Dec. 1, 1953 R. F. ZUMWALT 2,660,984

MACHINE TOOL WITH LIQUID SPRING ACTUATED RAM

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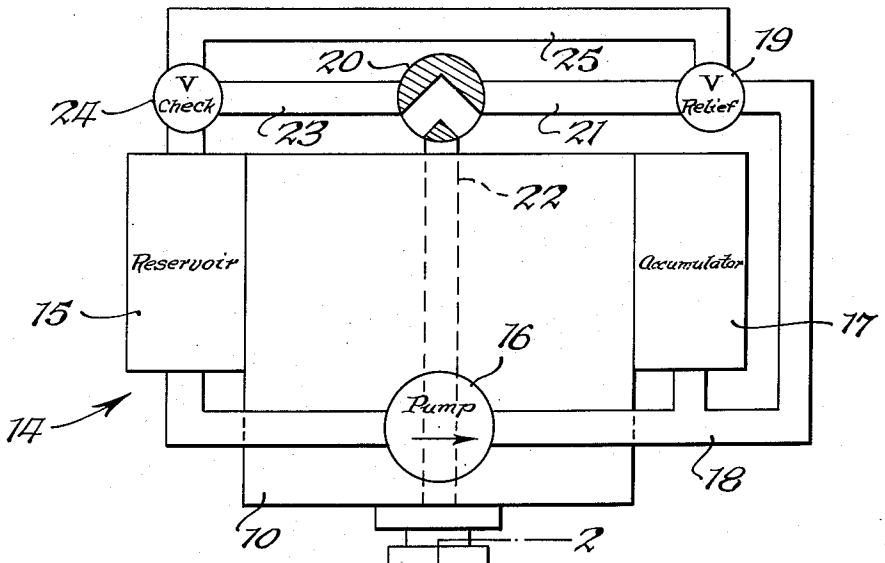


Fig. 1.

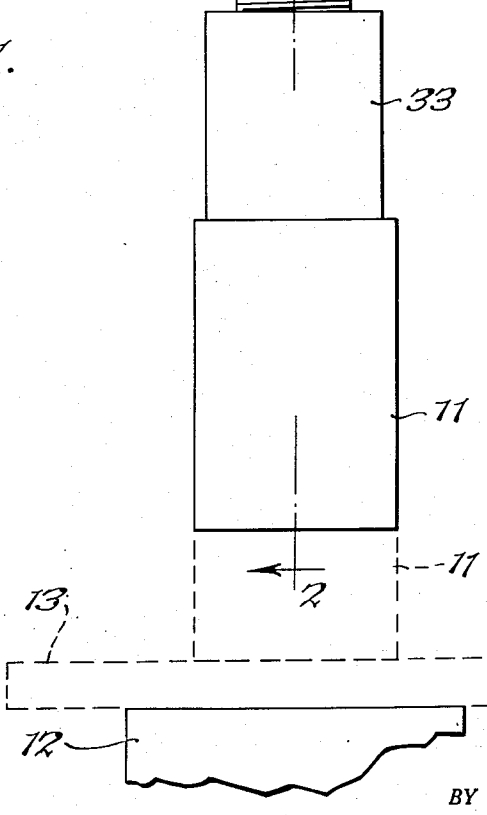
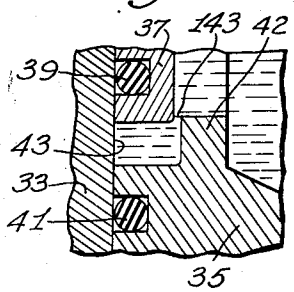


Fig. 4.



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Fig. 2.

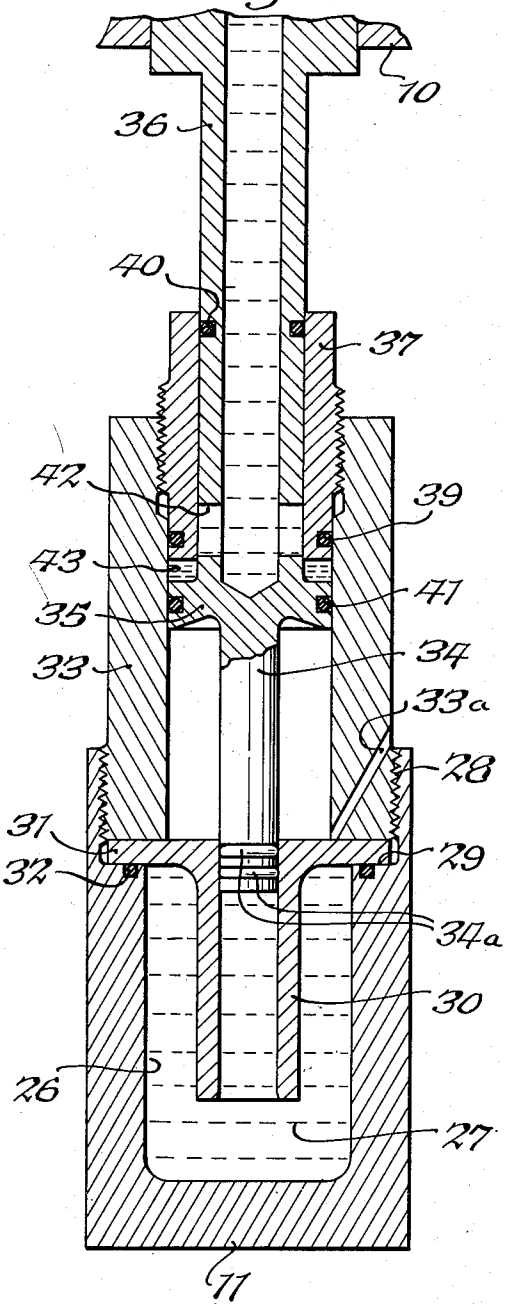
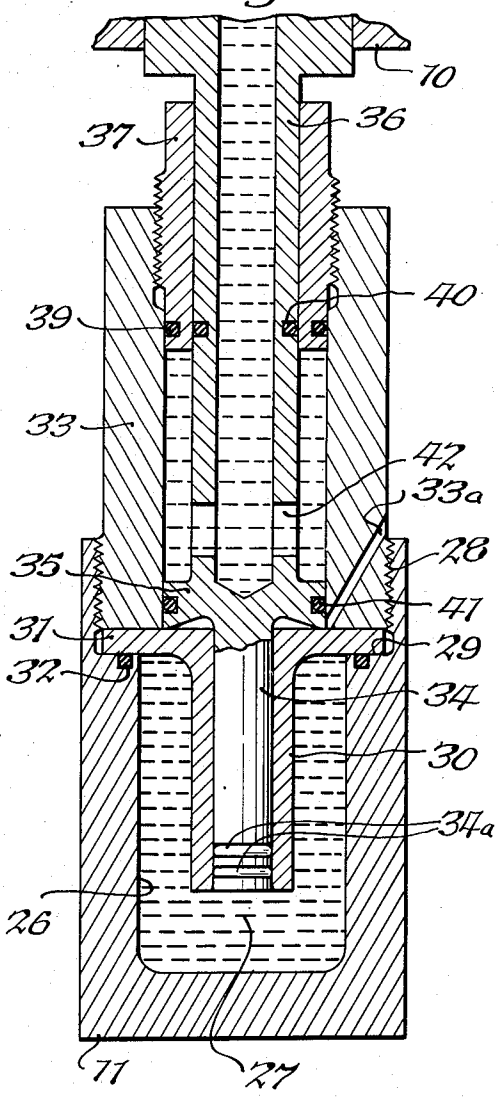


Fig. 3.



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MACHINE TOOL WITH LIQUID SPRING ACTUATED RAM

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Application March 1, 1951, Serial No. 213,322

10 Claims. (Cl. 121—13)

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This invention relates to a work-performing instrumentality which is operative during one stage to compress a fluid medium and in so doing store energy therein and which is operative during a second, or work-performing, stage to release and utilize such energy; and more particularly the invention is concerned with improvements in the work-performing instrumentality disclosed and claimed in the application of Paul H. Taylor, Serial No. 213,403 filed March 1, 1951.

The invention has many and varied applications. For example, it is advantageous in many press-working and forging operations to employ a drop hammer for carrying out desired press-working or forging operations upon work-pieces supported upon an anvil, or die.

In most operations of this type, it has heretofore been the practice to employ a double-acting air or steam cylinder for elevating the heavy hammer to the position at which it is released so that the force of gravity may be utilized to effect the working stroke of the hammer, the double-acting air or steam cylinder also being available to accelerate the hammer in its working stroke and to thereby increase the forces available for the press-working or forging operations. The utilization of the force of gravity and/or air or steam in the above manner has a number of objections. The air or steam employed for operating such cylinders ordinarily does not exceed 500 p. s. i. Hence a large air or steam cylinder is required to elevate a hammer and properly accelerate it, upon its release, in the direction of the anvil or die. Such large cylinders and associated parts are costly to machine, assemble and service. Moreover, the hammer and other actuating parts employed must necessarily be heavy. Other objections are the length of travel required to accelerate the hammer, the slowness of acceleration owing to the forces available for this purpose and the difficulty in controlling the stroke of the hammer and dissipating the dynamic energy created thereby.

In the work-performing instrumentality disclosed in the application referred to, as is also true of the present invention, a fluid medium is compressed to store energy therein and is permitted to expand so that the released energy may be utilized to actuate a member, a ram, for example, which is to be advanced to perform a working stroke. In such an instrumentality there is a possibility that if a work-piece is not present on the anvil or die, or is present

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but not of the proper configuration, and provision is not made to guard against this, the entire dynamic force of the ram will be transmitted by impact to the anvil or die. Such an occurrence may cause various failures including damage to the ram.

The principal object of the present invention is to overcome the above objection, this object contemplating a dynamic work-performing instrumentality of the type generally described wherein provision is made for cushioning the ram, or other member, as it approaches the end of its working stroke in the event that the dynamic force of such ram, or member, has not been otherwise dissipated.

A further object is to provide a novel means for cushioning the impact of the ram, or other work-performing member.

A still further object is a work-performing instrumentality in which the movement of the ram, or other member, is arrested at the end of the working stroke by a compressible fluid medium.

A still further object is to provide a cushioning means of the character described which will be operative to dissipate the dynamic force of the work-performing member through a small portion of the stroke thereof and which will not interfere with the normal operation of the work-performing member throughout its normal range of movement, becoming effective only after the work-performing member passes the point of normal impact.

A still further object is to provide a work-performing instrumentality wherein the parts are so designed that the normally incompressible fluid availed of in compressing the fluid which actuates the work-performing member may be trapped in such a manner that it will become compressible to cushion the work-performing member at the limit of its working stroke in the manner contemplated.

A still further object is a novel design and arrangement of the parts of the work-performing instrumentality, whereby to provide for simplicity and economy in construction and facilitate fabricating, assembling and servicing operations.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a work-performing instrumentality in the form of a press and embodying the features of the invention;

Figure 2 is an enlarged vertical section through the portion of the press which includes the ram

and the associated ram energizing parts and is taken along line 2—2 of Figure 1, the ram being shown extended to the limit of its working stroke;

Figure 3 is a similar section in which the ram is shown in its retracted, or loaded, position; and

Figure 4 is a fragmentary section on an enlarged scale showing a portion of the stationary piston, a portion of the upper cylinder, and a portion of the sleeve which is secured to this cylinder, and associated parts, and showing in a somewhat diagrammatic and exaggerated manner how leakage of the motive fluid may occur to effect retraction of the ram.

The invention is illustrated by way of example in connection with a press which is sufficiently illustrated for the purpose in view by a showing of an overhead support 10, a ram 11 and an anvil or die 12, the frame-work by which the overhead support and ram are mounted in the desired relation with respect to the anvil or die constituting no part of the invention and hence not being illustrated. A work-piece 13 is shown supported upon the anvil or die 12 under the ram 11.

The ram 11 is energized by a low-pressure hydraulic system 14 which includes a reservoir 15, a pump 16 and an accumulator 17. Fluid under pressure is conducted by a pipe 18 from the pump and accumulator through a relief valve 19 to a two-way selector valve 20. The latter is included in a pipe 21 and is operative in one position of adjustment to permit energizing fluid under pressure to enter a conduit 22 to retract the ram 11 in a manner to be described. In a second position of adjustment of the selector valve 20, fluid may leave the pipe 22 during working strokes of the ram and return to the reservoir 15 through the selector valve, pipe 23 and check valve 24. The relief valve 19 maintains constant the pressure of the fluid delivered to the conduit 22 by by-passing excess fluid through relief valve 19, pipe 25 and check valve 24 to the reservoir 15. The fluid employed in the low-pressure hydraulic system is preferably a liquid such as mineral oil, for example, and the system is so designed that the desired energizing pressures are obtained without compression of such fluid.

The manner in which the fluid from the low-pressure hydraulic system is utilized to operate the ram 11 is illustrated in Figures 2 and 3. Referring to the former figure, it will be noted that the ram 11 is hollow and that the interior thereof provides a chamber 26 for accommodating a body of fluid 27 which may be, and preferably is, an oil or other liquid which is more compressible than the mineral oil or liquid employed in the low-pressure hydraulic system, a silicone oil, for example. The ram 11 has an open upper end which is threaded as at 28 and which is enlarged to provide an internal shoulder 29. A cylinder 30 occupies the chamber 26, the external diameter of the cylinder 30 being substantially less than the diameter of the chamber 26 and the lower end of the cylinder being spaced from the bottom of said chamber, as illustrated. The upper end of the cyinder 30 is formed with a flange 31 which seats upon the shoulder 29 to support the cylinder in the chamber 26, a suitable sealing ring 32 being carried in an annular channel in the shoulder 29 and cooperating with the flange 31 on the cylinder to prevent leakage of the fluid medium between the shoulder and said flange.

The cylinder 30 is secured in the ram 11 in the manner described by the lower end of an upper cylinder 33, the lower end of the latter being externally threaded and occupying the threaded open end of the ram 11 so that the flange 31 of the cylinder 30 is tightly held between the shoulder 29 and the lower end of the cylinder 33. The ram 11, cylinder 30 and cylinder 33 are thus secured together so that they will move as a unit incident to the operation of the ram.

A small diameter piston 34 occupies the cylinder 30 while a large diameter piston 35 occupies the cylinder 33. The pistons 34 and 35, in the embodiment illustrated, are integral and are carried by a tubular member 36, the upper end of the latter being suitably connected to the overhead support 10. The tubular member 36, as shown, is integrally connected at its lower end to the upper end of the piston 35, the pistons 34 and 35 and the tubular member 36 being axially aligned and being supported as a stationary unit by the overhead member 10.

A sleeve 37 having an externally threaded central portion is screwed into the upper end of the cylinder 33 and is slidable along the tube 36 during operation of the ram. The sleeve 37 and the tubular member 36 may carry sealing rings 39 and 40, respectively, to prevent leakage of the low pressure hydraulic fluid which is supplied to the tubular member 36 from the low pressure hydraulic system while the piston 35 may be provided with a similar sealing ring 41.

The lower end of the tubular member 36 is ported at 42 so that fluid from the said member may enter the annular space between the tubular member and the inner wall of the cylinder 33 and act against the end of the sleeve 37 to cause the cylinder 33 to be elevated to the position shown in Figure 3. As the cylinder 33 is elevated in the manner described, the ram 11 and cylinder 30 are elevated with it. Consequently, as the piston 34 is stationary, the fluid in the chamber 27 will be compressed. This is clearly illustrated in Figure 3 wherein it will be noted that the cylinder 30 is entirely occupied by the piston 34. As the body of liquid 27 fills the chamber 26 when in its incompressed state and when the ram 11 is in the extended position, it will be apparent that as the ram is elevated in the manner described, the body of fluid 27 will be reduced in volume and energy will thereby be stored in said body of fluid.

Assuming the ram 11 to occupy the elevated position shown in Figure 3, a working stroke of the ram is effected by adjusting the selector valve 20 so that the fluid in the cylinder 33 may exhaust through the pipe 22 and return through the selector valve 20 and check valve 24 to the reservoir 15. As this occurs, the body of fluid 27 in the chamber 26, which was compressed when the ram was elevated, expands rapidly to its normal volume and in so doing transforms the pressure existing in the chamber 26 into kinetic energy and rapidly accelerates the ram 11 in the direction of the anvil or die to effect a press-working operation upon the work-piece supported thereon. The press-working operation is effected by the impact of the ram 11 rather than by a squeezing operation such as characterizes a conventional press-working operation.

As noted, as the fluid in the chamber 26 expands to actuate the ram 11 in the manner described, the cylinder 33 descends, forcing the fluid in the cylinder 33 out through the ports 42 and into the tubular member 36 so that it may exhaust into the reservoir 15. In accordance with the invention, the ports 42 are located above the head of the piston 35 so that as the ram 11 approaches the limit of its working stroke, a body of fluid 43 (Figure 2) will be trapped in the cylinder

33 in the annular chamber delimited by said cylinder, tubular member 36, piston 35 and sleeve 37. The body of fluid thus confined is compressible and resiliently resists any further downward movement of the ram, providing a fluid cushion which will not interfere in any way with the desired reciprocatory movements of the ram and ordinarily only coming into play in the event that a work-piece is not on the anvil at the time the ram is operated or if, for any other reason, the ram would otherwise strike the anvil. The parts are so designed that actuating fluid may leak between those parts of the tubular member 36 and the sleeve 37 which provide walls of the trap in which the fluid 43 is accommodated, it being noted in this connection (see Figure 2) that no seals are employed in connection with these parts of the tubular member 36 and the sleeve 37. Thus some of the trapped fluid may escape through the ports 42 as the ram 11 approaches the limit of its working stroke and as the trapped fluid 43 is compressed in the manner and for the purpose described. When the energy of the ram 11 is dissipated and when, preparatory to a succeeding working stroke, actuating fluid is again supplied through the tubular member 36, a portion of such fluid may leak through the ports 42 and into the annular trap chamber so that such fluid may act between the piston 35 and the lower end of the sleeve 37 to retract the ram 11 until the ports 42 are again open. The leakage path is shown in exaggerated manner in Fig. 4, this figure being a fragmentary section taken at the left of Fig. 2 at and adjacent the pocket in which the fluid 43 is trapped.

Preferably a port 33*a* connects with atmosphere the portion of the cylinder 33 below the piston 35, whereby to permit entry of air into and its escape from such portion of the cylinder during the operation of the ram.

The construction described has the advantage that the fluid medium in the low pressure hydraulic system is utilized to provide the fluid cushion and although said fluid medium is normally incompressible the parts may be so designed that the confined body of fluid 43 will be compressed to absorb energy as the ram approaches the limit of its working stroke.

The piston 34 may carry sealing rings 34*a* for preventing escape of fluid from the chamber 26 between the cooperating walls of the piston and the cylinder 30. If desired, the sealing rings 34*a* may serve only during the low-pressure portion of the compression strokes and sealing during the high-pressure range of such strokes may be obtained by so designing the cylinder 30 that it will be compressed around the piston as disclosed and claimed in the copending application of Paul H. Taylor Serial No. 180,966, filed August 29, 1950.

The work-performing instrumentality described has a number of highly desirable advantages. The parts may be so designed that extremely high forces may be developed in the compressed fluid by a low-pressure hydraulic energizing system, it being apparent that the parts may be so designed that any desired pressure, within limits, may be developed in the chamber 26 by the energizing fluid supplied to the cylinder 33. For example, the parts may be so designed that a pressure of 30,000 p. s. i. may be developed in the chamber 26, thereby pre-loading the ram 11 in its fully retracted position so that upon release of pressure in the chamber 26 in the manner described, the ram 11 will be actuated to utilize such energy in a press-working operation.

It will be noted that the energy which is released by the expanding fluid in the chamber 26 is transferred to the ram 11 throughout its full range of movement so that the reaction forces acting on the supporting frame structure are progressively transmitted to the latter in a similar manner. As the forces to which the supporting frame structure is subjected are dissipated over the entire stroke of the ram, such structure may be relatively light and of corresponding low cost.

Although the use of oils and liquids of different compressibilities in the low-pressure hydraulic system and high pressure energy storing system has been described, it will be apparent that the work-performing instrumentality contemplated is of such a character that oil or other liquids of the same compressibility may be employed in both systems, if desired.

The features of the invention may be employed to advantage in connection with various devices having a member which is advanced incident to a work-performing stroke and which is retracted preparatory to such a stroke. The specific embodiment illustrated and described, therefore, is intended by way of example only.

I claim as my invention:

1. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of liquid is confined, a cylinder extending into said chamber and spaced from the walls thereof, a stationary piston which occupies said cylinder, means for retracting said member and in so doing cause said piston to compress said body of liquid, means for relieving said last mentioned means so that said body of liquid may expand to effect said working stroke of said member, and means for cushioning said member as it approaches the limit of said working stroke.

2. Apparatus of the character described comprising a member having a hollow chamber therein, a cylinder extending into said chamber, said cylinder having its inner end open and communicating with said chamber, said chamber and cylinder being filled with a body of liquid and confining said body of liquid, a piston reciprocable through the outer end of said cylinder, a second piston rigidly secured to the first piston, a second cylinder rigidly secured to the first cylinder and in which said second piston reciprocates, means including a port through which a hydraulic motive fluid may be supplied to and exhausted from one side of said second piston to advance and retract the first piston in the first cylinder, said first piston when advanced into said first cylinder compressing said body of liquid, and valve means controlling the direction of flow of the hydraulic motive fluid to said one side of the second piston, said port being spaced sufficiently from said one side of said second piston that a body of said hydraulic motive fluid is trapped between said second piston and said second cylinder, when said valve is on exhaust, to cushion the last part of the movement of said second piston in said second cylinder when said valve is on exhaust.

3. A compound fluid motor comprising a hollow member open at one end, a cylinder extending into said hollow member and open at its inner end to communicate therewith, a piston reciprocable in said cylinder, means including said cylinder and said piston for closing the open end of said hollow member, said hollow member

and cylinder being filled with a body of liquid which is of high compressibility, a second piston secured to the first piston, a second cylinder in which the second piston reciprocates, said second cylinder being secured to the first cylinder, means including a port for supplying a liquid of low compressibility between one end of the second piston and the adjacent end of the second cylinder and for exhausting said last-named liquid therefrom to compress said body of highly compressible liquid and to permit the same to expand, respectively, and a valve controlling the direction of flow of the liquid of low compressibility, said port being spaced from said second piston a sufficient distance to trap a body of said second liquid between said second piston and said second cylinder when said second cylinder is on exhaust, to cushion the last part of the relative movement between said second piston and said second cylinder when said second cylinder is on exhaust.

4. Apparatus of the character described comprising a reciprocable member having a hollow chamber therein, a cylinder extending into said chamber and spaced from the inside wall of said chamber, said cylinder having its inner end open and communicating with said chamber, said chamber and cylinder being filled with a body of liquid and confining said body of liquid, a stationary piston reciprocable through the outer end of said cylinder, a second piston rigidly secured to the first piston, a second cylinder rigidly secured to the first cylinder and in which said second piston reciprocates, a tube connected to the first piston having ports therein for supplying and exhausting a second liquid to and from one side of the second piston, said ports being spaced from said second piston so that a body of the second liquid is trapped between the second piston and the second cylinder near the end of the movement of the second piston in the second cylinder when the second cylinder is on exhaust, and a valve controlling the direction of flow of the second liquid through said tube and ports.

5. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of fluid is confined and providing a cylinder, stationary first and second connected pistons, said first piston occupying said cylinder, a fluid motor having a second cylinder connected to said member and occupied by said second piston, means for supplying a second fluid under pressure to said motor to effect relative movement between said second cylinder and said second piston and in so doing cause said first piston to compress said body of fluid, means for relieving said last mentioned means so that said body of fluid may expand to effect said working stroke of said member, and means including said second cylinder and piston for trapping a body of said second fluid to cushion said member as it approaches the limit of said working stroke.

6. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of liquid is confined, a cylinder extending into said chamber and spaced from the walls thereof, stationary first and second connected pistons, said first piston occupying said cylinder, a fluid motor having a second cylinder connected to said member and occupied by said second piston, means for supplying a second liquid under pressure to said motor to effect relative movement between said second cylinder and said second piston and in so doing cause said first piston to compress said body of liquid, means for relieving said fluid motor so that said body of liquid may expand to effect said working stroke of said member, and means including said second cylinder and piston for trapping and compressing a body of said second liquid to cushion said member as it approaches the limit of said working stroke.

7. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of fluid is confined, a cylinder extending into said chamber, stationary first and second aligned, connected pistons, said first piston occupying said cylinder, a reciprocatory fluid motor having a second cylinder connected to said member and occupied by said second piston, a stationary tube which enters and which communicates with said second cylinder and axially of which said second cylinder may slide, means for supplying a second fluid under pressure through said tube to the interior of said second cylinder to effect relative movement between said second cylinder and said second piston and in so doing cause said first piston to compress said body of fluid, means for permitting the fluid in said second cylinder to exhaust so that said body of fluid may expand to effect said working stroke of said member, and means for trapping a body of said second fluid in said second cylinder to cushion said member as it approaches the limit of said working stroke.

8. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of fluid is confined, a cylinder extending into said chamber, stationary first and second pistons, said first piston occupying said cylinder, a reciprocatory fluid motor having a second cylinder connected to said member and occupied by said second piston, a stationary tube which enters and which communicates with said second cylinder and axially of which said second cylinder may slide, said first and second pistons and said tube being serially connected in axial alignment, means for supplying a second fluid under pressure through said tube to the interior of said second cylinder to retract it and in so doing cause said first piston to compress said body of fluid, means for permitting the fluid in said second cylinder to exhaust so that said body of fluid may expand to effect said working stroke of said member, and means for trapping a body of said second fluid in said second cylinder to cushion said member as it approaches the limit of said working stroke.

9. A device having a member which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said member having a chamber in which a body of liquid is confined, a cylinder extending into said chamber and spaced from the walls thereof, stationary first and second pistons, said first piston occupying said cylinder, a reciprocatory fluid motor having a second cylinder connected to said member and occupied by said second piston, a stationary tube which enters and communicates with said second cylinder and axially of which said second cylinder may slide, said first and second pistons and said tube being serially connected in axial alignment,

means for supplying a second liquid under pressure through said tube to the interior of said second cylinder to retract it and in so doing cause said first piston to compress said body of liquid, means for permitting liquid in said second cylinder to exhaust so that said body of liquid may expand to effect said working stroke of said member, and means for trapping a body of said second liquid in said second cylinder to cushion said member as it approaches the limit of said working stroke.

10. In a press of the character described, a ram which is advanced to perform a working stroke and which is retracted preparatory to a succeeding working stroke, said ram having a chamber in which a body of liquid is confined, a cylinder extending into said chamber and spaced from the walls thereof, stationary first and second pistons, said first piston occupying said cylinder, a fluid motor having a second cylinder connected to said ram and occupied by said second piston, means for supplying fluid under pressure to said second cylinder to retract the latter and in so doing retract said ram and cause said first piston to compress said body of liquid, means for permitting fluid in said second cylinder to exhaust so that said body of liquid may expand to effect the working stroke of said member, and means for trapping a body of said

fluid in said second cylinder to cushion said ram as it approaches the limit of said working stroke.

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