This invention relates to tube end forming machines, and more particularly to a manually-controlled hydraulically-operated machine for automatically beading, flaring, flanging, expanding, sinking, and otherwise shaping the end of a tube of any workable material, such as aluminum, steel, etc.

One object of the present invention is to provide a machine of the above nature, in which the tube will be manually inserted and pushed against an adjustable stop member and then clamped by means of a pair of cooperating chucking die members before the shaping or forming operation.

A further object is to provide a machine of the above nature, in which the stop member will be swung downwardly out of the way of the forming tool before the latter strikes the end of the tube.

A further object is to provide a machine of the above nature in which the stop member is pivotally connected to the upper crosshead of the machine, and is movable with it downwardly out of the way of the forming tool before the latter strikes the end of the tube.

A further object is to provide a machine of the above nature having a split horizontal chucking die, the upper section of which is movable downwardly by hydraulic action for clamping the work tightly against the lower section prior to and during the forming operation.

A further object is to provide a machine of the above nature in which provision is made of a set of interchangeable dies and punches, which will permit a wide variety of tube sizes and shapes to be formed on a single machine.

A further object is to provide a machine of the above nature in which sinking and expanding tools may also be selectively carried by the same ram which operates the beading, flaring, and flanging punch.

A further object is to provide a machine of the above nature, in which the tube end forming operation will be performed automatically in a fraction of the time required with former manual methods, and which machine may be operated by relatively unskilled labor on a mass production basis.

A further object is to provide a machine of the above nature which will be relatively simple in construction, inexpensive to manufacture, easy to install and manipulate, compact, ornamental in appearance, safe and quiet in operation, powerful, double-acting, self-lubricated, having a minimum of moving parts, and very efficient and durable in use.

With these and other objects in view, there have been illustrated on the accompanying drawings several forms in which the invention may conveniently be embodied in practice.

In the drawings,

Fig. 1 represents a front elevation of the improved heavy duty tube end forming machine embodying the present invention.

Fig. 2 is a rear elevation of the same, showing the arrangement of the operating valves and piping connections.

Fig. 3 is a top plan view of the same, showing a flaring punch holder secured on the forward end of the reciprocating ram.

Fig. 4 is a perspective view, on a larger scale, of one half of the split tube-chucking die.

Fig. 5 is a side view, partly in section, of a flared tube produced by the machine.

Fig. 6 is a longitudinal sectional view of the machine, taken along the line 6—6 of Fig. 3, looking in the direction of the arrows.

Fig. 6A is a fragmentary sectional view similar to a portion of Fig. 6, showing the die, the punch, and the stop bar in the positions they would occupy at the end of a flaring operation, and also showing the flared tube partly in section.

Fig. 7 is a transverse sectional view taken along the line 7—7 of Fig. 6.

Fig. 8 is a perspective view of an intermediate sinking die which is adapted to be detachably connected to the tool-carrying ram and which is interchangeable with the forward tube end forming punch holder.

Fig. 8A is a fragmentary sectional view showing the appearance of the sinking die when installed in operating position in the opposed slots of the ram.

Fig. 9 is a fragmentary sectional view of the forward part of the ram, showing the expanding punch installed at the rear of the ram recess.

The heavy duty hydraulic tube end forming machine herein disclosed is similar in some respects, and constitutes an improvement over a light weight pneumatically-operated tube end forming machine, disclosed in a prior application by the same inventor, Serial No. 556,189, filed September 28, 1944, and entitled "Tube End Forming Machine," patented May 26, 1948, No. 2,442,224.

In the cycle of operation of the present machine, when the "start" push button is pressed, the crosshead will first move down to close the chucking dies about the tube, which has previously been inserted manually through said dies. The horizontal ram (carrying the forming tool or
tools) will then move forwardly to process the tube end shapes, and then withdraw—each phase of the operating cycle progressing automatically without further attention on the part of the operator. The upper chucking die will then rise to permit the manual removal of the formed tube.

The present machine employs the cold forging principle. A steady hydraulic pressure is exerted on the full circumference of the tube end, with the result that more severe and complete working of the metal becomes possible than could be accomplished with any rolling or spinning process where only a small section of the tube was engaged at one time.

During the forming operation, the gauge may actually be increased, resulting in greater strength, and smooth tube end shapes will be obtained which are free from all rolling and spinning marks, as well as hammer impressions. Objectional vibrations are also eliminated due to the absence of rapidly rotating eccentric rolls and reciprocating swaging hammers.

A wide variety of tube end shapes may be produced with a single machine. The tools are relatively inexpensive and the machine is efficiently laid out to accommodate the numerous forming tools. Thus a simple set of tools consisting of a punch, and a pair of clamp blocks may be employed to produce work within commercial tolerances, or a more elaborate self-contained set of tools can be built requiring no adjustments, to obtain a combination of shapes to fit exacting specifications with one operation.

A safety feature of the machine is the emergency “stop” button, which, when depressed at any time during the operating cycle, causes the machine to reverse instantly, and open up the chucking dies so that the tube may be removed, whenever desired.

Essentially the machine is a versatile, double-action automatic hydraulic press. It is double-action by reason of the fact that it operates both the vertically-movable crosshead and the horizontally-movable forming ram. It is automatic in that the pressing of the “start” push button causes the machine to complete an entire cycle of operation within a short time.

The chucking crosshead and the tool-carrying ram are both actuated by pistons located in hydraulic cylinders in which oil under pressure is forced by a motor-driven pump from an oil reservoir which is built into the frame of the machine. The pump is operated from an independent control box which starts and stops the motor. Hydraulic valves installed in the hydraulic circuit, located at the rear of the machine, control the operating pressures of the system and the proper sequence of each phase of the cycle. All of these valves are accessible and easily adjusted.

By means of the present machine, numerous tube end shapes such as beads, single and double-lapped flares, single and double-lapped flanges, expanded and reduced sections, as well as combinations of the same, may be readily formed on tubes of any workable metal or alloy.

In view of the fact that the present machine has only a few moving parts and that only the motor and pump bearings and the horizontal traveling slide require lubrication, long life can be expected therefrom.

Referring now to the drawings in which like reference numerals denote corresponding parts throughout the several views, the numeral 19 indicates the rectangular frame of the machine, and the numeral 10a the upper portion thereof. The frame 10 is supported upon the floor by means of four vertical legs, as shown.

In the forward part of the upper frame portion 10a, provision is made of an upstanding end thrust lug 11 which is adapted to support a pair of complementary Cooperating bolt and top chucking dies 12, 13, the former of which is seated on the plane portion 19a. Each of the chucking dies 12, 13 is herein shown (Fig. 4) as being provided on one flat horizontal face with a plurality (three in this instance) of semi-circular die grooves 16, 17, 18, and is on its opposite face with a single semi-circular die groove 19. The die grooves 16, 17, 18, 19 are provided with beveled edges 20, 21, 22, 23, respectively, as shown. The outer sides of both chucking dies 12, 13 are provided with vertical rectangular slots 24, 25 which are adapted to absorb the end thrust of the forming ram and guide the movable chucking die in its up and down movements in cooperation with a pair of vertical ribs 23, 25 formed on a pair of U-shaped brackets 28, 25 secured to the upper frame 10a.

The upper chucking die 13 is adapted to be raised and lowered into and out of clamped position through a pair of vertical draw bars 30, 31, which are preferably round in cross section, and provided on their upper ends with a pair of nuts 32, 33, respectively, which engage tightly against a movable upper crosshead 35 which embraces said drawbars, and to which the upper movable chucking die is detachably secured as by screws 33a, 33a located in tapped holes 33b, 33b.

Provision is also made of a lower crosshead 35 which is secured to the drawbars 30, 31 by a pair of nuts 36, 37 located underneath said lower crosshead 35. The crosshead 35 is adapted to be connected by means of a chucking cylinder bolt 38, having a head 39 and a threaded lower end 40, to a tapped upper neck 41 of a chucking piston 42, which is adapted to reciprocate vertically within a chucking cylinder 43 supplied with light oil under pressure from an oil reservoir 45 through a pair of ports 44, 45.

By means of this construction, it will be seen that the chucking piston 42 is adapted to be moved upwardly and downwardly, respectively, to clamp and unclamp the tube T between the chucking dies 12, 13.

After the tube T has been clamped tightly between the chucking dies 12, 13, by the mechanism described above, it is adapted to be beaded, flared, flanged, expanded, sunk, double-lap flared, double-lap flanged, etc. by means of a horizontal tool-carrying U-shaped plunger gate or ram 48 which is adapted to slide within a pair of horizontal dovetailed ways 45a, 46a mounted in the top of the frame section 10a.

The ram 48 has secured thereto at its forward end, as by screws 49a, a punch-holding block 48, which has a punch 49 detachably held therein selectively, in any one of three horizontal sockets 50, by set screws 47.

The ram 48 is provided with a forward rectangular recess 47a having a pair of opposed intermediate vertical slots 51, 52 for selectively receiving a reducing (or sinking) die (Fig. 8), shaped to fit within said slots 51, 52 (see Fig. 8a) and having a pair of side flanges 54, 55 (see Fig. 8), said side flanges being adapted to rest upon the top surface of ram 48 at points adjacent said slots 51, 52.

The recess 47a in the ram 45 is also provided with a rear cylindrical socket 58 above which is a
vertical aperture 57 for receiving a vertical set screw 56a which is adapted to engage a centering plug 59 of a detachable expanding punch 58 (as clearly shown in Fig. 3)—said plug 59 being in said socket 55.

It will be understood that the end punch 49, the sinking die 53, and the expanding punch 58 may be selectively employed, and in use may be detachably secured on the front of the ram 45, in the opposed recesses 51, 52, and in the rear socket 55, respectively.

Embracing the rear end of the ram 46 is a U-shaped adaptor member 60 having a vertical pivot pin passing therethrough, said pivot pin being provided with a knurled top head 62 for convenience in manipulation.

The adaptor member 63 is provided with a reduced rear threaded section 63 which is adapted to be screwed into a ram-operating piston rod 64 which is connected to a piston located within a horizontal working cylinder 65 supplied with oil under pressure from the pump 80 through a pair of ports 66, 67.

In order to limit the inward movement of the tube T when it is being inserted between the chucking dies 12, 13, provision is made of a substantially vertically adjustable rectangular open bracket 58 having a forwardly-offset horizontal bottom stop bar 68. The bracket 68 is provided at its top with a forwardly inclined ear 70 which is pivoted on a horizontal pin 71, mounted in a pair of opposed pivot brackets 72, 73 secured to a raised section of the upper crosshead 34, as clearly shown in Figs. 6 and 7 of the drawing.

Provision is also made of a pair of rearwardly-extending coiled springs 74, 75 located in a horizontal position in sockets on the rear of the upper crosshead 34—said springs engaging intermediate sections of the vertical legs of the stop bracket 65, as shown.

In order to adjust the position of the bottom stop bar 68, provision is made of a horizontal adjusting screw 76 having a forward threaded end located in a tapped hole 77 on the rear of the upper crosshead 34, and being provided with a knurled rear head 78 for convenience in manipulation.

The intermediate portion of the stop-adjusting screw is adapted to be located within an elongated slot 79 formed in the bracket 65 below the forwardly inclined top ear 70.

The numeral 80 indicates a hydraulic pump which is adapted to be driven by an electric motor 81 under the control of a motor starter 82, having a pair of "start" and "stop" switch push buttons 83, 84, as clearly shown in Fig. 1. Oil for operating the hydraulic system is stored in the reservoir 48. Provision is also made of a pair of relays 85, 87 located near the lower portion of the frame 40—said relays being connected to a four-way valve 88, having a pair of solenoids 89, 90, as clearly shown in Fig. 2.

Operation

In the operation of the machine herein disclosed, the motor-driven pump 88 will force oil under pressure from the reservoir 85 to the chucking cylinder 43 for depressing the upper chucking die 13 against the lower die 12, thereby lowering the stop bar 69 out of the path of the forming tool, and subsequently will deliver oil under pressure to the working cylinder 65 to force the punch-carrying ram 45 forwardly toward the tube T.

The operating cycle of the machine is started by actuating the "start" push button 96, which is located conveniently at the upper front portion of the machine. This causes the contacts of the relay 85 to close, and energize one coil 89 of the solenoid-operated four-way valve 88. Oil under pressure will then flow from the pump 80 through the main relief valve 91, the solenoid valve 88, the secondary relief valve 92, into the chucking cylinder 43, causing the upper chucking die 13 to descend and clamp the tube T, which has previously been inserted manually through the end of the machine against the adjustable stop bar 89.

The oil pressure will then build up and cause the secondary relief valve 92 to open, permitting oil to flow into the rear of the piston in the main working cylinder 65, and thus causing the ram 45 to carry the forming tool against the tube T.

When the tube T has been shaped by the forming tool carried by the ram, the pressure will build up still further and cause the pressure switch 93 to close automatically and actuate the second relay 97 which will reverse the position of the solenoid valve 88. Oil will then be admitted to the forward side of the piston in the working cylinder 65, and the ram 45 will be caused to return to its original rear position.

It will be understood that during the rearward movement of the tool-carrying ram 45, the crossheads 34 and 35 will be held in the "down" position by the counter-balance and sequence valves 94, 95.

When the ram returns to its original rear position, it will also be understood that the operation of the valves 94, 95 will admit oil to the chucking cylinder 43 causing the vertical crossheads 34, 35 to rise to their original elevated positions.

The tube T may then be removed manually from the machine, which will then be ready for another operating cycle.

If at any time it is desired to remove a defective tube, or stop the machine for any other reason, without the necessity of completing the entire cycle of operation, it will only be necessary to depress the emergency "stop" button 97, causing the operating cycle to reverse itself immediately.

It will be understood that if desired, the system can be so regulated that only the crosshead will descend and rise, or that only the ram will reciprocate.

The relays 86, 87, are, of course, controlled by the "push" buttons 96, 97 and the automatic pressure switch 83. In other words, the actuation of the "start" button 96 will operate the relay 86, while the actuation of the "stop" button 97, or the automatic operation of the pressure switch 93, will cause the other relay 87 to function.

One advantage of the present machine is that it is extremely easy to operate, because it is merely necessary for the operator to sit or stand
in front of the machine and manually insert the tube T through an opening inside of the casing, until it engages the stop bracket S8. It will then only be necessary to operate the "start" push button S6, whereupon the upper chucking die 13 will close upon the tube T, and the successive steps of the forming operation will thereafter be performed automatically, including the retracting of the tool-carrying ram, and the opening of the chucking dies, after which the tube T may be removed manually by the operator.

A further advantage is that the stop bracket may be readily adjusted by the manipulation of the length screw 76 so as to control the outside diameter of the head or the shape of the flange, flange, etc., formed on the tube end, with a high degree of accuracy.

A further advantage is that all moving parts of the machine may be enclosed by a protective casing (not shown), thereby making it entirely safe for the operator.

A further advantage is that with the present machine it is possible to produce a flange in which all waviness is eliminated.

A further advantage is that progressive operations may be performed with the same machine by means of three sets of tools laid side by side (as shown in Fig. 4).

The present machine also makes it possible to produce a steep flare on the end of a tube, and, if desired, mandrels may be used, which may or may not be collapsible, and may or may not be used with strippers.

A further advantage of the present machine is that since the tube is arranged in a horizontal position, longer lengths may be handled than would be possible with vertical crank-operated presses.

While there has been disclosed in this specification several forms in which the invention may be conveniently embodied, it is to be understood that these forms are shown for the purpose of illustration only, and that the invention is not to be limited to the specific disclosures, but may be modified and embodied in various other forms without departing from its spirit. In short, the invention includes all the modifications and embodiments coming within the scope of the claims.

Having thus fully described the invention, what is claimed as new, and for which it is desired to secure Letters Patent, is:

1. In a machine for automatically forming the end of a tube made of a material capable of being cold-worked, hydraulic means for chucking said tube to hold it in stationary position, a punch for engaging the end of said tube, a hydraulically-operated punch-holding ram mounted to reciprocate in said machine, means for operating said chucking means to clamp said tube means, responsive to the completion of said chucking operation to automatically thereafter successively advance and retract said ram to force said punch into and out of engagement with the end of said tube and open said chucking means, and stop means to limit the inserted position of the end of said tube prior to the closing of said chucking means, said stop means being fixed upon said chucking means for movement therewith including clamping and unclamping movement thereof.

2. In a machine for forming the end of a tube made from a material capable of being cold-worked, a frame, a stationary lower chucking die secured to said frame, a hydraulically-operated downwardly movable crosshead, an upper chucking die secured to said crosshead for clamping said tube against said stationary chucking die, a forming tool, a hydraulically-operated ram having means for detachably holding said tool, means responsive to the completion of the clamping of said tube for automatically thereafter successively advancing and retracting said ram to force said tool into and out of forming engagement with the end of said tube and raising said upper chucking die, and stop means to limit the inserted position of said tube prior to the closing of said chucking dies, said stop means being fixed upon said upper chucking die for movement therewith including clamping and unclamping movement thereof.

3. In a machine for forming the end of a tube made from a material capable of being cold-worked, a frame, a stationary lower chucking die secured to said frame, a hydraulically-operated downwardly movable crosshead, an upper chucking die secured to said crosshead for clamping said tube against said stationary chucking die, a forming tool, a hydraulically-operated ram having means for detachably holding said tool, means responsive to the completion of the clamping of said tube for automatically thereafter successively advancing and retracting said ram to force said tool into and out of forming engagement with the end of said tube and raising said upper chucking die, and a rectangular open stop bracket pivoted to said crosshead above the position of said tube, said bracket having a bottom stop bar initially in alignment with said tube to limit the position thereof when it is being inserted through the chucking dies, prior to the closing thereof, the downward movement of said crosshead, and opening the chucking dies serving to move said stop bar out of alignment with said tube and ram.

4. In a machine for forming the end of a tube made from a material capable of being cold-worked, a frame, a stationary lower chucking die secured to said frame, a hydraulically-operated downwardly movable crosshead, an upper chucking die secured to said crosshead for clamping said tube against said stationary chucking die, a forming tool, a hydraulically-operated ram having means for detachably holding said tool, means responsive to the completion of the clamping of said tube for automatically forcing said upper die down upon said tube, and thereafter successively advancing and retracting said ram to force said tool into and out of forming engagement with the end of said tube and raising said upper chucking die, and a rectangular open stop bracket pivoted to said crosshead above the position of said tube, said bracket having a bottom stop bar initially in alignment with said tube to limit the position thereof when it is being inserted through the chucking dies, prior to the closing thereof, the downward movement of said crosshead, and opening the chucking dies serving to move said stop bar out of alignment with said tube and ram.

5. In a machine for forming the end of a tube made from a material capable of being cold-worked, a frame, a stationary lower chucking die secured to said frame, a hydraulically-operated downwardly movable crosshead, an upper chucking die secured to said crosshead for clamping said tube against said stationary chucking die, a forming tool, a hydraulically-operated ram having means for detachably holding said tool, means responsive to the completion of the clamping of said tube for automatically successively advancing and retracting said ram
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to force said tool into and out of forming engagement with the end of said tube and raising said upper chucking die, and said ram having an open rectangular recess at the forward end thereof, means for detachably and selectively securing to the end of said ram a punch for bending, flaring, or flanging the end of said tube, means on the opposite sides of said ram recess for detachably and selectively securing a tool for reducing the diameter of the end portion of said tube, and means in the rear of said ram recess for detachably and selectively securing a tool for expanding the diameter of the end portion of said tube.

6. In a machine for forming the end of a tube made from a material capable of being cold-worked, a frame, a stationary lower chucking die secured to said frame, a hydraulically-operated downwardly movable crosshead, an upper chucking die secured to said crosshead for clamping said tube against said stationary chucking die, a forming tool, a hydraulically-operated ram having means for detachably holding said tool, means responsive to the completion of the clamping of said tube for automatically forcing said upper die down upon said tube, and thereafter successively advancing and retracting said ram to force said tool into and out of forming engagement with the end of said tube and raising said upper chucking die, a U-shaped adaptor embracing the rear of said ram, and a removable vertical pivot pin passing through the arms of said adaptor and said ram, said adaptor having a reduced threaded rear end detachably connected to the hydraulic ram-operating piston.

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