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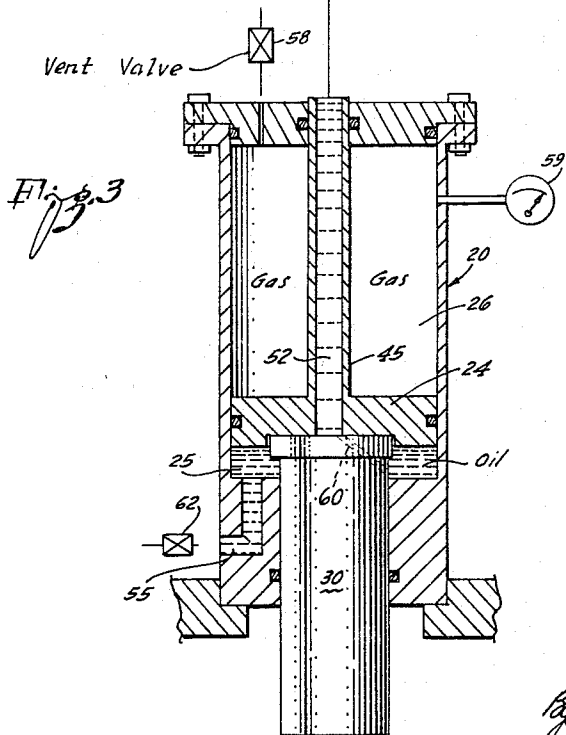
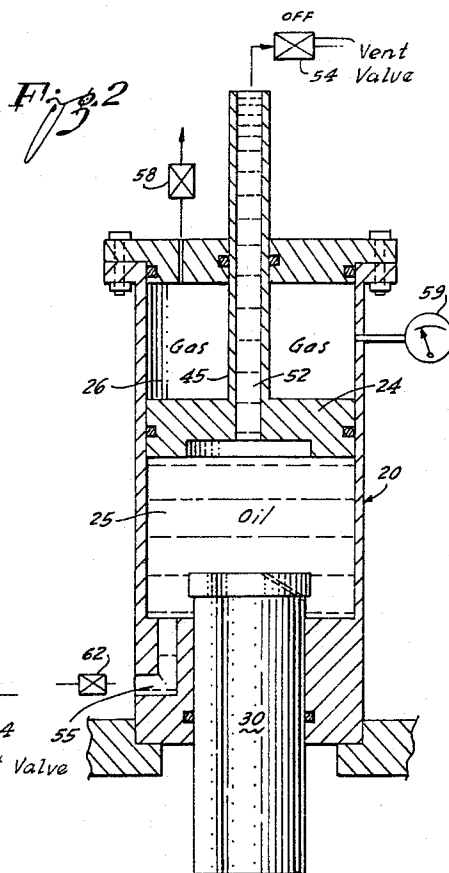
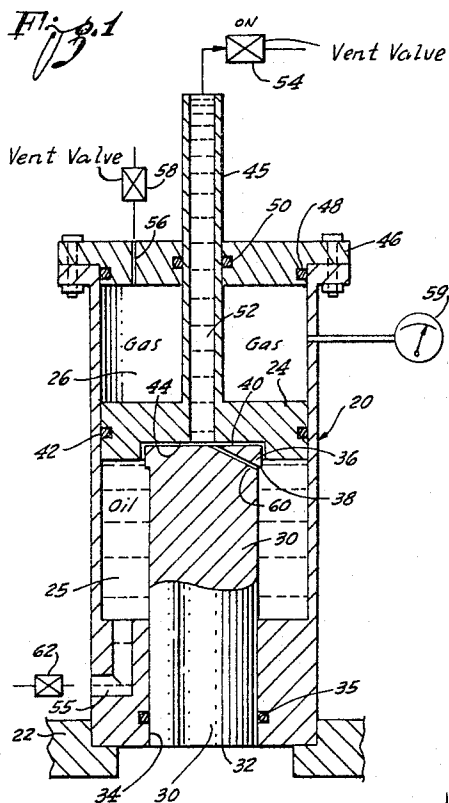
L. C. BOLLAR

3,267,677

IMPACT FORMING MACHINE

Filed May 9, 1963

2 Sheets-Sheet 1



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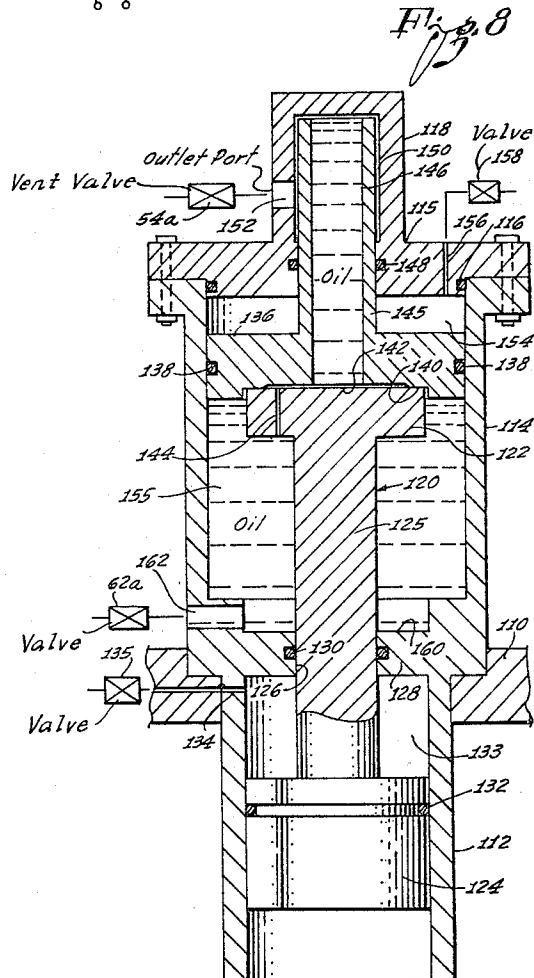
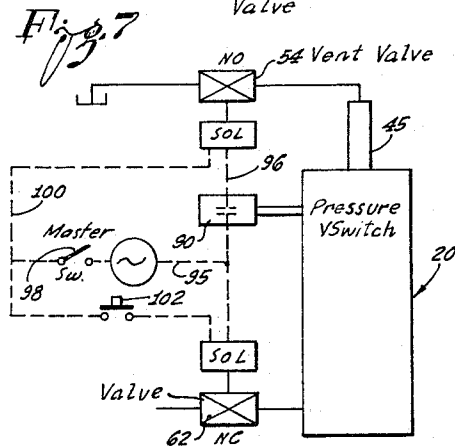
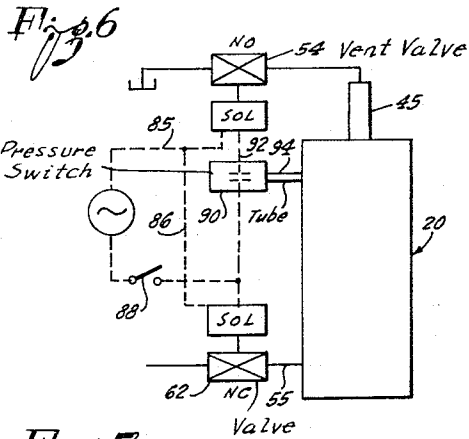
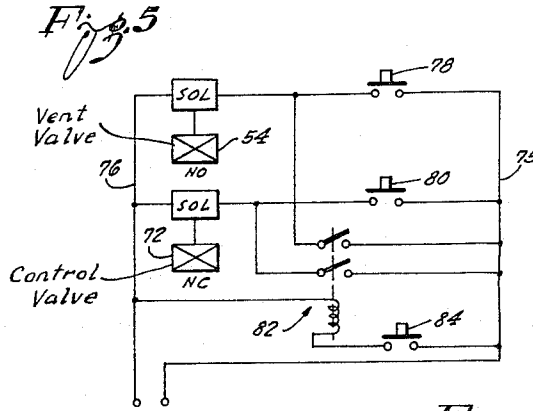
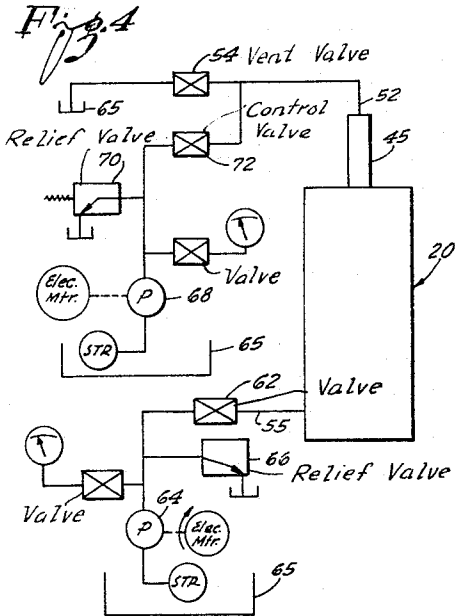
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IMPACT FORMING MACHINE

Filed May 9, 1963

2 Sheets-Sheet 2



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3,267,677

IMPACT FORMING MACHINE

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20 Claims. (Cl. 60—54.5)

This invention relates to a high-energy rate forming machine for processing workpieces, for example for forging or extruding metal parts by impact force. This invention is particularly directed to the problems of providing such an apparatus that is inherently capable of safe, simple and versatile control.

The importance of safety in the control of an impact forming apparatus is obviously foremost because of the abruptness and exceedingly high energy of a working stroke. The desirability of simplicity of control is closely related to safety because the working cycle of the apparatus is dependent upon valves and perhaps other control components which must be operated at correct timing and in correct sequence. A highly skilled operator is usually required and the continuous responsibility of making correct control manipulations causes even the most experienced operator to become tense and unnecessarily fatigued.

From the standpoint of production a further requirement is to speed up the frequency of the operating cycle. The difficulty is that most operating cycles require an unduly long period of time for resetting the apparatus after a working stroke. The gaseous actuating fluid must be restored to its starting pressure and usually some kind of triggering means must be restored or reset at the cost of slowing up production.

Versatility of control is also economically important because the optimum amount of impact energy required varies widely for different workpieces. It is highly desirable to have an apparatus that is adjustable in this respect and it is especially desirable to avoid the necessity of time-consuming adjustments.

The object of the invention is to meet all of these needs by providing an inherently safe apparatus that may be operated by simple push-button control, or, if desired, may operate automatically with repetitive cycles and, in addition, is capable of operation selectively over a wide range of energy levels with no set-up time required for shifting from one energy level to another over the wide range.

Broadly described, the invention attains these objects by introducing liquid under pressure into the apparatus to act on a forwardly facing area of a ram piston to retract the ram piston in opposition to an actuating body of pressurized gaseous fluid thereby storing operating energy in the gaseous fluid. Means inside the apparatus that is movable with the ram piston normally isolates at least a portion of the rearwardly facing area of the ram piston from the pressure of the introduced liquid to make the retraction of the ram piston possible. For this purpose the region of the isolated area of the ram piston may be vented to a low pressure zone, for example the atmosphere.

To initiate a working stroke, the region of the isolated rearwardly facing area of the ram piston is placed under sufficient pressure to cancel out the liquid pressure on the forwardly facing area of the ram piston and thereby release the ram piston for actuation by the high pressure gaseous body. The initial working movement of the ram piston separates the ram piston from the isolating means and thereby places the whole of the rearwardly facing area of the ram piston in communication with the liquid. In one practice of the invention the liquid surrounding the ram piston is placed under pressure by the gaseous fluid body and the liquid transmits the actuating pressure to

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the ram piston. In another practice of the invention the gaseous fluid acts directly on the ram piston.

A special advantage of the described control arrangement is that since the isolating means moves with the ram piston, the isolation of the portion of the rearwardly facing area of the ram piston may be terminated to initiate a working stroke at any point in the whole range of retraction movement of the ram piston. Thus the energy delivered by the ram piston may be varied by simply varying the range of retraction of the piston. The magnitude of the delivered energy, however, depends primarily on the pressure of the actuating body of gaseous fluid. For this reason precision in the selection of the magnitude of the delivered energy is provided by sensing the rise of pressure of the gaseous fluid instead of measuring the retraction of the ram piston and selecting the point in the pressure rise at which the ram piston is to be released.

The features and advantages of the invention may be understood from the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a diagrammatic sectional view of a selected embodiment of the invention with the apparatus poised for an operating stroke;

FIG. 2 is a similar diagrammatic sectional view showing the ram piston at the end of its working stroke;

FIG. 3 is a similar view showing how the ram piston is retracted by liquid pressure in preparation for a new operating cycle;

FIG. 4 is a diagram of the hydraulic system for controlling the apparatus;

FIG. 5 is a wiring diagram of a control circuit that may be employed with the hydraulic system;

FIG. 6 is a diagram of a control system for automatic operation of the apparatus with the apparatus repeating its operating cycle without loss of time for high production, hydraulic components being shown in solid lines and electrical components being shown in dotted lines;

FIG. 7 is a diagrammatic view similar to FIG. 6 showing a control system for push-button operation of the apparatus; and

FIG. 8 is a diagrammatic sectional view illustrating a second embodiment of the invention with the apparatus poised for a working stroke.

Referring to the first embodiment of the invention shown in FIGS. 1, 2 and 3, the apparatus comprises a fluid-confining structure in the form of an upright cylinder, generally designated 20, which is supported by suitable base structure 22. What may be termed a follower piston 24, which serves as the required isolating means, divides the interior of the cylinder 20 into a first lower chamber 25 and a second upper chamber 26. A ram piston 30 is mounted in the lower chamber with the leading or working end 32 of the ram piston exposed for delivering impact force. The leading end of the ram piston may act directly on workpieces or may transmit its energy to some movable body which in turn transmits the impact force to workpieces.

The ram piston 30 which is substantially smaller in diameter than the lower chamber 25 functions as a plunger and for this purpose is slidably mounted in an extensive cylindrical guideway 34, the guideway being equipped with a sealing O-ring 35. The upper end of the ram piston 30 is formed with a concentric enlargement 36 which forms an annular shoulder 38. It is apparent that the trailing end of the ram piston 30 has a rearwardly facing surface 40 to receive driving fluid pressure and the annular shoulder 38 presents a forwardly facing annular surface to receive pressure for retracting the ram piston after a working stroke.

The follower piston 24, which is provided with a suitable O-ring 42, is formed on its lower face with a concentric recess 44 which is shaped and dimensioned to receive and seat the enlargement 36 of the ram piston 30. The follower piston 24 is further provided with an axial extension 45 which extends to the exterior of the apparatus through a removable upper head 46 of the cylinder 20. The periphery of the upper head 46 is sealed by an O-ring 48 and the upper head is provided with a second O-ring 50 that slidably embraces the axial extension 45 of the follower piston.

The axial extension 45 of the follower piston is of tubular construction and forms a vent passage 52 of liberal cross-sectional area which extends from the lower face of the follower piston to the exterior atmosphere. The vent passage 52 is controlled by a suitable valve 54 which is normally open.

The first lower chamber 25 is provided with an angular port 55 through which hydraulic fluid such as a suitable grade of oil may be either introduced or withdrawn in the course of the operating cycle. The upper chamber 26 confines a body of suitable gaseous actuating fluid under high pressure for actuating the ram piston 30 and is provided with a suitable port 56 under the control of a valve 58 through which the gaseous body may be replenished when necessary. The pressure of the actuating fluid is indicated by a pressure gage 59 that is positioned for convenient observation of the operator.

FIG. 1 shows the ram piston 30 retracted and prepared for an operating stroke. The pressure of the confined gaseous body of actuating fluid in the upper chamber 26 urges the follower piston 24 downward against the ram piston 30 with two results. One result is that the high magnitude pressure of the gaseous actuating fluid is imposed on the liquid in the lower chamber 25. The other result is that the follower piston isolates the surface of the trailing end of the ram piston from the imposed high pressure of the liquid in the lower chamber 25.

Under the applied pressure some liquid from the lower chamber 25 continuously bypasses the trailing end of the ram piston to enter the vent passage 52 and with the valve 54 open the bypassed liquid escapes to the atmosphere without creating pressure on the trailing end surface 40 of the ram piston. The bypass flow occurs both by leakage past the trailing end of the ram piston and by flow through a small bypass bore 60 in the ram piston. The bypass bore may be omitted, if desired, so that the bypass is entirely by leakage around the ram piston. In either event the venting of the region of the trailing surface of the ram piston to the atmosphere keeps the vent passage 52 full of liquid without permitting the liquid to rise in pressure.

A valve 62 may be at least partially open for continuous introduction of liquid through the angular port 55 into the lower chamber 25 and whenever desired this replenishing flow may be regulated to equal the bypass flow to hold the ram piston 30 stationary. On the other hand the inflow of liquid through the valve 62 may be increased above the rate of bypass flow for retraction of the ram piston 30 prior to an operating stroke or may be reduced below the bypass flow to permit the ram piston to advance as may be desired in preparation for an operating stroke. Since the pressure on the trailing surface 40 of the ram piston 30 is substantially atmospheric pressure, the ram piston is held in its retracted position in opposition to gravity by the pressure of the liquid in the lower chamber 25 on the forwardly facing annular surface of the annular shoulder 38.

To initiate an operating stroke it is merely necessary to close the vent valve 54 to prevent escape of the bypassed fluid in the vent passage 52. With the valve 54 closed, pressure rises rapidly in the vent passage 52 to cause the pressure in the vent passage to equalize rapidly

with the pressure in the lower chamber 25. Pressure over the area of the trailing surface 40 of the ram piston overcomes the pressure on the forwardly facing annular surface of the shoulder 38 of the ram piston to cause a sudden separation between the ram piston and the follower piston 24. The body of gaseous fluid in the upper chamber 26 then expands against the confined liquid in the lower chamber 25 and the pressure of the liquid in the lower chamber acting on the trailing end surface of the ram piston 30 drives the ram piston downward with highly accelerated velocity. The piston is driven to a lower limit position, for example the position shown in FIG. 2.

At this time at the end of an operating stroke the follower piston 24 is separated from the ram piston 30 by intervening liquid in the lower chamber 25. The follower piston 24 may be lowered to make contact again with the ram piston 30 as shown in FIG. 3 either by releasing liquid from the lower chamber 25 through the angular port 55 or by releasing liquid from the chamber 25 by opening the vent valve 54. The preferred procedure is to cause liquid to flow continuously into the lower chamber 25 through the angular port 55 and to open the vent port 54 to permit the follower piston 24 to descend.

As soon as the follower piston 24 makes contact with the ram piston 30 as shown in FIG. 3 and thus again isolates the trailing surface 40 of the ram piston from the liquid in the lower chamber 25, the pressure of the continuously introduced liquid causes the ram piston to retract upward and to carry with it the follower piston 24 in opposition to the pressure of the gaseous fluid in the upper chamber 26. The liquid pressure on the annular surface of the shoulder 38 is sufficient to overcome the weight of the ram piston and lift the ram piston. At the same time the liquid pressure on the under side of the follower piston causes the follower piston to rise with the ram piston. As the two pistons retract upward they progressively contract the volume of the upper chamber 26 to progressively store energy in the confined gaseous fluid. It is apparent that the vent valve 54 may be closed at any time in the course of the rise of the two pistons to create an operating stroke at an energy level that is determined by the degree of pressure rise in the upper chamber 26. For guidance of the operator, the pressure gage indicates the pressure rise of the actuating fluid and also indicates the extent of retraction of the ram piston.

FIG. 4 shows diagrammatically an hydraulic system that may be associated with the described fluid confining structure. A suitable continuously running pump 64 actuated by an electric motor draws liquid from the reservoir 65 through a suitable strainer and delivers the liquid to the previously mentioned valve 62, excess liquid being returned to the reservoir through a suitably regulated relief valve 66. The vent passage 52 in the axial extension 45 of the follower piston is connected to the reservoir through the previously mentioned vent valve 54.

It is apparent that, with liquid continuously supplied through the angular port 55, the described operating cycle may be carried out solely by opening and closing the vent valve 54. Thus, with the parts positioned as shown in FIG. 1, closing the vent valve 54 initiates a working stroke by the ram piston. Then with the parts positioned as shown in FIG. 2 at the end of the working stroke, the vent valve is opened with two results in sequence. First, the follower piston 24 drops into contact with the ram piston and then both the ram piston and follower piston retract upward in preparation for a new working stroke.

In some practices of the invention it may be desirable to accelerate the pressure rise in the vent passage 52 when the valve 54 is closed and for this purpose the vent passage may be placed in communication with a high pressure source simultaneously with the closing of the valve 54. To this end the diagram in FIG. 4 includes a pump 68

which also draws liquid from the reservoir 65, the output side of the pump being connected to the usual relief valve 70 and to a control valve 72.

When the valve 54 is closed to initiate an operating stroke, the valve 72 is simultaneously opened to accelerate the pressure rise in the vent passage 52 for the purpose of expediting the initiation of the stroke. Obviously the pump 68 may be omitted by connecting the valve 72 to the output side of the first mentioned pump 64.

FIG. 5 shows a wiring circuit for push-button control of two valves 54 and 72 both of which are solenoid valves for remote actuation. One lead 75 from a suitable E.M.F. source is connected to the second lead 76 from the source through a push-button switch 78 in series with the solenoid of the valve 54 and is also connected to the second lead through a push-button switch 80 in series with the solenoid of the second valve 72. A relay 82 is connected across the two leads through a third push-button switch 84, the relay having two contactors to energize the two solenoids simultaneously.

It is apparent in FIG. 5 that the normally open vent valve 54 may be closed by the push-button switch 78 and the normally closed valve 72 may be opened by the push-button 80. If desired, the two valves may be actuated simultaneously by means of the third push-button 84.

FIG. 6 shows a control arrangement for automatically repeating the cycles of operation of the apparatus with no loss of time between cycles, the solid lines showing hydraulic components and the dotted lines showing the electric circuitry. One side of the E.M.F. source is connected by a wire 85 with one side of the solenoid vent valve 54 and is connected by a wire 86 to one side of the solenoid valve 62 that controls the flow of liquid into the lower chamber 25. The second side of the E.M.F. source is connected through a master switch 88 to the second side of the solenoid valve 62 and to one side of a pressure switch 90, the second side of the pressure switch being connected by a wire 92 to the second side of the solenoid vent valve 54. The pressure switch 90 is connected by a tube 94 to the upper chamber 26 containing the actuating gaseous fluid, the pressure switch being normally open and being adjustable to close in response to selected pressures in the upper chamber 26.

When the master switch 88 is closed, the normally closed solenoid valve 62 is opened to introduce liquid into the lower chamber 25 to cause the ram piston 30 and the follower piston 24 to retract upward in the manner heretofore described. When the upward retraction of the two pistons compresses the gaseous fluid 26 to the pressure predetermined by the adjustment of the pressure switch 90, the pressure switch 90 closes to close the normally open vent valve 54 and thereby initiate an operating stroke of the ram piston 30.

It is apparent that the ram piston 30 will operate at a highly productive frequency and that successive workpieces may be fed to the apparatus automatically by means well known in the art. It is also apparent that the length of the operating stroke and the precise energy output desired may be provided by simple adjustment of the pressure switch 90.

One advantage of such an arrangement is that it compensates for leakage of gaseous fluid from the upper chamber 26. If the volume of gaseous fluid in the upper chamber 26 is reduced by leakage, the pressure switch 90 correspondingly delays closing until the desired pressure is attained. Thus the length of stroke of the ram piston 30 increases automatically in compensation for leakage of gaseous fluid to maintain a constant predetermined magnitude of energy delivered by the ram piston.

The control system shown in FIG. 7 is designed for convenient push-button operation of the apparatus. One side of the E.M.F. source is connected by a wire 95 to one side of the solenoid valve 62 and also to one side of the pressure switch 90, the second side of the pressure switch being connected by a wire 96 to one side of the

solenoid vent valve 54. The second side of the E.M.F. source is connected to a master switch 98 and the second side of the master switch is connected to the solenoid vent valve 54 by a wire 100 and is connected to the second side of the solenoid valve 62 through a push-button switch 102.

With the master switch 98 in FIG. 7 closed and with the pressure in the upper chamber 26 at a relatively low magnitude, the upper solenoid vent valve 54 is open to place the vent passage in communication with the atmosphere and the lower solenoid valve 62 is closed to keep liquid under pressure from being introduced into the lower chamber 25. When the push-button switch 102 is closed the solenoid valve 62 opens to introduce liquid under pressure into the lower chamber 25 to lift the ram piston 30 and the follower piston 24. When the upward retraction of the two pistons compresses the gaseous fluid in the upper chamber 26 to the pressure corresponding to the adjustment of the pressure switch 90, the pressure switch 90 closes automatically to close the solenoid vent valve 54 and thus initiate an operating stroke in the manner heretofore described. It is apparent that the two pistons retract upward only when the push-button switch 102 is closed and it is a simple matter to hold the push-button switch 102 closed only long enough to create one operating stroke of the ram piston.

In FIG. 8, illustrating a second embodiment of the invention, a fluid-confining structure mounted on a suitable support 110 includes a lower cylinder 112 that is open at the bottom and an upper cylinder 114 that is closed by a removable head 115. The removable head, which is sealed by an O-ring 116, provides an uppermost auxiliary cylinder 118. A ram piston, generally designated 120, has an enlargement 122 on its trailing end and a piston head 124 on its leading end, the intermediate portion 125 of the ram piston slidingly extending through an opening 126 in a wall 128 that separates the lower cylinder 112 from the upper cylinder 114. The opening 126 is provided with an O-ring 130 and the piston head 124 which reciprocates in the lower cylinder 112 is provided with an O-ring 132.

The piston head 124 cooperates with the lower cylinder 112 to confine a body of gaseous fluid in an annular chamber 133 which acts under pressure against the annular area of the piston head to actuate the ram piston. The gaseous fluid may be replenished as desired through a port 134 under the control of a valve 135.

A follower piston 136 equipped with the usual O-ring 138 cooperates with the trailing end of the ram piston 120 in the manner heretofore described. In the construction shown the follower piston has the usual concentric recess 140 to seat the trailing end of the ram piston and is further provided with a clearance recess 142 which communicates with a bypass bore 144 in the ram piston. The follower piston 136 has the usual axial extension 145 which provides the usual vent passage 146. The axial extension 145 is sealed by an O-ring 148 and slidingly extends into the auxiliary cylinder 118 with liberal clearance 150 in the auxiliary cylinder around the axial extension. The clearance space 150 communicates through a port 152 with the usual vent valve 54a.

The follower piston 136 divides the interior of the upper cylinder 114 in the usual manner into an upper chamber 154 and a lower chamber 155. The upper chamber 154 contains an auxiliary body of gaseous actuating fluid under sufficient pressure to urge the follower piston downward effectively toward the ram piston 120 and this fluid may be replenished when desired through a port 156 controlled by a valve 158.

The lower end of the lower chamber 155 is preferably formed with a concentric recess 160 dimensioned to receive the enlargement 122 of the ram piston. Liquid is introduced into the lower chamber 155 through a port 162 under control of the usual valve 62a.

It is apparent that this second embodiment of the invention functions in the same general manner as the first embodiment, the two valves 54a and 62a being operated in the same manner to carry out an operating cycle. One difference, of course, is that the gaseous actuating fluid 5 confined in the annular chamber 133 acts directly on the ram piston instead of acting through the medium of the liquid in the lower chamber 155.

My description in specific detail of the selected embodiments of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In an impact apparatus, the combination of:
 - a fluid-confining structure;
 - a ram slidably mounted in said structure for movement from a retracted position through an operating stroke to deliver impact force,
 - said ram having a forwardly facing surface and a rearwardly facing surface;
 - a quantity of pressurized fluid in said structure acting on said forwardly facing surface to normally hold the ram at a retracted position;
 - means providing a vent passage in communication with said rearwardly facing surface to bleed said pressurized fluid to a low pressure zone;
 - means normally in contact with the ram to restrict the flow of the pressurized fluid to the region of said rearwardly facing surface to keep the pressure of the pressurized fluid from acting on the rearwardly facing surface sufficiently to overcome the pressure on the forwardly facing surface; and
 - means to cause separation between the ram and the normally contacting means to fully expose the pressurized fluid to the rearwardly facing surface to drive the ram through said stroke.
2. A combination as set forth in claim 1 in which said causing means includes means to cut off the vent passage from the low pressure zone.
3. A combination as set forth in claim 1 in which said causing means includes means to introduce fluid under pressure into said vent passage to act on said rearwardly facing surface.
4. In an impact apparatus, the combination of:
 - a structure adapted to confine fluid;
 - a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said piston having a rearwardly facing surface area inside the structure to receive driving fluid pressure and having a forwardly facing surface area to receive opposing fluid pressure;
 - a body of gaseous actuating fluid confined inside the structure to create pressure on the rearwardly facing surface area of the piston to drive the piston, said body being compressed by retraction of the piston with consequent rise in its pressure;
 - means operative to force liquid into the structure to exert pressure on said forwardly facing surface area in opposition to said actuating fluid;
 - means inside the structure movable with the piston and normally isolating a portion of said rearwardly facing area of the piston from the liquid to cause the liquid to retract the piston in opposition to the pressure of said body of gaseous fluid; and
 - means to place the isolated rearwardly facing surface area of the piston under pressure to cancel the opposite pressure of the liquid against the driving pressure of the gaseous fluid body to initiate a driving stroke of the piston.
5. In an impact apparatus, the combination of:
 - a structure adapted to confine fluid;
 - a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said piston having a rearwardly facing surface area inside the structure to receive driving fluid pressure and

- having a forwardly facing surface area to receive opposing fluid pressure;
- a body of gaseous actuating fluid confined inside the structure to create pressure on the rearwardly facing surface area of the piston to drive the piston, said body being compressed by retraction of the piston with consequent rise in its pressure;
- means operative to force liquid into the structure to exert pressure on said forwardly facing surface area in opposition to said actuating fluid;
- means inside the structure movable with the piston and normally isolating a portion of said rearwardly facing area of the piston from the liquid and normally permitting retarded flow of the liquid to the region of said portion of the rearwardly facing surface area, said region being normally vented to a low pressure zone to prevent rise of liquid pressure thereon; and
- control means to cut off said region from the low pressure zone to cause rise of liquid pressure against said portion of the rearwardly facing surface area to initiate a driving stroke of the piston.
6. In an impact apparatus, the combination of:
 - a fluid-confining structure;
 - a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said ram piston having a first surface inside the structure facing towards its leading end and also having a second oppositely facing surface on its trailing end;
 - a body of high pressure gaseous fluid confined in the structure and exerting pressure therein to drive the ram piston at high velocity;
 - a body of liquid confined in the structure and normally exerting pressure on said second surface of the ram piston to keep the piston from responding to the pressure of the gaseous fluid;
 - means inside the structure normally abutting the trailing end of the ram piston to keep the body of liquid from acting on said second surface thereof; and
 - control means to create pressure in the region of said second surface of the ram piston to separate the ram piston from the abutting means and thus expose said second surface to the pressure of the liquid body to release the ram piston for actuation by the pressure of the gaseous body.
7. In an impact apparatus, the combination of:
 - a fluid-containing structure;
 - a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said ram piston having a first surface inside the structure facing towards its leading end and also having a second oppositely facing surface on its trailing end;
 - a body of high pressure gaseous fluid confined in the structure and exerting pressure therein to drive the ram piston at high velocity;
 - a body of liquid confined in the structure and normally exerting pressure on said second surface of the ram piston to keep the piston from responding to the pressure of the gaseous fluid;
 - means inside the structure normally abutting the trailing end of the ram piston to isolate the body of liquid from said second surface, there being a first restricted path for retarded flow from said liquid body to the region of said second surface;
 - means providing a normally open second path of flow for the liquid from the region of said second surface to a low pressure zone to prevent rise of liquid pressure in the region;
 - a source of pressurized liquid; and
 - control means to close said second path and simultaneously place said source in communication with said region for creating rise in liquid pressure in the region to separate the ram piston and abutting means and thus expose said second surface to the pressure of the liquid body to release the ram piston for actuation by the pressure of the gaseous body.

8. In an impact apparatus, the combination of:

a fluid-confining structure;

a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said ram piston having a first surface inside the structure facing its leading end and also having a second oppositely facing surface on its trailing end; a follower piston inside the structure normally abutting the trailing end of the ram piston;

gaseous fluid confined in a portion of the space in said structure against a surface of at least one of said two pistons and exerting high pressure to drive the ram piston at high velocity;

means to introduce liquid under pressure into a second portion of the space in the structure while the two pistons are in abutment at advanced positions to act on said forwardly facing surface of the ram piston to retract both pistons in opposition to the pressure of the gaseous fluid, at least a portion of the rearwardly facing surface of the trailing end of the ram piston and the abutting follower piston cooperating to define a third portion of the space in the structure isolated from the high pressure of both the confined liquid and the confined gaseous body; and means to introduce fluid under pressure into said third portion of the space to separate the two pistons and thus place said third portion of the space in communication with the second portion for application of the pressure of confined liquid against said rearwardly facing surface to at least partially cancel the high pressure against said forwardly facing surface to release the ram piston for an impact stroke in response to the pressure of said gaseous body.

9. A combination as set forth in claim 8 in which the confined gaseous fluid acts directly on a third rearwardly facing surface of the ram piston for driving the ram piston; and

which includes additional confined fluid acting directly on a rearwardly facing surface of the follower piston to urge the follower piston towards the ram piston.

10. In an impact apparatus, the combination of:

a structure adapted to confine fluid;

a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said piston having a rearwardly facing surface area inside the structure to receive driving fluid pressure and having a forwardly facing surface area to receive opposing fluid pressure;

a body of gaseous actuating fluid confined inside the structure to create pressure on the rearwardly facing surface area of the piston to drive the piston, said body being compressed by retraction of the piston with consequent rise in its pressure;

means operative to force liquid into the structure to exert pressure on said forwardly facing surface area in opposition to the actuating fluid;

means inside the structure movable with the piston and normally isolating a portion of said rearwardly facing area of the piston from the liquid to cause the liquid to retract the piston in opposition to the pressure of said body of gaseous fluid; and

means responsive to a predetermined rise in pressure in the gaseous fluid body to place the isolated rearwardly facing surface area of the piston under pressure to cancel the opposite pressure of the liquid to initiate a driving stroke of the piston.

11. In an impact apparatus, the combination of:

means confining a body of gaseous fluid under pressure; an impact member;

means to retract said impact member progressively in opposition to the pressure of said gaseous body with consequent compression of the gaseous body and progressive rise in its pressure; and

means responsive to rise of said pressure to a predetermined magnitude to release the impact member

from the retracting means for a working stroke of the impact member by the pressure of the gaseous fluid, said responsive means being adjustable to vary said predetermined magnitude to vary the length and energy of the working stroke.

12. A method of creating impact force for forming a workpiece, characterized by the use of a ram piston and a cooperating means in a fluid-confining structure, the ram piston having a leading end to deliver impact force and having a forwardly facing surface forwardly of its trailing end, including the steps of:

confining a body of high pressure gaseous fluid in said structure to drive the ram piston at high velocity;

confining a body of liquid in said structure around the ram piston at a retracted position of the ram piston to exert pressure against said forwardly facing surface to keep the ram piston from responding to the pressure of the gaseous body;

abutting said cooperating means against the trailing end of the retracted ram piston to isolate the high pressure of the liquid body from at least a portion of the rearwardly facing surface of the rear end of the ram piston; and

separating the ram piston slightly from the cooperating means to place the high pressure of the liquid body in communication with said isolated surface to oppose the pressure on the forwardly facing surface and thus release the ram piston for an impact stroke in response to the pressure of the gaseous body.

13. A method as set forth in claim 12 which includes the additional steps of:

withdrawing at least a portion of the liquid body after the impact stroke to permit the ram piston and the cooperating means to return to mutual contact thereby again isolating at least a portion of the rearwardly facing surface of the ram piston; and then resorting the liquid body.

14. A method as set forth in claim 12 which includes the step of applying fluid pressure to said isolated surface to cause separation of the ram piston and the cooperating means.

15. A method as set forth in claim 12 which includes the step of applying the pressure of said liquid body to said normally isolated surface to cause the separation.

16. A method as set forth in claim 14 which includes the step of placing said isolated surface in communication with a high pressure fluid source to separate the two pistons.

17. In an impact apparatus of the character described, the combination of:

a fluid-confining structure;

a ram piston slidably mounted in the structure with its leading end exposed for delivering impact force, said ram piston having a rearwardly facing surface to receive fluid pressure for driving the ram piston; a body of liquid confined in the structure to exert driving pressure on said rearwardly facing surface;

a body of gaseous fluid in the structure to expand to transmit energy to the ram piston;

a freely movable piston slidably mounted in the structure to isolate the body of liquid from the body of gaseous fluid and to transmit pressure from the gaseous fluid to the body of liquid;

means in the structure normally isolating the rearwardly facing surface of the ram piston from the pressurized body of liquid at a retracted position of the ram piston to keep the ram piston from being driven; and

control means operable to give the pressurized body of liquid access to said rearwardly facing surface to drive the ram piston.

18. In an impact apparatus of the character described, wherein a confined pressurized fluid acts on a rearwardly facing surface of a ram piston to drive the ram piston and when the ram piston is retracted sealing means iso-

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lates the pressurized fluid from said rearwardly facing surface to prevent actuation of the ram piston until actuation of the ram piston is desired, the improvement comprising:

- a body of gaseous fluid serving as a highly resilient and expansile part of the confined fluid; 5
- a body of liquid serving as the rest of the confined fluid with the body of liquid in the region of said sealing means whereby the sealing means opposes liquid pressure as distinguished from gaseous pressure; and 10
- a freely movable wall member separating the body of liquid from the body of gaseous fluid and transmitting pressure from the body of gaseous fluid to the body of liquid for driving the ram piston, said wall member carrying said sealing means that isolates the pressurized fluid from said rearwardly facing surface to prevent actuation of the ram piston until actuation is desired. 15

19. An improvement as set forth in claim 18 in which the freely movable wall member is a piston and the ram piston cooperates with the freely movable piston to separate the body of liquid from the body of gaseous fluid. 20

20. In an impact apparatus of the character described, the combination of: 25

- structure forming a fluid-confining chamber;
- a piston variably dividing the chamber into a first compartment containing a body of liquid and a second compartment containing a body of pressurized gaseous fluid, the piston being freely movable to transmit the pressure of the gaseous fluid to the liquid body; 30
- a ram piston extending into said chamber with a rearwardly facing surface in the first compartment for actuation of the ram piston by the body of liquid whereby the position of the freely movable piston determines both the pressure of the body of gaseous fluid and the range of movement of the ram piston 35

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in which energy is transmitted to the ram piston by the body of liquid from the body of gaseous fluid; means to introduce liquid into the first compartment to retract the freely movable piston against the gaseous body to store energy for driving the ram piston; means in the structure normally isolating the rearwardly facing surface of the ram piston from the pressurized body of liquid at a retracted position of the ram piston to keep the ram piston from being driven; and

control means operable to give the pressurized body of liquid access to said rearwardly facing surface to drive the ram piston.

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