PUNCH RIVETING MACHINE
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ABSTRACT OF THE DISCLOSURE

An automatic punch riveting machine of the type having a single drive plunger and alternatively selective tools to be engaged by the plunger for performing the punching and riveting operation in rapid sequence. The tools are positioned in alignment with a drive plunger in sequence for performing the punching and riveting operations. The drive plunger directly communicates with a hydraulic power system which is operated and cycled by a novel pneumatic control circuit, which circuit also selectively positions the punching and riveting tools at the proper times. Provision is made for automatically causing the drive plunger to have a substantially rapid low pressure approach to the work and then to have its final punching and riveting work movement conducted under intensified pressure and thus with increased force.

The present invention relates to automatic riveting machines and, more particularly, to an improved punch riveter of the type having a single drive plunger and alternately selective tools to be engaged by said drive plunger for performing the punching and riveting operations in rapid sequence.

It has long been known in the aircraft industry to use portable punch riveters to perform the final assembly operation of the aircraft skin to the frame structure. This operation has proven to be very efficient and has been proven to give a satisfactory riveted joint in this environment and, as a result of this, production engineers have tried to apply these portable punch rivet machines to other production line assembly operations. However, as is well known, the skin and frame structure of an aircraft, as well as the rivets used, are fabricated from relatively thin, lightweight aluminum or alloys of aluminum, so that the punching and riveting operations in the particular case of aircraft assembly are carried out with relative ease and efficiency by these small, compact machines. Thus, while in this application the prior art punch riveters have proven to be efficient in terms of overall production costs and in terms of giving satisfactory riveted joints, when heavier metals, such as sheet steel and steel rivets, are attempted to be used to fabricate parts for automobiles and railway rolling stock, for example, these punch rivet machines designed specifically for the aircraft industry have been found to have a high attrition rate and to give nonuniform, and thus unsatisfactory, riveted joints.

These prior art machines designed for the aircraft industry have, infact, as we are aware, universally employed a camming arrangement to interconnect the drive piston to the drive plunger, which, in turn, performs the punching and riveting work strokes in accordance with the teachings first set forth in the patent to Marchant 2,069,842, issued Jan. 26, 1937. From this, it has been concluded that the large mechanical shocks and stresses associated with heavy duty punching and riveting of steel and the like is incompatible with this old design and that a new and improved portable punch riveter overcoming the above disadvantages would be desirable.

Therefore, it is one object of the present invention to provide an automatically controlled punch riveting machine which is capable of efficiently operating on heavier and stronger metals than has heretofore been possible.

It is another object of the present invention to provide a portable punch riveter that employs moving parts in the power system other than the drive plunger and drive piston whereby breakage and jamming of parts is minimized thereby increasing the expected life of the machine.

It is still another object of the present invention to provide a punch riveter of the type described wherein moving mechanical parts and linkages are held to a minimum whereby the effects of friction and inertia are substantially reduced to allow a more precise control of the drive plunger for forming a more uniform riveted joint and to provide a much rapid response during the automatic cycling of the machine.

Briefly, in accordance with the present invention, there is provided a hydropneumatic punch riveter which employs a drive plunger and alternately selective punching and riveting tools which are positioned in alignment with the drive plunger in sequence for performing the punching and riveting operations. The drive plunger directly communicates with a hydraulic power system and this system includes an intensifier means to cause the final work movement of the drive plunger thereby giving a very powerful working stroke in both the punching and riveting operations. The hydraulic power system is operated and cycled, in accordance with the present invention, by a novel pneumatic control circuit, which circuit also serves to selectively position the punching and riveting tools at the proper time. To increase the response time of the punch riveter, the control circuit includes a provision for automatically causing the drive plunger to have a substantially low pressure fast approach to the work and then to have a final punching and riveting work movement conducted under intensified pressure.

In accordance with one important feature of the present invention, there is provided in the pneumatic control circuit separate booster call-in circuits for independently controlling the punching and riveting work strokes of the drive plunger. More particularly, the punch stroke is terminated automatically in response to the travel of the drive plunger over a predetermined distance by sensing the movement of the drive piston in the booster cylinder; the rivet stroke, on the other hand, being controlled by the force of the drive plunger on the work by sensing the pressure acting on the rivet. This arrangement has been found to give a very precise control of the formation of the punched hole and the rivet so that the machine of the invention is extremely versatile in that a wide range of metals and sizes can be successfully riveted. Among the other features of the pneumatic control circuit is the provision of the timing circuit for initiating the operation of the booster cylinder at the precise time when the fast approach of the drive plunger and the shifting of the tool assembly has been completed and the provision of an enabling circuit for cycling the machine into the riveting operation only upon completion of the complete punching operation.

Another important aspect of the present invention concerns the design of the component parts of the hydropneumatic punch riveter in a unitized fashion so that there is provided comparatively simple, economically produced and maintainable mechanical equipment of the compact, portable type. Of particular value in this respect is the provision of a unitary valve unit which is housed within the working cylinder for control of the intensified hydraulic pressure in said cylinder. With this construction, the valve offers the most efficient control of the fluid while at the same time it may be quickly and easily removed for service or replacement.
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Thus, it is one object of the present invention to provide a versatile punch riveting machine employing a single drive plunger to perform both the punching and riveting operations wherein the drive plunger is given a powerful yet controllable working stroke.

It is another object of the present invention to provide a punch riveting machine of the type described which employs an integrated pneumatic control circuit having a rapid response for automatically cycling the operations of punching a hole, indexing the tool assembly, delivering the rivet and inserting it into the hole, and upsetting the rivet.

It is an additional object of the present invention to provide a punch riveter having a pneumatic control circuit capable of independently controlling the punching and riveting work strokes thereby insuring a fine, precise control of both operations.

It is a related and more specific object of the present invention to provide a hydropneumatic punch riveter wherein the integrated control circuit includes a start circuit capable of controlling the length of travel of the drive plunger during the punch stroke whereby different thickness sheet metal may be properly punched, and a second circuit for controlling the force of the drive plunger during the rivet stroke whereby different sizes of rivets may be properly headed.

It is another object of the present invention to provide a hydropneumatic punch riveter which is particularly adapted for limited mass production and low maintenance as a result of the minimal use of moving parts which would require expensive machining operations and the use of unitary components in strategic locations, which components can be easily serviced and/or replaced if necessary.

It is still another object of the present invention to provide a portable punch riveter having a unitary housing for three separate hydraulic work chambers and a pneumatic return chamber interconnected to perform the diverse punching and riveting strokes in a controlled manner in response to an integrated pneumatic control circuit.

Still other objects and advantages of the present invention will become readily apparent to those skilled in the art upon a consideration of the following detailed description, wherein we have shown and described only the preferred embodiment of the invention, simply by way of illustration of the best mode contemplated by us of carrying out our invention. As will be realized, the invention is capable of other and different embodiments, and its particular construction is not to be taken as restrictive.

In the drawings:

FIGURE 1 is an overall side view of a punch riveter constructed in accordance with the teachings of the present invention;

FIGURE 2 is a cross sectional view taken along a vertical axis of the punch riveter of FIGURE 1;

FIGURE 3 is a front view of the punch riveter of FIGURE 1;

FIGURE 4 is a detailed cross sectional view of a subcombination check valve for use with the preferred embodiment of the punch riveter constructed in accordance with the present invention;

FIGURE 5 is a cross-sectional view taken along line 5-5 of FIGURE 4;

FIGURES 6-10 are cross-sectional detailed views of the sequence of operation at the work station showing the relative positions of the drive plunger and the punching and riveting tool means;

FIGURE 11 is a schematic diagram of the hydraulic power means and the interconnected pneumatic control circuit of the punch riveter.

With reference now to FIGURES 1-5 of the drawings for a more specific description of a preferred embodiment of this invention, there is shown a hydropneumatic punch riveter 1 particularly adapted for punching and riveting metal sheets or the like at a work station 5. The punch riveter 1 comprises a punch 2 which is suitably cast in the general form required and then machined in the desired manner to provide the necessary support and mounting for the working components to be described. The housing 2 is or may be adapted to be positioned on a suitable stand 3 which is outlined in a dashed line fashion in FIGURE 1. Near the top of the punch riveter 1 is a conventional rivet hopper and conveyor assembly, generally designated by the reference numeral 4, and defining a downwardly and arcuate extending feed track 5 to suitably supply the rivets to said work station 5 during the operation of the machine, as will be discussed in detail subsequently.

With specific reference to FIGURE 2, a working cylinder, generally depicted by the reference numeral 6, is provided along the vertical work axis of the punch riveter 1; said cylinder 6 comprising, in part, an expandable hydraulic work chamber 7 and a complementary pneumatic return chamber 7a. Mounted for reciprocating movement in said cylinder 6 is a drive plunger 8 having a drive piston 8a at the upper end separating the work and return chambers 7, 7a, and a removable rivet set 9 mounted on the lower end thereof; it being understood that the reciprocating movement of the drive plunger 8 performs the punching and riveting operations, as will more fully appear later.

Positioned within the upper portion of the working cylinder 6 is a hydraulic one-way check valve unit, generally designated by the reference numeral 10, which is thereby interposed between the work chamber 7 and a head chamber 11. The valve unit 10 of the preferred embodiment illustrated threadedly engages the housing and is generally along the work axis so that it can be easily removed for servicing or replacement. The cylinder 6 is filled with a suitable hydraulic fluid, i.e., oil, to a level so that at all operative positions of the drive plunger 8 these is a residue of oil remaining in the chamber 11 above the internal valve unit 10. The chamber 11 is closed at the top by a suitable cover 12 fixed to the housing 2 by any number of suitable fastening means 13.

The chamber 11 is adapted to be cyclically pressurized by air and vented to atmosphere to force the oil in a first direction through the valve unit 10 against the piston 8a to thereby effect the fast approach and fast stroke of the plunger 8 during the work strokes and to allow the oil to flow back into the chamber 11 upon the return stroke, respectively, as will later more fully appear. The direct interface thus formed between the pressurized air and the oil in the head chamber 11 is particularly advantageous in that it allows the escape of any air bubbles that might become trapped in the hydraulic power system since the lighter air bubbles tend to rise to the top of the chamber 11 and escape each time it is vented on the return stroke.

Extending laterally from the cylinder 6 and opening directly into the work chamber 7 is a hydraulic power chamber, designated by the reference numeral 15. A chamber is actuated upon by pneumatic booster cylinder 16 to provide the intensified hydraulic pressure in the work chamber 7 needed to perform the final work movement of the drive plunger 8 on the punching and riveting work strokes. The booster cylinder 16 can be of any suitable construction with, for example, one end interlocking with the housing 2 and the other end being closed by a cap 17. Mounted for reciprocating
movement in the booster cylinder 16 is a booster piston 18 having suitable two-way packing 19 for powered movement in both the "work" and "return" directions, as indicated in FIGURE 2. A piston rod 20 carried by the piston 18 slidesly engages a tunnel member 21 which threadedly engages the housing 2 perpendicular to the work axis of the machine, said member 21 thereby serving to form the power chamber 15 in combination with a power piston 22 formed by suitable one-way packing on the free end of said rod 20. Suitable high pressure packing 23 is required in member 21 around the piston rod 20 to prevent the escape of high pressure hydraulic fluid from the intensifier power chamber 15. As is evident, the limit of movement of the booster piston 18 in the return direction is determined by an adjustable stop screw 24, the limit in the work direction being determined in accordance with the particular work function (punch or rivet) being performed, as will later be discussed.

Briefly, during the final work movement of the drive plunger 8, the work end of the booster cylinder 16 is supplied with air pressure and the return end in vened to drive the booster piston 18 and thus the power piston 22 forward in the work direction. Because of the disparity in size of said pistons 18, 22, it is clear that an intensified hydraulic pressure is generated in the work chamber 7 to drive the drive plunger 8 downwardly with a force substantially greater than has been obtainable in the prior art punch riveters of the Marchant type wherein cam linkage between the booster piston and the drive plunger is utilized. When the work movement has been completed and the booster cylinder 16 is "called out," the return end of said cylinder 16 is pressurized and the work end vened to return the piston 18 to its retracted position.

The upper or return limit of movement of the drive plunger 8 is determined, in the preferred embodiment illustrated, by a stop bar 25 that extends across the work chamber 7 and is held in position by a threaded plug 26. As shown in FIGURE 2, the lower end of the working cylinder 6 is provided with a removable sleeve 27, which is press fitted into position. The sleeve 27 not only serves to guide the plunger 8 during its reciprocating movement but also serves to form a seal at O-ring 28 for the expandable return chamber 7a so that the plunger 8 may be quickly returned to the retracted position by air pressure supplied to said chamber 7a. The retracted position of the drive plunger 8 is formed by a reduced diameter portion 29, which is positioned within the sleeve 27 and in engagement with a cam roller 29a only when said plunger 8 is in a retracted position of FIGURE 2 for a purpose which will presently be seen.

A tool assembly T is provided for the purpose of adapting the rivet set 9 to perform the punching and riveting operations on successive downward strokes of the drive plunger 8. Thus, as can be considered to be conventional, a die button 30 and rivet shoe 31 are adapted to be alternately positioned in alignment with the rivet set 9 and in opposed relationship to the anvil post assembly, generally designated by the reference indicia A, as can best be seen in FIGURE 3. The die button 30 and the rivet shoe 31 are supported in this position by downwardly extending carriers 32, 32a (note FIGURE 4) which are respectively carried for vertical up-lifting movement by respective mounting bars 33 (only one of which is shown) extending through the housing 2. The mounting bars 33 are splined along their length and are drivingly engaged by respective sleeves 34 (only one of which is shown) having outwardly extending lever arms 35, as best shown in FIGURE 5. In FIGURE 5 the lever arm 35 is a yoke 36 (FIGURE 1) which is adjustably attached to an actuating rod 37. As shown in FIGURE 1, a pair of L-shaped mounting plates 38 are attached to the side of the housing 2 so as to receive pivotal mounting pins 39 of a double acting shift cylinder 40 which serves to power the actuating rod 37. It should now be understood that upon actuation of the shift cylinder 40, the positions of the die button 30 and the rivet shoe 31 are exchanged by shifting of the carriers 32, 32a by the linkage just described.

To detect the approximate mid-point of travel of the tool assembly T for a purpose which will later be explained, there is provided a feeler cam 41 for operating a bleeder valve 42, which cam 41 is in engagement with the outer surface of the shift cylinder 40. Because of the overcenter arrangement of the lever 35, the cylinder 40 pivots outwardly about the pivot pin 46 attached to the feeler cam 41 to thereby pulse the valve 42 each time the tool assembly T is shifted. As is conventional, the tool assembly T is normally retained in its uppermost position shown in FIGURE 2 by a suitable spring (not shown) acting on the splined bar 33; however, upon movement of the drive plunger 8 on its working stroke, the tool assembly T is free to move downwardly against the action of the spring until engagement with the work is reached, whereby the work function can be performed.

When the drive plunger 8 is in this upper limit position of FIGURE 2, the reduced diameter portion 29 is in opposed relationship to a sliderable feeler bar 43, which is pivotally mounted in the housing 2 and guided by an adjustable key 44. The remote end of the bar 43 engages an actuating lever 45 which is mounted for pivotal movement with respect to the housing 2, by a pivot pin 46. The lever 45 is maintained in operative relationship with the sliderable bar 43 by a tension spring 47 which is fixed at one end by a threaded mount 48. Also pivotally mounted about the pivot pin 46 is a mounting plate 49 which carries a pneumatic bleeder valve 50, the function of which will be described during the discussion of the operation of the machine that follows. It is noted that the mounting plate 49 is angularly adjustable with respect to the lever 45 by means of a bolt 51 and this adjustment is for the purpose of setting the firing point of the valve 50.

Positioned at the lowermost portion of the punch riveter 1 of the invention is an anvil 55 for the purpose of supporting the anvil post assembly A in opposed operative relationship with the die button 30 and the rivet shoe 31, as described; the anvil 55 being attached to said housing 2 by any number of suitable screws 56 and a key 57. The anvil post assembly A has an anvil post 58 and concentrically disposed within said anvil post 58 is a punch 59, which is raised to the operative position (shown by the dashed line outline in FIGURE 2) by a reciprocating cam member 60 that is controlled by a single acting pneumatic cylinder 61. Concentrically arranged around the outside of the anvil post 58 is a stripper 62 that is slideable between the upper limit position shown and a lower limit position wherein it is substantially coextensive with said anvil post 58. The stripper 62 is resiliently biased into its upper limit position by a pivotal yoke 63 which engages reduced side faces 64 on the sides of said stripper 62 (note FIGURE 1); the yoke 63 being biased in a clockwise direction by a suitable compression spring 65 around pivotal mounting member 66 and as limited by a stop screw 67 (NOTE FIGURE 2).

The present invention contemplates the use of a conventional gravity type of rivet hopper and conveyor 4 for feeding the rivets into the rivet shoe 31 and thus this mechanism will be described only briefly and in so far as needed to understand the present invention. Thus, as shown in FIGURE 3, suitably attached to the side of the housing 2 by a supporting frame 70 is a hopper 71 for the storage of rivets and a rivet orientating and indexing drum assembly 72 to receive the rivet feed from the hopper 71. The drum 72 is rotated as required to properly feed the rivets during each complete cycle of the punch riveter 1, and for this purpose there is shown a crank 73 rotatably positioned an operating shaft 74, which serves to support the drum 72, and said crank 73 on the frame 70. A pawl 75...
is carried by the crank 73 for engagement with a rathe
wherein fixed to the shaft 74 to cause rotation thereof.
The crank 73 and the pawl 75 are operated by a single
acting pneumatic cylinder 77 in a manner to be sub-
sequently described.

As is well known, as the rivets are stepped around by the
drum 72, they are properly orientated with respect to
a conveyor track 60, which, in turn, delivers by way of a
conventional rivet selector the individual rivets to an
offset feed tube 81 that is operative to drop the rivets one
at a time into the rivet shoe 31 during the punching opera-
tion, i.e., when the punch die button 30 is in an operative
position along the work axis and rivet shoe 31 is in posi-
tion under said feed tube 81, as shown by the dotted line
outside of FIGURE 3.

Referring now to FIGURES 4 and 5 of the drawings,
there is shown in detail the one-way check valve unit 10,
which it will be remembered, is disposed within the work-
cylinder 6 between the head chamber 11 and the work
chamber 7. As illustrated, the check valve unit 10 con-
pists of a unitary body 85, which desirably houses all of the
operating components and passages necessary to its func-
tion so that said entire unit 10 can advantageously be
removed for servicing or replacement, which may be
required occasionally due to the need to maintain an
absolutely secure seal of the work chamber 7 from the
head chamber 11. The reason for this is that to gain an
efficient and uniform operation desired, the intensified
hydraulic pressure generated in the work chamber 7 must
be transposed into the final work movement of the drive
plunger 8 and this can not be done if the fluid is allowed
to escape back into the head chamber 11 during the power
stroke. Furthermore, the body 85 is threaded along the
lower outside portion thereof at 86 to further facilitate
this operation whereby said valve unit 10 can be easily
positioned in the punch riveter 1 of the present invention
by merely inserting it through the chamber 11 and then
screwing it into its mating socket in the housing 2.

To explain the essential network of fluid paths through
the valve unit 10, there is extending diametrically across
the body 85, a pair of crossed channels 87, which com-
unicate with a main control chamber 88 extending along
the central axis. The control chamber 88 has a spherical
stopper 89 seated in the lower end thereof under the action
of a compression spring 90. Crossed passageways 91 are
formed in the body 85 for communication with the lower
end of the control chamber 88 whenever the stopper 89 is
in an unseated position and there are provided four pas-
sages 93 which communicate with the outer ends of the
passageways 91 along their length and at right angles thereto.
The operational advantage of the placement of this
network of fluid passages lies in the valve's exhibited
ability to allow rapid passage of the hydraulic fluid be-
tween the chambers 7 and 11 with a minimum amount of
foaming and resistance, which, of course, improves the
response time as well as the work efficiency of the punch
riveter of the invention.

For the purpose of unseating the stopper 89, there is
provided a pneumatic motor, generally designated by the
reference numeral 94, and comprising a piston 95 with an
elongated actuator rod 96 which is positioned in a cylin-
drical guide channel 97 and extends through the chamber
88 for operational engagement with the top of the stopper
89. As shown, the piston 95 is retained in its upper posi-
tion by a spring 98 so that upon receipt of a pressurized
pneumatic signal in chamber 99 above the piston 95 the
stopper will be forced away from its seat thereby effect-
ing an opening of the valve unit. Thus, this arrangement
of the valve unit 10 for conveniently housed in a unitary
housing 2 so as to separate the head chamber 11 and the
work chamber 7, and further the particular arrangement
of the radially extending passageways 87, 91 and a single
connecting chamber 88, allows a substantially free flow
of fluid against the spring loaded stopper 89 in a first
direction upon pressurization of the work chamber 7 dur-
ning the fast approach of the drive plunger 8 and a quick
exhaust of the fluid in the opposite or second direction
upon actuation of the motor 94 to initiate the return
stroke.

To consider the operation of the punch riveter 1 of the
invention, attention is directed to FIGURES 6-10 illus-
trating the sequential operations that take place at the
working station S, and specific reference is made to FIG-
URE 11 wherein is disclosed an overall hydropneumatic
flow diagram in schematic form including the hydraulic
power system described above and a pneumatic control
circuit 100 for operating and cycling said punch riveter
1. It will be noted that in FIGURE 11 a general physical
outline of the punch riveter 1 is indicated by a dashed line
outline to indicate the approximate locations of the main
components of the same; however, it is to be understood
that in actual practice, the physical layout of the ma-
chine may vary as is convenient. In following the opera-
tion of the control circuit 100 with reference to the
schematic diagram, it should be realized that the length
of the fluid connections or lines is, in some cases, ex-
aggerated for ease of illustration, and that in reality the
complete control circuit 100 occupies only a very small
space and may be conveniently housed in a relatively
small package (not shown) physically attached at any
desired location on the punch riveter 1. It should also be
noted that all of the necessary fluid connections between
parts, as shown in FIGURE 11, have not been illustrated in
FIGURES 1-5 since such may be actually physically
arranged as desired or convenient.

To provide the necessary pressurized air for opera-
tion of the control circuit 100, there is shown an air
source 101, which is, in the usual case, taken from a cen-
tralized plant air supply, and is connected to said cir-
cuit 100 through an inlet or supply line 102 having a su-
table shutoff valve 103. A control line 104 directly controls the air pressure in the inlet line 102 and there is or may be provided a gauge 105 for quick refer-
ence as to the working pressure of the system.

The punch riveter 1 can be operated either auto-
matically or semi-automatically and for the purpose of se-
lection the desired mode, there is provided a manually
operated, two position selector valve 106 to control the
flow of air in a transfer line 107, the valve 106 being
capable of being selectively positioned in either an open
condition to permit fluid flow for automatic operation,
as shown, or in a closed condition to prevent fluid flow
for a semiautomatic operation. As will be seen later in the
description, a cycling signal passing through the valve
106 is effective to automatically initiate the riveting stroke
upon termination of the punching operation.

In order to be able to manually initiate the various
operations of the punch riveter 1 through the control cir-
cuit 100, there are included a punch valve 108, a rivet
valve 109, and a preset valve 110 to independently pro-
vide the necessary pneumatic control signal to perform
the designated function. As just indicated, if the se-
lector valve 106 is in the automatic position, the entire
punch riveting operation will be carried out by simply
pressing the punch valve 108. If, however, the semi-
automatic operation is selected, at the end of the punching
operation, the depression of the rivet valve 109 is re-
quired to independently initiate the riveting operation.
The preset valve 110 is for the purpose of insuring that the
circuit 100 is in proper standby condition for operation
when the machine is first set up for use, in a manner to be
discussed later.

Accordingly, when it is desired to initiate the oper-
atation of the punch riveter 1, assuming that the control
circuit 100 is in a standby or preset condition thereby
centering the rivet shoe 31 at the work station S and
placing the rivet set 9 in the retracted position (as shown
in FIGURE 3), the punch valve 108 is depressed. This
pressurizes a single impulse relay 111 by opening line 112
to live air from the inlet line 102; it being understood
that any suitable construction of the relay 111 may be used since the specific structure is not critical to this invention. For the purpose of understanding the operation of the circuit 100, suffice it to say that an incoming signal applying pressure to the pressure signal from actuation of the punch valve 108, said relay 111 is operative to exhaust bleed line 113 with a single pulse through exhaust port 113a of said relay 111. Because of the single impulse feature, no harm is done in case the operator inadvertently holds the punch valve 108 in the open position longer than required for the single impulse, and when said valve 108 is released the line 112 is bled back through bleed port 108a thus resetting the relay 111 for the start of the next cycle.

As shown, the bleed line 113 leads to a shift cylinder control valve 114 which preferably takes the form of a conventional four-way (two-position) spool valve having opposed actuator chambers C, C' to control the positioning of a reciprocable spool member 116 having a series of four reduced diameter passageways 117. Specifically, in the embodiment shown, the bleed line 113 communicates with the right-hand actuator chamber C of the spool member 116 via an exhaust or bleed signal is operative to bleed the chamber C to shift the spool member 116 to the right as viewed in this figure.

Once spool member 116 is positioned by th bleed signal, it is retained in that position by constant and equal pressure supplied to the corresponding channels 118, 118a. Open into and thus connected through to the middle two passageways 117 of the spool member 116 is a pressure feeder line 119 receiving live air from the inlet pressure line 102, as indicated. It can be seen that one of the middle passageways 117 is constantly under pressure from the feeder line 119 for the purpose of providing a pressure signal through the valve 114 in either position of the spool member 116. Communicating alternatively with the two outer passageways 117 are a pair of spaced bleed ports B, B' only one of which is operative to provide an exhaust or bleed signal through the valve 114 at any given time depending on the position of the spool member 116. As examples and not by way of limitation of the invention in any sense, suitable embodiments of the series BV4 valves manufactured by Modernair Corporation, Angola, Ind., will meet this requirement. Valves manufactured by Lubricator Fluid Power, Inc. may be considered to be of suitable construction for the valve 114 and for the similar valves to be described below.

For further identification of the positioning of the spool member 116 in the valve 114 and in similar valves to be described below, reference can be made to the directional arrows shown in this figure which refer to a corresponding position or operational mode of the drive plunger 8. Accordingly, as described above, when a bleed pulse is generated in the bleed line 113, the chamber C is momentarily relieved through bleed port 113a and this results in the spool member 116 being shifted to the right by a corresponding unbalancing of pressures to the "punch" position. This shifting, in turn, thus initiates the operations leading to and including the performance of the punch stroke of said drive plunger 8 now to be described.

Thus, to initiate the first step of the operation shown in FIGURE 6 of the drawings, the spool member 116 of the control valve 114 is shifted to the punch position whereby the middle passageway 117 connects the pressurized feeder line 119 to a pressure-bled or two-way connection 121 and the bleed port B to a similar two-way connection 121. The former connection 121 in the connection 121 is applied to the punch side of the shift cylinder 40 thereby initiating motion of piston 123 and piston rod 123a in the punch direction, as indicated by the arrow in this figure, and simultaneously, said signal is applied to the punch lift cylinder 61 through branch line 121a to activate the lift cam 60; the former condition resulting in shifting of the die button 30 toward its operative position at the work station S (note FIGURE 6) and the latter condition serving to raise the punch 59 into the operative position (note FIGURE 6 and dotted line position of FIGURE 2) for cooperation with button 30 in the succeeding step of the machine cycle.

The pressurization of the connection 121 is also effective to open a first booster call-out valve 124 in a punch call-out circuit, generally designated by the reference numeral 125, and finally to activate an automatic operation enabling circuit, generally designated by the reference numeral 126, by opening a permissive valve 127 to connect the transfer line 107 to a relay line 107a; it being understood that this operation has no end result at this time but is a first step toward bringing the enabling circuit 126 into action at the end of the punching operation to enable the machine to be automatically cycled into the riveting operation and thus will be further referred to at that point in the cycle. The venting of the two-way connection 122 releases pressure on the rivet side of the piston 123 of the shift cylinder 40 and prevents activation of a rivet call-out circuit 128 by insuring that second booster call-out valve 129 remains in the normally closed condition during this half of the cycle.

As the piston 123 moves in the punch direction, due to the overcenter movement of the lever 35 (note FIGURE 1) in effecting the shift of the tool assembly T, the shift cylinder 40 moves on the pivot pins 39 held in mounting members 38, thereby actuating the bleed valve 42 to release the pressure in bleed line 131 to evacuate the actuator chamber C' of a fast approach control valve 132, thereby causing said valve to shift in the work direction, as indicated. This actuation of the valve 132 opens a two-way or pressure-bleed connection 133 to live air through feeder line 134 to actuate the hopper drive cylinder 77 to step the ratchet wheel 76 (see FIGURE 5) through a single cycle. It will be remembered that this effects the feeding a rivet from the drum 72, along the track 80 and into the feed tube 81 whereupon it is deposited in the rivet shoe 31, which has now assumed the dotted line position of FIGURE 3 for this purpose. This pressurization of the connection 133 also pressurizes a feed port 136 which is controlled by the position of the rod 123a of the shift cylinder 40, as will later appear. At the same time, a pressure bleed connection 137 is vented by the bleed port B of the valve 132, which is effective to allow retraction of the piston 95 of the head chamber release valve unit 10 and to depressurize the actuator chamber C of a booster control valve 140; it being noted that forcible exhaustion of the return chamber 7a is also to begin at the same time. The connection 137 is by an adjustable one-way flow regulator 141, which comprises a needle valve 141a and a check valve 141b mounted in parallel with each other.

The regulator 141 can, if desired, be used to precisely control the speed of the fast approach movement of the drive plunger 8, i.e., since said plunger 8 can move downwardly on the work stroke only as fast as the return chamber 7a is bled through the adjustable needle valve 141a, its speed is capable of control. This, of course, prevents the drive plunger from building up excessive momentum prior to engagement of the punching station S thereby prevent any damage or premature deformation to the work or the rivet at this point, but to allow a firm clamping of the work between the tool assembly T and the anvil post assembly A in anticipation of the final work movement.

As the piston 123 of the shift cylinder 40 reaches its full stroke position in the punch direction, the pressurized port 136 is open to a transfer line 142 through a connection passageway 143 formed by a reduced portion of the piston rod 123a, as shown in this figure. This connection allows live air to travel through the transfer line 142 to the actuator chamber C of a fast approach supply valve 145, which is of the air pressure operated, spring return type of valve. The particular construction of the
valve 145 will be clear to those skilled in the art of fluid control and any number of suitable valves to perform its function will come to mind so that its particular construction need not be detailed here. For example, suitable modifications of the series S35 valves of Lehrl Fluid Power, Inc. of Easton, Pa., can be used, if desired. It need not be said for the purpose of understanding the present invention, that the actuation of this valve 145 supplies air from a feeder line 146 through a transfer line 147 to open a snap action exhaust valve 148, which may also be of conventional construction, as for example, a poppet type valve known in the art as "Peer-Trol" Quick-Exhaust Valve, Model Series EV. This pressurizes the hand chamber 11, whereby hydraulic fluid is forced through the release valve unit 10 into the expansible work chamber 7 whereupon the drive plunger 8 commences its downward fast approach for the punching operation. It will be realized that conditioning of the actuation of the supply valve 145 upon the positioning of the piston 123 in the limit position in the punch direction insures that the die button 30 has reached its final position and is thus aligned and ready for engagement by the rivet set 9 carried by the drive plunger 8 before it begins its downward work stroke.

As the drive plunger 8 continues on this punch work stroke, the expandible return chamber 7a is continuously being reduced in size and thus forcibly exhausted through the connection 137 by way of the regulator valve 141 in a controlled manner. Thus, the valve 141 in combination with a transfer line 150 and a pilot valve 151 forms a booster call-in timing circuit, generally designated by reference numeral 122. This means that after a predetermined time, set by the adjustment of the needle valve 141a, the return chamber 7a is completely bled and ambient pressure is present in the transfer line 150 thereby allowing the opening of the spring biased valve 151. This completion of the circuit 152 causes a pressurization by feeder line 153 of a transfer line 154 which, in turn, results in the pressurization of the actuator chamber C' of booster control valve 140 and since the opposite chamber C has been previously exhausted through the connection 137, the booster control valve 140 now shifts in the work direction with a resultant pressurizing of a pressure bleed connection 155 by way of a feeder line 156. Responsive to this, a snap action exhaust valve 157 is opened to bring live air into the work end of the booster cylinder 16 (right-hand end as viewed in FIGURE 2). Simultaneously, the booster control valve 140 effects a rapid venting of the return end of the booster cylinder 16 (left-hand side as viewed in FIGURE 2) by way of a pressure bleed connection 160 and snap action exhaust valve 161.

At this point, a sensor line 162 connected to the connection 160 and thus to the return end of said booster cylinder 16 is also vented thereby effecting an opening of a third booster call-out valve 163 in the punch call-out circuit 125. Similarly, the work end of the booster cylinder 16 has connected thereto a sensor line 164 and the pressurization of the same opens a fourth booster call-out valve 165 thereby completing the punch call-out circuit 125 to present a clear path for a pressure signal to pass through pilot line 166 to a booster call-out bleed valve 167 of the punch call-out circuit 125. This pressure signal is opened to open said bleed valve 167 and thus call out to terminate the booster operation on the punching work stroke, as will now be seen. First, it should be stated that here the transfer line 107 and the relay line 107a by way of the valve 127 of the automatic operation enabling circuit 126 are also pressurized since said transfer line 107 is interconnected with the sensor line 164 and that this initiates the second step toward operation of said enabling circuit 126, as will be discussed below.

120 170 is provided along the length of the booster cylinder 16 through which the pressure signal to call out the booster is progressively generated and to one of which the pilot line 166 is selectively connected through a valve 171. More particularly, as the booster piston 18 moves along in the work direction to punch the hole, the lagging lip of said piston 18 uncovers the selected one of the pilot ports 170 which thereby causes the pressurization of said pilot line 166 by way of the pressurized work end of the cylinder 16. With the call-out circuit 125 being open through the call-out valves 163, 165 and 124, as previously described, the pressure signal passes through relay line 173, actuates bleed valve 167 whereupon bleed line 175 is opened to atmosphere thereby effecting the termination of the punch stroke.

It will be realized that the call-out function of the third and fourth punch call-out valves 163, 165 is somewhat supplementary to the first punch call-out valve 124; however, they insure that the circuit 125 is not subject to activation from a stray or excursionsary pressure signal traveling through the selected one of the pressure ports 170 and the sensor line 164 from the booster cylinder 16. In other words, the work and return ends of the piston 18 must be actually pressurized and actuated to activate it, respectively, which indicates that the final work movement is in progress, before the circuit 125 is capable of producing a call-out of the booster. Thus, with this arrangement, the only signal possible in the sensor line 164 after the complete activation of the circuit 125 is a sudden increase in pressure as the packing 19 moves past the pilot ports 170 and this signal is easily and unmistakably discernible to the pilot actuator of the bleed valve 167 thereby eliminating the possibility of described false call out on the punch stroke.

At this point, it should be pointed out that the step of the cycle illustrated by the full line position of FIGURE 7 has been reached wherein the work W has been forced down against the spring biased stripper 62 onto the punch 59, which, it will be remembered, is in its raised or operative position during this operation. As a result of the intensified power stroke afforded by the rather large booster piston 18 operating the substantially smaller intensifier piston 22 against the hydraulic fluid in the work chamber 7 above the drive plunger 8, a clean rivet hole is made by shearing through the work W thereby removing a slug portion P.

Thus, the selection of one of the ports 170 is made to correspond to the point at which the punch stroke has just been completed, which is designated as that shown by the full line position of FIGURE 7. This arrangement has been shown to give a fine, precise control over the movement of the drive plunger 8 so that a wide range of thicknesses of work W may be operated on. The next is, with the selection of the proper one of the pilot ports 170, the punch stroke is carried out for the entire thickness of the work W, which has not been attainable with a high degree of consistency in prior art uncontrolled machines. It will be realized that with the proper selection of ports 170 described, the downward stroke of the drive plunger 8 and the rivet set 9 will be momentarily continued until the punch 59 has assumed the relative position with the die button 30 depicted by the dotted line position of FIGURE 7 wherein the slugs P are positioned in a transverse aperture 178 for easy removal, as will later appear.

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To return to the operation of the punch as the pressure in the bleed line 175 is released through the bleed valve 167 as above mentioned, the actuator chamber C of the fast approach control valve 132 is bled causing a shift in the return direction thus initiating the return operation of the drive plunger 8, as follows. Thus, the connection 137 is now pressurized which actuates the piston 95 of the valve unit 10 thereby unseating the stopper 89 against the intensified pressure in the expansible work chamber 7 thereby allowing the hy-
draulic fluid to return to the head chamber 11. In addition, the expandable return chamber 7a is pressurized with live air through the same connection 137 to thereby move the drive plunger 8 upwardly toward its retracted position. Also, the actuator chamber C of the booster control valve 140 is pressurized and the opposed chamber C is exhausted through the timing circuit 152 to thereby cause a shifting of said valve 140, as will presently be explained in detail.

First, however, it should be explained that through the connection 133, the hopper drive cylinder 77 is vented thereby readying the pawl and ratchet 75, 76 in standby condition for the next cycle. At the same time, bypass line 179 around the shift cylinder 40 vents the transfer line 142 thereby immediately releasing the actuating pressure on the fast approach supply valve 145 and thus shifting the same in the return direction, as indicated. This action effects the bleeding of line 147, the rapid opening of exhaust valve 148 and the release of pneumatic pressure through an exhaust tube 150; the exhaust tube 180 having its egress orifice 181 positioned opposite the aperture 178 of the die button 30 to blow the slug P from the top of the punch 59 (FIGURE 7).

In the meantime, the transfer line 150 has been pressurized by the connection 137 through the check valve 141, opening the bleeding of the transfer line of the pilot line 151. This releases the pressure on the actuator chamber C of the booster control valve 140 allowing said valve to shift in the return direction since it will be remembered that the actuator chamber C has been pressurized directly from the connection 137. The drive plunger 8 is now well on its way to being returned to its retracted position thus completing the punch operation at the working station S, as shown in FIGURE 8.

As the drive plunger 8 completes its return stroke, the feeder slide 43 is allowed to shift to the left as viewed in FIGURE 2 because of the cam portion 29 of the drive plunger 8 thereby causing lever 48 to pivot in a counterclockwise direction thus effecting the opening of the bleeder valve 50. This action connects bleed line 185 and thus the actuator chamber C of the shift cylinder control valve 114 to the bleed line 186 which is connected to an automatic circuit bleed valve 187 in the enabling circuit 126. It will be remembered that the relay line 107c was previously pressurized in what was described as the second step of initiating the operation of the circuit 126; the first step being the opening of the valve 127 at an earlier point in the cycle. Since the bleed valve 187 is arranged to be opened by the described pressurization of the relay line 107c, and since an inlet check valve 188 has held the bleed valve 187 open during the subsequent depressurization of the transfer line 107 at the termination of the punch stroke by the booster piston 18, the actuator chamber C is bled through said bleed valve 187 and the shift cylinder control valve 114 is shifted to the rivet position, thus initiating the rivet half of the cycle automatically. With the positioning of the valve 114 in the rivet position the connection 121 is immediately exhausted through the exhaust port B, which closes the valve 127 and bleeds the relay line 107a through outlet check valve 188 thereby deactivating the enabling circuit 126 so that at the end of said rivet half of the cycle the machine may be started only by actuation of the punch valve 109.

For semiautomatic operation, it will be clear that the switch 106 would have remained closed thus preventing the two-step activation of the enabling circuit 126 through connection 121 and through line 107 during the punching operation as above described. Thus, in this case, pressure will be retained in the bleed line 186 until such time as the operator manually engages the rivet valve 109 whereupon the bleed line 186 will be bleed to the atmosphere thus initiating the rivet half of the cycle, which occurs in exactly the same manner as during automatic operation when the valve 187 bleeds said line 186. It should be noted here that the arrangement of the bleeder valve 50 to be responsive to the movement of the drive plunger 8 into the fully retracted position insures that once the drive plunger 8 has started its movement to perform the punching work function which has been set up by the circuit 100, the accidental opening of the rivet valve 109 has no effect on the bleed line 185 and thus no effect on the control valve 114 thereby preventing an unintentional initiation of the half of the cycle before the end of the punching operation.

With the valve 114 thus shifted to the rivet position in accordance with either automatic or semiautomatic operation, the operation of the remainder of the control circuit 100 during the riveting operation is as described above for the punching operation except for several important differences, as now noted. First, the piston 123 of the shift cylinder 40 is, of course, shifted to the rivet position through the connection 122 and the second booster call-out valve 129 of the call-out circuit 128 is shifted to open the circuit 128 for operation during this half of the cycle. Secondly, the connection 121 is bled during this half of the cycle to prevent the opening of the first booster call-out valve 124 to thus insure that the call-out circuit 125 is not operative during the riveting operation. Further, of course, the pressure on the punch side of the shift cylinder 40 and in the branch line 121a is shifted to the latter serving to retract the punch lift cylinder 61 so that the punch 59 is capable of being positioned in the anvil post 58. Preferably, the punch 59 is retained in the punched hole of the work piece W by the friction between the sides of the hole and the punch 59 at this point, as shown in FIGURE 8, so that the work W is retained in an aligned position for the riveting operation.

At midstroke of the shift cylinder 40 the bleeder valve 59 is again opened to shift the fast approach control valve 132 in the work direction to set up the fast approach of the drive plunger 8, as before. An additional reduced diameter passageway 191 is provided on the piston rod 123a so that the fast approach supply valve 145 that finally initiates the fast approach of the drive plunger 8 is opened only after the tool assembly T has completed its shift, as illustrated in FIGURE 9. As the fast approach of the drive plunger continues, the rivet set 9 is firmly seated on a rivet R that appears in the rivet shoe 31 as a result of the operation of the rivet conveyor 4 during the punch half of the cycle. Then it will be understood that said rivet set 9 is brought down into engagement with the work piece W, with the end result being that the rivet R is pushed through the expandable rivet shoe 31, thence through the hole in said work W thereby releasing the punch 59 from fricitional engagement with said work W, whereby said punch 59 is now positioned in the full line position of FIGURE 2 so as to be resting on the adjustable stop 59a in readiness for the deformation of the rivet R.

When the timing circuit 152 is activated, the booster control valve 140 is shifted thereby pressurizing the work side of the piston 18 through the connection 155 just as before, to carry out the final work movement of the drive plunger 8 on this half of the cycle. As the booster piston 18 moves forward during this half of the cycle, the intensified pressure acts against the rivet R, now firmly seated against the anvil post 58 and the punch 59 as described, to controllably squeeze the end of the rivet R to form a head 194, as shown in FIGURE 10, thus completing the riveted joint.

During this squeezing of the rivet R, the intensified progressively increasing pressure required to form the head 194 is sensed in the sensor line 164 and is transferred to a pressure responsive valve 195 in the call-out circuit 128 through the open booster call-out valve 129. The operative portion of the valve 195 may be of any suitable construction, as, for example, with a spool member 196 having a reduced portion passageway 197 communicating
with a bypass passage 198, as illustrated in FIGURE 11. To provide the necessary adjustment of the pressure at which the passageway 197 opens through to a transfer line 199, there is provided a spring 200 which can be adjusted by a suitable screw 201. Upon pressurization of the transfer line 199 a booster call-out bleed valve 205 is opened whereupon the bleed line 175 to the fast approach control valve 132 is bled thereby shifting said valve in the return direction for initiation of the return stroke of the drive plunger 8 in the manner as in the punching operation from this point on.

Thence it will be seen that the rivet R is deformed with a head 194 to connect the work W in a controlled fashion by limiting the force of the drive plunger 8 as it acts on said rivet R against the anvil post and punch 58, 59, respectively. It will be realized that with this adjustment any size rivet can be set with a high degree of accuracy so that the rivet and joint will be uniform and thus of high quality.

As the drive plunger 8 reaches its full retracted position on its return stroke, it will be realized that the bleeder valve 50 is again opened by movement of the feeder slider 43 with the cam portion 27, however, as previously pointed out, the automatic operation enabling circuit 126 is inhibited during this half of the cycle so that the bleed valve 187 remains closed, the shift cylinder control valve 114 remains in the rivet position, and the machine is positioned in readiness for the initiation of another cycle by actuation of the punch valve 108.

If the punch riveter 1 is required to be depressurized between operating cycles to move the same to a new location for example, it is desirable to actuate the preset valve 110 in order to assure that the pneumatic control circuit 100 is properly preset for operation. It is noted that this presetting operation can be accomplished with the machine of the invention before live air from source 101 is admitted to the circuit 100 since the preset valve 110 is positioned upstream of the shut-off valve 103. Thus, the preset valve 110 operates through a transfer line 210 and a check valve 211 to pressurize the actuator chamber C of the shift cylinder control valve 114 to thereby insure that said valve 114 is in the rivet position. Further, the pressurization of the transfer line 210 is effective through check valve 212 to pressurize the actuator chamber C' of the fast approach control valve 132 and thereby place said valve 132 in the return position. With these two control valves 114, 132 thus positioned, all of the other components of the pneumatic control circuit 100 will be pressurized and since they are directly or indirectly controlled by said control valves 114, 132. Because of the positioning of the check valves 211, 212 in the transfer line 210, it will be realized that said transfer line 210 and the preset valve 110 are isolated during normal operation of the control circuit 100.

Results and advantages of the present invention will now be clear to those skilled in the art in that an entirely integrated hydropneumatic punch riveter has been provided which is capable of supplying a powerful yet controllable working stroke, and which at the same time, has a particularly rapid response during the automatic sequencing of the steps. Further, it will be realized that due to the independent control of the call out of the booster cylinder during the punching and riveting operations, maximum efficiency and uniform riveted joints are obtained. Also, because of the unique timing circuit which effects the call in of the booster, the work W and the punching and riveting tooling T is assured of being properly positioned prior to the final working movement of the drive plunger 8. Finally, it will be realized that the punch riveter 1 is of such construction as to be highly reliable due to the elimination of moving mechanical parts in the power system by employing the hydropneumatic intensifier means for causing the final work movement to effect the punching and riveting operations, and to be particularly adapted to inexpensive mass production and ease of maintenance through the unique unitizing of the component parts, such as the head chamber release valve unit 10.

In this disclosure, there is shown and described only the preferred embodiment of the invention, but, as aforementioned, it is to be understood that the invention is capable of various changes or modifications within the scope of the inventive concept as expressed by the accompanying claims. For example, it is contemplated that the pneumatic control circuit could employ different types of valves to perform the operations required, as previously indicated above in several places and even further, it is contemplated that pure fluid amplifiers and other pure fluid components having no moving parts other than the fluid itself could be used to perform the switching and actuating functions described, if desired.

We claim:

1. A hydraulic-pneumatic punch riveter for performing punching and riveting operations in succession comprising: a housing having a work axis, a working cylinder extending along said axis, a drive plunger having an operating piston positioned in said cylinder for reciprocating movement including a work stroke and a return stroke along said axis, said operating piston and said cylinder defining an expandable work chamber,

punching means mounted on said housing for positioning along said axis during said punching operation,

riveting means mounted on said housing for positioning along said work axis during said riveting operation,

means for selectively positioning said punching and riveting means into operative position along said axis,

hydraulic power means operatively connected to said work chamber for actuating said drive plunger into operative engagement with said punching means and said riveting means in succession to perform the punching and riveting work strokes, respectively, of said operations,

said hydraulic power means including intensifier means to cause the final work movement of said drive plunger during said punching and riveting work strokes,

and a pneumatic control circuit including a source of pressurized air for operating and cycling said hydraulic power means and said positioning means.

2. The combination of claim 1 wherein said hydraulic control circuit includes first call-out circuit means to interrupt said punching work stroke and initiate said return stroke, said first call-out circuit means being responsive to the length of travel of said drive plunger, and second call-out circuit means to interrupt said riveting work stroke and initiate said return stroke, said second call-out circuit means being responsive to the amount of driving force of said intensifier means transmitted to said drive plunger, whereby said punching and riveting work strokes of said drive plunger are independently controlled.

3. The combination of claim 1 wherein said intensifier means comprises a booster cylinder having a pneumatic-operated double-acting drive piston positioned for reciprocating movement therein, said drive piston having a relatively large surface area, and a power cylinder opening directly into said work chamber and having a power piston positioned for movement therein, said power piston being connected to said drive piston for movement therewith and having a relatively small surface area, and wherein said control circuit includes means to pressurize the work end of said booster cylinder, whereby a pneumatic signal from said pneumatic control circuit acting against said power piston generates a relatively large hydraulic driving force through said power cylinder to actuate said drive plunger to perform said final work movement.

4. The combination of claim 3 wherein said pneumatic control circuit includes first and second call-out circuit means having a first and second pressure responsive valve
means, respectively, communicating with said booster cylinder to thereby interrupt the respective work stroke and initiate the return stroke of said drive plunger in response to the final work movement of said drive plunger.

5. The combination of claim 4 wherein said first call-out circuit means further includes a plurality of sensor ports positioned along the length of said booster cylinder, said first valve means being selectively connected to one of said ports to thereby sense the travel of said drive plunger by detecting the increase in pressure due to the movement of said drive piston past the selected port.

6. The combination of claim 5 wherein said second call-out circuit means further includes a pressure port communicating with said pressured work end of said booster cylinder, said second valve means being connected to said port to thereby sense the force being applied by said drive plunger by detecting the pressure acting on said drive piston.

7. The combination of claim 1 wherein is further provided between said chamber communicating with said work chamber, a check valve positioned between said head chamber and said work chamber to allow free flow of hydraulic fluid in a first direction from said head chamber to said work chamber and prevent flow in a second direction from said work chamber to said head chamber, and wherein said pneumatic control circuit means comprises means to pressurize said head chamber from said source of pressurized air to cause said hydraulic fluid to flow in said first direction whereby to effect a rapid approach movement of said drive plunger during said work strokes, and release means for said check valve to allow said hydraulic fluid to flow in said second direction on said return stroke of said drive plunger.

8. The combination of claim 7 wherein said check valve includes a cylindrical body member threadedly engaging said housing generally along said work axis, a passageway in said member for allowing passage of said fluid in both directions, a closure element seated in said passageway, a spring biasing said closure member closed in said second direction, and wherein said release means comprises a pneumatic motor mounted in said body member to unseat said closure element in response to said pneumatic control circuit.

9. The combination of claim 7 wherein said pneumatic control circuit includes an automatic operation enabling circuit for initiating said riveting operation at the conclusion of said punching operation, said enabling circuit including a valve means responsive to the positioning of said drive plunger to initiate the work stroke at the end of said return stroke.

10. The combination of claim 7 wherein said working cylinder and said operating piston further define an expandable return chamber in opposed relationship to said work chamber, and said pneumatic control circuit includes a timing circuit to initiate the operation of said intensifier means, said timing circuit being connected to the expandable return chamber and comprising means for preventing said return chamber during said work strokes, a pilot valve for sensing a predetermind pressure in said return chamber indicating the completion of said rapid approach movement of said drive plunger, and adjustable regulator means for regulating the flow of air from said return chamber during said work strokes whereby said predetermined time can be varied.

11. The combination of claim 7 wherein said positioning means includes a shift cylinder mounted on said housing for reciprocating movement in a first and second direction to alternately position said punching and riveting means along said work axis, said welding means being selectively connected to said shift cylinder whereby the selected one of said punching and riveting means is positioned along said work axis before said drive plunger begins said rapid approach movement.

12. The combination of claim 9 wherein said enabling circuit further includes first and second call-out circuit means responsive to the initiation of said punching operation and second permissive means responsive to the actuation of said intensifier means and said first permissive means, whereby said riveting operation is initiated only at the conclusion of a complete punching operation.

13. The combination of claim 1 wherein said working cylinder and said operating piston further define an expandable return chamber in opposed relationship to said work chamber, said pneumatic control circuit includes first and second call-out circuit means having a first and second pressure responsive valve means, respectively, communicating with said booster cylinder to thereby interrupt the respective work stroke and initiate the return stroke of said drive plunger in response to the final work movement of said drive plunger, and wherein is further provided means for pressurizing said return chamber in response to said first and second valve means to effect said return stroke of said drive plunger, and a stop bar extending across said work chamber for engagement with said drive plunger to terminate said return stroke.

14. A hydraulic-pneumatic punch riveter for performing punching and riveting operations in succession comprising:

a. A unitary housing having a work axis, an elongated working cylinder extending along said axis,
b. A drive plunger having an operating piston positioned in said cylinder for reciprocating movement including a work stroke and a return stroke along said axis, said operating piston and said cylinder defining an expandable work chamber, said working cylinder and said operating piston defining an expandable return chamber in opposed relationship to said work chamber,
c. Punching means mounted on said housing for positioning along said axis during said punching operation,
d. Riveting means mounted on said housing for positioning along said work axis during said riveting operation,
e. Means for selectively positioning said punching and riveting means into operative position along said axis,
f. Hydraulic power means operatively connected to said work chamber for actuating said drive plunger into operative engagement with said punching means said riveting means in succession to perform the punching and riveting work strokes, respectively, of said operations,
g. Said hydraulic power means including a power cylinder extending laterally from said working cylinder, said power cylinder forming a power chamber opening directly into said work chamber, and a power piston in said power cylinder for interposing the hydraulic pressure in said work chamber,
h. A pneumatic booster cylinder for operating said power piston thereby causing the final work movement of said drive plunger during said punching and riveting work strokes,
i. And a pneumatic control circuit including a source of pressurized air for operating and cycling said hydraulic power means and said positioning means.

15. The combination of claim 14 wherein said pneumatic control circuit includes first and second call-out circuit means having a first and second pressure responsive valve means, respectively, communicating with said booster cylinder to thereby interrupt the respective work stroke and initiate the return stroke of said drive plunger in response to the final work movement of said drive plunger.

16. The combination of claim 15 wherein said first call-out circuit means further includes a plurality of
sensor ports positioned along the length of said booster cylinder, said first valve means being selectively connected to one of said ports to thereby sense the travel of said drive plunger by detecting the increase in pressure due to the movement of said drive piston past the selected port, a third pressure responsive valve means in said first call-out circuit means connected to the work end of said booster cylinder to selectively activate said first call-out circuit means in response to pressure in said work end, and a fourth pressure responsive valve means in said first call-out circuit means connected to the return end of the booster cylinder to selectively activate said first call-out circuit means in response to the absence of pressure in said return end, whereby said first circuit means is activated only in response to a sudden increase in pressure indicating said movement of said drive piston past said selected port.

17. The combination of claim 15 wherein said working cylinder further includes a head chamber communicating with said work chamber, a check valve positioned between said head chamber and said work chamber to allow free flow of hydraulic fluid in a first direction from said head chamber to said work chamber and prevent flow in a second direction from said work chamber to said head chamber, and wherein said pneumatic control circuit comprises means to pressurize said head chamber from said source of pressurized air to cause said hydraulic fluid to flow in said first direction whereby to effect a rapid approach movement of said drive plunger during said work strokes, and release means for said check valve to allow said hydraulic fluid to flow in said second direction on said return stroke of said drive plunger.

References Cited

UNITED STATES PATENTS
1,469,261 10/1923 Havener 227—73
2,216,403 10/1940 Oeckl 227—99 X
3,312,382 4/1967 De Voss 227—73
2,131,688 9/1938 Marchant 227—67 X
2,627,766 2/1953 Marchant 227—67

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227—68, 99