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PERCUSSIVE TOOLS AND MACHINES

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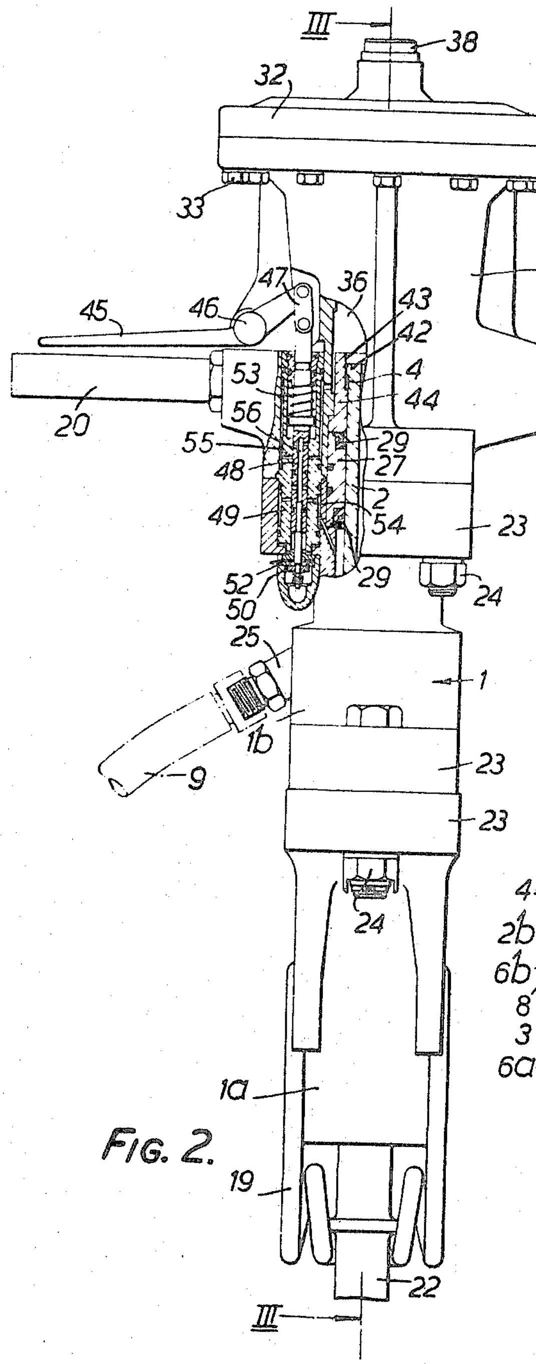

FIG. 2.

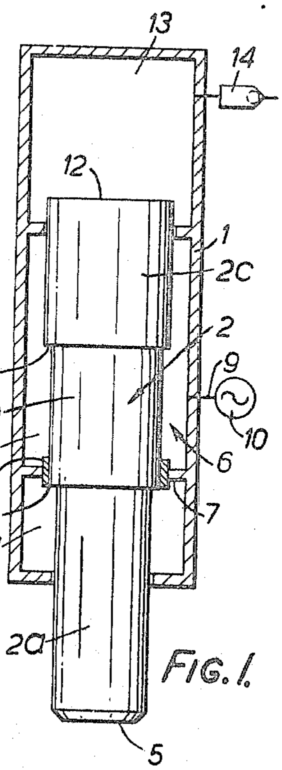

FIG. 1.

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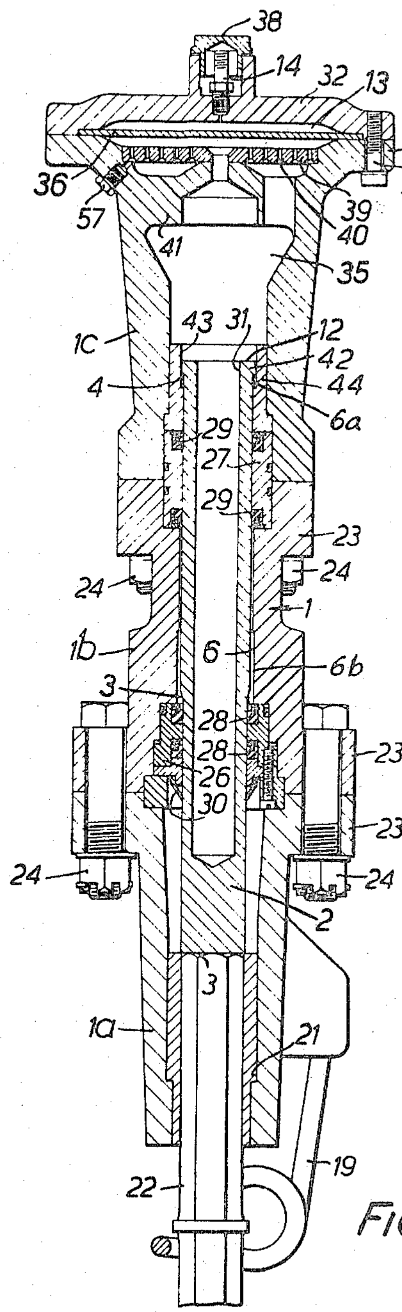

FIG.3.

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PERCUSSIVE TOOLS AND MACHINES

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ABSTRACT OF THE DISCLOSURE

A free-stroking percussive tool or machine, for example a road breaker, rock drill, hammer or forging machine, has hydraulic means for arresting and reversing a reciprocatory piston and striker. The piston and striker is stepped to provide a differential area which, when approaching the outer limit of the forward stroke of the striker, enters and closes or restricts an aperture of a chamber which is filled with liquid. Further forward movement of the piston and striker is arrested by the resultant pressure rise in the chamber.

This invention relates to percussive tools and machines hereinafter referred to generally as "percussive mechanisms," and is applicable to any free-stroking devices such as road breakers, rock drills, hammers and forging machines.

With a free-stroking percussive device it is necessary to provide means for arresting and reversing a striker at the end of the power stroke of the latter when the machine is free-running, i.e. not under load. Such conditions occur with a road breaker or rock drill, for example, during tool withdrawal when there is no impact between the striker and the tool. It is customary to fit a mechanical spring or springs to retain a nose piece or tool holder to a road breaker or rock drill to absorb the impact when free-running, and to protect the nose piece itself, an anvil is sometimes employed to spread the impact shock. The use of an anvil interposed between the striker and tool results in a considable waste of useful energy when working due to the mass and elasiticity of the anvil, and when free stroking the arresting springs are prone to failure due to the arduous shock load conditions to which they are subjected.

The object of the invention is to provide a percussive tool or machine in which a striker in the free-running condition is arrested by means not employing a mechanical spring, which is substantially indestructible and in which energy absorbed is stored and largely conserved.

According to the invention a percussive tool or machine has a reciprocatory striker with a stepped form to provide a differential area which, when approaching the outer limit of the forward stroke of the striker, enters and closes or restricts an aperture of a chamber which in use is filled with liquid, so that further forward movement is arrested by the resultant pressure rise of the liquid in the chamber. The "forward" stroke of the striker is the stroke which acts as the power stroke when the tool or machine is under load, i.e. is not free-running.

Preferably the striker is of stepped cylindrical form to provide said differential area which is thus of annular shape, and the step may be arranged to enter a restrictive sleeve which defines said aperture into the liquid chamber.

The invention is particularly applicable to a percussive

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tool forming a receiver of a power transmission 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 striker and piston of such a tool may be formed integrally and stepped within a pressure chamber to provide a differential area on which the alternating hydraulic pressure acts in the opposite sense to the power stroke. When the present invention is applied to such a construction the differential area which acts on the arresting liquid may be a portion of the total differential area on which the alternating pulse pressure acts during the reverse stroke. The pressure chamber may be divided into two portions separated by said aperture, one of the portions being permanently connected to the power line and the other portion isolated by the corresponding differential area for arresting purposes. The forward stroke of the piston and striker may be produced by a return spring acting through a fluid medium, which may be a liquid providing in effect a liquid shield between the spring and the piston. The present invention may conveniently be applied to such a construction by dividing the spring liquid chamber into two portions separated by said aperture one of the portions being permanently under the influence of the spring means and the other portion isolated as the limit of the forward stroke is approached so that the liquid therein provides the arresting action. To this end the piston and striker may be provided with an annular head or end step which enters and either seals or restricts said aperture.

When the first-mentioned differential area acts effectively to seal the arresting chamber the liquid in that chamber acts as a hydraulic spring to limit overstroke of the striker and prevent mechanical impact damage to the percussive tool or machine. When this differential area alternatively merely restricts the aperture which it enters, an arrangement particularly suitable for use in a road breaker hammer, the striker is arrested by a dashpot action as the liquid in the chamber is displaced past the differential area.

The dashpot action may generate a considerable amount of heat, and hence will normally only be used in embodiments which run intermittently whereas the hydraulic spring action is generally better used with a continuously running machine. A dashpot construction tends to generate a lower peak pressure in the arresting liquid and the arresting chamber can be of smaller dimensions than with the hydraulic spring construction. The chamber can be provided by an annular sleeve which surrounds the striker and provides a choke bore which is entered by the corresponding differential striker area. This bore may be of tapered form, or stepped, to provide progressive retardation of the striker as the latter is arrested. Progressive retardation in this manner acts to limit excessive dashpot pressures in the chamber.

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

FIGURE 1 is a diagrammatic sketch illustrative of the invention as applied to one basic form of percussive tool or motor in accordance therewith,

FIGURE 2 is a side view of the road breaker, partly in axial section, and

FIGURE 3 is an axial sectional view on the line III—III in FIGURE 2.

FIGURE 1 illustrates diagrammatically a percussive tool or motor which in use forms the receiver of an A.F. hydraulic power system and comprises a generally tubular body **1**. An integral piston and striker **2** of cylindrical form is slidable coaxially within the body **1** and has two steps **3** and **4** to provide three portions **2***a*, **2***b* and **2***c* of progressively increasing diameter with each step **3** or **4** providing an annular differential area. The forward end portion **2***a* of smallest diameter has an end striking face **5** which strikes a drill bit, or other element to be subjected to the percussive force, during a forward power strike of the piston and striker **2**.

Both differential areas of the steps **3** and **4** are movable in a pressure chamber **6** which is divided into two portions **6***a* and **6***b* by a transverse wall **7**, these portions intercommunicating through a central restrictor sleeve **8** and the rear portion **6***b* being arranged for permanent connection when in use to the power line **9** of the system. In use alternating hydraulic pulses supplied to the pressure chamber **6**, through the line **9** from a pulse generator **10**, act on both differential areas to provide reverse strokes of the piston and striker **2**, the return forward strokes being provided by spring means which act on the rear end **12** of the piston and striker **2**.

As the piston and striker **2** approaches the outer limit of the forward stroke under free-running conditions the front step **3** enters and effectively closes the restrictor sleeve **8**, so sealing the forward portion **6***a* of the pressure chamber. The approximate limit of the forward stroke is shown in FIGURE 1. During the final portion of the forward stroke the hydraulic liquid in the chamber portion **6***a* is compressed, thus acting as a hydraulic spring which arrests the free forward movement of the piston and striker **2** and stores the energy thereof. While the liquid is being compressed in this manner the differential area provided by the rear step **4** remains in the rear chamber portion **6***b* and is sensitive to pulse conditions therein, which is essential to prevent any possibility of a hydraulic lock being obtained.

During operation a fluid in a spring chamber **13**, in which the rear end **12** of the piston and striker **2** moves, acts as a fluid shield through which the spring means act on the piston and striker **2**. This chamber contains a relatively compressible fluid, for example compressed air or other suitable gas, which itself acts as the spring. It is compressed during a reverse stroke of the piston and striker **2**, thus storing energy which is re-imparted to the piston and striker **2** on the next power stroke thereof. The chamber **13** is pre-charged to a suitable operating pressure, for example 100 lbs. per square inch, through a check valve **14**.

Turning now to the practical embodiment of FIGURES 2 and 3, which where appropriate utilise the same reference numerals as the diagram of FIGURE 1, 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 **6** is formed in the body portion **1***b* in which is mounted an external hose adapter **25** for connection of the hose **9**. The adjoining ends of the body portions are counterbored to house and locate seal carriers **26** and **27**, each of which carries a duplex arrangement of the lip-type seals **28** and **29** respectively. The seals **28** define the forward end of the pressure chamber **6** with the seals **29** defining the rear end thereof. A scraper ring **30** mounted on the forward end of the carrier **26**

engages the piston and striker **2** 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 **10**, a typical operating frequency being 30 cycles per second.

The rear end **12** of the piston and striker **2** does not now enter the spring chamber **13** but is separated therefrom by an intermediate chamber **35**, with a substantially incompressible liquid fluid in the chamber **35** acting as a fluid shield and transmitting the spring force from the spring chamber **13**. The spring chamber **13** 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 **13** is separated from the chamber **35**, which is formed by the internal space of the body portion **1***c*, by a flexible diaphragm **36** which in FIGURE 3 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 chamber **35** is in use charged with the hydraulic operating liquid supplied to the pressure chamber **6**. The spring chamber **13** is pre-charged to the required spring pressure through the check valve **14** 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 **36** to its pre-charged 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 **13**. The plate **39** has concentric rings of multiple drillings such as **40** which permit liquid transfer across the plate to and from the chamber **35** and so that the pressure in the latter always acts on the diaphragm **36**. Central support for the plate **39** is provided by an apertured cross wall **41** in the body portion **1***c*, which cross wall has a central projection to which the plate **39** is riveted.

In this case only the one differential area provided by the forward step **3** of the piston and striker **2** is positioned in the pressure chamber **6** and subjected to the pressure pulses. The rear step **4** provides in effect a rear end flange **42** of the piston and striker, this end flange being movable in the liquid-containing chamber **35**. The absolute 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 3. This is the normal resting condition which obtains between periods of use, which periods will normally be somewhat intermittent. The differential area of the invention, provided by the flange **42**, as will now be described ensures 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. The flange **42** enters and restricts a choke bore formed by a rear end counterbore **43** in a bush **44** which is fitted in the body portion **1***c*, and provides an annular sleeve which surrounds the piston and strike **2** rearwardly of the seal carrier **27**.

The flange **42** enters the counterbore **43** as the outer limit of the forward stroke of the piston and striker **2** is approached. Thus some of the hydraulic liquid in the chamber **35** is trapped within the counterbore **43** which in effect provides an arresting chamber, continued forward movement of the piston and striker **2** producing a high pressure in 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 3 being reached, and this is so even when the hammer is free running. The liquid compressed in the counterbore **43** is ejected from the latter through the restriction provided by the small annular clearance between the flange **42** and the counterbore **43**, 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**. 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 2. An electrical lead (not shown) from the contact **52** runs back with the hose **9** to the pulse generator **10** 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 **9**.

In the run condition of the valve member **48** shown in FIGURE 2 ports **54** and **55** in the valve sleeve **49**, which respectively communicate with the pressure chamber **6** and the chamber **35**, are blanked off so that they do not communicate and hence the chambers **6** and **35** 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 **10** 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 **10** is inoperative as a result of the contacts **50** and **52** being open. This condition corresponds to a valve position in which the chambers **6** and **35** intercommunicate, and this ensures that when the hammer is idle the chamber **35** is pre-charged to the make-up pressure ready for operation. The make-up pressure is also applied to the rear end **12** of the piston and striker **2**, with resultant forward movement of the piston and striker to the forward limit position (illustrated in FIGURE 3) against the opposition of the same hydraulic pressure acting on the relatively small step **3** in the pressure chamber **6**. Thus movement of the valve member **48** to the idle position not only ensures that the chamber **35** 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 **35** 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 **6** past the seals **29**. During setting up of the hammer with the make-up pump running the valve member **48** provides for pre-charging of the chamber **35**, any air being displaced past a bleed screw **57** which is slackened off for the purpose. With the correct pressure condition in the chamber **35** the spring chamber **13** can be pre-charged 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 **35**, together with the flexible diaphragm **36**, provides a particularly convenient manner of utilising a pneumatic spring as there are no problems of air leakage from the spring chamber **13** or of contamination by leakage from the pressure chamber **6**, and yet the spring force is applied satisfactorily and directly to the piston and striker **2**. The liquid in the chamber **35** 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, 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.

I claim:

1. A percussive mechanism having a body containing a pressure chamber to which in use operating fluid under pressure is supplied and a further chamber which in use is filled with a liquid, a piston and striker which is reciprocable in the body and is closely surrounded in a substantially liquid-tight manner between said chambers, said piston and striker being stepped in each of said chambers whereby one step provides a differential area subject to the operating fluid pressure to drive the piston and striker in one direction into said further chamber and the other step provides a differential area which on the reverse stroke in the opposite direction enters a damping chamber portion of said further chamber at the end thereof adjacent the pressure chamber whereby the resultant pressure rise in said chamber portion damps the end of said return stroke, and spring means which act on the piston and striker through the liquid in said further chamber to produce the reverse stroke.

2. A mechanism according to claim **1**, wherein the piston and striker is closely surrounded by a seal which is mounted in the body and separates said chambers.

3. A mechanism according to claim **1**, wherein the piston and striker has an annular peripheral flange providing the step in said further chamber.

4. A mechanism according to claim **3**, wherein a sleeve within said further chamber defines said chamber portion which is contained within the sleeve between the latter and the piston and striker.

5. A mechanism according to claim **4**, wherein the sleeve has a counterbore at the end remote from the pressure chamber, which counterbore provides said chamber portion.

6. A percussive mechanism having a body containing a pressure chamber to which in use operating fluid under pressure is supplied and a further chamber, a reciprocatory piston and striker with a stepped form having two steps one of which moves in the pressure chamber, so that it is continuously subject to any operating fluid pressure in the pressure chamber, and the other of which provides a differential area which, when approaching the outer limit of the forward stroke of the striker, enters said further chamber which in use is filled with liquid, so that further forward movement is arrested by the resultant pressure rise of the liquid in the chamber, said mechanism being adapted to form the receiver of an A.F. hydraulic power transmission system in which a hydraulic pulse generator is connected through a supply line in the pressure chamber, the piston and striker being stepped within said pressure chamber in such manner as to provide a differential area on which the hydraulic pulse pressure acts in the opposite sense to the power stroke, the forward stroke of the piston and striker being produced by a diaphragm acting through a liquid medium which provides a liquid shield between the diaphragm and the piston and striker, and means for exerting yieldable pressure on the side of the diaphragm opposite said liquid medium.

7. A percussive mechanism according to claim **6**, wherein said further chamber communicates with a still

further chamber containing said liquid shield and is separated therefrom by an aperture which said other step enters to isolate the first named said further chamber so that the liquid therein provides the arresting action as the limit of the forward stroke of the piston and striker is approached.

8. A percussive mechanism according to claim **7**, wherein the piston and striker has an annular head movable in said still further chamber and providing the step which enters said aperture.

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U.S. Cl. X.R.

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