April 14, 1959 C. HUPPERT 2,881,739

HYDRAULIC PERCUSSION TOOL

Filed Nov. 15, 1956 6 Sheets-Sheet 1

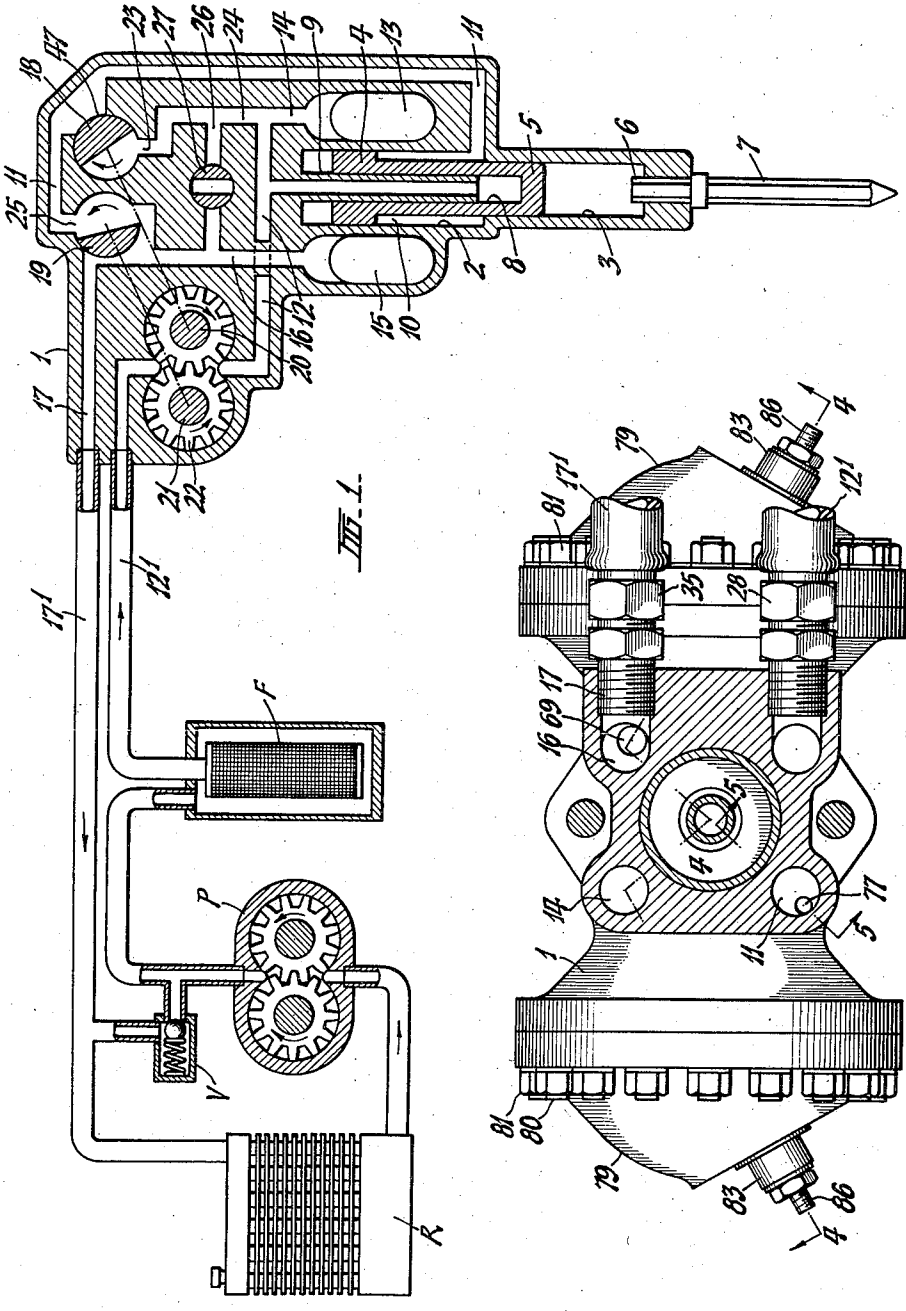


FIG. 1.

FIG. 3.

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HYDRAULIC PERCUSSION TOOL

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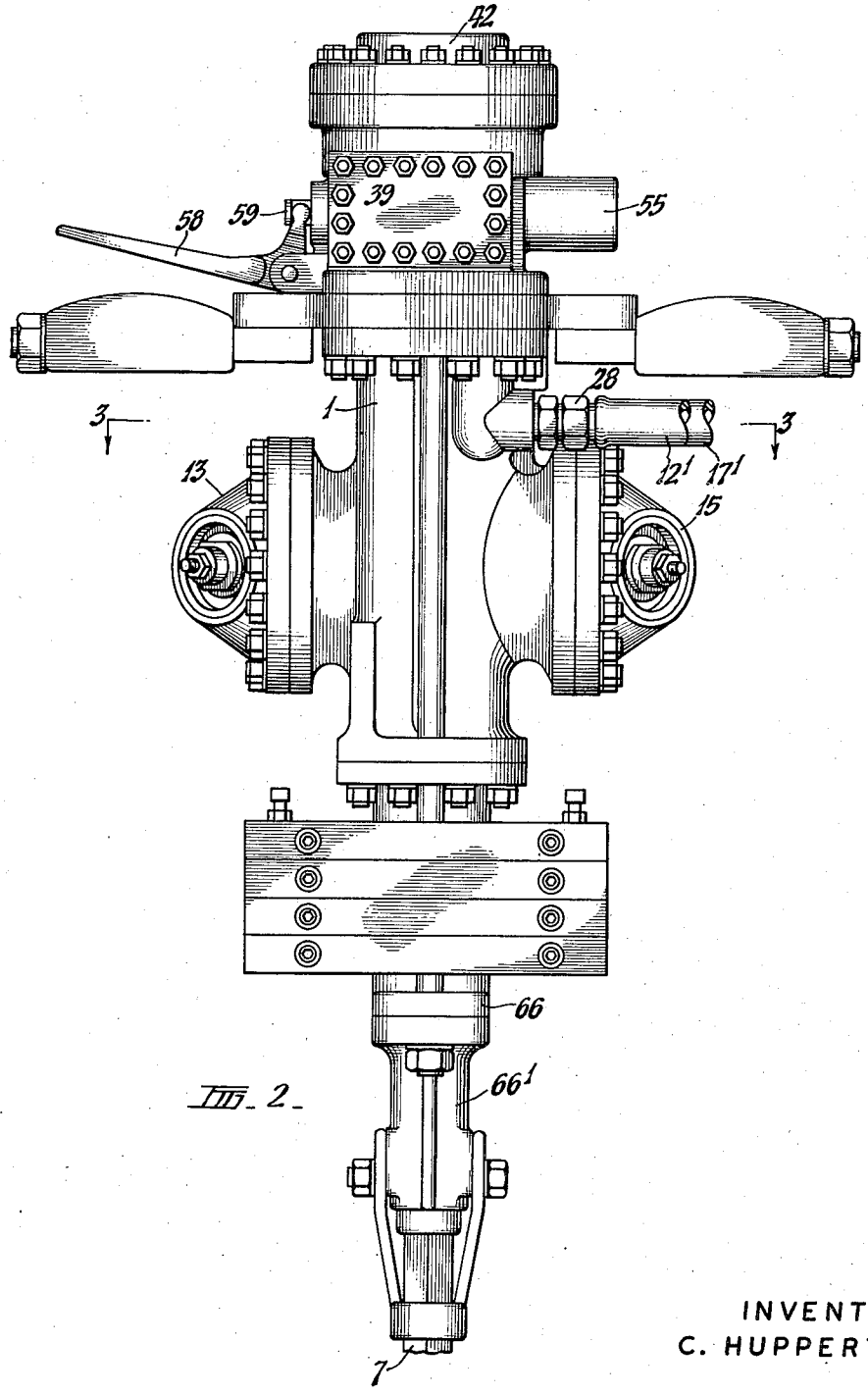


Fig. 2.

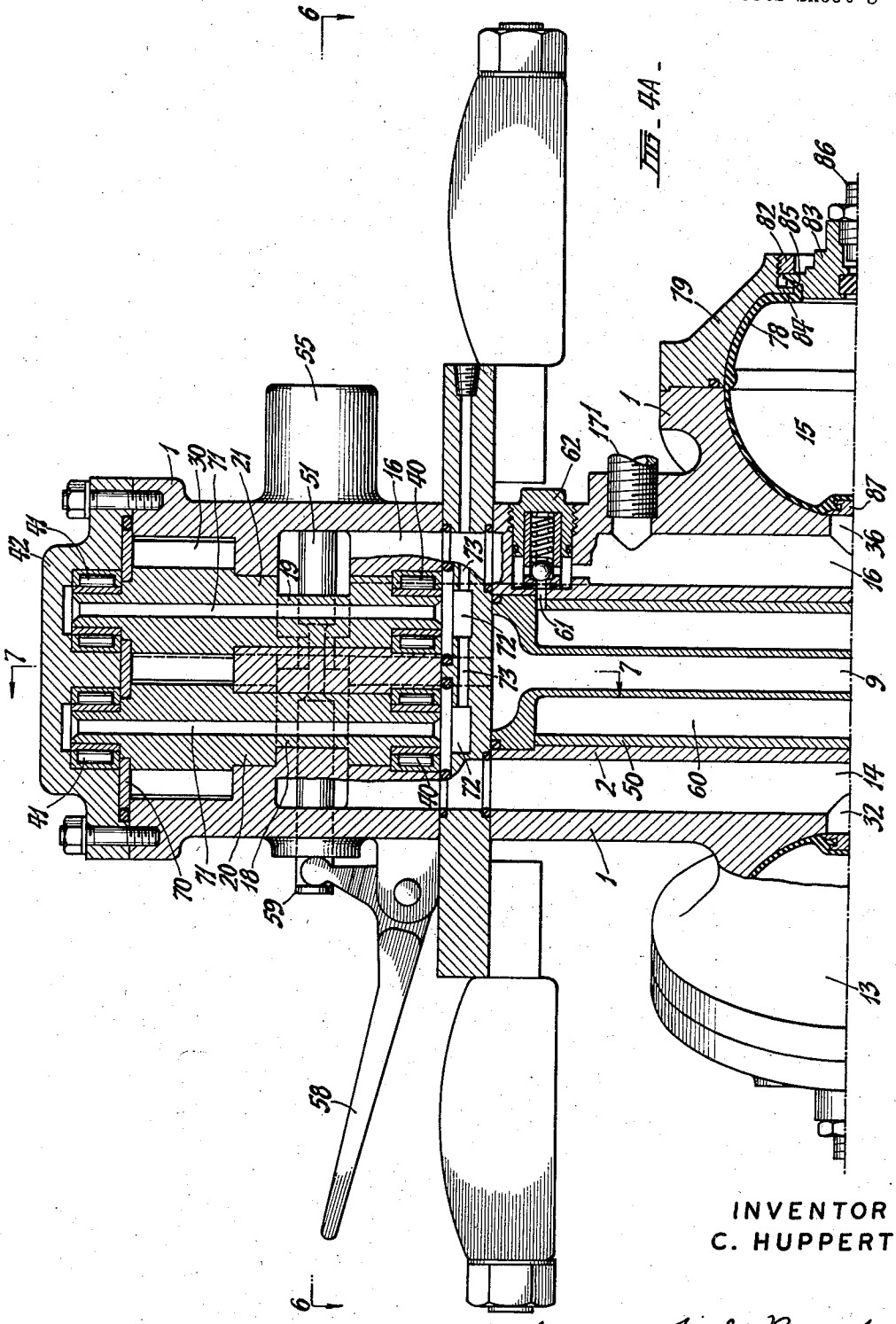
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HYDRAULIC PERCUSSION TOOL

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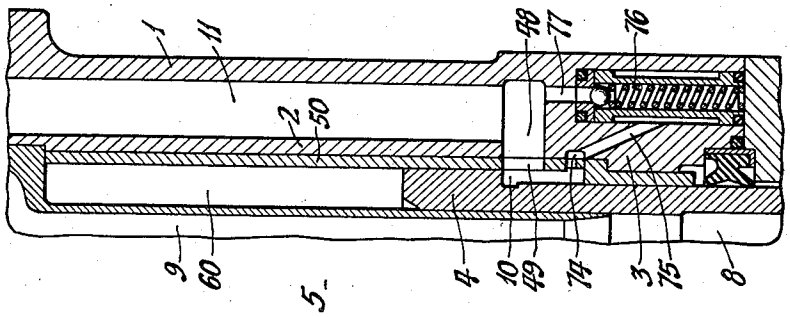


FIG. 5.

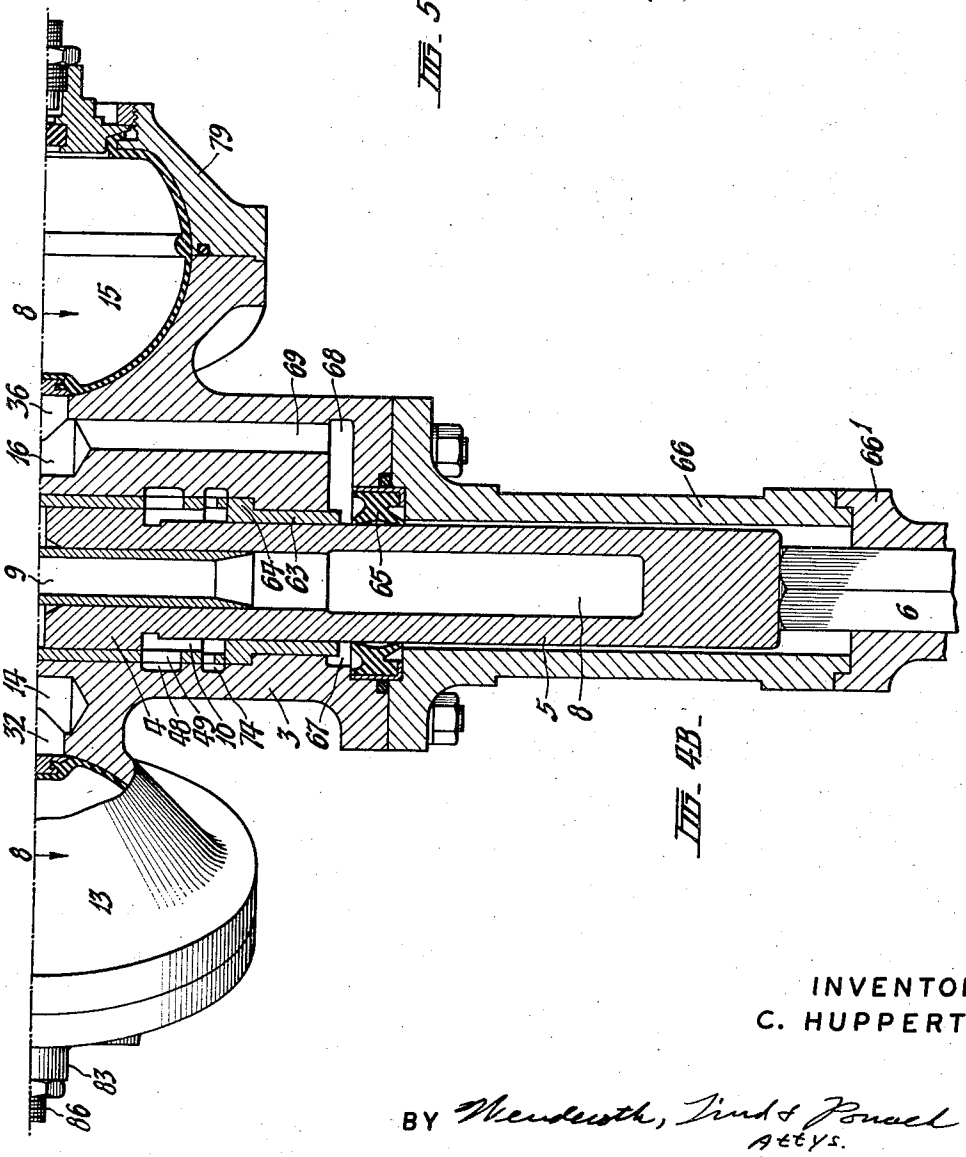


FIG. 4B.

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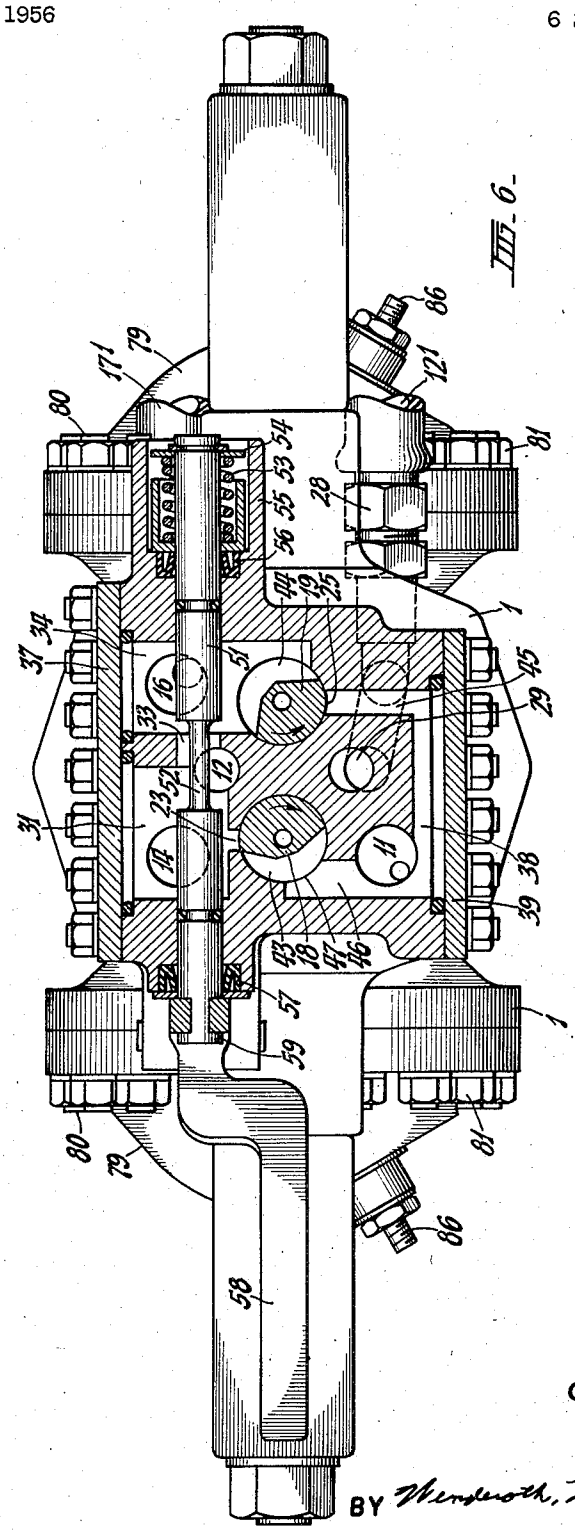


FIG. 6.

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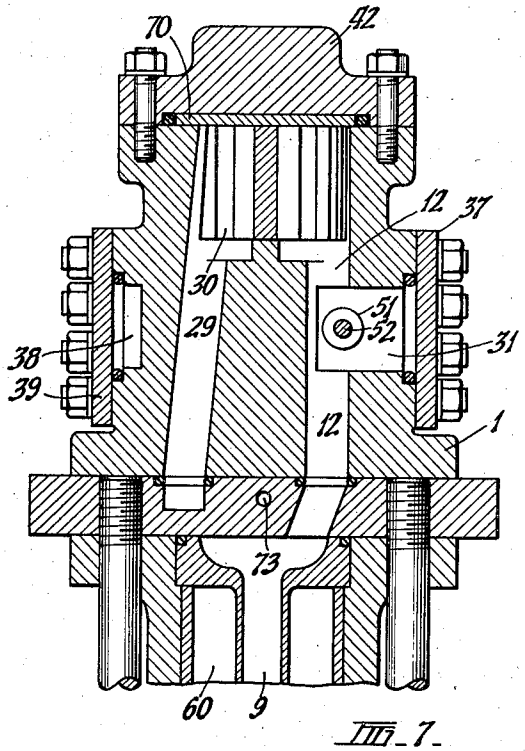


FIG. 7.

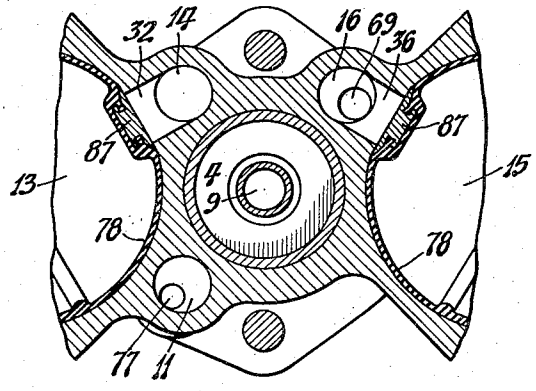


FIG. 8.

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United States Patent Office 2,881,739 Patented Apr. 14, 1959

2,881,739

HYDRAULIC PERCUSSION TOOL

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Application November 15, 1956, Serial No. 622,326

Claims priority, application Australia November 23, 1955

19 Claims. (Cl. 121—20)

This invention relates to percussion tools and is particularly though not exclusively directed to such a tool, e.g. a hammer, for performing the work usually carried out by the pneumatic tools now commonly employed.

It is recognised that pneumatic hammers have the disadvantage that they require a storage system and a complete plant including a bulky and powerful air compressor and storage air vessel so that for mobile purposes the pneumatic hammer is unsuitable or inconvenient for operation in locations where such a compressor plant cannot be provided or transported or only with difficulty. However, if pressure liquid were employed as the operating fluid instead of air, the pressure source could be of much smaller size, as only a very small reservoir would be required, yet the hammer would be equally effective. Furthermore, it would be practicable to drive the pressure liquid source from the power unit of a motor truck or tractor or, where a hydraulic power system is already installed on a motor vehicle, this could be employed directly to operate the tool.

Accordingly, it is the principal object of the present invention to provide an efficient hydraulically operated percussion tool to permit the convenient use of the latter where desired, and particularly in normally inaccessible areas or outdoor locations.

A further objective of the invention is to provide such a hydraulically operated percussion tool to be coupled to and driven from a source of pressure liquid available upon a tractor, motor truck or other vehicle, or from a stationary prime mover. Thus, the plant and equipment necessary to operate the above tool is reduced to a minimum and being transportable with and driven from a tractor motor truck or the like, the tool may be used anywhere and in particular in remote or restricted localities where conventional pneumatic hammers could not be taken or operated.

With the above stated objective in view, there is provided, according to this invention, a hydraulically operated percussion tool comprising a casing having a cylinder formed therein, a piston reciprocably mounted within the cylinder, a striker operable by and movable in unison with the piston, hydraulic pressure lines for conducting a pressure liquid to said cylinder for actuating the piston, control means for the pressure liquid, and at least one pneumatic pressure-accumulator coacting with the pressure liquid in the actuation of said piston.

In mechanical hammers of the percussion type the kinetic energy of the striker is built up by a liquid or gas acting under pressure against this striker over a certain stroke. For this type of hammer it is obvious that the maximum energy build-up in the striker is obtained, if the maximum available pressure is applied over the whole length of the stroke, i.e. from a constant-pressure source.

Where an elastic fluid is employed as the operating medium this can be attained by providing adequate storage capacity under pressure. For this reason, chiefly,

pneumatic hammers are fed from a constant-pressure source which is usually an air receiver in which the pressure, within limits, is kept constant. However, replacing the compressed air with a liquid under pressure as in the present invention two factors require to be taken into consideration:

(1) The liquid suitable for use in a hydraulically-operated hammer is practically incompressible and of relatively great mass and viscosity;

(2) Hydraulic pumps suitable for the purpose are constant flow units, i.e. they provide a constant-volume source.

It is, of course, possible to vary the flow rate in variable displacement pumps or to vary the speed of a fixed displacement pump, but it is not practicable to use these methods to meet the requirements of rapid oscillation of flow as demanded by a hammer. The pulsations produced by the hammer strokes set up resultant oscillations in the pressure liquid lines and, because of factor (1) above, the inertia of the liquid is considerable and increases with the length of the pressure line involved until it becomes prohibitive.

These difficulties are overcome according to the invention by converting the constant-volume system of the constant-flow hydraulic pump into a constant-pressure system, as required by the hammer, by the introduction of a pressure air-accumulator into the line between the pump and the tool.

It is also important to maintain an even non-pulsating flow through the return line, particularly the flexible rubber hose line, connecting the tool with the supply tank or like source of liquid, since in practice this line is found to whip as a result of rapid pressure fluctuations. The treatment indicated here is to introduce a second air-accumulator into the system between the tool and the said hose line.

Conveniently the invention, therefore, preferably provides two pneumatic pressure-accumulators, one high-pressure and one low-pressure, as close as possible to the striker of the tool itself to reduce to a minimum the inertia effects mentioned above. The pressure system, thus resolves itself into the combination of a constant flow system from supply tank, through pump and high pressure line, to the tool where it is converted into a constant pressure system by a high-pressure air accumulator and performs its required work, is then reconverted into a constant flow system by a low-pressure accumulator through the return line back to tank.

The incompressibility of the hydraulic fluid and the constant flow characteristic from pump to the hammer enables the insertion of a hydraulic motor in the tool itself, which motor may be arranged to operate a valve to control the supply of pressure liquid to the hammer thus ensuring that the number of oscillations in the latter are proportional to the speed, i. e. through-put of the pump.

A variety of hydraulic motors and types of valves may be employed for this purpose, but we have found in practice that a convenient arrangement is a simple gear-type motor (i.e. gear-pump in reverse) the two shafts of which are drive-coupled to a pair of valve rotors adapted to open and close ports in the hydraulic pressure lines connected to and from the operating piston of the hammer. By this means a repeated sequence of oscillating functions is produced in the hammer, the frequency of which varies directly as the motor speed which, in turn, is proportional to the pump through-put.

In our preferred construction we employ a stepped piston which incorporates a striker for the percussion tool, the piston being actuated on the well-known differential area principle, commonly called a differential pis-

ton. In the present construction, however, it is arranged that, contrary to the usual practice, the stepped area of the piston, which constitutes the lower or return side thereof, is the major area, whereas the effective area of the upper or working side of the piston is the minor area. This is achieved by providing a bore in the upper side of the piston which bore constitutes a blind cylinder to slidably receive an extension pipe of the high-pressure liquid supply line, the cross-sectional area of the bore thus becoming the effective area for actuating the piston on its downward or working stroke.

During operation high-pressure liquid is continuously applied to the abovementioned bore, via the extension pipe provided whilst the stepped area of the lower side of the piston is intermittently connected to the high-pressure line by one of the rotary valves. When this occurs the piston and striker will be lifted due to the differential areas. The valves are so timed that at a certain point the high pressure liquid is cut off from the lower piston area, which is then opened by the other rotary valve to the return line. The piston continues its upward travel due to inertia with retarding velocity due to counter pressure against the end of the pressure pipe and gravity, reaching its uppermost position where the motion is reversed downwards by the continued operation of the rotary valves.

The piston and striker are thus caused to descend rapidly under the influence of the high-pressure liquid, which is no longer opposed from the underside of the piston, the striker towards the end of its stroke impinging upon the shank end of the tool-bit and imparting a percussive blow thereto.

The importance of keeping the pressure liquid lines as short as possible between the oscillating member and the pneumatic pressure-accumulators has already been stressed, as the function of the latter is to absorb and reflect pressure impulses in the hydraulic system, and the shorter these lines the lower will be the inertia effects produced by the oscillations of the hammer.

For this reason the pneumatic pressure-accumulators are located as close as practicable to the operating piston and in this preferred construction we incorporate them in the main casing of the tool, one such accumulator being supported in a housing which is in hydraulic communication with the high-pressure supply line to the piston and the other being supported in a like housing but oppositely disposed which is in hydraulic communication with the low-pressure return line of the system.

The pressure-accumulators themselves are preferably independent, flexible, air or gas-filled containers arranged to be removably mounted in the said housings in hydraulic pressure-tight manner, the arrangement being such that each accumulator may be separately inflated to any desired pressure by external means without disturbing its mountings whilst the complete flexible container may be easily removed and replaced, if required, without disturbing any other mechanisms of the percussion tool.

These containers, which are of known type, may be made of any suitable material, such as rubber or synthetic plastic material, and are permanently sealed against ingress of the pressure liquid employed in the hydraulic system whilst being continuously in external contact therewith for the purpose stated above.

One practical arrangement of the invention as applied to a hydraulic hammer will now be described with reference to the accompanying drawings in which:

Fig. 1 shows schematically the layout of the hydraulically operated percussion tool in relation to a source of pressure liquid, the various elements being presented in such manner as to aid subsequent description without regard to practicability.

Fig. 2 is a side elevation of the tool in the position of use with a chisel-bit held in the base thereof. The flexible hose lines which convey the pressure liquid to and from the tool are also partly shown.

Fig. 3 is a cross section in line **3—3** of Fig. 2 and further shows the hydraulic connections and their relation to internal conduits in the hammer casing.

Figs. *4a* and *4b* comprise a vertical section of the tool taken on the irregular line **4—4** of Fig. 3 and occupy two sheets of the drawings to enable the scale to be enlarged to more clearly show the details of construction.

Fig. 5 is a part-vertical section on line **5—5** of Fig. 3 and shows the pressure liquid conduit leading to the annular stepped area of the return side of the piston and other details.

Fig. 6 is a cross-section of the valve portion of the tool body taken on the line **6—6** of Fig. *4a*.

Fig. 7 is a part-vertical section taken on line **7—7** of Fig. *4a* and shows the pressure liquid conduits leading to and from the hydraulic motor, portion of a by-pass valve, and portion of the upper end of the cylinder.

Fig. 8 is a part-cross-section taken on line **8—8** of Fig. *4b*, and shows the pressure liquid conduits leading to the high-pressure and low-pressure pneumatic accumulators respectively.

The operation of the percussion tool will first be described with reference to the schematic layout, Fig. 1, wherein the casing **1** has stepped coaxial cylinders **2** and **3** in which is reciprocally mounted a stepped piston **4** which incorporates a striker **5**, the latter serving to strike percussive blows on the upper end or shank **6** of a tool-bit **7** upon descending towards the end of its downward stroke under the influence of hydraulic pressure.

The piston **4** has a coaxial bore **8** which extends partly into the striker **5** to form a blind cylinder and which bore slidably engages a tubular extension **9** projecting from the upper end of the cylinder **2**. The extension **9** is in communication with high-pressure conduit **12**.

The annulus **10**, formed by the stepped piston **4** and striker **5** in the stepped cylinders **2** and **3**, constitutes the lower or return side of the said piston and, when subject to high-pressure liquid conducted thereto through conduit **11**, the piston is raised against the pressure liquid operating at the same high-pressure value within the bore **8** on the upper side of the piston.

It will be understood that the tool is so constructed that the area of the piston step, i.e. the cross-sectional area of the annulus **10**, is greater than the cross-sectional area of the bore **8**, and in practice the former may be twice as great as the latter.

The high-pressure pneumatic accumulator **13** is in continuous contact with the high-pressure system of the tool through conduits **12** and **14**, whilst the low-pressure pneumatic accumulator **15** is in continuous communication with the low-pressure or return line of the system by way of conduits **16** and **17**.

The source of hydraulic pressure as already explained, may be derived from any convenient constant-flow system, a typical example of which is diagrammatically shown in Fig. 1 in which R is an oil reservoir (which may include an oil cooler if necessary) P is a constant-flow pump, F an oil filter and V a relief-valve which is adjustable to permit oil to return direct from pump P to reservoir R should the pressure in the system exceed a predetermined desired value. All are of the type known per se and individually form no part of the present invention.

The valve rotors **18** and **19** are drive-coupled respectively to shafts **20** and **21** of the hydraulic motor **22** which being of the inter-meshing gear type causes the said valve rotors to revolve in positive constant relationship one to the other. The valve rotors **18** and **19** are so constructed and arranged that rotor **18** affects sequential opening and closing of port **23** and port **47** respectively in the high-pressure conduit **24** leading to conduit

11, whilst rotor 19 controls port 25 which opens or closes conduit 11 to the low-pressure line 17 in manner shortly to be described.

A controllable by-pass 26 is provided between the high-pressure conduit 24 and the low-pressure return line 16, the control means being indicated at 27 and may be any convenient form of valve operable at will to open or close the by-pass.

In operation, the by-pass being closed as shown in Fig. 1, oil is pumped under high-pressure by pump P in the direction indicated by the arrows from reservoir R along hose line 12' to conduit 12, to extension 9 and to conduit 24. In the shown position valve rotor 18 is closed to the high-pressure oil flow beyond port 23 and, as valve rotor 19 is in the open position, the oil in the annulus 10 will be free to flow via conduit 11, port 25, conduit 17 and hose line 17' to reservoir R. This will occur as high-pressure oil applied to the bore 8 through the extension 9 forces the piston 4 rapidly downwards resulting in a hammer blow being struck upon the tool-bit by the striker 5.

At the commencement of a working stroke (as shown in Fig. 1) the pneumatic pressure-accumulator 13, being constantly subjected to oil at high-pressure through conduits 14 and 12, will be partly collapsed storing energy which will be released as the piston descends and the flexible container expands thus converting the constant-volume hydraulic system into a constant-pressure system. When the piston 4 reaches the end of its stroke, however, the high-pressure liquid being supplied at constant-flow will again compress and partly collapse the pneumatic pressure-accumulator 13.

At the conclusion of the working stroke, or shortly thereafter, the rotary valve is so timed that rotor 19 closes port 25 and immediately afterwards rotor 18 opens port 23 (port 47 being already open), thus respectively disconnecting conduit 11 from return line 17 and connecting it with the high-pressure hydraulic supply through conduits 12 and 24. The admission of high-pressure oil to the annulus 10 which now follows will raise the piston 4 with its striker 5 to the initial position and in so doing stored energy in the pressure-accumulator 13 will again be released to convert the process to constant-pressure conditions. The presence of the high-pressure pneumatic accumulator in the system also serves to smooth out the liquid flow generally and prevents hydraulic shocks within the mechanism of the tool itself and the pumping unit which supplied oil at high-pressure thereto.

As the piston approaches a position approximately half way up its stroke, rotor 18 is so timed that it closes port 47, thus cutting off high-pressure oil supply to conduit 11 and annulus 10 and, immediately following, rotor 19 opens port 25, thus completing the cycle and restoring the respective parts to their initial position preparatory to a further working stroke as shown in Fig. 1.

Upon the sudden opening of port 25, however, the discharge of high-pressure oil into the low-pressure return line 17 tends to disturb the constant-flow characteristics of the hydraulic system causing excessive pulsating and possibly whipping of the flexible hose line 17'.

This is effectively counteracted by the inclusion in the system of a low-pressure pneumatic accumulator 15 which is in communication with the return line through conduit 16 and absorbs the impulses in this region by storing and releasing energy in like manner to pressure-accumulator 13, but in a lower pressure range, so that the oil returns to the reservoir R under substantially constant-flow conditions to be recirculated in a continuous cycle.

Referring now to the preferred practical construction of the hydraulic hammer in which certain important features are detailed, Fig. 6 shows the connection of the high-pressure supply hose line 12' to the casing 1 by means of coupling 28, the high-pressure oil being conducted through drilled holes (shown in dotted lines) to

vertical conduit 29 which leads upwardly to the inlet side of a gear motor 30 (Fig. 7) from which the outlet connects with conduit 12. One branch of conduit 12 leads downwardly to the tubular extension 9 and thence to the blind cylinder 8 bored in the piston 4 and striker 5. Conduit 12 also connects with a chamber 31 in the side of the casing 1, which chamber is in communication with the high-pressure pneumatic accumulator 13 through vertical conduit 14 and short horizontal conduit 32 (Figs. 4A and 4B, and Fig. 8). Chamber 31 is provided with a by-pass 33 which connects with a second chamber 34 communicating by way of vertical conduit 16 with the return line 17, which is coupled at 35 with return hose line 17' (Fig. 3). Conduit 16 also communicates chamber 34 with the low-pressure pneumatic accumulator 15 through short horizontal conduit 36.

Chambers 31 and 34 are adjacent and, for convenience in manufacture, are formed each with an open side which is eventually closed in liquid-tight manner by cover plate 37 and sealing rings as shown. On the opposite side of the casing a third chamber 38 is likewise formed which is closed on assembly by cover plate 39 using a sealing ring to render the joint liquid-tight in well-known manner.

In the preferred form, the valve rotors 18 and 19 are made integral with the respective gear wheels and their shafts 20 and 21 of a gear motor 30 as best shown in Fig. 4A, each gear-shaft-valve unit being supported at its lower end by roller bearings 40, housed in the casing 1, and at its uper end by roller bearings 41 housed in removable cap member 42.

Valve rotors 18 and 19 are adapted to rotate in cylindrical valve chambers 43 and 44 respectively, valve chamber 43 being provided with a port 23 which communicates with the chamber 31 and valve chamber 44 being ported at 25 to communicate with chamber 38 through a channel 45.

Valve chamber 43 also opens into a short horizontal conduit 46 through port 47 and thence to chamber 38 from which latter chamber there leads a vertical downwardly extending conduit 11 communicating with an annular recess 48 (Fig. 5) in the lower part of the casing 1. A number of circumferentially disposed holes 49 in a cylinder liner 50 of cylinder 2 connect conduit 11 with the annulus 10 on the lower side of the piston 4 for operating the latter on its return stroke.

Returning now to valve chamber 44, this opens into chamber 34, which is in communication with the low-pressure return line, over a wide arc of its circumference as shown in Fig. 6, the reason for this being explained later. In use the constant-flow pump P operates continuously, the operator starting and stopping the tool by respectively closing and opening the by-pass 33, for which purpose a manually operated control means is provided which may be of any convenient type. The preferred form of this control means is a piston valve 51 which is slidably supported in the casing 1 and transversely disposed thereto, and which passes through chamber 31 and 34 in co-axial alignment with the by-pass 33. Piston valve 51 is formed with a section of reduced-diameter 52, which is appreciably smaller in diameter than the diameter of the by-pass orifice 33 and which, in the open position of the valve, is arranged to be disposed within the said orifice as shown in Fig. 6. When moved to the left, however, the piston valve 51 accurately registers with the by-pass orifice 33 to close the latter and so render the by-pass ineffective.

The valve 51 is preferably biased to the open position by a spring 53 acting upon a washer 54 secured to one end of the piston valve 51 by a circlip or other convenient means. This spring assembly is suitably protected by being recessed in a boss 55 provided on one side of the casing 1 for this purpose.

Hydraulic seals of any suitable type are provided at 56 and 57 to prevent leakage of pressure liquid past

the piston valve 51 where the latter extends through the casing 1.

External control of the by-pass valve 51 is provided by a manually operated lever 58, suitably linked to the outwardly extending end 59 of valve 51, whereby the latter may be moved to the left to close or partially close the by-pass at the will of the operator.

It will be obvious that in the "open" position with the piston valve 51 to the right (Fig. 6) the high-pressure liquid entering the chamber 31 via conduit 12 will flow to the chamber 34 by way of by-pass 33 and so to the low-pressure return line 17', via conduits 16 and 17, without performing work in the hammer itself. This then constitutes the "stop" position for the tool. Pressure liquid will, however, pass through the gear-motor 30 so long as oil is being circulated through the system, and, therefore, valve rotors 18 and 19 will continue to rotate, though in an "idling" capacity, when the by-pass 33 is open.

When the by-pass 33 is closed by depressing handle 58 and thereby moving valve 51 to the left, oil under pressure will be directed by and through the valve rotors 18 and 19 to perform the functions of the hydraulic hammer as previously described.

In this regard the co-ordinated timing of the valve rotors 18 and 19 in relation to their respective ports requires further elaboration.

As previously mentioned, valve chamber 44 opens into low-pressure chamber 34 through a wide arc of its circumference which permits channel 45, leading to port 25, to communicate with the low-pressure return line 17' for the whole of that period of rotation of rotor 19 during which the said port 25 is opened thereby. In practice this period is found to be approximately 244 degrees for efficient operation.

On the other hand, it will be seen that valve chamber 43 is provided with two ports 23 and 47 which are so disposed in relation to the direction of rotation of rotor 18 that opening thereby of port 23 initiates flow of high-pressure liquid to conduits 46 and 11 (port 47 being already open), whereas the said flow is terminated by the closing of port 47 by rotor 18 at a later period in its rotation. This period has been found by practical experiment to be approximately 106 degrees for the efficient working of the tool, it being understood that a designed overlap of 2 x 5 degrees in the valve functions is provided to ensure that at no time will high-pressure chamber 31 be connected to the low-pressure chamber 34 except through the by-pass 33.

Referring now to the operation of the piston 4 it will be seen (Figs. 4A and 4B) that there is an annular space 60 formed between the extension 9 and cylinder liner 50 which space is traversed by the piston 4 during the working of the tool.

Means for venting space 60, and disposing of any liquid that might leak thereto from the bore 8 past extension 9, is provided at the upper end of cylinder 2 and includes a passage 61 communicating with conduit 16 and low-pressure return line 17' through a non-return valve 62. The latter may be of any suitable type, a spring-loaded ball check-valve, as shown in Fig. 4A, being preferred. This device prevents liquid from entering the space 60 during the downward stroke of the piston 4 whilst permitting partial evacuation of said space 60 during the return stroke of piston 4.

For purposes of structural convenience and maintenance the striker cylinder 3 is provided with a removable bush 63 the upper end of which is flanged at 64 (Fig. 4B). The upper surface of the flange 64 constitutes the lower fixed extremity of the annulus 10 and as the latter is subjected to high-pressure conditions during the return stroke of the piston 4, some oil may find its way past the bush 63. This is prevented from escaping further by the provision of a sealing ring 65 which is removably secured at the lower end of casing 1 by a cylindrical extension piece 66. The latter also serves to house the lower portion of the striker and provide a mounting for a socket 66' which supports the tool-bit 7. Drainage of the space 67 between the lower end of the bush 63 and the sealing ring 65 is effected by means of channels 68 and 69 provided for that purpose and which communicate with return line 17' by way of conduit 16.

In the construction of the hydraulic gear motor 30, a replaceable wear pad 70 is inserted between the casing 1 and the removable cap member 42 by means of which the end clearance of the respective gear wheels may be adjusted within very fine limits. It is recognized, however, that because of the high operating pressures involved some liquid will tend to escape past the boundary surfaces of the said motor and accordingly the design provides that any such oil leakage will be directed through the roller bearings 40 and 41, thereby assuring the efficient lubrication of these bearings.

Each gear-shaft-valve unit 20 and 21 (Fig. 4A) is drilled through its entire axis to provide drainage means 71 for oil leaking from the upper end of the motor 30 to join that leaking from the lower end thereof in recesses 72, which connect by drilled holes 73 with conduit 16 and thence to the low pressure return line 17'.

In normal operation the tool is so designed that the striker 5 impinges upon the end of the tool-bit shank 6, when the step of the piston 4 has arrived at the upper edge of the annular recess 48, as shown in Figs. 4B and 5.

Should the tool-bit be removed, however, the piston 4 will continue on its downward stroke thereby automatically closing off the holes 49, which communicate with the said recess 48 resulting in oil being trapped beneath the said piston step and within a second annular recess 74.

By this means metallic contact between the piston step and the upper surface of the flange 64 is prevented in the event of the striker 5, and therefore the piston 4, over-running their normal working stroke.

It follows, however, that in the circumstances just described, the piston 4 having cut off communication with the recess 48, the high pressure supply is unable to reach the annulus 10 to raise the piston 4 and so restore the latter to its normal working position. To meet this emergency a one-way by-pass is provided as shown in Fig. 5 consisting of a drilled hole 75 connecting the second annular recess 74 with the non-return side of a spring-loaded check-valve 76, inserted in a drilled passage 77 communicating with the oil supply conduit 11 through the recess 48. Thus a restricted quantity of oil is permitted to reach the underside of the piston 4 when the pressure in conduit 11 is sufficient to overcome the spring bias of check-valve 76, whereupon the said piston will commence to rise thereby uncovering holes 49 and so again opening communication between the annulus 10 and the pressure oil supply conduit 11.

The high-pressure and low-pressure pneumatic pressure-accumulators 13 and 15, are identical and are similarly mounted in their respective housings so that a description of one will apply to both. The low pressure accumulator 15 is best seen in Figs. 4A and 4B wherein the flexible container 78 is shown removably mounted in a detachable cover member 79 secured by studs 80 and nuts 81 to the casing 1 (Figs. 3 and 6).

The interior of the composite housing thus formed is neo-spherical in shape and the flexible container 78 conforms with, and closely fits, this interior when in the relaxed condition. The flexible container 78 is mounted in the cover member 79 in any suitable manner the preferred means being by ring-nut 82 which engages an internal thread in the cover member 79 to clamp a valve-supporting member 83 against a shoulder 84, formed in the said cover member, the neck-portion 85 of an opening in the said flexible container 78 being interposed therebetween to form a fluid-tight joint. A non-return valve 86 of known type is screwed into the valve-supporting member 83 to permit the pre-charging of the flex-

ible container **78** with air or other gas to any desired pressure.

In this regard it has been found in practice that a satisfactory pre-charged pressure for the high-pressure accumulator ranges between 200–600 p.s.i. whilst that of the low-pressure accumulator is atmospheric. These conditions will vary, however, according to the oil pressure employed in the hydraulic system, which, in turn, is dependent on the throughput of oil by the pump. Typical examples are:

Oil Pressure (measured at the tool)		Accumulators (pre-charging press)	
Supply	Return	High Pressure	Low Pressure
800 p.s.i.	70 p.s.i.	450 p.s.i.	Atmospheric

To protect the external surface of the flexible container **78** in the region where it opposes the liquid pressure conduit **36**, and to strengthen its periphery in this area, an insert **87** of reinforcing material, such as metal or plastic, is moulded into the said container surface as shown. The diameter of the insert **87** is somewhat greater than the diameter of the conduit **36** whereby the latter is completely bridged by the former when the flexible container is in the fully reflexed position as shown in Figs. 4A and 4B and Fig. 8.

The flexible container **78** is preferably made of rubber or like synthetic material which will permit it being partially collapsed within its housing when the liquid pressure in the adjacent conduits **36** and **16** (or, in the case of the high-pressure accumulator **13**, adjacent conduits **32** and **14**) exceeds the air or gas pressure within the pneumatic accumulator concerned.

In the preferred construction the hydraulic percussion tool is built up of several separate sections, as shown clearly in Fig. 2, for purposes of convenience in manufacture, it being understood that this construction may be varied as found expedient together with other practical details, without departing from the scope of the invention as defined by the claims which follow.

I claim:

1. A hydraulically operated percussion tool, comprising in combination a casing having a stepped cylinder, a piston having an extension forming a striker of reduced diameter, said piston and striker being reciprocally mounted within the stepped cylinder, the section of the stepped cylinder accommodating the piston having spaced ports therein, said casing having pressure liquid passages therein leading to said ports for conducting a pressure liquid to said ports to deliver pressure liquid therethrough to actuate said piston, and at least one penumatic pressure-accumulator carried by the casing to co-act with the pressure liquid in the actuation of said piston, said pneumatic pressure-accumulator comprising means defining a closed space in communication with said passages, and a gas filled flexible container in said closed space which container is permanently sealed against ingress of the pressure liquid while continuously in external contact therewith, so as to absorb and reflect pressure impulses in the liquid pressure passages.

2. A hydraulically operated percussion tool comprising in combination, a casing having a cylinder formed therein, a piston reciprocably mounted within the cylinder, a striker operable by and movable in unison with the piston, said casing having liquid pressure passages therein for conducting a pressure liquid to said cylinder for actuating the piston, and at least one pneumatic pressure-accumulator coacting with the pressure liquid in the actuation of said piston, said pneumatic pressure-accumulator comprising means defining a closed space, said space being in communication with said passages, and a gas filled flexible container in said closed space which container is permanently sealed against ingress of the pressure liquid while continuously in external contact therewith, so as to absorb and reflect pressure impulses in the liquid pressure passages.

3. A hydraulically operated percussion tool comprising in combination, a casing having a cylinder formed therein, a piston reciprocably mounted within the cylinder, a striker operable by and movable in unison with the piston, means for actuating said piston comprising two high-pressure hydraulic conduits for conducting a pressure liquid to said cylinder, one of which conduits communicates with the working side of the piston and the other of which conduits communicates with the return side of the piston, a low-pressure hydraulic return line for conducting pressure liquid from the return side of the piston on its working stroke, control means between said high-pressure conduits and said low-pressure hydraulic return line for control of the pressure liquid, and two pneumatic pressure-accumulators carried by the casing, one of said pressure-accumulators being operatively associated with both of said high-pressure conduits and the other of said pressure-accumulators being operatively associated with the low-pressure return line.

4. A hydraulically operated percussion tool comprising in combination, a casing having a stepped cylinder, a piston having an extension forming a striker of reduced diameter said combined piston and striker forming a stepped piston which is reciprocally mounted within the stepped cylinder, said casing having spaced ports in the portion of the stepped cylinder accommodating the piston, two high-pressure hydraulic conduits in said casing communicating with said ports, one of which conduits delivers high-pressure liquid continuously to the working side of the piston, and the other of which conduits delivers high-pressure liquid to the stepped return side of the piston for part of the cycle of operation of said tool, a low-pressure hydraulic return line leading from the said other of the high-pressure conduits to conduct liquid at low-pressure from the stepped return side of the piston on its working stroke, control means for the high-pressure liquid at the junction of said other of said high-pressure conduits and said low-pressure return line, control means in said low-pressure return line for the low-pressure liquid, and two pneumatic pressure-accumulators carried by the casing, one of said pressure-accumulators being operatively associated with both of said high-pressure conduits, and the other of said pressure-accumulators being operatively associated with the low-pressure return line.

5. A hydraulically operated percussion tool comprising in combination, a casing having a stepped cylinder, a piston having a coaxial extension forming a striker of reduced diameter said combined piston and striker forming a stepped piston having an annular return side and being reciprocally mounted within the stepped cylinder the stepped portions of which form a piston-cylinder and a coaxial striker-cylinder, said casing having spaced ports in the piston-cylinder, two high-pressure hydraulic conduits in said casing communicating with said ports, one of which conduits delivering high-pressure liquid continuously to the working side of the piston, and the other conduit delivering high-pressure liquid to the annular return side of the piston for part of the cycle of operation of said tool, a low-pressure hydraulic return line leading from the said other of the high-pressure conduits for conducting liquid at low-pressure from the annular return side of the piston on its working stroke, control means for the high-pressure liquid at the junction of said other of said high-pressure conduits and said low-pressure return line, control means in said low-pressure return line for the low-pressure liquid, a first pneumatic pressure-accumulator, a first chamber in said casing in communication with both high-pressure conduits in which said first pneumatic

pressure-accumulator is positioned and a second pneumatic pressure-accumulator, and a second chamber in the casing and in communication with the low-pressure return line in which said second pneumatic pressure-accumulator is positioned, each such accumulator comprising a gas filled flexible container permanently sealed against ingress of pressure liquid while continuously in external contact with the pressure liquid with which it is operatively associated.

6. A hydraulically operated percussion tool as claimed in claim 5, wherein the annular return side of the piston is actuable by hydraulic pressure application to raise the piston to its uppermost position preparatory to a downward working stroke, the working side of the piston having a bore forming a blind-ended cylinder within the piston and coaxial therewith, said bore slidably engaging a tubular projection mounted on the casing at the upper end of the piston cylinder and coaxial therewith and to which one of said high-pressure conduits is connected, the said bore constituting the effective working area of the piston for the application of hydraulic pressure conveyed through the tubular projection to effect the working stroke of said piston.

7. A hydraulically operated percussion tool, as claimed in claim 6, and a source of hydraulic pressure comprising a constant flow pumping unit connected to said hydraulic conduits, and in which said return line and said control means for the pressure liquid comprises valve means and a hydraulic motor in one of said high-pressure conduits connected to said valve means for intermittently opening and closing said valve means whereby during operation the high-pressure liquid is constantly supplied to the bore in the working side of the piston and intermittently supplied to the annular step of the return side of the piston, the area of the return side of said piston being greater than the area of the bore in the working side of the piston so that the piston functions as a differential piston to reciprocate in the cylinder in response to the intermittent supply of the high-pressure liquid.

8. A hydraulically operated percussion tool as claimed in claim 7, wherein the constant flow pumping unit comprises an oil reservoir, a constant flow pump having a supply line from the oil reservoir and a delivery line to deliver oil at high pressure to the inlet side of the hydraulic motor, the outlet side of said motor communicating directly with the working side of the piston through said tubular projection and with the return side of the piston through said valve means, said valve means each comprising a rotary valve drive-coupled to a rotary member of the hydraulic motor, said rotary valve at the junction between said high-pressure conduit and said low-pressure return line controlling the intermittent supply of high-pressure oil to the return side of the piston in accordance with the speed of the hydraulic motor, and a return pipe extending from the casing to the reservoir to permit oil to be circulated by the pump.

9. A hydraulically operated percussion tool, as claimed in claim 7, wherein said hydraulic motor consists of a rotary gear-type motor having two oppositely rotating parallel shafts directly connected to said rotary valves for oppositely rotating said valves for opening and closing the high-pressure conduits and the low-pressure return line respectively, said rotary valves being synchronized whereby immediately prior to admission of high-pressure oil to the high-pressure conduit leading to the return side of the piston to raise the latter, said conduit leading to the low-pressure return line which is connected to said return pipe is closed, and immediately after the supply of high-pressure oil to the said high-pressure conduit is cut off the high-pressure conduit is opened to communicate with the low-pressure return line and the return pipe to permit the piston to descend on its working stroke.

10. A hydraulically operated percussion tool as claimed in claim 5, having a controllable by-pass between the high-pressure conduit continuously communicating with the piston, and the low-pressure return line, and means for closing and opening said by-pass so as to respectively start or stop the operation of the tool.

11. A hydraulically operated percussion tool as claimed in claim 10, wherein means for opening and closing said by-pass comprises a spring-influenced valve in said by-pass biased to the open position and an external handle on said casing located conveniently to the operator's hand and connected to said valve for effecting gradual closure of the said by-pass at will to thereby control the speed of operation of the tool.

12. A hydraulically operated percussion tool as claimed in claim 6, and a member closing the upper end of the piston-cylinder on which member is mounted the tubular projection, the annular space defined by the walls of the cylinder and the said tubular projection being traversed by the piston, said annular space having a vent at its upper end communicating with the low-pressure return line.

13. A hydraulically operated percussion tool as claimed in claim 12, wherein the vent comprises a passage provided with a spring-loaded non-return valve permitting the partial exhaustion of fluid from the said annular space during the up-stroke of the piston, and preventing the return of fluid to the said annular space on the down-stroke of the piston.

14. A hydraulically operated percussion tool as claimed in claim 5, wherein the striker-cylinder has at its upper end a replaceable bush slidably fitting the striker and extending over only a portion of the length of the striker-cylinder, a hydraulic packing ring being disposed below said bush within said cylinder for preventing the escape of pressure liquid past the striker, said casing having a passage leading from between the bush and the packing ring to the low-pressure return line for the discharge thereto of any liquid passing said bush from the high-pressure side.

15. A hydraulically operated percussion tool as claimed in claim 14, wherein the replaceable bush has an annular flange at its upper end the upper face of which flange forms an annular step disposed between the two coaxial piston and striker cylinders and axially opposed to the annular step of the piston to define the lower limit of the piston stroke, said casing having at least one passage connecting the annular return side of the piston with the valve-controlled conduit communicating therewith, the latter serving as a return line for the pressure liquid during the downward stroke of the piston, said passages being spaced from the lower end of the cylinder whereby the piston approaching the end of its downward stroke will cover the passages and close the means of egress of pressure liquid, the pressure liquid trapped between the annular step of the piston and the upper face of the bush preventing the direct contact of these two surfaces should the piston over-run its normal working stroke.

16. A hydraulically operated percussion tool as claimed in claim 15, said casing having a one-way by-pass having a spring-loaded check-valve thereon, said by-pass being located between the said conduit and the cylinder to permit hydraulic pressure to be applied to the return side of the piston and raise the latter so as to again open the passages which normally communicate therewith and restore the piston to its working position.

17. A hydraulically operated percussion tool as claimed in claim 5, wherein the casing comprises a pair of detachable housings, located one upon each side of the casing in the region adjacent the piston-cylinder, each of said housings defining said chambers supporting one of the pneumatic pressure-accumulators in a hydraulic pressure-tight manner.

18. A hydraulically operated percussion tool as claimed in claim 5, wherein the pneumatic pressure-accumulators each have a non-return valve to enable each flexible

container to be pre-charged independently with gas at super-atmospheric pressure by external means.

19. A hydraulically operated percussion tool as claimed in claim 5, and means at the lower end of the casing for connecting and positioning a removable tool-bit in co-axial alignment with and extensible of the striker-cylinder, whereby the striker when approaching the end of its downward stroke contacts the inner end of the tool-bit and imparts a percussive blow thereto.

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