July 22, 1969 D. R. JAMES 3,456,741

PERCUSSIVE TOOLS AND MACHINES

Filed July 5, 1967 5 Sheets-Sheet 1

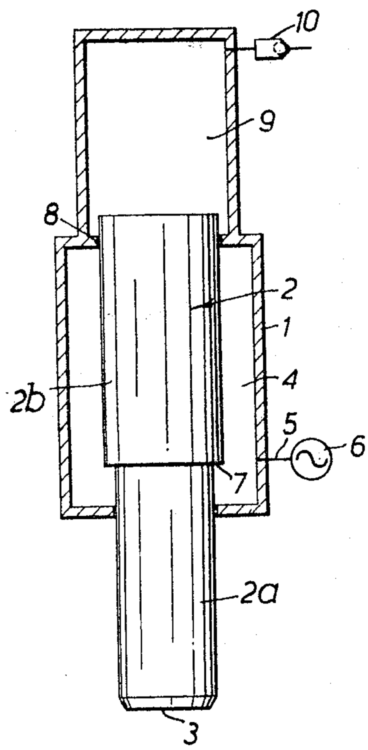

FIG. 1.

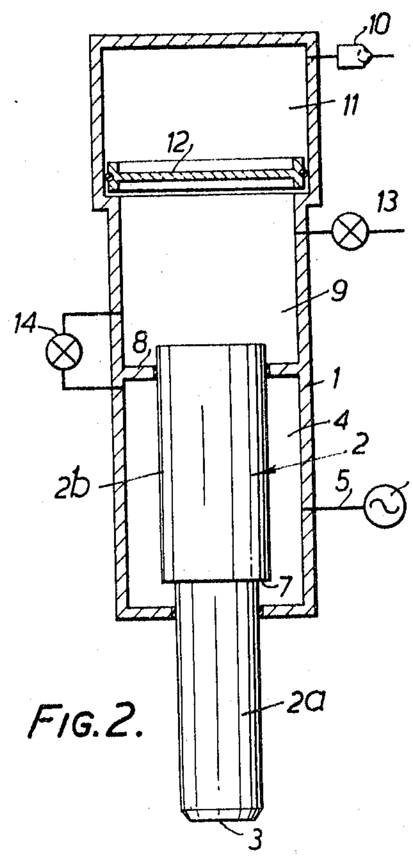

FIG. 2.

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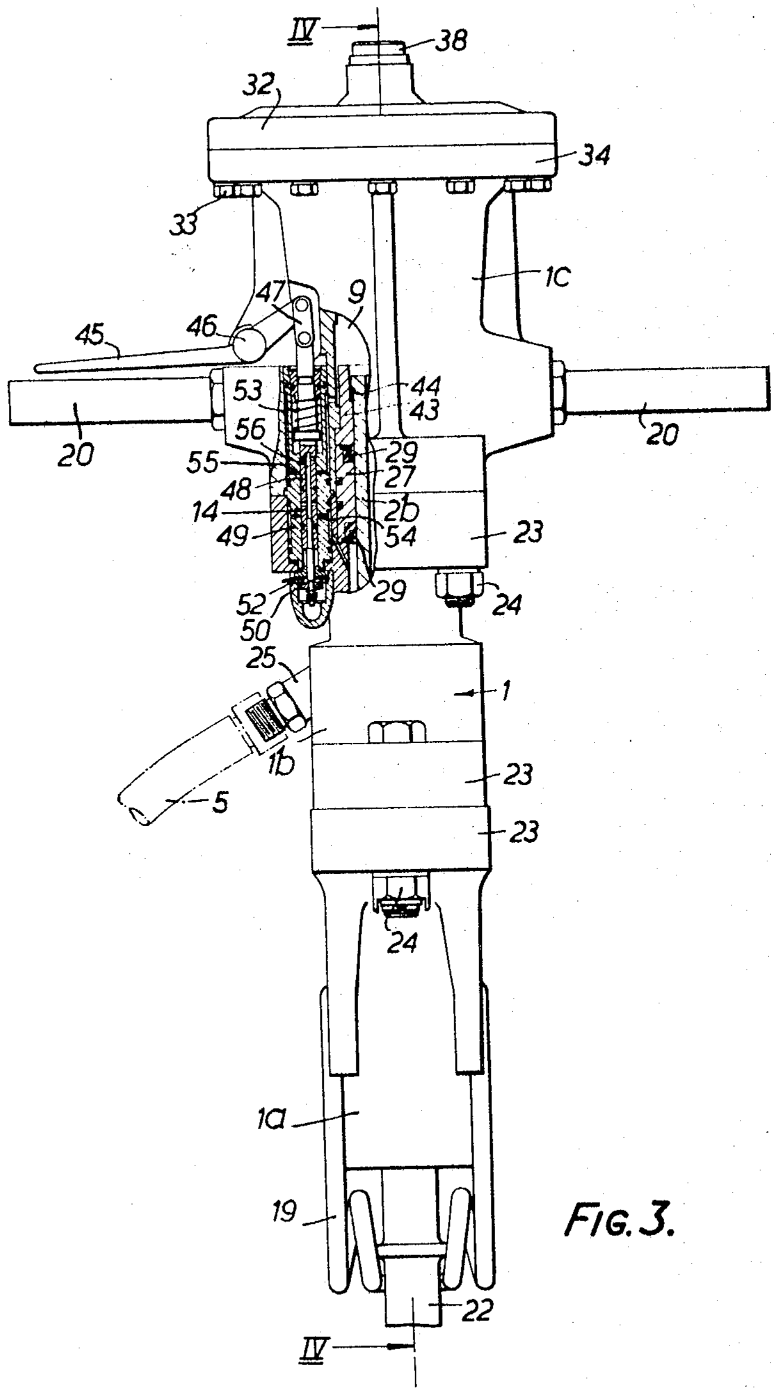

FIG. 3.

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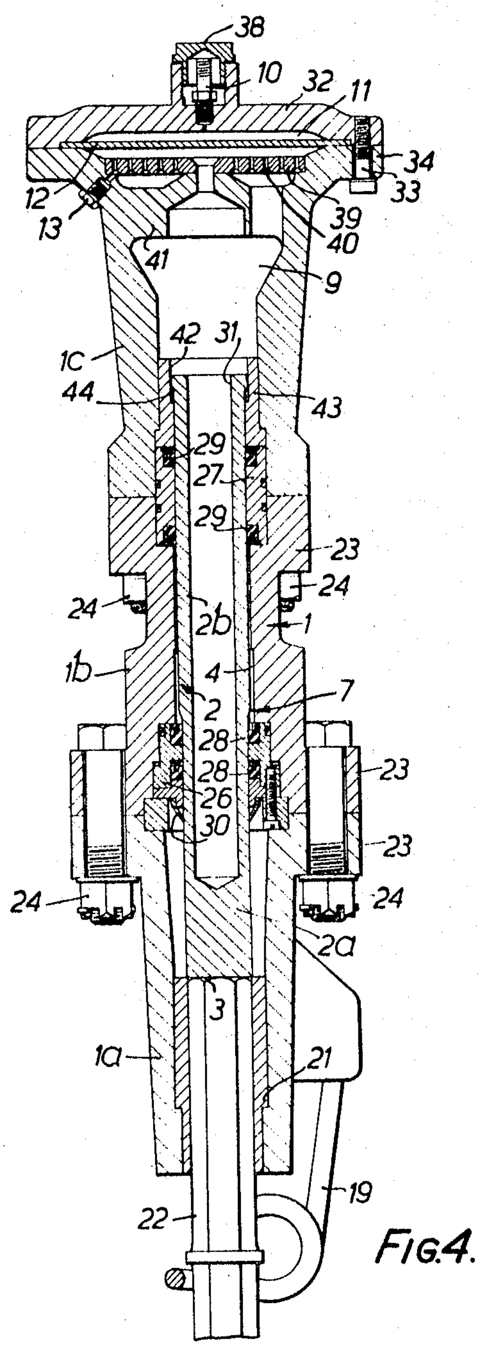

FIG.4.

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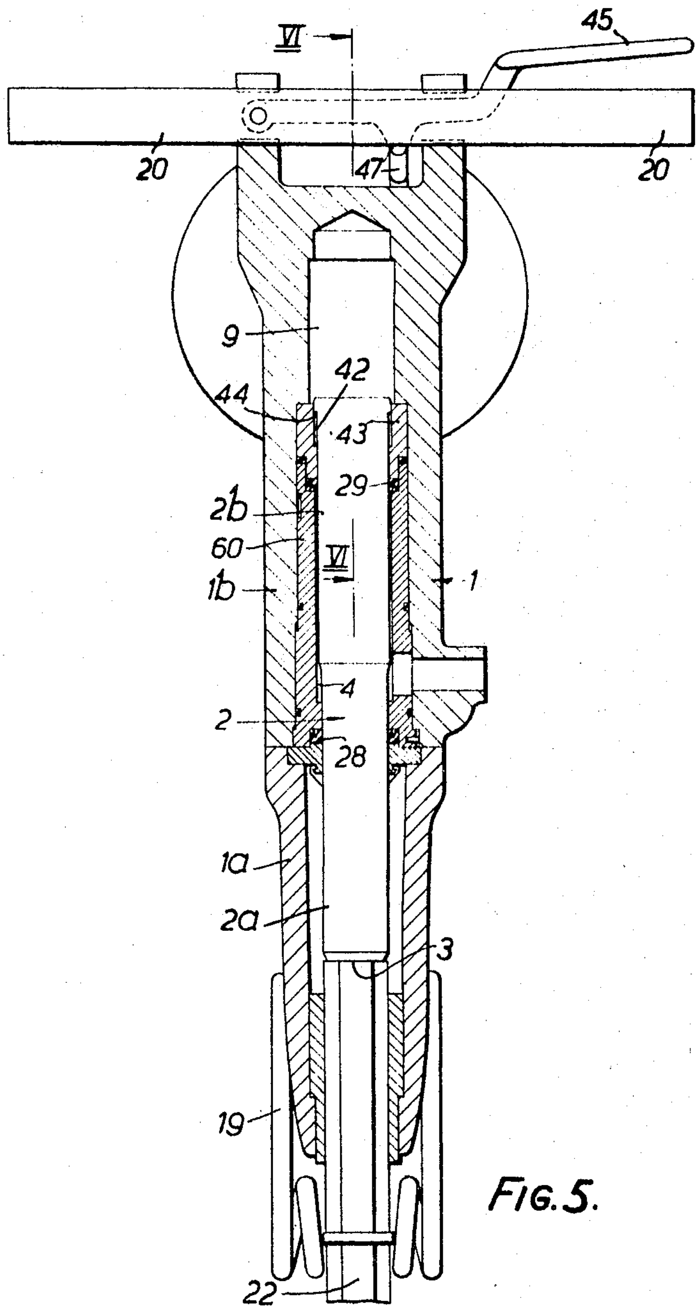

FIG. 5.

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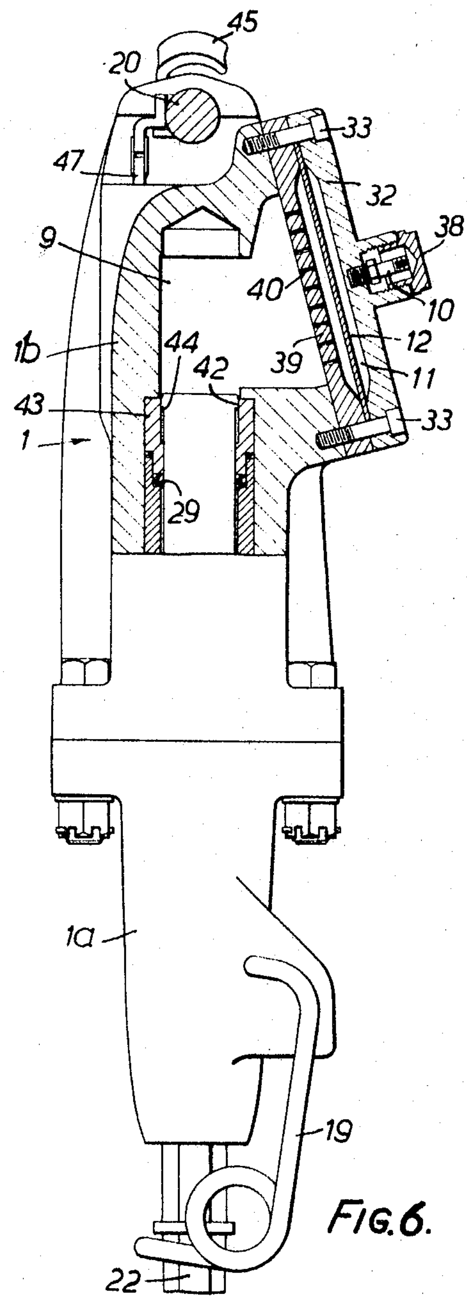

FIG.6.

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PERCUSSIVE TOOLS AND MACHINES

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Int. Cl. E21b *1/00;* E21c *3/00;* B25d *9/00*
U.S. Cl. 173—116 9 Claims

ABSTRACT OF THE DISCLOSURE

A percussive tool or machine derives motive power from a series of fluid pressure pulses. Movement of a piston and striker arrangement in one direction resulting from the application of fluid pressure pulses to the piston, and reverse movement is produced by a return spring which acts on the piston through a fluid medium contained in a chamber into which the piston enters. The fluid medium may be a compressed gas to provide a spring of pneumatic type, although the fluid medium may alternatively provide a fluid shield between the piston and the spring.

This invention relates to percussive tools and machines, hereinafter referred to generally as "percussive mechanisms" and of the type which derive motive power from a series of fluid pressure pulses. The pressure pulses may be produced either by valvular control of a substantially steady supply pressure or by means of an alternating pressure pulse generator. The invention is of particularly advantageous application to tools such as road breaker hammers and rock drills, forging hammers and the like.

Percussive tools and machines of the foregoing type normally employ a striker and piston arrangement, the kinetic energy of the striker which is employed to do useful work resulting from movement of the piston under fluid pressure in one direction and by a return spring in the opposite direction. At the moment of impact of the striker there is a very substantial shock load which in prior constructions, utilising a helical metal spring acting directly on the piston, materially reduces the life of the spring. In fact, rapid disintegration of the spring may result with a tool operating at high frequency, said as, for example, 30 cycles per second.

According to the invention a percussive tool or machine has a piston and striker arrangement, movement of the piston and striker in one direction in use resulting from the application of fluid pressure pulses to the piston and reverse movement being produced by a return spring which acts on the piston through a confined body of liquid.

The confined body of liquid provides in effect a fluid shield between the spring and the piston, and the spring and the piston, and the spring may be a suitably compressible fluid. One end of the piston may be arranged to move in a liquid-filled chamber from which the piston projects, the liquid providing the substantially incompressible fluid shield and the chamber having a movable or deformable wall which separates the liquid chamber from a spring chamber containing the compressible fluid providing the spring. The compressible fluid may be air or any other suitable gas. Alternatively the spring chamber may also contain an incompressible fluid but be formed with an elastic wall so that the chamber itself expands in accordance with the energy stored in the spring.

The confined body of liquid is preferably prepressurised prior to operation of the tool. Means are preferably provided to bleed off any gas which may accumulate in the medium.

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The invention is conveniently adopted with a percussive tool or machine in which a forward power stroke of the piston and striker is produced by the spring, movement under the fluid pressure pulses being in the opposite sense to the power stroke and merely serving to store energy in the spring. The tool or machine also conveniently forms the receive of a power transmission system of the type, sometimes referred to as an alternating flow or A.F. hydraulic system, in which an alternating pressure hydraulic pulse generator is connected through a power line, normally in the form of a single flexible hydraulic hose, to the receiver. The system may be charged at a predetermined positive make-up pressure, thus providing a datum above atmospheric pressure about which the system pressure alternates. In this case the fluid shield may utilise the hydraulic liquid, and be prepressurised to the system make-up pressure.

The spring may, for example, take any one of a number of alternative forms well known and in use as hydraulic accumulators.

The invention will now be further described with reference to the accompanying drawings which illustrate, by way of example, two forms of road breaker in accordance with the invention. In the drawings:

FIGURES 1 and 2 are diagrammatic sketches which are illustrative of the invention as applied to two basic forms of percussive tools or motors in accordance therewith,

FIGURE 3 is a side view of one of the road breakers, partly in axial section,

FIGURE 4 is an axial section on the line IV—IV in FIGURE 3,

FIGURE 5 is a view similar to that of FIGURE 4 but of the other road breaker, and

FIGURE 6 is a side view partly shown in section on the line VI—VI in FIGURE 5.

FIGURES 1 and 2 illustrate diagrammatically two percussive tools or motors which in each case forms in use the receiver of an A.F. hydraulic power system and comprises a generally tubular body **1**. An integral piston and striker **2** of cylindrical stepped from is slidable coaxially within the body **1** and has a reduced diameter section providing a striker portion **2***a* with a forward end striking face **3** which strikes a drill bit, or other element to be subjected to the percussive force, during a power stroke of the piston and striker **2** outwardly of the body **1**.

The stepped form of the piston and striker **2** is such that movement in the sense opposite to the power stroke results from pressure pulses applied to a pressure chamber **4** through which the piston and striker **2** passes and which in use is connected, through a single flexible hose **5**, to the alternating hydraulic power generator **6**. The step **7** in the piston and striker provides a differential area on which the pressure pulses act.

The striker portion **2***a* of the piston and striker **2** adjoins the piston portion **2***b* which projects through a seal in an end wall **8** of the pressure chamber **4** into a further chamber **9** containing a fluid medium through which a spring return force is applied to the free end of the piston portion **2***b*. Thus the energy stored in the spring during movement of the piston and striker **2** under the influence of the hydraulic pressure fluid pulses acts to provide a return power stroke during which the striker portion **2***a* engages said element.

In the arrangement of FIGURE 1 the fluid chamber **9** contains a compressible fluid, conveniently a gas such as air, so that this fluid itself is compressed and acts as a spring. Thus the chamber **7** itself forms a spring chamber. A check valve inlet **10** is provided so that the chamber **9** can be pre-pressurised to the requisite degree to provide the desired spring characteristic over a relatively short travel of the striker and piston **2** and excessive travel of the latter is not necessary. To compensate for any leakage from the chamber **9** the inlet may if desired be connected to an external source of make-up fluid under pressure, for example a source of compressed air which maintains the desired air pressure within the chamber **9**.

Instead of a compressible fluid such as air the fluid chamber **9** may still act as a spring and yet contain a substantially incompressible fluid, for example the hydraulic liquid supplied to the pressure chamber **4**, the wall of the chamber **9** in this case being at least in part elastic and deformable so that energy is stored in the fluid even though the volume of the latter remains constant.

In the arrangement of FIGURE 2 the fluid chamber **9** does not itself form the spring chamber and is separated from a further or spring chamber **11** by a movable wall, which may be a sliding piston **12** as shown or a flexible diaphragm. The spring chamber **11** may contain a compressible fluid providing the spring or other spring means, such as a metal coil spring, which acts on the separating wall **12**. In this case the check valve **10** supplies the chamber **11** and the fluid medium in the chamber **9** acts merely as a fluid shield which transmits pressure energy between the spring itself and the piston portion **2***b*, and a manually operable bleed valve **13** is provided to bleed off any gas which may accumulate in the chamber **9**. In order to prepressurise the latter a manually operable valve **14** is provided and can be opened to interconnect the pressure chamber **4** and the fluid shield chamber **9** which is filled with the hydraulic liquid providing the driving hydraulic pressure pulses. Opening the valve **14** while the whole system is under positive pressure thus pre-fills and pressurises the chamber **9**, gas or air in the latter being bled off through the bleed valve **13**.

The outward limit of movement of the piston and striker is defined by a mechanical stop (not shown), and opening the valve **14** when the system is under pressure but not pulsing automatically moves the piston and striker **2** to the limit position as the same fluid pressure acts in the outward direction against the full piston area whereas pressure acts in the opposite direction only against the step **7**. It is in some cases conveniently arranged that when idling the whole system, from the pulse generator onwards, can be subject to any desired pressure less than the lowest pulse pressure, so that pre-charging of the chamber **9** by means of the charging valve **14** can be accomplished under ideal conditions.

When the wall **12** separating the fluid shield chamber **9** and the spring chamber **11** is a flexible diaphragm it may, as in the two practical constructions now to be described, be supported in the idle condition upon an apertured plate. The diaphragm serves as a non-porous membrane which separates on the one hand the liquid pressure-transmitting fluid in the chamber **9** and, on the toher hand, a compressible gas in the spring chamber **11** which provides the spring action.

Turning now to the practical embodiment of FIGURES 3 and 4, which where appropriate together with the embodiment of FIGURES 5 and 6 utilises the same reference numerals as the diagrams of FIGURES 1 and 2, the tubular body **1** is now provided with two diametrically opposed and projecting tubular handles **20** by which the hammer is held when in use. At the forward end the body has a sleeve insert **21** in which a replaceable drill bit **22** of conventional form can be mounted, only a rear end section of the bit being illustrated in the drawings. The bit **22** is detachably retained by a retainer spring **19** mounted on the body **1**. The body **1** comprises a forward portion **1***a*, an intermediate portion **1***b* and a rear portion **1***c* in which the handles **20** are mounted. The portions **1***a* and **1***b* are flanged at **23** to enable the portions to be bolted together by rings of bolts **24**.

The pressure chamber **4** is formed in the body portion **1***b* in which is mounted an external hose adaptor **25** for connection of the hose **5**. The adjoining ends of the body portions are counterbored to house and locate seal carrier **26** and **27**, each of which carries a duplex arrangement of lip-type seals **28** and **29** respectively. The seals **28** define the forward end of the pressure chamber **4** with the seals **29** defining the rear end thereof. A scraper ring **30** mounted on the forward end of the carrier **26** engages the striker portion **2***a* and provides a seal against contamination of the forward seals **28** by dirt entering the forward end of the body **1**. The piston and striker **2** is hollow, having a blind bore **31** drilled from the rear end in order to reduce the inertia to suit the resonant conditions which are required to match the reciprocatory system to the frequency of the power generator **6**, a typical operating frequency being 30 cycles per second.

The embodiment is functionally similar to the construction of FIGURE 2, with a substantially incompressible liquid fluid in the chamber **9** acting as a fluid shield and transmitting the spring force from the spring chamber **11**. The spring chamber **11** contains air under pressure, this chamber being closed by an end cap **32** fixed by a ring of bolts **33** to a rear end flange **34** on the body portion **1***c*. The chamber **11** is separated from the chamber **9**, which is formed by the internal space of the body portion **1***c*, by a flexible diaphragm **12** which in FIGURE 4 is shown in the resting or uncharged position and which is clamped around its periphery between the end cap **32** and the flange **34**. The fluid chamber **9** is in use charged with the hydraulic operating liquid supplied to the pressure chamber **4**. The spring chamber **11** is pre-charged to the required spring pressure through the check valve **10** which is mounted centrally in the end cap **32** and protected by a screwed cover **38** which is removed to allow access to the valve.

A typical operating spring pressure is 100 lbs. per square inch, and this deflects the diaphragm to its precharged position in which it lies flat against an apertured support plate **39** let into the body portion **1***c* and in effect defining the volume limit of the spring chamber **11**. The plate **39** has concentric rings of multiple drillings such as **40** which permit liquid transfer across the plate to and from the fluid chamber **9** and so that the pressure in the latter always acts on the diaphragm **12**. Central support for the plate **39** is provided by an apertured cross wall **41** in the body portion **1***c*, which has a central projection to which the plate **39** is riveted.

The outward limit of movement of the piston and striker **2**, i.e. movement in the forward power stroke direction, is limited by engagement of the striker face **3** with the rear end of the insert **21** as shown in FIGURE 4. This is the normal resting condition which obtains between periods of use, which periods will normally be somewhat intermittent. Means which will now be described ensure that in the free-running condition the piston and striker **2** does not strike the insert **21** to produce arduous shock load conditions, with attendant noise and risk of mechanical damage. These means are hydraulic in operation and employ a rear end counterbore **42** formed in a bush **43** which is fitted in the body portion **1***c* and surrounds the piston portion **2***b* rearwardly of the seal carrier **27**. A step **44** at the rear end of the piston portion **2***b* enters the counterbore **42** as the outer limit of the forward stroke of the piston and striker **2** is approached. Thus some of the hydraulic liquid in the fluid chamber **9** is trapped within the counterbore **42** which in effect provides an arresting chamber, continued forward movement of the piston and striker **2** compressing this liquid to provide a dashpot action. In operation of the hammer this prevents the forward position of the piston and striker **2** illustrated in FIGURE 4 being reached, and this is so even when the hammer is free running. The liquid compressed in the counterbore **42** is ejected from the latter through a restriction provided by a small annular clearance between the piston portion **2***b* and the counterbore **42**, and in the illustrated construction this clearance is of the order of two thousandths of an inch.

Operation of the hammer is controlled by means of an operating lever **45** which is pivotally mounted on the body portion **1***c* at **46**. The lever **45** overlies one handle **20** and is connected through a link **47** to a piston valve member **48** of the balance valve **14**. The valve member **48** is slidable in a ported sleeve **49** mounted in a bore formed partly in the body portion **1***b* and partly in the body portion **1***c* alongside the seal carrier **27**. A spring-loaded moving electrical contact **50** is mounted on the forward end of the valve member **48** for cooperation with a fixed electrical contact **52** which is insulated from the body **1**. To operate the hammer the lever **45** is gripped to the adjacent handle **20**, and this closes the contacts **50** and **52** and moves the valve member **48** against the force of a valve spring **53** to the run position illustrated in FIGURE 3. An electrical lead (not shown) from the contact **52** runs back with the hose **5** to the pulse generator **6** for remote control of a hydraulic control valve at the generator. The electrical control circuit employs an earth return utilising metal reinforcing braid of the hose **5**.

In the run condition shown in FIGURE 4 ports **54** and **55** in the valve sleeve **49**, which respectively communicate with the pressure chamber **4** and the fluid chamber **9**, are blanked off so that they do not communicate and hence the chambers **4** and **9** are isolated one from the other during the operation of the hammer. On release of the lever **45** the valve member **48** is returned by the spring **53**; as a result the contacts **50** and **52** open to de-energise the control valve at the generator **6** and hence reciprocation of the piston and striker **2** ceases. The valve member **48** moves to a resting position in which a bore **56** in that member interconnects the ports **54** and **55**. The hydraulic system includes a make-up pump which tends to maintain a minimum hydraulic pressure of say 100 lbs. per square inch, and maintains this pressure when the generator **6** is inoperative as a result of the contacts **50** and **52** being open. This condition corresponds to a valve position in which the chambers **4** and **9** intercommunicate, and this ensures that when the hammer is idle the chamber **9** is pre-charged to the make-up pressure ready for operation. The make-up pressure is also applied to the rear end of the piston and striker **2**, with resultant forward movement of the piston and striker to the forward limit position (illustrated in FIGURE 4) against the opposition of the same hydraulic pressure acting on the relatively small step **7** in the pressure chamber **4**. Thus movement of the valve member **48** to the idle position not only ensures that the chamber **9** is pre-charged to the correct pressure but also that it contains the correct volume of hydraulic liquid, i.e. the volume corresponding to the forward limit defined by abutment of the piston and striker **2** with the insert **21**.

Thus the automatic operation of the valve **14** assists in maintaining steady and optimum running conditions, immediately after use the liquid in the chamber **9** being correctly adjusted as regards both pressure and volume. During operation there is a tendency for pressure in this chamber to increase, as a result not only of increasing temperature but also of any leakage from the pressure chamber **4** past the seals **29**. During setting up of the hammer with the make-up pump running the valve **14** operates to precharge the chamber **9**, any air being displaced past a bleed screw **57** which is slackened off for the purpose and provides the bleed valve **13** already described with reference to FIGURE 2. With the correct pressure condition in the chamber **9** the chamber **11** can be precharged with compressed air to the correct spring pressure, and the hammer is then ready for use by operation of the lever **45**.

The use of the fluid shield provided by the hydraulic liquid in the chamber **9**, together with the flexible diaphragm **12**, provides a particularly convenient manner of utilising a pneumatic spring as there are no problems of air leakage from the spring or contamination by leakage from the pressure chamber **4** and yet the spring force is applied satisfactorily and directly to the piston and striker **2**. The liquid in the chamber **9** in effect acts as a liquid connecting rod, and what can be termed a hydro-pneumatic spring system results. As an example of typical operating conditions in the embodiment of FIGURES 3 and 4, with the spring pre-charged to a pressure of 100 lbs. per square inch a maximum spring pressure of 380 lbs. per square inch results with a hydraulic operating pressure the pulses of which produce pressure variations between 60 and 1800 lbs. per square inch at an operating frequency of 30 cycles per second.

The embodiment of FIGURES 5 and 6 is fundamentally similar to that of FIGURES 3 and 4 but is somewhat simpler and has one important modification. This modification is that the spring chamber **11**, again defined between an end cap **32** and a flexible diaphragm **12**, is angled over to one side as shown more particularly in FIGURE 6. This produces a shorter and more compact tool ,in which the handles **20** and the operating lever **45** can be disposed at the rear end of the body **1**, which allows more convenient and comfortable operation particularly as the operator is well clear of the end plate **32** which during prolonged operation of the hammer may tend to become rather hot to the touch. The embodiment is simpler in that the body **1** now comprises only two portions, a forward portion **1***a* and a rear portion **1***b*. A sleeve **60** which fits a counterbore in the forward end of the body portion **1***b* acts as a carrier for the lip-type seals **28** and **29**, in this case only one such seal being employed at each end of the pressure chamber **4**. The use of the liquid in the chamber **9** to transfer the spring force to the piston and striker **2** now has the additional advantage that the angled position of the spring chamber **11** in no way affects the efficiency of operation.

In FIGURES 5 and 6 the apertured plate **39** is not let into the body **1**, but is sandwiched between the body portion **1***b* and the end cap **32**. This simplifies machining, and the plate **39** is fixed entirely by the cap securing bolts **33**.

I claim:

1. A percussive mechanism having a piston and striker, means for applying fluid pressure pulses to the piston to move the piston and striker in one direction, return spring means for causing reverse movement of the piston and striker, and a chamber containing a body of fluid, the spring means acting through said fluid on the piston to provide in effect a fluid shield between the spring means and the piston.

2. A percussive mechanism as claimed in claim **1**, said spring means being comprised by a relatively compressible fluid.

3. A percussive mechanism as claimed in claim **1**, one end of said piston being movable in said chamber, said piston projecting from said chamber, said chamber having a wall at least a portion of which is movable, said wall separating said chamber from a spring chamber in which said return spring means is disposed.

4. A percussive mechanism as claimed in claim **3**, said wall being comprised by a sliding piston.

5. A percussive mechanism as claimed in claim **3**, said wall being comprised by a flexible diaphragm.

6. A percussive mechanism as claimed in claim **5**, and an apertured plate within the fluid-filled chamber, said diaphragm seating against said plate when the volume of said spring chamber is at a maximum.

7. A percussive mechanism as claimed in claim **3**, said spring means comprising a compressible gaseous fluid in said spring chamber.

8. A percussive mechanism as claimed in claim **7**, said spring chamber having a wall which is at least in part elestic so that the spring chamber itself expands in accordance with the energy stored in the spring means.

9. A percussive mechanism as claimed in claim 1, in which said body of fluid is a liquid.

References Cited

UNITED STATES PATENTS

2,597,292	5/1952	Coates	173—119
2,807,021	9/1957	Chellis	173—15
3,156,309	11/1964	Swenson	173—119
3,216,510	11/1965	Briden	173—119
3,321,033	5/1967	Benuska et al.	173—119

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173—119