Oct. 25, 1966 R. L. DUGGER 3,280,508

DOOR

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FIG. 1

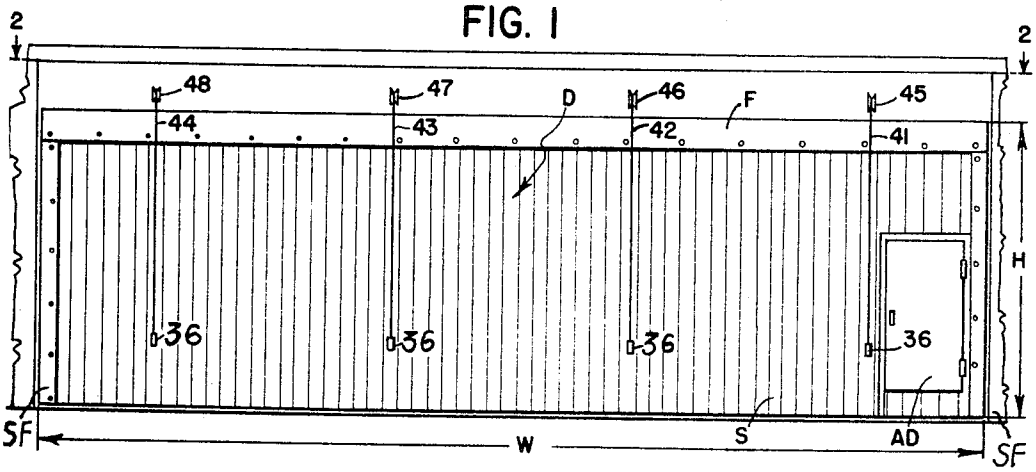
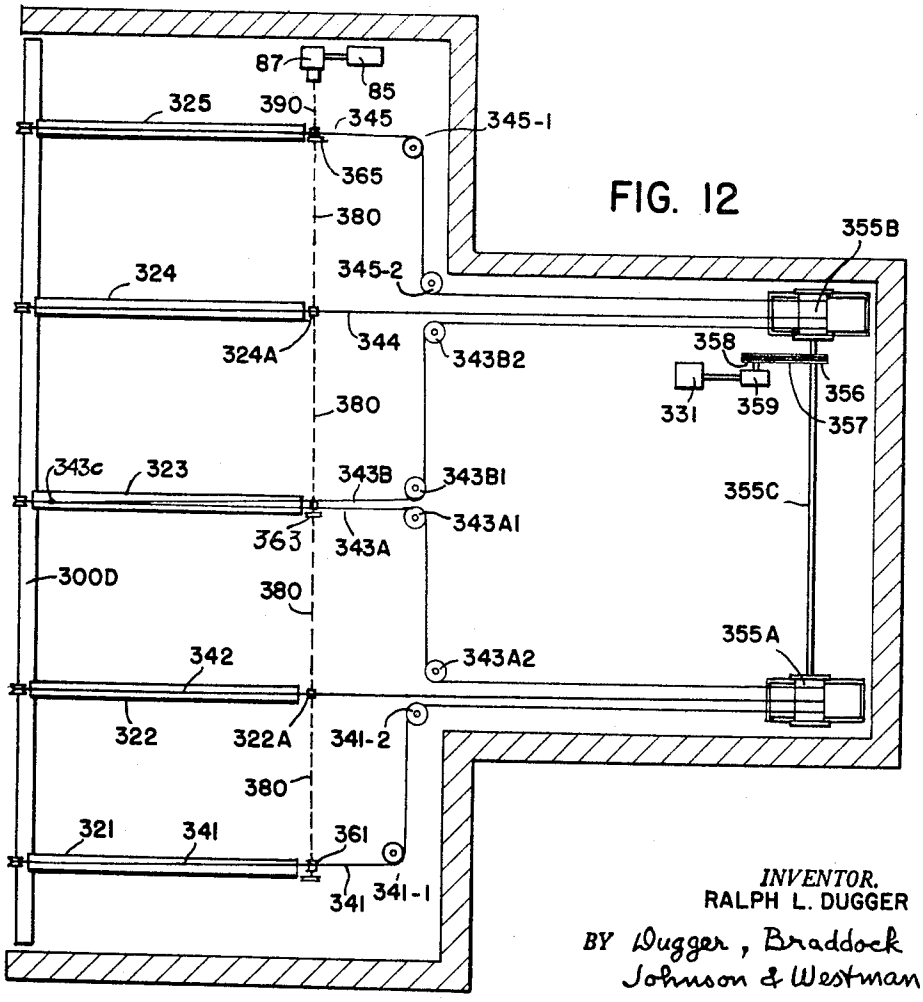


FIG. 12



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DOOR

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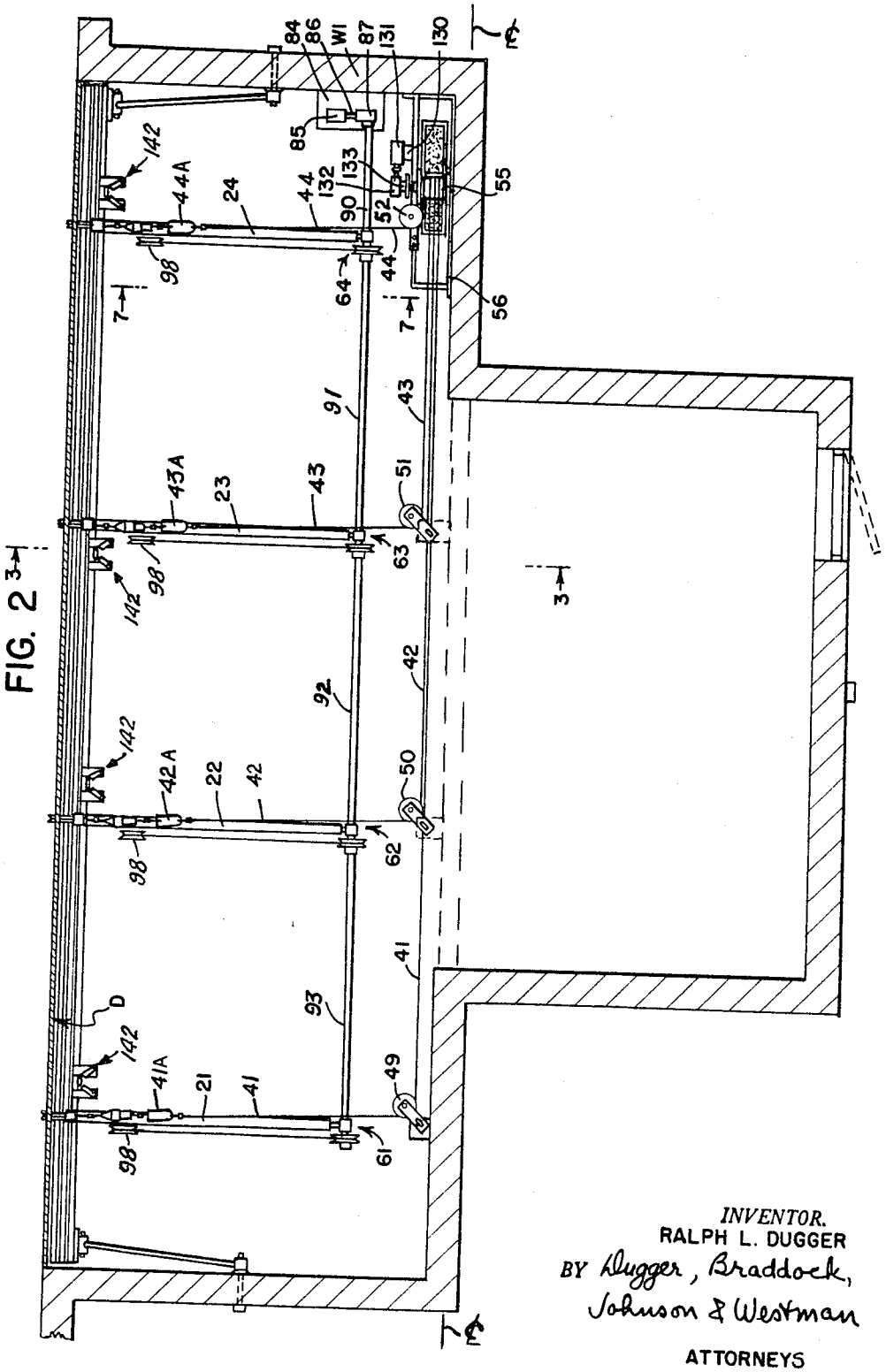

FIG. 2

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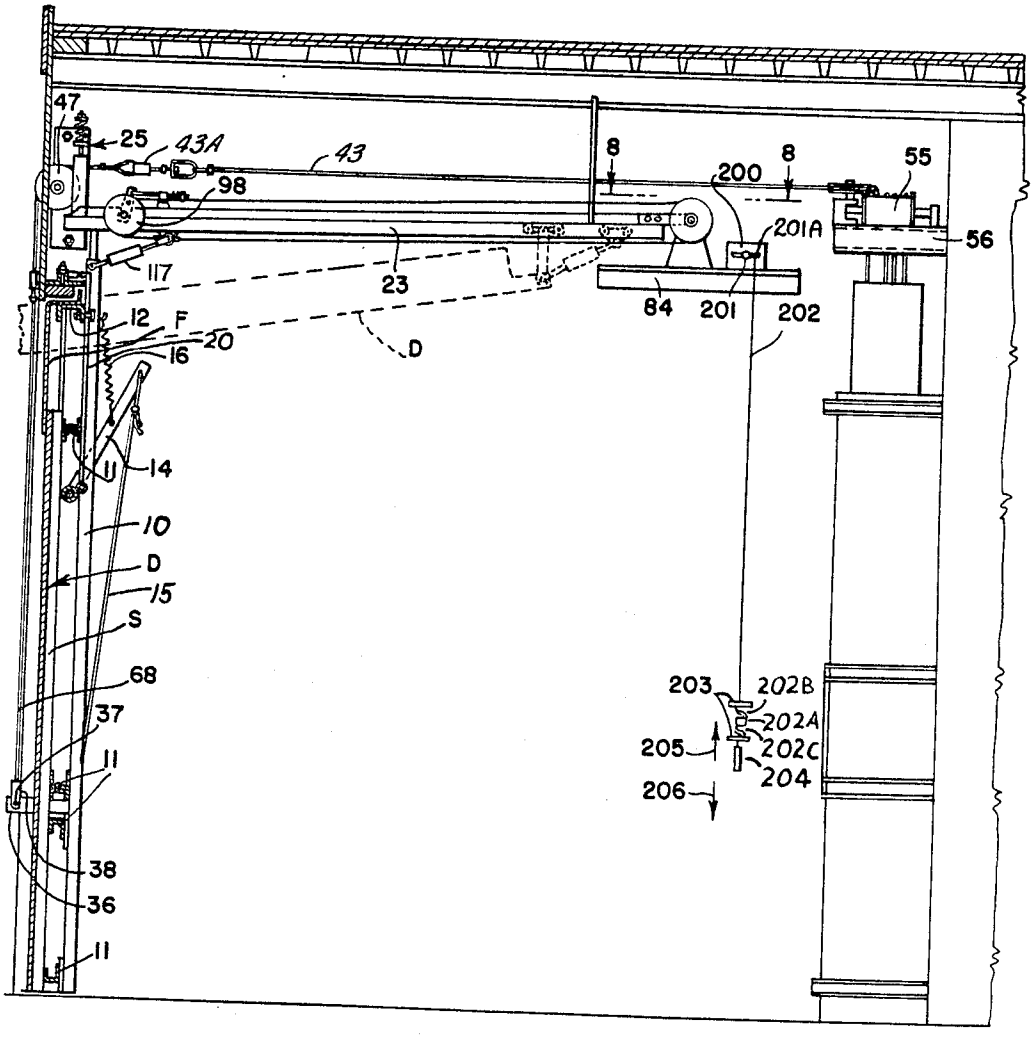
FIG. 3



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DOOR

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FIG. 4

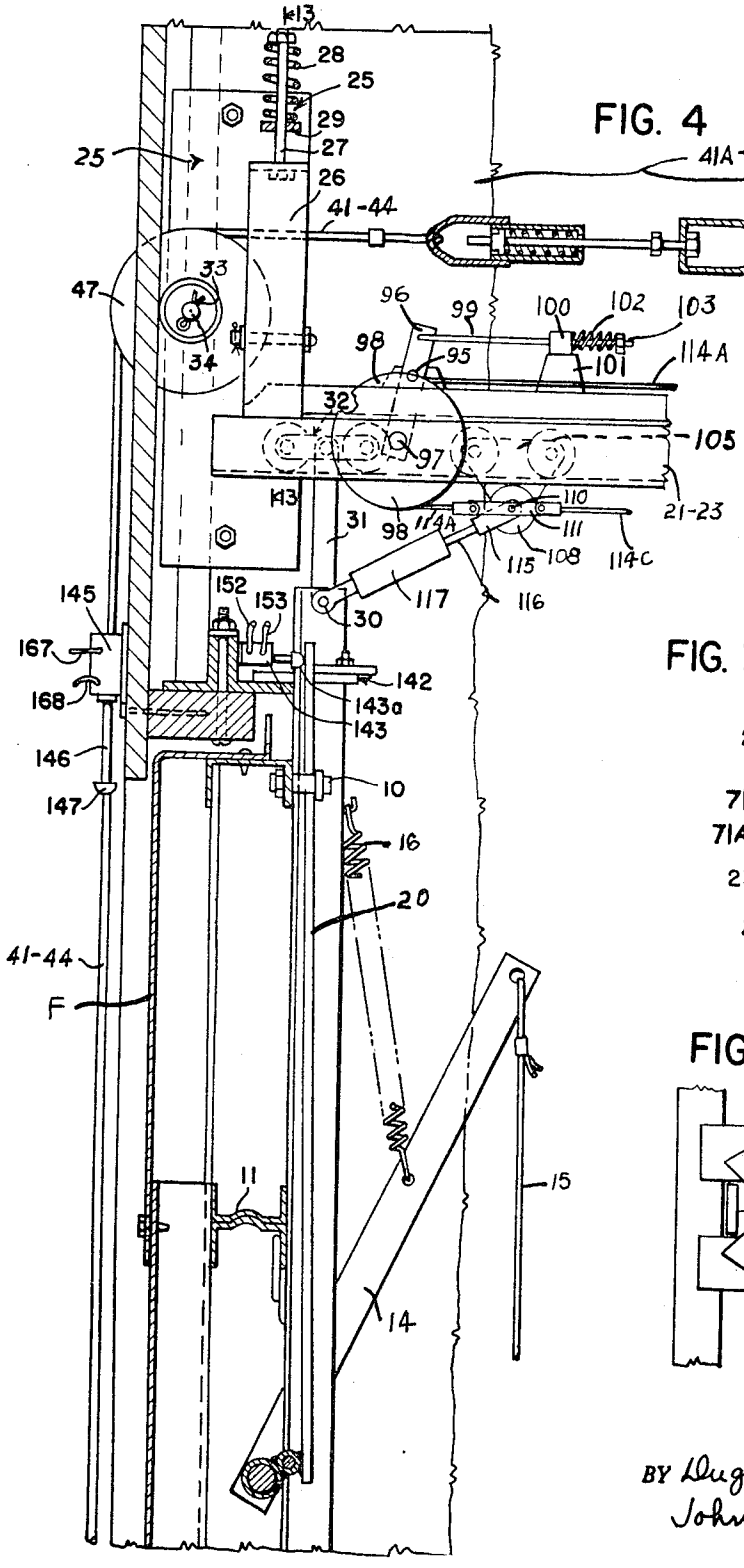

FIG. 13

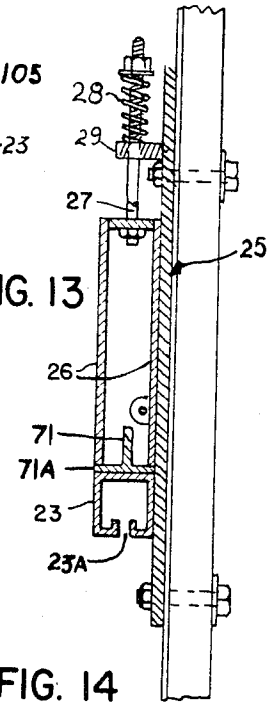

FIG. 14

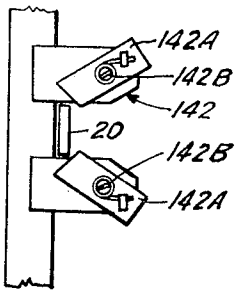

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FIG. 5

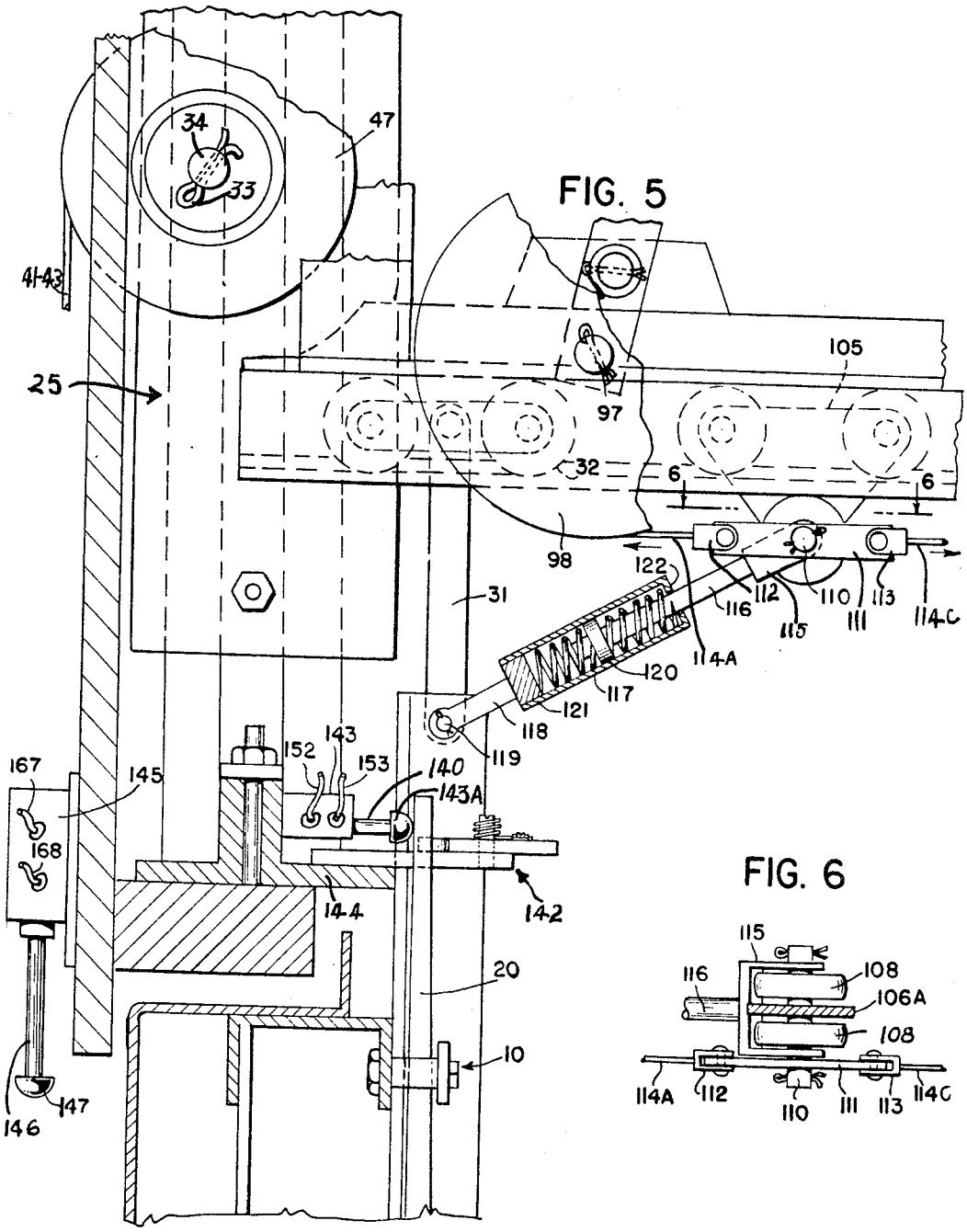

FIG. 6

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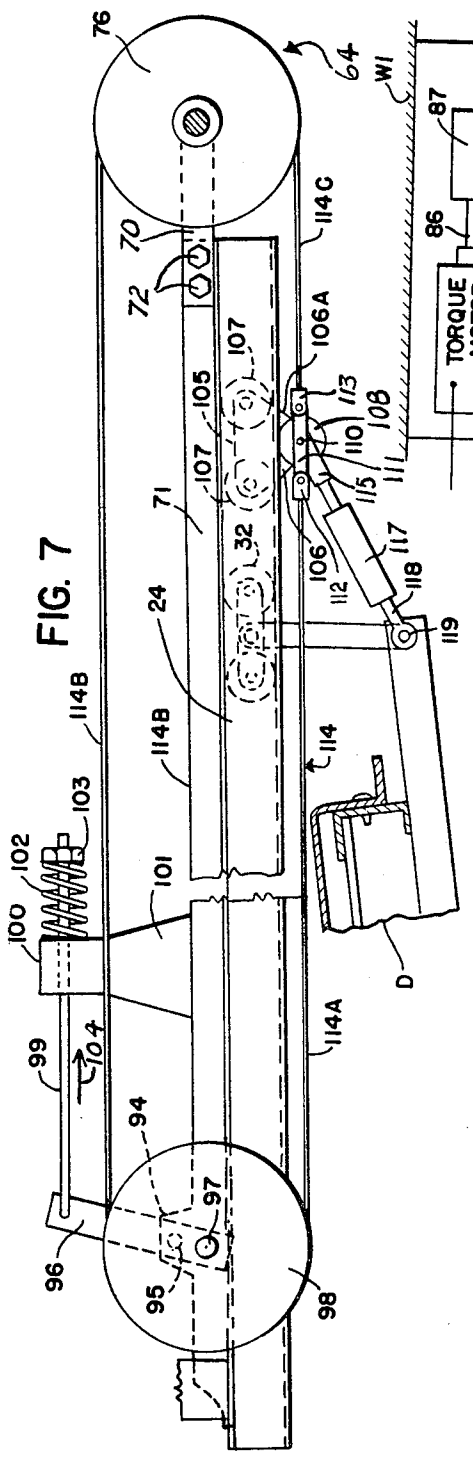

FIG. 7

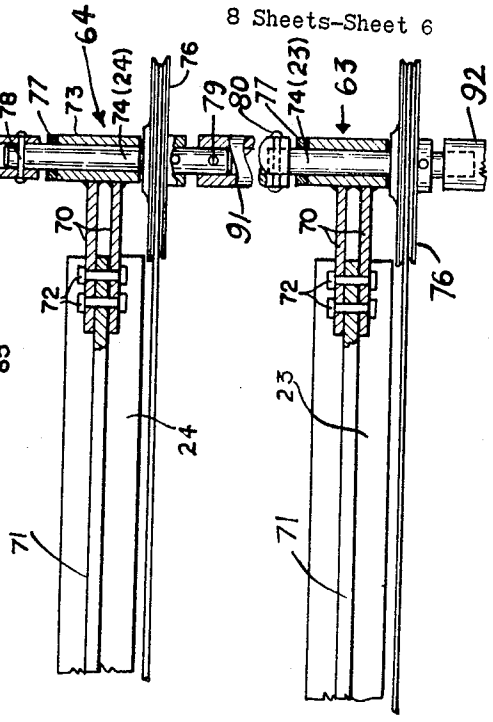

FIG. 8

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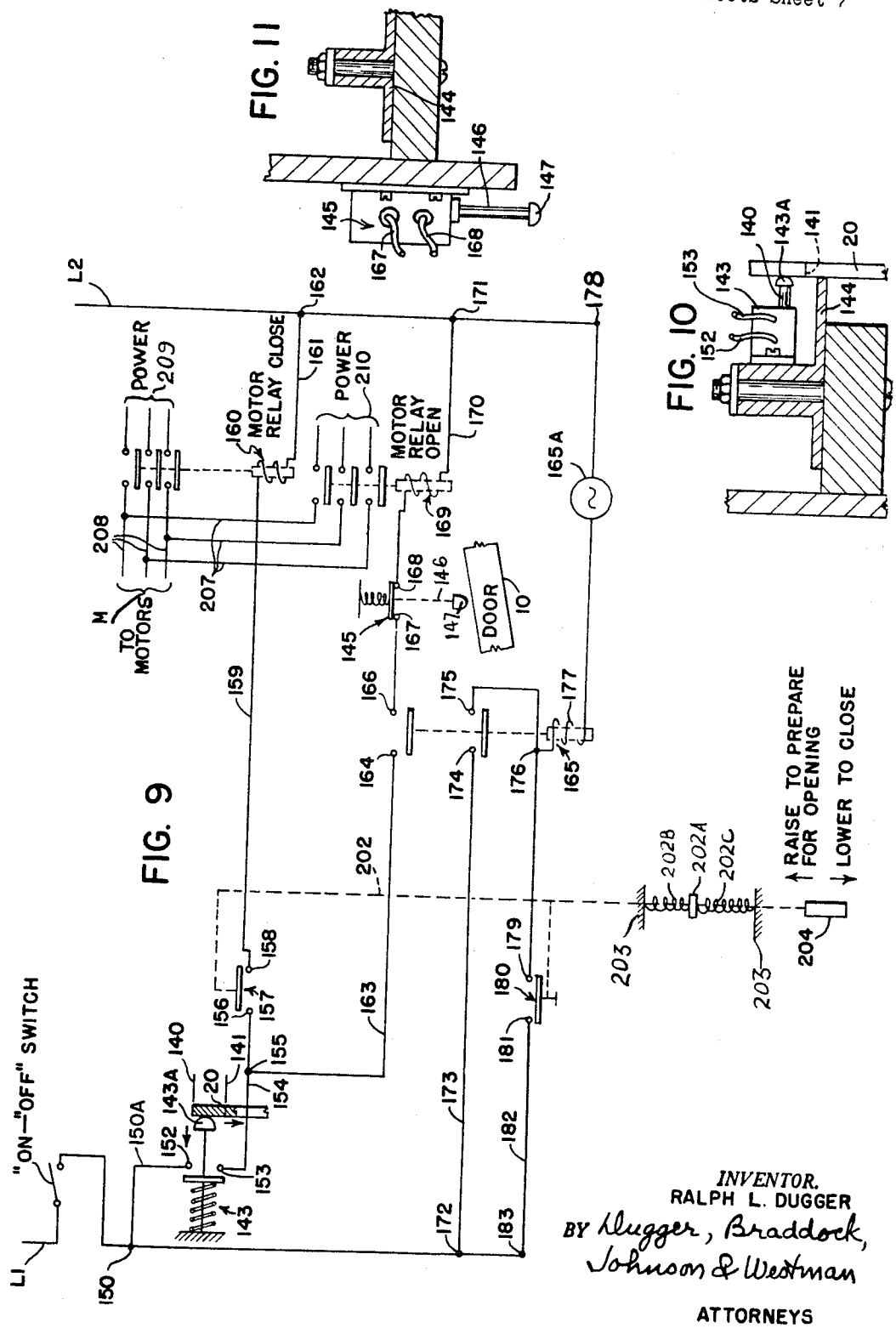

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DOOR

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FIG. 16

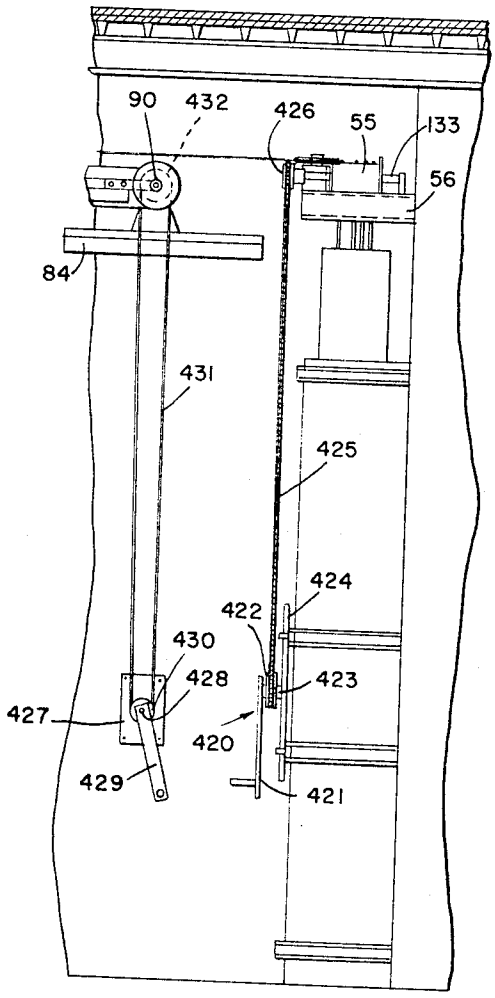
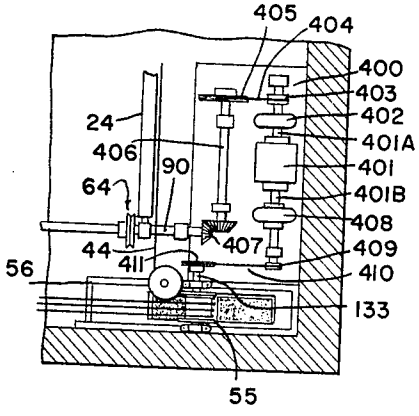


FIG. 15



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United States Patent Office 3,280,508 Patented Oct. 25, 1966

3,280,508

DOOR

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Filed Mar. 13, 1964, Ser. No. 351,734
12 Claims. (Cl. 49—200)

This application is a continuation-in-part of my application, Serial No. 17,023, filed March 23, 1960 and now abandoned which application, Serial No. 17,023, is, in turn a continuation-in-part of application Serial No. 454,365, filed September 7, 1954 now Patent No. 2,937,-415, and a continuation-in-part of application Serial No. 556,198, filed December 29, 1955 and now abandoned. All of the disclosures of the aforesaid applications are incorporated herein by reference.

This invention relates to improved power operated doors and more particularly to doors of large size such as those used in large airplane hangars and other similar large buildings requiring a large door opening and heavy doors. The invention relates particularly to power operated doors where the door is of the flat panel type that is moved from its closed position, in which the door is vertical, through an opening motion wherein the door is simultaneously rotated about a horizontal axis and elevated to a position in which, when fully open, the door is substantially horizontal and elevated, with a portion of the door protruding out of the door opening and a portion of the door inside the building, with the outer face of the door upward.

It is an object of the invention to provide an improved power operated door for large flat panel doors. It is another object of the invention to provide an improved power operated door which may be operated with motor means of low horsepower. It is another object of the invention to provide an improved power operated door wherein a closing operation is under the instant control of the operator, permitting thereby supervisory control of the closing and opening operations so as to avoid interference with devices that may be in the building of which the door is a closure. It is a further object of the invention to provide an improved power operated door wherein all electrical devices in connection with the door are kept at an elevated position whereby explosion proof fittings and motors are not required. It is another object of the invention to provide an improved power operated door wherein the opening of the door is initiated by unlatching of the door. It is a further object of the invention to provide an improved power operated door wherein resilient actuation thereof is enabled, thereby insuring closure over the full width of the door even though deflection takes place.

Other and further objects are those inherent in the invention herein illustrated, described, and claimed, and will be apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated with reference to the drawings wherein:

FIGURE 1 is a front elevational view of an exemplary door of the present invention;

FIGURE 2 is a horizontal sectional view at the section line 2—2 of FIGURE 1. In FIGURE 2, certain parts of the operating mechanism are not included due to small size in this view;

FIGURE 3 is a vertical sectional view through one-half of the building shown in FIGURE 2 including the lower portions, this view being taken along the line and in the

direction of arrows 3—3 of FIGURE 2. Here also, certain small size parts are omitted;

FIGURE 4 is an enlarged fragmentary vertical sectional view of the upper portions of the door suspension fittings and latching arrangements over the door;

FIGURE 5 is a further enlarged fragmentary vertical sectional view of a portion of the apparatus as shown in FIGURE 4;

FIGURE 6 is a horizontal sectional view looking in the direction of arrows 6—6 of FIGURE 5;

FIGURE 7 is a fragmentary side elevational view of the track support of the door and a portion of the door operating mechanism for opening and closing the door, taken along the line and in the direction of arrows 7—7 of FIGURE 2;

FIGURE 8 is a fragmentary horizontal sectional view, partly broken away, of a portion of the door operating mechanism taken at the level of section 8—8 of FIGURE 3;

FIGURE 9 is a wiring diagram of the electrical components;

FIGURES 10 and 11 are respectively vertical fragmentary sectional views illustrating the limit switches;

FIGURE 12 is a schematic plan view of a slightly modified form of installation made according to this invention;

FIGURE 13 is a cross-sectional view taken along line 13—13 of FIGURE 4;

FIGURE 14 is a fragmentary plan view of the latch structure shown generally at 142 in FIGURE 4.

FIGURE 15 is a fragmentary horizontal sectional view similar to a portion of FIGURE 2, showing another embodiment of the invention; and

FIGURE 16 is a fragmentary vertical sectional view similar to FIGURE 3, showing still another embodiment of the invention.

The type of doors to which the present invention is adapted are flat panel doors of integral construction which are adapted to be simultaneously raised and rotated as a unit for movement from a vertical position in which the door closes the opening to an elevated position wherein the front face of the door is upward and the door is in a generally horizontal plane with a bottom portion of the door protruding outwardly through the door opening and the balance of the door within the building structure. The exact construction of the door is per se not a part of the present invention since any form of framing and operating mechanism which provides a flat panel door capable of operating from closed to open position in the manner aforesaid, may be utilized as the underlying structure of the present invention. Without limitation on the present invention reference is made to my applications aforesaid wherein several forms of doors of this kind are disclosed, and one such form is herein illustrated.

Briefly the framing of an exemplary form of door D of this type consists of vertical members 10, several of which may be used at spaced intervals across the width of the door. These framing members or "backbones" serve as attachments to which a plurality of horizontally extending purlins 11 are adapted to be attached. The front sheeting of the door may consist of any form of sheeting, as for example, commercial roof deck or other suitable corrugated sheeting or "roof deck," or any other sheeting which may be desired such as wood, boards, etc. The sheeting is shown as S in the drawings. In the illustrated form of the door there is a top flashing at F and side flashings at SF–SF. Also in this form of the door there may be included if desired a small access door AD which is described in further detail in my application, Serial No. 822,809, filed June 25, 1959, now Patent No. 3,118,189, to which reference is here made.

A door of large size, as for example, a door on an airplane hangar may have a width W which is 40 feet or

more; a height H which is 10 to 15 feet or more. Any door of this size is inherently flexible unless it is made so heavy as to provide stiffness across its width. When this is done, the door is inordinately heavy and difficult to move from open to a closed position and vice versa. There is no sound reason for having excessive stiffness across the width of the door and I prefer to use a door construction as described in my applications aforesaid. In such construction, loadings are adequately supported by stops not shown, along the lower edge of the door at floor level. Such stops receive at least a part of the wind pressure loads exerted against the door on the outside, these forces being thereby transferred to the floor stops. Across the upper edge of the door, according to the teachings of my invention as set forth in the applications aforesaid, I provide a plurality of latches **142** as shown in FIGURES 4 and 14 which hold the upper edge or "head" of the door in a position such that the backbone members **10** face against the inner edge of the lower chord of the truss spanning the door opening. By a single operating lever **14**, actuated by a pull rope **15**, and normally held upwardly by the spring **16**, all of the latch bolts **20**, across the upper inner portion of the door, may be simultaneously released, according to the applications previously referred to. Therefore, wind pressures exerted against the outside of the door are in part at least transferred to the lower chord of the truss spanning the door opening and in part transferred to the floor.

According to my applications aforesaid, there are provided two or more track means, **21–24**, located in a generally horizontal plane and extending from a position above the upper edge of the door inwardly in respect to the building. The front ends of such tracks are supported by supporting brackets generally designated **25**, see FIGURE 5. The bracket **25** is bolted to the door truss. The front ends of the tracks **21–24** are supported by upwardly extending tension members **26—26**, see FIGURES 4 and 13, and bolt **27** and through a compression spring **28** which rests upon a perch **29** welded on the bracket **25**. Accordingly, the front ends of the tracks **21–24** each is resiliently supported, thereby equalizing the load of the door on the tracks. At the upper ends of each of the backbones **10** there is a pivot pin **30** attached to a pendant **31** on the roller hangar **32** which operates in the track **23**. The roller hangar **32** of the various tracks thereby supports the backbones **10** and accordingly the door.

The bracket **25** is also provided with a stub shaft **34** upon which a pulley **45–48** is mounted one for each of the brackets **25**. The pulley is held in place by cotter pin **33**.

From each of the backbone members **10** there is an outwardly extending member **36** (see FIGURES 1 and 3) having a pivot hole **37** at its outer end to which a clevis **38** is attached, and to the clevis there is attached a supporting cable, these being the cables **41–44** as shown in FIGURE 1, one for each backbone **10**. Each of these cables accordingly runs upwardly to and over a pulley, these being the pulleys **45**, **46**, **47**, and **48**, as shown in FIGURE 1.

Adjacent the center line of the hangar, see FIGURE 2, according to the particular plan of rigging herein illustrated (which is not, however, a limitation of this invention) there are provided guide pulleys **49–52** and the cables **41–44** are therefore each run upwardly to their respective pulleys **45–48** and thence directly into the building at a level somewhat above the tracks **21–24** respectively and thence to and around the guide pulleys **49–52** whereupon the cables **41–44** follow parallel paths until they reach the drum **55** which is supported in bearings mounted upon the drum and weight box frame **56**. Along the run of each cable there is put a combined cable length adjustment and spring tension device for allowing adjustment of the length of the cables and for equalizing the loading of the cables. These are shown at **41A–44A**, see FIGURES 2–4.

The weight box frame **56** is supported at an elevated level within the hangar and the drum **55** is mounted thereon for free rotation. It is emphasized here that the location of the weight box may be wherever convenient, and in some instances the weight box may be made as two or more weight boxes, operated simultaneously, as though one. An arrangement showing two weight boxes is shown in FIGURE 12.

For certain sizes of doors manual manipulation through a crank mechanism is all that is needed for supplying the requisite power input for opening and closing the doors, but in some instances, as where remote control is desired, or for larger sizes of doors, motor actuation is desirable. An examplary motor driven actuating system is as follows:

At the back end of each one of the track members **21–24** there is a drive pulley bracket assembly **61–64**. Not every track need be provided with a drive pulley. Only enough are provided to give needed operation. Thus in a door having five tracks, three drives may be used (every other track). These drive pulley assemblies are all similar and only one will be described in detail. At the front of each track **21** through **24** there is a tightener-idler pulley **98** in FIGURE 2. Referring to FIGURES 7 and 8, the pulley devices **61–64**, which are identical, consist of a bracket composed of spaced plates **70** extending rearwardly from the T-shaped stiffener **71** which is a part of the track assembly, it being noted parenthetically as shown in FIGURE 13, that the tracks used utilize standard rectangular cross-section tracks **23**, welded to the bottom flange **71A** of an inverted T-shaped structural member **25**. At the rear end of the central web of this T member there are bolted the two plates **70** being held in place by bolts **72**. The plates **70** extend rearwardly and are welded to a tubular bearing **73** in which a shaft **74** is adapted to turn. On one end of the shaft there is keyed a grooved pulley **76** and at the other end of the shaft there is fastened a collar **77** which accordingly keeps the shaft **74** from shifting endwise. The shaft **74** extends outwardly for several inches beyond the hub of the pulley **76** and beyond the collar **77** at each end of the shaft. At opposite ends of the shaft there are provided key holes, these being set at right angles to each other. It is noted parenthetically that in FIGURE 8 the shaft **74** is denoted **74(24)** since it is fastened to the track assembly **24** and that the shaft **74** in the adjacent track **23** is denoted **74(23)** since it is fastened on the track assembly **23** which is fastened to the shaft by means of the pins **79** for the shaft **74(24)** and **80** for the shaft **74(23)** the pins being through the key holes aforementioned. A certain amount of looseness is desirable in the fit of the pipe to the shaft and since the pins at opposite ends of the same pipe are at right angles, the two shafts and pipe thus act in the nature of a universal joint, thereby obviating difficulties due to misalignment. On the wall W1, see FIGURES 2 and 8, there is a bracket **84** serving as a mount for a torque-motor generally designated **85**. This is a motor of standard variety capable of generating a certain torque. The torque motor torque may be adjusted by varying suitable controls, not shown, and this torque is generated (even though the motor may be stalled or running). The output shaft of the motor at **86** is connected to a worm gear speed reducer **87** having an output shaft **88** which is connected by a key pin **89** to the pipe coupling connecting **90** which is, in turn connected to the shaft **74(24)** by a key pin **78** in the same manner as adjacent shafts **74—74** of adjacent pulley bracketing assemblies **61–64** are connected together, as previously described. Accordingly, when the motor **85** is energized it will, through the worm gearing **87**, produce a certain torque on the primary drive connection tube **90** and this torque is first transmitted by it to the assembly **64** and thence through the pipe **91** to

the assembly 63 and thence in succession through the pipe 92 to pulley assembly 62 and through pipe 93 to the pulley assembly 61, see FIGURE 2.

Thus the rotation of the output shaft 38 of the gear box 37 is transmitted in like amount to all of the pulleys 76 on each assembly 61–64 of the track.

On the central web of the T-shaped structural member 71 on the front of each track there is an upstanding bracket portion 94 adjacent the front end of the track, see FIGURE 7. To this there is attached a stub shaft 95 which sticks out on one side and upon the stub shaft there is pivoted a rocking arm 96 having at its lower end another outwardly extending stub shaft 97 upon which a grooved pulley 98 is mounted for rotation. The upper end of the lever 96 is connected through the draw link 99 which extends through an aperture 100 in another bracket 101 on the T member 71 and thence outwardly where it is surrounded by the spring 102 that is held in place by washer and nut assembly 103. By adjusting the nut any desired compressive force can be applied to the spring 102 which hence causes the lever 96 to be biased in the direction of arrow 104 thereby moving the pulley spindle 97 in the opposite direction.

In addition to the roller hangers 32 in each of the tracks, according to this invention I also provide another roller hanger assembly generally designated 105 (see FIGURE 7) which is similar to the roller hanger 32 except that a frame member 106 extends down through the slot 23A in the track, see FIGURE 13. This roller hanger is provided with the usual rollers 107 at its upper portion and is provided as shown in FIGURE 6 with a pair of rollers 108—108 on either side of the frame member 106 at the lower portion 106A. These rollers 108 are situated so that they run against the outside of the lower portion of the track, enough clearance being provided so that the entire assembly 108 can move freely along the track but the rollers 107—107 which form the normal set of four rollers in the track are held down against any tipping movement. The spindle 110 upon which the rollers 108 are journalled extends well out beyond these rollers (see FIGURE 6) and at one side there is provided a cable connector 111 having apertures in opposite ends thereof to which the cable clevises 112 and 113 are attached. These clevises are attached to opposite ends of a standard steel cable 114 which runs from the clevis 112 along the portion 114A, thence around the pulley 98 and thence along the run 114B and around the pulley 76 of the pulley assemblies 61–64, and thence along the portion 114C to the clevis 113. The stranded wire steel cable 114 thus forms a "belt" which runs around the pulleys 76 and 98, for each of the tracks to which this drive mechanism is attached. Any desired "tension" may be put in this wire belt arrangement by merely adjusting nut 103. It is not desirable to have the tension excessive because some slippage is acceptable, as will be explained.

Also from the spindle 110 (see FIGURES 5 and 6) there extends a larger clevis 115 which is attached to opposite ends of the spindle and extends forwardly and is thence attached to the staff 116, the latter extending forwardly and downwardly into a tube 117. The tube 117 is provided at its forward end with a flat strap 118 which extends forwardly and is fastened to the same pivot 119 by which the pendant 31 of the roller hanger 32 of that track is attached to the upper end of the backbone member 10 of the door.

Near the forward end of the staff 116 there is welded a collar 120 and on each side of this collar, there are compressed two springs 120A and 120B. The springs are held against the closed end 121 of the tube and against an inturned collar 122 at the opposite end. The end 121 may be threaded into the tube if desired for fabrication purposes or held in place by a cotter pin, not shown. The net effect of this arrangement is to provide

resiliency between the spindle 110 of the drive hanger 105 and the pivotal attachment 119 of the door.

Referring to FIGURE 2, the weight box and drum support frame 56 is provided with a bracket 130 and upon this there is also mounted a second torque motor 131 which is connected through a gear box 132, the output of the gear box being connected to the shaft 133 of the drum 55.

I have discovered that for very large doors, say those of more than forty feet width and more than twelve feet height can be opened and closed more positively by providing for the simultaneous application of work input to (1) the head of the door (as a translatory or "pushing" force) and (2) to the cable rigging for taking in or letting out the cables (and this latter work input is most conveniently applied at the drum shaft). Such dual channel of the work input (i.e. application of forces to two places in the door system) to the door is especially desirable in those instances where the door, when in its elevated (open) condition is in a horizontal or very nearly horizontal position. Increasing the width, height and weight of the door and rigging it so that it moves more nearly to a horizontal position when open are all factors which make it more desirable to use the invention hereof, i.e. simultaneous dual work input (dual force input) to the head of the door and the cable rigging of the door. By doing so, one is better assured of positive opening motion (from a closed position) and for positive initiation of closing motion (from an open position) and final closure. The reasons why the dual work input (dual force input) is desirable for large doors and for those reaching a substantially horizontal condition when open, will be apparent by analysis of the kinematic relationships of the various moving components of the system. A further explanation follows herein.

The dual input of force can obviously be by means of two hand operated work devices, such as two hand cranks, one for turning the shaft 133 of the drum 55 to provide the power input for taking in and letting out the cables 41–44 and another for rotating pipe 90 for applying the translatory force to the head of the door D. This can be done as in FIGURE 15, hereinafter described, for less extensive installations. However, in the larger, more sophisticated installations the dual force input is via power source means for independently supplying the work input to the two input locations, as for example, viz. shafts 133 and 90. Obviously one motor having two outputs, driving two independent torque drives, running to the two shafts 133 and 90, as in FIGURE 16 hereinafter described, may be used, but I prefer two separate and independent motors, as in FIGURES 2 and 3. In any case, the work input to each shaft, 133 and 90, is an independent torque drive, as for example, a torque motor or a regular motor fluid drive coupling, etc., and the shafts 133 and 90 will then have a torque applied to them and will accept as much rotation as, kinematically, they are able to accept (with consequent work input) for each increment of the opening and closing motion.

The dual work input (dual force input) construction and the improved operation thereby provided is a principal feature of the instant invention.

Reference should now be made to FIGURES 5, 9, 10, and 11, which illustrate the door latching mechanism and the electrical system for controlling the operation of the motor for actuating the door raising and lowering mechanism. One of the latch bolts 20 of the door (or a separate bolt like latch bolt 20 and operated in tandem with the active latch bolts but used for a purpose to be described), is provided on the door. It will be noted that this latch bolt, as shown in FIGURE 10, has a normal raised position which comes to a level which brings its top to the level 140 when the operating handle 14 is in the raised position as shown in FIGURE 3. However, when the operating handle is lowered, the upper end of the latch bolt will be lowered accordingly to the level of line 141.

In respect to the latching function (where the bolt serves this function also) this lowering of the bolt 20 has the effect of disengaging the upper end of the bolt 20 from the latch structure shown generally at 142, FIGURE 4, and in the plan view shown in FIGURE 14 the latch structure generally consists of a pair of pivotally mounted pawls 142A which are spring loaded by coil springs 142B in the normally closed position shown in FIGURE 14. These pawls cooperate with bolt 20 to hold the door in a locked position when the latch bolt 20 is in the position illustrated in FIGURE 4. In respect to the control of the electrical operations of the door, the latch bolt 20 is used to operate the limit switch generally designated 143, which is mounted upon the lower chord 144 of the truss, and the lowering of the bolt moves it out of a position to engage such switch. This limit switch 143 includes an operating button 143A which is normally spring biased outwardly (to the right as shown in FIGURES 9 and 10) and when in the outward position, the limit switch is effective to close the circuit through it. However, when the door is closed, and the latch bolt 20 is up and under such conditions, ready to latch into engagement with the latches 142, the latch bolt, or a bolt operating as a latch bolt, is in a position so that when the door does close, the upper end of the latch bolt will press against the operating button 143A of the limit switch 143 and thereby open that switch. This functioning is utilized for control purposes as will be described with reference to the wiring diagram, see FIGURE 9.

Also along the lower chord 144 of the truss there is mounted the closing limit switch 145 which has an operating spindle 146 and a button 147 thereon. When the button 147 is pushed upwardly by the door the switch 145 opens. When not pushed upwardly an internal spring in the switch will move switch 145 to the closed position.

Referring to FIGURE 9, L1 is connected through an "On-Off" switch to junction 150 and thence to one terminal 152 of the switch 143, just described, which is operated by a latch bolt 20 or a supplemental bolt movable in unison and having the same motion as a latch bolt. From the opposite terminal 153 of this switch, a line 154 extends to junction 155 and thence to a terminal 156 of a manually operated swtich 157, the opposite terminal 158 of which is connected to a line 159 and thence through the motor relay 160 which, when energized, causes the power to be applied to the motors of the system for closing the door. The circuit thence continues through line 161 to junction 162 on line L2. From junction 155 a line extends at 163 to a terminal 164 of the closing operating relay generally designated 165 and from the cooperating terminal 166 the circuit extends to a terminal 167 of the opening limit switch, generally designated 145, shown in FIGURE 11, and from the opposite terminal 168 of this switch, the circuit extends through the coil 169 of the motor relay (opening motion) and thence through the circuit 170 to terminal 171 on lines L2. When the motor relay 169 is energized, power is applied to the motors of the system for opening the door.

As shown in FIGURE 9, when the door 10 is raised, it will hit against the button 147 and open the "door open" limit switch 145. Also as shown, when the door is closed the latch bolt 20 (or a bolt operating in unison therewith) strikes the button 143A and opens the "door closed" limit switch 143. As illustrated, when bolt 20 is not in engagement with the button 143A an internal spring in the switch 143 closes this switch against its contacts 152–153.

From the line L1 at junction 172 a circuit extends via line 173 to terminal 174 of another contact of the closing preparation relay 165 and from the opposite terminal 175 of such contact, a circuit extends to junction 176 and thence through the coil 177 of the same relay 165 and through pilot lamp 165A to junction 178 on line L2. From the junction 176 a circuit extends back to one contact 179 of a manually operated switch 180, the opposite contact 181 of which is connected via line 182 to the junction 183 on line L1. The two switches 157 and 180, both manually operated, may most conveniently be housed in a single housing 200 which is mounted upon the frame 84, see FIGURE 3. I prefer that this housing 200 should be provided with a spindle 201 and an operative arm 201A and that the operating handle should have attached to it, at its upper end, an operating rod 202 which goes through a simple bracket 203 at operator lever and is provided with a handle 204. As shown in FIGURES 3 and 9, the rod is provided with a collar 202A against which springs 202B and 202C press, the springs also resting against bracket 203, so as thereby normally to hold rod 202 centered in its neutral (i.e. centered) position as shown in FIGURE 9. In this position switches 157 and 180 are open. When handle 204 is manually pulled down, switch 157 is closed and switch 180 is maintained open. When handle 204 is manually raised switch 180 is closed and 157 is maintained open. This operating rod may if desired be provided with two chains, one chain for opening the door and the other for closing the door. However, a stiff handle obviates the use of two chains (or chords). When the handle 204 is raised in the direction of arrow 205, the system is "prepared for opening" and opening will start when the latch bolts are released. When the operating handle 204 is pulled down, the door will close, but the handle must be held down through the entire closing operation. Referring to FIGURE 9, the operating stem 202 is illustrated by the dotted lines and when it is raised switch 180 is closed. When the stem 202 is lowered, switch 157 is closed, and the door closes. When stem 202 is raised, the "closing" motion of the door can be halted at any position.

Each of the motor relays is provided with the requisite number of contracts for handling the particular type of torque motor being used. Since single or multi-phase motors may be used, it will be understood that the two relays 160 and 169 are a junctive pair operating as the usual reversing relay systems for handling the control of a motor or motors for running in a forward direction and in a reverse direction. This is illustrated herein by providing output leads 207 from the relay 169 which are connected to the output leads 208 of the relay 160. Power input is via terminals 209 of relay 160 and 210 of relay 169. The power output for the relays to the motor is at the bracket M.

The operation of the systems is as follows: Assuming that the door is closed and latched, the handle 204 is raised, this closes switch 180 (but it does not close switch 157). The circuit is thereby established from junction 183 via line 182 to switch 180, junction 176, coil 177, and relay 165 to junction 178. This energizes relay 165 which closes contacts 174–175 thereby establishing a holding circuit from junction 172 via line 173, terminals 174–175 to junction 176. Contacts 164–166 of this relay are also closed. At this time, the door being in a closed condition, the opening limit switch 145 is closed against its contacts 167–168. However, the switch 143 is at this time open due to the fact that the latch bolt 20 is against the stem 143A of the switch 143. With the circuits thus prepared, the operator then goes to the door and pulls downwardly on the latch release rope 15 and this mechanically releases the upper portion of the door from the latches 142. At the same time, the bolt 20 which is in engagement with the stem 143A of the switch 143 is retracted downwardly to the level 141 as shown in FIGURES 9 and 10, thereby running out of engagement with the stem 143A. Accordingly, the internal spring of switch 143 closes that switch and a circuit is then established from junction 150 on line L1 via line 150A to terminal 152 and thence through switch 143 through terminal 153 and thence to junction 155. The circuit then continues via line 163 to the then closed relay contacts, 164–166, and the then closed limit switch 145 through the coil 169 of the motor relay (open) thence

via line 170 to the junction 171 on line L2. Motor relay 169 accordingly operates and energizes the motors of the system. Thus, power will be applied to the motor 85, see FIGURE 8, and to motor 131.

The opening movement of a door constructed as herein described and as illustrated in my application aforementioned, provided a motion which during the initial phases of the opening motion has a rapidly inward movement of the top of the door. However, there is very little upward motion on the cables at the time opening movement is initiated. Accordingly, motor 85 will begin to operate (rotate) much more quickly than the motor 131, but as the opening progresses, the motor 131 gradually increases speed and toward the fully opened condition the roller hangers 32 will not move nearly so fast as they did at the initial phases of the opening movement but, at the end portion of the opening movement, the cables 41–44 are being drawn in rapidly. The use of torque motors for this purpose is of an advantage since they may stall or run slowly whenever required while still providing the desired torque. As an alternative a fluid drive or friction clutch coupling may be used between the motor and the gear box.

The rotation of the motor 85 is imparted to each of the pulleys 76 and accordingly each door hanger assembly 105 is actuated. This causes the door to be moved toward the open condition. When the door reaches the fully open condition, the face of the door will lift against the opening limit switch actuating button 147 and this opens the switch 145, thereby deenergizing the relay 169 to stop the opening operation.

For closing the door the operator simply pulls down on the handle 204. This closes the switch 157 (but does not close switch 180). When this occurs, a circuit is established from junction 150 on line L1 through the then closed switch 143, to junction 155 and thence through the then closed switch 157 to line 159 and through coil 160 of the motor relay (closed) and line 161 to junction 162 on line L2. Accordingly, the motor relay 160 is closed and the closure of this contact provided power from source 209 through lines 208 to the two motors.

In this connection it is to be noted that stem 202 has on it a collar 202A which is biased to a central position by springs 202B and 202C which rest on frame supports 203—203. In the central position of stem 202, both switches 157 and 180 are open. It will be noted that the relay 160 remains closed only so long as the handle 204 is held down. This is a safety precaution because in closing a large door such as involved here, it is desirable that the operator monitor the operation closely and be in a position to instantly stop the closing motion, as for example, should the door engage some part of the airplane within the hangar. Assuming that the operation is unobstructed, the operator continues to hold the handle 204 downwardly and the door then runs to the fully closed position. It is recognized that there may be some slippage of the wire belts 114 with reference to some of their drive pulleys 76 and that the head of the door in moving toward the closed position may not be actually parallel to the bottom chord of the truss during all portions of that movement. However, the operator of the pulley 76 does move all of the belts 114 in unison and through the operating devices 105 applies a pressure against all of the backbones 10 to urge them toward the closed position and meanwhile the weight box is being elevated by the motor 131, where this is used. When the door moves to the closed position, some portions thereof may engage the bottom part of the truss before others and the limit switch 143 is accordingly located so that it will be operated only after through adjustment it is found that all of the latches 20 are moved to the latching position. The resiliency in the link mechanisms 116–121 provides some equalization of thrust against the inside of the door during the closing motion and a slight slippage in the wire belts 114 permits a portion of the door which may have reached closed position earlier than other portions to equalize with reference to other portions of the door. This is an advantage.

The following explanation is offered, without limitation upon the invention: In the operation of the door dual work inputs accordingly result from the dual forces applied to the door, the one being from motor 85 and drive 87 to shaft 90, and thence to the head of the door; the other being from motor 131, drive 132, shaft 133, drum 51 to cables 41–44. These two channels of work input are separate, complimentary and cooperative. The rate of work input via each of the two channels changes during the opening cycle and likewise changes during the closing cycle.

During the closing cycle (i.e. the door starts from the open position and is then closed) the rate of work input via motor 131 to drum 55 and to the cables 31–44 is maximum at the beginning of the closing cycle and diminishes to zero as the door approaches the vertical position at the end of the closing cycle, whereas simultaneously the work input to the head of the door via motor 85 and shaft 90, begins at a zero rate of work input when the door is horizontal (in the open position), or nearly so, and gradually builds to a maximum as the door approaches the vertical position and is latched. These two channels of work input complement each other in the cycle, insuring firstly a positive downward motion of the door at the beginning of the closing cycle and insuring secondly, a positive closing motion of the head of the door at the end of the closing cycle.

Similarly the dual channels of forces applied to the door and the resultant dual channels of work input complement each other during the opening cycle. Assuming the door to be closed (in the vertical position), at the beginning of the opening cycle, the work input via motor 85 and shaft 90 to the head of the door is at a maximum rate of work input, insuring a positive opening motion and firm withdrawal of the head of the door from its vertical position and from the latches where used, and this work input via this channel then diminishes through the partially open position and finally ends as a zero rate of work input at the end of the opening cycle, especially where the door rigging is such as to have the door horizontal when fully open. The more nearly such horizontal position, when open, the more nearly the work input via motor 85 and shaft 90 to the head of the door, will approach zero. In the illustrated embodiment, where, in the open position the door has a little slant (to shed rain, etc.) the work input via motor 85 and shaft 90 at the end of the opening cycle will be nearly but theoretically, not quite zero. Simultaneously, at the beginning of the opening cycle, when the door is vertical, the work input via motor 131 to drum 55 and to cables 41–44 will be at a zero rate, and as the opening motion progresses the work input via this channel increases and finally reaches full rate as the door proceeds to its terminal full open position. This insures that the door will reach such full open position.

Hence, in each cycle (opening and closing) the dual independent cooperating channels of work input complement each other in insuring full and positive operation of the door. This is especially helpful in very large doors and very heavy doors, and where windy conditions are encountered.

In FIGURE 12 there is schematically illustrated a layout of door and rigging for a large hangar door wherein the number of backbones and cables is an odd number (for example, five) and in which the weight box is made as two separate boxes, operated in tandem. In this layout, door 300D has five cables 341, 342, 343A and B, 344, and 345, and five tracks 321–325. There are two weight box drums 355A and 355B coaxially arranged in the hangar tailbay on cross shaft 355C which is provided with one sprocket 356 driven through chain 357 from sprocket 358 on speed reducer 359, which is driven by torque motor 331 (corresponding to motor 131 of FIG-

URE 2). All cables are suitably guided around pulleys as shown, so as to run from door 300D to one or the other of drums 355A or 355B. Thus cable 341 runs around pulleys 341–1 and 341–2 to drum 355A; cable 342 runs directly to drum 355A; cable 343A runs around 343A1 and 343A2 to drum 355A. Similarly cable 345 runs around pulleys 345–1 and 345–2 to drum 355B; cable 344 runs directly to drum 355B; cable 343B runs around pulleys 343B1 and 343B2 to drum 355B.

In this exemplary installation only three of the tracks (viz. 321, 323 and 325) are equipped with drives (viz. 361, 363, and 365) for moving the head of the door. These are identical with those shown in FIGURES 2 and 4–8 with the exception that intermediate tracks 322 and 324 are provided merely with bearings 322A and 324A for supporting the connecting pipe drive 380. The power input for this drive, via pipe shaft 390 is from speed reducer 87 from motor 85 as in FIGURE 8.

In FIGURE 15 there is illustrated the previously mentioned embodiment wherein a single motor is provided with a dual work output leading to shaft 90 and drum 55. Thus on frame 400, extending along the wingbay sidewall from the frame 56, there is mounted a motor 401 having two (double-end) output shafts. On shaft end 401A there is mounted a fluid-drive coupling 402 on the output shaft of which there is a sprocket 403 which through chain 404 drives sprocket 405 on shaft 406, the opposite end of which is coupled through angle gears 407 to shaft 90. On shaft end 401B there is similarly mounted another fluid drive coupling 408 the output shaft of which drives sprocket which is connected by chain 410 to and drives sprocket 411 on the shaft 133 of drum 55. The fluid drive couplings transmit torque to their output shafts, but the output shafts do not have to rotate. Accordingly, when motor 401 is running torque is applied to each of the shafts 90 and 133 in simultaneous dual driving relationship and these shafts 90 and 133 (drum 55) will rotate as previously described, as when driven indenpendently by separate torque motors.

In FIGURE 16 there is shown the previously mentioned embodiment of the invention wherein the shaft 90 and shaft 133 (of drum 55) are each independently driven by manually operated cranks. Thus in FIGURE 15, the shaft 133 on which drum 55 is keyed is provided with a sprocket 426 connected by chain 425 to lower sprocket 422 that is mounted on stub shaft 423 on plate 424 (adjustable up and down). Sprocket 422 is keyed to crank 421. This construction for driving drum 55 is illustrated and described in my Patent 3,118,189.

Shaft 90, which provides the work input to the head of the door is, in FIGURE 16, provided with a similar sprocket 432 which is connected by chain to be driven by sprocket 430 in stub shaft 428 on wall plate 427. Sprocket 430 has a crank 429 attached for rotating it.

Hence two men, independently applying torgue to cranks 421 and 429 can, in a very economical fashion handle the opening and closing of quite large doors. The sprocket drives for shafts 133 and 90 can be added as a mechanical safety factor in the power operated embodiments of FIGURES 2–3 and 14, for example, so as to allow door operation in the event of power failure, etc.

This exemplary installation shows the manner in which a larger door may be rigged and driven.

As many widely apparent different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments herein.

What is claimed is:

1. A door system, a flat panel overhead opening door, track means above the door and in a generally horizontal plane for translating the head of the door inwardly as it is opened, a plurality of cable hitch points on the exterior of the door, all of said cable hitch points being at a substantially horizontal hitch point level above the bottom of the door and below the middle of the door, counterweight means, drum means mounted in an elevated position remote from the door above said counterweight means, a plurality of cables extending one from each cable hitch point and each along its cable run to and thence partially around said drum means to and connected to the counterweight means below said drum means, means substantially at the hitch point level for guiding that level of the door up and down along a prescribed path, and a first power means connected to the drum means for simultaneously moving the cables, and second power means connected to the head of the door for translating the head of the door, said power means being independent and means for operating the independent power means simultaneously to move the head of the door towards closed position and for letting out the cables for lowering the body of the door, for closing it and vice versa, said system being characterized in that the first and second power means are independently connected to a single primary power unit each by means of drive coupling which permits slippage while transmitting torque.

2. In a door system a flat single panel overhead opening door, track means above said door and in a generally horizontal plane for translating the head of the door inwardly as it is opened, roller hanger means slidable mounted in said track, the head of said door being pivotally suspended from said hanger means, a plurality of cable hitch points on the exterior of the door, all of said cable hitch points being at a substantially horizontal hitch point level above the bottom of the door and below the middle of the door, counterweight means, drum means mounted in an elevated position remote from the door above said counterweight means, a plurality of cables extending, one from each cable hitch point and each along its cable run to and thence partially around said drum means to and connected to the counterweight means below said drum means, means substantially at the hitch point level for guiding that level of the door up and down along a prescribed path, first independent power means connected to the drum for applying a torque thereto in either direction selectively, shuttle means slidably mounted for movement generally paralleling said track means, means connecting the shuttle means to the head of the door and second independent power means for moving said shuttle for moving the head of the door and means connected to said first and second power means for simultaneously operating them for moving the head of the door away from closed position and for elevating the body of the door to open the door, and simultaneously operable, each in a reverse sense, for closing the door.

3. In a door system in accordance with claim 2 wherein a link means resiliently connects said shuttle and the head of the door.

4. In a door system in accordance with claim 2 in which said hanger means and shuttle means are pivotally connected at a common point to the head of said door.

5. In a door system in accordance with claim 2 wherein said second power means for moving said shuttle includes a roller shuttle member mounted on said track means, endless flexible drivers mounted on pulley means on said track means, means for rotating said pulleys equal peripheral amounts for driving said drivers equally, said shuttle means being connected to said drivers so as to be driven thereby.

6. In a door system a flat panel overhead opening door for a building, tracks above said door mounted in the building closed by said door, said tracks being in a generally horizontal plane for translating the head of the door inwardly as it is opened, roller hangers mounted in said tracks, the head of said door being pivotally connected from said hangers, a plurality of cable hitches on the exterior of the door, all of said cable hitches being at a substantially horizontal hitch level above the bottom of the door and below the middle of the door, a counterweight drum, means mounted in an elevated position

in the building and remote from the door above said counterweight, a plurality of cables extending one from each cable hitch, and each along its cable run to and thence partially around said drum means and to and connected to the counterweight below said drum means, means substantially at the hitch level for guiding that level of the door up and down along a prescribed path, shuttle means mounted for movement parallel to at least some of said tracks and connected to the head of the door, first independent motor means for applying a torque on said drum means for rotating it in either direction selectively to raise the counterweight for closing the door and for lowering the counterweight to raise the door, and second independent motor means connected to the shuttle means for independently moving said shuttle means in door closing or door opening direction coincidentally and in a direction to cooperate with and assist the movement of the door resulting from movement of the drum in a door-closing or a door-opening direction, and control means connected to said first and second motor means for operating them simultaneously and cooperatively in door opening and door closing directions.

7. In a door system a flat panel overhead opening door for a building, track means above said door mounted in the building closed by said door, said track means being mounted in a generally horizontal plane for translating the head of the door inwardly as it is opened, roller hangers mounted in said tracks, the head of said door being pivotally connected from said hangers, a plurality of cable hitches on the exterior of the door, all of said cable hitches being at a substantially horizontal hitch level above the bottom of the door and below the middle of the door, a counterweight, drum means mounted in an elevated position in the building and remote from the door above said counterweight, a plurality of cables extending, one from each cable hitches and each along its cable run to and thence partially around said drum means and to and connected to the counterweight below said drum means, means substantially at the hitch level for guiding that level of the door up and down along a prescribed path, shuttle means mounted in at least some of said tracks for movement therealong and connected to the head of the door, spaced pulleys mounted on each of said tracks having shuttle means, endless flexible drivers mounted on said pulleys, means for rotating said pulleys equal peripheral amounts for driving said drivers equally, said shuttle means being connected to said drivers and moved thereby, said shuttle means being connected to the head of the door for moving the head of the door when the drivers are moved, first, independent, reversible motor means connected to said pulleys for applying torque to said pulleys for rotating said pulleys in either direction for moving said shuttle means toward or away from door closed position, and second, independent, reversible motor means for applying the torque to the said drum for rotating it and control means connected to said first and second independent motor means for simultaneously energizing said first and second motor means for operating them simultaneously and cooperatively in a direction to rotate the drum and lower the counterweight coincidentally with the movement of the shuttle means away from the door-closed position to open the door, and vice versa.

8. In a door system in accordance with claim 7 in which said flexible drivers comprise endless belts frictionally driven by said pulleys, said pulleys being provided with means for maintaining said belts under constant tension.

9. In a door system a flat single panel overhead opening door, track means above said door and in a generally horizontal plane for translating the head of the door inwardly as it is opened, roller hanger means slidably mounted in said track, the head of said door being pivotally suspended from said hanger means, a plurality of cable hitch points on the exterior of the door, all of said cable hitch points being at a substantially horizontal hitch point level above the bottom of the door and below the middle of the door, counterweight means, drum means mounted in an elevated position remote from the door above said counterweight means, a plurality of cables extending, one from each cable hitch point and each along its cable run to and thence partially around said drum means to and connected to the counterweight means below said drum means, means substantially at the hitch point level for guiding that level of the door up and down along a prescribed path, first power means connected to the drum for applying a torque thereto in either direction selectively, shuttle means slidably mounted for movement generally paralleling said track means, means connecting the shuttle means to the head of the door and second power means for moving said shuttle for moving the head of the door as the first power means applies torque to the drum for moving the door open and closed, said system being further characterized in that it includes releasable latch means along the head of the door for mechanically holding the door against movement inwardly in an opening direction, latch release means for releasing said latch means, a control for said power-driven means including means actuated coincidental with the release of the latch means for initiating opening of said door, and means for controlling the opening of the door.

10. In a door system in accordance with claim 9 wherein said first and second power means is provided with means for controlling said first and second power means system for actuating them in door-opening and door-closing directions, said controller means including a circuit and manual means therein for preparing a circuit for operation of the power means in an opening direction and a control actuated coincidentally with release of said latch means for completing said circuit for thereby operating said power means to open said door.

11. In a door system a flat panel overhead opening door for a building, track above said door mounted in the building closed by said door, said track means being mounted in a generally horizontal plane for translating the head of the door inwardly as it is opened, roller hangers mounted in said tracks, the head of said door being pivotally connected from said hangers, a plurality of cable hitches on the exterior of the door, all of said cable hitches being at a substantially horizontal hitch level above the bottom of the door and below the middle of the door, a counterweight, drum means mounted in an elevated position in the building and remote from the door above said counterweight, a plurality of cables extending, one from each cable hitches and each along its cable run to and thence partially around said drum means and to and connected to the counterweight below said drum means, means substantially at the hitch level for guiding that level of the door up and down along a prescribed path, shuttle means mounted in at least some of said tracks for movement therealong and connected to the head of the door, spaced pulleys mounted on each of said tracks having shuttle means, endless flexible drivers mounted on said pulleys, means for rotating said pulleys equal peripheral amounts for driving said drivers equally, said shuttle means being connected to said drivers and moved thereby, said shuttle means being connected to the head of the door for moving the head of the door when the drivers are moved, first reversible motor means connected to said pulleys for applying torque to said pulleys for rotating said pulleys in either direction for moving said shuttle means toward or away from door closed position, and second reversible motor means for applying the torque to the said drum for rotating it and control means for simultaneously energizing said first and second motor means for operating them in a direction to rotate the drum and lower the counterweight coincidentally with

the movement of the shuttle means away from the door-closed position, to open the door and vice versa, said system being further characterized in that it includes releasable latch means along the head of the door for mechanically holding the door against movement inwardly in an opening direction, latch release means for releasing said latch means, and said control means includes means actuated coincidental with the release of the latch means for initiating opening of said door, and manual means for controlling the closing of the door.

12. In a door system in accordance with claim 11 wherein said control means includes a circuit and manual means therein for preparing a circuit for operating of the first and second power means in an opening direction and a control actuated coincidentally with release of said latch means for completing said circuit for thereby operating said power means to open said door.

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