against the latch lever **52**. The leaf blade **86** contacts the underside of this latch lever **52** through an arc **138**. This arc is defined by radial lines **139** and **140** with the first radial line **139** about 5–10 degrees from the second limit position **132** of the latch lever **52**. The second radial line **140** is about 20 to 30 degrees from the second limit position **132**.

The third limit switch **83** is a normally open switch and is open in the position shown in FIGURES 4 and 7. This switch in FIGURE 7 is shown distorted to a three dimensional view for clarity of action. In FIGURES 2 and 4, it will be noted that the first and second cable runs **73** and **74** are substantially parallel with both substantially vertical. This is the position of the cable runs **73** and **74** with the door closed. This may be considered a first limit position established by the radial line **141** on FIGURE 7. The phantom position **10B** in FIGURE 2 showing the door in full open position shows the position of the cable sheave **68** and it will be noted that the first cable run **73** which extends from the cable drum **36** to the sheave **68** will, at that time, be making an obtuse angle of about 160 degrees relative to the second cable run **74**. Thus, the first cable run **73** swings through an angle of about **160** degrees relative to the second cable run **74** during the door opening movement. Also and necessarily, the cable sheave guard **71** swings through this approximately 160 degree angle. On FIGURE 7, a radial line line **142** illustrates the position at which the third limit switch **83** will be actuated closed and this third limit switch **83** remains closed throughout the remainder of the approximately 160 degree movement in a counterclockwise direction as viewed in FIGURE 7.

Operation

As best shown in FIGURE 2, the door **10** is constructed to swing upwardly and outwardly in the door opening movement. The upper panel **16** swings from a generally vertical to a generally horizontal position and the lower panel **17** also moves from a generally vertical to a generally horizontal position but the second hinge means **22** and control arms **29** and **30** established that the lower panel **17** moves approximately 180 degrees relative to the upper panel **16**. The door **10** is supported substantially entirely in the closed position by the first hinge means **21** and the first pivot means **31**. These two points of support plus the control arms **29** and **30** provide support and control means for the door **10** and support a majority of the weight throughout the entire door opening and door closing movement. Thus, it has been found that a 385 lb. door required only 110 lbs. total pull on the cables **49** and **50** throughout the entire opening movement. Thus, the door **10** requires no counterbalancing means because the motor **39** may easily supply the necessary power to open the door **10** in a normal time of 10–15 seconds. The motor **39** drives the torque tube **36** to wind the cables **49** and **50** on the respective cable drums, thus exerting a generally vertical lifting force on the bottom of the lower panel **17** and this moves the door through the intermediate position **10A** to the open position **10B** shown in phantom in FIGURE 2.

The electrical control circuit **84** controls the door opening and closing movement. When the push button switch **108** is depressed or the radio control switch is actuated across the same terminal board **107**, the relay coil **105** will be energized. FIGURE 6 shows the control circuit **84** in the de-energized position corresponding to the door closed position. Energization of relay coil **105** moves armature **111** to move the ratchet **112** and the cams **113** to the first of four sequential positions. This first position corresponds to a door opening condition and closes contacts **114**, **116** and **117**. Contacts **116** energize the lamp **120** to illuminate the inside of the garage. Contacts **114** are closed to energize motor winding **97** directly and energize motor winding **96** through the capacitor **98** to rotate the rotor **99** in one direction for a door opening movement. The motor **39** drives through the worm **40** and worm wheel **41** to the friction clutch **42** and the torque tube **36**. During initial acceleration of the rotor **99**, the torque switch **101** is opened and latch lever **52** is partially rotated to open limit switch **81**. Accordingly, the torque tube **36** is rotated in a direction to wind the cables on the cable drums and thus exert a lifting force on the door panels **16** and **17**.

The initial movement of the cables pulls upwardly on the first cable run **73** and downwardly on the second cable runs **74**. This swings the latch lever **52** counterclockwise as viewed in FIGURES 5 and 7. This latch lever **52** has a total of about 100 degrees arcuate movement between the first and second limit position **131** and **132** and about the first 30 degrees of movement unlatches the cam lock portion **55** from the latch plate **58**. After about the first 40 or 50 degrees of movement of the latch lever **52**, the first limit switch **81** is opened.

This occurs quickly after energization of the motor **39**, and thereafter push button switch **108** may be released to de-energize the relay coil **105** without other change in the circuit condition. As the latch lever **52** swings about 70 or 80 degrees to the radial line **140**, the second limit switch **82** will be actuated but this does not change the circuit condition because the third limit switch **83** is still open at this time. When the latch lever **52** has swung about another 20 degrees to the radial line **139**, the second limit switch **82** will again become open. As the latch lever **52** reaches the second limit position **132**, the cables are placed under increased tension and begin to lift the door **10**. The return springs **61** may have a force of about 15 lbs. for example, but it has been found that only a slight excess of force, for exampie 20 lbs. force, is necessary on the cables **49** and **50** to commence the door opening movement. At this time, the cam lock portions **55** are fully disengaged from the latch plates **58** so that the door opens gradually without any sudden jumping movement away from the door stops **25** and **26**. As the door starts its opening movement, the cable runs **73** and **74** diverge to a point of divergence of about 5 or 10 degrees, at which point the second radial line **142** is reached to actuate closed the third limit switch **83**. This does not change the circuit condition, however, because the second limit switch **82** is open at this time. The door continues in its opening movement through an intermediate position **10A** to the full open position **10B** shown in phantom in FIGURE 2. It is in the intermediate position **10A** at which the maximum lifting force must be applied to the

cables **49** and **50** and this is about 30–35% of the total weight of the door **10**. This light load means that an ordinary household motor such as ¼ H.P. may easily raise the door **10** without aid from any counterbalance means.

As the door approaches the full open position **10B**, the load on the cables is again reduced to only about 20–25 lbs. force for a door in the order of 400 lbs. This is because the control arms **29** and **30** in effect act as a triangular brace to support the door **10** in the open position and because the second pivot means **32** is approaching a high enough position relative to the first and second hinge means **21** and **22** to almost lock the door in the up position. If the second pivot means **32** is made to lie above the line joining the first and second hinge means **21** and **22**, then it is found that the door **10** will lock up in the full open position **10B**. It is not desired to achieve this locking up condition in this motorized door because it is desired to have the door **10** close by gravity rather than being driven closed by the motor **39**.

When the door **10** reaches the full open position, the lower panel **17** is collapsed up against the upper panel **16** with the control arms **29** and **30** sandwiched therebetween and, thus, the lower panel **17** can go no higher. Accordingly, the torque tube **36** is stalled and the friction clutch **42** slips to deactuate the centrifugal mechanism **100** and close the torque switch **101**. This pulses or energizes the relay coil **105** through the then closed relay contacts **110** and **117**. The relay **104** is ratcheted to the third position which is a door open position. In this door open position, only the relay contacts **116** remain closed to keep the lamp **120** illuminated.

In the door open position, the motor **39** is of course de-energized with a small amount of weight from the door **10** acting through the cable runs **73** to apply a small torque to the torque tube **36**. This torque is resisted by the worm **40** and worm wheel **41** since this is a form of irreversible power direction means preventing transmission of power from the torque tube **36** to the motor **39**. Thus, this irreversible power direction means acts as a brake to hold the door in the open position **10B**.

The door closing movement is initiated by depressing the push button switch **108** or its counterpart radio control switch, not shown. This actuates the relay coil **105** to ratchet the cams **113** to the fourth position which is a door closing condition. This fourth position closes contacts **115**, **116** and **117** with contacts **116** again keeping the lamp **120** illuminated. Closing of the contacts **115** energizes the motor winding **96** directly and motor winding **97** through the capacitor **98** for reverse rotation of the rotor **99**. This is a door closing direction and thus the torque tube **36** is driven in the reverse direction. This does not push the door closed but does pay out the cables **49** and **50** to permit the door to close by gravity. Since the induction motor **39** is essentially a constant speed device, the door closing speed is approximately the same as the opening speed, with the motor **39** acting as a brake. During the door closing movement the door moves from position **10B** through position **10A** to the solid line position shown in FIGURE 2. As the door is almost closed, that is, with the lower panel **17** within about 5–10 degrees from its final closed position, the third limit switch **83** will be de-actuated to an open condition. This does not change the circuit operation since the second limit switch **82** is then also open. As the door is fully closed, the motor continues to pay out the flexible cables and, thus, the return springs **61** urge the latch levers **52** from the second limit position **132** toward the first limit position **131**. During the arc of movement **138**, the second limit switch **82** will be actuated, but this does not change the circuit condition because the third limit switch **83** is then open. At the radial line **135**, the first limit switch **81** is actuated closed and this does energize the relay coil **105** through the then closed relay contacts **117** and **110**. The relay **104** is thus ratcheted to return to the first position which is the door closed condition. In this position, all contacts **114–117** are open and, hence, the motor **39** is de-energized. The coasting of the motor rotor **99** is sufficient to permit the latch lever **52** to swing to the first limit position **131** where the cam lock portion **55** latches or locks the door. Thus, the door is locked at the two sides near the second hinge means **22** to prevent unauthorized entry into the garage. It will be noted that the exterior of the door **10** presents a smooth appearance with no external handles and, thus, nothing may be grasped to aid forcible entry into the garage.

The above description shows that the torque switch **101** is that which stops the motor in the full open position and the first limit switch **81** is that which stops the motor in the full closed position. The control circuit **84** also provides important safety features. One of these safety features is that at any point in the upward or downward closing movements of the door, the door may be stopped if a person notices that it needs to be stopped for any reason. This may be accomplished by simply depressing the push button switch **108** or the radio control switch, not shown, in parallel therewith. This push button switch **108** will actuate the relay coil **105** to index the relay **104** to the next position which is a motor and door stopped condition.

The second and third limit switches **82** and **83** provide still another safety feature, namely, to stop the door in the downward direction whenever the door closing movement is obstructed. For example, if some obstruction is under the door in the intermediate position **10A** of FIGURE 2, then the first limit switch **81** would actually stop the door, but not immediately because the latch lever **52** would need to swing through about 50 degrees to the radial line **135** to actuate this first limit switch **81**. The second limit switch **82** is much more sensitive to obstruction of downward movement of the door. Upon meeting any such obstruction, the cables are still being payed out and this quickly releases the tension on the cables. The return spring **61** thus quickly swings the latch lever **52** clockwise and about 5 or 10 degrees movement to the radial line **139** is all that is needed to actuate the second limit switch **82**. It will be noted that in the intermediate position **10A**, the cable sheave guard **71** is in such a position to close the third limit switch **83**, thus closing of the second limit switch **82** at this time will index the relay **104** to a motor and door stopped condition. The irreversible power direction means of worm **40** and worm wheel **41** thus stops the door when the motor **39** is stopped.

The first limit switch **81** is a switch sensitive to cable tension to shut off the motor **39**. The second limit switch **82** however is a switch sensitive to a greater cable tension and thus a smaller percentage change of tension from that established in the door closing movement, and thus is a safety switch. The third limit switch **83** is a switch sensitive to the door position, especially position of the lower panel **17**. This third limit switch **83** disables control of the relay **104** by the second limit switch **82** whenever the door is practically closed but permits the second limit switch **82** to be in control of the control circuit **84** throughout the entire intermediate range of downward movement of the door **10**. When the third limit switch **83** is actuated to an open position in the last small distance or minor distance of door closing, this disables the second limit switch **82** so that the latch lever **52** must swing through approximately 50 degrees to the radial line **135** before the motor **39** is de-energized. This permits the small coasting of the motor and torque tube **36** to complete the closing movement of the latch lever **52** to the fully latched position. Thus, this assures that the door will be closed and locked at the end of the door closing movement.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that

numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
drive means including an electric motor connected to pull on a movable link,
means connecting said movable link to said panel,
urging means urging said link toward a first limit position,
said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,
limit switch means connected to be actuated from a first to a second condition in accordance with movement of said door panel to a position within a minor distance of being closed on the door frame,
electrical circuit means controlling energization to said electric motor and including a second switch,
said circuit means including said limit switch means to disable control of said motor by said second switch until said limit switch means has been actuated to said second condition.

2. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
drive means including an electric motor connected to pull on a movable link via a flexible cable,
means connecting said movable link to said panel,
urging means urging said link toward a first limit position,
said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,
limit switch means connected for actuation in accordance with movement of said link and actuated from a first to a second condition in response to change in tension on said cable,
electrical circuit means controlling energization to said electric motor,
and said circuit means including said limit switch means connected to de-energize said motor upon actuation of said limit switch means.

3. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
drive means including an electric motor connected to pull on a movable link via a flexible cable,
means connecting said movable link to said panel,
urging means connected to urge said link toward a first limit position,
said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,
first limit switch means connected for actuation in accordance with movement of said link and actuated from a first to a second condition in response to change in tension on said cable,
second limit switch means connected to be actuated from a first to a second condition in accordance with movement of said door panel to a position within a minor distance of being closed on the door frame,
electrical circuit means controlling energization to said electric motor,
said circuit means including said first limit switch means connected to de-energize said motor upon actuation thereof,
and means connecting said second limit switch means in said circuit means to disable control of said motor by said first switch means until said second limit switch means has been actuated.

4. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
a movable link connected to said panel and having first and second limit positions,
drive means including an electric motor connected to pull on said movable link via a flexible cable,
urging means connected to urge said link toward said first limit position,
said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to said second limit position and said drive means exerting an upward opening force on said door at said second limit position,
first limit switch means connected for actuation in accordance with movement of said link and actuated from a first to a second condition in response to change in tension on said cable,
second limit switch means connected to be actuated in accordance with movement of said link and actuated from a first to a second condition by a second and greater amount of tension on said cable,
third limit switch means connected to be actuated from a first to a second condition in accordance with movement of said door panel to a position within a minor distance of being closed on the door frame,
electrical circuit means including a relay controlling energization to said electric motor,
said circuit means including said first limit switch means connected to de-energize said motor upon actuation of said first limit switch means,
means connecting said second limit switch means in said circuit means to stop downward movement of said door upon actuation of said second limit switch means,
and means connecting said third limit switch means in said circuit means to disable actuation of said relay by said second switch means until said third limit switch means has been actuated.

5. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
drive means including an electric motor and a movable link connected to said panel,
means urging said link toward a first limit position relative to the door,
said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,
limit switch means connected to be actuated from a first to a second condition by movement of said link within a minor portion of said path from said second limit position,
electrical circuit means controlling energization to said electric motor,
and said circuit means including said limit switch means acting as safety switch means to stop downward movement of said door during the intermediate range

of downward door movement whenever door movement is obstructed to move said link to actuate said limit switch means to said second condition.

6. A door for a door frame, comprising, in combination, at least one door panel,

means to mount said panel for upward opening movement,

drive means including an electric motor and a movable link connected to said panel,

means urging said link toward a first limit position relative to the door,

said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,

first limit switch means connected to be actuated from a first to a second condition by movement of said link within a minor portion of said path from said second limit position,

electrical circuit means controlling energization to said electric motor,

said circuit means including said first limit switch means acting as safety switch means to stop downward movement of said door during the intermediate range of downward door movement whenever door movement is obstructed to move said link to actuate said first limit switch means to said second condition,

second limit switch means connected to be actuated from a first to a second condition by movement of said door panel to a position within a minor distance of being closed on the door frame,

and means connecting said second limit switch means in said circuit means to disable control of said motor by said first switch means until said door panel has moved to a position actuating said second limit switch means to said second condition.

7. A door for a door frame, comprising, in combination, at least one door panel,

means to mount said panel for upward opening movement,

drive means including an electric motor and a movable link connected to said panel,

means urging said link toward a first limit position relative to the door,

said drive means connected to said link to pull same through a path of movement against the urging of said urging means from said first to a second limit position and said drive means exerting an upward opening force on said door at said second limit position,

first limit switch means connected to be actuated from a first to a second condition by movement of said link within a first minor portion of said path from said first limit position,

second limit switch means connected to be actuated from a first to a second condition by movement of said link within a second minor portion of said path from said second limit position,

electrical circuit means controlling energization to said electric motor,

said circuit means including said first limit switch means to de-energize said motor when said door has closed on the door frame and said urging means has moved said link to actuate said first limit switch means,

means connecting said second limit switch means in said circuit means acting as safety switch means to stop downward movement of said door during the intermediate range of downward door movement whenever door movement is obstructed to have said urging means move said link to actuate said second limit switch means,

third limit switch means connected to be actuated from a first to a second condition by movement of said door panel to a position within a minor distance of being closed on the door frame,

and means connecting said third limit switch means in said circuit means to disable control of said motor by said second switch means until said door panel has moved to a position actuating said third limit switch means.

8. A door for a door frame, comprising, in combination, at least one door panel,

means to mount said panel for upward opening movement,

a movable latch connected to said panel,

means urging said latch toward a latched first limit position relative to the door frame,

drive means including an electric motor,

said drive means connected to said latch to pull same through a path of movement against the urging of said urging means from said first to a second limit position with the first portion of movement on said path unlatching said latch from said door frame and said drive means exerting an upward opening force on said door at said second limit position,

limit switch means connected to be actuated from a first to a second condition by movement of said latch within a minor portion of said path from said second limit position,

electrical circuit means including a relay controlling energization to said electric motor,

and said circuit means including said limit switch means acting as safety switch means to stop downward movement of said door during the intermediate range of downward door movement whenever the door meets an obstruction to have said urging means move said latch to actuate said limit switch means to said second condition.

9. A door for a door frame, comprising, in combination, at least one door panel,

means to mount said panel for upward opening movement,

a movable latch connected to said panel,

means urging said latch toward a latched first limit position relative to the door frame,

drive means including an electric motor,

said drive means connected to said latch to pull same through a path of movement against the urging of said urging means from said first to a second limit position with the first portion of movement on said path unlatching said latch from said door frame and said drive means exerting an upward opening force on said door at said second limit position,

first limit switch means connected to be actuated from a first to a second condition by movement of said latch within a minor portion of said path from said second limit position,

electrical circuit means including a relay controlling energization to said electric motor,

said circuit means including said limit switch means acting as safety switch means to stop downward movement of said door during the intermediate range of downward door movement whenever the door meets an obstruction to have said urging means move said latch to actuate said limit switch means to said second condition,

second limit switch means connected to be actuated from a first to a second condition by movement of said door panel to a position within a minor distance of being closed on the door frame,

and means connecting said second limit switch means in said circuit means to disable actuation of said relay by said first switch means until said door panel has moved to a position actuating said second limit switch means to said second condition.

10. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
a movable latch connected to said panel,
means urging said latch toward a latched first limit position relative to the door frame,
drive means including an electric motor,
said drive means connected to said latch to pull same through a path of movement against the urging of said urging means from said first to a second limit position with the first portion of movement on said path unlatching said latch from said door frame and said drive means exerting an upward opening force on said door at said second limit position,
limit switch means connected to be actuated from a first to a second condition by movement of said latch within a first minor portion of said path from said first limit position,
electrical circuit means including a relay controlling energization to said electric motor,
and said circuit means including said limit switch means to actuate the relay to de-energize said motor when said door has closed on the door frame and said urging means has moved said latch to actuate said limit switch means to said second condition.

11. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
a movable latch connected to said panel,
means urging said latch toward a latched first limit position relative to the door frame,
drive means including an electric motor,
said drive means connected to said latch to pull same through a path of movement against the urging of said urging means from said first to a second limit position with the first portion of movement on said path unlatching said latch from said door frame and said drive means exerting an upward opening force on said door at said second limit position,
a first limit switch connected to be actuated from a first to a second condition by movement of said latch to a point within a first minor portion of said path from said first limit position,
a second limit switch connected to be actuated from a first to a second condition by movement of said latch to a point a second minor portion of said path away from said second limit position,
electrical circuit means including a relay controlling energization to said electric motor,
said circuit means including said first limit switch to actuate the relay to de-energize said motor when said door has closed on the door frame and said urging means has moved said latch to actuate said first limit switch to said second condition,
means connecting said second limit switch in said circuit means to stop downward movement of said door during the intermediate range of downward door movement whenever the door meets an obstruction to have said urging means move said latch to actuate said second limit switch to said second condition,
third limit switch means connected to be actuated from a first to second condition by movement of said door

panel to a position within a minor distance of being closed on the door frame,
and means connecting said third limit switch means in said circuit means to disable actuation of said relay by said second switch until said door panel has moved to a position actuating said third limit switch means to said second condition.

12. A door for a door frame, comprising, in combination, at least one door panel,
means to mount said panel for upward opening movement,
a latch lever pivoted to said panel,
return spring means urging said latch lever toward a latched first limit position relative to the door frame,
drive means including an electric motor connected to pull on a flexible cable,
said flexible cable connected to said latch lever to pull same through an arc against the urging of said return spring means to a second limit position with the first portion of said arc unlatching said latch lever from said door frame and exert an upward opening force on said door,
a first limit switch connected to be actuated from a first to a second condition by movement of said latch lever within a first small arc from said first limit position,
a second limit switch connected to be actuated from a first to a second condition by movement of said latch lever within a second small arc from said second limit position,
electrical circuit means including a relay controlling energization to said electric motor,
said circuit means including said first limit switch to actuate the relay to stop said motor when said door has closed and said return spring means has moved said latch lever to within said first small arc from said first limit position,
means connecting said second limit switch in said circuit means to stop downward movement of said door during the intermediate range of downward door movement whenever cable tension is released to have said return spring means move said latch lever to within said second small arc from said second limit position to actuate said second switch,
third limit switch means connected to be actuated from a first to a second condition by movement of said door panel to a position within a small distance of being closed on the door frame,
and means connecting said third limit switch means in said circuit means to disable said second switch until said door panel has moved to a position within said small distance of being closed on the door frame.

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