Nov. 14, 1967 L. C. BOLLAR 3,352,143
IMPACT APPARATUS
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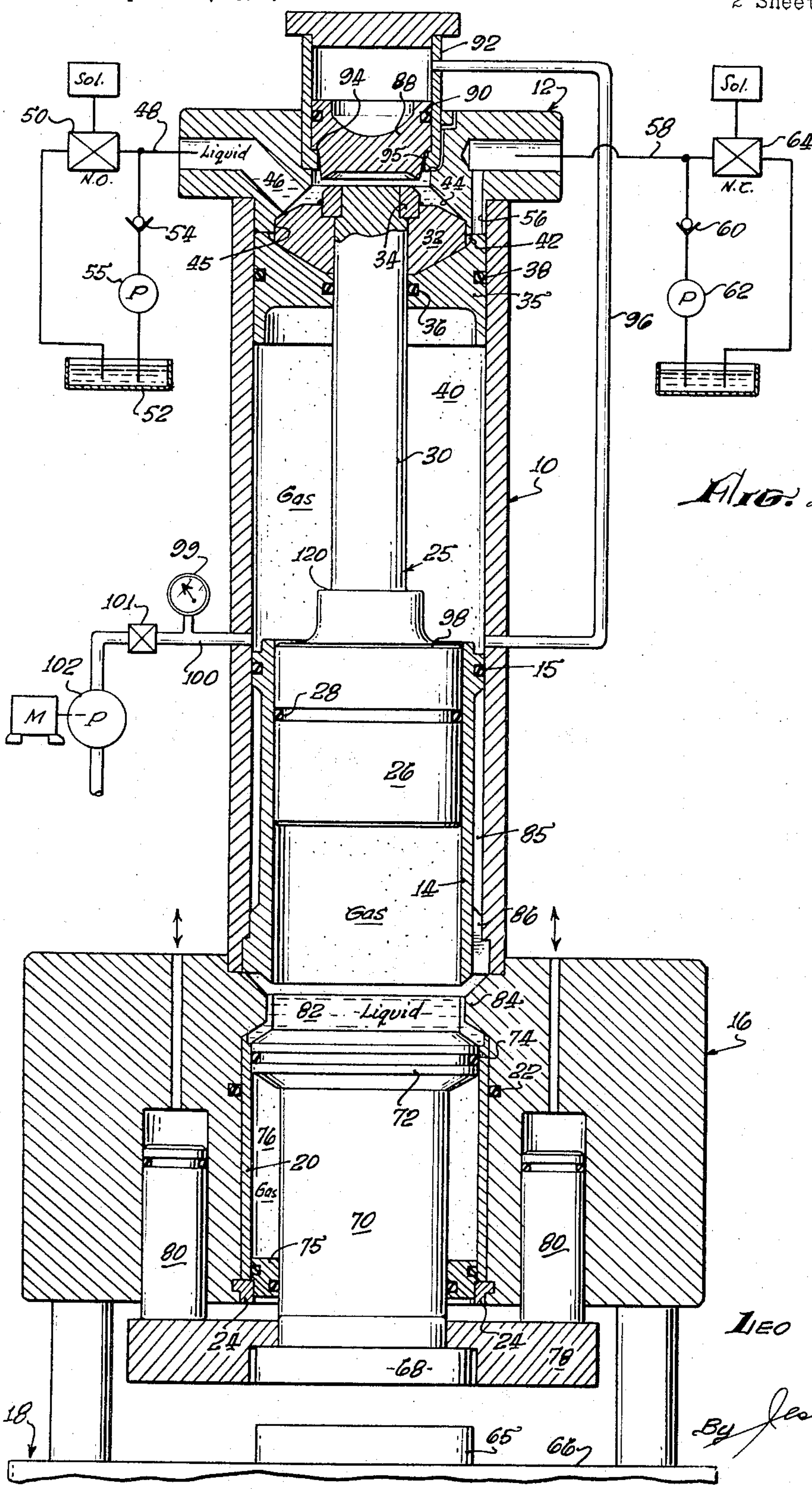

FIG. 1.

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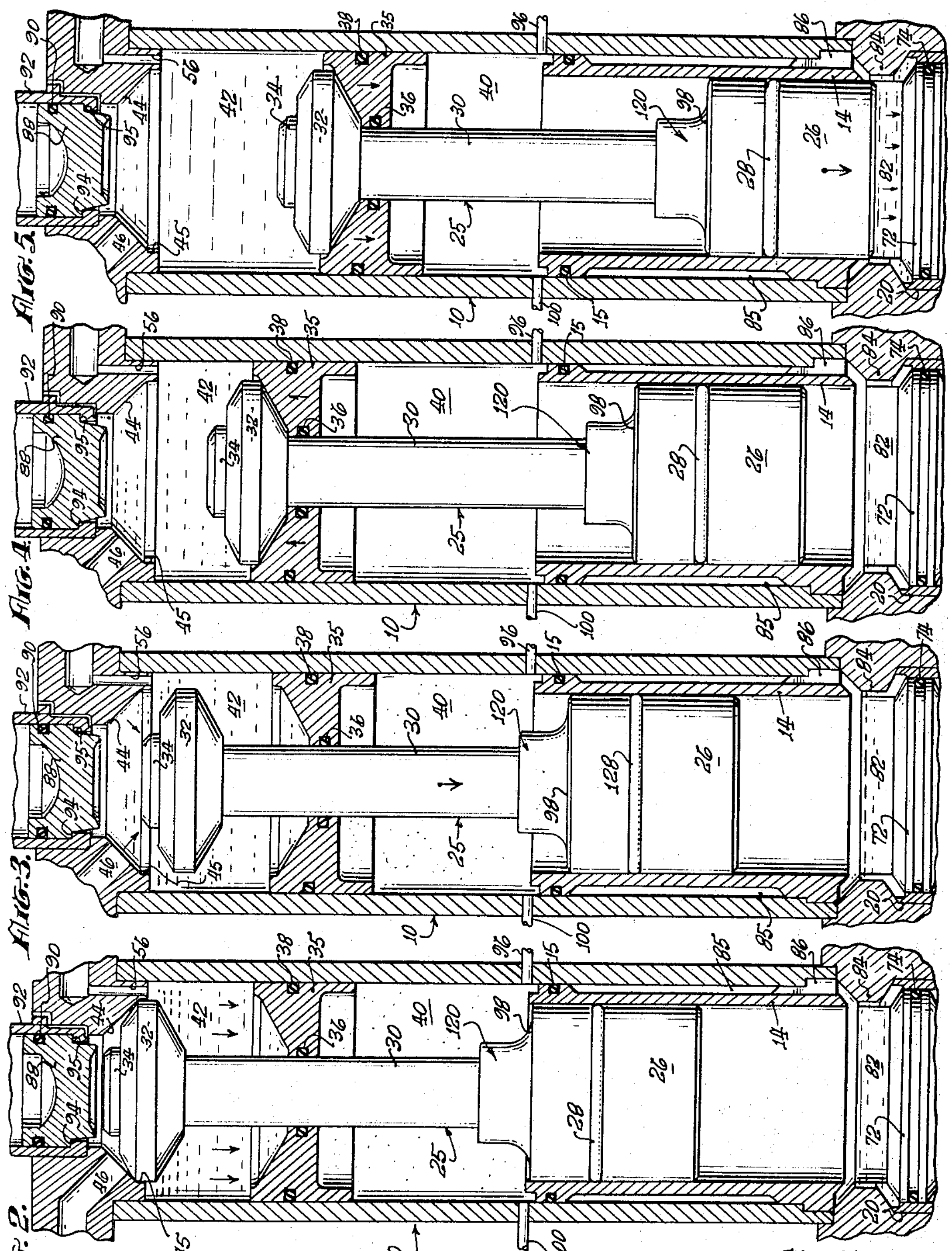

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ABSTRACT OF THE DISCLOSURE

A ram for delivering impact force is slidingly embraced by an annular piston which is a movable partition between an upper liquid filled compartment and a lower compartment filled with compressed air, the working end of the ram extending through the lower compartment into the atmosphere. Normally the upper end of the ram is held by fluid pressure in an upper low pressure seat that is vented to the atmosphere. Raising the pressure in the seat reverses the pressure differential on the ram to start the downstroke. During the first part of the stroke the compressed air expands to drive the ram downward with consequent upward shift of the annular piston until the upwardly moving annular piston meets an annular shoulder of the downwardly moving ram. During the second part of the stroke the ram carries the annular piston downward to compress the air in the lower compartment thereby to decelerate the ram.

This invention relates to an impact apparatus which may be adapted to impact forming of workpieces or may be adapted to deliver impact force for other purposes such as pile driving, demolition and the like. Certain features disclosed herein are also disclosed in my copending application entitled, Impact Forming Machine, Ser. No. 279,055, filed May 9, 1963, now Patent No. 3,267,677, and in my copending application entitled, Impact Forming Apparatus, Ser. No. 328,787, filed Dec. 2, 1963, now Patent No. 3,205,790.

An impact apparatus of the type to which the invention pertains comprises essentially a structure forming a rearward chamber to contain fluid under pressure, a guide passage extending forward from the chamber, and a ram slidingly mounted in the guide passage for actuation by the fluid. More specifically, the invention pertains to such an apparatus in which the rear end of the ram is backed into a cooperating sealing seat when the apparatus is ready for a working stroke, the sealing seat serving to isolate the rear end of the ram from the high pressure fluid to keep the ram retracted until the working stroke is desired.

The sealing seat is normally vented to a low pressure region to keep the pressure low at the rear end of the ram and the working stroke may be initiated with a time delay by simply cutting off the vent passage until leakage into the sealing seat raises the pressure therein to an effective magnitude. Such a time delay may be avoided by simply forcing fluid abruptly into the seat as soon as the vent passage is cut off.

Gaseous fluid is required in the chamber for expansion to drive the ram but it is highly desirable to employ a liquid fluid in the region of the sealing seat to facilitate control of leakage into the seat. Accordingly, a movable wall such as a floating piston is provided in the chamber to divide the chamber into a first compartment containing a body of gaseous fluid and a second compartment containing a body of liquid fluid, the floating piston separating the two bodies of fluid and serving to transmit actuating pressure from the body of gaseous fluid to the body of liquid. When the rear end of the ram is unseated to initiate a working stroke, the gaseous body expands to

actuate the ram by pressing the movable piston against the liquid body that encloses the rear end of the ram.

One of the important objects of the present invention is to increase the maximum number of operating cycles or working strokes of the piston that may be carried out in a unit of time. The initial embodiment of the invention is capable of delivering high energy impact strokes of the ram repeatedly at a frequency of fifteen times a minute, only one second being required for a complete operating cycle including the resetting of the ram. As will be apparent from the disclosure, this object is accomplished by a new organization of the working parts which shortens the time required to reset the apparatus for an operating stroke.

In the usual apparatus of this character constructed for impact forming of workpieces, the ram is decelerated by means outside of the working mechanism. Thus the ram is decelerated by transferring energy to a workpiece or to a platen or anvil in the absence of a workpiece. Such an apparatus cannot be used safely for purposes such as demolition because if the ram misses the mark or encounters too little resistance the ram becomes a hazard. A further important object of the present invention, therefore, is to provide a ram action that is self-limiting in that the stroke of the ram is divided into an initial range of energy input into the ram and a final range of deceleration in which energy is stored for immediate automatic retraction of the ram. Thus if the ram is not completely decelerated by encountering external resistance, the ram is automatically decelerated and retracted.

This last object is achieved by a number of provisions which work together. One provision is that the floating piston that divides the chamber into two compartments is in the form of an annular piston that slidingly embraces the ram. A second provision is that the gaseous body for driving the ram is in the forward compartment and the liquid which acts directly on the ram is in the rearward compartment. This arrangement is the reverse of an arrangement that has been employed heretofore and results in the floating piston retracting rearwardly, instead of advancing, as energy is transmitted to the forwardly moving ram. The third provision is means for engaging the advancing ram with the retracting floating piston to terminate the initial portion of the stroke in which energy is transmitted to the ram. Thereafter, the floating piston is advanced by the advancing ram during the final portion of the stroke of the ram.

The fourth provision is designing the forward compartment for contraction in volume by the floating piston when the floating piston is advanced by the ram during the final portion of the stroke of the ram. Thus during the final portion of the stroke of the ram the gaseous fluid in the forward compartment is compressed by the advancing floating piston to decelerate the ram and to store energy for subsequent return of the ram.

A feature of the preferred practice of the invention is the further provision of dashpot means to cushion the impact of the advancing ram against the retracting floating piston. Another provision in the preferred practice of the invention is means to cushion the automatic return movement of the ram to avoid damage to the apparatus.

In an impact forming apparatus of this type as heretofore constructed, it is often difficult to release a forming die from a formed workpiece. The present invention eliminates this difficulty by providing a body of compressed gaseous fluid to tend to retract the forming die from an advanced position and by further providing releasable holding means to block retraction of the forming die from its advanced position by the compressed gaseous fluid. After a part is formed by the dies the holding means is operated to release the forming die for retraction and subsequently means is employed to restore the forming die to its normal advanced position in opposition to the pressure of the gaseous fluid.

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

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

FIG. 1 is a diagrammatic sectional view of the presently preferred embodiment of the invention;

FIG. 2 is a simplified diagrammatic view showing the position of the working parts when the apparatus is set or ready for a work stroke;

FIG. 3 is a view similar to FIG. 2 showing how the apparatus is triggered by unseating the head of the ram to initiate a work stroke;

FIG. 4 is a similar view showing the ram head seated against the floating piston at the end of the initial energy-input portion of the stroke of the ram; and

FIG. 5 is a similar view showing the ram at the end of its stroke.

FIG. 1, illustrating the presently preferred embodiment of the invention for the impact forming of parts, shows a fluid-confining structure comprising a main cylinder **10** closed at its upper end by a head casting **12**, and an inner cylinder **14** which is telescoped into the main cylinder and is sealed by an O-ring **15**. The main cylinder **10** is mounted in a fluid-tight manner on a large block of metal **16** which in turn is mounted on a base structure **18**. A lower cylinder **20** in the form of a liner sealed by an O-ring **22** is mounted in the block **16** in axial alignment with the main cylinder **10**, the liner being removably secured by a split collar **24**. The main cylinder **10** forms a fluid-confining chamber and the inner cylinder **14** forms a guide passage that extends downward from the chamber and is of smaller diameter than the chamber.

A ram, generally designated **25**, which extends into the fluid-confining chamber for actuation by fluid pressure therein has a body or main portion **26** that is slidingly mounted in the guide passage provided by the inner cylinder **14**, the ram carrying an O-ring **28**. The ram **25** is further formed with a long neck or shank **30** of uniform diameter and an enlargement or head **32** is retained on the upper end of the neck by a welded collar **34**.

Slidingly embracing the neck **30** of the ram **25** in a freely movable manner is a movable wall in the form of an annular piston **35** that is preferably of light weight and may be made of aluminum. The annular piston is provided with an inner O-ring **36** for sealing contact with the neck **30** and is further provided with an outer O-ring **38** for sealing contact with the surrounding main cylinder **10**. The annular piston **35** in cooperation with the neck **30** of the ram divides the fluid-confining chamber into a forward or lower compartment **40** which contains a body of gaseous fluid such as air and a rearward or upper compartment **42** (FIG. 2) which contains a body of liquid fluid such as a suitable grade of oil.

The head casting or cylinder head **12** forms a seat **44** for the ram head **32** which seat serves to isolate the rearward surface of the ram head from the high pressure of the body of liquid in the upper compartment **42**. It is to be noted that the seat **44** has a cylindrical entrance **45** of appreciable axial dimension and that the ram head **32** has a corresponding peripheral cylindrical surface of appreciable axial extent. Normally the seat **44** is placed in communication with a low pressure zone by a vent passage **46** which communicates with an external pipe **48**.

As shown diagrammatically in FIG. 1, the pipe **48** communicates through a normally open solenoid valve **50** with a reservoir or tank **52** and the pipe **48** is also connected through a check valve **54** with a power actuated pump **55** for withdrawing liquid from the reservoir. When the ram head **32** is in the seat **44**, as shown in FIG. 2, leakage occurs at a slow rate from the pressurized oil in the upper compartment **42** but as long as the passage **46** is in communication with the low pressure zone at the reservoir **52**, pressure cannot build up in the seat. The fact that the seat has the cylindrical entrance **45** for cooperation with the cylindrical portion of the ram head **32** is a safety feature because the ram head must be retracted an appreciable distance from its fully seated position to make the rear surface of the ram head accessible to the high pressure oil.

A second passage **56** in the cylinder head **12** places the upper compartment **42** in communication with a suitable source of high pressure oil. As shown diagrammatically in FIG. 1, passage **56** is connected to a pipe **58** through a suitable power-actuated pump **62** which draws liquid from the reservoir **52**. The pipe **58** may be placed in direct communication with the low pressure reservoir **52** by opening a normally closed solenoid valve **64**.

As may be seen in FIG. 1, the lower side of the ram head **32** is of convex configuration and the upper side of the floating piston **35** is of corresponding concave configuration to form a seat for the ram head. The significance of this relationship is that when the ram head and the annular piston are abruptly moved together a certain dashpot effect cushions the impact.

For impact forming of a part or workpiece, a stationary lower die **65** mounted on a platen **66** cooperates with an upper die **68** which is attached to a normally stationary metal body **70** which serves to transmit energy from the ram **25** to the upper die. The metal body **70** is slidingly mounted in the lower cylinder **20** and for this purpose is formed with an enlargement or head **72** that is equipped with a suitable O-ring **74**.

The lower end of the metal body **70** is guided by an annular sealing ring **75** which cooperates with the head **72** to form a variable annular chamber **76** which contracts when the metal body **70** is moved downward by the force of the ram **25**. This annular chamber **76** is filled with compressed gaseous fluid such as air to serve as resilient means for retracting the metal body after a working stroke thereby to free the upper die **68** from the formed part.

In preparation for a working stroke, the upper die **68** is held at a normal advanced position in contact with the workpiece by suitable hydraulic means in opposition to the pressure of the gaseous fluid in the annular chamber **76**. For this purpose, a pressure ring **78** engages the upper die **68** from above and is held down by a pair of hydraulic rams **80**. After an impact stroke has been delivered to form a workpiece, the two hydraulic rams **80** are retracted to permit the gaseous fluid in the annular chamber **76** to retract the upper die **68** from the workpiece so that the formed workpiece can be removed. When a new workpiece is in position for a forming operation the two hydraulic means are advanced to restore the upper die to its normal advanced position. The pressure of the gaseous fluid in the annular chamber **76** may vary between 100 p.s.i. and 2,000 p.s.i. depending upon the character of the workpiece and the degree to which the workpiece is deformed by the impact.

The space between the ram **25** and the metal body **70** constitutes a lower chamber which is contracted as the ram moves toward the metal body. A small body of oil **82** is provided at the bottom of this lower chamber to serve as means for transmitting the energy of the ram to the metal body **70**. It is to be noted that the circumferential wall **84** surrounding the body of oil **82** is dimensioned for relatively snug fit with the ram **25** so that the body of oil is effectively trapped as the ram approaches the lower metal body **70** and it is to be further noted that the diameter of the head **72** of the metal body **70** is of substantially larger diameter than the circumferential wall **84**. Thus the area of the lower body **70** that is exposed to the pressure of the oil **82** is desirably greater than the cross-sectional area of the ram **25**.

The space in the lower chamber above the oil body **82** is occupied by air at low pressure and it is desirable to provide a space into which the air may be displaced by the working stroke of the ram. For this purpose the inner cylinder **14** cooperates with the main cylinder **10** to form an annular chamber **85**. Communication with the annular chamber **85** is provided by a passage **86** which is close to the level of the body of oil **82**. Thus when the ram **25** makes a working stroke the air between the advancing ram and the body of oil **82** may be displaced through the passage **86** into the annular chamber **85**.

As will be explained the high pressure gaseous fluid in the lower compartment **40** causes the ram **25** to be returned upward at high velocity after a working stroke. In some installations of the device it may be desirable to make some provision for preventing the creation of a destructive pressure rise in the upper compartment **42** when the ram is returned at high velocity when both of the valves **50** and **64** are closed to prevent escape of the hydraulic fluid. For this purpose an auxiliary piston **88** provided with an O-ring **90** may be mounted in an auxiliary cylinder **92** that communicates with the seat **44** in the upper end of the upper compartment **42**.

The auxiliary piston **88** is formed with a circumferential shoulder **94** which normally seats against a corresponding shoulder **95** of the auxiliary cylinder, the auxiliary piston being urged to this position by pressurized gaseous fluid in the auxiliary cylinder. A feature of the invention in this regard is that the auxiliary cylinder **92** is in continuous communication with the lower compartment **40** through a suitable pipe **96** to maintain the desired pressure in the auxiliary cylinder.

Operation

FIG. 2 shows the apparatus ready for a working stroke with the ram head **32** in the seat **44** and with the annular piston **35** spaced a substantial distance below the ram head. As shown in FIG. 1, the holding means in the form of the two hydraulic rams **80** holds the upper die at its normal advanced position with the body **70** at a corresponding advanced position in opposition to the gaseous pressure in the annular chamber **76**. It is apparent that while the two hydraulic rams **80** block retraction of the upper die **68** from its normal advanced position, the upper die is free to advance towards the lower die **65** to carry out the forming operation on a workpiece. The gaseous fluid in the lower compartment **40** is under high pressure and this pressure is transmitted to the oil in the upper compartment **42** by the annular piston **35**. Oil continually leaks at a slow rate from the compartment **42** past the ram head **32** into the seat **44** but the pressure of the oil in the seat **44** is low because the vent passage **46** is open to a low pressure region.

The ram head **32** may unseated with a time delay by simply cutting off the vent passage **46** so that the leakage of the oil into the seat **44** eventually builds up the pressure in the seat. In the preferred practice of the invention, however, the time delay is avoided by operating the pump **55** (FIG. 1) in addition to closing the solenoid valve **50**. The pump delivers oil into the seat **44** to force the ram head **32** downward. As soon as the ram head **32** clears the seat **44** as shown in FIG. 3, the highly pressured oil in the upper compartment **42** has free access to the rear surface of the ram head **32**.

With the pressure of the oil in the upper compartment **42** acting on the rear face of the ram head **32** and with the pressure of the gaseous fluid in the lower compartment **40** acting on the annular surface **98** of the body of the ram, the ram is accelerated downwardly at a high rate. As a progressively increasing proportion of the ram enters the lower compartment **40** from the upper compartment **42**, the resultant change in displacement results in corresponding upward retraction of the annular piston **35**.

As the ram head **32** approaches the annular piston **35** and makes impact therewith as shown in FIG. 4, the previously mentioned dashpot action occurs to cushion the impact. Up to this point the gaseous fluid in the lower compartment **40** expands to deliver energy to the ram **25**. Beyond this point of impact of the ram head against the annular piston no further energy is delivered to the ram. On the contrary, beyond this point the downward movement of the annular piston by the ram head contracts the volume of the lower compartment **40** to store energy by compressing the gaseous fluid therein.

When the ram **25** at its lowest point shown in FIG. 5 is completely decelerated by impact against the lower oil body **82** and the consequent transfer of energy to the upper die **68**, the ram is promptly returned upward primarily by expansion of the gaseous fluid in the lower compartment **40**. The downward movement of the ram displaces air into the annular chamber **85** with consequent compression of the air and re-expansion of this compressed air further assists to a minor degree to return the ram. It is also to be noted that the downward movement of the ram after the ram head makes contact with the annular piston, creates a void in the upper compartment **42** which also facilitates upward return of the ram.

It is apparent that the working stroke of the ram is divided into two parts or ranges and the return stroke of the ram is also divided into two parts or ranges. Thus on the working stroke of the ram, the first portion of the stroke terminates when the ram head makes contact with the annular piston and on the return stroke of the ram the first portion of the return stroke terminates when the annular piston separates from the ram head upon impact of the annular piston against the oil body in the upper compartment **42**.

When the returning ram and annular piston make impact against the oil body in the upper compartment **42** the resultant abrupt pressure rise causes the auxiliary piston **88** to retract in the auxiliary cylinder **92** to limit the pressure rise and to provide time for the disengagement of the annular piston from the ram head. As the ram head **32** continues to move upward away from the annular piston into the oil body in the upper compartment **42**, the volume of the lower compartment **40** is rapidly contracted both by the upward movement of the ram body **26** and by the downward movement of the annular piston that is caused by displacement of oil in the upper compartment **42**. As a consequence the ram is rapidly decelerated to terminate its return movement.

It is apparent that there is some tendency for the ram to oscillate but the oscillation is of brief duration and is not troublesome. At the end of the oscillation the parts come to rest at the positions shown in FIG. 4 with the ram head **32** seated against the annular piston **35**.

To reset the apparatus in preparation for a new working stroke, oil is released from the upper compartment **42** and this step may be carried out quickly by opening both valves **50** and **64** to permit the oil to escape rapidly through the passages **46** and **56** in the cylinder head. As the oil escapes from the upper compartment **42**, the gaseous fluid in the lower compartment **40** expands to lift the annular piston **35** and thereby lift the ram head **32** into the seat **44**. When the ram head is fully seated the parts are positioned as shown in FIG. 1.

As soon as the main ram **25** starts to rise, the two hydraulic rams **80** are retracted to permit the gaseous pressure in the chamber **76** to lift the upper die **68** to a retracted position to permit the formed workpiece to be removed from the dies. A new workpiece is then placed in the lower die **65** and the hydraulic rams **80** are again operated to restore the upper die **68** to its normal advanced position.

The second step to reset the apparatus for a new working stroke is to close the valve **64** (FIG. 1) and to start the pump **62** to return oil to the upper compartment **42** in opposition to the pressure of the gaseous fluid in the lower compartment **40**. As new oil is pumped into the upper compartment **42**, the annular piston is correspondingly advanced downward away from the seated ram head 32.

Introduction of new oil is terminated when the downward movement of the annular piston 35 raises the pressure of the gaseous fluid into the lower compartment 40 to a desired magnitude which depends upon how much energy is required for a particular workpiece. Thus the annular piston may be restored to the starting position shown in FIG. 2.

It is apparent that maximum energy may be stored for application to a workpiece by advancing the annual piston to the maximum where the piston abuts the upper end of the inner cylinder 14. The operator determines how much oil is to be returned to the upper compartment 42 by watching the pressure in the lower compartment 40 as registered by a gauge 99 (FIG. 1) in a pipe 100 that communicates with the lower compartment. The pipe 100 is normally closed by a valve 101 which may be opened whenever desired either to release gaseous fluid from the lower compartment or to permit gaseous fluid to be introduced by a power actuated pump 102. In shifting from the forming of one workpiece to the forming of a different workpiece, it is ordinarily not necessary to increase or decrease the amount of gaseous fluid in the lower compartment.

If the apparatus is to be employed for impact purposes other than impact forming, for example if the apparatus is to be employed for demolition or for pile driving or the like, only the structure above the block 16 is required, i.e., only the structure that is associated with the main cylinder 10. The open end of the main cylinder 10 is presented to whatever object is to be struck by the leading face of the ram 25. The compression of the gaseous fluid in the lower compartment 40 by the operating stroke of the ram 25 now has special importance because it limits the degree to which the ram is advanced on the operating stroke without regard to external resistance encountered by the ram. Thus if the ram encounters no obstacle whatsoever the ram will simply decelerate and retract after making an operating stroke.

Dimensional relationships

Certain dimensional relationships are to be noted for a complete understanding of the invention. A feature of the preferred practice of the invention is that the ram head 32 is of slightly larger diameter than the body 26 of the ram. Thus the area of the annular surface on the underside of the ram head 32 is slightly larger than the annular surface 98 of the ram body 26. The advantage of this relationship is that once the ram head 32 is in the seat 44 a pressure differential exists which continuously urges the ram head into its seat. This pressure differential together with the fact that the ram head must advance appreciably to open the seat is important for safe operation of the device and insures that the working stroke will not be triggered by vibration of the apparatus by external causes.

Another dimensional relationship is that the inside diameter of the main cylinder 10 must be sufficiently larger than the diameter of the ram head 32 to permit the ram head to move freely on its working stroke, i.e., to permit free displacement of the oil around the periphery of the advancing ram head. For this purpose, the area of the annular clearance around the ram head 32 may be approximately half of the area of the ram head.

It is not essential in all practices of the invention that the gaseous fluid in the lower compartment 40 be compressed during the latter part of the operating stroke but the advantages of such compression are of great importance. In this regard it is to be noted that the inside diameter of the main cylinder 10 must be substantially larger than the inside diameter of the inner cylinder 14. In other words the diameter of the annular piston 35 must be greater than the diameter of the body 26 of the ram if the downward movement of the annular piston is to have the effect of recompressing the gaseous fluid in the lower compartment 40.

Another dimension to be considered is the diameter of the uniform neck 30 of the ram. The diameter must be substantial but the greater the diameter the greater the rate at which the annular piston 35 moves upward to meet the ram head 32 during the initial portion of the working stroke of the ram. The length of the neck 30 of the ram is also important. The range of movement of the annular piston from its uppermost position shown in FIG. 1 to a lowermost limit position against the end of the inner cylinder 14 must be greater than the distance in FIG. 1 from the lower face of the ram body 26 to the surface of the lower oil body 82. With such a relationship the annular piston cannot interfere with the working stroke of the ram.

Finally, the cross-sectional area of the passage 86 that communicates with the annular chamber 85 should be on the order of one-tenth of the cross-sectional area of the body 26 of the ram. If the cross-sectional area of the passage 86 is substantially less than one-tenth of the area of the ram the freedom for flow of air into the annular chamber 85 will be unduly restricted. On the other hand, if the cross-sectional area of the passage 86 is substantially more than one-tenth of the area of the ram a substantial quantity of the oil 82 will pass through the passage into the annular chamber 85. With the cross-sectional area of the passage 86 approximately one-tenth of the area of the ram the passage has a certain selective effect in that it permits the free flow of air but, in effect, substantially blocks the flow of oil.

Automatic high energy cycling

Automatic recycling may be accomplished by arranging for the advance of the annular piston 35 to unseat the ram and thereby trigger a working stroke. By way of example, FIG. 1 shows a shoulder 120 on the neck 30 of the ram positioned for abutment by the annular piston 35 as the annular piston advances in response to the introduction of oil through the passage 56. When oil continues to be introduced through passage 56 after the advancing annular piston 35 makes contact with the shoulder 120, the annular piston advances the ram and thereby withdraws the ram head 32 from the seat 44 to give the highly pressurized oil access to the rear face of the ram head.

As the working stroke is carried out, the annular piston 35 retracts in the manner heretofore described until it comes into abutment with the ram head 32 and then the annular piston is advanced with the ram to complete the working stroke in opposition to the rising of pressure of the gaseous fluid in the lower compartment 40. After the operating stroke is completed, the pressure of the gaseous fluid in the lower compartment 40 acting on the annular piston 35 returns the ram to its initial position with the ram head 32 in the seat 44.

To make such automatic recycling possible, the solenoid valve 50 is continuously open, the vent passage 46 is of large flow capacity and the pump 62 is run continuously with the solenoid valve 64 continuously closed. With the vent passage 46 of large flow capacity, oil flows with sufficient freedom through the vent passage to permit the annular piston 35 to return the ram head 32 quickly to its seat under the pressure of the gaseous fluid in the lower compartment 40. It is apparent that the flow capacity of the vent passage 46 must take into account that oil is being continuously pumped into the upper compartment through the passage 56. As soon as the ram head 32 is seated to cut off the vent passage 46, the oil pumped into the upper compartment through the passage 56 causes the annular piston 35 to advance into contact with the shoulder 120 to initiate a new operating cycle.

Since the amount of energy that is delivered on a working stroke depends on how far the annular piston is advanced before the working stroke is initiated, it is apparent that the advanced position of the shoulder 120 in

FIG. 1 results in a high energy output on each working stroke when the apparatus is recycling automatically. If a lower energy output is desired with automatic recycling, a spacer sleeve may be mounted on the neck **30** in abutment with the shoulder **120** to cause the ram to be unseated at an earlier point in the advance of the annular piston **35**.

My description in specific detail of the presently preferred embodiment 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 structure forming a rearward chamber with a guide passage extending forward therefrom;
   an impact ram having a forward impact portion slidingly mounted in the guide passage and a rearward portion extending into the rearward chamber, said rearward portion being of smaller cross-sectional area than the rearward chamber;
   an annular piston slidingly mounted in the rearward chamber and slidingly embracing the ram to cooperate therewith to divide the chamber into a rearward compartment and a forward compartment;
   a rearward body of liquid fluid in the rearward compartment to act on the rear end of the ram to drive the ram;
   a forward body of compressed gaseous fluid in the forward compartment,
   the annular piston being freely movable for transmission of pressure from the forward body of gaseous fluid to the rearward body of liquid fluid to permit the forward body of gaseous fluid to expand to drive the ram forward with consequent rearward retraction of the annular piston; and
   means on the ram to engage the annular piston at the end of an initial portion of the forward stroke of the ram to terminate the retraction of the annular piston thereby to terminate the expansion of the forward gaseous body and to advance the annular piston with the ram over a final portion of the forward stroke of the ram.

2. A combination as set forth in claim **1** in which the rearward portion of the ram is formed with an enlargement to engage and drive the annular piston.

3. A combination as set forth in claim **2** in which the rear face of the annular piston is recessed to form a seat for the enlargement of the ram to provide a dashpot action when the enlargement approaches the annular piston.

4. A combination as set forth in claim **1** in which the part of the ram that is slidingly embraced by the annular piston is of reduced diameter to reduce the extent of retraction of the annular piston during the initial portion of the stroke of the ram.

5. A combination as set forth in claim **1**, in which the cross-sectional area of the guide passage and the portion of the ram therein are smaller than the cross-sectional area of the forward compartment whereby the forward movement of the anular piston by the ram during the final portion of the forward stroke of the ram compresses the forward body of gaseous fluid to decelerate the ram and to restore energy for return movement of the ram.

6. A combination as set forth in claim **1** which includes:
   a seat in the rear end of the rearward compartment for the rear end of the ram to isolate the rear end of the ram from the fluid pressure in the rearward compartment; and
   means to terminate the isolation of the rear end of the ram to initiate a working stroke of the ram.

7. A combination as set forth in claim **6** in which the rearward portion of the ram that is embraced by the annular piston is smaller in cross section than the forward portion of the ram whereby the gaseous fluid in the forward compartment exerts a forward thrust on the forward portion of the ram; and
   in which the rear end of the ram has an enlargement to seat in said seat, the enlargement being smaller in cross section than the rearward chamber but larger in cross section than the forward portion of the ram,
   whereby when the enlargement is seated in the seat the fluid in the rearward chamber exerts a rearward thrust on the enlargement that is greater than said forward thrust on the forward portion of the ram whereby the thrust differential normally tends to keep the ram retracted in said seat.

8. In an impact apparatus of the character described, the combination of:
   a cylindrical structure to confine fluid under pressure, said structure having a forward longitudinal portion of a first diameter and a rearward longitudinal portion of a second larger diameter;
   a ram having a forward portion slidingly mounted in said forward portion of the structure and a rearward end portion extending into said rearward portion of the structure,
   the diameter of said rearward portion of the ram being less than said second diameter whereby fluid confined in the rearward portion of the structure may flow around the rear end of the ram to act on the rear end surface of the ram;
   a floating annular piston sealingly and slidingly embracing the rearward portion of the ram and sealingly and slidingly contacting the inner circumferential surface of said rearward portion of the structure thereby cooperating with the ram to divide the interior of the structure into a rearward compartment and a forward compartment, the rearward compartment enclosing part of the rear portion of the ram including the rear end surface of the ram, the forward compartment surrounding an intermediate portion of the ram;
   a body of liquid in the rearward compartment;
   a body of compressed gaseous fluid in the forward compartment acting on the floating piston to place the body of liquid under pressure;
   means in said rearward compartment to releasably seat the rear end of the ram to isolate the rear end face of the ram from the pressure of the liquid body;
   means to unseat the rear end of the ram to give the liquid body access to the rear end face of the ram to drive the ram; and
   cooperating means on the ram and the floating piston respectively for mutual engagement to limit the retraction of the floating piston relative to the ram whereby the stroke of the ram is divided into an initial portion wherein the gaseous body expands with rearward movement of the floating piston to act on the liquid body to drive the ram and a second portion wherein the ram carries the floating piston forward to compress the gaseous fluid to a degree determined by the difference between the first and second diameters to decelerate the ram and to store energy for return movement of the ram.

9. A combination as set forth in claim **8** in which said cooperating means on the ram and the floating piston respectively constitute dashpot means to cushion said mutual engagement.

10. In an impact apparatus, the combination of:
   a structure forming a rearward chamber with a guide passage extending forward therefrom;
   an impact ram having a forward impact portion slidingly mounted in the guide passage and a rearward portion extending into the rearward chamber, said rearward portion being of smaller cross-sectional area than the rearward chamber;

an annular piston slidingly mounted in the rearward chamber and slidingly embracing the ram to cooperate therewith to divide the chamber into a rearward compartment and a forward compartment;

a rearward body of liquid fluid in the rearward compartment to act on the rear end of the ram to drive the ram;

a forward body of compressed gaseous fluid in the forward compartment,

the annular piston being freely movable for transmission of pressure from the forward body of gaseous fluid to the rearward body of liquid fluid to permit the forward body of fluid to expand to drive the ram forward with consequent rearward retraction of the annular piston;

means on the ram to engage the annular piston at the end of an initial portion of the forward stroke of the ram to terminate the retraction of the annular piston thereby to terminate the expansion of the forward gaseous body and to advance the annular piston with the ram over a final portion of the forward stroke of the ram,

the cross-sectional area of the guide passage being smaller than the cross-sectional area of the forward compartment whereby the forward movement of the annular piston by the ram during the final portion of the forward stroke of the ram compresses the forward body of gaseous fluid to decelerate the ram and to store energy for return movement of the ram;

a seat in the rearward compartment for the rear end of the ram to isolate the rear end of the ram from the fluid pressure in the rearward compartment until a working stroke of the ram is desired;

means to terminate the isolation of the rear end of the ram to initiate a working stroke of the ram; and

means to release liquid from the rearward compartment in response to excessive rise of pressure therein to prevent the creation of a destructive pressure therein when the ram is returned by expansion of the forward body of gaseous fluid.

11. A combination as set forth in claim **10** in which said means to release liquid from the rearward compartment includes:

an auxiliary cylinder in communication with said seat;

an auxiliary piston in said auxiliary cylinder;

means placing the auxiliary cylinder in communication with said forward compartment to create pressure in the auxiliary cylinder against the rearward surface of the auxiliary piston; and

means to vent the space between the auxiliary piston and the seat whereby a pressure differential is normally created across the auxiliary piston to urge the auxiliary piston toward the seat.

12. In an impact apparatus, the combination of:

a cylindrical structure having a rearward longitudinal portion with a closed rear end and a forward longitudinal portion of smaller inside diameter than the rearward portion;

a ram in said structure having a leading end slidingly mounted in the forward longitudinal portion of the structure, said ram having a trailing end with a trailing end face in the rearward longitudinal portion of the structure,

the ram having an intermediate longitudinal portion smaller in diameter than the inside diameter of the rearward portion of the structure and forming with the rearward portion an annular space;

a floating annular piston in said annular space and dividing the interior of the structure into a rearward compartment at the closed end of the structure and a forward compartment;

a body of liquid in the rearward compartment;

a body of compressed gaseous fluid in the forward compartment;

a seat in the closed end of the rearward compartment to receive the trailing end of the ram to isolate the trailing end face of the ram from the liquid in the rearward compartment, said seat being normally vented to keep the fluid pressure therein relatively low;

means operable to release liquid from said rearward compartment to permit the gaseous fluid in the forward compartment to retract the floating piston, the floating piston being constructed to engage the ram to retract the ram to place the trailing end of the ram in said seat;

means operable to introduce hydraulic fluid into the rearward compartment when the trailing end of the ram is seated, thereby to advance the floating piston to compress the body of gaseous fluid in the forward compartment to a desired degree; and

means to unseat the seated trailing end of the ram to expose the trailing end face of the ram to the pressure of the liquid in the first annular chamber to cause the fluid pressure in the two compartments to drive the ram forward.

13. In an impact forming apparatus in which a first forming die is mounted on a normally stationary movable body and a ram makes impact against the movable body to drive the first forming die against a stationary second forming die, the improvement to facilitate retraction of the first die after a workpiece is formed by the two dies, comprising:

means confining a compressed body of gaseous fluid, said confining means including a surface united with the movable body to urge retraction of the movable body thereby to retract the first die from the second die to a retracted position after a forming operation;

means normally holding the first die at a normal position advanced beyond said retracted position in opposition to the pressure of said body of gaseous fluid and in preparation for a forming operation, said holding means blocking retraction of the first die without blocking advance of the first die for a forming operation,

said holding means being releasable to permit the pressure of said body of gaseous fluid to retract the first die to said retracted position after a forming operation; and

means to restore the first die from its retracted position to its normal advanced position.

14. An improvement as set forth in claim **13** in which said restoring means is hydraulically actuated.

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

a cylindrical structure to confine fluid under pressure, said structure having a forward longitudinal portion of a first diameter and a rearward longitudinal portion of a second larger diameter:

a ram having a forward portion slidingly mounted in said forward portion of the structure and a rearward end portion extending into said rearward portion of the structure,

the diameter of said rearward portion of the ram being less than said second diameter whereby fluid confined in the rearward portion of the structure may flow around the rear end of the ram to act on the rear end surface of the ram;

a floating annular piston sealingly and slidingly embracing the rearward portion of the ram and sealingly and slidingly contacting the inner circumferential surface of said rearward portion of the structure thereby cooperating with the ram to divide the interior of the structure into a rearward compartment and a forward compartment, the rearward compartment enclosing part of the rear portion of the ram including the rear end surface of the ram, the forward compartment surrounding an intermediate portion of the ram;

a body of liquid in the rearward compartment;

a body of compressed gaseous fluid in the forward compartment acting on the floating piston to place the body of liquid under pressure;

means in said rearward compartment to releasably seat the rear end of the ram to isolate the rear end face of the ram from the pressure of the liquid body;

cooperating means on the ram and the floating piston respectively for mutual engagement to limit the retraction of the floating piston relative to the ram whereby the stroke of the ram is divided into an initial portion wherein the gaseous body expands with rearward movement of the floating piston to act on the liquid body to drive the ram and a second portion wherein the ram carries the floating piston forward to compress the gaseous fluid to a degree determined by the difference between the first and second diameters to decelerate the ram and to store energy for return movement of the ram; and

cooperating means on the ram and the floating piston respectively for mutual engagement to limit the advance of the floating piston relative to the ram and to cause the advancing floating piston to unseat the rear end of the ram to give the liquid body access to the rear end face of the ram to initiate an operating stroke of the ram whereby an operating stroke of the ram is initiated automatically by advance of the floating piston in response to the introduction of liquid into the rearward compartment.

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