# United States Patent

**Mead**

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## [54] APPARATUS AND METHOD FOR INSTALLING BLIND FASTENERS


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[73] Assignee: **Briles Manufacturing,** El Segundo, Calif.



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[52] **U.S. Cl.** ..... **72/114,** 72/391

[51] **Int. Cl.** ..... **B21d 9/05**

[58] **Field of Search** ..... 72/391, 114, 453



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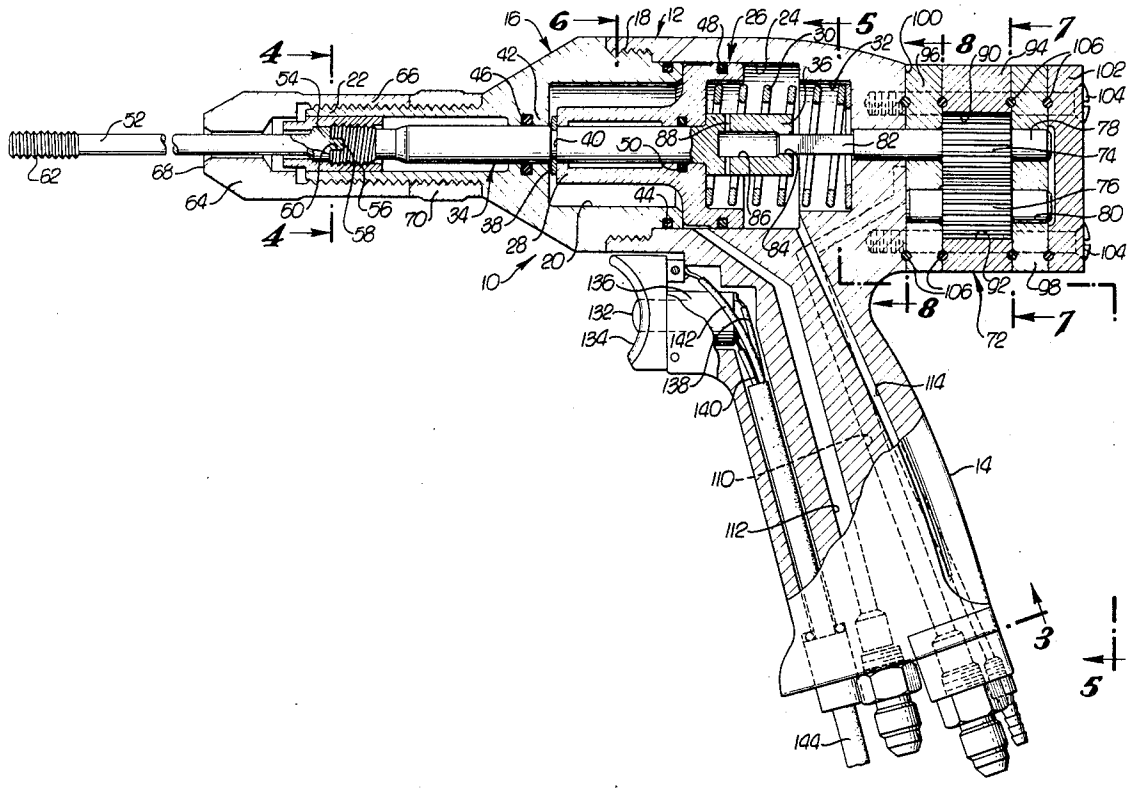
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*Attorney*—Albert L. Gabriel



[57] **ABSTRACT**

An automatically sequencing, hydraulically powered pre-entry pull-up tool for upsetting blind fastener sleeves on the blind side of a structure, and a novel sequencing method employed by said tool to assure complete and uniform fastener upsetting. The tool includes a hand gun having a protruding threaded mandrel insertable into a blind fastener sleeve to be upset, the mandrel rotating in one direction to engage with the sleeve, axially retracting to pull up and upset the sleeve, and then rotating in the opposite direction to disengage from the sleeve, these three steps being hydraulically powered in the hand gun by hydraulic power from a remote source, and being electrically controlled. According to the method of the disclosure uniform upsetting is assured by effecting the automatic shifting from stage to stage of the operation by sensing back pressure in the hydraulic system.


**23 Claims, 23 Drawing Figures**



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SHEET 1 OF 9

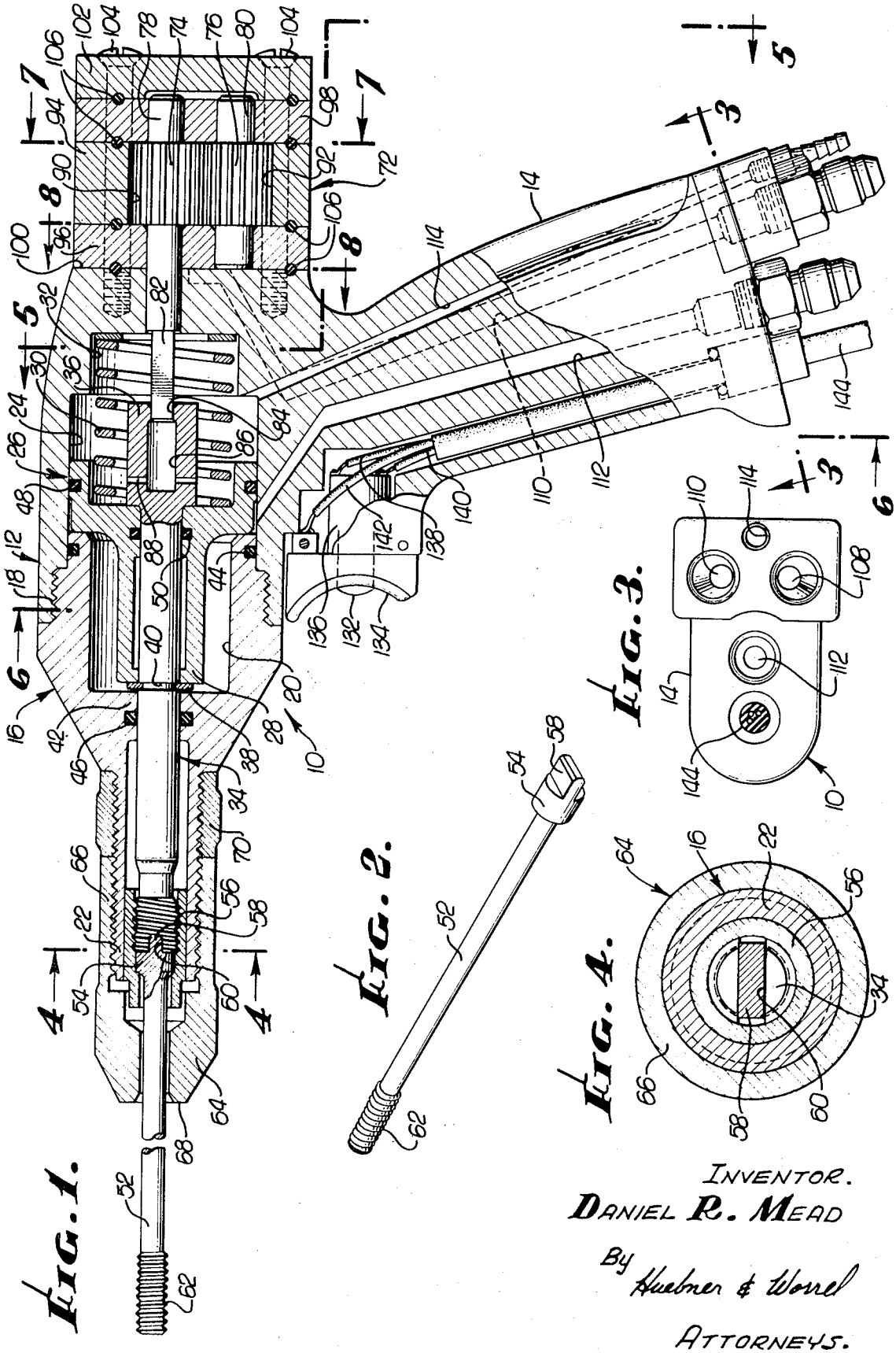


FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

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FIG. 5.

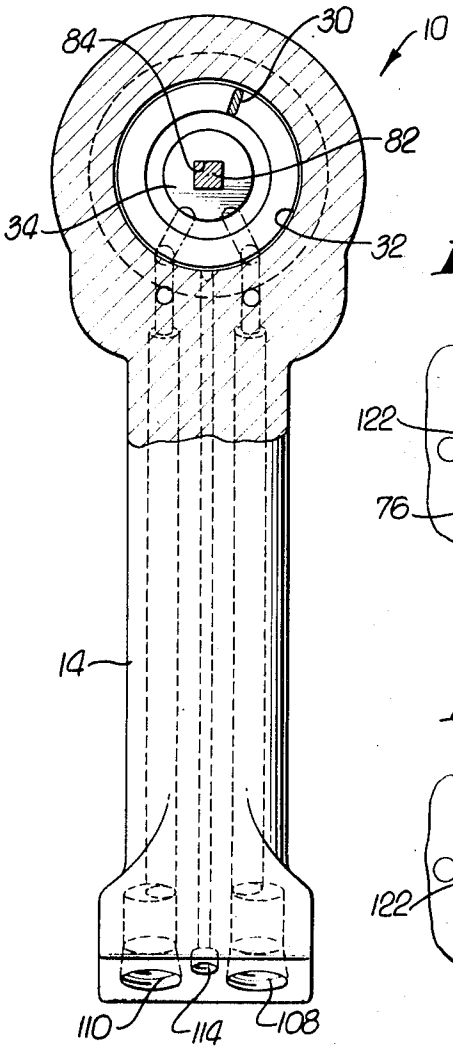



FIG. 6.

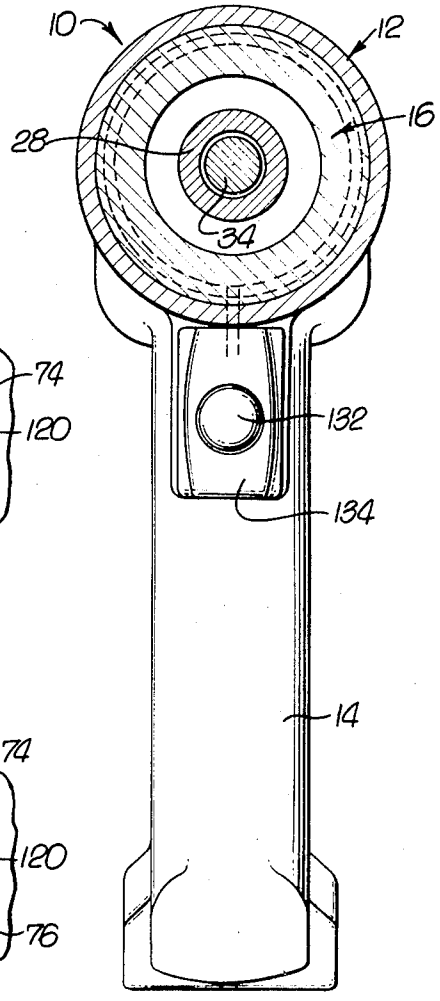



FIG. 13.

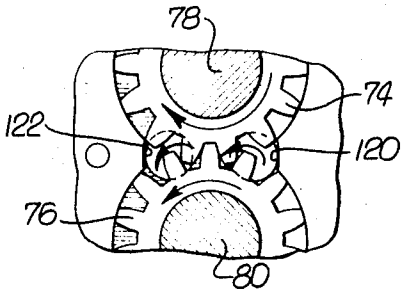



FIG. 14.

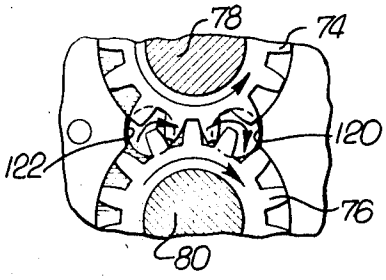
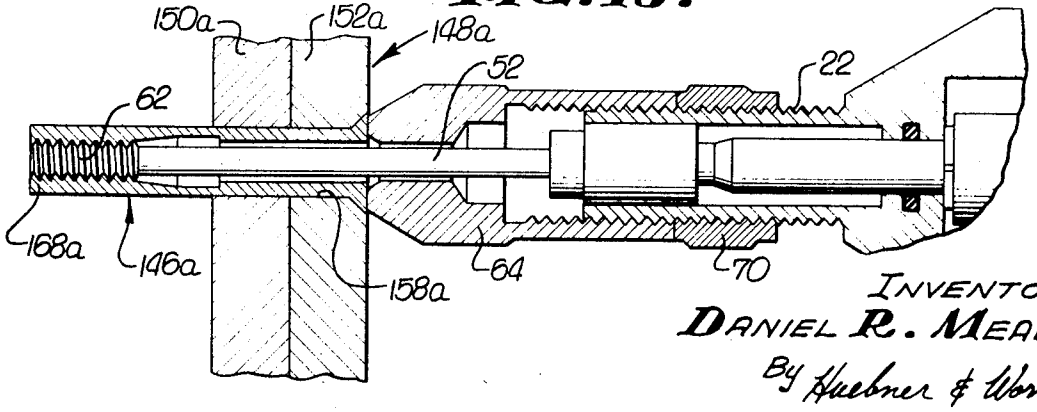



FIG. 15.




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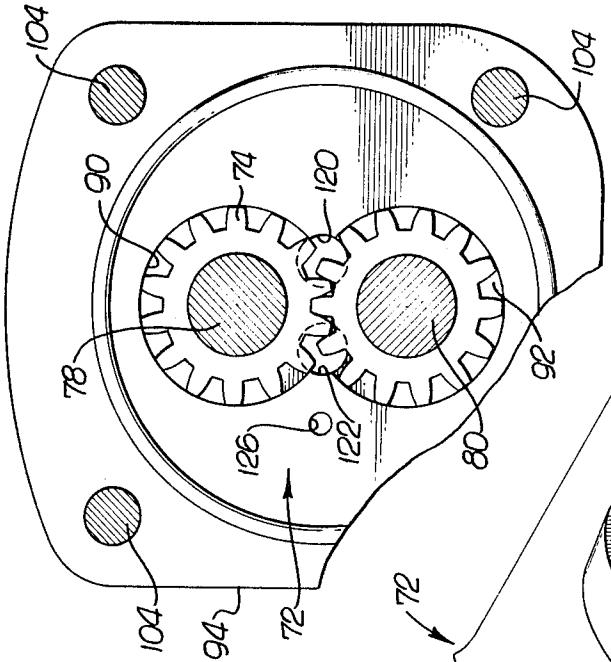



FIG. 7.




FIG. 9.

FIG. 8.

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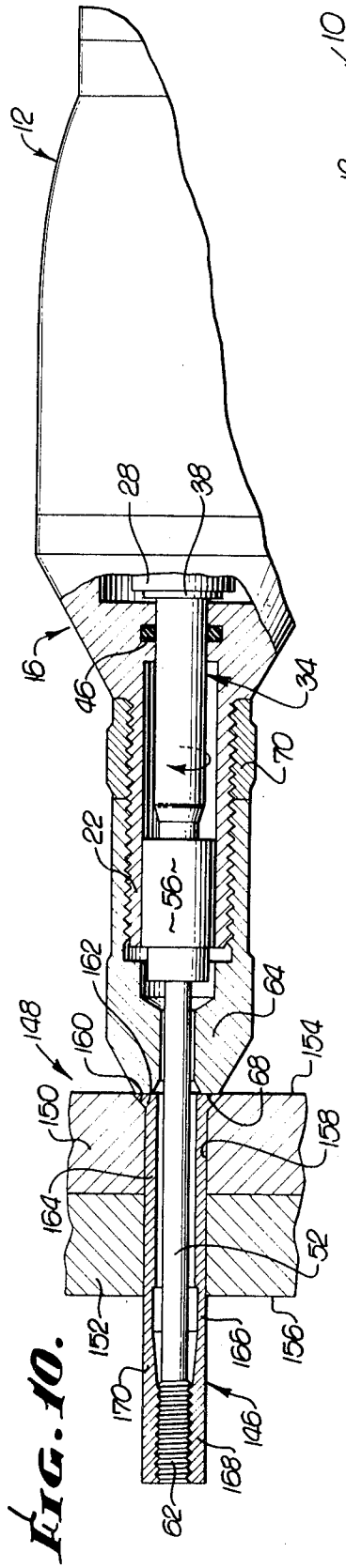


FIG. 10.

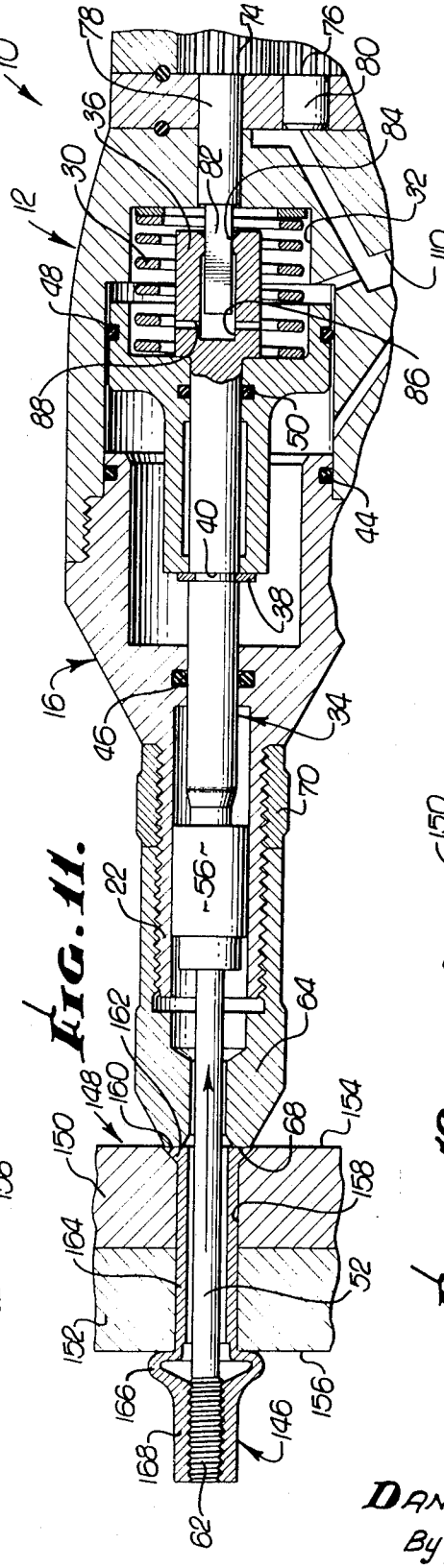


FIG. 11.

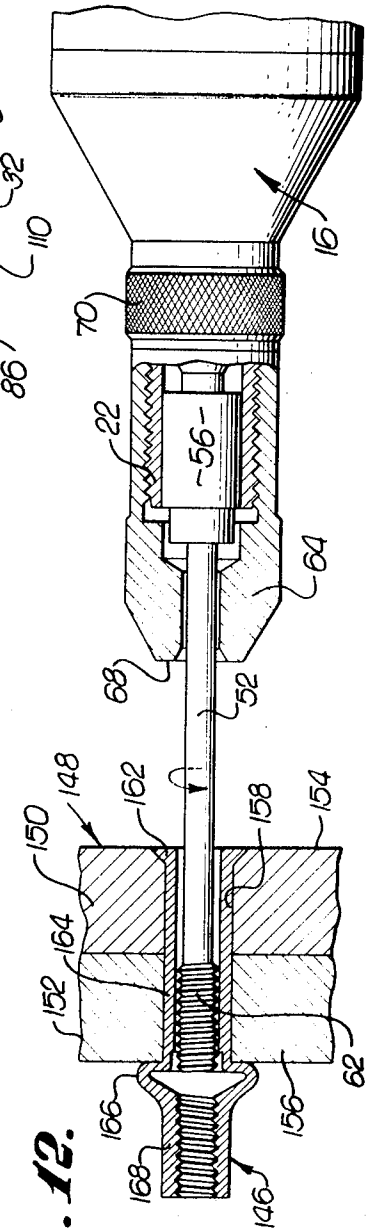


FIG. 12.

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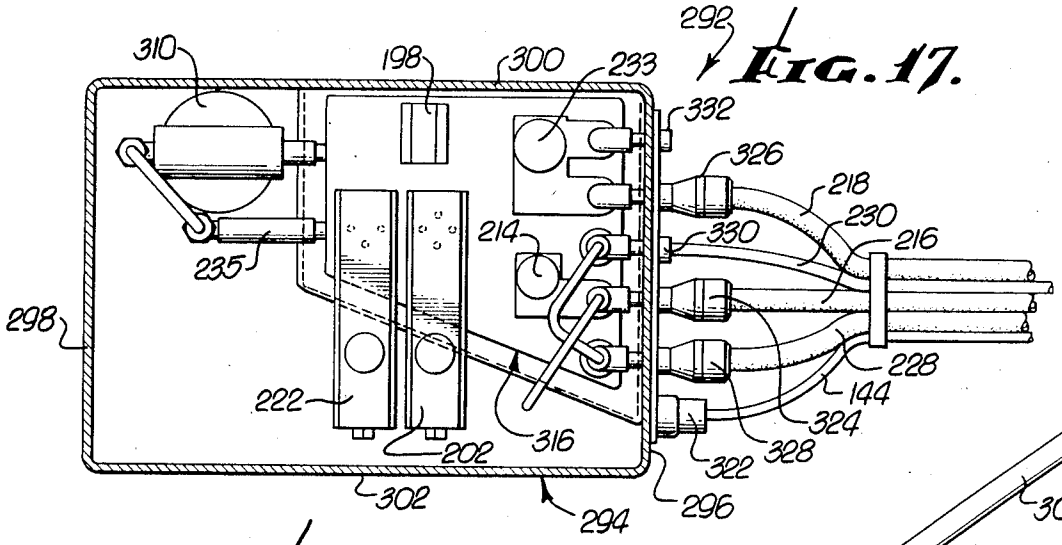
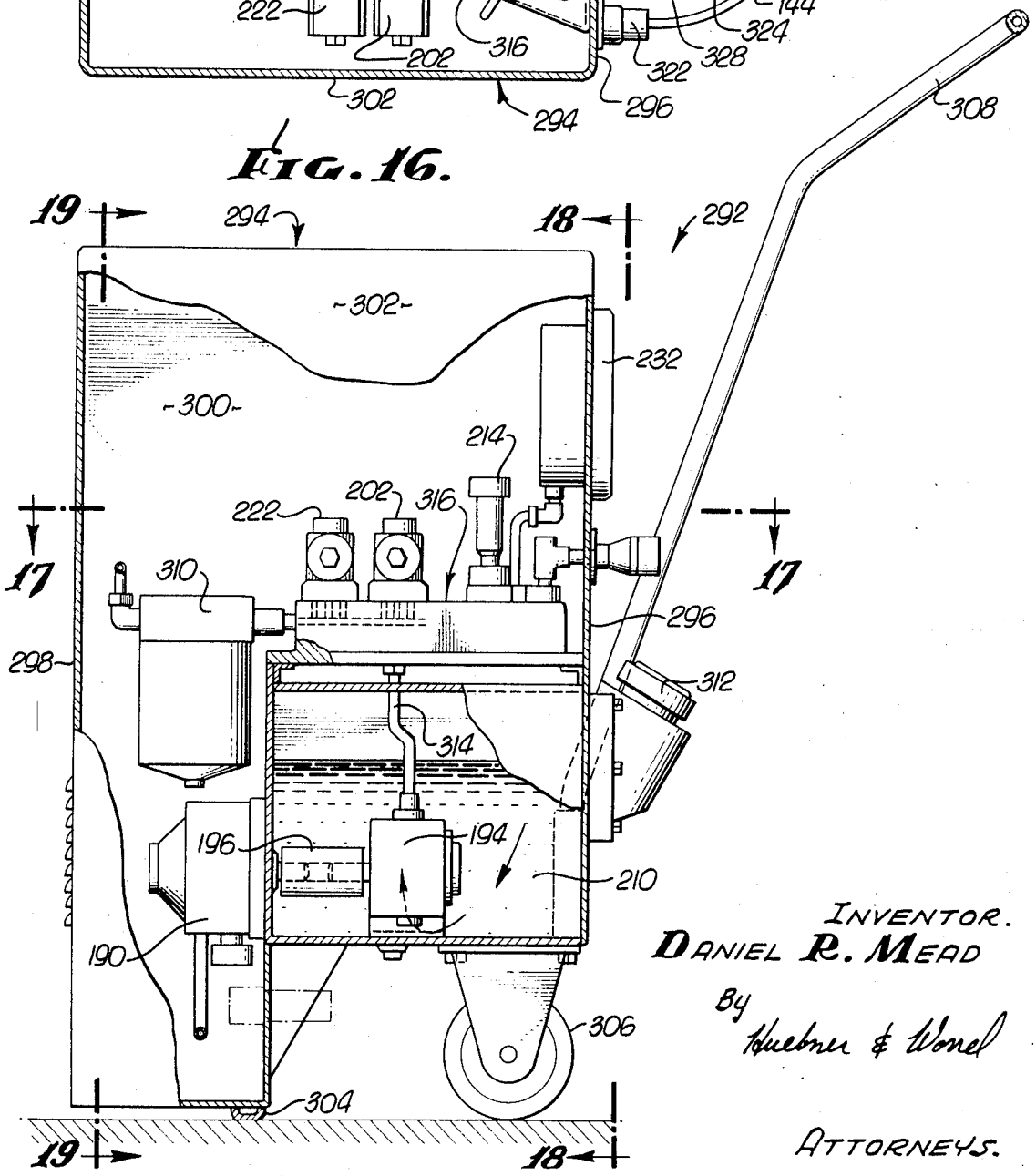



FIG. 17.

FIG. 16.




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FIG. 18.

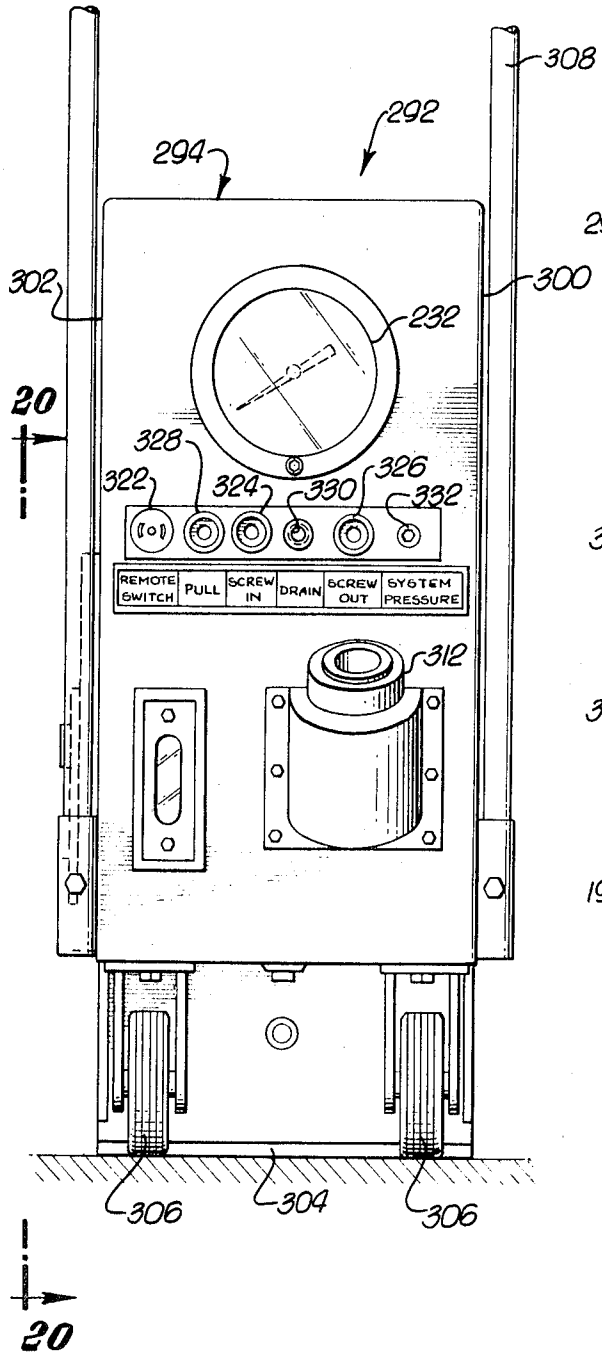
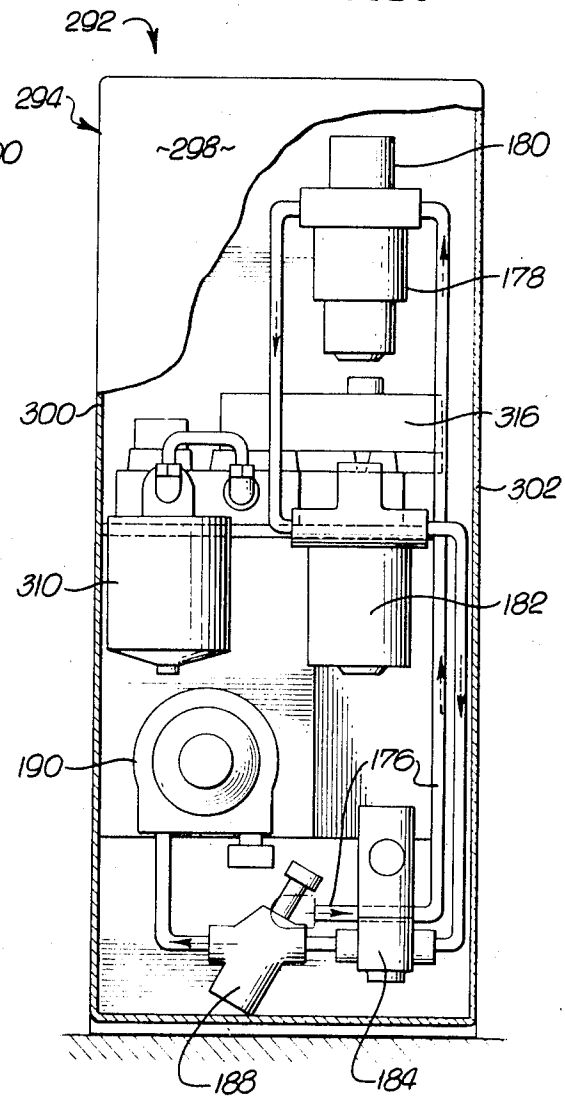
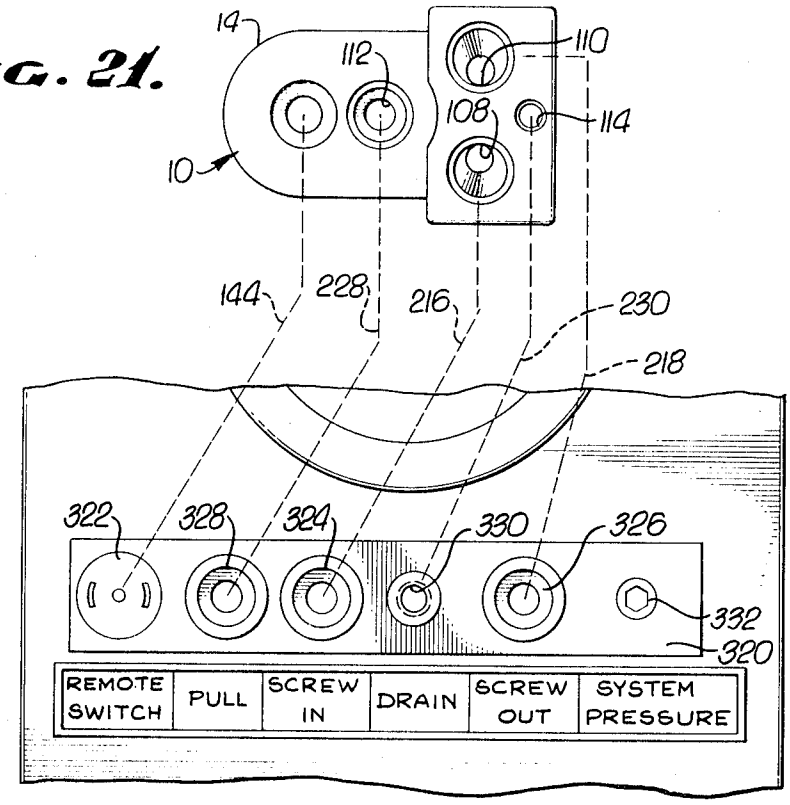



FIG. 19.




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FIG. 21.



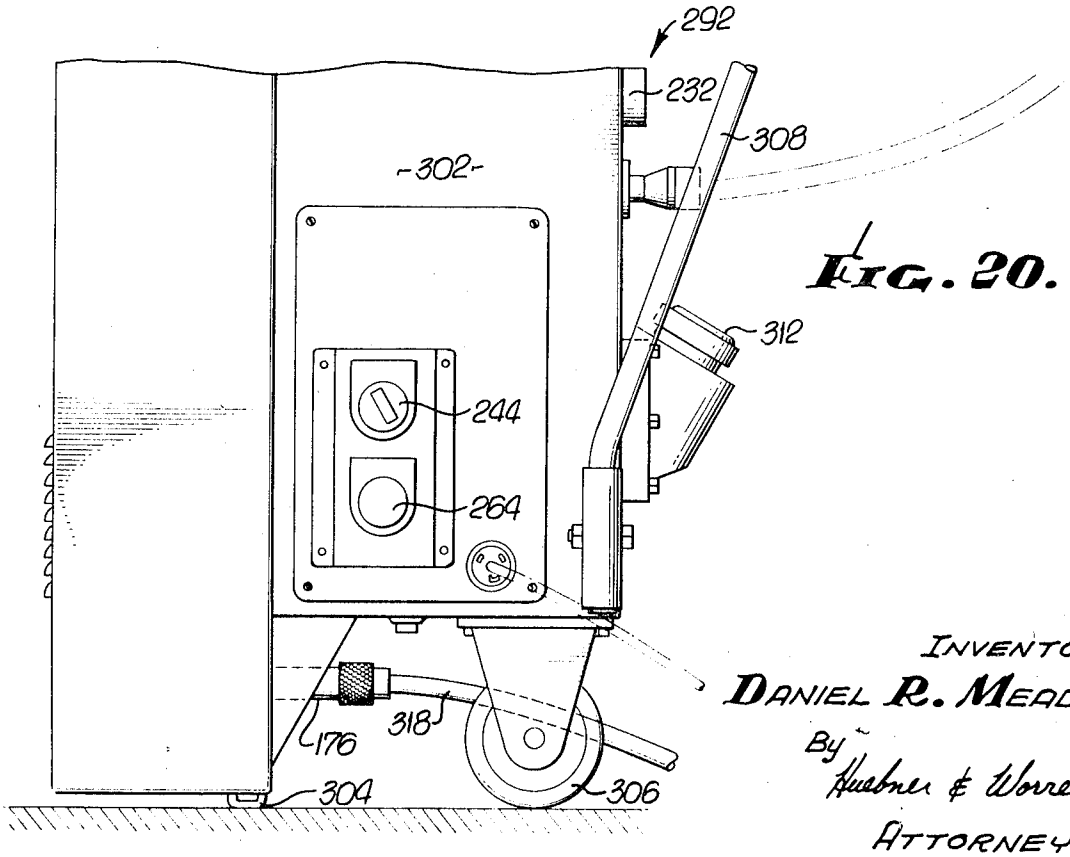
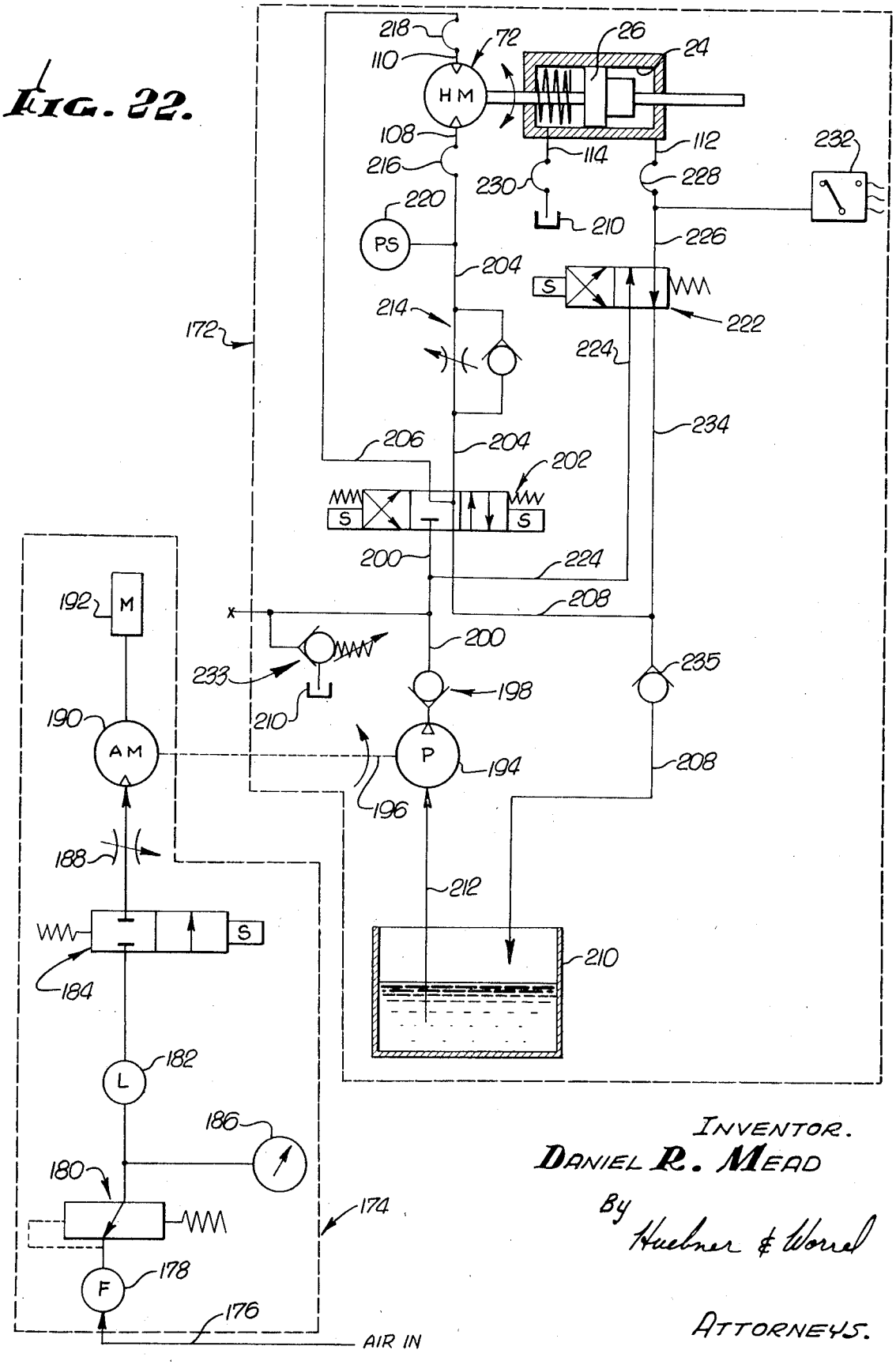




FIG. 20.

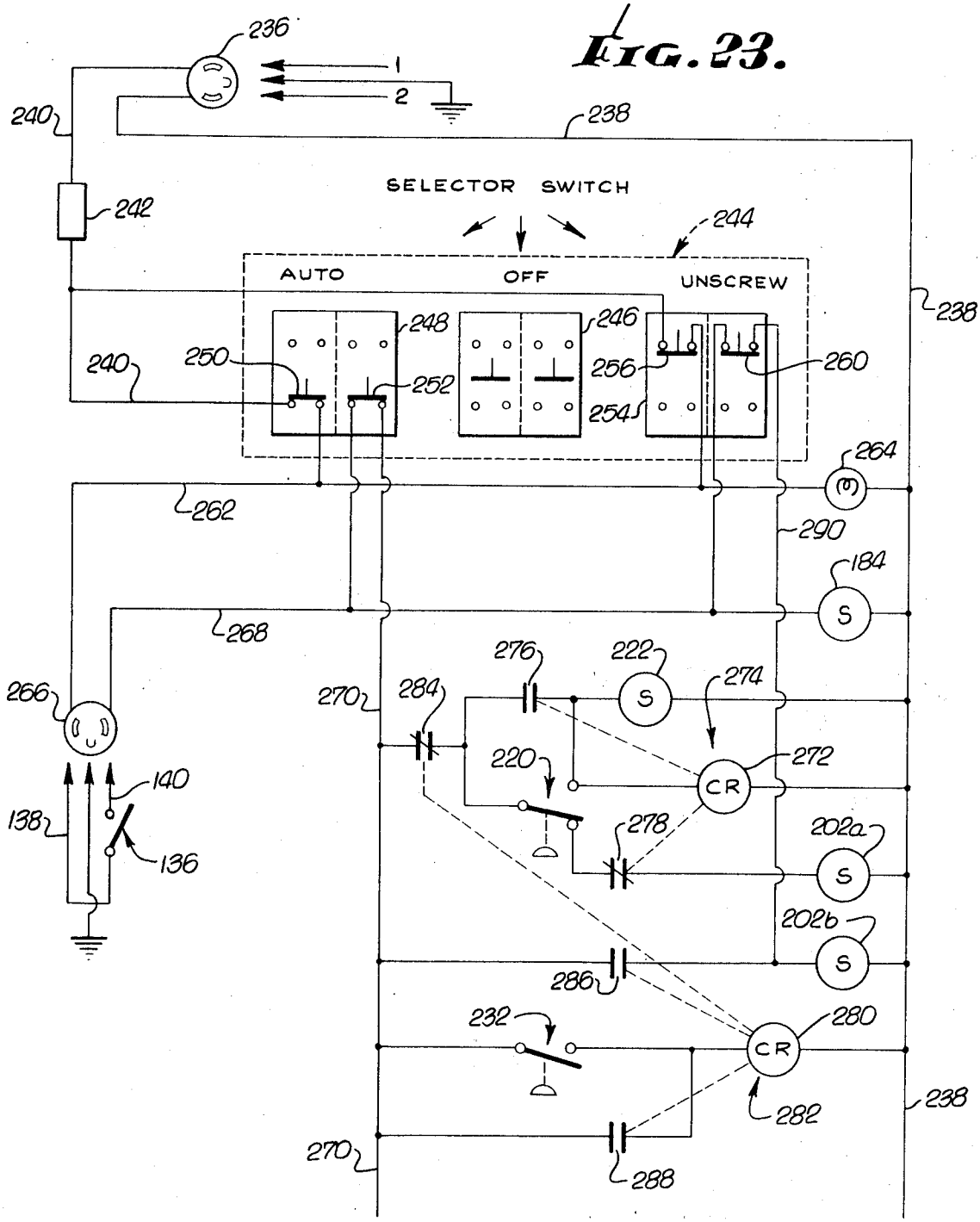
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FIG. 22.




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FIG. 23.




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# APPARATUS AND METHOD FOR INSTALLING BLIND FASTENERS

## BACKGROUND OF THE INVENTION

The present invention relates to blind fasteners, i.e., bolt type fasteners which are capable of being installed from one side only of a structure, and it relates more particularly to apparatus and methods for installing blind fasteners efficiently and rapidly, and with assurance that each of a series of blind fasteners will be fully expanded on the blind side of the workpiece and will be uniformly pulled up in the axial direction.

Large numbers of blind fasteners are required in such highly stressed structures as modern aircraft structures, in regions thereof where access to one side of a structural joint in difficult.

Most of such blind fasteners which are employed in modern high-speed aircraft embody a sleeve portion which is inserted from the access side of the structure into a bore through the structure, the sleeve having a head at one end adapted to seat on the access side of the structure, an internally threaded pull-up portion adjacent the other end thereof which is engageable by a threaded mandrel insertable through the sleeve from the access side, and an intermediate deformable section adapted to buckle outwardly in response to pull-up movement of the mandrel. In this way, the structure is axially clamped between the head part of the sleeve on the access side and the outwardly buckled deformable section of the sleeve which functions as a nut. While some blind fasteners include only such a sleeve, in most cases the sleeve is secured against radial inward deformation under tension, and is provided with additional shear strength, by insertion of a core pin or bolt into the central passage of the sleeve after the sleeve has been installed in the structure as aforesaid.

A major problem in the installation of such blind fasteners is that the proper amount of axial take-up and radial expansion of the sleeve on the blind side of the structure is critical in achieving the fully rated strength of the fastened joint, but at the same time the part of the fastener which is thus taken up and expanded is on the blind side of the structure and is inaccessible to visual inspection to assure that it has in fact been taken up and expanded to the correct extent. Conventional apparatus and methods for pulling up and expanding blind fastener sleeves rely substantially completely on a determination by the installing operator as to the extent of engagement of the pull-up mandrel with the internally threaded pull-up portion of the sleeve, and the amount of axial movement of the mandrel that is applied to expand the deformable section of the sleeve and provide axial clamp-up force. One type of hydraulically powered tool currently widely used for this purpose has a cycle of operation for installing each blind fastener sleeve that includes three separate manual controls which must be sequentially actuated in order to complete an installation. A first manual control button is depressed to cause the pull-up mandrel to rotate in a clockwise direction for engagement with the internally threaded pull-up portion of the sleeve on the blind side of the structure. The extent of threaded engagement of the mandrel with the sleeve depends upon how long the appropriate button is depressed, and is accordingly variable according to operator judgement. The extent of threaded engagement of the mandrel with the sleeve is made further uncertain with such equipment by pulsating hydraulic power from a reciprocating type hydraulic pump, with the result that torque is applied intermittently to the threaded mandrel. Then, when the mandrel is thus threadedly engaged with the sleeve and the first button is released, a second button is manually depressed to produce pull-up force on the mandrel for buckling the deformable section of the sleeve, this pull-up force being released only upon release of the second actuating button. The final step with such conventional equipment is to provide anticlockwise rotation of the mandrel to unscrew the mandrel from the sleeve either by depressing a third button or by flipping a reversing lever and depressing the first button again.



With conventional equipment of this type, the extent of threaded engagement of the mandrel in the sleeve is uncertain, and consequently the extent of axial take-up is not fully predictable and reliable. If the operator should happen to let up too soon on the first button so that the threaded engagement is inadequate withstand the stresses of the second stage, then the threads can be torn out in the second stage and the fastener left in only partially assembled condition. Also, it is not infrequent that such fasteners are damaged by the operator inadvertently depressing the wrong button. Additionally, expansion and pull-up may be left incomplete if the operator should release the second button too soon.

## SUMMARY OF THE INVENTION

In view of these and other problems in the art, it is an object of the present invention to provide a novel hydraulically powered pre-entry pull-up tool for expanding blind fastener sleeves on the blind side of a structure and axially clamping the sleeves, wherein the extent of each of the critical operative steps is automatically determined by the tool rather than manually so as to assure uniform installation characteristics of a series of similar blind fastener sleeves.

Accordingly, it is a more particular object of the invention to provide a hydraulically powered pre-entry pull-up tool of the character described wherein the extent of threaded engagement of the pull-up mandrel of the tool into the internally threaded part of the blind fastener sleeve is determined by sensing a predetermined reaction torque on the mandrel. Similarly, it is a more particular object of the invention to provide a tool of the character described wherein the extent of axial pull-up of the mandrel, and hence the extent of the axial upsetting movement and pull-up force on the blind fastener sleeve, is determined by sensing a predetermined axial reaction force on the mandrel.

Another object of the invention is to provide a hydraulically powered apparatus of the character described for installing blind fastener sleeves wherein the aforesaid predetermined reaction torque and axial reaction force on the mandrel are determined in the apparatus by sensing back pressures in the hydraulic system.

A further object of the present invention is to provide apparatus of the character described for installing blind fastener sleeves which is hydraulically powered, with the hydraulic power means electrically controlled so as to be automatically sequencing between screw-in, take-up, and screw-out modes of operation.

A still further object of the invention is to provide apparatus of the character described for installing blind fastener sleeves wherein the operator simply manipulates a hand gun having a protruding threaded mandrel that is insertable into each blind fastener sleeve, and wherein the entire sequence of operation for installing each blind fastener sleeve, including screw-in, pull-up, and screw-out, is effected by actuating a single triggering device on the hand gun which causes automatic electrical control of a hydraulic power unit remote from the hand gun.

An additional object of the invention is to provide a novel method of installing blind fastener sleeves of the character described, wherein uniform upsetting and pull-up in a series of blind fastener sleeves is assured by effecting the automatic shifting from stage to stage of the operation in response to back pressure in the hydraulic system at the completion of each stage of operation.

Other objects and advantages of the present invention will appear during the course of the following part of the specification, wherein the details of construction, mode of operation, and method steps of a presently preferred embodiment are described with reference to accompanying drawings, wherein:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial, vertical section, with portions shown in elevation, illustrating the hand gun forming a part of the present invention.

FIG. 2 is a perspective view illustrating the mandrel portion of the hand gun separated from the rest of the gun.

FIG. 3 is a fragmentary, plan view taken on the line 3—3 in FIG. 1 illustrating the bottom of the handle of the hand gun, and in particular illustrating the hydraulic and electrical passages into the hand gun.

FIG. 4 is a cross-sectional view taken on the line 4—4 FIG. 1 showing structural details in the forward portion of the gun.

FIG. 5 is a vertical sectional view taken on the line 5—5 in FIG. 1, with a portion thereof in elevation, showing further details of the gun in the region of the handle and body portions thereof.

FIG. 6 is another vertical sectional view, partly in elevation, taken on the line 6—6 in FIG. 1, also showing details of the handle and body portions of the gun.

FIG. 7 is an enlarged, fragmentary, vertical section taken on the line 7—7 in FIG. 1 showing details of the hydraulic motor in the gun.

FIG. 8 is also an enlarged, fragmentary, vertical section, taken on the line 8—8 in FIG. 1, illustrating a portion of the gun forward of the motor.

FIG. 9 is an exploded perspective view illustrating a portion of the body of the hand gun and illustrating the various parts of the gun making up the hydraulic motor and the support and housing structure therefor.

FIG. 10 is a fragmentary, vertical, axial, section, partly in elevation, illustrating the forward part of the hand gun operatively engaged in a blind fastener sleeve at the completion of the screw-in phase of operation of the gun.

FIG. 11 is a view similar to the FIG. 10, but illustrating a further portion of the tool in section, showing the pull-up phase of operation of the gun.

FIG. 12 is a view similar to FIGS. 10 and 11, but illustrating the screw-out phase of operation of the tool.

FIG. 13 is an enlarged, fragmentary, vertical section showing a portion of the structure illustrated in FIG. 7, and illustrating the screw-in phase of operation of the hydraulic motor in the hand gun.

FIG. 14 is a view similar to FIG. 13, but illustrating the screw-out phase of operation of the hydraulic motor in the hand gun.

FIG. 15 is a fragmentary, axial, vertical section, partly in elevation, similar to FIG. 10, but showing the forward portion of the hand gun adjusted to accommodate a blind fastener sleeve which is shorter than the blind fastener sleeve shown in FIG. 10.

FIG. !6 is a side elevational view, partly in section, illustrating the remote power unit which provides the hydraulic driving power to the hand gun, and is electrically controlled from the hand gun.

FIG. 17 is a horizontal section, partly in elevation, taken on the line 17—17 in FIG. 16.

FIG. 18 is a front elevational view, partly in section, taken on the line 18—18 in FIG. 16.

FIG. 19 is a vertical section, partly in elevation, taken on the line 19—19 in FIG. 16.

FIG. 20 is a fragmentary side elevational view of the remote power unit that is shown in FIGS. 16 to 19, taken on the line 20—20 in FIG. 18.

FIG. 21 is a diagrammatic view showing both the bottom of the handle of the hand gun as illustrated in FIG. 3 and a portion of the front panel of the remote power unit as shown in FIG. 18, with the hydraulic and electrical lines from the remote power unit to the hand gun illustrated diagrammatically.

FIG. 22 is a diagram of the hydraulic system of the apparatus, together with a pneumatic system employed to drive the hydraulic system.

FIG. 23 is a diagram of the electrical system of the apparatus.

## DETAILED DESCRIPTION

Referring to the drawings, and at first particularly to FIGS. 1 through 9 thereof, these figures illustrate the structure of the hand gun portion of the apparatus, which is generally designated 10. The hand gun 10 includes a generally hollow body 12 having an integrally formed handle 14 depending therefrom.

An annular nose piece 16 is threadedly engaged with the body 12 at the front end thereof by threaded coupling 18, the nosepiece 16 having a rearwardly opening cylindrical chamber 20 in its rearward portion, and tapering down to a forwardly projecting, externally threaded, tubular forward portion 22.

The body 12 defines a cylindrical chamber 24 therein, which is axially aligned with and somewhat larger than the nosepiece cylinder 20, immediately to the rear of nosepiece 16. A piston 26 is slidably mounted within the body cylinder 24, the piston 26 having an integral forwardly extending tubular axial shaft portion 28 which extends into the nosepiece cylinder 20. The piston 26 is forwardly biased so as to normally seat against the rearward annular edge of the nosepiece 16 as illustrated in FIG. 1 by means of a coil compression spring 30, the forward end of which is engaged against the piston, and the rearward end of which is seated in an annular recess 32 in body 12 immediately to the rear of cylinder 24.

A spindle 34 is both rotatably and slidably mounted in the gun 10, with a forward portion thereof extending coaxially into the tubular forward portion 22 of nosepiece 16, and a rearward portion thereof extending coaxially through the tubular piston shaft 28. The spindle 34 has an enlarged, hollow rear end portion which projects rearwardly from the piston 26 and serves as a drive coupler for application of rotary power to the spindle. A snap ring 38 is engaged in a groove 40 in the spindle immediately forward of the tubular piston shaft 28, whereby the piston 26 and its integral shaft 28 are axially secured on the spindle 34 between the rear spindle enlargement 36 and the snap ring 38. In this manner, the piston 26 and spindle 34 move as a single unit in the axial direction. Accordingly, the piston spring 30 biases the spindle 34 toward its forwardmost position as illustrated in FIG. 1.

It will be noted that the spindle 34 is held in axially centered position within the body 12 and nosepiece 16 by engagement of the spindle in a constricted portion 42 of nosepiece 16, and by engagement of the rearward portion of the spindle in the piston assembly which in turn is centered by engagement of the piston in the body cylinder 24.

An O-ring seal 44 is engaged between the body 12 and nosepiece 16 rearwardly of the threaded coupling 18 to prevent escape of hydraulic field to the outside of the hand gun 10. Another O-ring seal 46 is engaged between the constricted portion 42 of the nosepiece and the spindle 34 so as to prevent escape of pressurized hydraulic fluid forwardly into the threaded tubular portion of the nosepiece. Escape of pressurized hydraulic fluid rearwardly past the piston 26 is opposed by a third O-ring seal 48 engageable between the piston and the body cylinder 24 in the form of a conventional piston ring, and a fourth O-ring seal 50 engageable between the piston 26 and the spindle 34.

The pull-up mandrel 52 of the tool has an enlarged rearward connector portion 54 which is coupled to the forward end portion of spindle 34 by means of a collet 56 which is threadedly connected to the forward end portion of spindle 34 by means of a left-hand threaded coupling. The mandrel 52 has a rearwardly projecting flat key 58 which is engaged in a complementary key slot 60 in the front end of spindle 34, whereby the spindle 34 and mandrel 52 will move as a single unit both axially and rotationally in both directions of rotation. The collet 56 has a cylindrical outer surface which is both slidably and rotationally engaged in the cylindrical inner surface of the tubular forward portion 22 of the nosepiece 16, providing axially centering support for the forward end of the spindle 34 and for the mandrel 52. The mandrel 52 is provided at its for-

ward end portion with right-hand threads **62**, this threaded portion being releasably threadedly engageable with complementary internal threads in a blind fastener sleeve as described hereinafter in detail.

A tubular anvil **64** is annularly disposed about the mandrel **52**, anvil **64** having a rearwardly extending, internally threaded skirt portion **66** which is threadedly coupled over the externally threaded tubular forward portion **22** of the nosepiece **16**. Mandrel **52** is freely rotatable and slidable relative to the anvil **64**, and anvil **64** has a generally flat forward working face **68** which engages against the blind fastener sleeve head during the screw-in and pull-up phases of operation of the apparatus as will hereinafter be described in detail.

Also threadedly engaged over the externally threaded tubular forward portion **22** of nosepiece **16**, immediately to the rear of the anvil skirt portion **66**, is a locking ring or nut **70** which serves to lock the anvil axially relative to the nosepiece. In FIG. **1** the anvil **64** is at its rearwardmost position on the nosepiece **16**, which leaves a maximum length of the mandrel **52** projecting forwardly from the working face **68** of the anvil, to accommodate a relatively long blind fastener sleeve. Forward adjustment of the anvil **64** on the nosepiece **16**, secured by means of the locking ring or nut **70**, will accommodate blind fastener sleeves of shorter lengths.

Rotary power is supplied to the spindle **34** by means of a reversible, gear-type hydraulic motor mounted on the rear end of the hand gun body **12**, the motor being generally designated **72**. Motor **72** includes a power gear **74** and an idler gear **76** meshed with the power gear **74**, the gears **74** and **76** having standard involute gear teeth. Respective integral shafts **78** and **80** extend from both ends of the gears **74** and **76**. The shaft **78** for power gear **74** includes a forwardly extending portion **82** of square cross section which is engaged in a complementary square aperture **84** in the enlarged coupler portion **36** of the spindle **34**. The coupler portion **36** of the spindle has a cavity **86** extending axially forwardly of the square aperture portion **84** to allow substantial rearward sliding movement of the drive coupler **36** over the square shaft portion **82** during the pull-up phase of operation of the tool, and dampening of this relative axial movement between the coupler **36** and the square shaft portion **82** due to a close-fitting relationship therebetween, and due to the presence of hydraulic fluid in the cylinder **24**, is avoided by providing bleeder passage means **88** which extends radially outwardly from the cavity **86** to the outside of drive coupler **36**.

The motor gears **74** and **76** are rotatably mounted in respective parallel, communicating, arcuate cavities **90** and **92** which extend axially through a motor gear housing plate **94** of substantially the same axial thickness as the length of the gears **74** and **76**. Inside and outside manifold plates **96** and **98**, respectively, seat flush against the front and rear surfaces of the motor gear housing plate **94**, the manifold plates **96** and **98** each being provided with a pair of bores that are coaxial with the respective gear cavities **90** and **92** in the housing plate **94**, to provide journals for the respective gear shifts **78** and **80**.

The inside manifold plate **96** is adapted to seat flush against a generally flat rearwardly facing surface **100** of body **12**, while a generally flat motor cover plate **102** is adapted to seat against the rear surface of outside manifold plate **98**.

The entire assembly consisting of motor gear housing plate **94** and the gears **74** and **76** therein, the two manifold plates **96** and **98**, and the motor cover plate **102**, is secured to the gun body **12** by means of a plurality of screws **104** which extend through aligned apertures in the plates **94, 96, 98** and **102**, and threadedly engage in the rear of body **12** as best seen in FIG. **1**. Sealing rings **106** are engaged between each pair of mating surfaces in this assembly radially outwardly of the hydraulic motor gears **74** and **76** and shafts **78** and **80**, to prevent the escape of hydraulic fluid through the interfaces.

The hydraulic fluid passage system of the hand gun **10** includes three inlet conduits which receive hydraulic fluid under pressure from the remote power unit and one hydraulic fluid drain conduit. Thus, referring in particular to FIGS. **1, 3,** and **5**, looking forwardly from the rear of the gun as in FIG. **5**, at the right-hand side of the handle is a conduit **108** which is connected to the remote power unit by a flexible hose to receive hydraulic actuating fluid for the screw-in phase of mandrel operation. Similarly, fluid conduit **110** in the left-hand side of the gun handle looking forwardly as in FIG. **5** receives hydraulic actuating fluid from the remote power unit through a suitable flexible hose for the screw-out phase of mandrel operation. Centered between the sides of the handle, and located forwardly of the conduits **108** and **110**, is a third conduit **112** which receives hydraulic actuating fluid from the remote power unit through a suitable flexible hose for the pull-up phase of mandrel operation. Finally, a drain conduit **114** is centered between the sides of the handle to the rear of the conduits **108** and **110**, the conduit **114** being connected to the remote power unit through a fourth flexible hose to return hydraulic fluid from the gun back to the power unit.

The fluid conduits **108** and **110** extend upwardly through the handle **14** and then rearwardly, generally parallel to each other, through the body **12** of the gun, opening into respective upwardly extending grooves **116** and **118** in the rear surface **100** of body **12**. The upper ends of grooves **116** and **118** communicate with respective ports **120** and **122** which extend in the axial direction through inside manifold plate **96** and open in horizontally spaced relationship to the gear cavities **90** and **92** proximate the constriction where the cavities **90** and **92** come together; i.e., the ports **120** and **122** communicate with the gear cavities **90** and **92** proximate the horizontal centerline therebetween. As best shown in FIG. **7**, the ports **120** and **122** are spaced apart slightly more than the thickness of a single tooth of either of the gears **74** and **76**, and by providing a close tolerance fit between the gears **74** and **76** there will always be substantially a one-tooth seal between the ports **120** ad **122**. A close tolerance fit is also provided between the outer periphery of power gear **74** and its gear cavity **90**, and between the periphery of the idler gear **76** and its gear cavity **92**. In this manner, the gears **74** and **76** provide a labyrinth type seal in their respective cavities **90** and **92** and the pressure falls off in a steep gradient from the parts **120** and **122** peripherally outwardly about the cavities **90** and **92**. With this arrangement, the gear motor is highly efficient, and it is unnecessary to provide conventional bleed passages diametrically through the gears.

When fluid under pressure is supplied to the fluid conduit **108** in the handle **14**, it passes upwardly through conduit **108** into groove **116** in surface **100** of the body and thence through the respective port **120** into the region where the gear cavities **90** and **92** join. Then, the fluid flows to the left as viewed in FIGS. **7** and **13**, in the direction of the arrows in FIG. **13**, displacing the meshed gear teeth to the left the fluid then discharging out through port **122**, groove **118** and thence out of the hand gun portion of the tool through the fluid conduit **110**. Thus, fluid flowing in this direction will cause the power gear **74** to rotate clockwise as viewed in FIGS. **5, 7, 9,** and **13**. Correspondingly, the shaft **78** of gear **74** will be rotated clockwise, and the square portion **82** thereof will cause the spindle **34** and the mandrel **52** to rotate in a clockwise direction.

Conversely, when hydraulic fluid under pressure is introduced into the hand gun through fluid conduit **110**, it passes upwardly through the handle and rearwardly through the body portion of conduit **110** into groove **118**, from which it passes rearwardly through port **122**, and as indicated by the flow arrows in FIG. **14**, flows to the right in the region where the gear cavities **90** and **92** join, forcing the meshing gear teeth to the right as viewed in FIG. **14**. The fluid then flows out through the port **120**, groove **116** and fluid conduit **108**. Thus, when fluid under pressure is introduced into the gun through fluid conduit **110**, it causes the power gear **74** to rotate in an anticlockwise direction as viewed in FIGS. **5, 7, 9,** and **14**, thereby rotating the power gear shaft **78** and its square forward portion **82** anticlockwise, and correspondingly rotating the spindle **34** and mandrel **52** anticlockwise.

A small amount of the hydraulic fluid which is thus introduced into the hand gun through the fluid conduits **108** and **110** will flow into the journals for the gear shafts **78** and **80** so as to lubricate the latter, from the gear cavities **90** and **92** adjacent the ends of the gears **74** and **76**.

Such of the hydraulic fluid as may seep into the interfaces between rear body surface **100** and manifold plate **96** or between plates **96**, **94**, **98**, and **102**, from any source, as for example from the grooves **116** and **118**, the ports **120** and **122**, the gear shift journals, or the gear cavities **90** and **92**, will be prevented from escaping to the outside of the hand gun by the sealing rings **106** as aforesaid, and will be collected by a series of axially aligned leakage ports **124**, **126**, and **128**, respective plates **98**, **94**, and **96**, and fed to a further leakage port **130** in the body **12** opening at rear surface **100** thereof, the final leakage port **130** extending forwardly into communication with the annular recess **32** in the body **12**, from which such drainage fluid is enabled to flow out of the hand gun through the drain conduit **114**.

Hydraulic fluid under pressure introduced into the fluid conduit **112** passes upwardly through the handle **14** and thence forwardly in the body **12** into the body cylinder **24** forwardly of piston ring **48**, thereby building up fluid pressure forward of the piston in the chambers **24** and **20** and forcing the piston **26** rearwardly against the forward biasing force of spring **30**, thus moving spindle **34** and mandrel **52** axially rearwardly in the hand gun relative to the anvil **64** Hydraulic fluid which may seep rearwardly past the piston ring **48** is simply collected in the cylindrical chamber **24** and annular recess **32** to the rear of the piston, and drains out of the hand gun through the drain conduit **114** which communicates at its upper end with the cylindrical body chamber **24**. Actually, hydraulic fluid previously accummulated in the cylinder **24** and recess **32** from bypassing the piston **26** and from leakage out of the hydraulic motor **72**, is pumped out of the hand gun through drain conduit **114** each time the piston **26** is driven rearwardly during a cycle of operation of the tool.

Upon release of pressure of the hydraulic fluid in the conduit **112**, the spring **30** is enabled to return the piston **26**, and consequently the spindle **34** and mandrel **52**, forwardly to the position shown in FIG. **1**, with excess fluid from chamber **20** in the nosepiece **16** and from the cylindrical body chamber **24** forward of piston ring **48** simply flowing back out through the fluid conduit **112**.

The hand gun **10** has a single finger-actuated switch button **132** thereon which projects forwardly from a trigger-shaped, concave finger guide **134** projecting forwardly from the upper front portion of the handle **14**. The switch button **132** actuates a normally open electrical switch **136**, the two contacts of which are electrically connected to a pair of wires **138** and **140** which, together with a ground wire **142**, constitute the electrical elements of an electrical cable **144** that extends from the hand gun **10** to the remote power source. Depressing the switch button **132** to close switch **136** completes an electrical circuit which causes the hand gun **10** to hydraulically drive the mandrel **52** through a complete cycle of operation.

Such a complete cycle of operation is illustrated in the sequence of FIGS **10**, **11**, and **12** of the drawings which show the installation of a blind fastener sleeve generally designated **146** in a structure generally designated **148** comprising a pair of overlapping panels **150** and **152**. The exposed side **154** of panel **150** shall be considered to be the access side of the structure **148**, while the exposed side **156** of the panel **152** shall be considered to be the blind side of structure **148**. The structure **148** has a bore **158** extending therethrough from the access side **154** to the blind side **156**, the bore **158** having a counterbore **160** at the access end thereof to receive the head **162** of the blind fastener sleeve where, as shown, the blind fastener sleeve has a tapered type head.

The blind fastener sleeve **146** includes, in addition to the head portion **162** thereof, a tubular body portion **164** which is generally coextensive with the panel bore **158**, but preferably terminates just short of the blind side **156** of the structure, a thin-walled, undercut, deformable section **166** which extends substantially beyond the blind side **156** of the panel, and terminating in an internally threaded pull-up portion **168** of the sleeve.

Installation of the blind fastener sleeve **146** in the structure **148** is accomplished by first inserting the fastener sleeve **146** into the bore **158** from the access side **154** thereof until the sleeve head **162** seats in the counterbore **160**. The hand gun **10** is then moved into position so that its forwardly projecting mandrel **52** is generally axially aligned with the sleeve **146**, and the mandrel **52** is then inserted through the sleeve **146** until the forward end of the mandrel comes into contact with the threads in the pull-up portion **168** of the sleeve where that portion of the sleeve joins with the deformable section **166** of the sleeve. Both as an aid to guiding the forward end of the mandrel into the internally threaded pull-up portion **168** of the sleeve, and to achieve the desired nut configuration of the deformable section **166** of the sleeve after pull-up, the deformable section **166** preferably includes a radially inwardly tapering guide portion **170**.

When the mandrel **52** is thus positioned, the operator simply presses the finger switch button **132** and holds the button down until the cycling has been completed. The first response to actuation of the switch **136** in the gun will be provision by the remote power source of hydraulic fluid under pressure to the fluid conduit **108** in the handle of the gun, which will provide fluid pressure to the gear motor **72** through port **120**, thereby causing the mandrel **52** to be rotated clockwise so that the threaded end portion **62** of mandrel **52** will automatically screw into the internally threaded pull-up portion **168** of the blind fastener sleeve **146**. This screw-in first phase of operation of the hand gun will continue until the forward working face **68** of anvil **64** and the sleeve head **162** are brought tightly into engagement and the tubular column comprising the nosepiece **16** and anvil **64** of the hand gun and the fastener sleeve **146** oppose further threaded engagement of the front end portion of mandrel **52** into the pull-up portion **168** of the sleeve, at which time the hydraulic motor **72** will stall, and corresponding back pressure in the fluid conduit **108** will be sensed in the remote power unit to automatically switch to the second phase of operation of the apparatus.

The second phase is effected by introduction of hydraulic fluid under pressure into the hand gun through fluid conduit **112**, which builds up fluid pressure forward of the piston **26**, forcing the piston **26** and hence the mandrel **52** rearwardly from the first-phase stall position shown in FIG. **10** to cause the deformable section **166** of the blind fastener sleeve to buckle outwardly as shown in FIG. **11**. This pull-up phase of the operation continues until the deformable section **166** of the sleeve is collapsed to the point where it applies sufficient force in opposition to further collapse to build up back pressure of the hydraulic fluid in conduit **112** to a predetermined pressure which is sensed in the remote power unit and employed to automatically effect the shift from the second phase of operation of the tool to the third phase of operation which is illustrated in FIG. **12**.

According to the third phase of operation, hydraulic fluid under pressure is introduced into the hand gun through the fluid conduit **110**, from which it is conducted to the hydraulic motor **72** through port **122** to cause anticlockwise rotation of the mandrel **52**, whereby the threaded forward end portion **62** of the mandrel will screw out of the internally threaded pull-up portion **168** of the blind fastener sleeve. The three-phase installation cycle is complete when the threaded forward end of the mandrel clears the threads of the pull-up portion **168** of the blind fastener sleeve as illustrated in FIG. **12**, and at that point the finger switch button **132** can be released by the operator to turn off the tool, and the mandrel withdrawn from the fully installed blind fastener sleeve **146**.

FIG. **15** is similar to FIG. **10**, illustrating the mandrel **52** of the tool fully threadedly engaged with the internally threaded pull-up portion of a blind fastener sleeve at the termination of the first or screw-in phase of operation of the tool. However,

FIG. 15 differs from FIG. 10 by showing a shortened blind fastener sleeve 146*a* engaged through a bore 158*a* in structure 148*a* composed of a pair of relatively thin panels 150*a* and 152*a*. Because of the shortened length of the fastener sleeve 146*a*, if the tool were adjusted as in FIG. 10, with the anvil 64 and locking ring 70 fully rearwardly positioned on the tubular forward portion 22 of the nosepiece, then the threaded front end portion 62 of mandrel 52 would screw too far through the internally threaded pull-up portion 168*a* of the fastener sleeve and there would be an insufficient axial length of threaded engagement therebetween when the forward face of the anvil 64 bottomed against the head of the fastener sleeve at the completion of the first phase to assure that the pull-up phase could be accomplished without damaging the fastener sleeve. In fact, with an even shorter fastener sleeve than the sleeve 146a illustrated in FIG. 15, the threaded forward end 62 of the mandrel 52 might screw completely on through the threaded pull-up portion of the fastener sleeve so that the hydraulic motor stall-out to complete the first phase of operation might never occur.

To accommodate such a shorter fastener sleeve 146a, all that is necessary is to screw the anvil 64 forwardly on the tubular forward portion 22 of the nosepiece a sufficient amount to assure full threaded engagement of the threaded forward end 62 of the mandrel in the internally threaded pull-up portion 168*a* of the fastener sleeve, and then to lock the anvil 64 in this position by tightening the locking ring 70 against the rearward end of the anvil. The operation of the tool through the three phases, screw-in, pull-up, and screw-out, will then be identical to the operation described in connection with FIGS. 10, 11, and 12.

FIG. 22 diagrammatically illustrates the hydraulic system, which is generally designated 172. Also illustrated in FIG. 22 is a pneumatic power system, generally designated 174, which provides the driving power to the hydraulic system. While the hydraulic pump of the hydraulic system 172 can be powered by any conventional prime mover, as for example an electric motor, the pneumatic power system 174 is particularly desirable in that it does not produce the sparks of an electric motor, and hence the explosion hazard of an electric motor, and it utilizes readily available shop air which is capable of bringing the hydraulic pump up to operational speed with a minimum time lag.

Referring at first to the pneumatic power system 174, shop air is supplied thereto through air inlet conduit 176, the air being directed through a filter 178, a pressure regulator 180, and a lubricator 182 to a normally closed solenoid-operated air valve 184. The lubricator 182 suspends a small amount of oil in the air for lubrication of the air motor. A pressure gauge 186 is connected between regulator 180 and valve 184 for monitoring the air pressure that is supplied through valve 184 to the air motor. When the solenoid-operated air valve 184 is energized and thereby moved from the closed position that is illustrated to its open position, it permits air to flow therethrough and thence through a flow control valve 188, which adjustably meters the rate of air flow, to air motor 190, which is silenced by a suitable muffler 192. The air motor 190 drives the hydraulic pump 194 of the hydraulic system 172 through a suitable drive shaft connection 196.

The hydraulic pump 194 is energized in response to actuation of the hand gun switch button 132 to close the normally open electrical switch 136 located in the hand gun. Closure of switch 136 moves the normally closed solenoid-operated air valve 184 to its open position, thereby energizing the air motor 190 and consequently hydraulic pump 194.

The hydraulic pump 194 furnishes hydraulic fluid under pressure through a check valve 198 to fluid output conduit 200 which is connected to directional control valve 202. Valve 202 is a four-way, three-position, solenoid-operated valve having a normally closed centered position as illustrated in FIG. 22, and being movable to a first off-center position wherein the mandrel 52 of the hand gun 10 is caused to rotate clockwise for the screw-in operation, and alternatively to a second off-center position wherein the mandrel 52 of the hand gun is caused to move anticlockwise for the screw-out operation.

When the hand gun switch button 132 is initially depressed to close the normally open electrical switch 136 in the hand gun, this not only opens electrical switch 136 in the hand gun, this not only opens the solenoid-operated air valve 184 as aforesaid to cause energization of the hydraulic pump 194, but also energizes the solenoid-operated directional control valve 202 to shift the valve element thereof as diagrammatically illustrated in FIG. 22 to the right, which connects the pump output conduit 200 to hydraulic line 204, and also connects hydraulic line 206 to a line 208 which returns the hydraulic fluid to reservoir 210. The hydraulic system is a recirculating one, the reservoir 210 being the source of the hydraulic fluid for the hydraulic pump 194, which receives this fluid through input conduit 212.

Hydraulic line 204 is connected through a speed control valve 214 and flexible hose 216 to the fluid conduit 108 that leads to one side of the hydraulic motor 72 in hand gun 10. The fluid conduit 110 leading to the other side of the hydraulic motor 72 in the hand gun is connected through flexible hose 218 to the hydraulic line 206.

Thus, in the initial mode of operation of the apparatus when the gun switch 136 is closed by depressing the switch button 132, with the hydraulic pump 194 energized and the directional control valve 202 in its first off-center position, to the right as illustrated in FIG. 22, hydraulic fluid will pass from the pump 194 through conduit 200 and valve 202 into the hydraulic line 204, and thence through flexible hose 216 to the hand gun conduit 108 so as to drive the hydraulic motor 72 in the hand gun clockwise to screw the mandrel 52 into the pull-up portion of the blind fastener sleeve. After driving the hydraulic motor, the fluid then returns to the reservoir 210 through hand gun conduit 110, flexible hose 218, hydraulic line 206, directional control valve 202 and hydraulic return line 208.

A pressure switch 220 is operatively connected to the hydraulic line 204, and when the hydraulic motor 72 stalls at the completion of the screw-in mode, the back pressure increase in hydraulic line 204 corresponding to this stall condition of the hydraulic motor 72 causes actuation of pressure switch 220, which in turn causes release of the directional control valve 202 back to its center position as illustrated in FIG. 22, thus cutting of the connection between conduit 200 and line 204 and thereby stopping the flow of hydraulic fluid to the hydraulic motor 72. Simultaneously, such actuation of the pressure switch 220 energizes a piston operating valve 222 to shift it from its normal position as illustrated in FIG. 22 to the right to its actuated position wherein it provides hydraulic fluid under pressure from the pump 194 to the hand gun cylinder 24 so as to force the hand gun piston 26 and the mandrel 52 rearwardly in the pull-up mode of operation of the tool. With the piston operating valve 222 thus shifted to the right as illustrated in FIG. 22 to effect the second or pull-up mode of operation, hydraulic fluid pressure is conducted from the pump 194 through output conduit 200 and thence through hydraulic line 224 and valve 222 to a hydraulic line 226, flexible hose 228, and fluid conduit 112 in the hand gun, to the cylinder 24 in the hand gun. Drainage fluid from cylinder 24, and from hydraulic motor 72, returns to the reservoir 210 through hand gun drain conduit 114 and a further flexible hose 230.

An adjustable pressure switch 232 is operatively connected to the hydraulic line 226, and when the back pressure in line 226 reaches a predetermined value, as preset on the switch 232, the switch 232 is actuated so as to cause release of the piston operating valve 222 back to its normal position as illustrated in FIG. 22, wherein the line 226 is disconnected from the pressure line 224 and line 226 is connected through valve 222 to a drain line 234. The drain line 234 is connected to a hydraulic return line 208, whereby fluid pressure from hand gun cylinder 24 is relieved through hand gun conduit 112,

flexible hose 228, line 226, valve 222, and lines 234 and 208 back to the reservoir 210, thereby allowing the hand gun piston 26 to be returned to its initial, inoperative position.

Such closing of the adjustable pressure switch 232 in response to back pressure in the hydraulic line 226 marks the completion of the pull-up cycle of the tool, and also causes the directional control valve 202 to shift to the left from its center position as illustrated in FIG. 2 so as to provide fluid connection from the pump output conduit 200 to hydraulic line 206, and also to connect the hydraulic line 204 to the hydraulic return line 208. This causes the hydraulic motor 72 in the hand gun to be driven anticlockwise to produce the third mode of operation of the tool, which is the screw-out mode wherein the mandrel 52 screws out of the internally threaded portion of the blind fastener sleeve. In this mode hydraulic fluid under pressure flows from the pump 194 through output conduit 200 and through directional control valve 202 to hydraulic line 206, from which the fluid passes through flexible hose 218, and fluid conduit 110 in the hand gun to the hydraulic motor 72. Fluid discharge from the motor 72 passes through conduit 108 in the hand gun and thence through flexible hose 216, hydraulic line 204, valve 202 and hydraulic return line 208 back to the reservoir 210. This third mode of operation continues until the operator releases the hand gun switch button 132 to open the switch 136, which allows directional control valve 202 to return to its center position as illustrated in FIG. 22, and which also releases the solenoid-operated air valve 184 in the pneumatic power system 174, the air valve 184 thus being allowed to return to its normally closed position as illustrated in FIG. 22.

Over-pressurization of the system is prevented by a relief valve 233 connected to output conduit 200. Slight pressure is maintained in the system when it is inoperative by a back pressure valve 235 in return line 208.

Reference will now be made to FIG. 23 of the drawings, which diagrammatically illustrates the electrical system employed in the present invention for controlling the hydraulic and pneumatic systems 172 and 174, respectively. Line current is fed through a wall plug 236 to a pair of conductors 238 and 240, the conductor 238 being shown as a bus line for one side of the system. Line 240 has a fuse 242 therein, and leads to a selector switch generally designated 244 which has three positions, an "off" position an "auto" position for automatic cycling of the apparatus through the screw-in, pull-up and unscrew modes of operation, and an "unscrew" position which causes the screw-in and pull-up modes to be bypassed, and allows the apparatus to operate only in the third or unscrew mode. The "off" section 246 of the selector switch 244 is an open contact section. The "auto" section 248 of switch 244 is an open contact section. The "auto" section 248 of switch 244 has two sets 250 and 252 of normally open contacts which are closed by moving the selector switch 244 to the "auto" position. Similarly, the "unscrew" section 254 of selector switch 244 has two sets 256 and 260 of normally open contacts which are closed by moving the selector switch 244 to the "unscrew" position.

Assuming that the selector switch 244 is moved to the "auto" position for normal automatic operation of the apparatus, this will connect line conductor 240 through switch contacts 250 to a conductor 262. An indicator light 264 connected between conductor 262 and the bus line 238 will become illuminated to indicate that the apparatus is turned on. The energized conductor 262 is connected through electrical connector 266 to one of the wires 138 leading to the normally open hand gun switch 136, the other hand gun wire 140 leading through connector 266 to a conductor 268 that is connected to one side of the solenoid-operated air valve 184, the other side of which is connected to the bus line 238. Solenoid-operated air valve 184 is closed in its normal, unenergized condition, and since the hand gun switch 136 is normally open as illustrated in FIG. 23, the air valve 184 will remain closed until the hand gun switch 136 is closed by depressing the switch button 132. When the hand gun switch 136 is closed, it then completes an electrical circuit from the energized conductor 262 through the hand gun switch 136 to conductor 268 so as to actuate the solenoid-operated air valve 184, thus opening the valve 184 and actuating the air motor 190 and consequently the hydraulic pump 194.

When the selector switch 244 was initially moved to the "auto" position, contacts 252 thereof were closed to provide electrical connection between conductor 268 and a second bus line 270. Thus, when the hand gun switch 136 is closed to commence operation of the tool, and the conductor 268 is thereby energized as aforesaid, the bus line 270 is likewise energized by the connection from conductor 268 through selector switch contacts 252. The directional control valve 202 has two solenoid coils 202*a* and 202*b* diagrammatically illustrated in FIG. 23. Energization of solenoid coil 202*a* causes the directional control valve 202 to shift to the right from the central position as illustrated in FIG. 22 for the screw-in phase of operation of the tool, while energization of the solenoid coil 202*b* causes the directional control valve 202 to shift to the left from the central position as illustrated in FIG. 22 for the unscrew or final phase of operation of the tool. Energization of the bus line 270 upon closure of the hand gun switch 136 as aforesaid provides electric current to the solenoid coil 202*a*, thereby initiating the screw-in phase of operation. One side of solenoid coil 202*a* is electrically connected to the bus line 238. The other side of coil 202*a* is connected to the other bus line 270 through normally closed pressure switch 220.

Thus, closure of the hand gun switch 136 causes simultaneous energization of the solenoid-operated air valve 184 and of solenoid coil 202*a* of directional control valve 202, thereby simultaneously turning on the hydraulic pump and directing the fluid flow therefrom to turn the hydraulic motor 72 clockwise for the screw-in phase of operation of the tool.

When the hydraulic motor 72 of the hand gun stalls at the end of the screw-in mode of operation, the increased pressure in the hydraulic line 204 causes the pressure switch 220 to momentarily open, thereby releasing the solenoid coil 202*a* and allowing the directional control valve 202 to shift back to the center position as illustrated in FIG. 22. The momentary opening of pressure switch 220 also completes an electrical connection from bus line 270 to the coil 272 of a relay generally designated 274 which has normally open contact 276 and normally closed contact 278. Energization of relay coil 272 opens the normally closed contact 278 which is in the circuit to solenoid coil 202*a*, so that when the pressure switch 220 again closes after its momentary opening, it will not again energize the solenoid coil 202*a*. Energization of relay coil 272 closes the relay contact 276, which electrically connects the relay coil 272 between the bus lines 270 and 238, thereby holding the relay 274 in its energized condition with contact 278 open and contact 276 closed. Closure of contact 276 also electrically connects the piston operating valve 222 between the bus lines 270 and 238, thereby actuating the valve 222 to provide hydraulic fluid under pressure to the hand gun cylinder 24 to effect the second or pull-up phase of operation of the tool.

This condition of the circuit remains in effect until pull-up is completed as sensed by the adjustable pressure switch 232 which, due to increase of back pressure in the hydraulic line 226, moves from its normally open position to a momentarily closed position wherein it electrically connects the coil 280 of a relay 282 between the bus lines 270 and 238. Relay 282 has three contacts, a normally closed contact 284, and normally open contacts 286 and 288. The momentary closure of adjustable pressure switch 232 to energize the relay coil 280 causes a relay holding circuit to be completed between bus lines 270 and 238 by closure of the normally open relay contact 288, so that when pressure switch 232 again opens upon a drop of pressure in hydraulic line 226, the relay 282 will remain actuated. Actuation of relay 282 opens relay contact 284 which is in the circuit providing current to relay coil 272 and piston operating solenoid valve 222, thereby releasing the relay 274 and the piston operating solenoid valve 222, cutting off the supply of hydraulic fluid pressure to the hand gun cylinder 24.

Actuation of relay **282** further closes its normally open contact **286** which serves to electrically connect the directional control valve solenoid **202***b* between bus lines **270** and **238** so as to shift the directional control valve **202** to the left from the center position as illustrated in FIG. **22**, thereby actuating the hand gun hydraulic motor **72** in the anticlockwise direction for the final or unscrew mode of operation of the apparatus.

Accordingly, when relay **282** is actuated at the commencement of the third or unscrew mode of operation, it causes release of the remainder of the circuit except for the solenoid-operated air valve **184** which remains energized to keep the hydraulic pump **194** operative, and except for the solenoid **202***b* of the directional valve **202** and the holding circuit itself for the relay **282**. Then, when the hand gun mandrel **52** has unscrewed free of the installed blind fastener sleeve, release of the trigger switch button **132** allowing the hand gun switch **136** to open disconnects the power source from conductor **268** and hence from the bus line **270**, thereby releasing relay **282** and hence also releasing the solenoid coil **202***b* of directional control valve **202** so that valve **202** returns to the center position as illustrated in FIG. **22**. This returns the circuit to its full reset position, ready for another cycle of operation upon closing of the hand gun switch **136**. However, with the selector switch **244** left in the "auto" position, the indicator light **264** will remain illuminated to indicate that the apparatus is prepared for another cycle of operation.

The "unscrew" position of selector switch **244** permits the unscrew mode of operation of the apparatus to be employed pursuant to actuation of the hand gun switch **136** without cycling through the screw-in and pull-up modes. Such independent use of the unscrew mode of operation may be desirable in the event the mandrel **52** should inadvertently become stuck in a blind fastener sleeve and it should be desired to simply back the tool out of the sleeve. Moving the selector switch **244** to the "unscrew" position closes contacts **256** and **260** thereof. Contact **256** connects line conductor **240** to the conductor **262**, which turns on the indicator light **264** and energizes the circuit to hand gun switch **136**. Closure of contact **260** connects the conductor **268** from the hand gun to a conductor **290** which is connected to one side of the directional control valve solenoid coil **202***b*, the other side of which is connected to bus line **238**. Accordingly, closure of the hand gun switch **136** simply completes a circuit to the solenoid coil **202***b* to cause the directional control valve **202** to shift to the left from the center position as illustrated in FIG. **22**, thereby causing the hand gun hydraulic motor to turn anticlockwise for the unscrew mode, which mode continues until the hand gun switch **136** is released.

If the hand gun switch button **132** is released to open the hand gun switch **136** at any time during either the automatic operation of the apparatus with the selector switch **244** in the "auto" position or during the unscrew mode as determined by positioning the selector switch **244** in the "unscrew" position, the entire electrical system will be de-energized, with the exception of the indicator light **264** which will remain illuminated, and all functions will cease. If the selector switch **244** is in the "auto" position, when the hand gun switch button **132** is again depressed to close the switch **136**, cycling of the apparatus will again commence from the beginning, the apparatus going through the screw-in, pull-up and unscrew modes in sequence. If the selector switch is on the "unscrew" position, reclosing the hand gun switch **136** will simply cause resumption of the unscrew mode.

If, for example, the automatic operation of the apparatus should be interrupted by opening of the hand gun switch **136** during the screw-in mode, rotation of the mandrel **52** will simply stop. Then, when the switch **136** is again closed, the first or screw-in mode will assume, and will continue until the stall condition of the hydraulic motor switches the apparatus to the second or pull-up mode, and the cycling will continue through the pull-up and unscrew modes. As another example, if the hand gun switch **136** should be opened during the pull-up mode, the complete de-energization of the system will release the pull-up force, but leave the mandrel **52** screwed into the blind fastener sleeve. Then, when the hand gun switch **136** is reclosed, the system will go through all three cycles, although the screw-in cycle will be quickly traversed since the hydraulic motor **72** will almost immediately stall due to the fact that the mandrel is already fully threadedly engaged with the blind fastener sleeve. This stall condition of the hydraulic motor **72** switches the apparatus to the pull-up mode which is then effective for complete pull-up as determined by back pressure in the hydraulic system acting upon the adjustable pressure switch **232**, and then the system will automatically switch to the unscrew mode.

Similarly, if automatic operation is terminated by opening of the hand gun switch **136** during but before the completion of the unscrew mode, when the switch **136** is again closed, the apparatus will cycle through all three modes. During the screw-in mode, the mandrel will screw back into the blind fastener sleeve to the extent that it had already screwed out, at which time the hydraulic motor **72** will stall to switch to the pull-up mode. The pull-up mode will be quickly traversed since the blind fastener sleeve will already be fully upset, and then the apparatus will again automatically switch to the unscrew mode, which will be completed assuming the hand gun switch **136** is held long enough in the closed position.

FIGS. **16** through **21** illustrate a presently preferred remote power unit generally designated **292** for providing the hydraulic driving power to the hand gun **10** pursuant to electrical control from the hand gun. The power unit **292** is preferably constructed in the form of a movable cart having a housing **294** with front, rear, and right and left side walls **296**, **298**, **300** and **302**, respectively. The housing **294** stands on a stationary rear rest member **304** and a pair of forward wheels **306**, and a forwardly and upwardly projecting handle **308** permits convenient moving of the power unit **292** by simply tipping the housing forwardly on the wheels **306** to raise the rear rest member **304** above the floor.

FIG. **16** illustrates the air motor **190** coupled to the hydraulic pump **194** through the drive connection **196**, and also illustrates a hydraulic fluid filter **310** in the rear of the housing and a hydraulic reservoir filler port **312** projecting from the front of the housing which are not illustrated in the hydraulic system diagram of FIG. **22**. The hydraulic pump **194** is shown located within the reservoir **210**, and the hydraulic pump output is fed through a pipe **314** to a manifold **316** which contains most of the hydraulic system lines or conduits diagrammatically illustrated in FIG. **22**. The manifold **316** is laid out generally horizontally in overlying relationship above the reservoir **210**. As best shown in FIGS. **16** and **17**, supported on top of the manifold **316** are the check valve **198**, the directional control valve **202**, speed control valve **214**, piston operating valve **222**, and relief valve **233**. Projecting rearwardly from the manifold **316** are the back pressure valve **235** and hydraulic filter **310**.

As best illustrated in FIGS. **16** and **18**, the adjustable pressure switch **232** is mounted on the front wall **296** of the power unit housing **294**.

The air system is best shown in FIG. **19** looking from the rear inside the housing **294**. Illustrated in FIG. **19** are air filter **178** and pressure regulator **180**, which are shown as a combination unit, lubricator **182**, the solenoid-operated air valve **184**, air flow control valve **188**, and air motor **190**. The air inlet conduit **176** is provided with shop air through an air input hose **318** shown in FIG. **20**.

Also shown in FIG. **20** on the left-hand wall **302** are the selector switch **244** and indicator light **264** forming part of the electrical circuit diagram in FIG. **23**.

The connections of the flexible hoses and electrical cable from the hand gun at the front wall **296** of the power unit are best illustrated in FIGS. **17**, **18**, and **21**. Suitable connectors for the hoses and electrical cable are mounted on a connector panel **320** on front wall **296**. These connectors include an electrical connector **322** for the electrical cable **144** from the hand gun, and hose connectors **324**, **326**, **328**, and **330**, for the respective hoses **216**, **218**, **228**, and **230**, all of which are dia-

grammatically illustrated in FIG. 22. Also mounted on the connector panel 320 is a plugged connection 332 to which a system pressure gauge may be connected for testing purposes. The electrical cable and hose connections to the hand gun are diagrammatically illustrated in FIG. 21, which illustrates the connector panel 320 and the base of the handle of the hand gun 10 substantially as illustrated in FIG. 3, with dotted line electrical cable and hose connections therebetween.

While one automatic sequencing circuit arrangement has been illustrated in FIGS. 22 and 23 and described herein, it is to be understood that other circuit means may be employed to provide automatic sequencing of the hand gun between the screw-in, pull-up, and screw-out modes of operation thereof within the scope of the invention. Thus, for example, the circuit means may include as a part thereof a conventional "-sequence valve" which has built into it pressure responsive sequencing means which would serve as the equivalent of the pressure responsive sequencing means illustrated in FIGS. 22 and 23 and described in connection therewith.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein.

I claim:

1. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3 ) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, and manually actuable means operatively connected to said control circuit means for initiating the automatic sequencing operation thereof.

2. A pre-entry pull-up tool as defined in claim 1, wherein said power source is remote from said hand gun, and a flexible power transmitting connection between said power source and said hand gun.

3. A pre-entry pull-up tool as defined in claim 1, wherein said control circuit means includes electrical switch means on the hand gun and connected to said manually actuable means for initiating the operation thereof.

4. A pre-entry pull-up tool as defined in claim 1, wherein said rotary drive means and said translational drive means are hydraulically actuated, and said power source includes a hydraulic fluid pressure system hydraulically connected to said rotary drive means and to said translational drive means.

5. A pre-entry pull-up tool as defined in claim 4, wherein said hydraulic system is pneumatically energized.

6. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, and automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3) driving the mandrel in said second direction of rotation in a screw-out mode of mode of operation to disengage the mandrel from the sleeve, said automatically sequencing control circuit means including sensing means responsive to increased torque load on said mandrel for initiating the automatic sequencing step from said screw-in mode of operation to said pull-up mode of operation.

6. A pre-entry pull-up tool as defined in claim 6, wherein said rotary drive means is a motor in the gun, and said sensing means is responsive to substantially a stall condition of said motor.

8. A pre-entry pull-up tool as defined in claim 7, wherein said motor is hydraulically driven, said power source including a hydraulic fluid pressure system hydraulically connected to said motor, and said sensing means being responsive to a hydraulic fluid pressure increase in said hydraulic fluid pressure system.

9. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, and automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3 ) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, said automatically sequencing control circuit means including sensing means responsive to increased pulling load on the mandrel for initiating the automatic sequencing step from said pull-up mode of operation to said screw-out mode of operation.

10. A pre-entry pull-up tool as defined in claim 9, wherein said translational drive means is hydraulically driven, said power source including a hydraulic fluid pressure system hydraulically connected to said translational drive means, and said sensing means being responsive to a hydraulic fluid pressure increase in said hydraulic fluid pressure system.

11. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, and automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode or operation to upset the sleeve, and (3) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, said rotary drive means and said translational drive means both being hydraulically actuated, said power source including a hydraulic fluid pressure system hydraulically connected through a first hydraulic connection to said rotary drive means and through a second hydraulic connection to said translational drive means, first sensing means associated with said first hydraulic connection and responsive to a hydraulic fluid pressure increase in said first hydraulic connection for initiating the automatic sequencing step from said screw-in mode of

operation to said pull-up mode of operation, and second sensing means associated with said second hydraulic connection and responsive to a hydraulic fluid pressure increase in said second hydraulic connection for initiating the automatic sequencing step from said pull-up mode of operation to said screw-out mode of operation.

12. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, and automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, said gun including a body having front and rear ends, said mandrel projecting forwardly from said body, and an anvil mounted on the front end of the body, said anvil having an aperture therethrough through which said mandrel extends, the anvil being engageable against the exposed end of a blind fastener sleeve into which the mandrel is inserted, said automatically sequencing control circuit means including sensing means responsive to increased torque load on the said mandrel for initiating the automatic sequencing step from the said screw-in mode of operation to said pull-up mode of operation, such increased torque load resulting from further threaded engagement of the mandrel into a blind fastener sleeve after said anvil is seated against the exposed end to the sleeve.

13. A pre-entry pull-up tool as defined in claim 12, wherein said anvil is adjustable on said body relative to the axis of the mandrel for adjusting the relative axial positions of the mandrel threads and the anvil to accommodate blind fastener sleeves of different lengths.

14. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, and automatically sequencing control circuit means connected to said power source for (1) driving the mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, said rotary drive means being a reversible hydraulically driven motor, and said power source including a hydraulic fluid system hydraulically connected to said motor, said hydraulic system including a fluid reservoir, a hydraulic pump having an input connected to the reservoir and having an output, a hydraulic loop circuit having first and second ends and having said motor therein arranged so that fluid flow from said first end toward said second ends operates the motor to drive the mandrel in said first direction of rotation, and fluid flow in the opposite direction in said loop operates the motor to drive the mandrel in said second direction of rotation, and valve means connected to said reservoir, to said pump, and to both ends of said loop circuit, said valve means being shiftable between a first position wherein it connects said first end of the loop circuit to said pump output and said second end of the loop circuit to said reservoir to cause the mandrel to be driven in said first direction of rotation, and a second position wherein it connects said second end of the loop circuit to said pump output and said first end of the loop circuit to said reservoir to cause the mandrel to be driven in said second direction of rotation.

15. A pre-entry pull-up tool as defined in claim 14, wherein said valve means is also shiftable to a third, shut-off position wherein it blocks said pump output from both ends of said loop circuit, and pressure-responsive means connected to said loop circuit between said first end thereof and said motor, said pressure responsive means being operatively connected to said valve means to shift said valve means from its said first position to its said third position in response to a substantial pressure increase in said loop circuit caused by substantially a stall condition of said motor.

16. A pre-entry pull-up tool as defined in claim 15, which includes solenoid means connected to said valve means for shifting said valve means between its said positions, said pressure responsive means comprising a pressure which electrically connected to said solenoid means.

17. A pre-entry pull-up tool as defined in claim 14, wherein said translational means is hydraulically driven, said hydraulic fluid system including a second hydraulic circuit having second valve means therein, said second circuit including fluid connections between said second valve means and said reservoir and pump respectively, and a fluid conduit between said second valve means and said translational drive means, said second valve means being shiftable between a first position wherein it connects said conduit to said reservoir to allow fluid drainage from said translational drive means so that the latter is inoperative, and a second position wherein it connects said conduit to said pump output to drive the mandrel axially in said pull-up mode of operation.

18. A pre-entry pull-up tool as defined in claim 17, which includes pressure-responsive means connected to said conduit and operatively connected to said second valve means to shift said second valve means from its said second position to its said first position in response to a substantial pressure increase in said conduit caused by a substantial increase in the pulling load on the mandrel.

19. A pre-entry pull-up tool as defined is claim 17, wherein said first-mentioned valve means is also shiftable to a third, shut-off position wherein it blocks said pump output from both ends of said loop circuit, pressure-responsive means connected to said loop circuit between said first end thereof and said motor, said pressure-responsive means being operatively connected to said first-mentioned valve means and to said second valve means to shift said first-mentioned valve means from its said first position to its said third position and to shift said second valve means from its said first position to its said second position in a response to a substantial pressure increase in said loop circuit caused by substantially a stall condition of said motor, whereby the response of said pressure-responsive means to substantially a stall condition of said motor causes automatic shifting of said tool from said screw-in mode of operation to said pull-up mode of operation.

20. A pre-entry pull-up tool as defined in claim 19, which includes second pressure-responsive means connected to said conduit and operatively connected to said second valve means and to said first-mentioned valve means to shift said second valve means from its said second position to its said first position and to shift said first-mentioned valve means from its said third position to its said second position in response to a substantial pressure increase in said conduit caused by a substantial increase and the pulling load on the mandrel, whereby the response of said second pressure-responsive means to a substantial increase in the pulling load on the mandrel causes automatic shifting of said tool from said pull-up mode of operation to said screw-out mode of operation.

21. A pre-entry pull-up tool for upsetting internally threaded blind fastener sleeves, which comprises a hand gun having a protruding, threaded mandrel that is insertable into a

blind fastener sleeve to be upset, reversible rotary drive means in the gun connected to the mandrel for driving the mandrel in first and second directions of rotation, translational drive means in the gun connected to the mandrel for axially driving the mandrel inwardly of the gun, a source of motive power operatively connected to said rotary and translational drive means, automatically sequencing control circuit means connected to said power source for (1) driving a mandrel in said first direction of rotation in a screw-in mode of operation of the tool to effect threaded engagement of the mandrel in a blind fastener sleeve, (2) driving the mandrel axially in a pull-up mode of operation to upset the sleeve, and (3) driving the mandrel in said second direction of rotation in a screw-out mode of operation to disengage the mandrel from the sleeve, and manually operable selector means operatively connected to said control circuit means and movable between a first position wherein said control circuit means causes automatic sequencing of said tool through said screw-in, pull-up, and screw-out modes of operation, and a second position wherein said control circuit means causes said tool to operate only in said screw-out mode of operation.

22. The method of upsetting an internally threaded blind fastener sleeve which comprises the steps of inserting a threaded mandrel into said sleeve, rotating said mandrel in a first direction of rotation for screwing the mandrel into the sleeve, sensing the torque load on the mandrel during said rotation thereof, terminating said rotation of the mandrel and initiating translational pull-up movement of the mandrel to upset the sleeve in response to a substantial increase in said torque load, sensing the pulling load on the mandrel during said pull-up movement, and terminating said axial pull-up movement and initiating rotation of the mandrel in a second direction of rotation for screwing the mandrel out of the sleeve in response to a substantial increase in said pulling load.

23. The method of upsetting an internally threaded blind fastener sleeve which comprises the steps of inserting a threaded mandrel into said sleeve, rotating said mandrel in a first direction of rotation for screwing the mandrel into the sleeve, sensing the torque load on the mandrel during the said rotation thereof, terminating said rotation of the mandrel and initiating translational pull-up movement of the mandrel to upset the sleeve in response to a substantial increase in said torque load, sensing the pulling load on the mandrel during said pull-up movement and initiating rotation of the mandrel in a second direction of rotation for screwing the mandrel out of the sleeve in response to a substantial increase in said pulling load, the rotational and translational movements of the mandrel being effected by a hydraulic power system, the torque and pulling loads on the mandrel being sensed by sensing back pressures in the hydraulic power system.

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