

[54] INTERNALLY REACTIVE STRUCTURAL JOINDER SYSTEM

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[58] Field of Search ..... 81/55, 56, 57.39, 81/57.11, 57.13, 57.14

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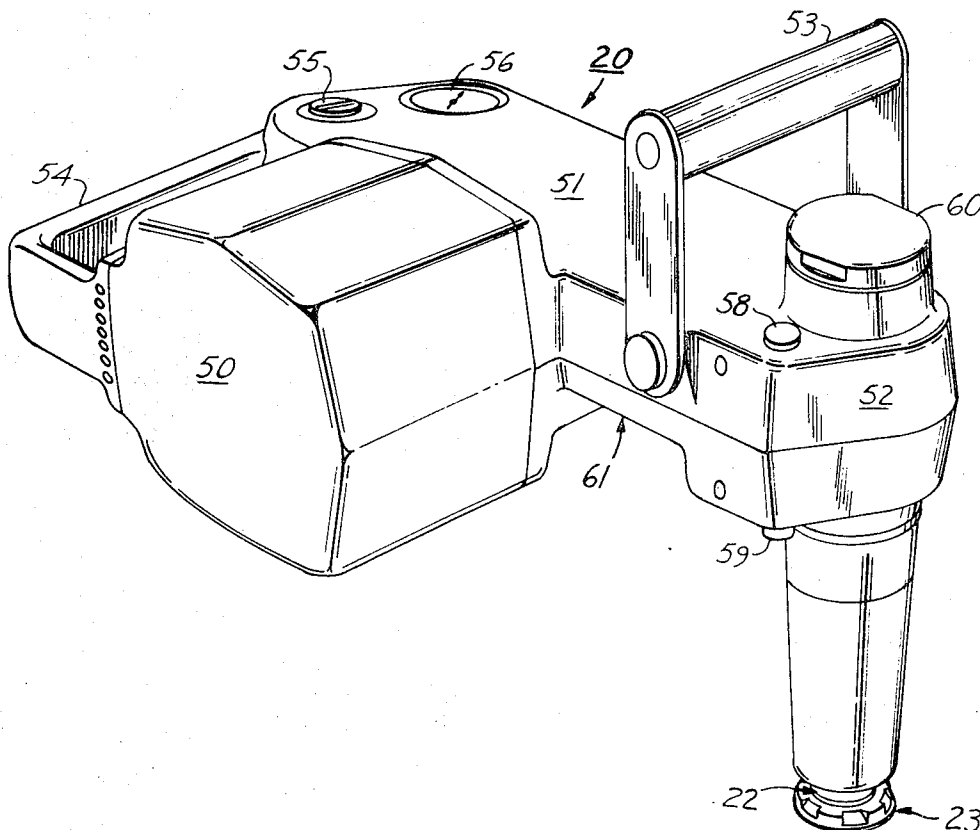
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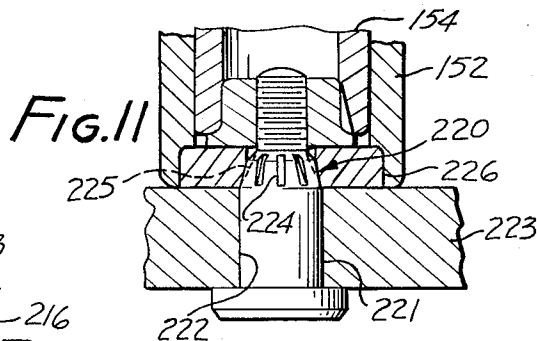
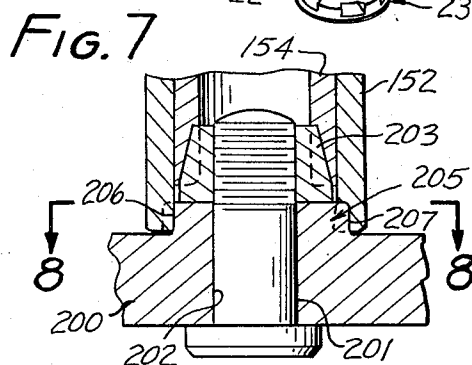
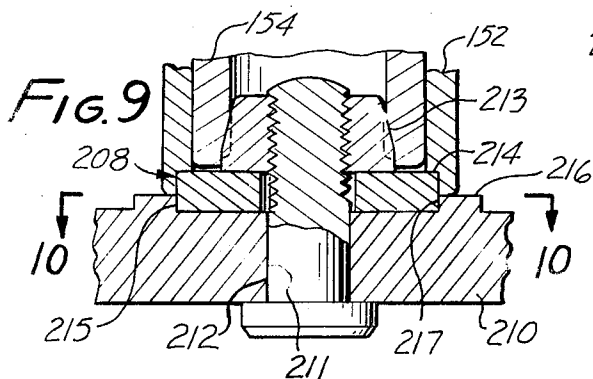
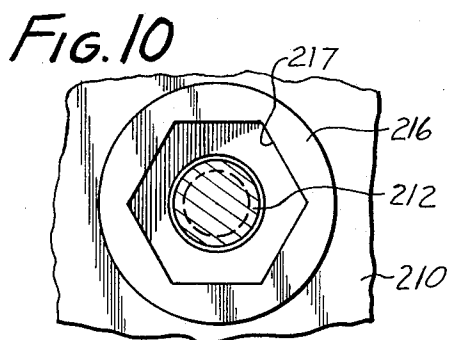
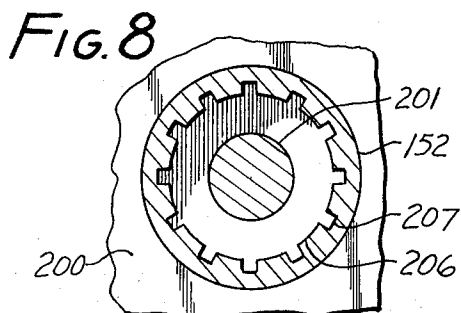
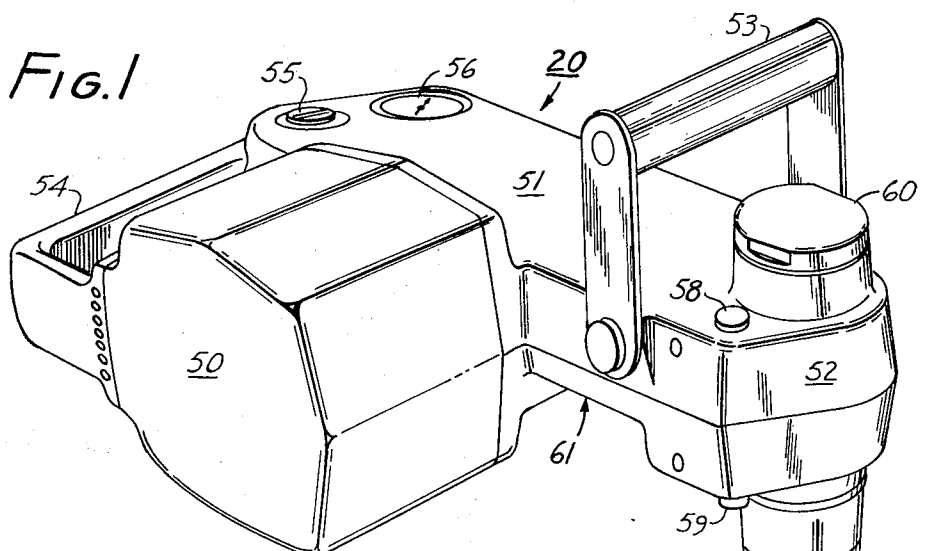
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[57] ABSTRACT

An internally reactive system for attaching one of its elements to another at a predetermined torque and axial tensile pre-load. The system includes a driver element, a fastener element, a workpiece element, and an interlinking element for interlinking the driver element and the workpiece element. The driver element constitutes a wrench with a driving arm, and a pressure-regulated fluid motor which turns the arm. The fluid motor exerts a force limited by the pressure of its motive fluid, and this force is directly proportional to the resulting torque level, because the system has no portion which during driving accelerates independently of any other portion, and no portion which overruns or impacts any other portion. The interlinking means may be a washer engaged by the frame of the driver element, and restrained relative to the workpiece element.

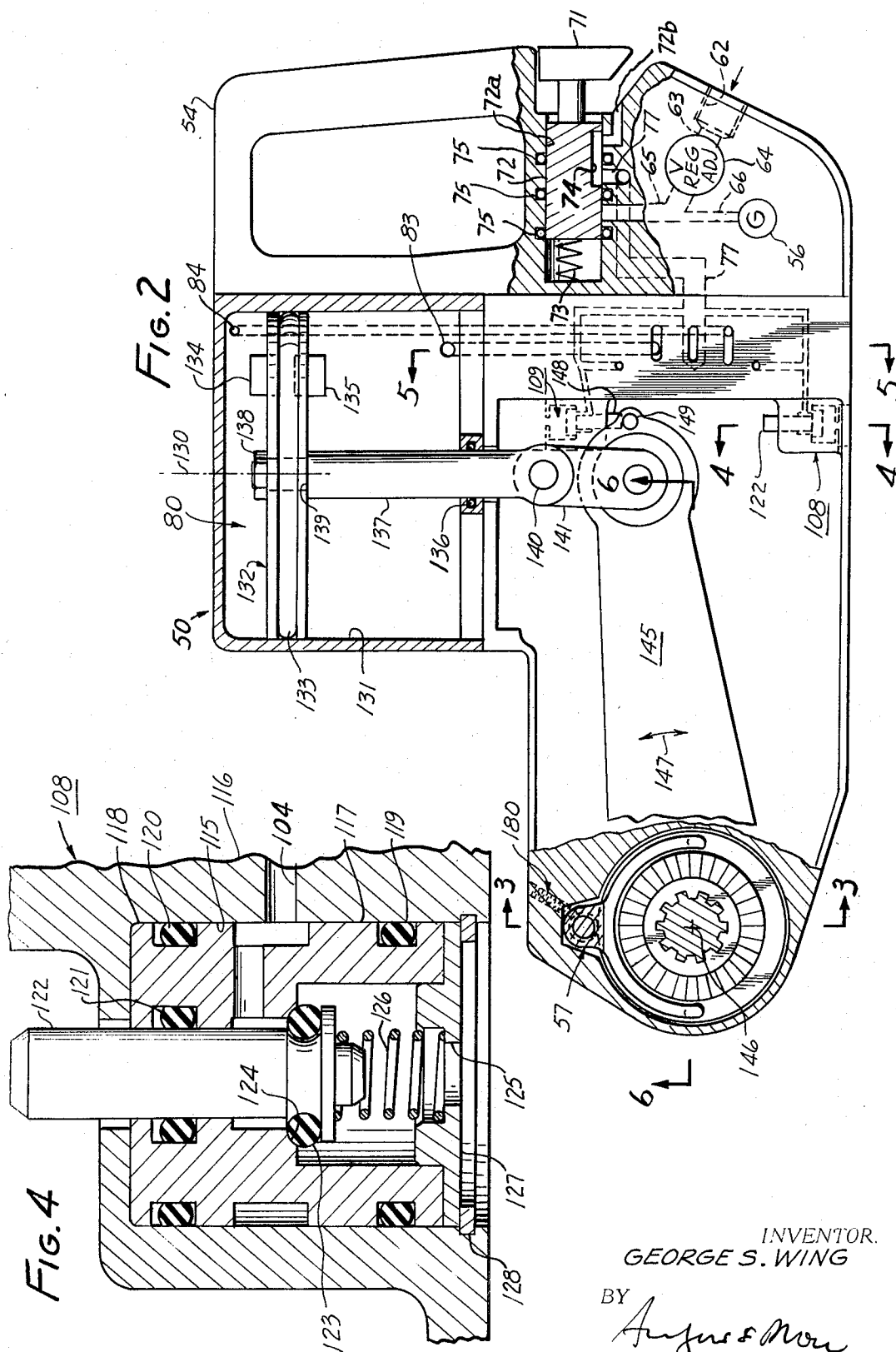
14 Claims, 14 Drawing Figures

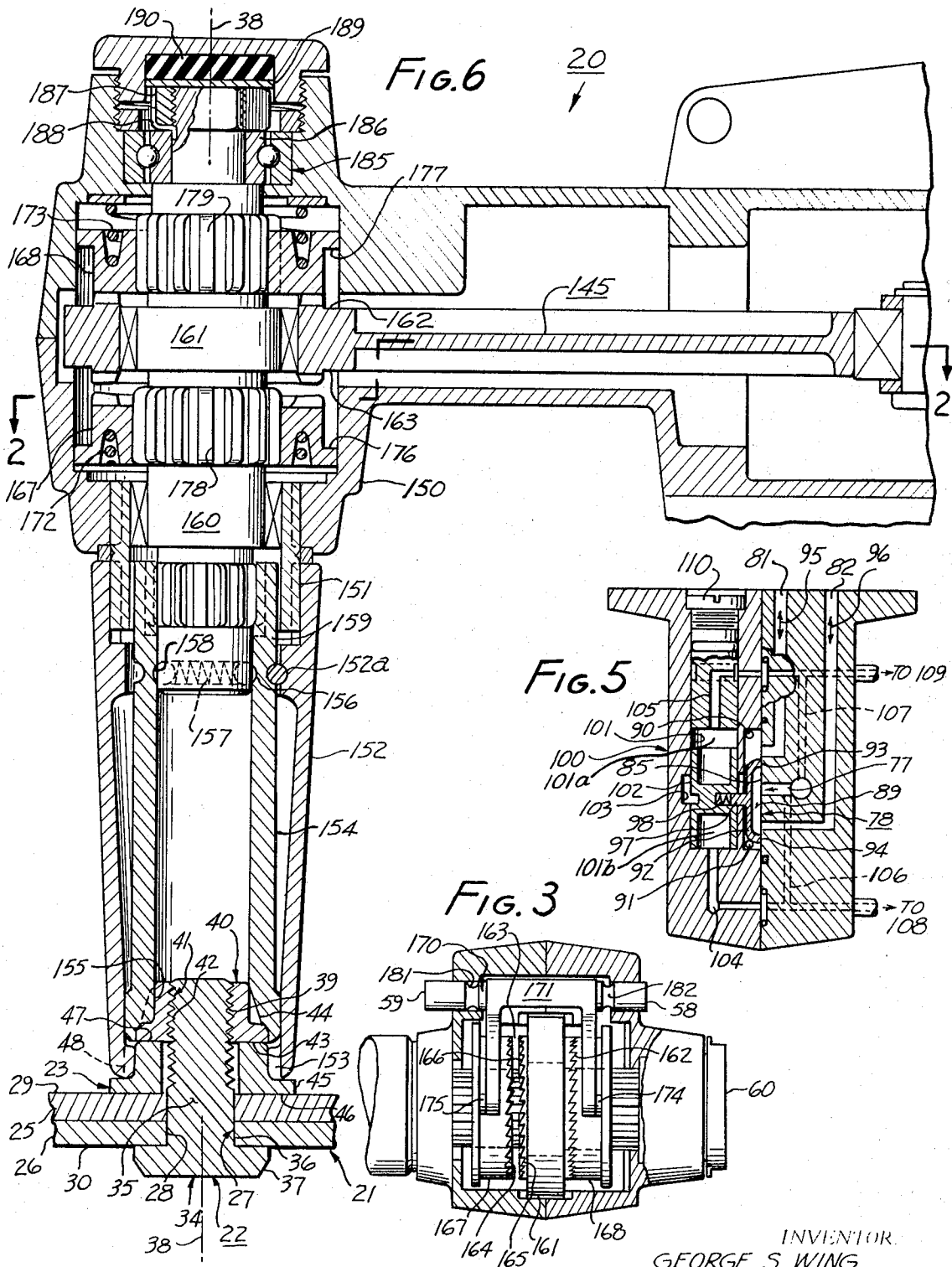




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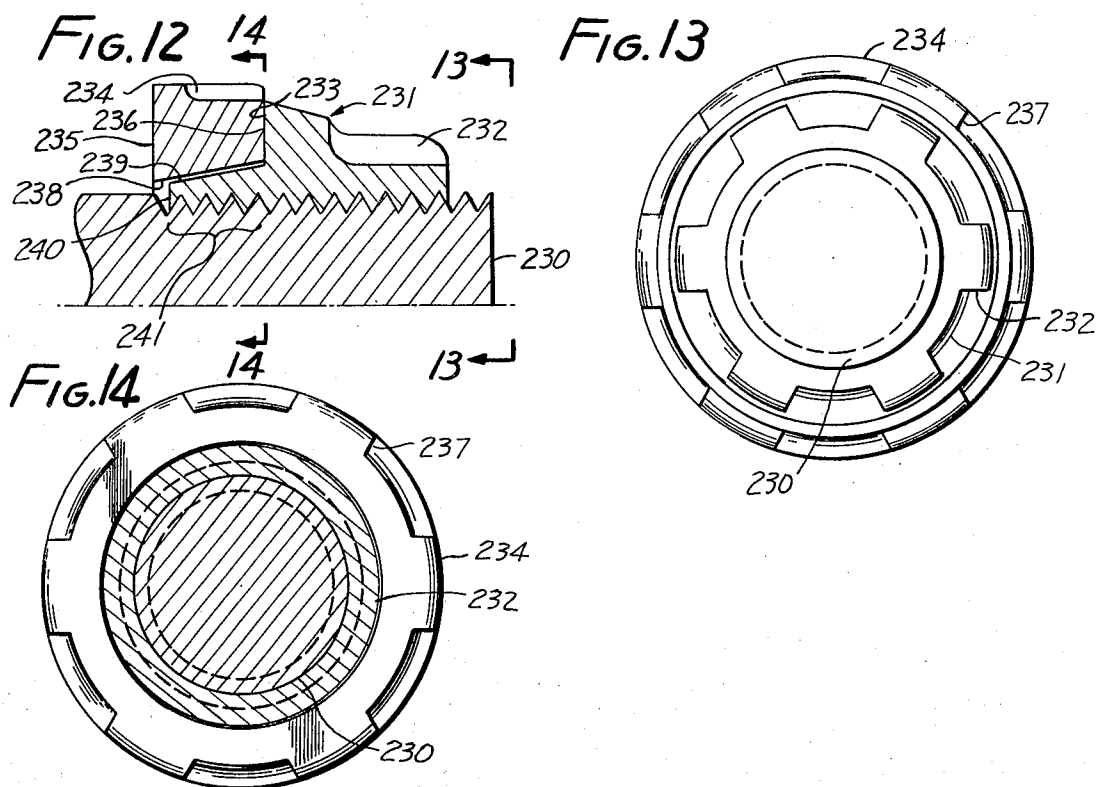




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## INTERNALLY REACTIVE STRUCTURAL JOINDER SYSTEM

This invention relates to fastener systems, to joinders provided by them, and to elements of such a system.

The combination of a threaded nut and bolt is one of the most common fastener systems. All parts of this system have been intensively investigated, commented on, improved and standardized, with the objective of providing a reliable means for joining together a plurality of objects. Over the years, as joinder requirements have become more rigorous, the state of the art as to threaded fasteners has been steadily advanced. There is relatively little latitude for changes in basic thread shapes and in fit-of-the-fastener concepts, so it is not surprising that recent thrusts toward fastener improvement have been in the direction of improving the fastener's reaction in the total system, and in tools and peripheral concepts for taking advantage of the inherent advantages of threaded fasteners.

Especially in joints which are subjected to relatively large loads, and to cycling loads, the installation of the fastener can make a vital difference in the reliability, strength, and life of the joint, and of the assembly which it holds together. Common examples are related to the resistance of a joint to fatigue failure. Three examples of areas in which advances have been sought are: (a) good surface finish, which reduces points of stress concentration; (b) interference fits of the bolt in the wall of the workpiece, which radially compresses the material of the workpiece at the wall of the hole so as to isolate it at that point from cyclical forces up to a predetermined level; and (c) general tightness of the joint which prevents slack movements in the joint with attendant high shock loads. In each case, substantial improvements have in fact been made. The ultimately desired result is evident — a joint which is as strong as the workpiece, and which does not by its own presence create problems. As stated, joints of this type can indeed present such problems.

Of the examples given above, the general tightness is the one which is subject to greatest variation in the course of actual installation, and at the same time has one of the greatest effects on the strength and longevity of the joint. The tightness is, in turn, related to the axial clamping force exerted by the fastener. When a nut is tightened onto a bolt, the bolt is stretched, and its relaxation force is a clamping one. This is called "axial pre-load", and its uniform attainment results both in a reliable fastener, and in a joint comprised of many identical fasteners, of a more reliable joint.

The ideal means for measuring pre-load is by measuring the actual stretch of the bolt. However, means for doing this quickly and accurately in production do not exist. Therefore, the only useful and controllable parameter is the torque applied to the collar (nut) relative to the pin (bolt). At least in theory, the torque applied will be proportional to the axial pre-load on the fastener, because when the collar is tightened down and bears against an adjacent washer or face of a workpiece, the thread reaction stretches the bolt. The tensile force exerted by the stretched bolt is the axial tensile preload. This load holds the joint tightly clamped together, and the torque level used is commonly selected to produce a desired pre-load, on the assumption that the two are directly proportional. However, in practice, this direct proportionality can be adversely affected by several important variables.

Especially in critical installations, the attainment of the design objective for each joinder, and repetitiveness of effect from joinder to joinder are critical considerations. In theory, and to a significant extent in practice, a threaded joint can be set to an exact torque and preload level by an individual who exerts a steady and measured force on a lever arm at a closely measured distance from the center of rotation of the collar. However, this technique is not well-suited for high production rate applications, because it is too slow and painstaking. Neither is it suitable for large fasteners wherein the torque loads are in hundreds or thousands of inch pounds, because one man cannot exert that much force, and with too many men the force load actually exerted becomes uncertain. Torque wrenches for measuring the torque involve calibration problems, and exertion of strong forces, or forces quickly applied, involve the risk of excessive or peak loads which may apply excessive torques. Excessive torque can constitute a severe risk, because the threads may be stripped, and because the fastener may be pre-loaded to too great a percentage of its capacity.

These problems have been treated in various ways. In one system, as exemplified by George S. Wing U.S. Pat. No. 2,940,495, entitled "Lock Nut with Frangible Driving Portion", torque limitation is made inherent in the collar by providing a shear section which shears at a design torque, and causes the driving surfaces to separate from the threaded body of the collar at the desired torque level. This system has enjoyed widespread acceptance. However, when large-diameter fasteners are involved, such as for 1 inch and greater diameter bolt threads, the manufacture of the driving section to suitable tolerances makes the fastener more expensive than one would wish. Also, when the shear section fractures, the release of the driving surfaces causes a mechanical shock to be exerted on the installer, which many installers object to.

To overcome this latter disadvantage in setting an inherently torque-limited fastener, the wrench shown in U.S. Pat. No. 3,247,741, issued Apr. 26, 1966, to R. W. Batten, entitled "Machine Wrench with Torque Reaction Means", was invented. In this wrench the frame is engaged to a washer, which washer is restrained relative to the pin. The frame is also restrained to the pin. Then when fracture occurs, the release occurs exclusively within the tool, and is not felt by the installer. This system constitutes a very substantial advantage in the application of larger sizes of inherently torque-limited fasteners. It does not, however, suggest or provide means for setting a driver to a given torque and axial pre-load level when no inherent limitation is provided in the fastener itself.

The Batten wrench does suggest a solution to one problem of setting fasteners to a given level, and that is by the divorcement from the applied torque level of the degree of the restraint on the handle of the wrench. It is evident that the torque on the wrench must be equal and opposite to that which is applied to the fastener, and that if the support on the frame yields, then the torque level will change. Apart from the class of driver exemplified by the Batten device, the applied torque is very difficult to control, and even in the Batten device, where the wrench handle's reaction with its surroundings is rendered unimportant, no means is provided for determining the exact torque which is exerted by the wrench, because that level is unimportant so

long as the torque applied exceeds the level at which the inherent limitation in the collar functions, i.e., the shear section fractures.

Still another problem in the prior art relates to the rate of application of force to the fastener by the wrench. Various impact and override type wrenches are known which approximate the applied torque by the application of a blow by a hammer of known weight against an anvil, or slip a clutch as a function of a frictional grip on a driving socket. In these devices the velocities or accelerations of the driving means are permitted to exceed those of the object being driven, and accordingly, a peak load can be exerted by a blow, or by sudden stoppage of the collar. In either event, a force other than the design force may be exerted, thereby setting the fastener to an unknown torque, or at least to one other than its design level. The usage of such devices requires the consideration of many variables, such as the tightness of the joint, relative surface finishes, and the like, all of which are themselves subject to variation from joint to joint.

It is an object of this invention to provide an internally reactive structural joinder system wherein a fastener element may be set in a workpiece element by a wrench element acting through an interlinking element so that the operator's skill and judgment can be ignored as to the accuracy of the joinder, and in which a fastener element, which need not include inherent torque limitation means, can be set to precise, adjustable, and repeatable torque and axial pre-load levels.

It is also an object of this invention to provide a torque wrench which is useful with fastener elements other than those of this system, and with which, provided the wrench frame is properly restrained, the said fastener elements can be set accurately and quickly to predetermined torque and axial pre-load levels. The levels can readily be selected by a simple adjustment of a pressure regulator. Large forces can be exerted by the wrench itself so that large fasteners may be set to high torques.

It is another object of this invention to provide a fastener element for use in a system of this type wherein the inherent resistance of the collar to being tightened onto the pin is standardized, and a deleterious effect on the first few thread convolutions of the collar which often occurs in conventional installations is greatly minimized.

The system of this invention is provided for the purpose of attaching one of its elements to another of its elements. It includes a driver element, a fastener element, a workpiece element, and an interlinking element for interlinking the drive element and the workpiece element. The driver element constitutes a wrench with a driver arm and a fluid motor which turns the arm. The fluid motor exerts a force limited by the pressure of its motive fluid. The torque exerted in the system is directly related to this pressure, because the system has no portion which accelerates independently of any other portion, and no portion which overruns or impacts any other portion.

According to a preferred but optional feature of this invention, the fluid motor is a linear actuator; for example, a piston-cylinder combination.

According to still another preferred but optional feature of this invention, an adjustable pressure regulator regulates the fluid pressure and thereby the applied torque.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is a perspective view of the presently preferred embodiment of the invention;

FIG. 2 is a top view of FIG. 1, partially in schematic and partially in cutaway notation;

FIGS. 3, 4, 5 and 6 are cross-sections taken at lines 3—3, 4—4, 5—5 and 6—6, respectively, of FIG. 2;

FIG. 7 is a cross-section showing another embodiment of the invention;

FIG. 8 is a cross-section taken at line 8—8 of FIG. 7;

FIG. 9 is a cross-section showing still another embodiment of the invention;

FIG. 10 is a cross-section taken at line 10—10 of FIG. 9;

FIG. 11 is a cross-section of still another embodiment of the invention;

FIG. 12 is a cross-section showing a preferred embodiment of a portion of the invention; and

FIGS. 13 and 14 are cross-sections taken at lines 13—13 and 14—14, respectively, of FIG. 12.

The system according to the invention is best shown in FIG. 6 and includes a wrench element 20, a workpiece element 21, a fastener element 22 and an interlinking element 23. It is a function of this system to set the fastener element to the workpiece element at a predetermined torque and axial pre-load.

Workpiece element 21 comprises a body 25 of material such as aluminum, stainless steel or the like and preferably will be entirely metallic. The workpiece is shown comprising bodies 25 and 26 which schematically represent a plurality of objects to be held together by the fastener element.

An aperture 27 is formed through the workpiece with a cylindrical inner wall 28 having a reference diameter. It has a first surface 29 and a second surface 30 which preferably but not necessarily are parallel to each other.

The fastener element 22 comprises a pin 34 with an elongated shank 35 having a cylindrical outer wall 36 adapted to be fitted in the wall of aperture 27. This outer wall frequently will have a larger diameter than the reference diameter for the purpose of making an interference fit in the hole, although this is not essential to the practice of the invention.

A head 37 is formed at one end of the shank to bear against the first surface of the workpiece. This is an example of a means for restraining the shank from axial removal from the workpiece. The aperture and the shank share a common central axis 38. An external thread 39 is formed on the pin 34 at the end opposite the head and projects from the aperture beyond the second said surface.

The said fastener also includes a collar 40 which is annular and has a central passage 41 therethrough with an internal thread 42 adapted to engage and be tightened onto external thread 39.

The collar includes a bearing face 43 surrounding the end of the passage closer to the workpiece. A plurality of blades 44 project beyond the outer periphery of the nut for an engagement by a drive socket yet to be described. It will be seen that the fastener element thereby comprises pin 34 and collar 40 which are adapted to be used as a nut and bolt.

Interlinking element 23 comprises in the preferred embodiments as shown in FIGS. 6 and 12-14, an annu-

lar body 45 in the form of a washer having a first bearing face 46 abutting the second surface 30 of the workpiece and a second bearing face 47 in abutment with bearing face 43 on the collar. It carries a plurality of blades 48 on its periphery for engagement by a driver means yet to be described.

The driver element 20 is shown in detail in FIGS. 1-6. It is an assembly comprised of a motor section 50, a transmission section 51 and a wrench section 52. It is held together by appropriate assembly means and is provided with a pair of handles 53, 54 so that it may conveniently be held by the installer.

A control knob 55 for an adjustable pressure regulator valve, which will later be described, is provided at the top surface of the driver element, together with a gage 56 which will indicate the regulated pressure, preferably in numerals calibrated as to torque.

A clutch selector 57 providing a pair of buttons 58, 59 for the installer is also included at a readily accessible location. A drag adjustment means 60 is also accessible to the user. Fastener element 22 is shown at the bottom end of the wrench section. These sections and their component parts will now be described in greater detail with initial reference to FIGS. 2.

A frame 61 which comprises the assembled structure of the various sections serves to house the various portions of the invention. In order to apply power thereto, there is a pressure inlet port 62 adapted to be connected to any desired fluid under pressure, which fluid may be compressed air, pressurized hydraulic fluid, or whatever is preferred for the use at hand and the pressures to be utilized. The pressure inlet port feeds pressure to a pressure conduit 63. In the pressure conduit there is provided a pressure regulator valve 64 which is adjustable by turning control knob 55. This is a relieving-type regulator valve of conventional design and discharges gas into the downstream portion 65 of the pressure conduit and maintains it therein at the adjusted pressure. Gauge 56 is connected to portion 65 by branch 66.

Pressure is fed to a trigger valve 70, which trigger valve includes a button 71 adjacent to handle 54. The button is carried by an axially shiftable valve spool 72, which is spring-loaded by spring 73 to a vented position, with the button biased away from the frame. The valve spool is slightly fitted in bore 72a. A vent conduit 72b open to the atmosphere also opens into the wall of the bore. Position 65 of the pressure conduit and conduit 77 similarly open into the said wall. A slot 74 is formed in the wall of the spool, and extends for such a length that it overlaps conduits 72b and 77 when the trigger is released so as to vent conduit 77, and to overlap conduits 65 and 77 when the trigger is depressed so as to connect conduit 77 to the pressure source to operate the wrench. O rings 75 are provided as necessary to prevent leakage of fluid under pressure.

The venting of conduit 77 "unlocks" the wrench when power is off so its drive mechanism can be manually moved without impediment from fluid trapped in conduit 77 and the motor downstream from it.

Conduit 77 connects to a direction selector valve. This direction selector valve is shown only schematically in FIG. 2 and is shown in full detail in FIG. 5. It is the function of the direction selector valve to determine the direction of supply of pressure and exhaust fluid to and from a fluid motor 80 (best shown in FIG. 2). It does so through supply conduits 81, 82, which ex-

tend to supply ports 83, 84 of the fluid motor, respectively. Conduit 77 opens medially in a valving surface 85, and conduits 81, 82 open into said surface on opposite sides thereof. A valving chamber 89 faces said valving surface. Valving surface 85 is planar. Exhaust ports 90, 91 extend from the valving chamber to atmosphere or to reservoir as the case may be.

The direction selector valve 78 comprises a slide valve utilizing said valving chamber and a slider 92, which slider has a pair of arms 93, 94 and which are axially spaced apart from each other and which slide in fluid sealing contact along the valving surface. It will be seen that in all axial positions of the slider, the arms will span the entry point of conduit 77 and may selectively also bridge one or the other of supply conduits 81, 82. Exhaust ports 90 are always open to exhaust. They will, however, be connected only to that one of conduits 81, 82 which is not at the time connected to the supply pressure. This device thereby constitutes a four-way valve, providing for a selectable bi-directional flow of fluid through conduits 81, 82 as indicated by arrows 95, 96. It therefore follows that the axial position of the slider will determine which of conduits 81, 82 is under pressure and which is under exhaust conditions at any given time.

The slider is provided with a tang 97, which is spring-loaded by spring 98 to press the arms 93 and 94 firmly against valving surface 85 and also to provide for axial reciprocation of the slider. This reciprocation is accomplished with a shuttle valve 100 which includes a cylinder 101 within which there is fitted a cylindrical shuttle 102 having a cavity to receive the tang so that, when the shuttle shifts axially in its cylinder, it will take the slider with it. A relief 103 is provided to pass the tank through the wall of the cylinder 101.

A pair of shuttle passages 104, 105 open into the opposite ends of cylinder 101. They proceed to connect to branches 106, 107 which are connected to conduit 77 of the pressure conduit 63. They are also connected to pilot valves 108, 109 (see FIG. 2). Cylinder 101 is bored into the body of the mechanism and is closed by a plug 110. The pilot valves 108 and 109 are identical to one another so that only pilot valve 108 will be described in detail. It includes a bore 115 in body 116 in which a pair of insert 117, 118 are placed. The inserts are provided with appropriate O-ring seals 119, 120 and 121. An axially shiftable valve stem 122 projects from the body and carries inside the body a peripheral seal 123 which is adapted to close a seat 124 to isolate conduit 104 from vent passage 125. A bias spring 126 bears against a spring retainer 127 which is held in place by a snap ring 128 to bias this valve to a closed position. The strength of this spring is sufficient to withstand the force of the pressure in conduit 104. When this valve is closed as shown in FIG. 4, fluid is trapped in shuttle passage 104 and when it is open the shuttle passage is vented to the atmosphere or to such reservoir as might be provided in view of the class of working fluid being used.

The motor section 50 includes the bi-directional fluid motor 80 which operates bi-directionally along axis 130. In the presently preferred embodiment of the invention as shown in FIG. 2, the motor is a linear actuator and a piston-cylinder variety. A cylinder 131 is provided in which a piston 132 is axially slidable. The piston is conventional, and makes a sliding fluid sealing fit in the cylinder by means of a piston ring 133. Supply

ports 83 and 84 enter the cylinder on opposite sides of the piston so that neither is ever covered by the piston and they are always separated by it.

Two bumpers 134, 135 act as a safety limit means to limit the excursion of the piston.

A sliding seal 136 in the nature of a packing is provided around shaft 137 which shaft is attached to the piston by means of nut 138 that presses it against a shoulder 139 on the shaft. The shaft is slidable through the opening formed by the sliding seal 136 and extends to a knuckle joint 140 which joins the shaft to a link 141. The link is in turn pinned to a lever arm 145. The lever arm pivots around a wrenching axis 146 and swings in an arc shown by arrow 147. This arc will ordinarily be on the order of 14° and this will cause it to move from a limiting position shown in FIG. 2 where it bears against valve stem 148 of pilot valve 109 to its other limiting position where it bears against valve stem 122 of pilot valve 108. It will be seen from the foregoing that when the trigger is depressed, the direction selector valve will cause motion of the motor in one or the other of its directions and when it reaches the extent of that motion, pin 149 which projects from the lever arm to contact the respective stems, will react with the respective pilot valve so as to shift the direction selector valve to the opposite position, causing reversal of the fluid connections. These will be described in more detail later but are given at this point as to make it plain that the lever arm 145 will oscillate in the arc of the plane of FIG. 2 so as to operate the wrench section yet to be described.

The wrench section is best shown in FIG. 6. The objective of the wrench section is to apply counter-rotative force to set the fastener. It includes a frame 150 which makes a splined attachment 151 with an outer tubular anchor means 152. When the driving element is not to be attached to an interlinking element, then anchor means 152 may be eliminated. Blades 153 are provided to make an engagement with blades 48 on the interlinking element. These blades are geometrically congruent with one another for this purpose.

Inside the anchor means is provided a driver socket 154 which has blades 155 in its inner end to engage blades 44 on the collar so as to drive the same, and blades 44 and 155 are geometrically congruent for this purpose. Anchor means 152 is generally made non-rotative relative to the frame, and driver socket 154 is rotated relative thereto. A spring-loaded ball detent comprising a ball 156, a spring 157 and a groove 158 is provided for releasably retaining the drive socket axially on drive shaft 160. A dowel 152a is provided for retaining anchor means to the drive socket. It is a cross pin seated in the frame. It permits rotation of the drive socket, because the external groove on the drive socket is fully peripheral, and the center part of the dowel merely rides in it, while still retaining the drive socket axially. A splined joint 159 joins the drive socket to a drive shaft 160, which is rotatively mounted in the frame. Therefore, rotation of the drive shaft will turn the drive socket in the respective direction of rotation. Lever arm 145 terminates at a rotatable drive ring 161, which has a first and a second drive surface 162, 163, respectively. These surfaces are provided with teeth 164, which have driving faces 165 facing in one direction and ramp-releasing faces 166 facing in the other direction, whereby turning the arm in one direction will cause a driving action through the driving faces, and

reversal will cause a ratcheting-release action over the releasing faces. The driving faces of the two surfaces face in opposite directions so that, when one set is engaged, driving will occur in one direction for a given direction of movement of the lever arm, and the opposite take place at the other face. Selection is made by means of a pair of selector rings 167, 168, which respectively face surfaces 162 and 163. These selector rings carry teeth which match the ramp-releasing faces and driving faces of the drive surface to which it is opposed, and it will thereby be seen that selectively engaging a selector ring with its respective drive surface will cause respective corotation. This is accomplished by providing slide means for this purpose such as shown in FIG. 3, where buttons 58 and 59 are shown on the end of a shaft 170, which is joined to a yoke 171.

The yoke is adapted to bear against the two selector rings so as to permit one to be brought into bearing contact with a respective drive surface and to move the other one out of contact. For this purpose, there is provided a pair of bias springs 172, 173, which bias the respective selector rings toward the drive ring. Respective branches 174, 175 of the yoke will be brought to bear against peripheral flanges 176, 177 on the selector rings so as to press one away from the drive ring and permit the other spring to bring the other selector ring into contact therewith. It will thereby be seen that shifting the shaft 170 along its axis will enable one or the other of the selector rings to make contact with the drive ring.

Transmission of the rotation to the drive shaft 160 is by means of splines 178, 179 for selector rings 167 and 168, respectively. In FIG. 6, selector ring 168 is shown drivingly connected, and selector ring 167 is shown disconnected, and it will be assumed that the driving faces and ramp-releasing faces will face in the counter-clockwise direction, and the selector ring 167 will have no effect because it is not selected. Ball detent 180 (see FIG. 2) is provided to engage grooves 181, 182 in the shaft 170 for holding the shaft in an adjusted selected position. In every case, the combination of one of the drive surfaces and a respective selector ring constitutes a unidirectional clutch means. In pairs, they also constitute a means for selecting the direction of driving rotation, which, in this case, may be selected for left or right hand rotation.

It is not desirable for the drive shaft to rotate completely freely, and therefore, a small drag is provided. For this purpose, at the top of the drive shaft there is provided a bearing 185, the inner race 186 of which gives side support and axial support to the upper end of the drive shaft 160. A nut 187 and nut retainer 188 are threaded to the top of the drive shaft and bear against a drag plate 189. This drag plate is borne against by a deformable disc 190, such as a rubber disc, the pressure of which against the drag plate is determined by the tightness of drag-adjusting means 60, which is a threaded cap threaded into the end of the body. It will thereby be seen that the drag force between the drag plate and the upper end of the shaft will provide some small and adjustable drag opposing free rotation of the drive shaft.

Other means for obtaining the objectives of the invention utilizing the interlinking means with the fastener means are shown in FIGS. 7-14, inclusive. In FIG. 7, workpiece 200 is shown with a pin 201 installed in an aperture 202 therein. A collar 203 is threaded

thereon by means of a socket by means of anchor means 152 and socket 154. The distinction between the device of FIG. 7 and of FIG. 6 resides in the fact that the interlinking element 205 comprises a boss 206 formed as a part of the workpiece surrounding the aperture. It has blades 207 to engage the blades on anchor means 152.

FIGS. 9 and 10 show a restraint for an interlinking means 208 exerted by a direct physical abutment rather than by frictional contact. The workpiece 210 has an aperture 211 to pass a pin 212 therethrough. A collar 213 is brought against a washer 214, which washer has a hexagonal outer boundary 215. A raised ring 216 formed on the workpiece surrounds the aperture and has an internal hexagonal boundary 217, which restrains the washer against rotation. The wrench socket drives the collar. The anchor means is restrained by the washer, and the washer is physically restrained by ring 216 on the workpiece.

In FIG. 11 there is shown still another interlinking means 220. Pin 221 is tightly held in aperture 222 in a workpiece 223 by virtue of a close fit therein. Splines 224 on the pin are engaged by splines 225 on a washer 226 to hold the washer against rotation, the washer being engaged by the anchor means.

The presently preferred embodiment of interlinking element and collar is shown in FIGS. 12-14 wherein on the threaded end of a pin 230 there is threaded a collar 231, which collar has blades 232 to be engaged and driven by the drive socket, and a bearing face 233 to engage the interlinking element 234. The interlinking element has first and second bearing surfaces 235, 236 to be sandwiched between the bearing surface of the collar and the surface of the adjacent workpiece. The interlinking element has blades 237 to be engaged by the anchor means. Of importance to this embodiment of the invention is a tapered internal wall 238 in the interlinking element and a tapered outer wall 239 on the collar, which tapered walls are at least partially axially coextensive when the device is installed, and they are also radially spaced apart from one another. It will thereby be seen that a nose 240 is provided on the collar which is not subjected to radial pressures by the interlinking element, and this frees the first three fully formed convolutions 241 of the collar from the uncertainties and stresses generated by external radial deformation which so frequently causes complications in the design of fasteners when their end is brought firmly against the workpiece.

It is well known that the first three fully formed thread convolutions of a collar transfer a disproportionate percentage of the load from the pin, compared to the remaining threads. Accordingly, variables at these threads are to be avoided should a standardized joint be desired. When the end of a collar is brought to bear against a surface, and the first three fully formed threads are located directly adjacent to the interface, distortion effects may occur which can change the interface conditions at the engaging surfaces of these threads. In the embodiment of FIGS. 12-14, these threads are in nose 240, in a region "ahead" of the distorting forces, and radially spaced from the washer. Accordingly these convolutions, which will still transfer a disproportionately larger share of the load, do so in a free and undistorted condition.

The operation of this system will now be described. First, the interlinking element is selected and assem-

bled with the fastener and the pin inserted in the aperture. Then the anchor means is applied to the interlinking means and the drive socket to the collar. One or the other of buttons 58 or 59 will have been pressed to determine the direction of driving rotation, clockwise or counter-clockwise. In the event that it is to be clockwise, the setting will have been made as illustrated in FIG. 6, whereby drive ring 161 and selector ring 168 are engaged for driving rotation.

The trigger is pressed, and the spool is shifted so slot 74 overlaps and connects conduits 65 and 77, and pressurized liquid at the adjusted pressure passes through the trigger valve and to the direction of selector valve and shuttle valve. Assuming that the end of the lever arm is between the two pilot valves, and that the shuttle will be on one or the other of its extreme positions, then fluid from conduit 77 will flow to a respective one of conduits 81 and 82 to one side or the other of the piston. Exhaust fluid will flow to the other of those back into the valving chamber 89 and out the respective one of exhaust ports 90 or 91. This motion will continue and may initially be either a ratcheting release of the clutch, or a forward driving of the same. In either event, when one or the other of the pilot valves is struck by the lever arm, it will be opened and will vent the pressure in its respective line 104 or 105. This will then unbalance the shuttle 102 and will cause it to move in the direction of the released pressure because the other side will remain under full system pressure. This will carry the direction selector valve to its opposite position and will reverse the pressurization of the conduits 81 and 82. There will, therefore, follow a continuous cycling operation of the motor so long as the trigger is held down and so long as the torque resistance through the wrenching portion of the device does not exceed the torque generated by the motor.

When the lever arm moves in the clockwise direction, the drive faces of the clutch means will cause rotation of the wrench, and when the reversal occurs by virtue of contact with pilot valve 108, then there will be a ratcheting release. The opposite situation would be true were the setting of the direction selector opposite, and driving would occur in a counter-clockwise direction.

The direction selector valve is simply a four-way valve for directing the pressure to one of the sides of the piston at a given time, and the shuttle valve is for the purpose of resetting the selector valve as a function of pilot valve operation.

It is plain that the torque exerted is a direct function of the pressure established by the pressure regulator 64 and that the force delivered is a function of the product of that pressure and the area of the piston.

Link 141 is provided to take out any slack and to minimize as far as possible the small-angle error resulting from angular movement of the lever arm.

The motor will stall when the resistive torque from the fastener element equals the torque exerted by the driver means. It is important to note that at this time there is no over-running of the device. The motor simply stalls, and this is an important distinction from prior art torque limited drivers. Except for the very small unavoidable motion in the re-engagement of the clutch in the driving action after a reversal, there is no overrunning of any part of this system, and even this may be reduced by utilizing a roller type clutch, or by increasing the number of teeth on the clutch faces.

When the trigger is released, spring 73 returns the spool to the illustrated position, conduit 77 is cut off from pressurized fluid and vented, and motion stops.

It will now be seen that when the anchor means is utilized so as to couple the system between the drive socket and the anchor means, the operator is entirely removed from the torque setting operation and that a readily adjustable, completely accurate and reproducible torque is applied to the fastener.

Similarly, this device provides a very accurate torque wrench which may be utilized without the anchor means provided only that means is provided for the restraining the frame against counter-rotated motion derived from the system.

The various embodiments of interlinking means are provided to illustrate the wide range of selections one has at his disposal with this system for achieving the objective of anchoring the driver element to the workpiece element. In the preferred embodiment, the restraint is attained by the frictional drag between the abutting faces of the workpiece and of the washer. The area of contact at this interface is preferably greater than that between the collar and the washer in order that the greater force may be that which tends to restrain them. Although the washer is initially freely rotatable, as soon as the collar is lightly tightened the frictional force will prevent further rotation of the interlinking means and will provide a firm anchorage for the frame of the driver. Similar results are attained by provided bosses on the surface of the workpiece or by anchoring the washer either by means of the workpiece directly and mechanically as in FIGS. 9 and 10 or through the pin as shown in FIG. 11.

It is evident that the fluid motor may be a linear or a rotary type actuator depending on the preference of the user or designer so long as a torque is applied at the end of a fixed lever arm as a consequence of a fluid pressure applied to a resistive but movable surface. It is also true that the axis of motion of the fluid motor need not be in a plane normal to the wrench axis as shown, but this will be found to be a compact and very versatile arrangement for a practical wrench.

This invention is not to be limited by the embodiments which are shown in the drawings and described in the description which are given by way of example and not of limitation but only in accordance with the scope of the appended claims.

I claim:

1. A torque wrench comprising: a frame, a drive shaft mounted in said frame and rotatable therein around a central axis; a lever arm; unidirectionally-driving clutch means engaging the lever arm to the drive shaft member for driving the drive shaft in one direction and releasing it in the other direction; a bi-directional fluid motor mounted to said frame and drivingly connected to said lever arm, said fluid motor having a pair of supply ports; pressure conduit means; exhaust conduit means; an adjustable pressure regulator in said pressure conduit means maintaining pressure downstream therefrom at a constant and selected value; direction selector valve means in said pressure conduit downstream from said regulator; a pair of supply conduits connected to said direction selector valve means, one being connected to each supply port of the fluid motor;

pilot means contactible by the lever arm and operatively connected to said direction selector valve means for setting the same and thereby determining the direction of operation of the fluid motor, the fluid motor thereby cycling bi-directionally and driving the lever arm back and forth and driving the drive shaft unidirectionally as a consequence of the alternate engagement and release of the clutch means.

2. A torque wrench according to claim 1 in which the fluid motor exerts its force at all times while operating in its driving direction without release, whereby it continues to exert a steady torque even at stall conditions.

3. A torque wrench according to claim 1 in which the fluid motor is a rotary motor.

4. A torque wrench according to claim 1 in which the fluid motor is a linear actuator.

5. A torque wrench according to claim 1 in which the fluid motor is a piston-cylinder type, having an axis of actuation along which it exerts its force.

6. A torque wrench according to claim 5 in which said axis of actuation lies in a plane which is normal to the axis of rotation of the wrench.

7. A torque wrench according to claim 1 in which the direction of drive of the clutch means is reversible and selectable.

8. A torque wrench according to claim 1 in which a shuttle valve is connected to said pilot means and to the direction selector valve means, the shuttle valve including a pressure-balanced shuttle exposed at opposite ends to chambers connected to a source of pressure and to the pilot means, opening of respective pilot means changing the pressure in respective chambers whereby to move the shuttle and thereby change the selection of the direction selector valve means, the pilot valves being opened by contact with the said lever arm at respective ends of its stroke.

9. A torque wrench according to claim 2 in which the direction selector valve means is a four-way valve.

10. A torque wrench according to claim 1 in which the clutch means comprises a pair of faces on the drive shaft, and a pair of faces on the lever arm, the faces being adapted to be pressed together in selected pairs whereby to determine the direction of driving rotation.

11. A torque wrench according to claim 10 in which the said faces include surfaces engageable to drive in one direction, and to release in the other.

12. A torque wrench according to claim 10 in which a shuttle valve is connected to said pilot means and to the direction selector valve means, the shuttle valve including a pressure-balanced shuttle exposed at opposite ends to chambers connected to a source of pressure and to the pilot means, opening of respective pilot means changing the pressure in respective chambers whereby to move the shuttle and thereby change the selection of the direction selector valve means, the pilot valves being opened by contact with the said lever arm at respective ends of its stroke.

13. A torque wrench according to claim 12 in which the fluid motor is a piston-cylinder type, having an axis of actuation along which it exerts its force.

14. A torque wrench according to claim 13 in which said axis of actuation lies in a plane which is normal to the axis of rotation of the wrench.

\* \* \* \* \*

UNITED STATES PATENT OFFICE  
**CERTIFICATE OF CORRECTION**

Patent No. 3,759,119Dated September 18, 1973Inventor(s) GEORGE S. WING

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

|                     |                                                                                                               |
|---------------------|---------------------------------------------------------------------------------------------------------------|
| Col. 1, lines 38-39 | "as stated . . . such problems." should read --Threaded joints can involve problems in each of these areas.-- |
| Col. 1, line 43     | "greaest" should read --greatest--                                                                            |
| Col. 1, line 64     | after "desired" insert --axial--                                                                              |
| Col. 3, line 9      | after "or" insert --which--                                                                                   |
| Col. 3, line 25     | "wrench" should read --driver--                                                                               |
| Col. 3, line 52     | "drive" should read --driver--                                                                                |
| Col. 3, line 57     | "reated" should read --related--                                                                              |
| Col. 4, line 10     | "sectiona" should read --section--                                                                            |
| Col. 4, line 24     | "wrench" should read --driver--                                                                               |
| Col. 4, line 29     | "a body 25" should read --bodies 25 and 26--                                                                  |
| Col. 4, line 31     | after "workpiece" insert --element--                                                                          |
| Col. 4, line 35     | after "workpiece" insert --element--                                                                          |
| Col. 4, line 54     | "second" should read --first--                                                                                |
| Col. 4, line 66     | "the" should read --to be--                                                                                   |
| Col. 5, line 2      | "second surface 30" should read --first surface 29--                                                          |
| Col. 5, line 6      | "means" should read --element--                                                                               |
| Col. 5, line 24     | "Figs." should read --Fig.--                                                                                  |
| Col. 5, line 28     | "inlet" should read --supply--                                                                                |
| Col. 5, line 32     | "inlet" should read --supply--                                                                                |
| Col. 5, line 33     | after "conduit" first occurrence, insert --(sometimes called "pressure conduit means")--                      |
| Col. 5, line 46     | "slightly" should read --slidingly--                                                                          |
| Col. 5, line 48     | "Position" should read --Portion--                                                                            |
| Col. 5, line 61     | between "valve" and the period insert --78 (sometimes called "direction selector valve means")--              |
| Col. 5, line 67     | after "through" insert --pressure--                                                                           |
| Col. 6, line 1      | after "to" insert --pressure--                                                                                |

# UNITED STATES PATENT OFFICE

## CERTIFICATE OF CORRECTION

Patent No. 3,759,119 Dated September 18, 1973

Inventor(s) GEORGE S. WING

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Col. 6, line 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | "be." should read --be, and constitute      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "exhaust conduit means".--                  |
| Col. 6, line 16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "90" insert --and 91--                |
| Col. 6, line 35                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "tank" should read --tang--                 |
| Col. 6, line 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "into" insert --respective chambers   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 101a and 101b at--                          |
| Col. 6, line 37                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "They" should read --Passages 104 and 105-- |
| Col. 6, line 38                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "to" first occurrence, insert         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | --respective--                              |
| Col. 6, line 44                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "115" insert --(see Fig. 4)--         |
| Col. 6, line 45                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "insert" should read --inserts--            |
| Col. 6, line 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "conduit" should read --shuttle passage--   |
| Col. 6, line 59                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | insert the following paragraph:-            |
| <p>--Pilot valves 108 and 109 are sometimes referred to as "pilot means", and constitute examples of means which are contact-ible by the lever arm and are operatively connected to the direction selector valve means 78 to set means 78, and thereby to determine the direction of operation of fluid motor 80. In the example given, the operative connection to the direction selector valve means is by means of shuttle valve 100. The shuttle 102 is "pressure balanced" in the sense that it will not assume any particular position when the forces in chambers 101a and 101b are equal, but moves only in response to a difference of pressure in these two chambers.--</p> |                                             |
| Col. 6, line 61                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "axis" insert --of actuation--        |
| Col. 7, line 23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | after "motion," insert --pilot--            |
| col. 7, line 28                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | cancel "as"                                 |
| Col. 7, line 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "driving" should read --driver--            |
| Col. 7, line 62                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "surface" should read --face--              |
| Col. 7, line 63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | "surfaces" should read --faces--            |
| Col. 8, line 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | "surfaces" should read --driver faces--     |
| Col. 8, line 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | "take" should read --takes--                |

# UNITED STATES PATENT OFFICE

## CERTIFICATE OF CORRECTION

Patent No. 3,759,119Dated September 18, 1973Inventor(s) GEORGE S. WING

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

|                      |                                                          |
|----------------------|----------------------------------------------------------|
| Col. 8, line 8       | "surfaces 162 and 163" should read --faces 163 and 162-- |
| Col. 8, line 13      | "corotation" should read --co-rotation--                 |
| Col. 8, line 42      | "surfaces" should read --faces--                         |
| Col. 8, line 67      | "threaded" should read --tightened--                     |
| Col. 9, line 1       | cancel "means of a socket by means of"                   |
| Col. 10, line 24     | "struct" should read --struck--                          |
| Col. 10, line 42     | after "selector" insert --valve 78--                     |
| Col. 11, line 50     | "in" should read --to--                                  |
| (cl. 1, line 2)      |                                                          |
| Col. 11, lines 52-53 | cancel "member"                                          |
| (cl. 1, lines 4-5)   |                                                          |
| Col. 11, line 53     | after "direction" insert --of lever                      |
| (cl. 1, line 5)      | motion --.                                               |
| Col. 12, line 22     | "wrench" should read --drive shaft--                     |
| (cl. 6, line 3)      |                                                          |
| Col. 12, line 26     | after "which" insert --there is a pair of                |
| (cl. 8, line 1)      | said pilot means, and in which--                         |
| Col. 12, line 27     | after "to" first occurrence, insert                      |
| (cl. 8, line 2)      | --both of--                                              |
| Col. 12, line 30     | "chambers" should read --a respective                    |
| (cl. 8, line 5)      | chamber that is--                                        |
| Col. 12, line 31     | "the" should read --a respective--                       |
| (cl. 8, line 6)      |                                                          |
| Col. 12, line 31     |                                                          |
| (cl. 8, line 6)      |                                                          |
| Col. 12, line 34     | after "means," insert --each pilot means                 |
| (cl. 8, line 9)      | comprising a valve which can be opened,                  |
| Col. 12, line 35     | the--                                                    |
| (cl. 8, line 10)     | "the", second occurrence, should read                    |
| Col. 12, line 46     | -- respective --.                                        |
| (cl. 11, line 3)     | "valves" should read --means--                           |
|                      |                                                          |
|                      | between "direction" and the comma insert                 |
|                      | --of lever motion--                                      |

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTIONPatent No. 3,759,119Dated September 18, 1973Inventor(s) GEORGE S. WING

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

|                   |                                           |
|-------------------|-------------------------------------------|
| Col. 12, line 47  | after "which" insert --there is a pair of |
| (cl. 12, line 1)  | said pilot means, and in which--          |
| Col. 12, line 48  | after "to" first occurrence insert        |
| (cl. 12, line 2)  | --both of--                               |
| Col. 12, line 51  | "chambers" should read --a respective     |
| (cl. 12, line 5)  | chamber that is--                         |
| Col. 12, line 52  | "the" should read --a respective--        |
| (cl. 12, line 6)  |                                           |
| Col. 12, line 52  | after "means," insert --each pilot means  |
| (cl. 12, line 6)  | comprising a valve which can be opened,   |
|                   | the--                                     |
| Col. 12, line 55  | "the" second occurrence, should read      |
| (cl. 12, line 9)  | --respective--                            |
| Col. 12, line 56  | "valves" should read --means--            |
| (cl. 12, line 10) |                                           |
| Col. 12, line 63  | "wrench" should read --drive shaft--      |
| (cl. 14, line 3)  |                                           |

Signed and sealed this 17th day of September 1974.

(SEAL)

Attest:

McCOY M. GIBSON J.  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents