

April 27, 1965

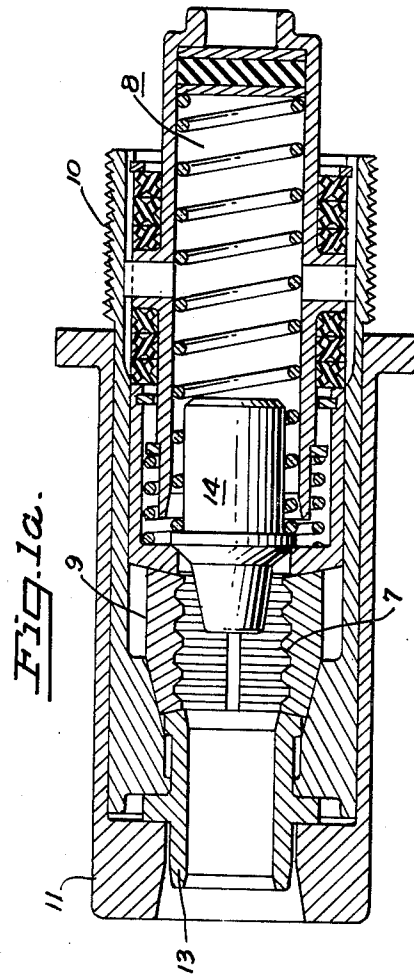
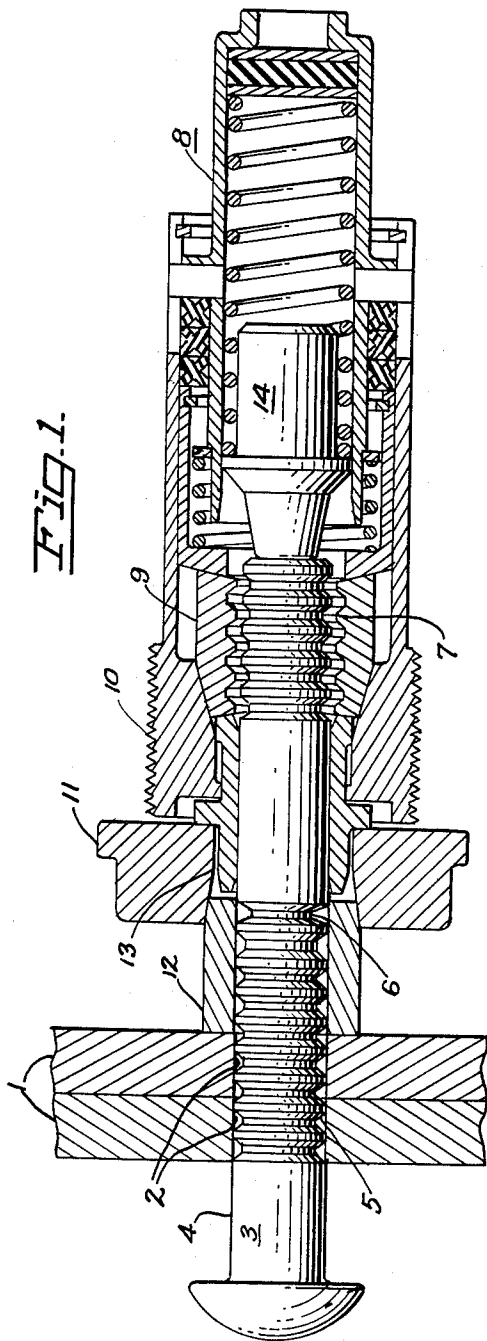
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3,180,017

LOCK BOLT GUN

Filed Feb. 12, 1962

5 Sheets-Sheet 1



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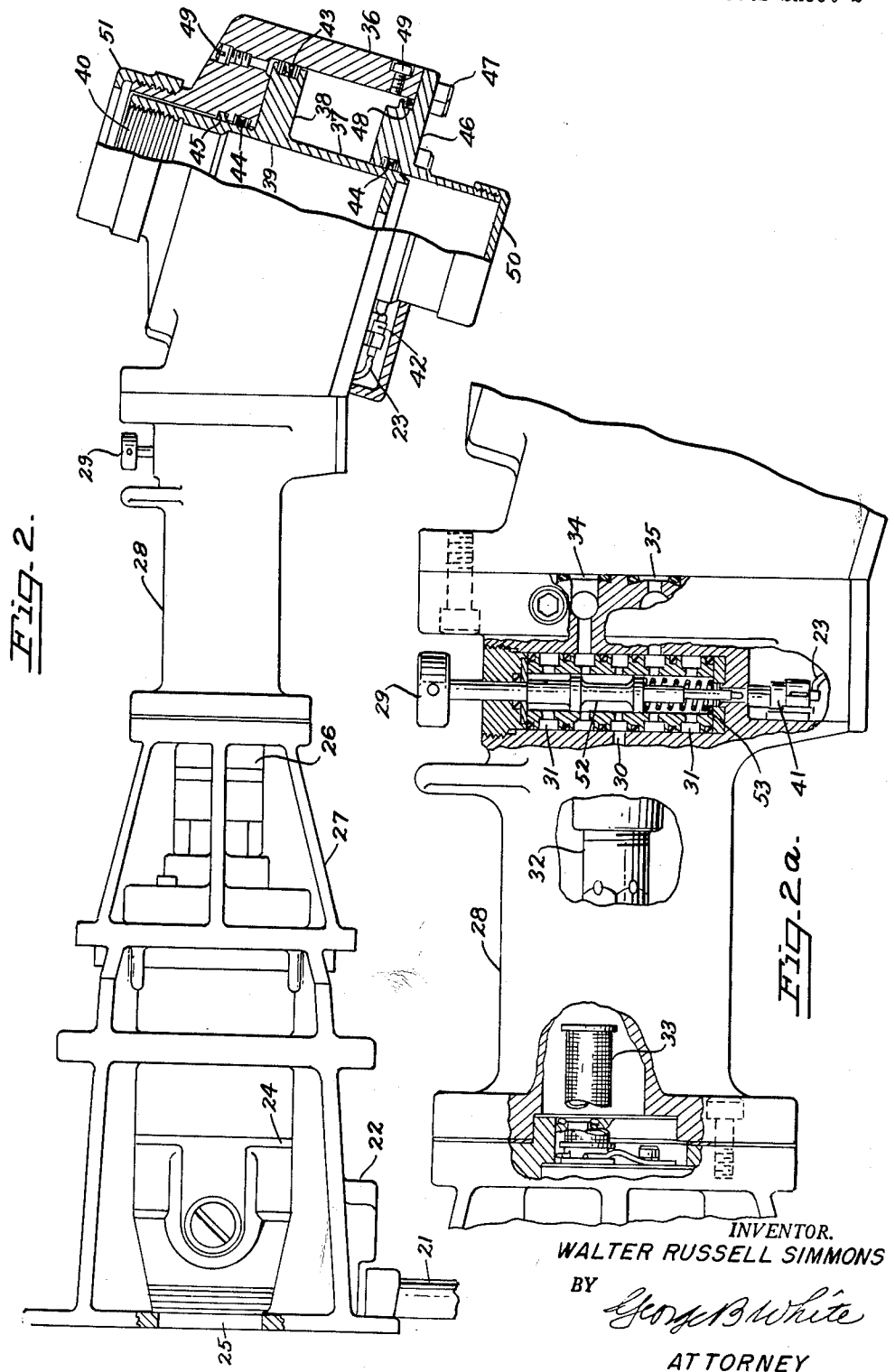
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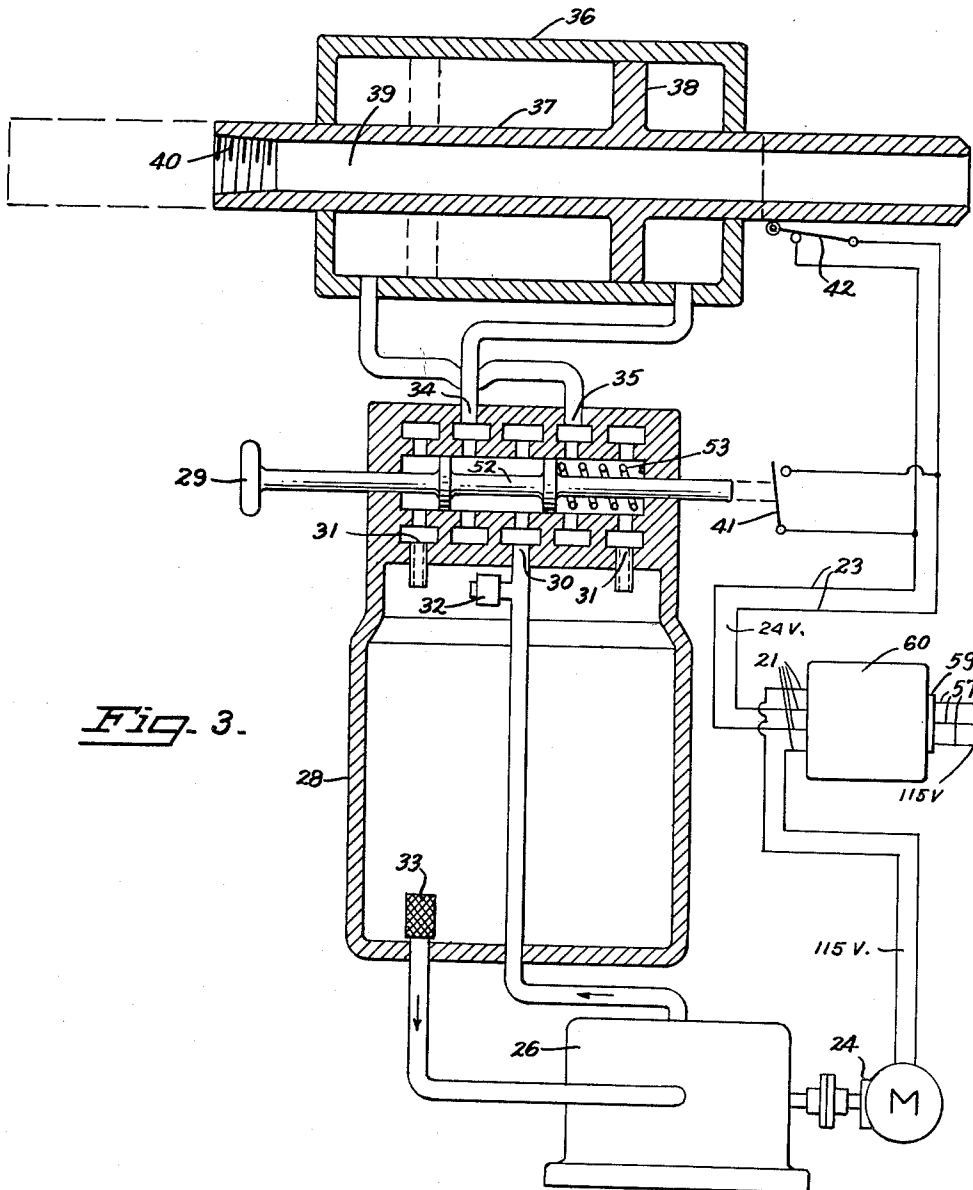
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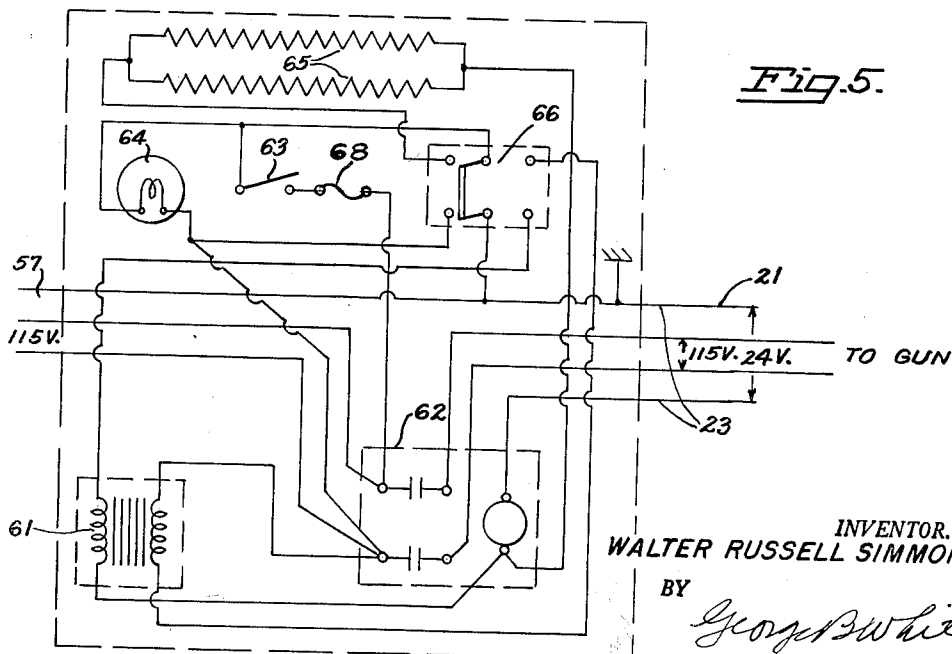
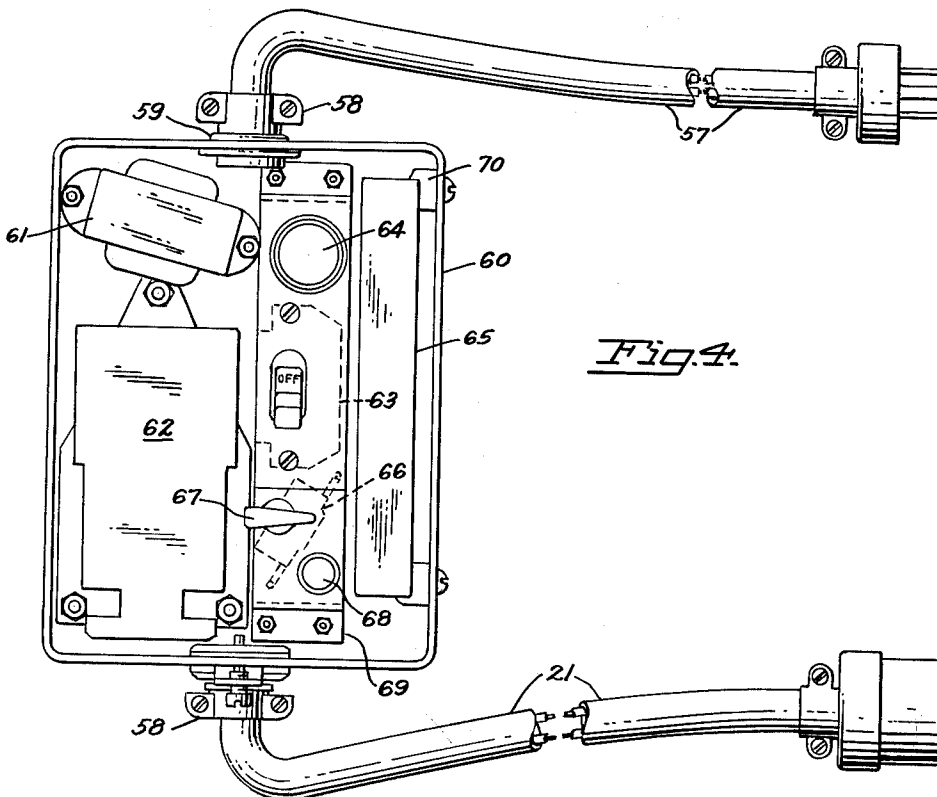
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5 Sheets-Sheet 4



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Fig. 6.

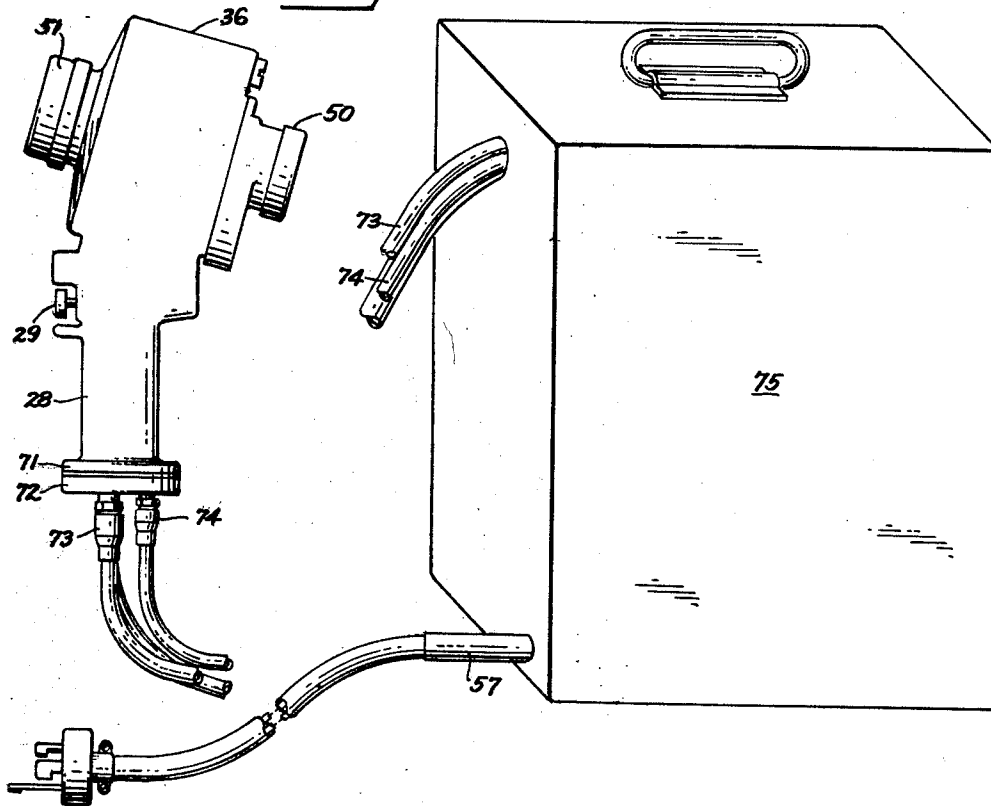
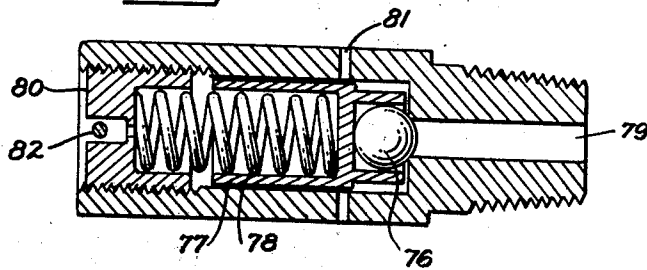


Fig. 7.



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3,180,017

LOCK BOLT GUN

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3 Claims. (Cl. 29—252)

This invention relates to an apparatus for fastening together plates, or similar objects, by means of bolts or rivets. It involves the method in which the fastening is accomplished from one side only of the articles being fastened and makes use of a lock bolt equipped with grooves into which a suitable lock nut is swaged after the articles have been pulled tightly together, after which the surplus portion of the rivet or bolt is broken off under tension.

In this method of fastening it is necessary to utilize relatively high pressures and forces which must be applied in a short interval of time to effect a proper and economical joint. This necessitates the use of heavy fastening apparatus and rather bulky and cumbersome auxiliary machinery. Previous devices have used elaborate hydraulic and combinations of hydraulic and pneumatic equipment to supply the pressures required. These have likewise entailed the use of complicated systems of control and operation involving difficulty in operation and high maintenance. The large size and heavy weight of existing devices for performing this operation have militated heavily against the use of this method of fastening heretofore.

It is therefore an object of this invention to provide an apparatus for fastening of the class described which would be simple and more efficient than those now in use.

It is another object of this invention to provide an apparatus of the class described which would be smaller and lighter and permit more rapid operation than those now in use.

It is yet another object of this invention to provide an apparatus for fastening articles from one side only which would be extremely flexible in its applications.

It is a more specific object of this invention to provide an apparatus or gun for fastening together articles from one side only which would be exceedingly simple in operation and yet entirely reliable.

I am aware that some changes may be made in the general arrangements and combinations of the several devices and parts, as well as in the details of the construction thereof without departing from the scope of the present invention as set forth in the following specification, and as defined in the following claims; hence I do not limit my invention to the exact arrangements and combinations of the said device and parts as described in the said specification, nor do I confine myself to the exact details of the construction of the said parts as illustrated in the accompanying drawings.

With the foregoing and other objects in view, which will be made manifest in the following detailed description, reference is had to the accompanying drawings for the illustrated embodiment of the invention, wherein:

FIG. 1 is a cross-section showing a typical type of fastener and fastening device which may be used with this invention.

FIG. 1a is another type of fastening device which is suitable for use with this invention.

FIG. 2 is an elevation, partly cut away, showing a preferred embodiment of the lock bolt gun of this invention.

FIG. 2a is an enlarged elevation, partly cut away, showing the trigger and associated parts of this invention.

FIG. 3 is a diagrammatical layout, partly in section, illustrating the operation of this invention.

FIG. 4 is a cut away view of the electrical control box of this invention.

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FIG. 5 is a preferred wiring diagram for the electrical control for this invention.

FIG. 6 is an alternate embodiment of this invention in which the pulling head cylinder, handle, trigger and valve, comprise a separate unit from the motor and pump.

FIG. 7 is a cut away view of relief valve 32 of FIG. 2.

The method of fastening for which the apparatus is used may best be understood by reference now to FIG. 1. The articles to be joined are shown as two plates 1 with aligned holes 2. A rivet, bolt, or pin 3, of the special construction shown and having a preformed head is inserted in aligned holes 2 as shown. The bolt is equipped with a hole-filling section 4, a grooved section 5, and a break groove 6. At the other extremity of the bolt there is another grooved section which is known as the pulling section 7. A lock nut or collar 12 which is later to be swaged into grooves 5 is slipped over the bolt and up against the plates 1. A pulling device or pulling head assembly 8 is used to adapt the lock bolt and lock nut to the operation of the apparatus of this invention. This pulling head assembly 8 comprises a pair of pulling or gripping jaws 9 which engage the pulling section 7. The pulling collar 10 screws into head piston 37 of FIG. 2, as explained below. Positioned on one end of the pulling head assembly is anvil 11 which bears against lock nut 12. The ejector 13 serves to kick the gun loose from the bolt after completion of the fastening operation. A pin ejector 14 may be employed to eject the fractured end of the bolt from the pulling assembly if desired.

The method of fastening will now be evident to those skilled in the art and is briefly as follows. Initial movement of the pulling collar 10 FIG. 1 to the right by the action of pulling piston 37 of FIG. 2 as hereinafter set forth serves to clamp gripping jaws 9 upon grooves of pulling section 7. Further movement of collar 10 draws bolt 3 through holes 2, which movement is backed up by the reaction of lock nut 12, backed up by anvil 11, which is held by head nut 51 of the gun of FIG. 2. As the pulling action progresses, hole-filling section 4 fills the holes 2 and the action of anvil 11 swages the lock nut 12 into grooves 5. Still further pulling action fractures bolt 3 in tension at break groove 6. Reverse action of pulling collar 10 then kicks the gun loose from the joint and ejects the fractured portion of the rivet.

In FIG. 1a in which like parts bear like numbers, the pulling collar 10 is shown on the opposite end of pulling head assembly 8. This embodiment is advantageous in certain arrangements, as for example where a longer protrusion from the gun is required for side clearance. The operation of the device however, is identical in other respects.

It will now be obvious to those skilled in the art that the forces required to be exerted on lock bolt 3 and lock nut 12 in order to effect a sufficient joinder of plates 1 will be quite substantial. In fact, it has been discovered that in order to satisfactorily fasten a bolt having a diameter of $\frac{3}{4}$ inch a force of 35,000 pounds is required to be exerted in collar 10. It will be further evident that this force must be built up from zero to 35,000 pounds in as short a time as possible in order to result in economical operation. It is likewise evident that this force must be released and the action of collar 10 reversed promptly so that the entire cycle would be completed as rapidly as possible. It has been discovered that by the use of the apparatus of this invention these results may be accomplished in a manner heretofore not found possible. It has likewise been discovered that these results may be accomplished with an apparatus that is exceedingly simple, flexible, and light, as well as of small size, a detailed description of which follows.

Reference should now be had to FIG. 2 which repre-

sents a preferred embodiment of this invention and to FIG. 3 which shows diagrammatically its method of operation, like parts on both figures being represented by like numbers. A four conductor electrical cable 21 is connected to terminal box 22 from which control cable 23 leads to micro-switches 41 and 42, the function of which is more fully described below, and two conductors furnish power supply to motor 24. Motor base 25 supports motor 24 which is direct-connected to pump 26 which in turn is supported by pump frame 27. The handle 28 has a hollow interior which functions also as a reservoir for the hydraulic fluid used to operate the gun. Trigger 29 is part of a control valve of the piston type, the operation of which may be better seen in FIG. 3. Pressure inlet port 30 connects with discharge of pump 26, while outlet ports 31 connect with reservoir located inside of handle 28. A relief valve 32 to protect against excess pressure is located on the discharge of pump 26. This valve is unique as will be described below. Relief valve 32 discharges into the reservoir in pump handle 28. A strainer 33 is positioned on the suction intake of pump 26 which connects with the bottom of the reservoir. Upper ports 34 and 35 connect to opposite ends of a hydraulic cylinder 36, which is also known as a pulling head cylinder, as shown. A pulling head piston 37 is positioned within cylinder 36. Piston 37 comprises an annular or pressure section 38 and a hollow central pulling section 39. The pulling head piston is adapted to receive a pulling head similar to that described in FIG. 1 above by engaging its threaded section 40 with threaded section 10 of the pulling head. Micro-switch 41 is so located that it would be closed upon depressing of trigger valve 29. Micro-switch 42 is so located that it would be closed by piston 37 soon after the latter starts its pulling stroke. Micro-switches 41 and 42 are connected in parallel and comprise an important part of the control circuit more fully described below.

Other features of the construction of the embodiment shown in FIG. 2 are as follows. Sealing rings 43 which may be of neoprene, or similar material, are positioned on the pressure part of the cylinder 36, while outside packing rings 44 are positioned on the outside of the pulling part of the piston 39. The latter may also be of neoprene. A felt washer 45 is likewise positioned on the outside of the piston as shown. Cylinder cover or head 46 is secured to cylinder 36 by means of socket head cap screws 47. O-ring 48 completes the seal. Filling port and screws 49 are located as shown. A cap 50 serves to protect the open end of the pulling head piston 37, while head nut 51 secures the anvil 11 of FIG. 1 to opposite end. Inner slide 52 of trigger valve 29 serves to provide communication between the ports, as explained below, while spring 53 tends to return the trigger valve to its normal position at the start of the cycle.

Reference should now be had to FIGS. 4 and 5 which show the assembly of the electrical components of the control system of the invention and their wiring diagram, respectively. A three conductor cable 57 provides a 115 volt A.C. or D.C. supply from an outside source, while four conductor cable 21 provides the feed and control to the gun mentioned above. These are secured by cable grips and lock nuts 58. Knockout opening 59 is provided in control box housing 60. Transformer 61 provides a 24 volt supply for the control circuit. Contactor 62 which is energized from the control circuit makes and breaks the 115 volt supply in order to start and stop the motor. Main disconnect switch 63 is of the single pole, single throw type and is connected to the power source through pilot lamp 64 which indicates that electrical power is on the gun. Where D.C. is used as a source of power supply the 24 volt source for the control circuit is provided through resistor 65 which may be of 100 watt, 50 ohm capacity. A double pole, double throw switch 66 having control knob 67 may be used

in switching from A.C. to D.C. and vice versa. The fuse 68 completes the electrical circuit in the control box. The components are mounted in an assembly on plate 69 as shown. Insulator 70 protects the resistor from the housing.

From the wiring diagram of FIG. 5 it will now be seen how a 115 volt two wire and ground A.C. or D.C. supply is converted to a two wire 115 volt supply to the motor and a 24 volt one wire and ground supply to the micro-switches. The principal operating components of FIG. 4 bear like numbers on the wiring diagram FIG. 5.

The power supply is indicated at 57, and the various lines may be given color designations to facilitate tracing of the circuit. Thus the two power lines of the feed are run directly to the contactor 62, while the ground line runs through to the motor directly and comprises a grounded leg of the entire electrical circuit. The pilot light 64 is connected across the main power supply and in series with single pole, single throw switch 63 and fuse 68. One leg of the main power supply and a ground are connected to double pole, double throw switch 66 which may be used to energize transformer 61 when A.C. is used or resistor 65 when D.C. is employed. Consequently, either the secondary of transformer 61 or the output of resistor 65 will supply a two wire 24 volt circuit to the gun, as is seen at 21. This circuit is completed through the micro-switches 41 and 42, as above described and in turn energizes the solenoid of contactor 62 to throw the power on and off the motor in line with the operation as described below.

Operation

The operation of the invention with special reference to FIGS. 1, 2, and 3 will now be understood to be as follows. Pulling head 8 of FIG. 1 is first inserted in head piston 37 of FIG. 2, as previously described. Lock bolt 3 is inserted in the holes 2 of plate 1 and lock nut 12 placed in position for start of the operation. The gun is then gripped by handle 28 and placed in contact with lock bolt 3 and lock nut 12. Trigger valve 29 is depressed against spring 53, which closes micro-switch 41. This energizes the contactor on the main power supply starting motor 24 and pump 26, thus supplying a fluid under hydraulic pressure to port 30 of the trigger valve. This depressed position of the trigger valve permits the fluid under pressure to flow from port 30 to port 35 and into cylinder 36. At the start of the cycle, piston 37 is in a position shown approximately by the dotted lines of FIG. 3. The piston will move under considerable pressure to the right approaching the position shown in solid lines of FIG. 3 and perform the pulling and swaging operation on the lock bolt and nut described above. After the piston moves approximately 1/8" it closes micro-switch 42 which being in parallel with micro-switch 41 has the effect of continuing operation of the motor and pump, even though trigger valve 29 is released. When the latter occurs, port 30 communicates with port 34, thus applying pressure to the opposite side of the piston, while port 35 communicates with port 31, thus permitting return of the fluid in cylinder 36 back to the reservoir in handle 28. If the trigger valve 29 should not be released by the operator before or immediately after piston 37 reaches its extreme right position pump 26 will be pumping against a non-moving piston or non-expanding system and the pressure will tend to increase rapidly. Under such conditions the ball valve 76 of FIG. 7 is moved away from its seat and against cage 77 and spring 78 which has been preset to yield under a predetermined pressure in body opening 79. Once the ball is off the seat, fluid from opening 79 exerts pressure not only on the ball but also on the much larger end area of cage 77 thus continuing its motion until its opposite end seats against adjustment nut 80 and opens fluid exit ports 81 which communicate directly into the reservoir inside handle 28. It

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will be apparent that cage 77 will be held in its open position with exit ports 81 open until the fluid pressure decreases to a much lower value than that required to lift the ball 76 from the seat initially. For example, if the cross-sectional area of the cage 77 is ten times the cross-sectional area of the ball seat the fluid pressure required to hold the valve open could be 300 p.s.i. as compared to 3,000 p.s.i. required to open the valve initially. This is a most important feature in preventing excessive heating in this type of pumping system. As soon as the trigger valve 29 is released, the fluid from pump 26 is directed against the opposite end of piston 37 which will start to move freely back to its initial position against practically no resistance. Pumping pressure is almost immediately lowered and ball 76 of relief valve FIG. 7 seats firmly. When the piston approaches its initial position micro-switch 42 opens, de-energizing the contactor coil and the motor is shut off. Locking pin 82 serves to hold adjustment nut 80 in any desired predetermined position as explained above.

From the above description of the construction and operation of this invention it will now be evident that this invention makes possible the application of high pulling forces and an efficient cycle involving rapid riveting and return in a simple and efficient manner and that the apparatus employed is very simple and extremely easy to operate, particularly by virtue of being much lighter and more compact than any others now in use. In addition to the rapid return features of the pulling piston, it will also be evident that this invention provides an automatic cushion or dash-pot effect on the piston by utilizing the interlocking electrical and hydraulic circuits in a manner to prevent excessive hammer, shock, excessive heating, and similar effects which would seriously hamper the operation of other types of equipment, without employing elaborate preventive devices.

Where it is desirable to physically separate the gun proper comprising the pulling cylinder and handle from the rest of the apparatus comprising the motor and hydraulic pump, the embodiment of FIG. 6 may be used. In this figure there is seen an outline of the gun proper showing handle 28, trigger valve 29, cylinder 36, head nut 51, and cap 50. The bottom flange 71 of handle 28 connects with companion flange 72. The latter is arranged to receive hydraulic fluid lines 73, one of which is the suction of the pump connecting with the strainer 33 of FIG. 2 and the other the discharge of the pump connecting with port 30 of FIG. 2 and FIG. 3. Control cable 74 carries the 24 volt circuit to the microswitches as in other embodiments of the invention. The motor pump and control box are housed in portable container 75 to which a 115 volt power supply is introduced through three conductor cable 57.

While I have shown an electric motor and controls for the operation of the hydraulic system of my invention, I may substitute air for electricity as a source of power without departing from the spirit of the invention. That this may be accomplished very readily is further apparent by reference again to FIG. 2 and FIG. 3. I may substitute an air motor for the electric motor 24 and a pilot operated air valve for the control box 60. Micro-switches 41 and 42 are then replaced with pilot valves connected by suitable air lines to the main air supply valve. These pilot valves could be of bleed type, thereby permitting the air to be bled from the pilot circuit by the respective positions of trigger control valve 29 and pulling head piston 37 which in turn would open the main air supply valve supplying air motor 24. The operation of my invention using an air supply would be in every other respect the same as when using alternating or direct current electrical supply as described above.

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I claim:

1. A bolt fastening apparatus comprising:
a bolt fastening mechanism in combination with means for imparting reciprocating motion to said mechanism comprising:

a hydraulic circuit comprising:

a motor driven pump;

a fluid reservoir;

a piston reciprocally mounted in a cylinder and operatively engaging said bolt fastening mechanism;

manually operated means for starting said motor and simultaneously admitting fluid from said pump to the first end of said cylinder while admitting fluid from the second end of said cylinder to said reservoir;

means for admitting fluid from said pump to the second end of said cylinder while relieving fluid from said first end;

means for admitting fluid from said first end to said reservoir while continuously operating said motor driven pump;

independent means operatively connected to said piston for cutting power off said motor when said piston reaches a predetermined position in said cylinder.

2. A bolt fastening apparatus comprising:

a bolt fastening mechanism in combination with means for imparting reciprocating motion to said mechanism comprising:

a hydraulic circuit comprising:

an electric motor driven pump;

a fluid reservoir;

a piston reciprocally mounted in a cylinder and engaging said bolt fastening mechanism;

a manually operated slide valve arranged for alternately connecting each end of said cylinder to the discharge of said pump while simultaneously connecting the opposite end to a return to said reservoir thereby effecting a forward stroke and a return stroke and further arranged to connect said opposite end of said cylinder to the discharge of said pump before the end of said forward stroke;

a first micro-switch responsive to the position of said slide valve;

a second micro-switch responsive to the position of said piston;

said micro-switches being connected in parallel and controlling the power supply to said electric motor;

whereby said first micro-switch starts said motor when said valve is placed in position to start said forward stroke;

and whereby said second micro-switch causes said motor to continue running after said piston reaches a predetermined position on said forward stroke and after said valve is placed in position to start said return stroke, and stops said motor after said piston has returned to said predetermined position on said return stroke.

3. In a bolt fastening apparatus comprising:

a bolt fastening mechanism;

a reciprocating bolt pulling piston operatively connected to said bolt fastening mechanism;

a hydraulic circuit connected to both sides of said piston;

an electrically driven pump supplying hydraulic fluid under pressure to said circuit;

an electric circuit supplying power to said pump;

the improvement comprising:

a manually operated spring loaded slide valve controlling the flow of said hydraulic fluid to and

from said piston by alternately admitting said fluid to one side of said piston while relieving said fluid from the opposite side;

a first micro-switch positioned at one end of said slide valve to close said electric circuit when said slide valve is positioned to admit fluid to a first side of said piston thereby to initiate a pulling cycle;

a second micro-switch in operating relation with said piston to maintain said electrical circuit closed until said piston completes said cycle;

whereby the reciprocating action of said piston may be controlled, by admitting the flow of hydraulic fluid to both sides of said piston.

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