This invention relates to electric motor driven actuating mechanisms, and particularly to an improved electric motor driven actuating mechanism for operating folding tops of motor vehicles.

Hitherto, the majority of actuating mechanisms for vehicular folding tops have been of the electrohydraulic type comprising an electric motor driven pump connected in closed hydraulic circuit with a pair of hydraulically operated actuators of the piston and cylinder type which are connected to the top linkage. Hydraulically actuated folding top mechanisms have not been entirely satisfactory since such systems do not ordinarily include means for limiting the maximum thrust of the hydraulic actuators; hydraulic systems are susceptible to leakage; and hydraulic systems do not maintain the top linkage under tension when the top is down. The present invention relates to an electric motor operated folding top actuating mechanism including a pair of mechanically synchronized cable driven actuators of the jackscREW type including means for maintaining the top linkage under tension when the top is either up or down.

Accordingly, among our objects are the provision of an improved electric motor driven actuating means for vehicular folding tops; the further provision of an electric motor operated folding top actuating means including means for automatically limiting the thrust thereof in both directions; the further provision of means for automatically deenergizing the electric motor when either actuator is subjected to an overload; and the Still further provision of means for automatically deenergizing the electric motor and control means therefor which maintain the top linkage under tension when the top is either up or down.

The aforementioned and other objects are accomplished in the present invention by embodying load sensing means in the form of a Belleville spring washer stack in each actuator for controlling limit switches when the actuator exerts a thrust of a predetermined magnitude in either direction. Specifically, the improved folding top actuating mechanism comprises a single reversible electric motor having a double ended output for rotating a pair of flexible drive shafts in synchronism. Each flexible drive shaft is drivenly connected through a gear reduction unit to a jackscREW. Each jackscREW is engaged by a nut carried by a tube assembly which is connected to one side of the top linkage. The gear reduction unit of each jackscREW is supported in a housing, and a spring housing is attached to each gear housing. The combined gear and spring housing assembly and the jackscREW is supported for limited axial movement in a mounting bracket by a pair of washers which are normally held in a predetermined spaced relation by a Belleville spring washer stack. A pair of limit switches are carried by the mounting bracket, and a switch arm for operating the limit switches is attached to the spring housing. When the jackscREW is subjected to a thrust load exceeding a predetermined magnitude in either direction, the spring and gear housing and the jackscREW moves relative to its mounting bracket thereby compressing the Belleville spring washer stack and opening one of the limit switches to deenergize the electric motor.

The control system for the actuating mechanism comprises an instrument panel mounted switch of the single pole double throw type for controlling the energization of an external or retract relay. The relays in turn operate switches for effecting energization of the split series reversible electric motor in the forward or reverse direction. The limit switches associated with each jackscREW are connected in series with the relay coils whereby the control circuit for the electric motor does not have to carry full motor current.

When the folding top is up, or moving from the down, or retracted, position to the up, or extended position, the electric motor will automatically be deenergized when either jackscREW exerts a predetermined thrust on the windshield header. During retraction of the top, the electric motor will be automatically deenergized when either jackscREW exerts a predetermined thrust on the top linkage when the top is fully lowered. In this manner the top linkage will be maintained under tension when the top is lowered thereby preventing rattles in the top linkage and reducing chafing action between the top fabric and the top linkage when the top is in the top well.

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 present invention is clearly shown, and wherein similar reference numerals depict similar parts throughout the several views.

In the drawings:

FIGURE 1 is a fragmentary view with certain parts broken away, partly in section and partly in elevation, of a vehicle having the folding top actuating mechanism of this invention.

FIGURE 2 is a fragmentary view, in elevation, of the folding top actuating mechanism in the extended position.

FIGURE 3 is an enlarged fragmentary view, partly in section and partly in elevation, of the left actuator in an extended position depicting the operation of the load sensing means, taken along line 3--3 of FIGURE 2.

FIGURE 4 is a schematic wiring diagram for controlling the motor.

FIGURE 5 is an enlarged fragmentary view, partly in section and partly in elevation, of the left actuator in the fully retracted position depicting the operation of the load sensing means.

FIGURES 6 and 7 are sectional views taken along lines 6--6 and 7--7, respectively, of FIGURE 5.

FIGURE 8 is a sectional view taken along line 8--8 of FIGURE 7.

With reference to FIGURE 1, a vehicle is depicted having a folding top 10 shown in the fully raised, or extended, position wherein it engages the header 12 of the windshield 14. The folding top 10 is retracted into a top well 16 located behind the rear seat 18. The folding top 10 includes a conventional collapsible top linkage, a portion of which is depicted by the numeral 20. The improved actuating mechanism of this invention comprises a reversible electric motor 22 suitably attached to the vehicle beneath the top well 16 and a pair of jackscREW actuators driven through flexible shafts 24 and 26. In the conventional manner, the jackscREW actuators are located in the side portions of the top well, the right hand actuator 28 being illustrated in FIGURE 1.

Referring to FIGURE 2, the electric motor 22 has a double ended output and is supported by a mounting bracket 32 attached to the motor housing by bolts 34. The mounting bracket 32 supports a pair of relays 36 and 38, the purpose of which will be pointed out more particularly hereinafter. The flexible shafts 24 and 26 are enclosed by casings 40 and 42, respectively, which carry Belleville spring washer stacks 44 and 46, respectively, for engaging externally threaded fittings on opposite ends of the motor 22. As alluded to hereinafter, the flexible shaft 24 is drivenly connected to the right hand actuator 28, and the flexible
shaft 26 is drivingly connected to the left hand actuator 30. Since the left and right hand actuators 30 and 28 are of identical construction with the exception of oppositely threaded jackscrews 48 and 50, respectively, a detailed description of one actuator is deemed to be sufficient. The jackscrews 48 and 50 threadedly engage angle cut nuts 114 and 116, respectively, carried by tubes 56 and 58, respectively, having clevises which are connected by pins 60 to parts of the top linkage 28, which connections prevent rotation of the tubes 56 and 58.

With particular reference to FIGURES 2, 3 and 6 through 12, each actuator includes a gear housing 62 having a tubular spring housing 64 attached thereto. The spring housing 64 has a pair of diametrically located axially extending slots 66 and a lower flanged edge 70 over which the end 72 of the gear housing 62 is swaged. The lower end of the jackscrew 48 or 50 is journaled in the gear housing 62 by a ball bearing assembly 74 and is suitably drivenly connected to a nylon or sintered iron worm gear 76 having an integral sleeve bearing portion 78 journaled in the end plate 80 of the gear housing 62.

The ball bearing assembly 74 comprises a combined thrust and radial bearing which precludes relative axial movement of the jackscrew and the gear housing 62. A thrust washer 79 is held in engagement with the end of the sleeve bearing portion 78 by a spun over end portion of the jackscrew.

As seen particularly in FIGURE 8, the gear housing 62 is connected to an integral angularly offset tubular portion 82 having a worm shaft 84 journaled therein. The worm shaft meshes with the worm gear 76 and constitutes a gear reduction unit for the jackscrew. The right hand end of the worm shaft 84 as seen in FIGURE 8 is journaled by a sleeve bearing 86 and has a recess 88 which receives a thrust ball 90. A lubricant wick 92 is arranged between the end of the shaft and a press-fitted thrust cap 93.

The left hand end of the worm shaft 84 is journaled by a sleeve bearing 96, a thrust washer 98 being disposed between the sleeve bearing 96 and a shoulder 100 on the worm shaft. The left hand end of the worm shaft 84 is formed with a noncircular recess 102 for driving connection to one of the flexible shafts 24 or 26. The casing for the flexible shaft is secured to the portion 82 of the gear housing by a nut 104.

Referring to FIGURE 3, a stack of Belleville spring washers 106 is disposed within the spring housing 64 between a pair of steel washers 108 and 110 having diametrically located radially extending fingers 112 and 114, respectively, projecting through the diametrically located slots 66 of the spring housing. The fingers 112 and 114 of the washers 108 and 110 also project through axially extending diametrically located slots 116 in a U-shaped mounting bracket 118 having a clevis 120 at its lower end as seen in FIGURE 2. Each leg of the U-shaped bracket 118 has a pair of spaced upstanding lugs 122 which extend through a U-shaped retainer plate 124 and are thereupon twisted as seen in FIGURES 3 and 6. The washer 108 normally engages the retainer plate 124 and the washer 110 normally engages the ends of the slots 116 in the bracket 118 to preload the Belleville spring stack.

The clevis 120 on the mounting bracket 118 is connected by a pin 126 to a mounting plate 128 that is rigidly secured to the floor 130 of the motor vehicle as seen in FIGURE 1. Accordingly, the actuator including the jackscrew, the gear housing 62, the spring housing 64 and the bracket 118 are free to pivot about the pin 126 relative to the floor of the vehicle during extension and retraction of the jackscrew.

The spring housing 64 is formed with a plurality of circumferentially spaced integral tabs 67, constituting movable abutment means, which normally engage the upper surface of the washer 108. The washer 110 normally engages movable abutment means comprising the upper end 63 of the gear housing 62. In addition, the spring housing 64 has a radially extending switch actuating arm 65 attached to its upper end, the end of the arm 65 being located between a pair of switch plungers 132 and 134 for actuating limit switches 136 and 138, respectively, attached to a switch bracket 140 suitably attached to the bracket 118. The mounting plate 140 and the retaining plate 124 are restrained against axial movement relative to the mounting plate 128. However, the gear housing 62 and the spring housing 64 as well as the washers 108 and 110 together with the jackscrew are axially movable relative to the mounting bracket 118 under overload conditions.

The tubes 56 and 58 carry nuts 52 and 54 which are press fitted therein and have a chamfered edge 144 engaging an internal shoulder 146 on the tube. The nuts 52 and 54 are slotted, and the tubes are slacked at 147 into the slots of the nuts so as to preclude relative rotation therebetween. The upper end of each jackscrew carries a snap ring 148 and a retainer 149 for preventing disengagement between the nut and the jackscrew.

With reference to FIGURE 4, the circuit for controlling the actuators will be described. The motor 22 is of the split series reversible direct-current type including an armature 150 having a commutator engaged by brushes 152 and 154. The brush 152 is connected through a thermal overload circuit breaker 156 to ground. The brush 154 is connected by wire 158 to the ends of series field windings 160 and 162. The other end of forward, or extend, rotation series winding 160 is connected to a stationary contact 166. Contact 164 can be engaged by movable contact 168 upon energization of a relay coil 170, and contact 166 can be engaged by movable contact 172 upon energization of a relay coil 174. The coils 170 and 174 constitute relay 36, and the coil 174 and the switch 166, 172 constitute relay 38. The contacts 168 and 172 are connected by a wire 176 to one terminal of a battery 178, the other terminal of which is connected to ground. One end of relay coil 170 is connected to the switch contact 168, and the other end is connected through a pair of limit switches 138L and 138R to a stationary contact 180 of a single pole double throw manually operable switch 182. Similarly, one end of relay coil 174 is connected to the contact 172, and the other end of relay coil 174 is connected to a pair of limit switches 136L and 136R to a second stationary contact 184 of the single pole double throw switch 182.

Since the instrument panel mounted, manually operable switch 182 only controls the energization of the relay coils 170 and 174, this circuit carries relatively low current, whereas the high motor current is carried by the circuit including the relay operated switches.

With particular reference to FIGURE 5, operation of the load sensing means and automatic deenergizing of the motor 22 when the folding top is fully retracted, or lowered, and maintained under tension, will be described. During retraction operation, the jackscrew is rotated in a direction causing the nut 52 and its tube to move downwardly from the position of FIGURE 3 to the position of FIGURE 5. When the top is completely retracted, further movement of the top linkage 26 and the tube is arrested by a cylindrical rotation of the jackscrew will cause the jackscrew, the gear housing 62, the spring housing 64 and the washer 110 to move axially upward relative to the mounting bracket 118 and the washer 108. The washer 110 in moving upwardly relative to the washer 108 will compress the Belleville spring stack 106. When an upward thrust load of approximately 800 lbs is exerted on the Belleville spring stack 106, the spring housing 106 will be in the full line position of FIGURE 5 where the actuating arm 65 engages the switch plunger 132 thereby opening the limit switch 136 to de-energize the retract circuit of the motor 22. In this manner continued energization of the motor 22 in the
retraction due to manual operation of the switch 182 will be precluded. The normal operating position of the spring housing 64 and the switch arm 65 is shown in phantom lines in FIGURES 3 and 5. It is pointed out that the load sensing means is also operative at any position of the folding top during retraction if the top mechanism should engage an obstruction or otherwise become locked, immovable, so as to prevent damage to the actuating mechanism. Furthermore, when the top is fully retracted the Belleville spring stock 106 is maintained under compression by the washer 110 thereby maintaining a tension load on the top linkage so as to prevent rattling thereof and chafing of the top fabric within the top well.

Referring to FIGURE 3, when the actuator is moved from the retracted position to the fully extended position wherein the top engages the windshield header, upward movement of the tube and its nut 52 is restrained whereupon continued rotation of the jack screw will result in downward movement of the jack screw, the gear housing 62, the spring housing 64 and the washer 108 relative to the washer 110 and the mounting bracket 118. When the washer 105 moves downwardly relative to the mounting bracket 118, it compresses the Belleville spring stock 106, and when the predetermined thrust load of 800# is exerted on the Belleville spring stock 106, the switch actuating arms 65 engage the switch plunger 134 so as to open the limit switch 135. When limit switch 135 is opened, the forward, or extend energizing circuit of the motor 22 will be automatically interrupted thereby deenergizing the motor. Moreover, the load sensing means will operate to automatically deenergize the motor 22 at any point in the extending movement of the actuator if an obstruction should be engaged which prevents movement of the folding top.

In operation, both the right and left hand actuators 28 and 30 are mechanically synchronized since the flexible shafts 24 and 26, respectively, are driven by the single motor 22. Accordingly, the jack screws driven by the flexible shafts 24 and 26 will actuate the top linkage 20 in a manner which prevents canting thereof during extension and retraction. Furthermore, since each actuator includes load sensing means, the motor 22 will automatically be deenergized when either actuator is subjected to the predetermined thrust load for instance 800#, thereby preventing damage to the actuating mechanism as well as the top linkage in instances where movement of the folding top becomes obstructed on either side, or the folding top is misaligned relative to the windshield header of the vehicle.

While the embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. Folding top actuating mechanism including, a reversible electric motor, a pair of actuators, each actuator comprising a rotatable and axially movable jack screw and a nonrotatable nut threadedly engaging each jack screw, a housing for each jack screw, means rotatably journaling each jack screw in its respective housing, means drivingly connecting both of said jack screws with said reversible electric motor, a gear housing for each housing, means interconnecting each housing and its respective mounting bracket for restraining relative rotation therebetween while permitting relative axial movement therebetween, preload spring means reacting between each mounting bracket and its respective housing for retarding retraction of axial movement of each housing and its respective jack screw relative to its mounting bracket when its respective jack screw is subjected to a thrust load of a predetermined magnitude in either direction.

2. A screw and nut actuator comprising, a mounting bracket, a housing supported for axial movement relative to said mounting bracket, a jack screw rotatably journaled in said housing, a nut threadedly engaging said jack screw, preload spring means reacting between said bracket and said housing for normally restraining axial movement of said jack screw, an electric motor drivingly connecting the said jack screw for rotative movement, a limit switch attached to said bracket, and a switch actuator attached to said housing for opening said limit switch in response to axial movement of said housing and said jack screw when said jack screw is subjected to a thrust load of a predetermined magnitude.

3. A screw and nut actuator including, a mounting bracket, a housing supported for axial movement relative to said mounting bracket but restrained against rotation relative thereto, a jack screw rotatably journaled in said housing, a nut threadedly engaging said jack screw, preload spring means reacting between said housing and said bracket for normally restraining axial movement of said housing and said jack screw relative to said bracket, a reversible electric motor drivingly connected to said jack screw, a pair of limit switches connected in circuit with said motor and with said bracket, and a switch actuating arm attached to said housing for opening one or the other of said limit switches in response to axial movement of said housing and said jack screw in either direction relative to said mounting bracket when the jack screw is subjected to a thrust load of a predetermined magnitude in either direction.

4. A screw and nut actuator including, a U-shaped mounting bracket having a pair of upstanding legs with diametrically located slots therein, a housing assembly disposed between the legs of said bracket and having a pair of diametrically located slots in radial alignment with the slots in said bracket legs, a pair of spaced washers having radially extending fingers projecting through the aligned slots in said housing assembly and said bracket legs, a preload Belleville spring washer stack disposed between said spaced washers and normally urging said washers in opposite directions into engagement with spaced abutment means on said housing assembly, a retaining plate interconnecting the legs of said bracket adjacent the upper ends thereof, a jack screw rotatably journaled in said housing assembly, and a nonrotatable nut threadedly engaging said jack screw whereby said jack screw is subjected to a thrust load of a predetermined magnitude in either direction said jack screw and said housing assembly will move axially in one direction or the other relative to said mounting bracket thereby compressing said Belleville spring stack.

5. The screw and nut actuator set forth in claim 4 including a reversible electric motor drivingly connected to said jack screw, a switch bracket attached to said mounting bracket, a pair of limit switches attached to said switch bracket and connected in circuit with said motor, and a switch actuating arm attached to said housing assembly for opening one of said limit switches in response to axial movement of said housing assembly and said jack screw relative to said mounting bracket in either direction.

6. A screw and nut actuator including, a U-shaped mounting bracket having a pair of upstanding legs with diametrically located slots therein, a housing assembly disposed between the legs of said bracket and capable of axial movement relative thereto, said housing assembly comprising a gear housing and a spring housing rigidly attached thereto, said spring housing having a pair of diametrically located slots in radial alignment with the slots in the legs of said bracket, a pair of spaced washers disposed within said spring housing having radially extending fingers projecting through the aligned
slots in said spring housing and said bracket legs, a retaining plate interconnecting the legs of said bracket adjacent the upper ends thereof, a preloaded Belleville spring washer stack disposed between said spaced washers and normally urging said washers in opposite directions into engagement with spaced movable abutment means on said housing assembly and said retaining plate and the ends of the slots in said bracket legs, said movable abutment means on said housing assembly comprising a plurality of circumferentially spaced inwardly extending tabs on said spring housing and the upper surface of said gear housing, a jackscrew rotatably journaled in said gear housing, and a nonrotatable nut threadedly engaging said jackscrew whereby when said jackscrew is subjected to a thrust load of a predetermined magnitude in either direction said jackscrew and said housing assembly will move axially in one direction or the other relative to said mounting bracket thereby compressing said Belleville spring washer stack.

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Certificate
Patent No. 3,049,935

Milton E. Simmons and Carl J. Finsterwalder

Application having been made jointly by Milton E. Simmons and Carl J. Finsterwalder, the inventors named in the patent above identified; General Motors Corporation, Detroit, Michigan, a corporation of Delaware, the assignee; James D. Leslie, Birmingham, Michigan, and Wilson H. West, Royal Oak, Michigan, for the issuance of a certificate under the provisions of Title 35, Section 256 of the United States Code, adding the names of the said James D. Leslie and Wilson H. West to the patent as joint inventors, and a showing and proof of facts satisfying the requirements of the said section having been submitted, it is this 18th day of August 1963, certified that the names of the said James D. Leslie and Wilson H. West are hereby added to the said patent as joint inventors with the said Milton E. Simmons and Carl J. Finsterwalder.

[SEAL]

EDWIN L. REYNOLDS,
First Assistant Commissioner of Patents.