Oct. 30, 1945. Z. C. BRADFORD 2,387,713

ACTUATOR

Filed June 27, 1944 2 Sheets-Sheet 1

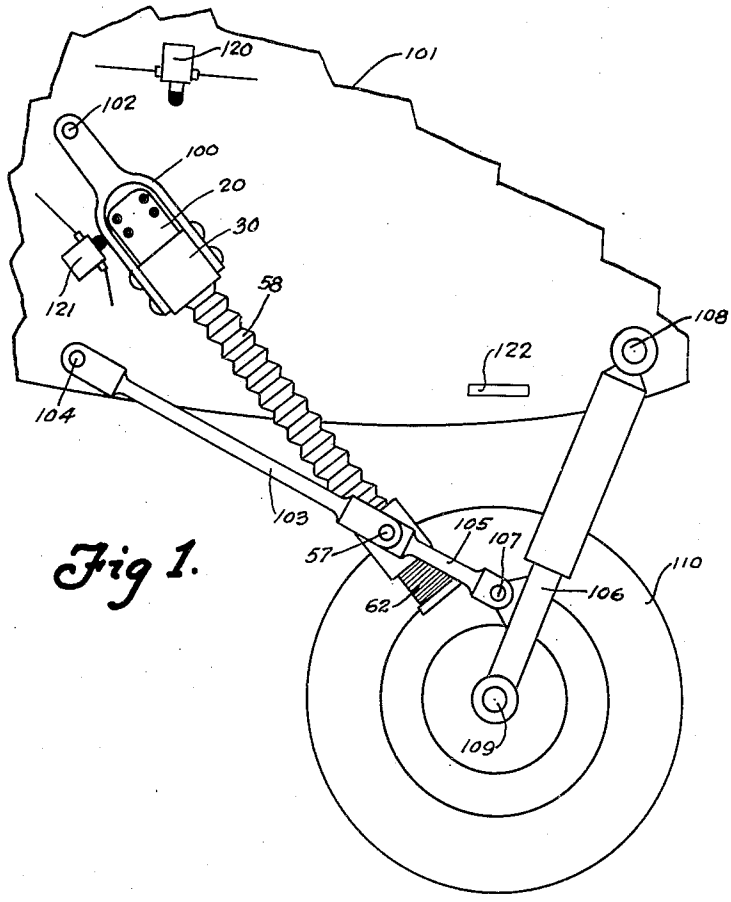


Fig 1.

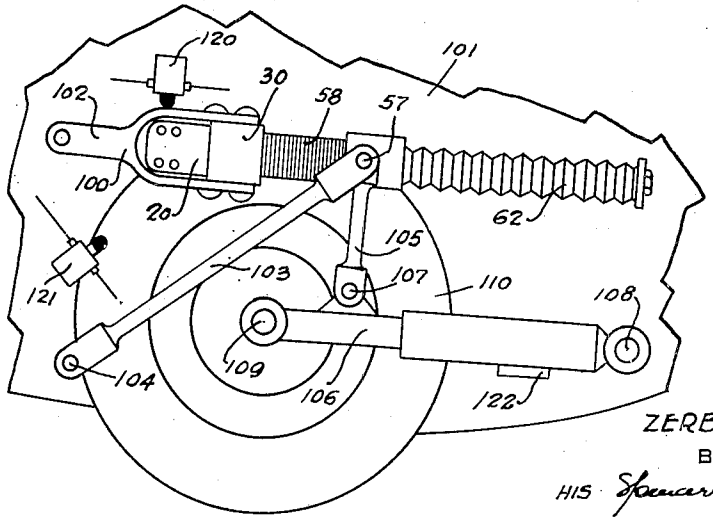


Fig. 2.

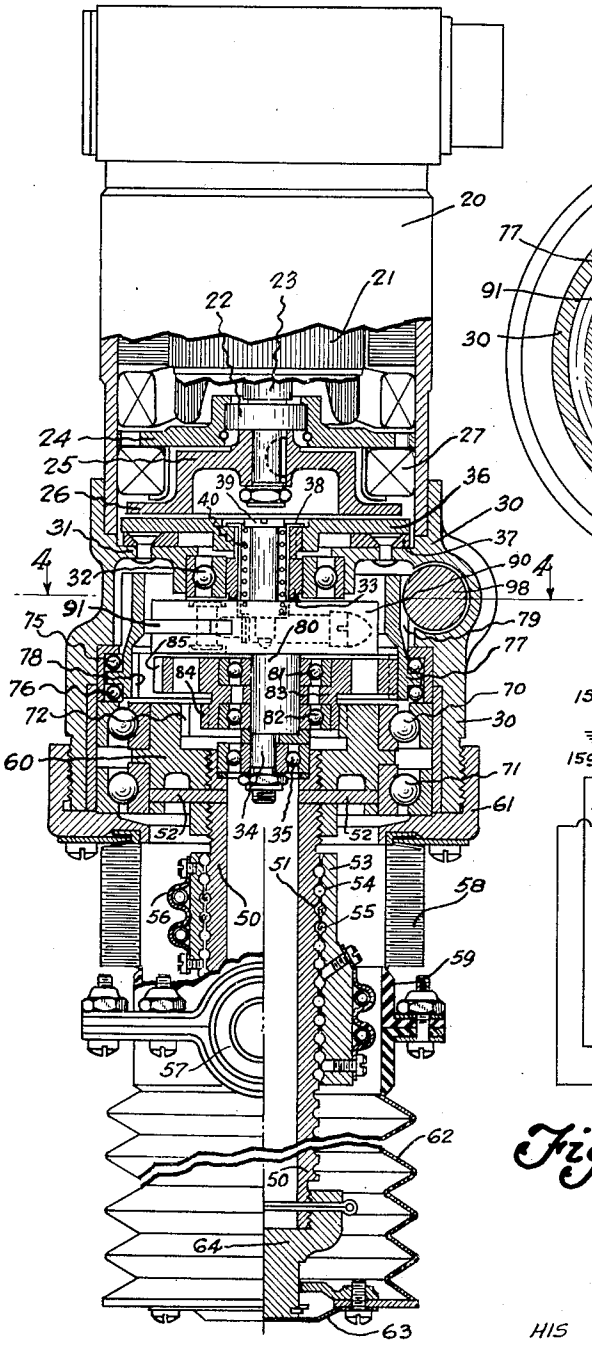
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Fig. 3



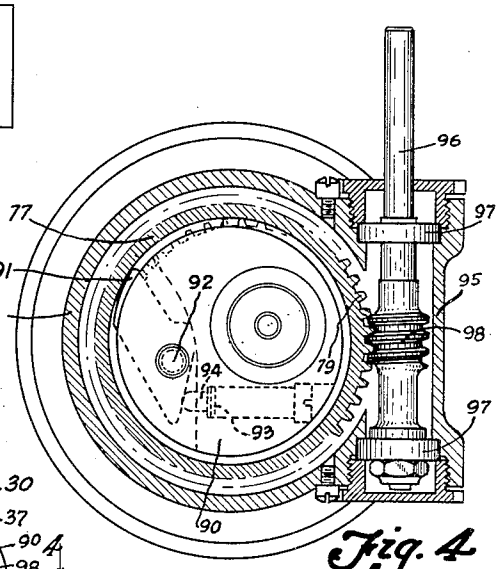


Fig. 4

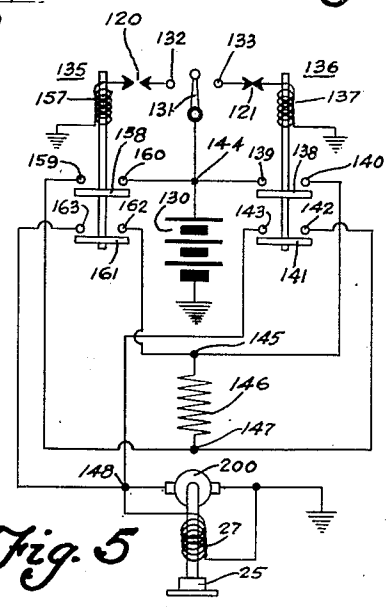


Fig. 5

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ACTUATOR

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4 Claims. (Cl. 74—291)

This invention relates to an improved actuator driven by an electric motor for raising and lowering a load.

It is among the objects of the present invention to provide an electrically driven load raising and lowering actuator which operates in either direction at a predetermined speed regardless of the influence of weight to increase its speed as the actuator is being operated to lower the weight.

A further object of the present invention is to provide a motor actuated load raising and lowering device having a braking member adapted to hold the device immovable while the motor is inoperative and having also a centrifugal brake adapted to retard the operation of the device when under the influence of the load being lowered, the speed of the device tending to exceed that at which the motor is rotating it.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred embodiment of the invention is clearly shown.

In the drawings:

Fig. 1 is a fragmentary view of one form of installation of the present device showing the device attached to the landing gear of an airplane for purposes of retracting and lowering said landing gear. In this figure the wheels are in the lowered position.

Fig. 2 is a view similar to Fig. 1, however, showing the landing gear wheel in its retracted position.

Fig. 3 is a longitudinal view partly in section and partly in elevation of the actuating device.

Fig. 4 is a transverse section with certain parts in elevation, the view being taken along the line 4—4 of Fig. 3.

Fig. 5 is a diagrammatic view showing the electrical devices and their electrical connections as used in the installation.

The actuator comprises a motor frame or housing 20 in which the motor armature 21 is supported by a ball bearing 22 at the one end of the armature shaft 23, the ball bearing being retained within a recess provided in a partition member 24 to the housing 20. The armature shaft 23 has a cup-shaped driving disc 25 keyed thereto so as to rotate therewith, said driving cup being provided with an outwardly extending annular flange 26, the peripheral edge of which lies adjacent the inner wall of the motor frame or housing 20. An electromagnet winding 27 is supported within the housing 20 and surrounds the driving cup 25.

A gear housing 30 is recessed to receive and support the one end of the motor housing 20. This housing 30 has a partition 31 centrally recessed to receive and carry the ball bearing 32. This ball bearing 32 provides a journal in which the end 33 of a stub shaft is supported, the opposite end of said stub shaft, designated by the numeral 34, being concentric with the end 33 thereof and being rotatably supported in a ball bearing 35. The end of the stub shaft portion 33 extending beyond the ball bearing 32 is formed to provide key-ways for receiving inwardly extending keys formed on the inner surface of the hub portion of the electromagnet armature disc 36, which disc normally rests upon and frictionally engages a brake ring 37 secured to the partition 31 in the housing 30. When in this normal position, that is, when resting upon the brake ring 37, the armature disc 36 lies horizontally with and is spaced from the annular flange 26 of the driving cup 25 secured to the rotating armature shaft 23 of the motor. A retainer cup extends into a recess formed in the stub shaft portion 33, said retainer cup having an outwardly extending flange 38 resting upon the upper surface of the armature disc 36. A headed screw 39 is secured in the stub shaft centrally of the recessed portion 33 thereof, said screw having a spring 40 surrounding it, the one end of said spring abutting against the under surface of the head of screw 39, the opposite end of the spring seating upon an inwardly extending flange provided on the retainer cup 38. This spring yieldably urges the armature disc 36 normally to engage the braking ring 37 inasmuch as the said armature disc is slidably keyed to the stub shaft portion 33.

A tubular screw shaft 50 having a helical groove 51 formed in its outer surface for substantially its entire length, is threadedly received by an annular gear 60 and is securely fastened to said gear by pins 52. The screw shaft 50 has a nut 53 thereon, the inner annular wall of which is provided with a helical groove 54 coinciding in size and pitch with the helical groove 51 formed on the screw shaft. Helical grooves 51 and 54 of the screw shaft and nut 50 and 53 respectively, coincide to form an annular helical passage in which a plurality of balls 55 are provided which act as threads mechanically to connect the screw shaft with the nut. Ducts 56 in the nut provide return passages for the ball tubes. This is a standard construction similar to that completely illustrated and described in the copending application of Calvin J. Werner, Serial No. 468,475,

filed Dec. 10, 1942. This nut 50 has a trunnion member 57 adapted to receive a lever supporting the rod raised and lowered by the actuating device. An accordion plaited seal 58 has its one end secured to a collar 59 attached to the trunnion 57, the opposite end of said seal being secured to a ring 61 interiorly threaded so as to be received by the threaded lower end of the gear housing 30. A similar accordion plaited sealing sleeve 62 has its one end secured to collar 59, the other end being secured to a fixture 63 attached to a member 64 which is secured to the lower end of the screw shaft 50.

The upper end of the screw shaft 50 is recessed to form a seat for the ball bearing 35 in which the lower end 34 of the stub shaft is journalled. Two ball bearings 70 and 71 are provided in the gear housing 30, said ball bearings rotatably supporting the gear 60. This gear 60 is recessed at its upper end to provide internal gear teeth 72. Two ball bearings 75 and 76 in the housing 36 rotatably support the annular ring gear 77 having an internal ring gear 78 at its lower end and an external ring gear 79 adjacent its upper end.

A portion of the stub shaft directly above the portion 34 journalled in bearing 35 and concentric with the screw shaft 50 is designated by the numeral 80 and is eccentric to the stub shaft portions 34 and 33. Two ball bearings 81 and 82 are supported by this eccentric portion 80 of the stub shaft, said ball bearings supporting a single member 83 providing two epicycloid gears, the numeral 84 designating the lowermost epicycloid gear, the teeth of which mesh with the teeth 72 of the gear 60, while the numeral 85 designates the other epicycloid gear, the teeth of which mesh with the interior gear teeth 78 of the ring gear 77. Another portion of the stub shaft which is designated by the numeral 90 being above the eccentric portion 80 of the upper end 33 of said stub shaft forms a counterbalance and also a means in which the centrifugal brake shoe 91 is pivotally supported. This pivotal brake shoe as illustrated in Fig. 4 is carried by a pin 92 secured in the counterbalance portion 90 of the stub shaft. A spring 93 urges a plunger 94 into engagement with one end of the centrifugal braking weight 91 normally urging it away from the adjacent inner annular wall of the portion of the ring gear 77 having the outer gear teeth 79.

Housing 30 has a tangential tubular extension 95 in which a shaft 96 is rotatably supported by bearings 97. Shaft 96 has a worm pinion 98 which meshes with the teeth 79 in the annular gear 77. Any suitable manual means for actuating the shaft 96 may be attached thereto. The shaft 96 with its worm pinion 98 meshing with the teeth 79 of ring gear 77 performs two functions, (1) the function of holding the ring gear 77 against rotation when the electric motor actuates the screw shaft 50, and (2) as a means for manually rotating the ring gear 77 to effect manual rotation of the screw shaft 50 when for any reason the electric motor is inoperative.

The Figs. 1 and 2 show one application of use for the improved actuator of the present invention. The gear housing 30 is secured to the forked end of a lever 100 which may be pivoted to the fuselage 101 of an airplane as at 102.

As has previously been described, the nut 53 operatively connects with the screw shaft 50 so that rotation thereof will cause the nut to move longitudinally in either direction on said shaft, provides a trunnion 57 to which the one end of the lever 103 is pivotally attached, the opposite end of said lever being pivotally secured to a pin 104 on the structure 101 of the airplane. The one end of another lever 105 is pivotally secured to the trunnion 57, the opposite end being hinged to the shock absorbing lever 106 by the pin 107. The one end of the shock absorbing lever 106 is hingedly secured to the pin 108 on the fuselage 101, the opposite end of said lever 106 providing the spindle 109 upon which the landing wheel 110 of the airplane is mounted. The diagrammatic Fig. 5 illustrates the electrical device applied to the installation as described in Figs. 1 and 2. The numeral 120 designates a limit switch closed to complete its circuit when the landing gear moves from its nested position toward its extended position as shown in Fig. 1 and opened to break its circuit when the landing gear is moved to its nested position as shown in Fig. 2. The numeral 121 indicates a similar switch opened to break its circuit when the landing gear is in its fully extended position as shown in Fig. 1 and closed to complete its circuit when the landing gear is moved from its extended position toward its retracted position as shown in Fig. 2. In its retracted position as shown in Fig. 2 the landing gear engages any suitable locking mechanism designated by the numeral 122 which securely holds the landing gear in this retracted position and takes all the load thereof from the trunnion 57 on the nut. To lower the landing gear from its retracted position to its extended position the operator must first actuate the mechanism represented by the numeral 122 to release the landing gear and permit its downward movement from the nested into its extended position. Inasmuch as this locking mechanism may be of any suitable standard construction, no detailed showing thereof has been made, the mechanism merely being represented in the Figs. 1 and 2.

The electric motor referred to as a whole by the numeral 200 is the prime mover of the present device. The source of power for operating this electric motor is shown to be a storage battery 130. One side of the battery is grounded, the other side is connected to the movable contact arm 131 of a selector switch having two stationary terminals 132 and 133 with which the movable contact 131 may be engaged to complete operating circuits. Two contactors 135 and 136 are provided automatically to control the motor circuit after the operator has actuated the selector switch contact 131 into the proper position to effect motor operation.

Assuming that the actuator is in the up or retracted position, in which position the nut is shown in the Fig. 3 and in which position the device is shown in Fig. 2 and assuming that the operator wishes to extend his landing gear for purposes of landing the plane, he will actuate the selector switch contact 131 clockwise so that it will engage the contact 133. Now current from the battery flows through the selector switch contact 131 to terminal 133 of said switch thence through the closed limit switch 121 through the magnet winding 137 of the contactor 136 back to the battery via ground connections. Current flowing through the magnet winding 137 will move the actuator 136 so that the bridging member 138 thereof connects stationary contacts 139 and 140 and the bridging member 141 thereof connects the stationary contacts 142 and 143. With the contactor 136 closed, current from the battery may now flow from the junction point 144 across

terminals 139 and 140 via the bridge 138 thence to the junction point 145 through the field winding 146 of the motor 200 to the junction point 147 thence across contacts 142 and 143 via the bridging member 141 to the junction point 148 at which point there will be a division of the current flow, a portion flowing across the armature of the motor 200 back to the battery via ground connections, the other portion of the current flow flowing through the electromagnet winding 27 and thus back to the battery via the ground connections. Completion of these circuits causes the electric motor 200 to operate and at the same time energizes the electromagnetic clutch winding 27 so that the armature disc 36 of the electromagnet clutch will be attracted and move out of engagement with the braking member 37 and into operative engagement with the motor driven ring 25 thereby to connect the rotating motor with the screw shaft 50 through the reduction gearing aforedescribed. The screw shaft 50 is now rotated in a direction causing the nut 53 thereon to move outwardly along the screw shaft away from the gear housing 30 toward the end member 64 on said screw shaft. As a result the levers 105, 103 and 106 are moved to lower the landing wheel 110 toward its extended position as shown in Fig. 1. It will be seen that as the wheel moves from the position as shown in Fig. 2, which is the full nested position, toward the position as shown in Fig. 1, which is the fully extended position, the enormous weight of the landing gear is applied upon the nut 53 and it will have a tendency to cause said nut to exert a turning effort upon the screw shaft 50 causing it and the speed reduction gearing and motor to be rotated at an excessive speed which might in time or under certain circumstances be dangerous. To avoid this, applicant has provided a centrifugal braking weight 91 in the stub shaft of the speed reducing gearing which, when the rotating speed of the shaft predeterminately exceeds the speed at which it is being driven by the electric motor 200 to lower the load, will move outwardly in response to centrifugal force, said weight frictionally engaging the inner surface of the annular gear 77 thereby braking the rotational speed of the reducing gear, retarding it and holding it below the danger limit. As soon as the landing gear reaches its fully extended position, the switch 121 through which the operating circuit of the motor is completed will be opened, thereby breaking the motor circuit and discontinuing its operation. During this time the limit switch 120 has been permitted to close, however its closing has no effect on circuits as long as the movable contact 131 of the selector switch is in neutral or even in engagement with the contact 133 of said switch.

When the operator desires to retract his wheels for flying purposes, the selector switch contact 131 is actuated to engage the stationary terminal 132. Switch 120 being closed as long as the landing gear is in extended position and being opened only when said landing gear has reached its fully retracted position, will now permit current to flow from the battery 130, selector switch contact 131 and its terminal 132 across switch 120 through the electromagnet winding 157 of the contactor 135 and back to the battery via ground connections. Energization of the winding 157 will cause the bridging element 158 to bridge contacts 159 and 160 and also the bridging member 161 to bridge contacts 162 and 163. Now current from the battery flowing to the junction point 144 may cross from contact 160 to contact 159 via the bridging member 158, then pass to the junction point 147 thence through the motor field winding 146 (in a direction opposite however to the flow when contactor 136 is effective) to the junction point 145 thence from contact 162 to contact 163 via the bridging member 161 to the junction point 148 where the same division of current flow takes place, one through the armature of the motor 200, the other through the electromagnet winding 27 thence back to the battery via ground connections. Now the motor operates in the opposite direction and the electromagnet winding 27 being energized will cause the motor again to be connected with the screw shaft 50, rotating it however in the opposite direction so that now the nut 53 thereon will be caused to move upwardly from the end member 64 toward the housing 30. As this occurs the landing gear wheel 110 will be lifted through its lever connections with the nut trunnion 57 and be moved into its nested position as shown in Fig. 2 where it will be held and maintained within the locking member 122 and where again switch 120 is opened and switch 121 is again closed. During this operation the centrifugal device is unnecessary, and therefore it has been designed so that the braking weight 91 thereof may move outwardly only in response to rotation of the speed reducing gearing in a direction to operate the screw shaft 50 so that it will lower the nut 53.

If at any time the electric motor 200 is rendered inoperative for any cause the operator actuates the manual mechanism attachable to the shaft 96 so that the shaft 96 will be rotated manually. Manual operation of the shaft 96 causes the worm pinion 98 to rotate the annular gear 77 and, due to the fact that the eccentric stub shaft is held against rotation by the engagement of the armature disc 36 with the braking ring 37 under the influence of the spring 40, this rotation of the annular gear 77 will rotate the epicycloid gear 83 about the eccentric portiton 80 of the shaft, causing said epicycloid gears to in turn effect a rotative effort upon the annular gear 72 which is secured to the screw shaft 50 and consequently by the manual operation of the worm pinion 98, the screw shaft 50 may be rotated independently of the electric motor.

From the aforegoing it has been shown that applicant has provided a motor actuated load raising and lowering device which is equipped with a braking member adapted to hold the device immovable while the motor is inoperative and thereby retain the load thereon in its position, said device having also a centrifugal brake designed and constructed to retard the operation of the device when, under the influence of the load being lowered thereby, the speed of the device tends to exceed that safe limit at which the motor is rotating.

While the embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a device of the character described, the combination with a screw shaft; a load supporting, travelling nut on said shaft; an electric motor for rotating said shaft in one direction to lift the load and in the opposite direction to lower the load; speed reducing gearing comprising two ring gears, the first held against rotation, the

second attached to the screw shaft and an epicyclic gear meshing with both ring gears; a stub shaft driven by the electric motor and having an eccentric portion upon which the epicyclic gear is rotatably supported; and a spring loaded weight pivotally carried by the stub shaft, said weight being operative to be thrown into frictional engagement with the first ring gear at a predetermined speed of the stub shaft, thereby providing a centrifugal brake for limiting the rotational speed of the screw shaft in the load lowering direction.

2. In a device of the character described the combination with a screw shaft; a load supporting, travelling nut on said shaft; an electric motor for rotating said shaft in one direction to lift the load and in the opposite direction to lower the load; speed reducing gearing for connecting the electric motor with the screw shaft, said gearing comprising two ring gears, one of which is normally held against rotation the second being attached to the screw shaft, a stub shaft driven by the motor and an epicyclic gear on the stub shaft and operatively engaging both ring gears; and a weight pivotally carried by the stub shaft said weight being operative to be thrown into frictional, braking engagement with the said one ring gear under the influence of the load on the downwardly moving nut, when the speed of said stub shaft predeterminately exceeds the speed at which the electric motor drives it in this one direction.

3. In a device of the character described the combination with a screw shaft; a traveling nut on said screw shaft, adapted to carry a load; a reversible electric motor; speed reducing gearing comprising a stub shaft driven by the electric motor, an epicyclic gear on the stub shaft and two ring gears meshing with said epicyclic gear, one normally held stationary the other secured to the screw shaft; means for connecting the stub shaft of the speed reducing gearing with the motor; and means for limiting the speed of the screw shaft when it is being rotated to move the nut to lower its load, said means comprising a centrifugal weight supported by the rotating stub shaft of the speed reducing gearing and adapted to be thrust into braking engagement with the stationary ring gear of the speed reducing gearing in response to rotation of the screw shaft in one direction at a predetermined speed.

4. In a device of the character described the combination with a screw shaft; a traveling load supporting nut threadedly carried by the screw shaft; speed reducing gearing comprising an epicyclic gear mounted on a stub shaft driven by the motor and meshing with two separate ring gears one of which is normally held against rotation the other being operatively connected to said screw shaft; a reversible electric motor; a brake member; an electromagnet clutch having a movable armature slidably keyed to the stub shaft of the speed reducing gearing and yieldably urged into normal gripping engagement with the brake member to hold the speed reducing gearing and the screw shaft attached thereto, against rotation, said electromagnet having a winding adapted to be energized when the electric motor is energized to run in either direction for moving the armature from the brake member, into operative engagement with the electric motor; and a centrifugal weight supported by the stub shaft of the speed reducing gearing said weight being operative frictionally to engage the non-rotatable ring gear for limiting the rotational speed of the screw shaft as it is being operated by the electric motor to move the nut for lowering the load.

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