United States Patent

Sanders et al.

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[54] LOCK BOLT PLACING APPARATUS

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[21] Appl. No.: **861,960**

[52] **U.S. Cl.** .....**61/54.5 HA,** 60/54.5 H, 60/52, 60/54.6 R, 227/10

[51] **Int. Cl.** **F15b 7/00,** B25c 1/12, F15b 15/18

[58] **Field of Search** .....60/54.5 H, 54.5 P, 54.5, 54.5 HA; 29/252; 72/391

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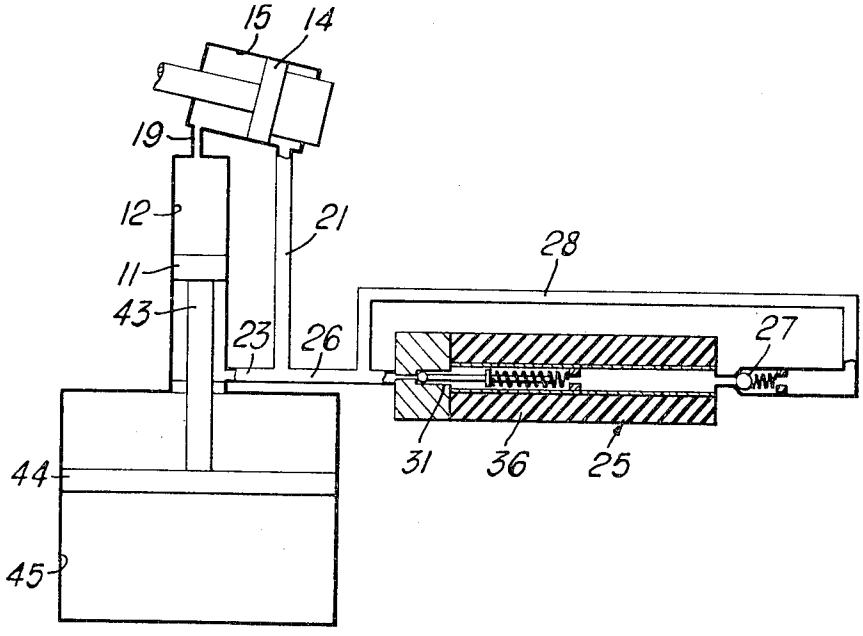
[57] **ABSTRACT**

The invention relates to a hydraulically operated lock bolt placing tool of the type comprising a double-acting master piston and cylinder and a double-acting slave piston and cylinder, connected together by two conduits to form a hydraulic intensifier. The relative size of the pistons is such that, on the return stroke, an excess of hydraulic fluid is generated in the return conduit. Connected to the return conduit is a hydraulic reservoir with a pressurized inlet valve. This ensures that, on the return stroke of the tool, pressure builds up in the return conduit to provide a force to pull the anvil off the swaged lock bolt collar. The hydraulic reservoir contains resilient sponge rubber.

8 Claims, 10 Drawing Figures



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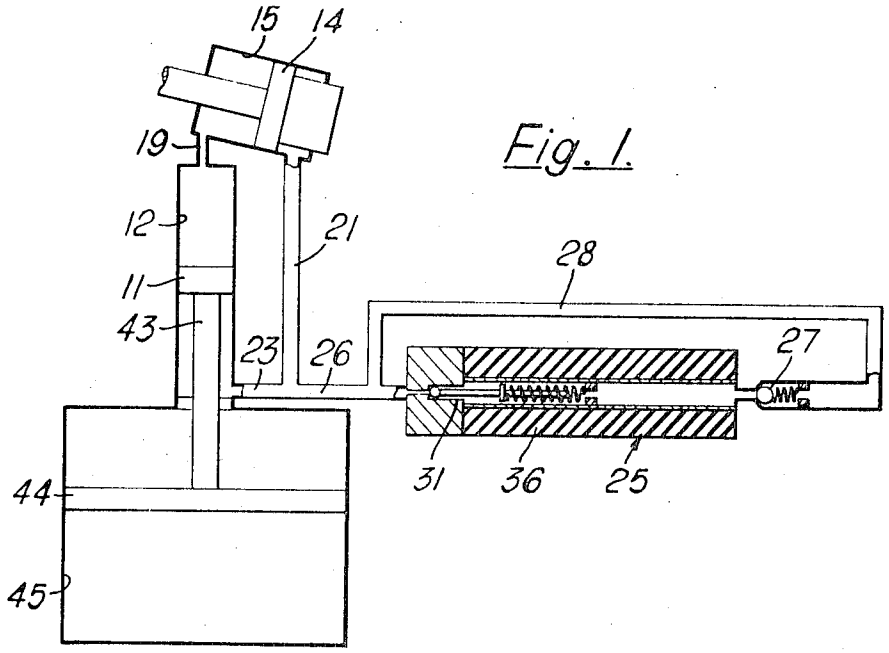
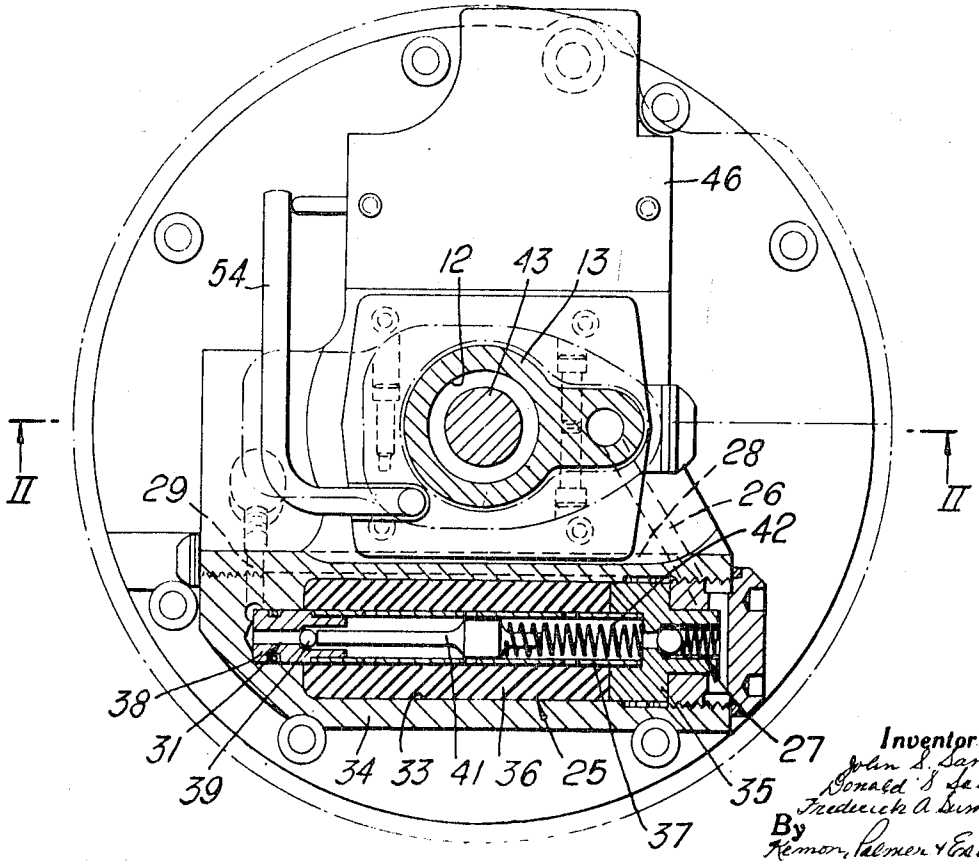


Fig. 1.

Fig. 3.



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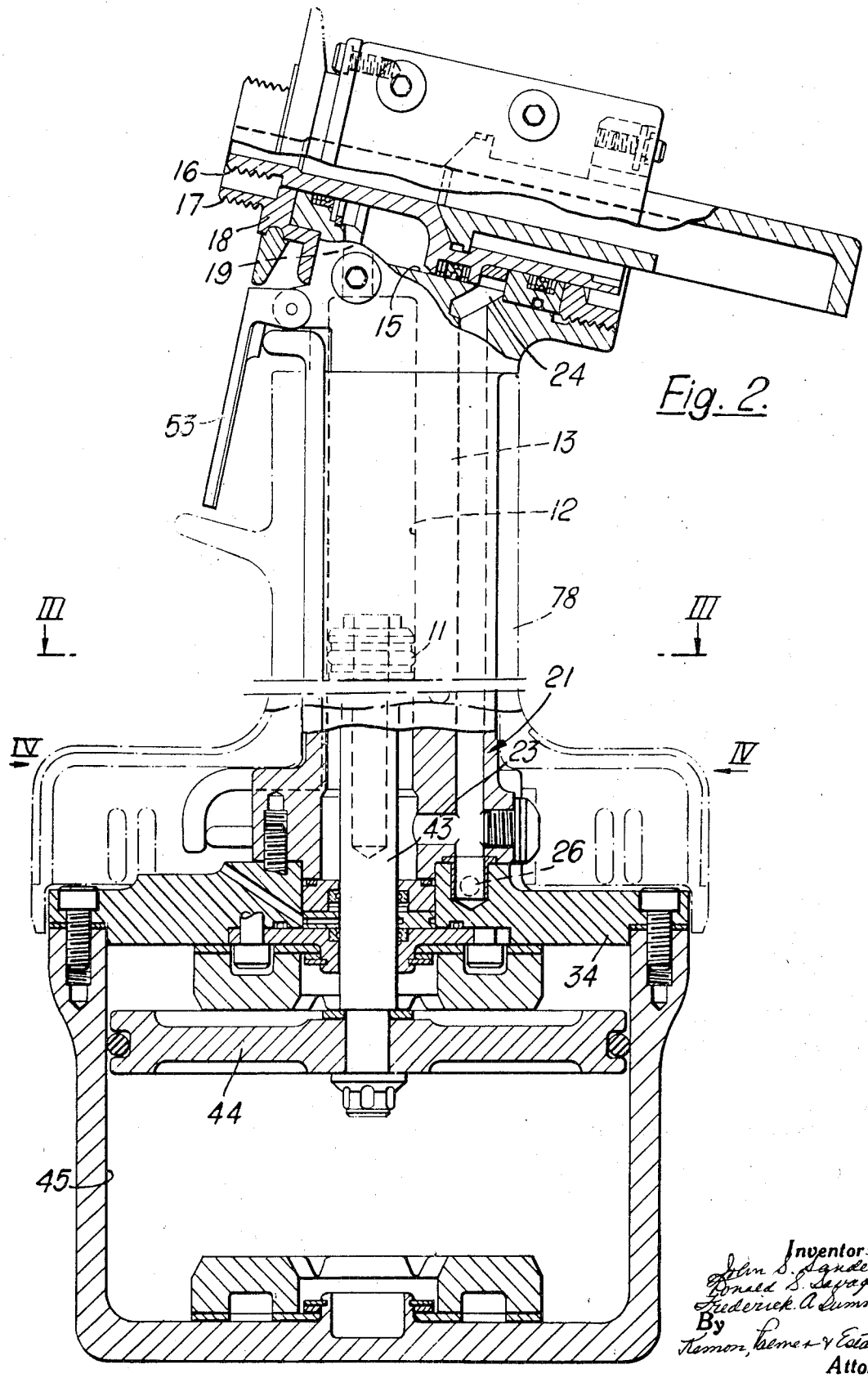

Fig. 2.

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Fig. 4.

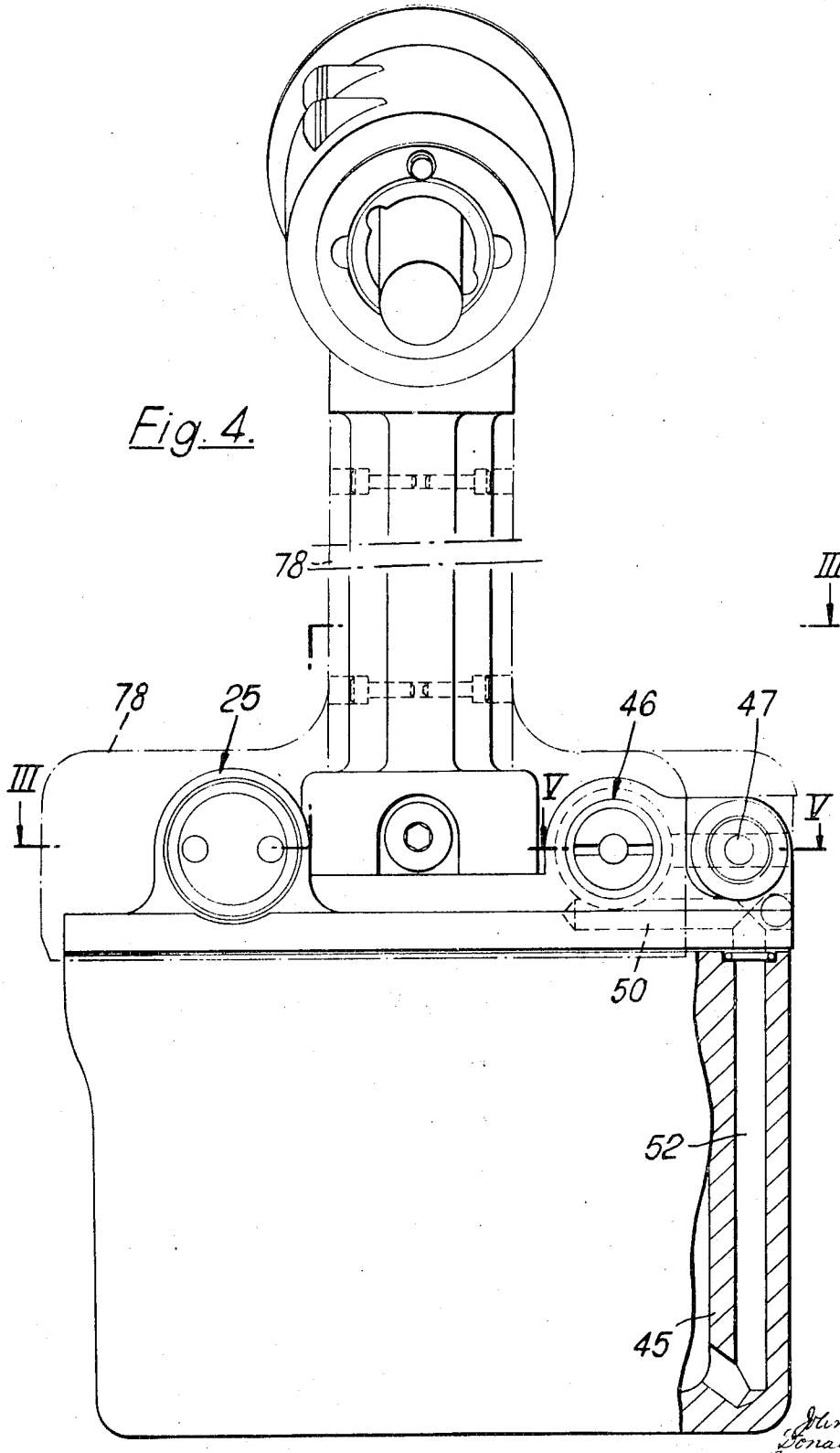

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Fig. 5.

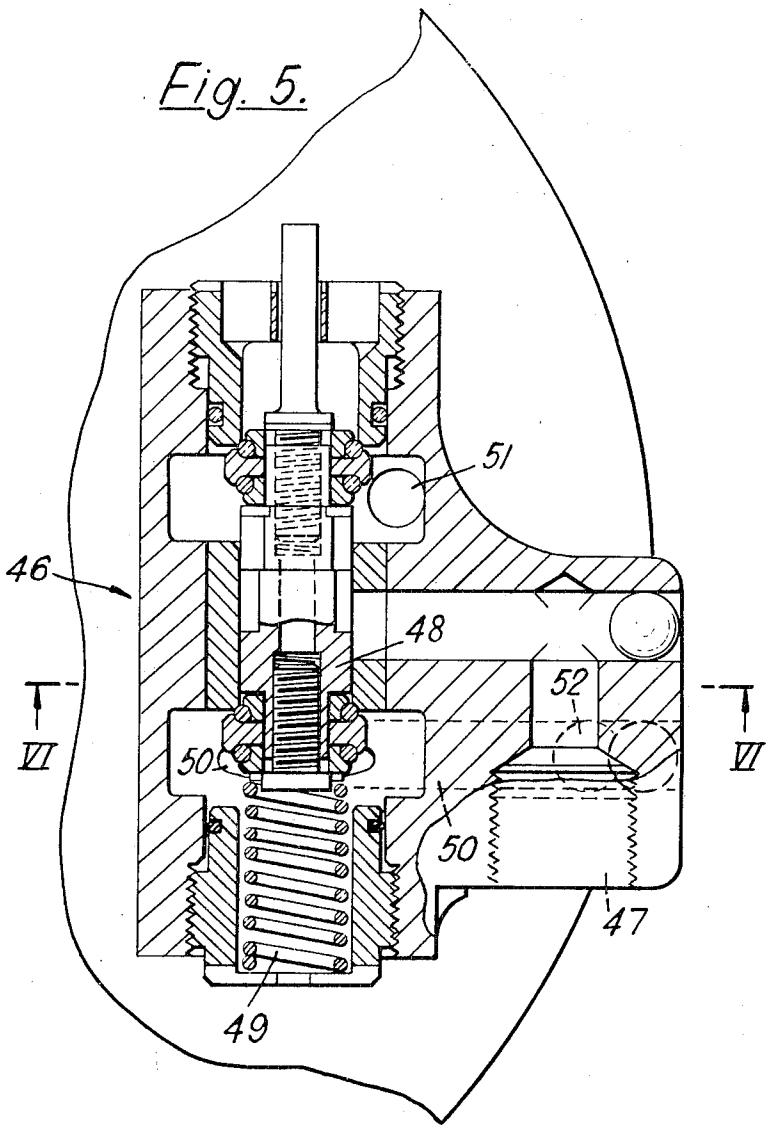
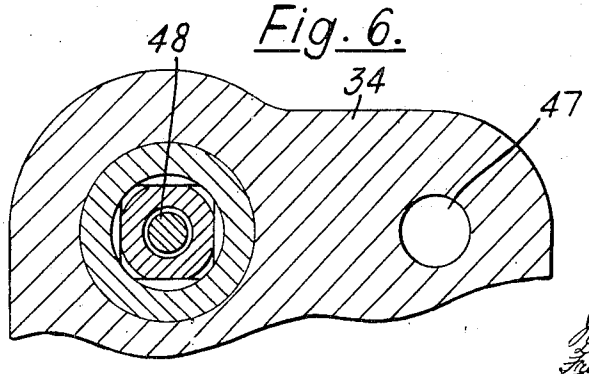


Fig. 6.



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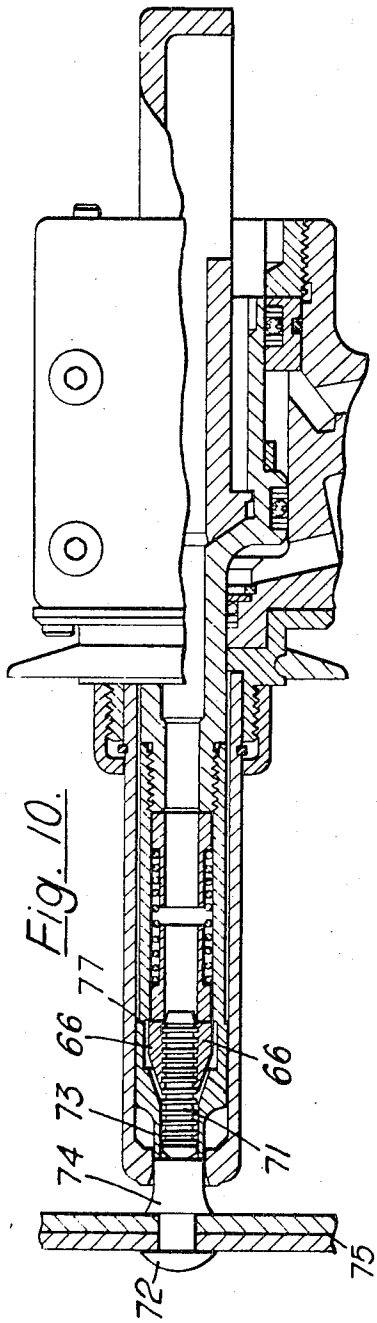

Fig. 10.

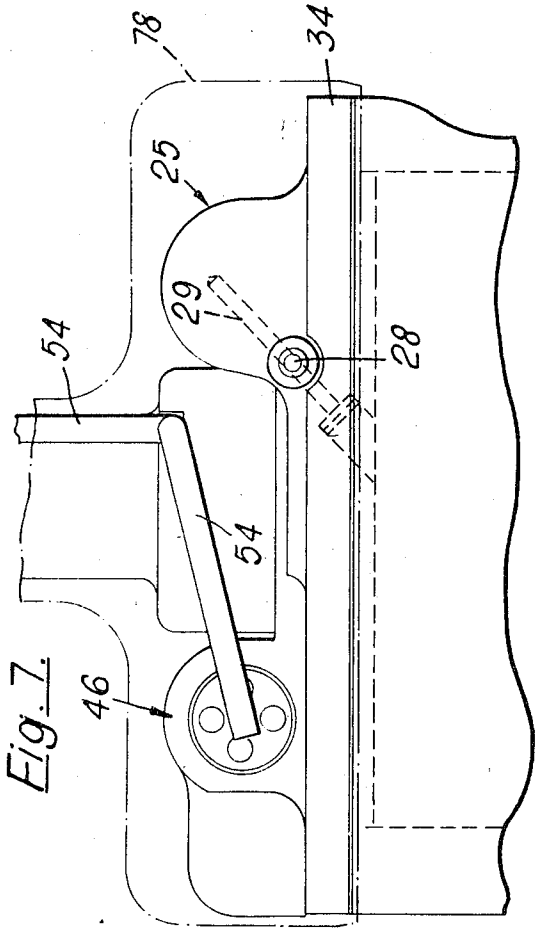

Fig. 7.

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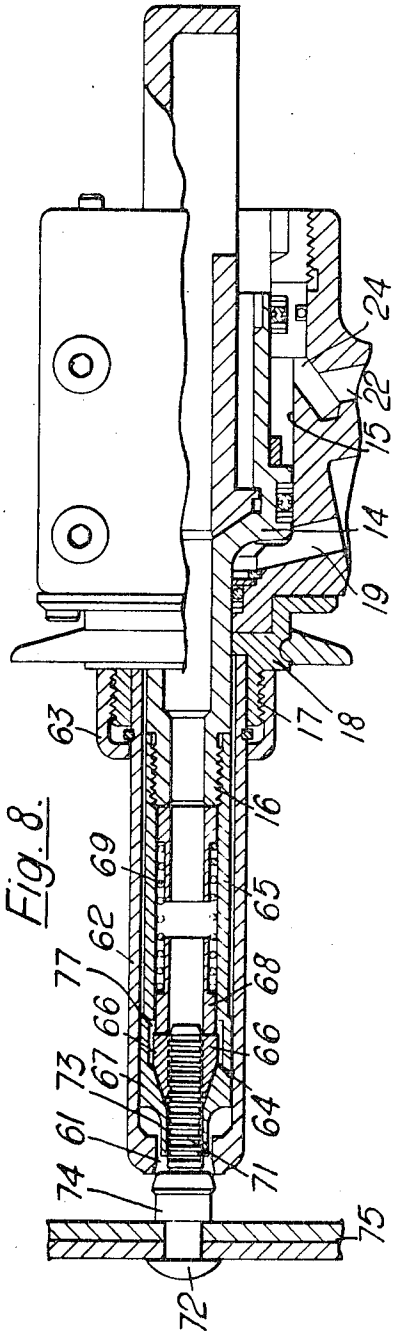

Fig. 8.

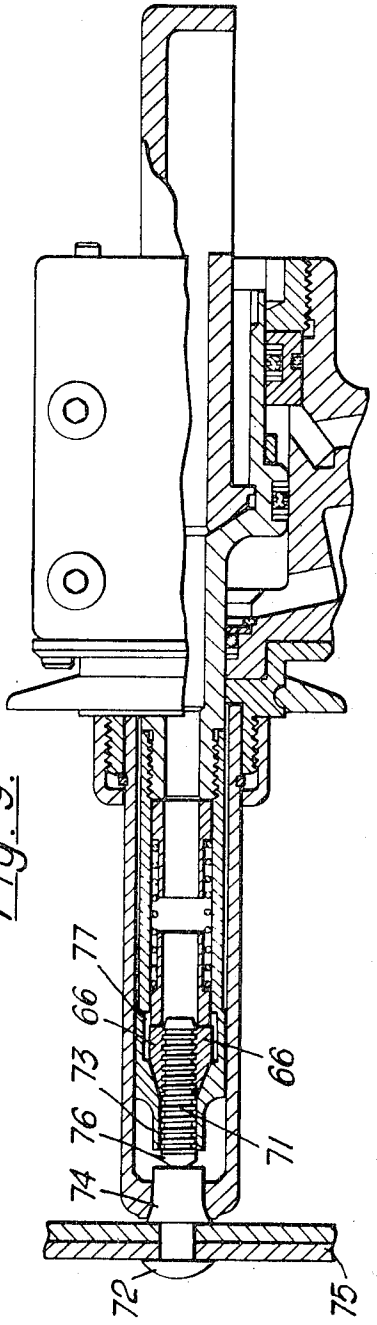

Fig. 9.

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LOCK BOLT PLACING APPARATUS

This invention relates to lock bolt placing apparatus.

By "lock bolt" is meant a fastener of the type comprising a pin with a head at one end and one or more locking grooves on the stem of the pin at a position spaced from the head, and a collar which fits over the stem of the pin and which, in placing of the fastener, is swaged into the aforesaid locking groove or grooves to lock it to the pin.

Such lock bolts are usually placed or set by means of a placing tool which comprises gripping means (e.g., a pair of jaws) which grip a portion of the stem extending beyond the locking groove(s) of the pin, and an annular anvil which abuts the collar. The pin is inserted through aligned apertures in workpieces to be joined together with the head adjacent one face of the workpieces, and the collar is placed over locking grooves on the part of the pin stem projecting from the other side of the workpieces so that the collar is adjacent the other face of the latter. The placing tool is then offered up to the projecting part of the pin stem so that the gripping portion of the stem goes through the aperture in the annular anvil and is gripped by the gripping means, while the anvil receives and rests against the collar. The tool is then operated (e.g., by hydraulic power) to retract the gripping means with respect to the anvil. The head of the pin is pulled hard against one face of the workpieces and the collar is pushed hard against the other face by the anvil. This push on the anvil increases until the collar deforms and the anvil passes over the collar and swages the collar into the locking groove(s) on the pin stem, thus placing the fastener.

Such lock bolts and lock bolt placing apparatus are well known and are well understood by those skilled in the art of industrial fasteners, one example of such being those commercially available under the Registered Trademark "Avdelok."

Considerable force on the anvil is required to deform and swage the collar, and difficulty is sometimes experienced in pulling the anvil off the swaged collar.

The present invention provides lock bolt placing apparatus which comprises:

a hydraulic master piston reciprocable in a master cylinder;

a hydraulic slave piston reciprocable in a slave cylinder;

the slave piston being connectable to stem-gripping means for gripping the stem of a lock bolt, and the slave cylinder being connectable to an anvil for abutting the collar of the lock bolt;

a first hydraulic connection between one side of the master cylinder and one side of the slave cylinder, such that when the master piston is moved, movement of the slave piston is controlled in accordance therewith by flow of hydraulic fluid along the said first hydraulic connection, and such that movement of the master piston in one direction causes flow of hydraulic fluid along the said first connection from the said one side of the master cylinder to the said one side of the slave cylinder and controls the slave piston to move in a direction to retract the gripping means with respect to the anvil;

a second hydraulic connection between the other side of the master cylinder and the other side of the slave cylinder;

and a hydraulic reservoir connected to the said second hydraulic connection;

the relative dimensions of the master and slave pistons being such that the volumes swept, during such movement of the master and slave pistons, by those faces of the master and slave pistons respectively which are in communication with the second hydraulic connection, are different, such that when the master piston is moved in the said one direction (whereby when the tool is in use the anvil is caused to swage the locking collar on to the stem) there is a deficiency of fluid in the second hydraulic connection which is made up from the reservoir, and when the master piston is moved in the opposite direction there is an excess of hydraulic fluid in the second hydraulic connection which is discharged into the reservoir; the reservoir having a pressurized inlet valve, whereby when the master piston is moved in the said opposite direction hydraulic pressure in the slave cylinder on that side of the slave piston communicating with the second hydraulic connection increases to assist in pulling the anvil off the swaged collar.

The stem-gripping means and the anvil are preferably detachable from the remainder of the apparatus to enable lock bolts of different sizes to be placed by the use of appropriate stem-gripping means and anvils.

Preferably the hydraulic reservoir contains resilient material which contracts to accommodate hydraulic fluid when the latter is discharged into the reservoir and which expands to replace hydraulic fluid when the latter is drawn from the reservoir.

In a preferred embodiment of the invention, the resilient material comprises a body formed with a multiplicity of noninterconnecting voids, e.g., cellular rubber.

In a preferred embodiment of the invention, the hydraulic reservoir comprises a tubular pressure body, and the resilient material is tubular in shape and is a close fit within the bore of the tubular pressure body.

Preferably the pressurized inlet valve is accommodated within the reservoir, preferably within the bore of the tubular resilient material.

Preferably the maximum extent of movement of the master piston is limited to a predetermined distance, and

the hydraulic reservoir is capable of accommodating the whole of the volume of hydraulic fluid displaced by the master piston during movement in the aforesaid opposite direction in the event that the salve piston is prevented from moving by jamming or some other cause.

A specific embodiment of the invention, in the form of a hydropneumatic hand-held lock bolt placing gun, will now be described by way of example and with reference to the accompanying drawings, in which:

FIG. 1 is a theoretical diagram of the hydraulic circuit of the gun;

FIG. 2 is a vertical axial longitudinal section through the gun (which does not have an anvil and gripping jaws attached to it) on the line II—II of FIG. 3;

FIG. 3 is a section on the lines III—III in FIGS. 2 and 4;

FIG. 4 is an elevation (with part in section) taken in the direction of the arrow IV of FIG. 2;

FIG. 5 is a section (on an enlarged scale) on the line V—V of FIG. 4;

FIG. 6 is a section on the line VI—VI of FIG. 5;

FIG. 7 is a partial elevation taken in the direction of the arrow VII of FIG. 2;

FIGS. 8, 9, and 10 are sections, corresponding to the uppermost part of FIG. 2, showing the gun with an anvil and gripping jaws in use during the placing of a lock bolt, illustrating successive stages during the placing of the lock bolt.

The lock bolt placing gun of this example is conventional in its general arrangement and basic manner of functioning. It comprises a hydraulic master piston **11** working within a master cylinder **12** formed by a cylindrical bore within a main casting **13**. The gun also has a hydraulic slave or head piston **14** working within a slave cylinder formed by a transverse bore **15** at the head or top of the main casting. The slave piston **14** can be connected to stem-gripping means by means of an externally threaded portion **16** at one end thereof, and the slave cylinder is connectable to an anvil by means of an externally threaded portion **17** of an adapter **18** which is secured to the head casting around one end of the cylinder **15** (see FIGS. **8, 9** and **10**). The threaded portions **16** and **17** are coaxial, and lie at the forward end of the piston **14** and cylinder **15**, i.e., that end which in use of the gun is nearer the workpiece. There is a first hydraulic connection, in the form of a short bore **19**, between the upper end of the master cylinder **12** (above the master piston **11**) and the forward end of the slave cylinder **15** (forward of the slave piston **14**). There is a second hydraulic connection **21** between the rearward end of the slave cylinder **15** (behind the slave piston **14**) and the bottom end of the master cylinder **12** (below the master piston **11**). This second hydraulic connection **21** comprises a main bore **22** within the

main casting and running parallel to the master cylinder **12**, a short transverse bore **23** connecting the lower end of the bore **22** with the lower end of the master cylinder **12**, and a short inclined bore **24** connecting the upper end of the bore **22** with the rear end of the slave cylinder **15**.

Connected to the second hydraulic connection **21** is a hydraulic reservoir **25**, which is cylindrical in configuration. An inclined oblique bore **26** leads from the lowermost end of the bore **22** to the outside of the outlet valve **27** of the reservoir. Another bore **28**, opening out of the bore **26**, runs parallel to the reservoir **25** and connects, via a further cross bore **29**, with the outside of the inlet valve **31** of the reservoir. (It should be noted that in the theoretical hydraulic circuit diagram of FIG. **1**, the bore **26** is shown as meeting the bore **28** at the end thereof nearer the inlet valve **31**, whereas in the gun of this example the physical arrangement of the hydraulic bores is as just described above.) As illustrated in FIG. **3**, the reservoir **25** comprises the cylindrical bore **33** within a casting **34** forming part of the lower portion of the gun. The bore **33** is blind at one end and has the other end closed by a plug **35**. Closely fitting within the bore **33** is a tubular body of neoprene sponge rubber **36**. This sponge rubber is of a closed cellular construction, i.e., the rubber is formed with a multiplicity of small cells (in this example, of means diameter of the order of 20–25 thousandths of an inch) throughout its body, the cells being nonintercommunicating. The body of rubber is highly compressible and resilient. The inside of the tubular body **36** fits closely (when in its undeformed state) around a perforated tube **37**, one end of which is located on the body **38** of the inlet valve **31** and the other end of which is received within the plug **35** at the other end of the reservoir. The inlet valve **31** comprises a small spherical steel ball **39** held against its seat by means of a stem **41** under the urging of a strong helical compression spring **42**, the stem **41** and spring **42** being accommodated within the perforated tube **37** inside the reservoir. In this example, the inlet valve **31** is arranged so that it does not open until a pressure differential of about 1,500 lbs. per sq. inch exists across it. The outlet valve **27** is also a nonreturn valve, but is arranged to open under a relatively low pressure differential. As illustrated in FIG. **3**, the outlet valve **27** is accommodated within the plug **35** sealing one end of the bore **33**.

Movement of the master piston **11** within the master cylinder **12** is achieved by a pneumatic piston and cylinder arrangement integral with the gun. The construction and operation of this pneumatic arrangement is well known in hydropneumatic lock bolt placing tools, and will be described only briefly in the present specification. The hydraulic master piston **11** is formed as the upper end of a piston rod **43**, the lower end of which protrudes through the bottom end of the cylinder **12** and has secured to it a pneumatic piston **44** working within a pneumatic cylinder **45** which forms the bottom part of the gun. The top of the pneumatic cylinder **45** is closed by the casting **34** referred to earlier. On top of this casting there is arranged, on one side of the bottom of the cylinder **12**, the hydraulic reservoir **25**, and on the other side a pneumatic valve **46**, which is illustrated in detail in FIG. **5**. Compressed air is supplied by means of a compressed air line to an inlet **47**. The valve **46** has a valve member **48** which is biassed by means of the helical compression spring **49** into the position shown in FIG. **5**. In this position, compressed air from the inlet **47** is fed by means of a hole **51** communicating with one end of the valve chamber and through the casting **34** directly into the upper part of the pneumatic cylinder **45** above the pneumatic piston **44**, while the lower part of the pneumatic cylinder **45** below the pneumatic piston **44** is vented to atmosphere by means of a conduit **52** (illustrated in FIG. **4**), cross bore **50** communicating with the other end of the valve chamber, and past the valve spring **49**. Thus the piston is normally in its lowermost position (*not* as illustrated in FIG **2**). A trigger **53** is connected by means of a mechanical linkage **54** to the valve member **48** of the valve **46**. When the trigger **53** is compressed, the valve member **48** is moved to interchange the pneumatic connections. Compressed air is then fed to the bottom of pneumatic cylinder **45**, while the top of the pneumatic cylinder is vented to atmosphere. The pneumatic piston **44** has a relatively large area, so that the thrust on the piston rod **43** moves the hydraulic master piston **11** upwards in the cylinder **12**. Hydraulic fluid is forced out of the upper part of the cylinder **12**, through the bore **19** and into the forward part of the slave cylinder **15**, thus driving the piston **14** backwards. The uppermost position of the pistons **11** and **44** is illustrated in FIG. **2**. When the trigger **53** is released, the valve **46** returns to its original position and the piston rod **43** is driven downwards, thus returning the hydraulic slave piston **14** forwardly. Since the hydraulic fluid is substantially incompressible, and the gun is primed with fluid so that the whole of the space in front of the slave piston **14**, above the master piston **11** and in the connection **19**, is full of hydraulic fluid, movement of the salve piston **14** is controlled by movement of the master piston **11** by hydraulic fluid flowing in one direction or the other through the bore **19**.

When the master and slave pistons move, there is also a flow of hydraulic fluid along the second connection **21**. It will be observed from FIG. **2** that the effective area of the top of the master piston **11** is greater than the effective area of its bottom, and that likewise the effective area of the front of the slave piston **14** is greater than the effective area of its rear. In the gun of this example, these areas are as follows:

Area of Master piston top	0.442 sq. in.
Area of master piston bottom	0.245 sq. in.
Area of slave piston front	1.460 sq. in.
Area of slave piston rear	0.777 sq. in.

The relationship between these areas is such that, whenever the master piston **11** is moving upwardly and the slave piston **14** is moving rearwardly, the underneath face of the master piston **11** sweeps out a greater volume than the rear face of the slave piston **14**. Consequently there is a deficiency of hydraulic fluid in the connection **21**, which is made up from the reservoir **25**. Similarly, whenever the master piston **11** is moving downwardly and the slave piston **14** is moving forwardly, there is an excess of hydraulic fluid in the connection **21**, which is discharged into the reservoir **25**. Since the inlet valve **31** of the reservoir cannot open to admit hydraulic fluid to the reservoir until a pressure differential of 1,500 lbs. per sq. inch exists across it, pressure in the second hydraulic connection **21** builds up when the master piston **11** is moving downwardly and the slave piston **14** is moving forwardly.

FIGS. **8**, **9** and **10** illustrate how the gun is used in placing a lock bolt. An annular anvil **61** is provided at the forward end of an anvil tube **62** which is secured to the slave cylinder **15** by means of a collar **63** at the other end of the tube screwed onto the threaded position **17** of the adaptor **18**. Inside the tube **62** a stem-gripping mechanism **64** is provided at the forward end of a draw tube **65** screwed onto the threaded portion **16** at the front of the slave piston **14**. The stem-gripping mechanism **64** is of a type well known in lock bolt placing tools, comprising a set of three jaws **66** urged into a tapering collet **67** inside the front end of the tube **65** by means of a backup tube **68** and a helical compression spring **69**. The inner faces of the jaws are grooved to engage and grip the grooved stem **71** of a lock bolt **72**. From the forward end of the draw tube **65** projects a pushoff sleeve **73** which passes through the annular anvil **61** around the stem of the lock bolt in order to contact the rear face of the lock bolt collar **74**. FIG. **8** illustrates the start of a placing cycle. The lock bolt **72** has been inserted through an aperture in sheets **75** to be secured together and the collar **74** placed over the projecting stem. The lock bolt placing gun, with the slave piston and jaw mechanism in its forward position has been applied to the lock bolt, so that the annular anvil **61** is in contact with the rear of the lock bolt collar **74**, with the grooved stem **71** of the lock bolt engaged between the jaws **66** and firmly gripped by them. This is the position illustrated in FIG. **8**. The operator then depresses the gun trigger **53**, so

that the slave piston **14** is retracted into the cylinder **15**. Since the lock bolt stem is securely gripped within the jaws **66**, the anvil **61** is forced over the collar **74**, deforming it and swaging it into locking grooves (not seen in the drawings) on the lock bolt stem underneath the collar. This movement continues until the build up of deformed material of the collar prevents the anvil **61** moving further along the deformed lock bolt. Since the pull on the draw tube **65** is still increasing, the lock bolt stem then breaks, under the increasing tension on it, at a breaker groove which is situated between the locking grooves and the jaw-engaging grooves. FIG. **9** illustrates the position when the breaker groove has just broken, one side of the deformed breaker groove being just visible at the outside end of the swaged collar, and indicated by the reference numeral **76**. The operator will normally release the trigger **53** as soon as the bolt stem breaks, although it is usually found that the slave piston **14** has had time to move further rearwardly on the sudden release of resistance to its movement on the breaking of the stem. During the whole of the rearward movement of the slave piston, the deficiency of hydraulic fluid in the connection **21** previously mentioned has been made good from the hydraulic fluid stored within the reservoir **25**, fluid being drawn out through the nonreturn outlet valve **27**.

When the trigger **53** is released, movement of the master piston **11** is reversed, so that there is a reduction in the hydraulic pressure in front of the slave piston **14** and an increase in hydraulic pressure behind it. As soon as downward movement of the master piston **11** and forward movement of the slave piston **14** starts, there is produced an excess of hydraulic fluid in the connection **21**, which can be discharged only into the reservoir **25** through the pressurized inlet valve **31**. Consequently the hydraulic pressure in the connection **21** and behind the slave piston **14** immediately builds up to, and remains at sufficient pressure to open the inlet valve **31**. As the slave piston **14** moves forwards, so does the jaw mechanism **54** carrying the broken bolt stem with it. The forward end of the broken portion of the bolt stem then contacts the broken rear end of the placed lock bolt. As the draw tube **65** continues to move forwards, the broken portion of the stem pushes the jaws **66** backwards out of their tapered collet **67**, although the jaws continue to grip the broken stem since they are firmly engaged in the grooves. Rearward movement of the jaws is limited by a shoulder **77** within the draw tube **65**. As the draw tube **65** continues to move forwards with respect to the anvil tube **62**, the forward end of the ejector sleeve **73** then contacts the rear of the lock bolt collar which is swaged onto the lock bolt. The considerable pressure differential which still exists across the two sides of the slave piston **14** provides sufficient forward thrust on the ejector sleeve with respect to the anvil to pull the anvil off the swaged collar.

This removal of the anvil from the swaged collar has previously presented difficulties, since a considerable force is necessary to remove the anvil. The pull on the anvil must be directly axially backwards, without any twisting or transverse force on the anvil with respect to the collar, which would tend to distort the anvil. In the gun of the foregoing example, the thrust on the ejector sleeve pulls the anvil **61** off the swaged collar, thus disengaging the gun from the placed lock bolt, and returning the various parts of the gun to their initial position.

During the whole of the forward movement of the slave piston **14**, the excess hydraulic fluid in the connection **21** has been accommodated within the hydraulic reservoir **25**, by the compression and reduction in volume of the cellular foam rubber cylinder **36**. When, on the next placing action of the gun, hydraulic fluid is withdrawn from the reservoir **25**, the rubber cylinder **36** expands again to fill up the space occupied by the withdrawal of the fluid, the resilience of the rubber assisting in ejecting the fluid through the nonreturn outlet valve **27**.

It is sometimes found that the slave piston may be prevented from returning forwardly, for example due to jamming of the jaws. The reservoir of the gun of the foregoing example is capable of accommodating, in addition to the excess hydraulic fluid normally produced on the return stroke, all of the further excess which would not be accommodated due to the nonreturn of the slave piston during the full return (i.e., downwards) stroke of the master piston. This is a considerable advantage from the safety point of view, since the high pressures which could otherwise be produced have been known to burst open a lock bolt placing gun. The capability of the reservoir to absorb this extra excess fluid is due to the resilient filling provided by the sponge rubber cylinder.

The hydraulic lock bolt placing gun of this example is also advantageous in the way mentioned above, namely that it provides automatic pushoff of the anvil from the swaged lock bolt collar. Furthermore the particular arrangement of the various parts of the gun in this example, with the pneumatic valve **46** and hydraulic reservoir **25** positioned on the top of the pneumatic cylinder **45**, provides a neat and compact gun. The gun is provided with a synthetic plastics cover **77** (illustrated in chain lines in FIGS. **2** and **7**), the upper part of which provides a convenient handgrip, and the lower part of which encloses the pneumatic valve and the reservoir and is perforated to allow the passage of air. The accommodation of the pressurized inlet valve **31** within the hydraulic reservoir, and particularly within the tubular rubber body **36**, also leads to compactness of construction.

The invention is not restricted to the details of the foregoing example. For instance, instead of the single straight anvil tube and draw tube illustrated in FIGS. **8**, **9** and **10**, an offset nosepiece may be used.

The lock bolt placing tool may be supplied to a user substantially in the form illustrated in FIGS. **1** to **7**, i.e., without the anvil, jaws and associated mechanism, for use with such mechanism which the user already has. Alternatively, the tool may be supplied complete with such mechanism.

We claim:

1. Lock bolt placing apparatus incorporating a closed hydraulic circuit and comprising:

a double-acting hydraulic master piston reciprocable in a master cylinder;

a double-acting hydraulic slave piston reciprocable in a slave cylinder;

the slave piston being connectable to stem-gripping means for gripping the stem of a lock bolt, and the slave cylinder being connectable to an anvil for abutting the collar of the lock bolt;

a first hydraulic connection between one side of the master cylinder and one side of the slave cylinder, and a second hydraulic connection between the other side of the master cylinder and the other side of the slave cylinder, said first and second hydraulic connections remaining uncorrected with each other throughout their operation and such that when the master piston is moved in either direction movement of the slave piston is controlled in accordance therewith by flow of hydraulic fluid along the said first hydraulic connection, and such that movement of the master piston in one direction causes flow of hydraulic fluid along the said first connection from the said one side of the master cylinder to the said one side of the slave cylinder and controls the slave piston to move in a direction to retract the gripping means with respect to the anvil and such that movement of the master piston in the opposite direction over substantially the whole of its stroke causes flow of hydraulic fluid along the said second hydraulic connection from the said other side of the master cylinder to the said other side of the slave cylinder and causes the slave piston to return,

a hydraulic reservoir connected to the said second hydraulic connection by means of pressurized inlet valve means and pressurized outlet valve means;

the relative dimensions of the master and slave pistons being such that the volumes swept, during such movement of the master and slave pistons, by those faces of the master and slave pistons respectively which are in communication with the second hydraulic connection, are different,

such that when the master piston is moved in the said one direction whereby when the tool is in use the anvil is caused to swage the locking collar on to the stem there is a deficiency of fluid in the second hydraulic connection which is made up from the reservoir, and when the master piston is moved in the opposite direction there is an excess of hydraulic fluid in the second hydraulic connection which is discharged into the reservoir;

said pressurized inlet valve means requiring such pressure to open it that when the master piston is moved in the said opposite direction hydraulic pressure in the slave cylinder on that side of the slave piston communicating with the second hydraulic connection increases to assist in pulling the anvil off the swaged collar.

2. Lock bolt placing apparatus as claimed in claim 1, in which the hydraulic reservoir contains resilient material which contracts to accommodate hydraulic fluid when the latter is discharged into the reservoir and which expands to replace hydraulic fluid when the latter is drawn from the reservoir.

3. Lock bolt placing apparatus as claimed in claim 2, in which the resilient material comprises a body formed with a multiplicity of noninterconnecting voids.

4. Lock bolt placing apparatus as claimed in claim 3, in which the resilient material is cellular rubber.

5. Lock bolt placing apparatus as claimed in claim 2, in which the hydraulic reservoir comprises a tubular pressure body, and the resilient material is tubular in shape and is a close fit within the bore of the tubular pressure body.

6. Lock bolt placing apparatus as claimed in claim 1, in which the pressurized inlet valve is accommodated within the reservoir.

7. Lock bolt placing apparatus as claimed in claim 5, in which the pressurized inlet valve is accommodated within the bore of the tubular resilient material.

8. Lock bolt placing apparatus as claimed in claim 1, in which the maximum extent of movement of the master piston is limited to a predetermined distance, and in which the hydraulic reservoir is capable of accommodating the whole of the volume of hydraulic fluid displaced by the master piston during movement in the aforesaid opposite direction in the event that the slave piston is prevented from moving by jamming or some other cause.

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