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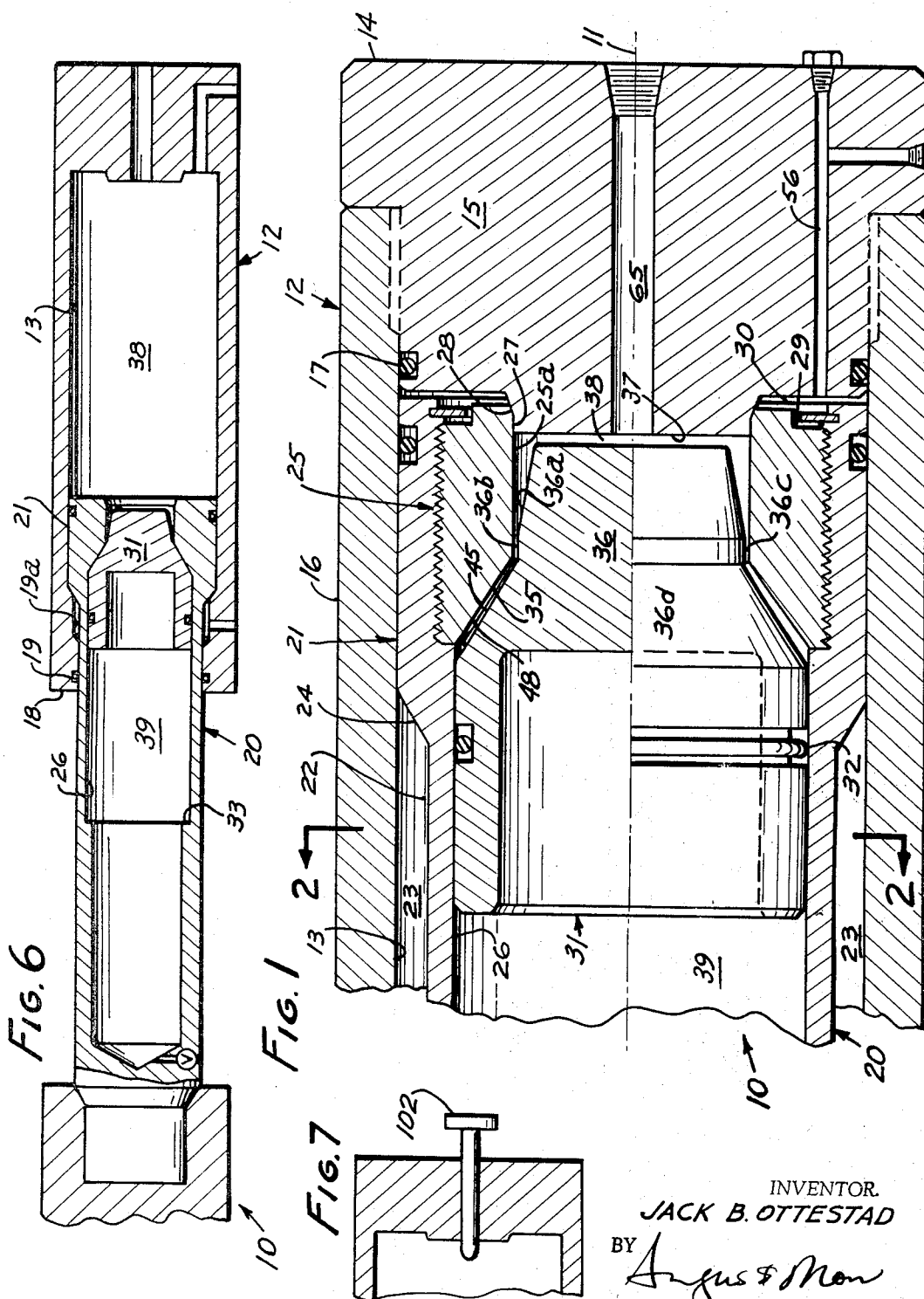
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IMPACT RAM

Filed Aug. 13, 1965

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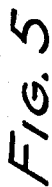
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IMPACT RAM

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ABSTRACT OF THE DISCLOSURE

This invention relates to an impact ram wherein a body has an internal plunger, which plunger is adapted to be axially driven relative to the body in order to deliver a blow. Means is provided for quickly impacting on the face of the plunger, energy which is stored in a chamber in preparation for rendering said blow.

This invention relates to fluid-powered impact rams.

Devices for striking bodies or surfaces are widely known. Their objective is to impart to the body or surface a quantity of energy in a relatively short time. The energy is usually derived from propelled or freely falling weights, from powered linkages, from the quick release of a fluid stored under pressure, or from an explosion. The field of mechanisms powered by quick release of a fluid stored under pressure has been the subject of much development, which development has been characterized by a steady increase in the complexity of the devices. It is an object of this invention to provide an impact means which utilizes a minimum of parts which are easily and inexpensively manufactured and assembled.

It is another characteristic of conventional impact rams that their energy output is not readily adjustable so that blows of greater or lesser energy can be produced. This invention provides for ready selectivity from blow to blow of the energy level.

A very serious deficiency inherent in conventional fluid-powered devices is the risk of misfire when attempting to "unload" them after the device is charged or "cocked." Occasionally it is necessary, after charging the machine, to release the energy but without causing the machine to undergo a work-cycle. This has been difficult, and sometimes even impossible, to arrange for in previously-known machines, and these machines, when once charged, remain a potential danger to their operators until after a work stroke is completed, so that the energy is discharged. The same problem arises when the energy of the charge is only partially discharged. This invention provides a safe, fluid-powered impact device which can always safely and quickly be "unloaded" without undergoing a work cycle.

Another serious problem in conventional devices occurs when the device fires, but fails to strike a workpiece which would receive the energy. Then the traveling parts of the machine would continue in rapid motion, and serious damage to the machine is likely to result. The disadvantage and danger of such a situation is obvious, for were the machine to misfire, or fire when for some reason there were no workpiece in position (both of these being possibilities in routine factory operations), then serious damage is done to expensive capital equipment. This invention provides means which inherently decelerates the rapidly-moving parts toward the end of a stroke, so that the device is fully protected against damage from this cause.

It is another object of this invention to provide a device which, while useful for impacting objects, can also provide a steady force to act as an arbor press, for example, or an oscillatory force to provide vibrational energy.

An impact ram according to this invention includes a body having an internal body cylinder extending along an axis of motion. The cylinder is closed at a first end of the

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body and open at a second end. A plunger is axially slidable in the body cylinder, and is adapted to be connected to an object, an example being an impact head for use as a hammer, which object is disposed outside the body. The plunger or means projects through the open second end of the body cylinder.

The plunger has a lateral dimension which is less than a corresponding internal lateral dimension of the body cylinder. The plunger carries a collar which makes a continuous peripheral fluid-sealing contact with the inside wall of the body cylinder. A sliding seal disposed between the plunger and the body forms one boundary of a variable volume return chamber, the other boundaries of which are an inner wall of the body, the collar, the inner wall of the body cylinder, and the exterior surface of the plunger which has said lesser lateral dimension.

A return face is disposed on the collar which faces into the said return chamber. Fluid pressure in the return chamber tends to return the plunger axially toward the first end of the body. A triggering surface on the collar faces the closed end of the cylinder.

A plunger cylinder extends axially in the plunger. A piston axially floats in the plunger cylinder. The piston makes a fluid-sealing sliding fit with the inner wall of the plunger cylinder. The plunger cylinder is open at its end facing the said first end of the body cylinder and is closed at its other end. The piston forms an accumulator chamber of variable volume between itself and the closed end of the plunger cylinder.

A peripheral charging seal includes a surface on the plunger that is disposed laterally of the triggering surface, and a complementary surface on the body inside the cylinder. When these surfaces mate to form a seal, there is an axial spacing which forms a triggering chamber between the triggering surface and the body. The triggering chamber, when the elements of the device are in such a position, is fully enclosed. At this time, the piston faces the region of the body which is inside the seal. It faces this region through the open end of the plunger, and forms a charging chamber therein.

Respective port means is provided for admitting fluid under pressure to the return chamber, the triggering chamber, the charging chamber, and the accumulator chamber.

According to a feature of the invention, gas pressure is used to decelerate the moving portions of the device toward the end of the stroke.

According to a preferred but optional feature of the invention, the cylinders, the plunger, the piston and the seals are concentric around the axis.

The above and other features of the invention will be fully understood from the following detailed description and accompanying drawings in which:

FIG. 1 is a partial view in axial cross-section showing the presently preferred embodiment of the invention;

FIG. 2 is a cross-section taken at line 2—2 of FIG. 1;

FIGS. 3—6 are axial cross-sections showing the device of FIG. 1 in successive operative positions; and

FIG. 7 is a fragmentary drawing of optional triggering means for this invention.

An impact ram 10 according to the invention has an axis 11 of motion in order that oppositely directed forces may be exerted between two objects such as a frame, and an object or surface to be struck or pressed. An example of such an object is a pin to be driven into or out of a hole. The ram includes a body 12 which encloses an axially-extending body cylinder 13. At a first end 14, the cylinder is closed by an end cap 15 that is threaded into the tubular portion 16 of the body. A peripheral sealing ring 17 seals between the tubular portion and the end cap.

At the second end of the body, there is an inwardly projecting collar 18 (FIG. 6) which includes a seal 19

and a counterbore 19a for purposes yet to be described. The second end of the body is open so as to receive and make a fluid sliding fit with a plunger 20 that is fitted into the body cylinder.

A peripheral collar 21 is formed on the plunger, and it projects laterally from a generally cylindrical side wall 22. It will now be seen that a return chamber 23 of variable volume is formed between collars 18 and 21, cylinder 13 and sidewall 22. Sidewall 22 has a lesser lateral (radial) dimension than the wall of cylinder 13. Return surface 24 is formed on collar 21 and presents a net lateral area to pressure in the return chamber.

A seat insert 25 is threaded to the plunger so as to form a part thereof. The insert includes an opening 25a from an inside plunger cylinder 26 to the end of the plunger adjacent to the first end of the body cylinder.

At the end of the plunger which is adjacent to said first end, there is a peripheral surface 27 that is intended to mate with a like surface 28 on the end cap. The region of collar 21 which lies radially outside of these surfaces when they are joined, and which faces toward the end cap, constitutes a triggering surface 29. The region between triggering surface 29 and the end cap, which lies radially outside of surfaces 27 and 28 when they are joined, is denoted as a triggering chamber 30.

A piston 31 is slidably fitted in plunger cylinder 26. A sealing ring 32 makes a fluid-sealing fit between the piston and the plunger cylinder. A stop shoulder 33 (FIG. 6) is formed in the plunger cylinder to limit the movement of the piston to the left in FIG. 3.

Insert 25 includes a tapered surface 35 which tapers inwardly toward opening 25a, which it intersects. A nose 36 on the piston includes a metering pin 36a which is tapered, a cylindrical surface 36b which enters opening 25a, leaving a clearance 36c, and a taper 36d with a smaller conical angle than that of surface 35. The metering pin and the clearance decelerate the piston near the end of its stroke, and enable fluid readily to reach the full right-hand face of the piston when the charging operation is started.

The region between the central portion 37 of the end cap and the piston, within the plunger cylinder, is denoted as a charging chamber 38. The region within the plunger cylinder between its closed end and the piston is denoted as an accumulator chamber 39.

The piston carries a seat 45 intended to form a substantially fluid-tight seal with surface (seat) 35 on insert 25 when the nose is fully to the right as illustrated in FIG. 6. As soon as the piston moves slightly to the left as in FIG. 1, spacing 48 between surfaces 35 and 45 becomes part of the charging chamber.

A residual charge of gas is injected into accumulator chamber 39 from a source 50 (see FIG. 3) through a valve 49. Valve 49 may simply be a plug, if desired, or any standard type of pressure retentive filling valve. Once this residual charge is injected, it is left in the accumulator chamber, and this chamber requires no further attention except for replacing gas which may leak out.

A triggering charge port 56 (FIGS. 1 and 3) passes through the end cap and enters the triggering chamber. It receives triggering pressure from a source 57 through a valve 58. Valve 58 has two settings. In one position it vents port 56 to reservoir 59, and in the other connects it to pressure.

A return port 60 opens into the return chamber. It is adapted selectively to be connected to a source of gas under pressure 61 such as bottle gas or a compressor or to vent 62 by a valve 63.

A charge port 65 opens into the charging chamber. A valve 66 is adapted to connect or disconnect this port from a source 67 of fluid under pressure. Valve 66 is adapted to vent charging chamber 38 through line 68.

Sources 57 and 67 provide liquid, although they could provide gas. Sources 50 and 61 provides a compressible gas such as compressed nitrogen or helium.

The operation of the device as an impact ram is as follows.

Initially the accumulator chamber will be charged with its residual charge. The pressure selected is one of the determinants of the energy output of the impact ram. In one device wherein the diameter of the plunger cylinder is about 3 inches, nitrogen gas, or some other inert gas is injected into the accumulator chamber to a pressure of about 1000 p.s.i.g. to 1500 p.s.i.g. At this time all other regions in the device are vented to atmosphere. Then valve 49 is closed. As a result of this residual charge, the piston will be moved relative to the plunger just past the location shown in FIG. 1, and the piston will be firmly seated against surface 35. A fluid tight seal is not essential, although it is desirable. The same is true of the other seals in these devices, because minor leakage therein does not impede the function of the device, nor render it subject to misfires.

At this time, the position of the plunger in the body is indefinite. Next, valve 58 is set so as to vent triggering port 56. Valve 63 is set to apply pressure in return chamber 23. This pressure, acting against the return face, and with the other side of collar 21 vented, moves the plunger fully to the right, to the position shown in FIG. 1. Pressure is built up to the desired level, and valve 36 closed, thereby to trap a gas charge in the return chamber. Alternatively, the valve may be left open, maintaining the return chamber at the pressure of source 61. At these conditions, surfaces 27 and 28 meet and seal, and triggering chamber 30 is fully isolated from the rest of the system. This plunger condition is shown in FIG. 1.

Next, pressure is applied to charging port 65 through valve 66, and begins to overcome the resistance of the charge in the accumulator chamber, and moves the piston to the left. This is the start of the charging operation which is shown partially completed in FIG. 3. In FIG. 3 the device is shown charged, but to less than its maximum energy. The plunger is locked in the position of FIGS. 1 and 3, because of the different forces on the return and triggering surfaces, the force on the return surface being the greater. The residual charge in accumulator chamber 39 is compressed as the piston moves to the left, the amount of compression being proportional to the pressure exerted in charging chamber 38. There therefore exists a discrete axial position of the piston in the plunger for each pressure level within a wide range, and the energy level can be set by adjusting the charging pressure.

If the charging pressure is great enough, the piston will be moved against stop 33, and there will be no further compression of the accumulator charge. In the example given, a charge pressure of 2500 p.s.i.g. is often used to fully charge the device. Energy is now stored in the accumulator chamber, and the plunger is locked onto the body by differential force across collar 21.

At this time it is perfectly safe to vent charging chamber 38 to line 68, and the energy will harmlessly be dissipated and the device safetied, should a work stroke not be desired. The piston would simply return to its initial position at the open end of the plunger. This is a very important safety advantage over prior art devices.

Assuming the charge is to be used for impact purposes, the ram may be triggered by setting valve 58 to apply pressure to triggering port 56 and thereby triggering chamber 30. The force in the triggering chamber will overcome the force maintaining the seal at surfaces 27 and 28 and move the piston axially to the left, and the triggering and charging chambers will then be fully interconnected past the separated surfaces. Quite suddenly, the charge pressure is exerted over the full area of the right-hand face of the plunger. The plunger therefore moves to the left, as shown in FIG. 4. Because the return chamber pressure is independent of the pressure in the charging chamber, triggering may also be accomplished by exerting an over-pressure in the latter so as to overcome the force in the return chamber. This over-pressure will

separate the seals, and then the triggering chambers will quickly receive their pressure and complete the triggering operation. In this regard, the higher pressure may be considered "triggering means."

The movement of the plunger to the left is caused by movement of the piston to the right (relative to the plunger), thereby exerting the energy of the accumulator charge on the liquid in the charging chamber. The plunger expels liquid from the plunger cylinder into the body cylinder as it moves.

Preferably, the piston will approach the end of its stroke and have transferred the maximum energy to the plunger, by the time the plunger has traveled between about $\frac{1}{3}$ and $\frac{1}{2}$ of its maximum length of stroke. The device is shown at this condition in FIG. 5. It is preferable for impact to occur at the point shown in FIG. 5 and the impact would dissipate the energy.

However, now assume that nothing is struck by a body such as hammer 100, or that the blow is not totally absorbed. Then the plunger must decelerate, or the device will be damaged. The remainder of the stroke accomplishes that deceleration. This deceleration is accomplished by compression of gas in return chamber 23. Finally, the end of the stroke is reached as shown in FIG. 6 and recycling can be done. The pressure in the return chamber tends to return the plunger toward the first end of the cylinder. An undesirable "slam-back" is prevented by the cushioning effect of the piston and the gas in the accumulator.

Counterbore 19a provides a residual chamber for return fluid, and also keeps port 60 from being blocked by the plunger.

To repeat the cycle, the plunger will be returned to seal at surfaces 27 and 28 by pressure in return chamber 23 with valve 66 set so as to vent port 65. With valve 58 again set to vent, application of pressure to the charging chamber will compress the charge in accumulator chamber 39 to ready the machine for another stroke. Applying pressure to triggering chamber 30 again initiates the stroke.

Attention is called to the fact that seals 27 and 28 are cylindrical. They need not be, but it has been found that when the device is being cycled rapidly, for example once per second, that if laterally-extending seals are used, they may bounce, and the device chatters and slows down. There can be no bounce between concentric cylindrical seals. Slight leakage between these seals is of no consequence, because the triggering chamber is vented except when triggering is desired.

The triggering circuitry is optional. Instead of a fluid pressure, a triggering pin 102 (FIG. 7) could be provided through the end cap mechanically to force the plunger off its seal with the body to initiate the cycle.

Triggering chamber 30 is not placed under pressure to trigger the device in the embodiment of FIG. 12 as it is in the embodiment of FIG. 1. In FIG. 12 a mechanical force to move the plunger away from end cap 15 is exerted directly on the plunger by pin 102. However, in both embodiments, chamber 30 must be provided in order for the plunger to be retained in the charged condition until it is fired, and the term "triggering" is used in both embodiments as a matter of convenience and uniformity in description even though the chamber itself is not used for the provision of a fluid triggering force in the embodiment of FIG. 12.

The peripheral seals, cylinders and chambers are all preferably coaxial and round. The relative motions are all axial, along axis 11.

Any suitable gas may be used where gas is called for, but preferably the gas used should be inert and inexpensive. Nitrogen is the preferred gas. Any good hydraulic fluid which will not break down under the rapid flow conditions involved herein may be used where working liquid is called for.

The device can also be used as a standard press, by

venting the return chamber to reservoir and applying pressure through the triggering port, or simply by applying pressure to the triggering port and compressing the gas in return chamber 23 by overpowering it with a greater force. Return motion is accomplished by reversing these connections or venting the charging or triggering port.

The invention provides a versatile impact ram which can be made in a wide range of sizes, each of said sizes being operable over a wide range of residual accumulator charges and charge levels in charging chamber 38, which is fail safe, includes effective deceleration means, and can be used as a standard press and as a vibrating device. Its simplicity is evident from the drawings. It requires only a bare minimum of parts, all of simple configuration, with only a bare minimum of critical dimensions.

It is to be noted that the accumulator charge need not be fully compressed to operate the device. With less compression, less energy will be imparted per blow.

This invention is not to be limited by the embodiments shown in the drawings and described in the description, which are given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. An impact ram having an axis, comprising: a body having an internal, axially-extending body cylinder; a plunger having an internal, axially-extending plunger cylinder; a piston axially slidably fitted in said plunger cylinder, the body and plunger, and the piston and plunger being relatively axially slidable; a laterally-extending collar on the body making a substantially fluid-sealing fit with the external surface of the plunger; a laterally-extending collar on the plunger making a substantially fluid-sealing fit with the body cylinder, whereby a return chamber of variable volume is defined by the body cylinder, the plunger and the collars, the return chamber being adapted to receive gas under pressure; a return surface on the plunger collar facing into the return chamber; a triggering surface on the plunger collar facing toward a first, closed end of the body within the body cylinder; a peripheral seal carried by the body at said first end thereof inside the body cylinder; a peripheral seal carried by the plunger at its end adjacent said seal on the body, the plunger cylinder having an opening communicating with said last-named seal, whereby the said two seals are adapted to make a fluid-sealing closure when the plunger is moved to its full extent toward said first end, said closure separating a triggering chamber formed between the said first end and the triggering surface within the body cylinder from a charging chamber formed between said first end and the piston inside the plunger cylinder, the opposite end of the plunger cylinder being closed, whereby the piston forms an accumulator chamber of variable volume, said accumulator and charging chambers being separated from each other by the piston; an accumulator port opening into the accumulator chamber for admitting gas under pressure therein; means movable with the piston for containing the gas in the accumulator chamber; conduit opening into the body in fluid communication with the charging chamber; valve means controlling flow of fluid in said conduit; and triggering means for moving the plunger away from said first end; whereby fluid under pressure in the return chamber moves the plunger to said full extent to cause said seals to seat, and then fluid from the conduit enters the charging chamber to move the piston against gas in the accumulator chamber, and thereafter the triggering means is actuable to move the plunger so as to separate the seals and exert pressure of the charging chamber over the full lateral area of the plunger, and the plunger body moves axially so as to increase the spacing between the first end of the body and the triggering surface under force derived from pressure in the charging chamber.

2. An impact ram according to claim 1 in which the opening in the plunger adjacent said first end is tapered, narrowing toward said first end, and in which the piston includes a reduced portion adapted to enter said opening so as gradually to reduce the lateral separation between them, thus decelerating the plunger's motion away from the first end.

3. An impact ram according to claim 1 in which a stop shoulder is formed in the plunger cylinder, spaced from the open end for limiting the travel of the piston away from said first end.

4. An impact ram according to claim 3 in which the opening in the plunger adjacent said first end is tapered, narrowing toward said first end, and in which the piston includes a reduced portion adapted to enter said opening so as gradually to reduce the lateral separation between them, thus decelerating the plunger's motion away from the first end.

5. An impact ram according to claim 1 in which the triggering means comprises a mechanical element adapted to force the plunger away from said first end.

6. An impact ram according to claim 1 in which the triggering means comprises a triggering port opening into the triggering chamber, and a conduit adapted to supply fluid under pressure thereto.

7. An impact ram according to claim 1 in which the conduit comprises a charging port opening into the charging chamber for admitting fluid under pressure thereto; and a valve adapted to connect the charging port to a source of pressure in one condition.

8. An impact ram having an axis, comprising: a body having an internal, axially-extending body cylinder; a plunger having an internal, axially-extending plunger cylinder in fluid-sealing relationship therewith, the body and plunger, and the piston and plunger being relatively axially slidable; a laterally-extending collar on the body making a fluid-sealing fit with the external surface of the plunger; a laterally-extending collar on the plunger making a fluid sealing fit with the body cylinder, whereby a return chamber of variable volume is defined by the body cylinder, the plunger and the collars, the return chamber being adapted to receive gas under pressure; a return surface on the plunger collar facing into the return chamber; a triggering surface on the plunger collar facing toward a first, closed end of the body within the body cylinder; a peripheral seal carried by the body at said first end thereof inside the body cylinder; a peripheral seal carried by the plunger at its end adjacent said seal on the body, the plunger cylinder opening into said last-named seal, whereby the said two seals are adapted to make a fluid-sealing closure when the plunger is moved to its full extent toward said first end, said closure separating a triggering chamber formed between the said first end and the triggering surface within the body cylinder from a charging chamber formed between said first end and the piston inside the plunger cylinder, the opposite end of the plunger cylinder being closed, whereby the piston forms an accumulator chamber of variable volume, said accumulator and charging chambers being separated from each other by the piston; an accumulator port opening through the plunger into the accumulator chamber for admitting a residual charge of gas under pressure; accumulator chamber valve means for closing said accumulator port to retain the residual charge therein; conduit opening into the charging chamber; valve means controlling flow of fluid in said conduit; a triggering port opening through the body into the triggering chamber for admitting fluid under pressure thereto; and triggering chamber valve means controlling flow of fluid through the triggering port, whereby pressure in the return chamber moves the plunger to said full extent to cause said seals to seat, and pressure next introduced into the charging chamber moves the piston and compresses the gas in the accumulator chamber, fluid under pressure

next being admitted to the triggering chamber to move the plunger so as to separate the seals and exert pressure of the charging chamber over the full lateral area of the plunger, thereby to cause the plunger body to move axially so as to increase the spacing between the first end of the body and the triggering surface.

9. An impact ram according to claim 8 in which the opening in the plunger adjacent said first end is tapered, narrowing toward said first end, and in which the piston includes a reduced portion adapted to enter said opening so as gradually to reduce the lateral separation between them, thus decelerating the plunger's motion away from the first end.

10. In an impact ram which has an axis, a body with an internal, axially-extending body cylinder, a plunger axially slidable in said body cylinder, which plunger forms with the body cylinder adjacent to a first end of each a charging chamber adapted to receive a fluid under pressure, the improvement comprising: an internal, axially-extending plunger cylinder in said plunger which opens at the first end of said plunger and which is closed at the other end, and a piston making a sliding fit in said plunger cylinder whereby to define an accumulator chamber of variable volume in said plunger cylinder, the accumulator chamber being adapted to contain a charge of gas under pressure, means movable with the piston forming a movable fluid-sealing interface between the said gas and the fluid in the charging chamber, whereby with the plunger and body in mutual axial restraint, a positive differential pressure in the charging chamber will move the piston into the accumulator chamber to reduce its volume and compress the gas therein, the compressed gas in the accumulator chamber supplying energy to the charging chamber and thereby to the first end of the plunger when said restraint is released, so as to move the plunger axially relative to the body while the piston moves in the plunger cylinder axially toward the said first end of the plunger.

11. Apparatus according to claim 10 in which the plunger cylinder opens onto the first end of the plunger through an opening, which opening includes a restriction, and in which the piston has a nose of lesser lateral dimensions than those of the restriction whereby cooperatively to regulate the axial velocity of the piston relative to the plunger over at least a portion of the axial traverse of the piston.

12. Apparatus according to claim 11 in which the restriction and nose include tapered portions.

13. Apparatus according to claim 11 in which the restriction and the nose include seats which seal with one another at the farthest excursion of the piston toward said first end.

14. Apparatus according to claim 10 in which the restriction includes a plurality of steps, and in which the piston nose includes a plurality of steps, whereby there is provided a plurality of pairs of mutually cooperating segments to regulate the velocity of the piston as aforesaid.

15. Apparatus according to claim 14 in which the steps are spaced apart by axially-extending cylindrical segments.

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