United States Patent

Flagge

[15] **3,686,983**

[45] **Aug. 29, 1972**

[54] **TORQUE APPLYING AND TENSION CONTROLLING DEVICE**

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[73] Assignee: **Thor Power Tool Company,** Aurora, Ill.

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[21] Appl. No.: **56,402**

[52] **U.S. Cl.** **81/52.4,** 173/12

[51] **Int. Cl.** **B25b**

[58] **Field of Search** 81/52.4, 52.5; 173/12

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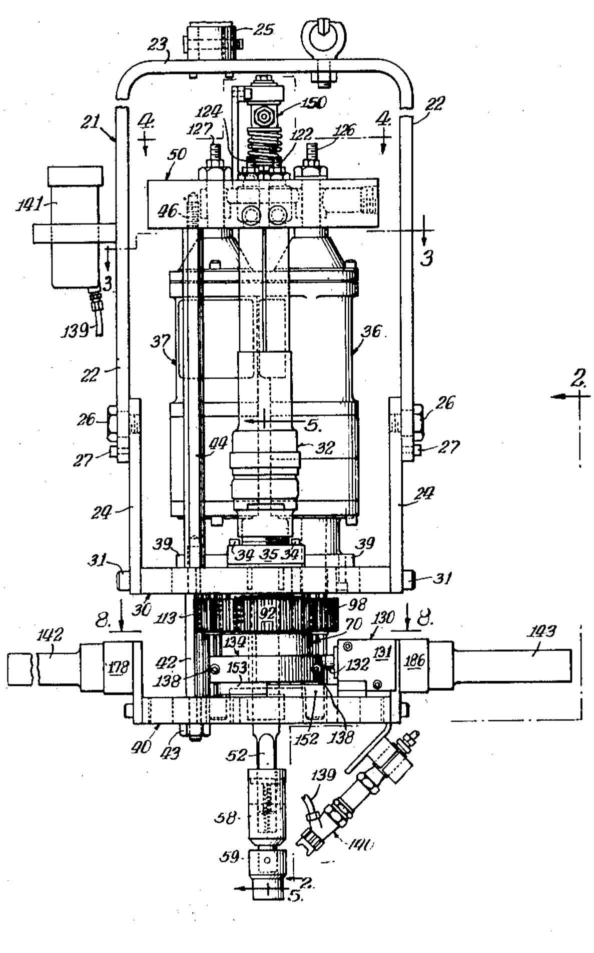
[57] **ABSTRACT**

A torque transmitting and controlling device is disclosed, wherein at least one fluid motor having a low stall torque is connected to one end of a shaft and is adapted to apply a predetermined low torque to one of a pair of threaded members connected to the other end of the shaft. At least one other fluid motor is connected to the shaft through an overrunning clutch so that the first motor is prevented from driving the second fluid motor during the low torque applying operation. When fluid under pressure is supplied thereto, the second fluid motor rotates the shaft an additional number of degrees to develop a desired tension in one or the other of the threaded members. A cam carried by one of the rotatable parts of the device actuates a valve in the fluid circuit of the device to shut off the flow of fluid to the second fluid motor after the shaft has rotated the additional number of degrees. At the completion of the torquing and tensioning operation, the device automatically applies a mark to structure adjacent the threaded members to indicate that the members have been tensioned. During or after disengagement of the device from the threaded members, an automatically or manually actuated valve in the fluid circuit of the device causes the first fluid motor or a separate fluid motor to rotate the shaft in a direction opposite from the direction of rotation thereof during the torquing operation until a pair of stops respectively carried by one of the parts of the overrunning clutch and the supporting frame of the device engage each other. The spacing between the two stops is adjustable to permit adjustment of the final tension obtained in one or the other of the threaded members.

19 Claims, 18 Drawing Figures



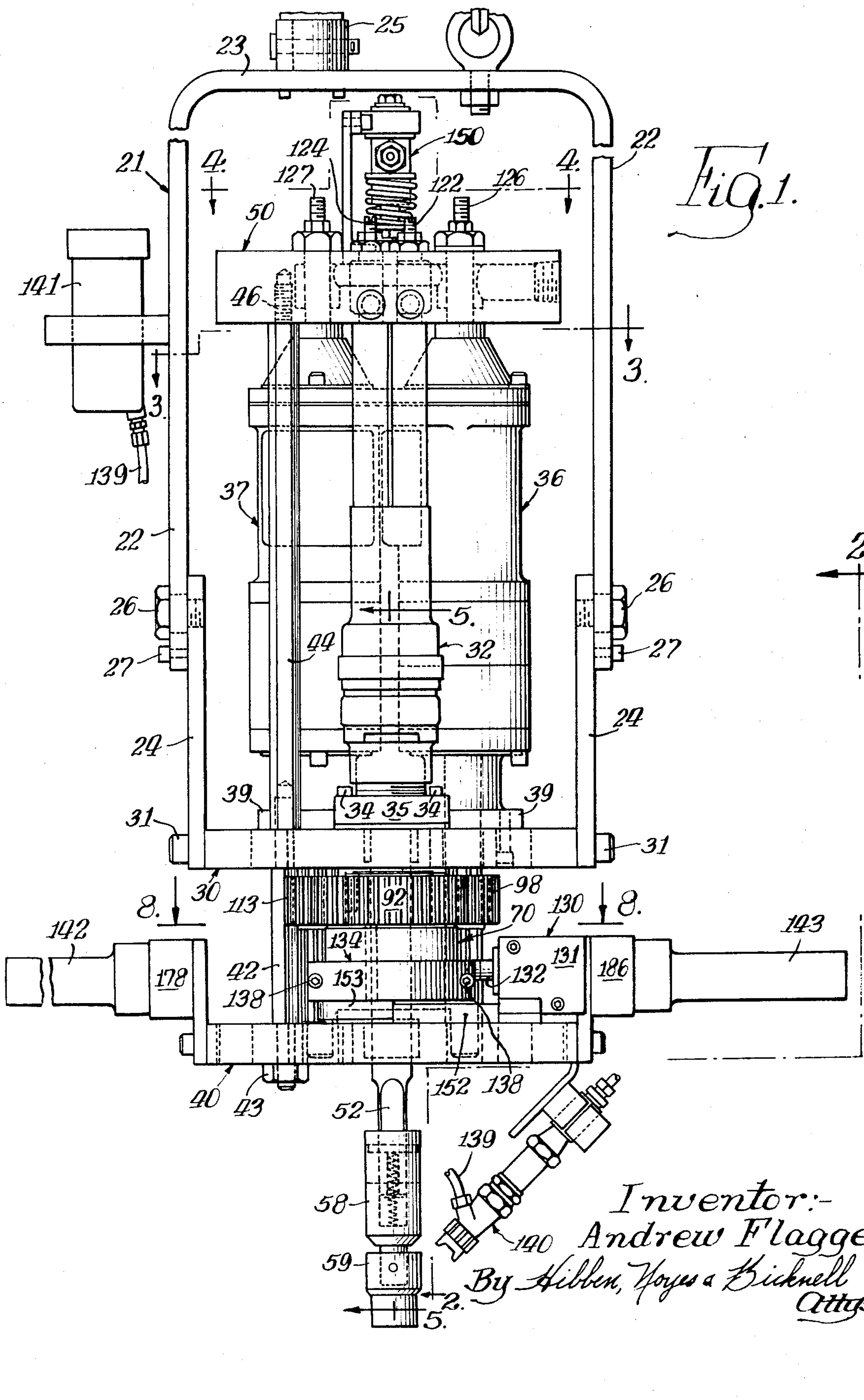


Fig. 1.

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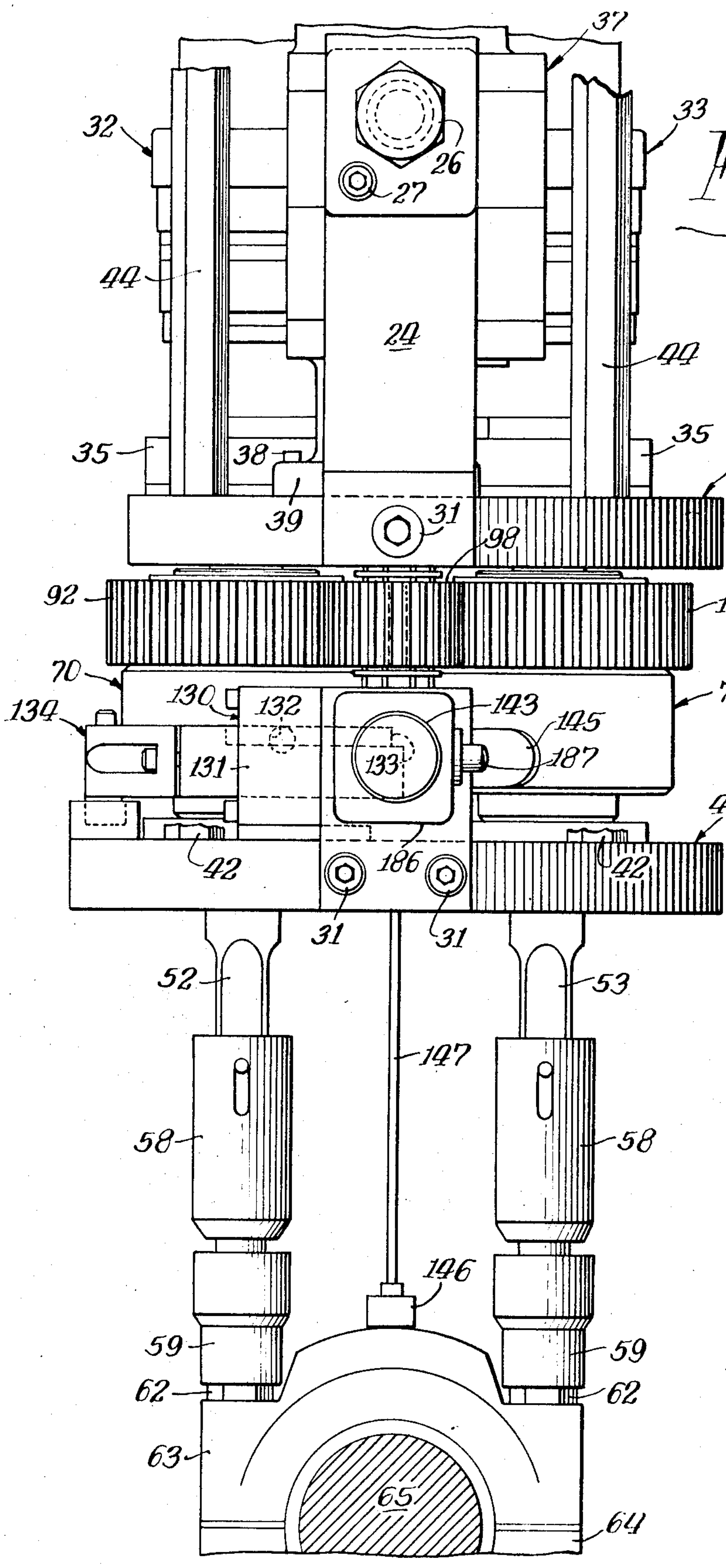
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Fig. 2.

Fig. 3.

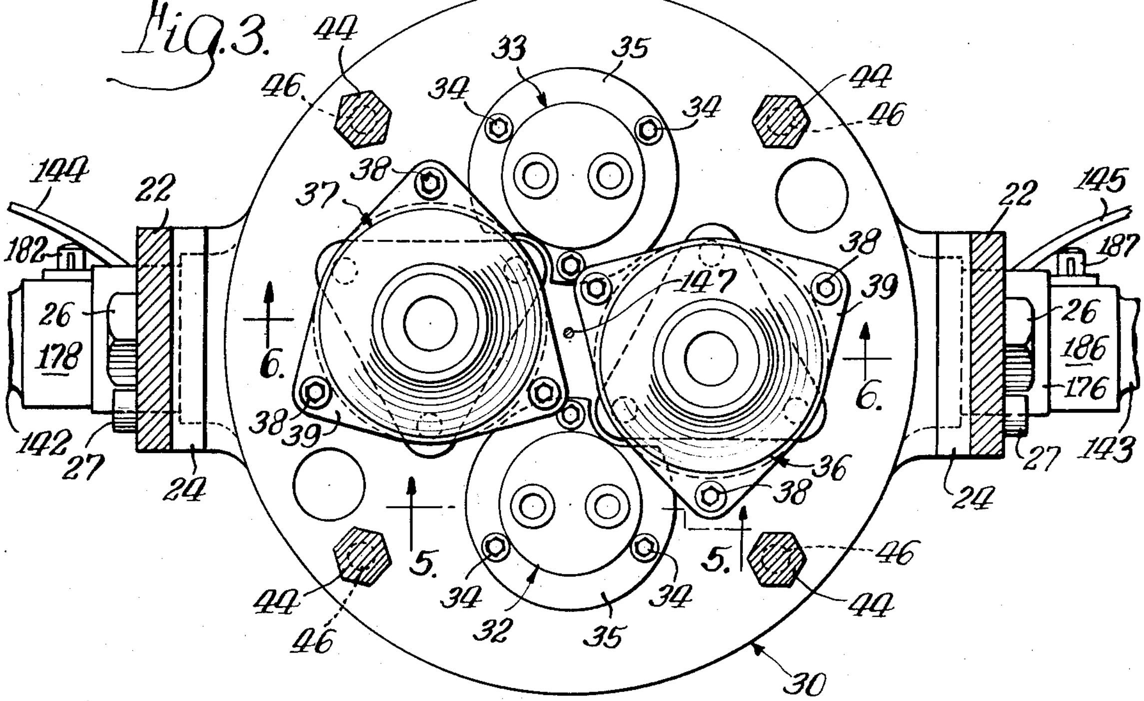
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Fig. 4.

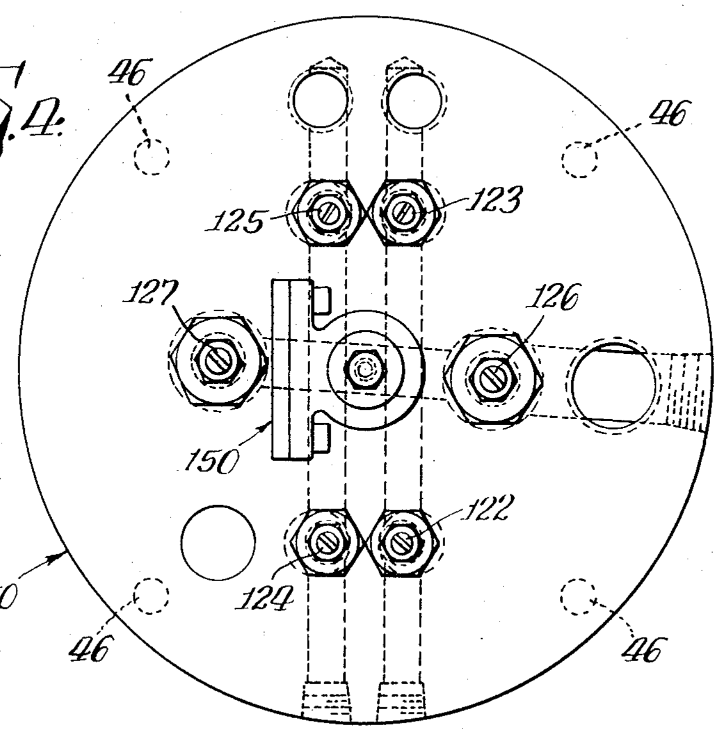
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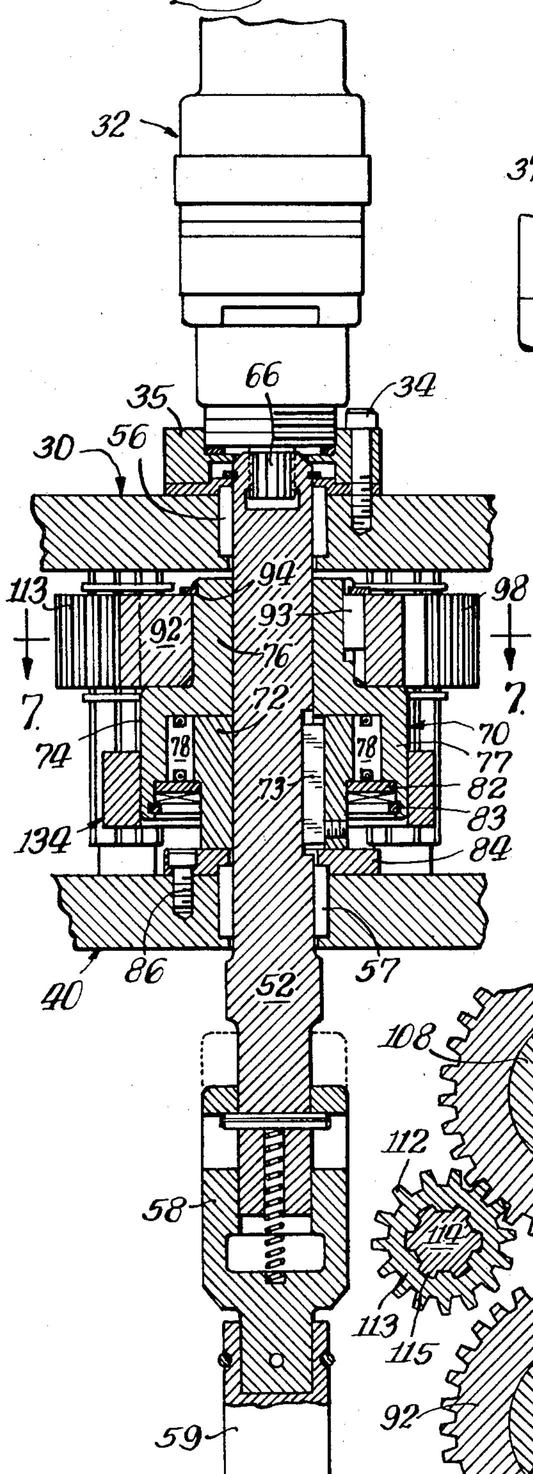
Fig. 5.



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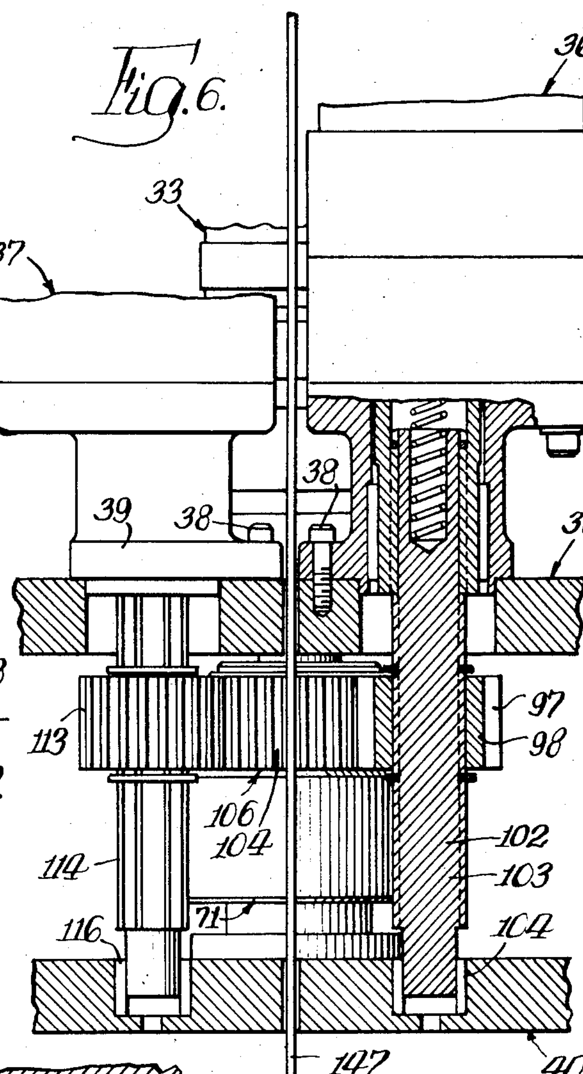

Fig. 7.

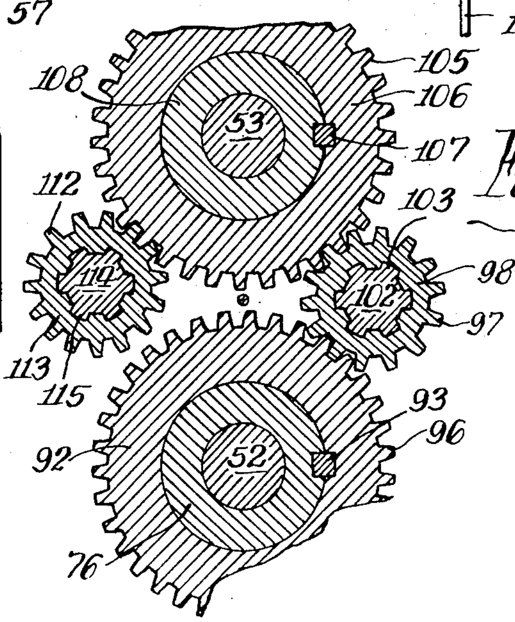

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Fig. 8.

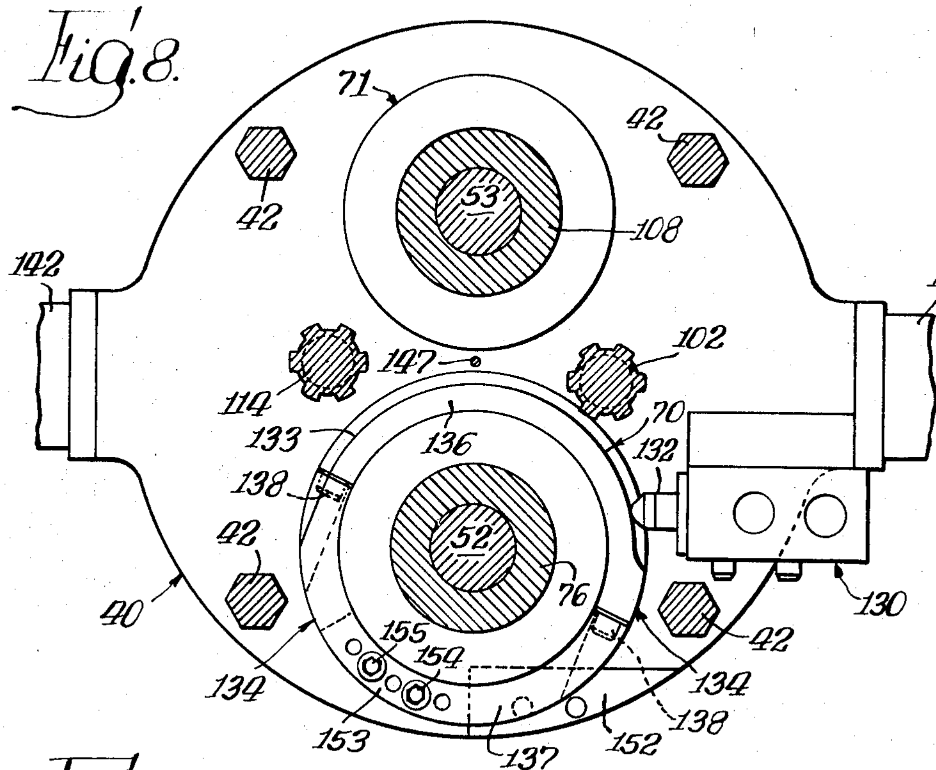
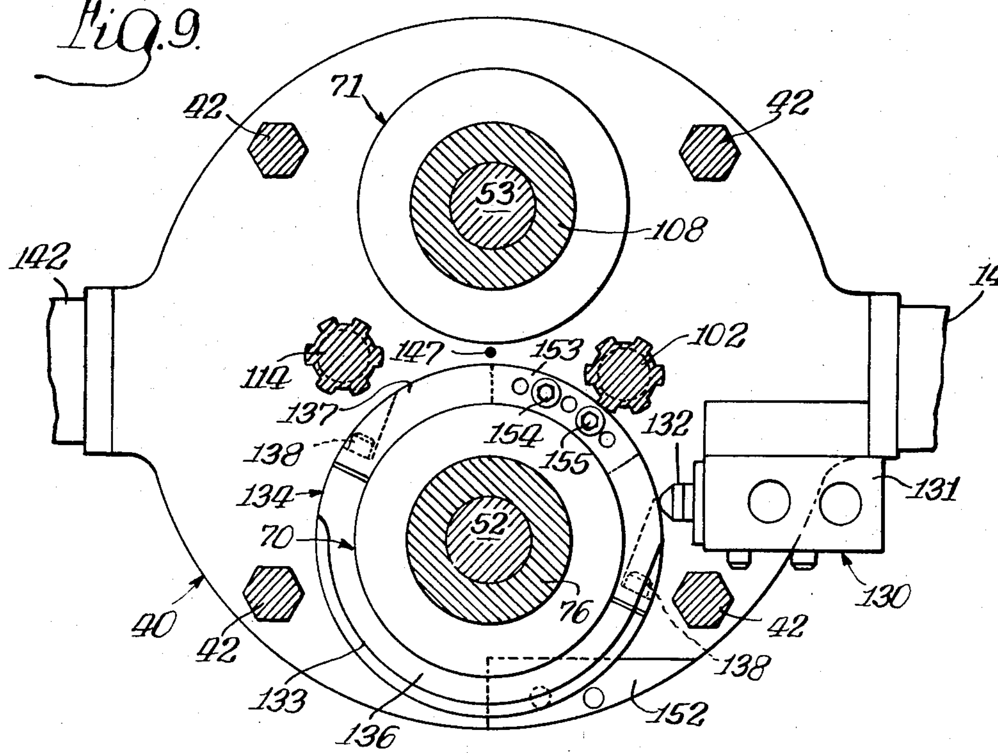


Fig. 9.



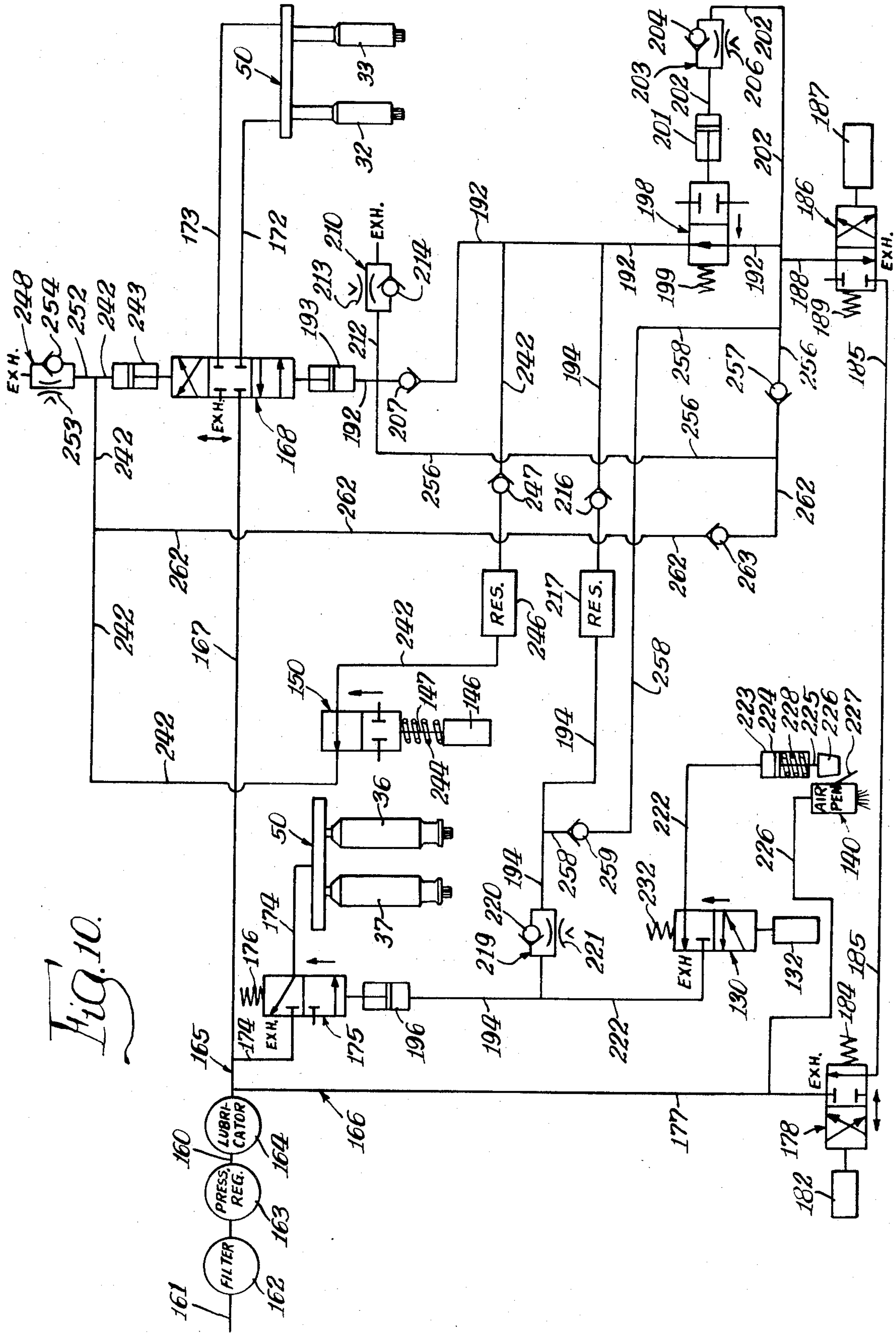


FIG. 10.

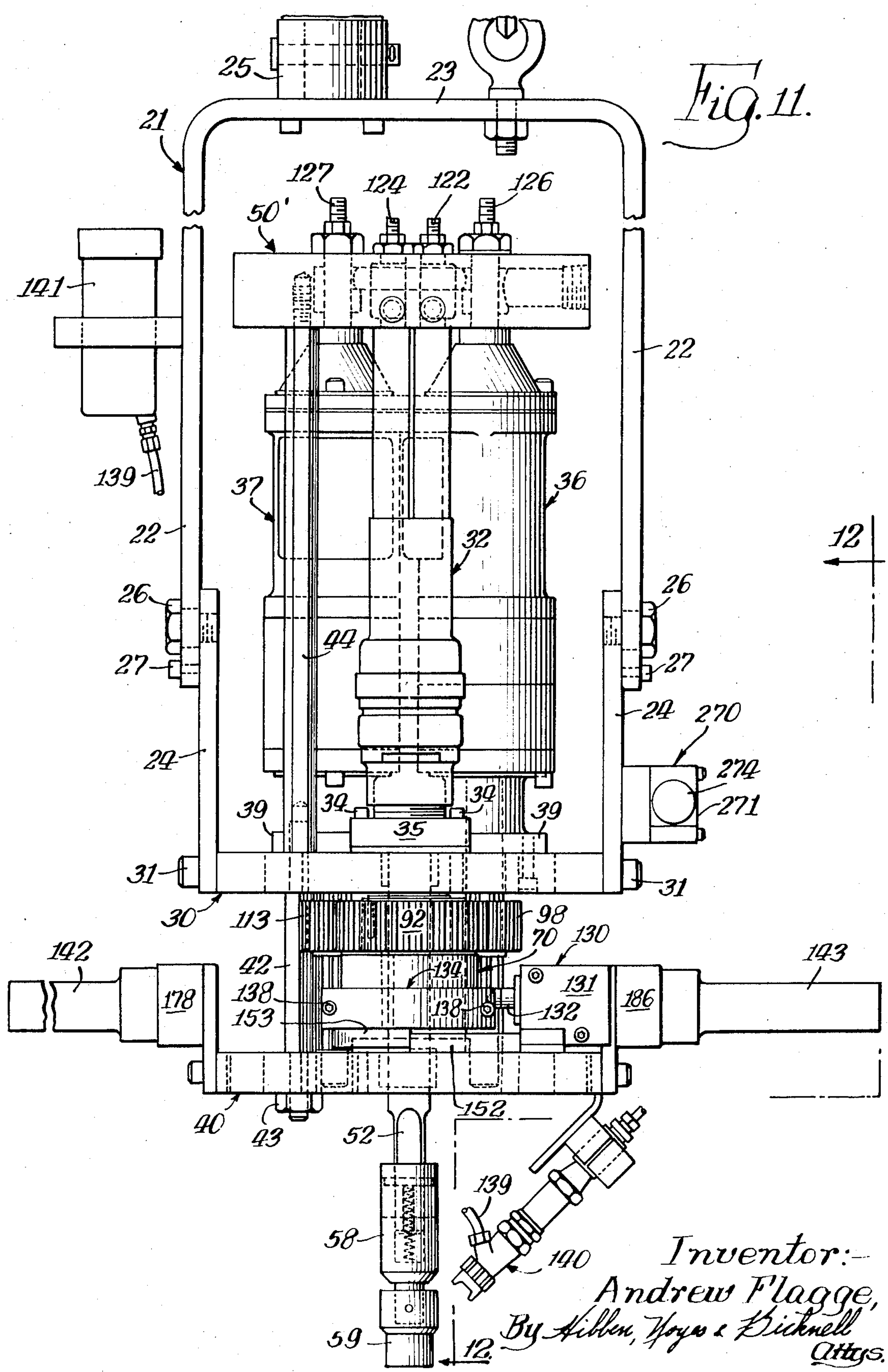


Fig. 11.

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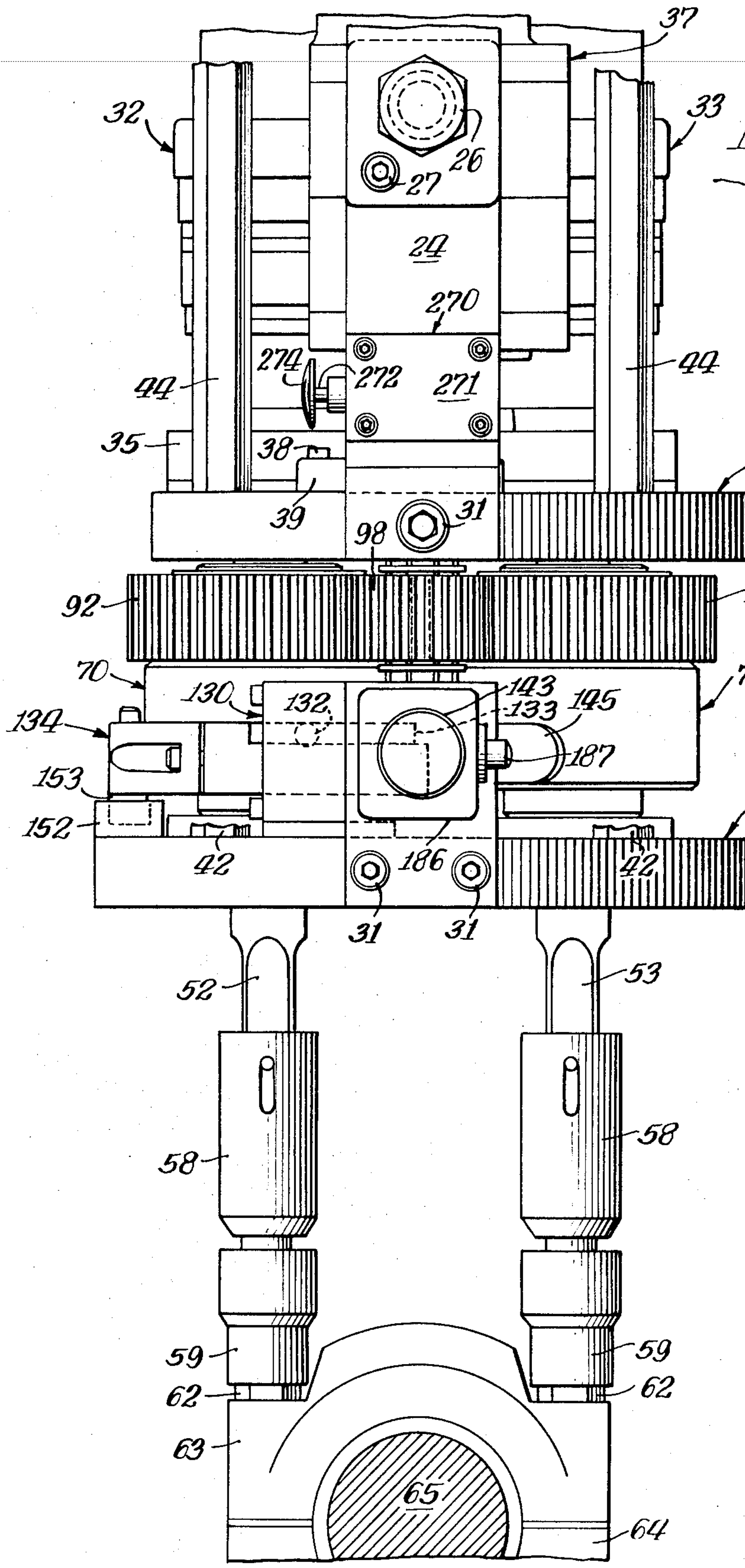
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Fig. 12.

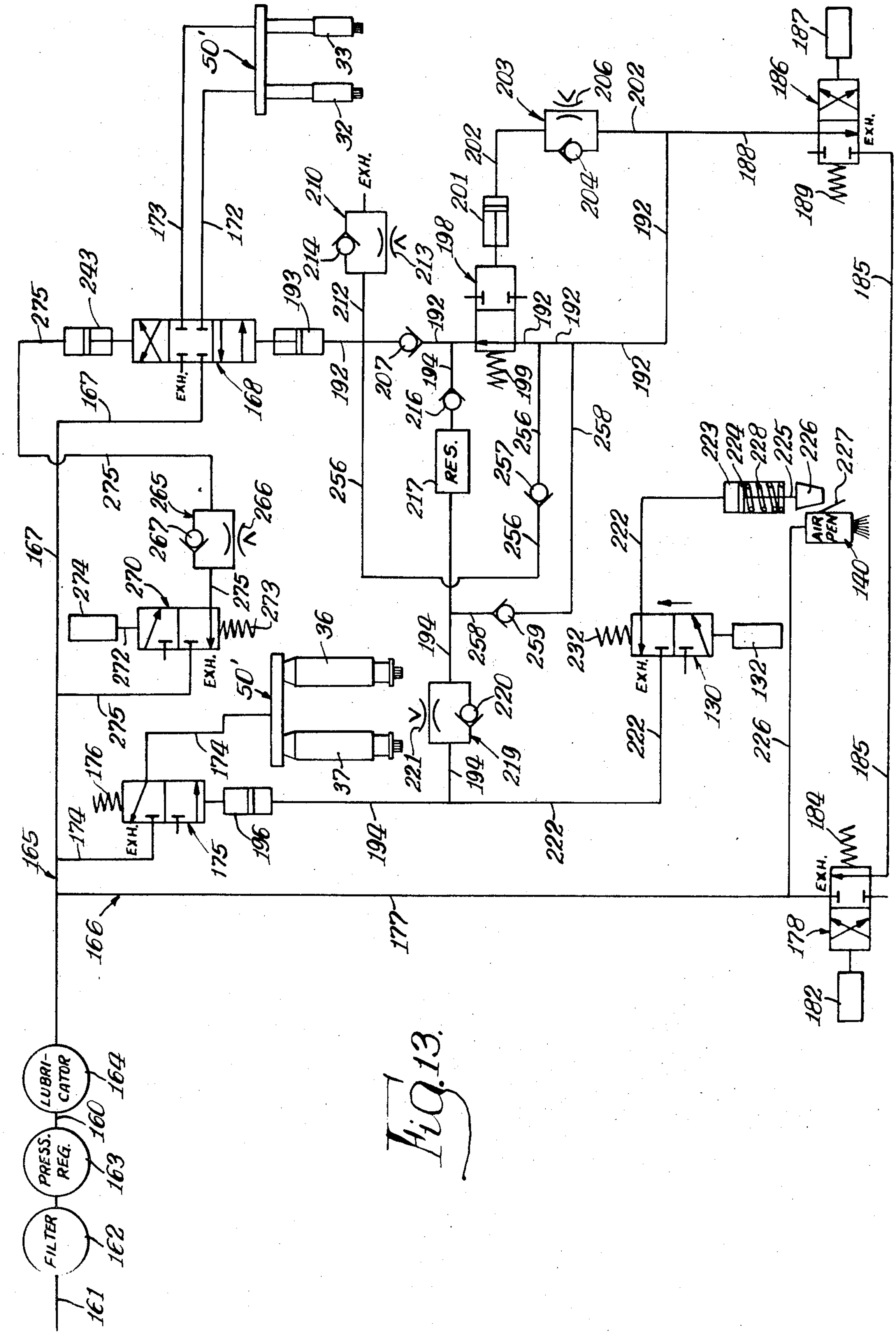

Fig. 13.

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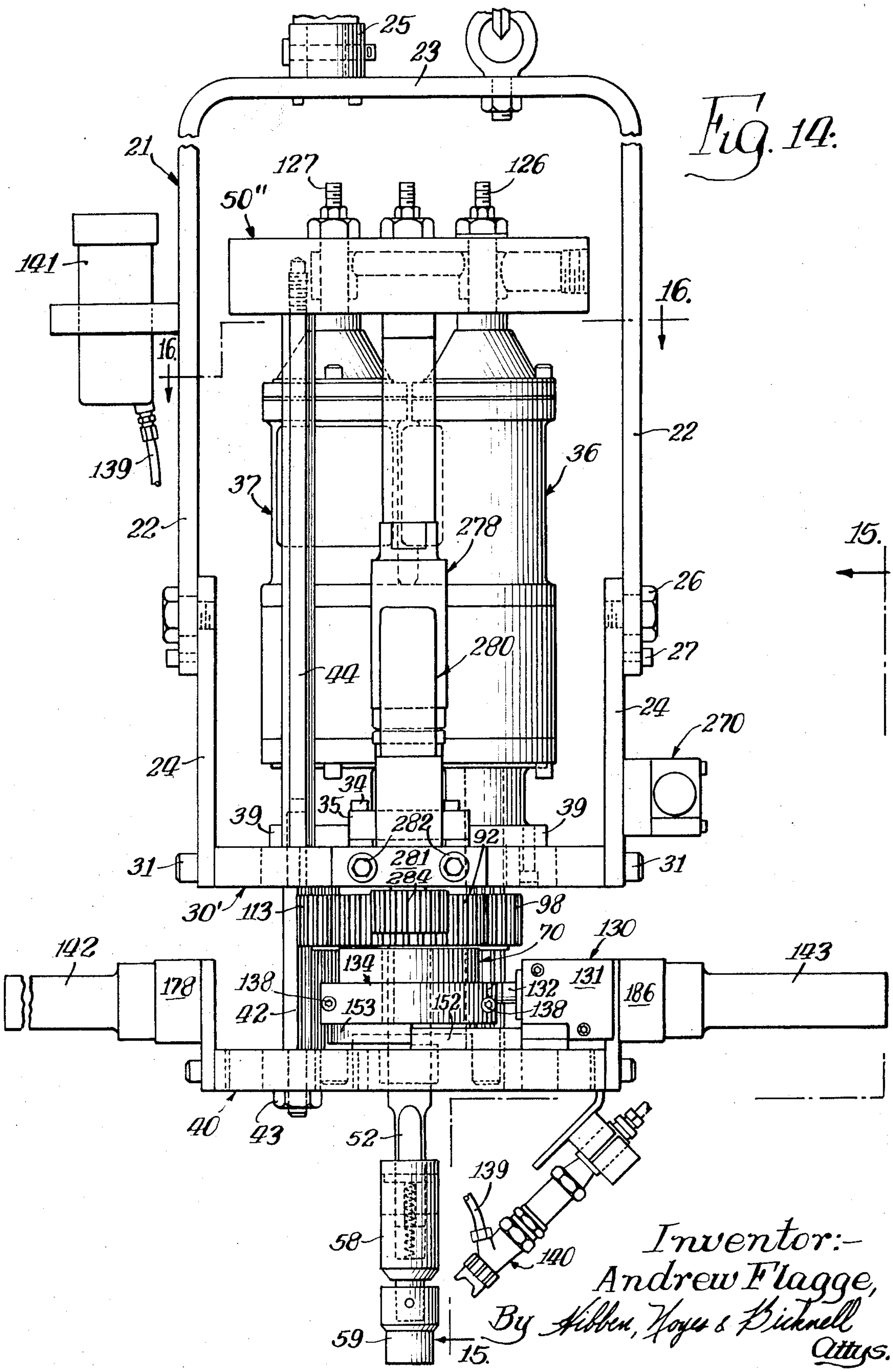

Fig. 14.

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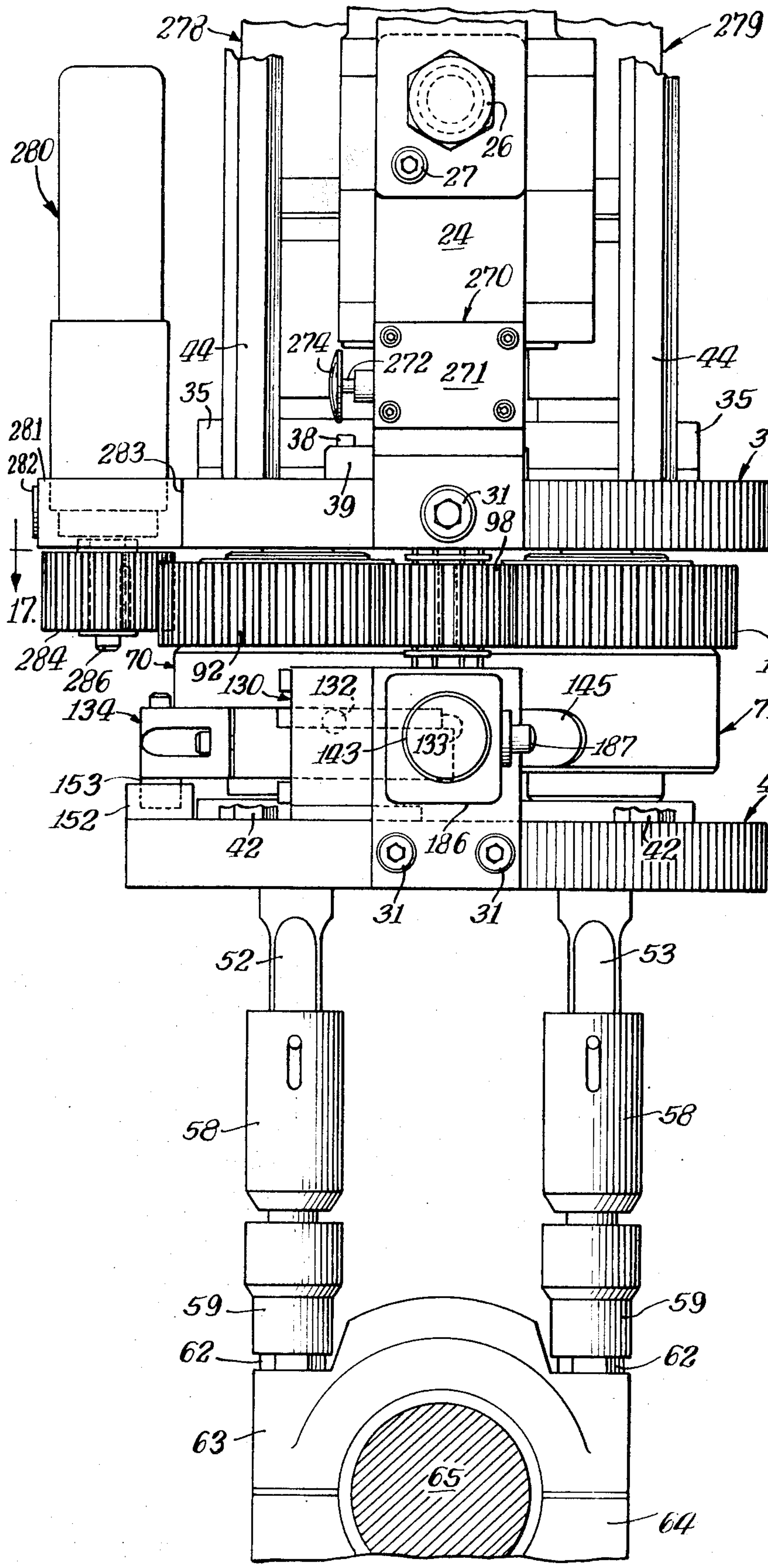
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Fig.15.

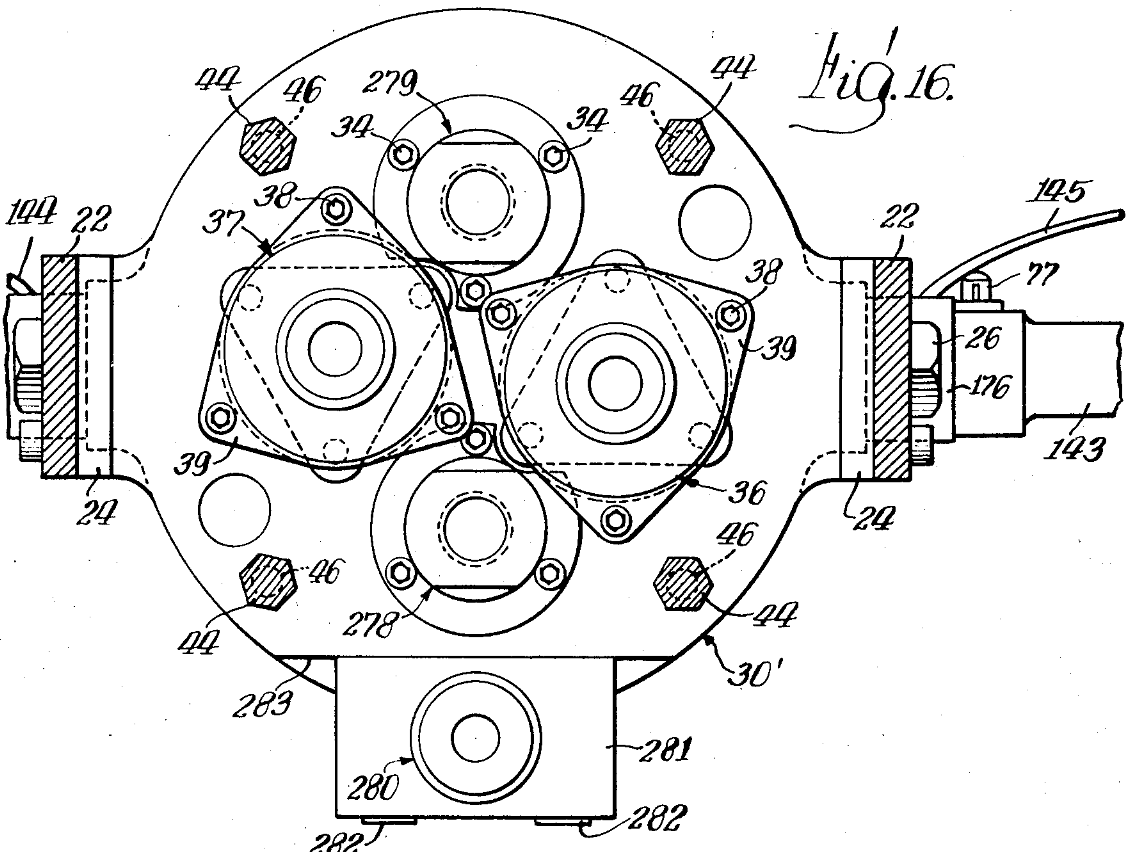
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Fig. 16.

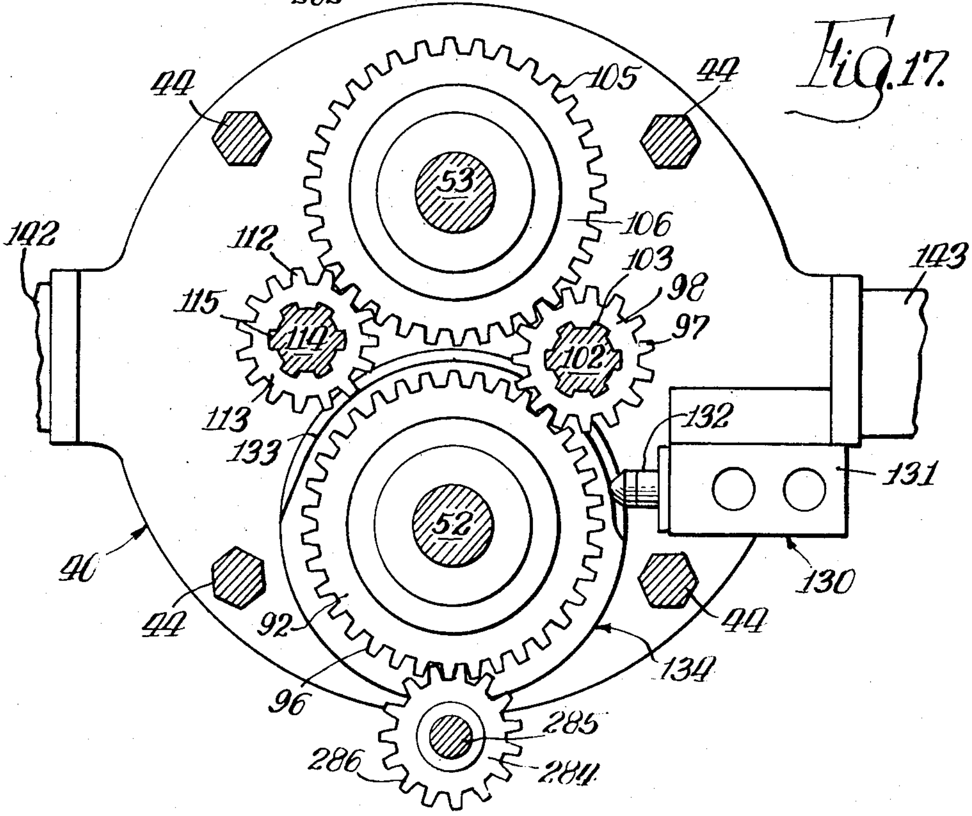
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Fig. 17.

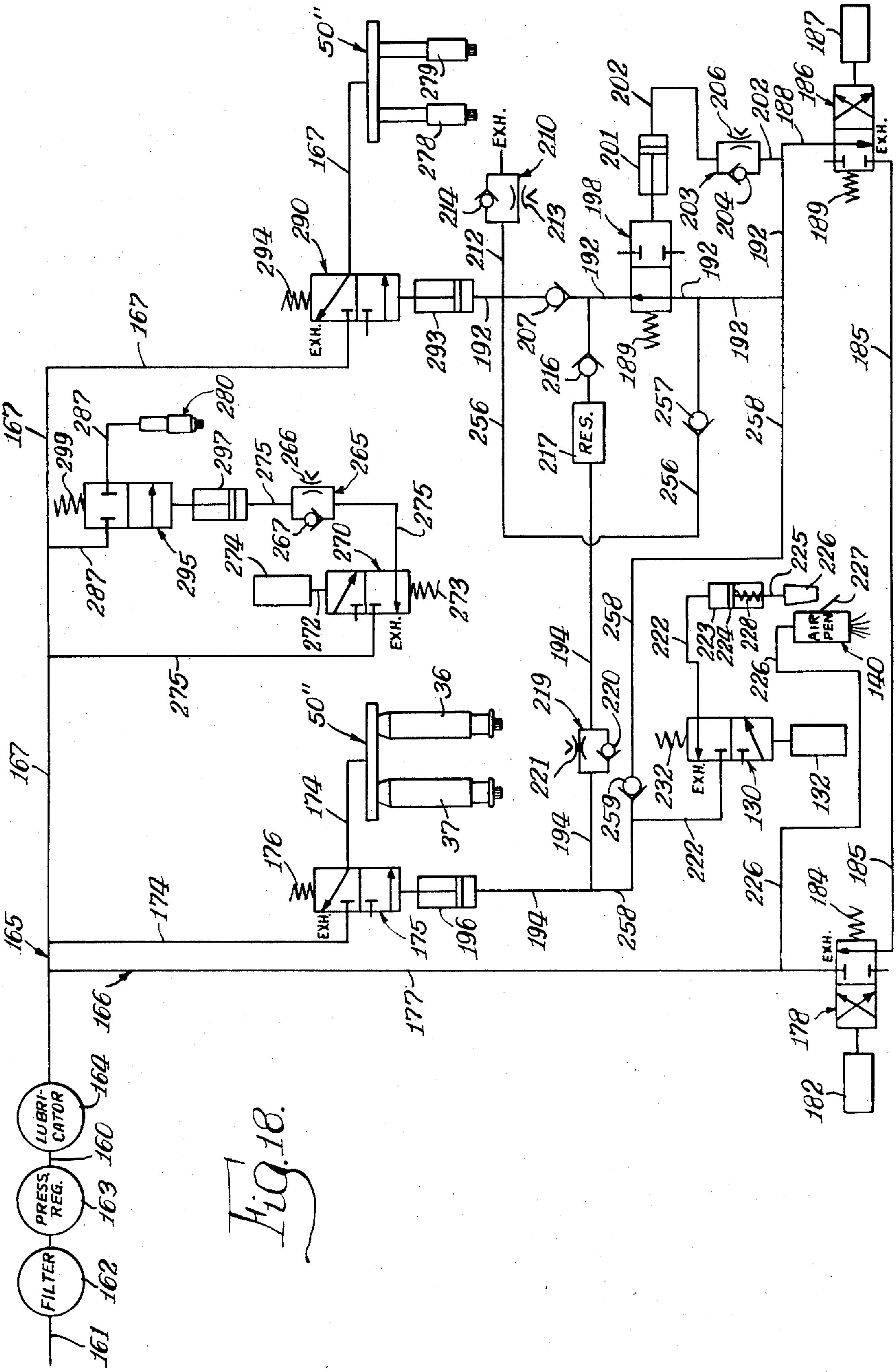

Fig. 18.

TORQUE APPLYING AND TENSION CONTROLLING DEVICE

This invention relates to a torque applying and tension controlling device and more particularly to a device for rapidly and accurately controlling the tension in one or the other of a pair of threaded members.

Various devices have been developed heretofore practicing the so-called "turn-of-the-nut" method of tensioning one or the other of a pair of threadedly engaged members in order to accurately control the tension developed in one of the members. Such method involves the application of a predetermined low torque to one or the other of the threaded members to eliminate any clearance between the members and to establish a reference torque setting, and thereafter rotating one or the other of the threaded members a predetermined additional number of degrees in a direction to increase the tension in one or the other of the threaded members to a desired value. A more detailed explanation of the "turn-of-the-nut" method of tightening threaded fasteners is contained in an article by J.O. Almen entitled "How Tight Should a Bolt Be?," which appeared in the Volume 1, Number 2 issue of *Fasteners* magazine (1944).

Accurate control of the tension in one or the other of a pair of threaded members is important where the members comprise a fastener for holding other parts in assembled relation. For example, it is important that the tension forces in the fasteners that secure the connecting rods to the cranks of an internal combustion engine be substantially equal and within prescribed limits. If such forces are unequal or outside the prescribed limits, premature wear of the connecting rod bearings and/or failure of the fasteners may occur. While many of the devices heretofore advanced have proven generally satisfactory for this purpose, others have not for various reasons, such as inability to achieve uniform and accurate tensioning between successive operations, complexity of construction, and unreliability of operation.

Accordingly, it is the general object of the present invention to provide a novel and improved torque applying and tension controlling device for accurately controlling the tension developed in one or the other of a pair of threadedly engaged members.

Another object is to provide a novel torque applying and tension controlling device of the foregoing character, which is capable of rapidly and automatically developing a desired tension in one or the other of a pair of threaded members.

A further object is to provide a novel torque applying and tension controlling device of the foregoing character, which is particularly suited for use in mass production operations.

A more particular object is to provide a novel torque applying and tension controlling device for developing a predetermined tension in one or the other of a pair of threaded members wherein the stall torque of at least one fluid motor is utilized to apply a predetermined low torque to one of the threaded members such as will establish positive contact between the members and wherein at least one other fluid motor is utilized to rotate the threaded member a predetermined additional number of degrees in the same direction to establish a final tension in one or the other of the threaded members.

A specific object is to provide a novel and improved torque applying and tension controlling device which is capable of simultaneously and automatically tensioning a pair of threaded members, such as the nuts which secure the connecting rod bearing cap to the lower end of a connecting rod of an internal combustion engine.

Other objects and advantages of the invention will become apparent from the following detailed description and accompanying sheets of drawings, wherein:

FIG. **1** is a front elevational view of a torque applying and tension controlling device embodying the features of the present invention;

FIG. **2** is an enlarged side elevational view of the lower portion of the device shown in FIG. **1**, taken substantially along the line **2—2** of FIG. **1**, and showing the device as it would appear when in operation;

FIG. **3** is a transverse sectional view taken substantially along the line **3—3** of FIG. **1**;

FIG. **4** is a top plan view taken substantially along the line **4—4** of FIG. **1**;

FIG. **5** is a fragmentary, longitudinal sectional view, with some parts in elevation, taken substantially along the line **5—5** of FIG. **3**;

FIG. **6** is a fragmentary, longitudinal sectional view, with some parts in elevation, taken substantially along the line **6—6** of FIG. **3**;

FIG. **7** is a transverse sectional view taken along the line **7—7** of FIG. **5**;

FIG. **8** is a transverse sectional view taken substantially along the line **8—8** of FIG. **1**, and showing the positions that certain parts of the device occupy during one portion of the operating cycle thereof;

FIG. **9** is a view similar to FIG. **8** but showing certain parts of the device in the positions they occupy during another portion of the operating cycle of the device;

FIG. **10** is a schematic diagram of the fluid circuit utilized in the torque applying and controlling device illustrated in FIGS. **1–9**, inclusive;

FIG. **11** is a front elevational view of another torque applying and controlling device embodying the features of the present invention;

FIG. **12** is a side elevational view of the lower portion of the device shown in FIG. **11**, taken substantially along the line **12—12** of FIG. **11**, and showing the device as it would appear when in operation;

FIG. **13** is a schematic diagram of the fluid circuit employed in the torque applying and controlling device illustrated in FIGS. **11** and **12**;

FIG. **14** is a front elevational view of another torque applying and tension controlling device embodying the features of the present invention;

FIG. **15** is a somewhat enlarged side elevational view of the lower portion of the device shown in FIG. **14** taken substantially along the line **15—15** of FIG. **14** and showing the device as it would appear when in operation;

FIG. **16** is a transverse sectional view taken along the line **16—16** of FIG. **14**;

FIG. **17** is a transverse sectional view taken along the line **17—17** of FIG. **15**; and

FIG. **18** is a schematic diagram of the fluid circuit utilized in the torque applying and tension controlling device illustrated in FIGS. **14–17**.

Briefly described, the present invention contemplates a novel torque applying and tension controlling device for applying a predetermined low torque to one or the other of a pair of threadedly engaged members and then rotating one or the other of the threadedly engaged members an additional number of degrees to obtain a desired tension in one of the members. While the specific embodiments of the device, to be hereinafter described in detail, are adapted to simultaneously apply torque to a pair of nuts so as to tension studs on which the nuts are threaded, such embodiments may also be used to apply torque to and simultaneously tension a pair of cap screws, if such mode of operation is desired. The torque applying and tension controlling device comprises a support in the form of an elongated frame having driving means extending from one end thereof. Such driving means comprises a pair of longitudinally extending, transversely spaced spindles which are rotatably mounted in the lower portion of the frame. The lower ends of the spindles may be provided with a socket or other device for transmitting torque to an associated threaded member.

First drive means in the form of at least one and preferably a pair of fluid motors are mounted on the frame and connected to the spindles to effect rotation thereof in a direction to apply a predetermined low torque to the threaded members with which the spindles are engaged and thereby establish positive contact between the members. Such low torque is obtained by adjusting or designing the first pair of fluid motors so that they will stall at the predetermined low torque.

Second drive means in the form of at least one other and preferably a pair of second fluid motors are also mounted on the frame closely adjacent to and in side-by-side relation with the first pair of fluid motors and are connected to the spindles through overrunning clutches. The second pair of fluid motors are turned on after the first pair of fluid motors have stalled and serve to rotate the spindles a predetermined additional number of degrees to thus obtain a final tension in one or the other of the threaded members. The overrunning clutches are arranged so that during the application of the low torque to the threaded members the second pair of fluid motors are not driven by the first pair of fluid motors.

Shut-off of the second pair of fluid motors after the desired tension is obtained in the threaded members is achieved by rotation limiting means in the form of a valve mounted on the frame of the device and operable to effect a shut-off of the flow of fluid under pressure to the second pair of fluid motors. Such rotation limiting valve, in the present instance, is actuated by a plunger which rides on a cam secured to one of the clutch members of one of the overrunning clutches.

On completion of the tensioning operation, the torque applying and tension controlling device of one of the embodiments includes means for automatically restarting the first pair of fluid motors upon disengagement of the device from the previously tensioned threaded members so that the device is recycled and ready to be engaged with and tension another pair of threaded members. In this embodiment, an actuating member in the form of an elongated push rod is shiftably mounted in the frame of the device for engaging structure between or adjacent to the threaded members. The push rod is connected to a flow reversing valve in the fluid circuit of the device and such valve effects a reversal of the direction of flow of fluid to the first pair of fluid motors, which are reversible in this embodiment, to thus effect rotation of the spindles in a reverse direction. The cam carried by one of the clutch members of one of the overrunning clutches thus also runs in a reverse direction until stopped by stop means.

Such stop means comprises a first stop member mounted on the frame of the device and another stop member mounted on the clutch member which carries the cam. Thus, in this embodiment, the device is automatically reset for another torquing and tensioning operation upon removal or disengagement of the sockets on the lower ends of the spindles from the threaded members with which the device was previously engaged.

In a second embodiment, reversal of the first set of fluid motors to recycle the device after the completion of a torquing and tensioning operation is effected by actuation of a manually operated reversing valve mounted on the frame of the device. Thus, in this embodiment, after the first pair of fluid motors has applied a predetermined low torque to the threaded members and the second pair of fluid motors has rotated the threaded members through a predetermined number of degrees to obtain a final tension therein, restarting of the first pair of fluid motors and rotation thereof in a reverse direction after the device has been removed from the threaded members is achieved by manually operating the aforementioned reversing valve. In this embodiment, the first pair of fluid motors are also reversible but operation thereof in a reverse direction to recycle the device requires actuation of a manually operated valve.

In a third embodiment, recycling of the device also requires actuation of a manually operated valve carried on the frame of the device. However, unlike the previous embodiments, the first pair of fluid motors of this embodiment are not reversible. Instead, on additional or auxiliary fluid motor is connected to the gearing of the driving means and the first pair of fluid motors. Thus, when the auxiliary fluid motor is operated, the spindles and consequently the cam carried by one of the clutch members of one of the overrunning clutches rotate in a reverse direction until the stop members engage each other.

In each of the embodiments, marking means in the form of an air pen is provided for automatically applying paint or other marking material to structure between or adjacent to the threaded members to indicate completion of a torquing and tensioning operation.

The torque applying and tension controlling device of the present invention also includes a fluid circuit for supplying fluid under pressure to and controlling the operation of the first and second pairs of fluid motors. Such circuit comprises supply conduit means adapted to be connected to a source of fluid under pressure, preferably compressed air, for supplying fluid under pressure to the first and second pairs of fluid motors. The supply conduit means includes a first supply branch conduit connected to the first pair of fluid motors and a second supply branch conduit connected to the second pair of fluid motors. First and second fluid pressure actuated valve means are also respectively provided in the first and second supply branch conduits for controlling the flow of fluid under pressure to the fluid motors.

The fluid circuit also includes control conduit means connected to the supply conduit means for controlling the operation of the first and second fluid pressure actuated valve means. Thus, the control conduit means includes a first control branch conduit connected to the first fluid actuated valve means and a second control branch conduit connected to the second fluid pressure actuated valve means. In addition, at least one and preferably a pair of throttle valves are provided in the control conduit means for starting and stopping the device.

The arrangement is such that when an operator shifts the throttle valves to a position to start the device, fluid under pressure is communicated to the first fluid pressure actuated valve means and the latter shifts in one direction to permit fluid under pressure to be supplied to first pair of fluid motors through the first supply branch conduit. A predetermined low torque is thus applied to the threaded members. Sequencing means in the form of a restriction in the second control branch conduit connected to the second fluid pressure actuated valve means prevents actuation of the second fluid pressure actuated valve means and operation of the second pair of fluid motors until a predetermined time interval has elapsed sufficient to allow the first pair of fluid motors to apply the low torque to the threaded members.

After the second fluid pressure actuated valve means has shifted to a position permitting fluid under pressure to be supplied through the second supply branch conduit to the second pair of fluid motors and the latter are rotating, a rotation limiting and position responsive valve in a third control branch conduit of the circuit causes the second fluid pressure actuated valve means to shift to another position preventing fluid under pressure from being supplied to the second pair of fluid motors. Consequently, the second pair of fluid motors are shut off after the threaded members with which the device is engaged have rotated the predetermined additional number of degrees. At the same time, the marking means is actuated and the structure adjacent to the threaded members is marked to indicate completion of the tensioning operation.

In the one embodiment, disengagement of the device from the threaded members after completion of a tensioning operation permits the flow reversing valve in a fourth control branch conduit of the circuit to be opened by extension of the push rod. The first fluid pressure responsive valve is then shifted to another position reversing the flow of fluid under pressure in the first supply branch conduit to reverse the direction of rotation of the first pair of fluid motors and thus recycle the device.

In the second embodiment, the flow reversing valve is manually operated when the device is disengaged from the work after a tensioning operation, rather than being automatically operated by a push rod.

In the third embodiment, the additional or auxiliary fluid motor is provided in a third supply branch conduit of the circuit and the manually operated flow reversing valve is mounted in a fourth control branch conduit and is connected so as to cause a third fluid pressure actuated valve means to permit fluid under pressure to be supplied to the additional or auxiliary fluid motor to recycle the device at the completion of a tensioning operation.

THE EMBODIMENT SHOWN IN FIGS. 1-10

In FIG. 1 a torque applying and tension controlling device embodying the features of the present invention is illustrated. The device shown in FIG. 1 comprises a support or frame 21 upon which the other components of the device are mounted. As shown in FIG. 1, the frame 21 includes a yoke having vertically extending legs 22 and a connecting portion 23 connecting the upper ends of the legs 22. A socket 25 is shown mounted on the upper side of the connecting portion 23 for receiving the lower end of a support arm (not shown) which facilitates movement of the device.

The upper ends of a pair of extensions 24 are pivotally connected, as by screws 26, to the lower ends of the legs 22 of the yoke to permit pivotal movement of the extensions 24 about the screws 26. Set screws 27 may be threaded into the lower ends of the legs 22 for engaging the extensions 24 and maintaining a desired angular relationship between the extensions 24 and the legs 22.

A generally circular plate 30 (FIGS. 1, 2 and 3) is secured, as by screws 31, to the lower ends of the extensions 24 and serves as a mounting for first and second drive means of the device. Such first drive means, in the present instance, comprises a pair of closely adjacent, transversely spaced fluid motors 32 and 33 (FIG. 2) secured to the upper surface of the plate 30 by screws 34 which extend through a mounting plate 35 at the lower end of each motor and which are threaded into the plate 30. The fluid motors 32 and 33 are preferably of the type manufactured and sold by the Thor Power Tool Company of Aurora, Illinois, and identified by their number 3301 M-275, model No. 11011A.

Second drive means in the form of another pair of closely adjacent, transversely spaced motors 36 and 37 (FIGS. 1 and 2) are also mounted on the upper surface of the plate 30, in side-by-side relation with the motors 32 and 33, as by screws 38 which extend through a mounting flange 39 at the lower end of each motor and which are threaded into the plate 30. The fluid motors 36 and 37 are likewise preferably of the type manufactured and sold by the Thor Power Tool Company of Aurora, Illinois and identified by their number 6M-300R, model No. S-09819-AA. The function and sequence of operation of the fluid motors 32,33 and 36,37 will be described more fully hereafter and in connection with the operation of the device shown in FIG. 1.

Another generally circular plate 40 is connected to the underside of the plate 30 and maintained in vertically spaced relation therefrom by four, vertically arranged, symmetrically spaced rods 42 (FIGS. 1 and 2). The rods 42 are preferably hexagonal in cross section between the plates 30 and 40 and have threaded, smaller diameter cylindrical upper and lower ends which extend through openings in the plates 30 and 40 and which define shoulders on the rods 42 that engage the lower surface of the plate 30 and the upper surface of the plate 40, respectively. A nut 43 may be threaded onto the lower end of each rod 42 to secure the plate

40 thereto. The upper ends of the rods 42 extend through openings in the plate 30 and are threaded in axial bores in the lower ends of four other rods 44 (FIGS. 1, 2 and 3) which extend upwardly from the upper surface of the plate 30. The rods 44 are also hexagonal in cross section and have their upper ends 46 threaded into another circular plate 50 spaced above the plate 30. The plate 50 serves as a mounting for the upper ends of the motors 32,22 and 36,37, and also as a manifold for directing fluid under pressure into and receiving fluid discharging from the motors, as will be more fully described hereafter.

The device illustrated in FIG. 1 also includes driving means for applying torque to and increasing the tension to a desired value in one or the other of two pairs of threadedly engaged members. Such driving means, in the present instance, comprises a pair of spindles 52 and 53 (FIGS. 1, 2 and 5) which are rotatably mounted in bearings 56 and 57 in the plates 30 and 40, respectively. The lower end of each spindle 52 and 53 may be provided with a spring loaded adaptor 58 to which a socket 59 or other torque transmitting device may be secured. In FIG. 2, the sockets 59 are shown engaged with a pair of hexagonal nuts 62 such as are used to secure a bearing cap 63 to the lower end 64 of a connecting rod of an internal combustion engine and around a crank portion 65 of the engine crank shaft.

The upper end of the spindles 52 and 53 are splined to the output shafts of the motors 32 and 33, respectively, so that the motors 32 and 33 impart rotation to the sockets 59 directly through the spindles 52 and 53 when the motors 32 and 33 are in operation. The output shaft of the motor 32, is indicated at 66 in FIG. 5.

As heretofore mentioned, the torque applying and tension controlling device illustrated in FIG. 1 includes overrunning clutch means for transmitting torque from the second pair of fluid motors 36 and 37 after the first pair of fluid motors 32 and 33 have applied a predetermined low torque to the threaded members with which the device is engaged and after the first pair of fluid motors have stalled and are shut off. Such overrunning clutch means comprises a pair of overrunning clutches 70 and 71 (FIGS. 1, 2 and 5), respectively mounted on the spindles 52 and 53. The overrunning clutch 70, in the present instance, comprises a first or inner, annular clutch member 72 mounted on the spindle 52 and fixed against rotation relative thereto as by a key 73. A second or outer clutch member 74 includes a hub portion 76 mounted on and relatively rotatable with respect to the spindle 52 and a larger diameter, annular portion 77 which depends from the hub portion 76 and is spaced radially outwardly from the clutch member 72. A plurality of intermediate clutch elements 78 are positioned between the clutch member 72 and the annular portion 77 of the clutch member 74, and are retained in such relation by an annular plate 82 which engages the lower ends of the clutch elements 78. A snap ring 83 holds the plate 82 in the clutch member 74. The lower end of the inner or first clutch member 72 bears against a plate 84 which is secured to the annular plate 40 by a plurality of screws, only one of which is shown in FIG. 5 and is indicated at 86. The plate 84 also serves to retain the lower bearing assembly 57 for the spindle 52 in the plate 40.

An annular gear 92 is mounted on the hub portion 76 of the second clutch member 74 and is fixed against rotation relative thereto as by a key 93 positioned in axially extending key ways respectively formed in the outer surface of the hub portion 76 and the inner surface of the opening in gear 92. A snap ring 94 retains the gear 92 on the hub portion 76 and confines the key 93 in the key ways.

As best seen in FIG. 7, the gear 92 has external teeth 96 which mesh with external teeth 97 on another gear 98 that is mounted on and fixed against rotation with respect to the output shaft, indicated at 102, of the fluid motor 36. In order to prevent relative rotation between the shaft 102 and gear 98, the shaft 102 is externally splined as at 103 and the inner surface of the gear 98 is axially grooved to receive the splines 103 of the shaft 102. The lower end of the shaft 102 is supported in a bearing 104 in the plate 40.

The teeth 97 of the gear 98 are also meshed with external teeth 105 on another annular gear 106 secured, as by a key 107, to the hub portion indicated at 108, of the outer clutch member of the overrunning clutch 71 (FIGS. 6, 8 and 9). The hub 108 of the overrunning clutch 71 is mounted on the spindle 53 and is rotatable relative thereto in the manner of the clutch member 74 of the overrunning clutch 70. The overrunning clutch 71 also includes an annular, inner clutch member (not shown) secured to the spindle or shaft 53 as by a key (also not shown), and a plurality of intermediate clutch elements, identical to the clutch elements 78 of the overrunning clutch 70, are positioned between the inner and outer clutch members of the overrunning clutch 71. The overrunning clutch 71 is otherwise identical in construction and operation with the overrunning clutch 70.

The teeth 105 of the gear 106 mesh with external teeth 112 on another gear 113 mounted on the output shaft, indicated at 114, of the fluid motor 36. The gear 113 is fixed against rotation relative to the shaft 114 in the same manner as the gear 98 and shaft 102, that is, the shaft 114 is provided with external splines 115 which are received in axial grooves in the inner periphery of the gear 113. The lower end of the shaft 114 is rotatably journaled in a bearing 116 in the plate 40, in the same manner as the shaft 102.

Thus, when the motors 32 and 33 are in operation and the spindles 52 and 53 are being driven in a direction to apply torque to the threaded members with which the device is engaged, the overrunning clutches 70 and 71 prevent the motors 32 and 33 from transmitting torque to the motors 36 and 37. In other words, the overrunning clutches 70 and 71 freewheel when the motors 32 and 33 are operating in a direction to apply a predetermined low torque to the threaded members with which the device of FIG. 1 is engaged.

The amount of torque applied by the motors 32 and 33 during the low torque applying operation is controlled by torque limiting means. Such torque limiting means, in the present instance, comprises at least one pair of control valves which are respectively positioned in the fluid passages of the motors 32 and 33 and which restrict the cross sectional areas of the passages. The control valves thus limit to a predetermined value the torque developed by each motor and transmitted to the threaded members with which the device is engaged.

Thus, the motors **32** and **33** stall when the predetermined low torque is reached. In the present instance, the torque control valves of the motors **32** and **33** are positioned in the supply portions of the fluid passages in the motors and are adjustable by manipulation of extensions, indicated at **122** and **123** in FIG. **4**, respectively, which project above the plate **50**. Another pair of extensions **124** and **125** are also shown in FIG. **4** and these may be used to adjust another pair of valves located in the return portions of the fluid passages in the motors **32** and **33**, if the latter were to be operated in a reverse or left-hand direction during a low torque applying operation of the device. The motors **36** and **37** also include torque control valves having extensions **126** and **127** (FIGS. **1** and **4**), respectively, which likewise project above the plate **50** and which permit adjustment of the maximum torque developed by these motors by restricting fluid flow through the fluid passages of the motors.

As heretofore mentioned, after a predetermined low torque has been applied to the threaded members by the motors **32** and **33** and the latter have been shut off, the fluid motors **36** and **37** are brought into operation to rotate the spindles **52** and **53**, and consequently the threaded members, a predetermined additional number of degrees to obtain a final tension in the members with which the device is engaged, or in an associated pair of threaded members. Thus, when fluid under pressure is supplied to the motors **36** and **37**, as will be described hereafter in connection with the operation of the device, the shafts **102** and **114** thereof are driven in a counterclockwise direction as viewed in FIG. **7**. Consequently, the gears **92** and **106** and likewise the outer clutch members associated with the hubs **76** and **108**, rotate in a clockwise direction. Rotation of the outer clutch members of the overrunning clutches **70** and **71** in a clockwise direction causes the clutch elements to interconnect the inner and outer clutch members. Consequently, the spindles **52** and **53** rotate in a clockwise direction and likewise the threaded members with which the device is engaged. The tension in the threaded members is therefore increased.

In order to limit the amount of rotation of the spindles **52** and **53** by the fluid motors **36** and **37** to a predetermined number of degrees, rotation limiting means is provided. Such rotation limiting means, in the present instance, comprises a valve **130** (FIGS. **1, 2, 8** and **9**) in the fluid circuit of the device operable when opened to effect a shut-off of the flow of driving fluid under pressure to the motors. The valve **130** includes a valve body **131** that is mounted on the upper surface of the plate **40** (FIG. **1**) and includes a reciprocable plunger **132** which extends outwardly from the valve body **131** and into engagement with a cam surface **133** formed in the outer periphery of an annular cam member **134**. The cam member **134** is secured around the outer surface of the annular portion **77** of the outer clutch member **74** of the overrunning clutch **70** and, in the present instance, comprises a pair of semi-circular rings **136** and **137** secured together as by screws **138**. The screws **138** extend tangentially of the cam member and across the end faces of the rings with the heads of the screws engaging recessed shoulders in the ring **137**.

The cam surface **133** is preferably formed by a circumferentially extending groove or reduced diameter portion around the upper end of the cam member **134** which extends over an angle of about 180°. The ends of the groove merge with the full diameter of the ring within a few degrees from each end of the cam surface **133**. Thus, when the plunger **132** of the valve **130** is engaged with the cam surface **133**, the valve **130** is closed and the fluid circuit is set up so that fluid under pressure is supplied to the motors **36** and **37**. While fluid under pressure is being supplied to the motors **36** and **37** to cause rotation thereof and the spindles **52** and **53** for the final tensioning operation, the plunger **132** rides on the cam surface **133** as shown in FIG. **8** as the cam member **134** rotates with the clutch member **74**.

After the spindles **52** and **53** have rotated the aforementioned additional number of degrees, in the present instance about 180° plus or minus 10°, the outer end of the plunger **132** of the valve **130** rides up onto the full diameter portion of the cam member **134**, as shown in FIG. **9**. Consequently, the plunger **132** is shifted inwardly into the valve body **131** causing the valve **130** to open. When this occurs, fluid under pressure is prevented from being supplied to the motors **36** and **37** and rotation of the motors as well as spindles **52** and **53** is terminated.

Opening of the valve **130** to shut off the motors **36** and **37** also actuates marking means for applying indicia to structure adjacent to the threaded members to provide a visual indication of the fact that the members have been tensioned. Such marking means preferably comprises an air pen **140** (FIG. **1**) secured to the plate **40** of the device and positioned so as to spray a small quantity of paint onto structure between the threaded members, such as the bearing cap **63** of the connecting rod shown in FIg. **2**. A reservoir **141** (FIG. **1**) for paint for the air pen **140** is shown mounted on one of the legs **22** of the yoke and is connected to the air pen **140** by a conduit **139**. The air pen **140** receives air under pressure in manner to be described hereinafter in connection with the description of the fluid circuit of the device of FIG. **1**.

After the motors **36** and **37** have ceased to rotate due to opening of the valve **130**, and after a spot of paint has been applied to structure between the threaded members by the air pen **140**, the operator moves the device away from the threaded members until the sockets **59** are disengaged from the threaded members. Thereafter, a pair of operating levers **144** and **145** (FIG. **3**) pivotally mounted adjacent the inner ends of the handles **142** and **143**, respectively, are released. Release of the levers **144** and **145** opens an associated pair of throttle valves in the fluid circuit of the device and sets up the circuit for a recycling operation.

As the device is lifted away from the work, the lower end, indicated at **146**, of an elongated spring-pressed push rod **147** (FIG. **2**) remains in contact with structure between or adjacent to the threaded members so that the push rod **147** moves outwardly or downwardly relative to the device. In FIG. **2**, the lower end **146** of the push rod **147** is shown engaged with the bearing cap **63** at the lower end of the connecting rod **64**. Such movement permits a valve **150** in the fluid circuit of the device, which is mounted on the upper surface of the plate **50** (FIG. **1**) and which is normally closed when the sockets **59** of the device are engaged with the threaded members or nuts **62**, to move to an open position. When the sockets 59 are disengaged from the threaded members or nuts 62 at the completion of a tensioning operation, the flow of fluid under pressure supplied to the fluid motors 32 and 33 is reversed. Consequently, the motors 32 and 33 rotate in a reverse or left-hand direction.

Rotation of the motors 32 and 33 in a reverse direction effects a similar rotation of the spindles 52 and 53 and also of the inner clutch members connected thereto. Reverse rotation of the inner clutch members of the overrunning clutches 70 and 71 cause the clutch elements to interconnect the inner and outer clutch members. Thus, the cam members 134 is caused to rotate with the outer clutch member 74 in a counterclockwise direction from the position thereof shown in FIG. 9 toward the position thereof shown in FIG. 8.

Rotation of the cam member 134 in a counterclockwise direction from the position thereof shown in FIG. 9 continues until such movement is arrested by stop means. Such stop means preferably comprises a generally triangularly-shaped stop member 152 mounted on the upper surface of the plate 40, and a generally arcuately-shaped stop member 153 mounted on the under surface of the cam member 134 and positioned to engage the stop member 152 as the cam member 134 rotates. In order to permit adjustment of the rotated position of the cam member 134 when the stop member 153 engages the stop member 152, as shown in FIG. 8, the stop member 153 may be provided with a series of circumferentially spaced, axial bores therethrough for receiving a pair of screws 154 and 155 which are inserted into a selected pair of the axial bores in the stop member 153 and threaded into holes in the cam member 137. Thus, since each cycle of operation of the device of FIG. 1 is initiated when the stop members 152 and 153 are engaged and since the position of the stop member 153 is adjustable, the amount of additional rotation imparted to the spindles 52 and 53 by the motors 36 and 37 during the final tensioning operation of the threaded members with which the device is engaged can be accurately controlled. In other words adjustment of the position of the stop member 153 permits accurate control of the point at which the valve 130 is opened and consequently the number of degrees through which the spindles 52 and 53 will rotate before the valve is opened and the motors 36 and 37 are shut off.

After the stop members 152 and 153 are engaged and rotation of the motors 32 and 33 as well as the spindles 52 and 53 has ceased, the flow of fluid under pressure to the motors 36 and 37 is shut off after a predetermined delay. When this occurs, the cycle of operation of the device is completed.

If the operator of the device should at any time release one or the other or both of the operating levers 144 and 145 during a torquing and tensioning operation, the device must be recycled and the operation begun again. To do this, the sockets 59 must be disengaged from the threaded members and the device must be shifted a sufficient distance away from the work area to cause the push rod 147 to open the valve 150 and effect a reversal of the direction of flow of fluid under pressure to the motors 32 and 33. These motors will then run in a reverse direction until the stop member 153 engages the stop member 152 and the device is recycled.

DESCRIPTION OF THE FLUID CIRCUIT OF FIG. 10

In FIG. 10 the fluid circuit of the torque applying and controlling device of FIG. 1 is a diagramatically illustrated. Like reference numerals have been used to identify the parts of the device shown in the diagram and illustrated and described in the preceding figures.

The circuit includes an inlet portion 160 having an inlet end 161 that is adapted to be connected to a source of fluid under pressure, preferably compressed air. However, it will be understood that fluids other than compressed air could be used in the circuit shown in FIG. 10.

A filter 162, pressure regulator 163, and a lubricator 164 are represented by circles in the inlet portion 160 of the circuit and identified by legend. Downstream from the lubricator 164, the inlet portion 160 of the circuit divides into a supply conduit means, indicated generally at 165, and a control conduit means, indicated generally at 166.

The supply conduit means 165 includes a first supply branch conduit 167 connected to a first fluid pressure actuated valve means in the form of a four-way valve 168. Downstream from the four-way valve 168, the supply branch conduit 167 divides into reversible supply and discharge branch conduits 172 and 173, which are connected to the fluid motors 32 and 33 through passages in the manifold plate 50. Thus, the direction of rotation of the motors 32 and 33 is determined by which one of the conduits 172 and 173 receives compressed air from the supply branch conduit 167 and this is determined by the position of the valve 168. The arrangement is such that the motors 32 and 33 will be driven in a clockwise direction to apply a predetermined low torque to the threaded members with which the device is engaged when compressed air flows through the branch conduit 172, and in a counterclockwise direction when compressed air flows through the branch conduit 173.

Another or second supply branch conduit 174 is connected to other passages in the manifold plate 50 for supplying compressed air to the passages in the motors 36 and 37 to effect operation thereof. A second fluid pressure actuated valve means in the form of a three-way valve 175 is provided in the supply branch conduit 174 for controlling the flow of air under pressure to the manifold plate 50 and the motors 36 and 37. The three-way valve 175 is normally biased to a position preventing flow through the conduit 174 by a spring 176. When in the latter position, the valve 175 vents the fluid passages in the motors 36 and 37 to the atmosphere.

The control conduit means 166 of the circuit illustrated in FIG. 10 includes a first portion 177 connected to a shiftable throttle valve 178 to which the left handle 142 of the device is secured. The throttle valve 178 includes a plunger 182 (FIG. 3) positioned to be shifted by movement of the operating lever 144 of the device. A spring 184 normally maintains the valve 178 in a closed position preventing flow through the valve and into a second portion, indicated at 185, of the control conduit means 166, downstream from the throttle valve 178.

The second portion 185 of the control conduit means 166 is connected to another throttle valve 186 (FIGS. 1, 2 and 3) having a plunger 187 positioned to be shifted by the operating lever 145 to open the throttle valve **186** and establish a connection between the second portion **185** of the control conduit means and a third portion **188** of the control conduit means. The throttle valve **186** also includes a spring **189** which normally maintains the valve **186** in a position preventing air under pressure from flowing through the second portion **185** of the conduit means to the third portion **188**. The valve **186** is shown in the latter portion in FIG. **10**.

The third portion **188** of the control conduit means **166** divides into a first control branch conduit **192** connected to a pilot or actuating portion **193** at one end of the four-way valve **168**, and a second control branch conduit **194** connected to a pilot or actuating portion **196** at one end of the three-way valve **175**. A two-way valve **198** is provided in the first control branch conduit **192** and is normally biased to an open position or a position permitting flow through the control branch conduit **192** by a spring **199**. Movement of the two-way valve **198** to a position preventing flow through the first control branch conduit **192** is controlled by a pilot or actuating portion **201** which is connected to the third portion **188** of the control conduit means **166** by conduit **202**. A control valve **203** which includes a check valve **204** having a restriction **206** in parallel with the check valve **204**, delays closing of the two-way valve **198** for a predetermined time interval after the throttle valves **178** and **186** have been opened.

A check valve **107** is provided in the first control branch conduit **192** for preventing flow of fluid from the pilot portion **193** toward the two-way valve **198**, and one end of another control valve **210** is connected to the first control branch conduit **192** between the pilot portion **193** and check valve **207** by a conduit **212**. The control valve **210** includes a restriction **213** and a check valve **214** in parallel with the restriction **213**, and is operable to prevent free flow of fluid through the other end of the valve to the atmosphere.

As heretofore mentioned, the control conduit means **166** includes a second control branch conduit **194** which extends between the first control branch conduit **192** and the pilot or actuating portion **196** of the three-way valve **175**. A check valve **216**, reservoir **217**, and another control valve **219** having a check valve **220** and a restriction **221** therein in parallel with the check valve **220** are provided in the control branch conduit **194**. The restriction **221** prevents unrestricted flow from the reservoir **217** through the control valve **219** into the pilot portion **196** of the three-way valve **175** so that opening of the three-way valve **175** is delayed until the motors **32** and **33** have stalled. The restriction **221** thus comprises sequencing means for preventing operation of the motors **36** and **37** until a predetermined time interval has elapsed after fluid under pressure is supplied to the motors **32** and **33**.

The check valve **216** is positioned between the reservoir **217** and the connection of the second control branch conduit **194** with the first control branch conduit **192** and prevents flow from the reservoir **217** past the check valve **216** toward the control branch conduit **192**. The reservoir **217** is positioned between the check valve **216** and the control valve **219**.

A third control branch conduit **222** is connected at one end to the second control branch conduit **194** between the control valve **219** and the pilot portion **196** of the three-way valve **175**, and the other end of the third control branch conduit **222** is connected through the valve **130** to a cylinder **223** having a piston **224** therein. A plunger **225** connects the piston **224** with a cam **226** which is positioned to engage an operating lever **227** of the marking device or air pen **140** when air under pressure is applied to the cylinder **223**. A spring **228** normally biases the piston **224** into a retracted position into the cylinder **223** and the cam **226** out of engagement with the lever **227**.

The rotation limiting and rotative position responsive valve **130** illustrated in FIGS. **1**, **2**, **8**, and **9** and represented symbolically in FIG. **10**, is positioned in the third control branch conduit **222** between the cylinder **223** and the connection of the control branch conduit **222** with the second control branch conduit **194**. The valve **130** is normally maintained in a position preventing flow through the third control branch conduit **222** to the cylinder **223** by a spring **232** (not shown in FIGS. **1**, **2**, **8** and **9**). When so positioned, the valve **130** also vents the cylinder **223** to the atmosphere through the portion of the third control branch conduit **222** between the valve **130** and the cylinder **223** and a port in the valve **130**.

When the valve **130** is moved to an open position due to movement of the end of the plunger **132** onto the full diameter portion of the cam **134** (FIG. **9**), the valve **130** connects the pilot portion **196** of the three-way valve **175** and the cylinder **223**, and also vents the third control branch conduit **222** to the atmosphere. Connection of the pilot portion **196** with the cylinder **223** causes the piston **224** to momentarily move the cam **226** into engagement with lever **227** of the air pen **140** and operate the latter, as previously described.

The control conduit means **166** also includes a fourth control branch conduit **242** connected at one end to the first control branch conduit **192** and at its other end with another pilot or actuating portion **243** at the opposite end of the four-way valve **168** from the pilot portion **193**. Communication of fluid under pressure to the pilot portion **243** is controlled by the flow reversing or two-way valve **150**.

The valve **150** is maintained closed by contact between the end **146** of the push rod **147** with the work during the torquing operation, and is shifted to an open position by a spring **244** (FIG. **10**) when the device is lifted away from the work.

A reservoir **246** is provided in the fourth control branch conduit **242** between the valve **150** and the connection of the branch conduit **242** with the first control branch conduit **192**, and a check valve **247** is provided in the fourth control branch conduit **242** between the reservoir **246** and the connection of the control branch conduit **242** with the control branch conduit **192**. The check valve **247** prevents flow from the reservoir **246** past the check valve **247**.

Another control valve **248** is connected at one end by a conduit **252** to the fourth control branch conduit **242** between the valve **150** and the pilot portion **243**. The opposite end of the control valve **248** is connected to the atmosphere. Unrestricted flow through the control valve **248** to the atmosphere is prevented by a restriction **253**, and a check valve **254** in parallel with the check valve **253** permits unrestricted flow through the control valve **248** and conduit **252** into the pilot portion **243** of the four-way valve **168**.

OPERATION OF THE DEVICE OF FIGS. 1-9 AND THE FLUID CIRCUIT OF FIG. 10

The torque applying and controlling device of FIG. 1 and the fluid circuit therefor illustrated in FIG. 10 operate as follows: Assuming that an operator wishes to apply torque to and tension a pair of threaded members, such as a pair of cap screws or bolts having nuts threaded thereon, the device is lowered toward the threaded members by the operator until the sockets **59** on the lower ends of the spindles **52** and **53** engage the threaded members. In FIG. **2** the sockets are shown engaged with hexagonal nuts **62** which are threaded onto the ends of a pair of studs (not shown) that extend through the bearing cap **63** at the lower end **64** of the connecting rod of an internal combustion engine. Thus, the studs on which the nuts **62** are threaded will be tensioned as torque is applied to the nuts. Prior to the time that the sockets **59** are engaged with the nuts **62**, the latter are hand threaded or otherwise partially threaded onto the ends of the studs which project beyond the bearing cap.

While the device is being lowered toward the work, the lower end **146** of the push rod **147** contacts some part thereof, in this instance the bearing cap **63**, and shifts the push rod **147** upwardly so as to close the valve **150** (FIGS. **1**, **4** and **10**). Thus, the reservoir **246** in the fourth control branch conduit **242** is disconnected from the pilot portion **243** of the four-way valve **168** at the beginning of a torquing operation.

After the sockets **59** are fully engaged with the nuts **62** and the push rod **147** has closed the valve **150**, the operator squeezes the operating levers **144** and **145** (FIG. **3**) depressing the plungers **182** and **187** causing the throttle valves **178** and **186** to be shifted to an open position against the force of the springs **184** and **189**, respectively. Opening of the throttle valves **178** and **186** permits air under pressure from the inlet portion **160** of the fluid circuit to flow through the portions **185** and **188** of control conduit means **166**. The filter **162**, pressure regulator **162** and lubricator **164** perform their usual functions at this time.

Compressed air in the first control branch conduit **192** thus flows through the two-way valve **198** and check valve **207** into the pilot portion **193** of the four-way valve **168**, thereby causing the valve **168** to be shifted upwardly, as seen in FIG. **10**, or in a direction to permit air under pressure to flow through the first supply branch conduit **167** and four-way valve **168** into the reversible branch conduit **172**. Air under pressure thus flows through the bores in the manifold plate **50** (FIGS. **1**, **4** and **10**) and then into the fluid passages in the motors **32** and **33** in a direction to cause the motors **32** and **33**, and consequently the spindles **52** and **53**, to rotate in a clockwise direction as viewed in FIGS. **7**, **8** and **9**. Air discharging from the passages in the motors **32** and **33** flows through the passages in the manifold plate **50** to the reversible branch conduit **173** and is then discharged to the atmosphere through an exhaust port in the valve **168**. Thus, a predetermined low torque is applied to the nuts **62** and any clearances between the parts are taken up.

At the same time that air is flowing through the first control branch conduit **192** to the pilot portion **193** of the four-way valve **168**, air is also flowing through the second control branch conduit **194** and check valve **216** into the reservoir **217** to charge the same. Air is likewise flowing through the fourth control branch conduit **242** and check valve **247** at this time to charge the reservoir **246**.

After an interval of about 1 or 2 seconds, which is usually sufficient time for the motors **32** and **33** to rotate the spindles **52** and **53** and cause the nuts **62** to take up any clearance between the parts, the flow of air through the conduit **202** and restriction **206** of the control valve **203** and into the pilot portion **201** of the two-way valve **198** is sufficient to shift the valve **198** to its position shutting off the flow of fluid through the first control branch conduit **192**. Closing of the valve **198** traps air in the pilot portion **193** of the four-way valve **168** and also shuts off the flow of air to the reservoirs **217** and **246**.

When a predetermined low torque has been applied to the nuts **62** by the motors **32** and **33** sufficient to take up any clearance between the parts, the motors **32** and **33** stall. Such stalling is determined by the setting of a torque control valve in each of the motors **32** and **33** and may be adjusted by rotating the extensions **122** and **123** (FIG. **4**) connected to the valves, in opposite directions.

As will be apparent from FIGS. **5** and **7**, when the motor **32** is rotating in a clockwise direction, the inner clutch member **72** of the overrunning clutch **70**, which is keyed to the spindle **52**, does not cause any corresponding rotation of the outer clutch member **74** since the overrunning clutch **70** is freewheeling at this time. The same is true of the motor **33** and its overrunning clutch **71**.

Shortly after the motors **32** and **33** have stalled, the motors **36** and **37** are actuated to rotate the spindles **52** and **53** a predetermined additional number of degrees in the direction of their initial rotation sufficient to obtain the desired tension in the threaded members with which the device is engaged or in members on which the nuts **62** are threaded. The motors **36** and **37** begin to rotate when the three-way valve **175** is shifted to a position permitting flow through the second supply branch conduit **174** and bores in the manifold plate **50** which are connected to the fluid passages in the motors **36** and **37**. Movement of the valve **175** to the aforementioned position occurs when fluid under pressure is communicated to the pilot portion **196** of the valve **175**, such air being supplied to the pilot portion **196** from the reservoir **217** through the control valve **219**. However, because such air must flow through the restriction **221** of the control valve **219**, the pressure in the pilot portion **196** of the three-way valve **175** builds up gradually. Consequently, the valve **175** does not open immediately and the motors **36** and **37** are not actuated until after a predetermined time internal has elapsed sufficient to permit the motors **32** and **33** to stall.

When the motors **36** and **37** are in operation, the output shafts **102** and **114** thereof (FIGS. **6** and **7**) rotate in a counterclockwise direction as viewed in FIG. **7** and thus effect counterclockwise rotation of the gears **98** and **113** secured to the shafts **102** and **114**. Counterclockwise rotation of the gears **98** and **113** cause clockwise rotation of the gears **92** and **106** keyed to the hub portions **76** and **108** of the outer clutch members of the overrunning clutches **70** and **71**, respectively, and such clockwise rotation of the outer clutch members of the overrunning clutches **70** and **71** is transmitted through the clutch elements **78** to the inner clutch members and thus to the spindles **52** and **53**.

When the outer clutch members of the overrunning clutches **70** and **71** begin to rotate in clockwise direction as viewed in FIGS. **8** and **9**, the stop member **153** on the underside of the cam member **134** is engaged with the stop member **152** on the plate **40**, as shown in FIGS. **1** and **8**. The plunger **132** of the valve **130** is also engaged with the cam surface **133** at this time so that the valve **130** (FIGS. **1, 2, 8, 9** and **10**) is in the position shown in FIG. **10**. Thus, air is prevented from flowing through the third control branch conduit **222** to the cylinder **223** which actuates the air pen **140**.

After the motors **36** and **37** have rotated the spindles **52** and **53** a predetermined additional number of degrees in a clockwise direction or in a direction to increase the tension therein to a desired value, the inner end of the plunger **132** will ride upon the full diameter portion of the cam member **134** as shown in FIG. **9** and open the valve **130**. When this occurs, the pressure in the pilot portion **196** (FIG. **10**) of the three-way valve **175** is exhausted to the atmosphere through a port in the valve **130**. The spring **176** then shifts the valve **175** to a position preventing further flow of fluid under pressure to the motors **36** and **37** and connecting the passages in the motors **36** and **37** as well as the bores in the manifold **50**, to the atmosphere. The motors **36** and **37** are thus shut off and the spindles **52** and **53** cease to rotate.

When the valve **130** initially establishes communication between the portions of the third control branch conduit **222**, air flows through the third control branch conduit **222** to the cylinder **223** and causes the cam **226** on the end of the plunger **224** to momentarily actuate the operating lever **227** of the air pen **140**. Consequently, a quantity of paint or other marking material is sprayed by the air pen **140** onto the connecting rod bearing cap **63** to indicate completion of the tensioning operation.

As soon as the operator notes the application of paint to the bearing cap **63**, he releases the operating levers **144** and **145** (FIG. **3**) so that the springs **184** and **189** (FIG. **10**) shift the throttle valves **178** and **186** to positions preventing fluid under pressure from flowing into portions **185** and **188** of the control conduit means **166**, and at the same time venting these portions to the atmosphere.

After the portions **185** and **188** of the control conduit means **166** are vented to the atmosphere, the operator lifts the device away from the work a sufficient distance to permit the push rod **147** to extend and the spring **244** to shift the valve **150** to the position thereof shown in FIGS. **9** and **10**. When so positioned, air in the reservoir **246** flows through the fourth control branch conduit **242** into the pilot portion **243** of the four-way valve **168**. The four-way valve **168** is then shifted in a direction to permit fluid under pressure in the first supply branch conduit **167** to flow into the branch conduit **173**. When this occurs, the flow of fluid under pressure through the bores in the manifold plate **50** and passages in the motors **32** and **33** is in a direction to cause counterclockwise rotation of the motors **32** and **33** and likewise the spindles **52** and **53**. Counterclockwise rotation of the spindles **52** and **53** causes the inner clutch members of the overrunning clutches **70** and **71** to drive the outer clutch members of the overrunning clutches **70** and **71** through their intermediate clutch elements. Thus, the cam members **134** (FIGS. **5, 8** and **9**) will rotate in a counterclockwise direction until the stop members **153** engages the stop member **152**, as shown in FIG. **8**. When this occurs, the cam member **134** is properly indexed for the next cycle of operation of the device.

Shortly after the cam member **134** begins to rotate in a counterclockwise direction from the position thereof shown in FIG. **9** toward the position thereof shown in FIG. **8**, the plunger **132** of the valve **130** will move onto the cam surface **133** as shown in FIG. **8**. Consequently, the valve **130** is shifted to the position thereof shown in FIG. **10**, which prevents communication between the portions of the third control branch conduit **222** and which connects the portion of the branch conduit **222** between the valve **130** and cylinder **223** with the atmosphere.

While the motors **32** and **33** are running in a reverse direction, air in the reservoir **246** as well as in the pilot portion **243** of the control valve **248** is bleeding to the atmosphere through the restriction **253** of the control valve **248** and a port in the control valve. Thus, after a predetermined time interval sufficient to permit the stop member **153** to engage the stop member **152**, the pressure in the reservoir **246** and pilot portion **243** falls below that necessary to maintain the four-way valve **168** in its position connecting the first supply branch conduit **167** with the branch conduit **173**. Consequently, the valve **168** will shift to its centered or neutral position and shut off the flow of fluid to the branch conduit **173**. Springs (not shown) tend to bias the valve **168** to its centered or neutral position in opposition to the force caused by pressure in the pilot portions **193** and **243**. The device is then ready for another cycle of operation.

If the operator should at any time release either one or both of the throttle levers **144** and **145** while the device is in operation, the device will shut down. Thus, assuming that the operator releases the lever **144** adjacent the left handle **142**, the spring **184** will shift the throttle valve **178** to the position shown in FIG. **10** and thereby disconnect the second portion **185** of the control conduit means **166** from the first portion **177**. At the same time, the second portion **185** is connected to the atmosphere through an exhaust port in the throttle valve **178**. Since the second portion **185** is connected to the third portion **188** through the throttle valve **186** at this time, air in the pilot portion **193** of the four-way valve **168** will be vented to the atmosphere through a conduit **256** which extends between the first control branch conduit **192** and the third portion **188** of the control conduit means **166**. Such flow passes through a check valve **257** in the conduit **255** on its way to the third portion **188**.

Venting of the second portion **185** of the control conduit means to the atmosphere also causes immediate venting of the pilot portion **196** of the three-way valve **175** so as to permit the spring **176** to shift the valve **175** to the position thereof shown in FIG. **10**. When so positioned, the flow of fluid to the motors **36** and **37** is cut off and they immediately cease to rotate.

The path through which air in the pilot portion **196** reaches the atmosphere includes the check valve **220** of the control valve **219** and a conduit **258** connected at one end to the second control branch conduit **194** and at its other end to the conduit **256**. A check valve **259** is provided in the conduit **258** to prevent fluid under pressure from bypassing the reservoir **217** during a normal cycle of operation. Pressure in the reservoir **217** is also relieved to the atmosphere through the conduit **258**. Pressure in the reservoir **246** is relieved to the atmosphere through the fourth control branch conduit **242**, valve **150**, and another conduit **262** connected to the branch conduit **242** and the conduit **256**. A check valve **263** in the conduit **262** prevents fluid under pressure from flowing directly into the pilot portion **243** when the device is started.

In the event that an operator only releases the throttle lever **145**, the foregoing sequence of events will occur except that the second portion **185** of the control conduit means will remain pressurized instead of being vented to the atmosphere.

Thus, the device can be rendered inoperative by an operator at any portion of its cycle of operation merely by releasing one or the other or both of the operating levers **144** or **145**. Consequently, the device of FIGS. **1–10** may be safely used by either skilled or unskilled workers. However, if the device is interrupted during a cycle of operation, it must be moved away from the work a sufficient distance to permit the push rod **147** to extend so that the spring **244** shifts the valve **150** to its FIG. **10** position to cause the device to recycle before another torquing and tensioning operation is initiated.

THE EMBODIMENT SHOWN IN FIGS. 11-13

In FIGS. **11–13**, inclusive, another torque applying and tension controlling device embodying the features of the present invention is illustrated. Most of the parts of the device shown in FIGS. **11** and **12**, and the fluid circuit thereof in FIG. **13**, are identical with those of the device shown in FIGS. **1** and **2**, and the fluid circuit thereof in FIG. **10**, and therefore like reference numerals have been used to identify identical parts. Since the construction and mode of operation of the device of FIGS. **11** and **12** is, in most respects, the same as the device of FIGS. **1** and **2**, only the differences in construction and operation between the respective devices will be hereinafter described in detail.

Thus, the torque applying and tension controlling device of FIGS. **11** and **12** differs from the device of FIGS. **1** and **2** in that the former utilizes a manually operated valve **270** mounted on the right extension **24** of the right leg **22** of the frame **21**, instead of the valve **150** of the previous embodiment, for reversing the direction of rotation of the motors **32** and **33** and recycling the device after a torque applying and tensioning operation. The valve **270** includes a valve body **271** having an axially movable plunger **272** mounted therein for operating the valve. The plunger **271** is biased out of the valve body **271** by a spring **273** (FIG. **13**), and a knob **274** is secured to the outer end of the plunger **271** to facilitate inward movement of the plunger by the operator.

Due to the absence of the valve **150**, the manifold plate for the device of FIG. **11** differs slightly from the manifold plate **50** of the device of FIG. **1**, and the former has therefore been indicated by the reference numeral **50'**.

The fluid circuit of the device shown in FIGS. **11** and **12** is illustrated in FIG. **13** and also differs from the fluid circuit of FIG. **10** for the device of FIG. **1** in that the three-way valve **270** is disposed in a fourth control branch conduit **275** connected at one end to the first supply branch conduit **167** upstream from the four-way valve **168** and at its other end to the pilot or actuating portion **243** of the four-way valve **168**. In addition, a control valve **265** is provided in the fourth control branch conduit **275** between the three-way valve **270** and the pilot portion **243**. The control valve **265** includes a restriction **266** and a check valve **267** in parallel with the restriction **266**, the restriction **266** preventing free flow through the control valve **265** toward the three-way valve **270**.

The three-way valve **270** is normally biased by the spring **273** to a position preventing fluid under pressure from being communicated through the branch conduit **275** to the pilot portion **243** of the four-way valve **168**. When positioned as shown in FIG. **13**, the valve **270** also vents the portion of the fourth control branch conduit **275** between the valve **270** and the control valve **265** to the atmosphere.

The function and operation of the valve **270** will be described hereafter in connection with the description of the operation of the device of FIGS. **11–13**.

In addition, due to the omission of the valve **150** from the fluid circuit illustrated in FIG. **13**, the reservoir **246**, as well as the control branch conduit **242**, and the check valve **247** of the fluid circuit of FIG. **10** are omitted from the fluid circuit illustrated in FIG. **13**. Also, the conduits **256** and **258** are connected somewhat differently in the FIG. **13** circuit from their counterparts in FIG. **10**. However, their purpose and mode of operation is the same.

OPERATION OF THE DEVICE OF FIGS. 11 AND 12 AND THE FLUID CIRCUIT OF FIG. 13

The operation of the torque applying and tension controlling device of FIGS. **11** and **12**, and the fluid circuit thereof illustrated in FIG. **13**, is as follows: Assuming that an operator wishes to apply torque to and tension a pair of threaded members, such as the studs (not shown) that extend through the bearing cap **63** at the lower end **64** of the connecting rod shown in FIG. **12**, the device is lowered toward the hexagonal nuts **62** that have previously been partially threaded onto the ends of the studs which project beyond the bearing cap **63**.

After the sockets **59** are fully engaged with the nuts **62**, the tensioning operation is begun when the operator squeezes the operating levers **144** and **145** to shift the throttle valves **178** and **186** to positions permitting fluid under pressure in the inlet portion **160** of the circuit to flow into the various supply and control branches thereof, in the manner of the previous embodiment. The operation of the device of FIGS. **11–13**, inclusive, up to and including the application of a spot of paint to structure adjacent the threaded members, is the same as the operation of the torque applying and tension controlling device of FIGS. **1–10**, inclusive. Accordingly, reference should be made to the description of the operation of the torque applying and tension controlling device of FIGS. **1–10**, inclusive for an understanding of this portion of the operation of the device of FIGS. 11–13, inclusive.

At the completion of the tensioning operation and the application of a quantity of paint by the air pen **140** to structure adjacent the threaded members with which the device of FIGS. 11–13 is engaged, such as the connecting rod bearing cap **63**, the operator releases the throttle operating levers **144** and **145** so that the springs **184** and **189** (FIG. 13) shift the throttle valves **178** and **186** to the positions thereof shown in FIG. 13. When so positioned, fluid under pressure is prevented from entering the portions **185** and **188** of the control conduit means, and the portions **185** and **188** are vented to the atmosphere.

After the portions **185** and **188** have been vented to the atmosphere, the operator lifts the device away from the work until the sockets **59** are disengaged from the nuts **62** and then momentarily depresses the knob **274** of the valve **270**. Such movement momentarily connects the pilot portion **243** of the four-way valve **168** with the first supply branch conduit **167**. Such connection is made through the conduit **175**, valve **270**, and check valve **267** of the control valve **265**. The four-way valve **168** is then caused to shift to a position permitting fluid under pressure in the supply branch conduit **167** to flow through the branch conduit **173** to cause the motors **32** and **33** to rotate in a reverse or counterclockwise direction. Such rotation continues until the stop member **153** engages the stop member **152** as shown in FIG. **11**. When this occurs, the cam member **134** of the device of FIGS. **11–13** is properly indexed for another operating cycle.

While the motors **32** and **33** are running in a reverse direction, fluid is gradually flowing out of the pilot portion **243** of the four-way valve **168** through the conduit **275** and the restriction **266** of the control valve **265** to the atmosphere through a port in the valve **270**. Thus, after a predetermined period of time sufficient to permit the stop member **153** to engage the stop member **152**, the four-way valve **168** moves to its centered or neutral position and the flow of fluid under pressure to the motors **32** and **33** is shut off. When this occurs, the device is recycled and ready for another tensioning operation.

The fluid circuit illustrated in FIG. **13** is also effective to shut off the device any time the operator releases either one or both of the throttle levers **144** or **145**. The manner in which the torque applying and tension controlling device of FIGS. **11–13**, inclusive, is shut off when the device is in operation and when either one or both of the throttle levers **144** and **145** are released by an operator, is the same as the device of FIGS. **1–10**, inclusive.

THE EMBODIMENT SHOWN IN FIGS. 14-18

In FIGS. **12–18**, inclusive, another torque applying and tension controlling device embodying the features of the present invention is illustrated. Most of the parts of the device shown in FIGS. **14–17**, inclusive, and in the fluId circuit thereof in FIG. **18**, are identical with those of the previous embodiments and therefore like reference numerals have been used to identify such identical parts. However, since the device of FIGS. **14–18**, inclusive, is most similar to the device of FIGS. **11–13**, only the differences in construction and operation between these respective devices will be hereinafter described in detail.

Thus, the torque applying and tension controlling device of FIGS. **14–18**, inclusive, differs from the device of FIGS. **11–13**, inclusive, in that the former utilizes a pair of nonreversible fluid motors **278** and **279** in place of the reversible motors **32** and **33**, respectively, for rotating the spindles **52** and **53** in a clockwise direction. The motors **278** and **279** are preferably of the type manufactured and sold by the Thor Power Tool Company of Aurora, Illinois, and identified by their number 301M-300, model No. S-09681-AD.

In addition, the device of FIGS. **14–18**, inclusive, differs from the previous embodiments in that a fifth fluid motor, indicated generally at **280**, is utilized for rotating the gear **92** secured to the outer clutch member **74** of the overrunning clutch **70** in a counterclockwise direction at the completion of a torquing and tensioning operation, to cause the stop member **153** to engage the stop member **152** when the device is recycling. The motor **280** is likewise preferably of the type manufactured and sold by the Thor Power Tool Company of Aurora, Illinois, and identified by their number 201-300, model No. S-08964-AL.

The fluid motor **280** is mounted on a block **281** (FIGS. **14**, **15** and **16**) secured as by screws **282** to a flattened portion **283** on the front edge of a mounting plate **30'** at the lower ends of the leg extensions of the yoke **21**. A gear **284** is keyed to the output shaft, indicated at **285**, of the motor **280**, and the teeth, indicated at **286**, of the gear **284** mesh with the teeth **96** of the gear **92**. The fluid passages in the motor **280** are arranged so that when fluid under pressure is supplied thereto through a third supply branch conduit **287** (FIG. **18**), the gear **284** will be driven in a clockwise direction as viewed in FIG. **17**. Consequently, the cam member **134** secured to the outer clutch member **74** of the overrunning clutch **70** will rotate in a counterclockwise direction until the stop member **153** engages the stop member **152**, in the manner illustrated in FIG. **14**, when the device is recycling.

The fluid circuit of the device of FIGS. **14–17**, inclusive, is illustrated in FIG. **18**, and differs from the fluid circuit of FIG. **10** in that a three-way valve **290** is utilized in the circuit of FIG. **18** instead of the four-way valve **168** of the previous embodiments, to control the flow of air to the motors **278** and **279**, and the first supply branch conduit **167** does not divide into reversible branches downstream from the valve **290**. Consequently the passages in the manifold plate are somewhat different than in the previous embodiments and such plate is therefore indicated at **50''**. The valve **290** includes a pilot portion **293** which is connected to the first control branch conduit **192** in the manner of the previous embodiments, and a spring **294** normally biases the valve **290** toward a position preventing fluid under pressure from being supplied to the motors **278** and **279**.

In addition, a two-way valve **295** is provided in the third supply branch conduit **287** which is connected to the first supply branch conduit **167**, the valve **295** controlling the operation of the motor **280**. The valve **295** includes a pilot portion **297** to which the downstream end of the fourth control branch conduit **275** is connected, and a spring **299** biases the valve **295** to its closed position.

The fluid circuit illustrated in FIG. **18** is, in all other respects, substantially the same as the fluid circuit illustrated in FIG. 13.

OPERATION OF THE DEVICE SHOWN IN FIGS. 14-17 AND THE FLUID CIRCUIT OF FIG. 18

The torque applying and tension controlling device of FIGS. **18–17**, inclusive, and the fluid circuit therefor illustrated in FIG. **18**, operate as follows: Assuming that an operator wishes to apply torque to and tension one or the other of a pair of threadedly engaged members, such as the studs (not shown) that extend through the bearing cap **63** at the lower end **64** of the portion of the connecting rod illustrated in FIG. **15**, the device is lowered toward the hexagonal nuts **62** that have previously been partially threaded onto the studs until the sockets **59** are fully engaged with the nuts.

After the sockets **59** are engaged with the nuts **62**, the operator squeezes the operating levers **144** and **145** (FIG. **16**) so as to shift the throttle valves **178** and **186** to their positions permitting fluid under pressure in the inlet portion **160** of the circuit to flow into the various supply and control branch conduits thereof, in the manner of the previous embodiments. The operation of the device of FIGS. **14–18**, inclusive, up to and including the application of a spot of paint to structure adjacent the threaded members, is the same as the operation of the torque applying and tension controlling device of FIGS. **1–10**, inclusive. Accordingly, reference should be made to the description of the operation of the device of FIGS. **1–10**, inclusive for an understanding of this portion of the operation of the device of FIGS. **14–18**, inclusive.

At the completion of the tensioning operation and the application of a quantity of paint by the air pen **140** to structure adjacent the threaded members with the device of FIGS. **14–18** is engaged, such as the rod bearing cap **63**, the operator releases the throttle operating levers **144** and **145** so that the springs **184** and **189** shift the throttle valves **168** and **176** to the positions thereof illustrated in FIG. **18**. When so positioned, the valves **178** and **186** prevent fluid under pressure from entering the portions **185** and **188** of the control conduit means **166**, and also vent the portions **185** and **188** to the atmosphere.

After the portions **185** and **188** have been vented to the atmosphere, the operation lifts the device away from the work until the sockets **59** are disengaged from the nuts **62** and then momentarily depresses the knob **274** of the valve **270**. Such movement shifts the valve **270** to a position permitting fluid under pressure to be applied to the pilot portion **297** of the two-way valve **295** through the fourth control branch conduit **275** and the check valve **267** of the control valve **265**. When this occurs, air under pressure flows through the third supply branch conduit **287** to the fluid motor **280** to operate the same and cause the shaft **286** thereof, and consequently the gear **284**, to rotate in a clockwise direction as viewed in FIG. **17**. Such movement is transmitted through the gears **92**, **98** and **106** to the spindles **52** and **53** so as to cause them to rotate in counterclockwise direction.

Rotation of the spindles **52** and **53** in a counterclockwise direction continues until the stop member **153** secured to the underside of the cam member **134** engages the stop member **152** mounted on the upper surface of the plate **40**, in the manner illustrated in FIG. **14**. When this occurs, the cam member **134** of the device of FIGS. **14–18** is properly indexed for another cycle of operation.

While the motor **280** is operating, fluid is gradually flowing out of the pilot portion **297** of the two-way valve **295** through the fourth control branch conduit **275**, restriction **266** of the control valve **265** through an exhaust port in the valve **270**. Thus, after a predetermined period of time sufficient to permit the motor **280** to cause the stop member **153** to engage the stop member **152**, the two-way valve **295** is shifted by the spring **299** to its closed position. When this occurs, the flow of fluid to the motor **280** is shut off and the device is recycled and ready for another tensioning operation.

The fluid circuit illustrated in FIG. **18** is also effective to shut off the device any time an operator releases either one or both of the throttle levers **144** and **145** carried by the handles **142** and **143**. The manner in which the torque applying and tension controlling device of FIGS. **14–18**, inclusive, is shut down when the device is in operation and one or the other or both of the throttle levers are released is the same as is described in connection with the embodiment illustrated and described in FIGS. **1–10**, inclusive.

While the motors and the components of the torque applying and tension controlling device of the preceding embodiments are of the character adapted to utilize air under pressure as their operating medium, it will be understood that motors and circuit components adapted to be operated by fluids other than air could also be utilized.

I claim:

1. A device for applying torque to and controlling the tension in one or the other of a pair of threadedly engaged members, comprising driving means adapted to engage and transmit torque to one of said members, first drive means connected to said driving means and adapted to rotate said driving means and one of said members in one direction until a predetermined low torque has been applied to said one member, and second drive means connected to said driving means and adapted to rotate said driving means and said one member a predetermined additional number of degrees in said one direction after the application of said predetermined low torque to said one member to increase the tension in one or the other of said members, said first and second drive means being disposed in closely adjacent, side-by-side relation, whereby the height of said device is reduced.

2. The device of claim **1**, further characterized in that said first drive means includes torque limiting means operable to limit the torque applied to said driving means and said one threaded member by said first drive means.

3. The device of claim **2**, further characterized in that said first drive means comprises at least one fluid motor adapted to receive fluid under pressure from a source thereof and having a driven element adapted to be subjected to said fluid under pressure, and said torque limiting means comprises a valve in said motor and operable to limit the pressure of the fluid acting on said driven element.

4. A device for applying torque to and controlling the tension in one or the other of a pair of threadedly en-

gaged members, comprising driving means adapted to engage and transmit torque to one of said members, first drive means connected to said driving means and adapted to rotate said driving means and one of said members in one direction until a predetermined low torque has been applied to said one member, second drive means connected to said driving means and adapted to rotate said driving means and said one member a predetermined additional number of degrees in said one direction after the application of said predetermined low torque to said one member to increase the tension in one or the other of said members, said driving means including an overrunning clutch having a first clutch member fixed to said shaft, a second clutch member rotatably mounted on said shaft and connected to said second drive means, and at least one clutch element between said first and second clutch members and operable to prevent said first drive means from driving said second drive means when said shaft is being driven by said first drive means.

5. The device of claim **4**, further characterized in that said first drive means comprises at least one fluid motor and said second drive means comprises at least one other fluid motor, a fluid circuit is provided for supplying fluid under pressure to said motors, a cam member is carried by said second clutch member, and valve means is provided in said fluid circuit and responsive to the rotative position of said cam member, said valve means being operable to effect a shut off of the flow of fluid under pressure to said other fluid motor when said second clutch member rotates an amount equal to said predetermined additional number of degrees.

6. The device of claim **5**, further characterized in that said valve means comprises a fluid pressure actuated valve in said fluid circuit and controlling the flow of fluid under pressure to said other fluid motor, and a cam actuated valve in said fluid circuit and having a plunger engaging said cam member, said cam actuated valve controlling the application of fluid under pressure to said fluid pressure actuated valve, whereby said cam actuated valve controls the operation of said fluid pressure actuated valve.

7. The device of claim **5**, including reversing means for effecting rotation of said shaft in a direction opposite from said one direction after said shaft has rotated said predetermined additional number of degrees in said one direction, said reversing means comprising another valve in said fluid circuit and operable to reverse the direction of flow of fluid under pressure to said one fluid motor and the direction of rotation thereof.

8. The device of claim **5**, including reversing means for effecting rotation of said shaft in a direction opposite from said one direction after said shaft has rotated said predetermined additional number of degrees in said one direction, said reversing means comprising at least one additional fluid motor connected to said shaft and operable to rotate said shaft in said opposite direction.

9. The device of claim **5**, including reversing means for effecting rotation of said shaft in a direction opposite from said one direction after said shaft has rotated said predetermined additional number of degrees in said one direction, a frame having said first and second fluid motors mounted thereon, and stop means for limiting the extent of rotation of said shaft in said opposite direction, said stop means comprising a first stop member mounted on said cam and a second stop member mounted on said frame, said first stop member being positioned to engage said second stop member when said shaft is rotated in said opposite direction through an amount substantially equal to said predetermined additional number of degrees.

10. The device of claim **9**, further characterized in that the position of said first stop member is adjustable on said frame to permit adjustment of the additional number of degrees through which said shaft rotates in said one direction and the final tension in one or the other of said threaded members.

11. In a device for applying torque to and controlling the tension in one or the other of a pair of threadedly engaged members, including driving means adapted to engage and transmit torque to one of said members, at least one fluid motor connected to said driving means and adapted to rotate the latter and one of said members in one direction to apply a predetermined low torque to said one member, and at least one other fluid motor connected to said driving means and adapted to rotate said driving means and said one member a predetermined additional number of degrees in said one direction after the application of said predetermined low torque to said one member to increase the tension in one or the other of said members to a desired value, a fluid circuit for supplying fluid under pressure to and controlling the operation of said one fluid motor and said other fluid motor, said fluid circuit comprising supply conduit means adapted to be connected to a source of fluid under pressure and including a first supply branch conduit connected to said one fluid motor and a second supply branch conduit connected to said other fluid motor, first and second fluid pressure actuated valve means in said first and second supply branch conduits for controlling the flow of fluid under pressure to said one fluid motor and said other fluid motor, and control conduit means connected to said supply conduit means and including a first control branch conduit connected to one end of said first fluid pressure actuated valve means for communicating fluid pressure thereto to shift said first valve means to a position permitting flow through said first supply branch conduit, and a second control branch conduit connected to said second fluid pressure actuated valve means and operable to communicate fluid pressure thereto to shift said second valve means to a position permitting flow through said second supply branch conduit.

12. The device of claim **11**, further characterized in that at least one throttle valve is provided in said control conduit means for relieving the pressure therein and preventing fluid under pressure from being supplied to said one fluid motor and said other fluid motor through said supply conduit means.

13. The fluid circuit of claim **11**, further characterized in that sequencing means is provided for permitting fluid under pressure to be applied first to said first fluid pressure actuated valve means and then to said second fluid pressure actuated valve means after a predetermined time interval to effect sequential operation of said one fluid motor and said other fluid motor.

14. The fluid circuit of claim 13, further characterized in that said sequencing means comprises a restriction in said second control branch conduit.

15. The fluid circuit of claim 13, further characterized in that said control conduit means includes a third control branch conduit connected to said second control branch conduit and having a valve therein responsive to the rotative position of said driving means, said position responsive valve being operable to reduce the pressure in said second control branch conduit and thereby cause said second fluid pressure actuated valve means to shut off the flow of fluid under pressure to said other fluid motor after said driving means and said one member have rotated said predetermined additional number of degrees in said one direction.

16. The fluid circuit of claim 15, further characterized in that said control conduit means includes a fourth control branch conduit connected at one end to said first control branch conduit and at its other end to the other end of said first fluid pressure actuated valve means, said fourth control branch conduit having a flow reversing valve therein that is normally closed when said device is in operation, said flow reversing valve being movable to an open position upon disengagement of said driving means from one or the other of said threadedly engaged members at the completion of a tensioning operation to permit fluid pressure to be communicated to said other end of said first fluid pressure actuated valve means to shift the latter to another position, said first fluid pressure actuated valve means when in said other position being operable to reverse the direction of flow of fluid under pressure in said first supply branch conduit and cause said one fluid motor to rotate in a direction opposite from said one direction to recycle said device.

17. The fluid circuit of claim 16, further characterized in that said flow reversing valve includes a plunger adapted to engage structure adjacent said threadedly engaged members and a spring biasing said flow reversing valve toward an open position, said plunger being operable to shift said flow reversing valve to said closed position when said device is engaged with one or the other of said threadedly engaged members and said spring being operable to shift said flow reversing valve to said open position when said device is disengaged from said one or the other of said threadedly engaged members.

18. The fluid circuit of claim 15, further characterized in that said control conduit means includes a fourth control branch conduit connected at one end to said first supply branch conduit and at its other end to the other end of said first fluid pressure actuated valve means, said fourth control branch conduit having a manually actuated, normally closed, flow reversing valve therein, said flow reversing valve being operable when moved to an open position to permit fluid under pressure to be communicated to said other end of said first fluid pressure actuated valve means to shift the latter to another position, said first fluid pressure actuated valve means when in said other position being operable to reverse the direction of flow of fluid under pressure in said first supply branch conduit and cause said one fluid motor to rotate in a direction opposite from said one direction to recycle said device.

19. The fluid circuit of claim 15, further characterized in that said supply conduit means includes a third supply branch conduit connected at one end to said first supply branch conduit and at its other end to at least one additional fluid motor, said third supply branch conduit having a third fluid pressure actuated valve means therein and said additional fluid motor being connected to said driving means and operable to rotate said driving means in a direction opposite from said one direction, a fourth control branch conduit connected at one end to said first supply branch conduit ant at its other end to said third fluid pressure actuated valve means, said fourth control branch conduit having a manually actuated, normally closed, flow reversing valve therein, said flow reversing valve being movable to a position permitting fluid under pressure to be communicated to said third fluid pressure actuated valve means, and said third fluid pressure actuated valve means being operable to permit fluid under pressure to flow through said third supply branch conduit to cause said additional fluid motor to rotate said driving means in said opposite direction and thereby recycle said device.

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