April 27, 1954 C. F. WARREN 2,676,464

HYDRAULIC IMPACT PULSATOR TRANSMISSION SYSTEM

Filed April 12, 1946 4 Sheets-Sheet 1

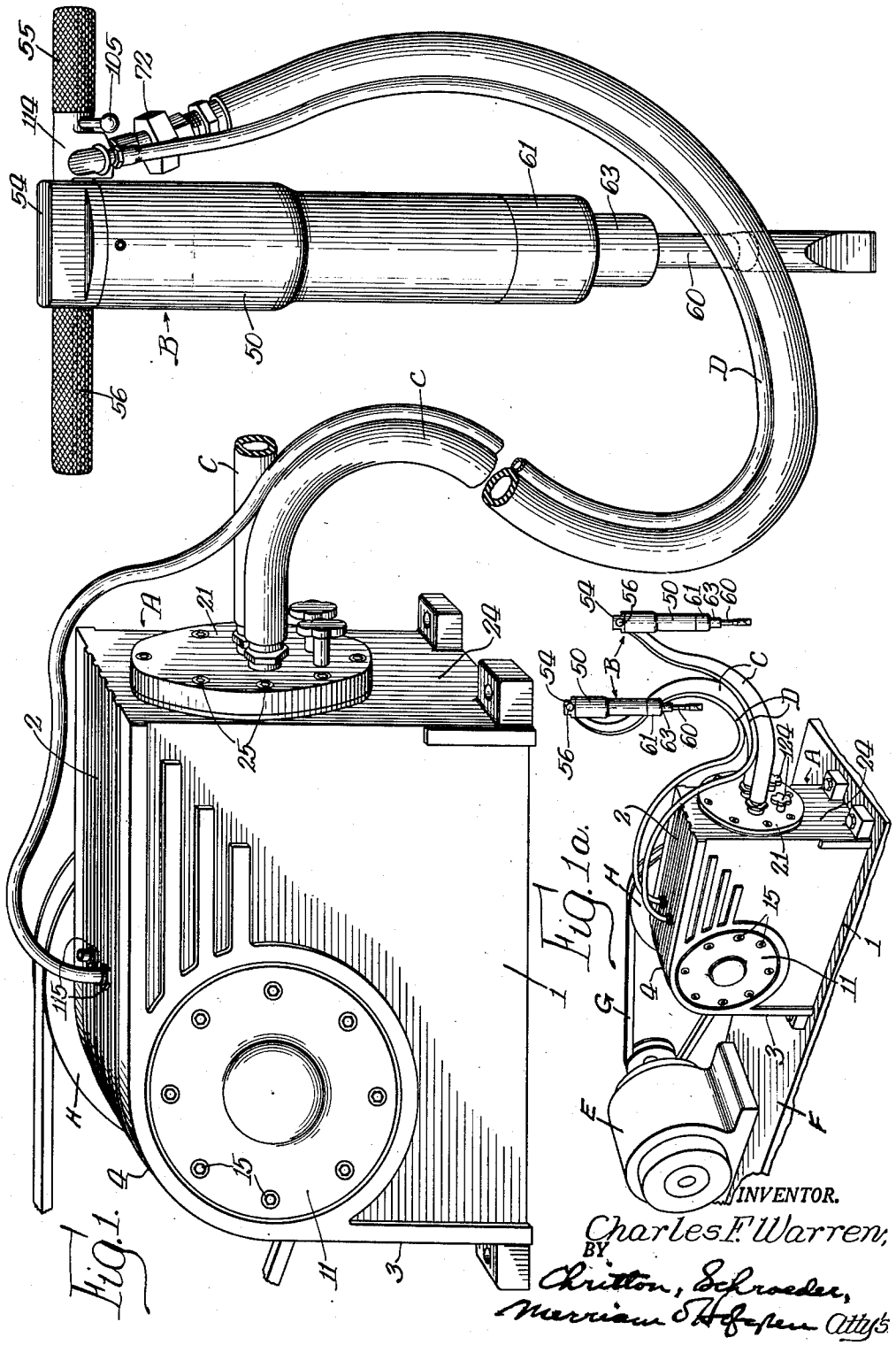


Fig. 1.

Fig. 1a.

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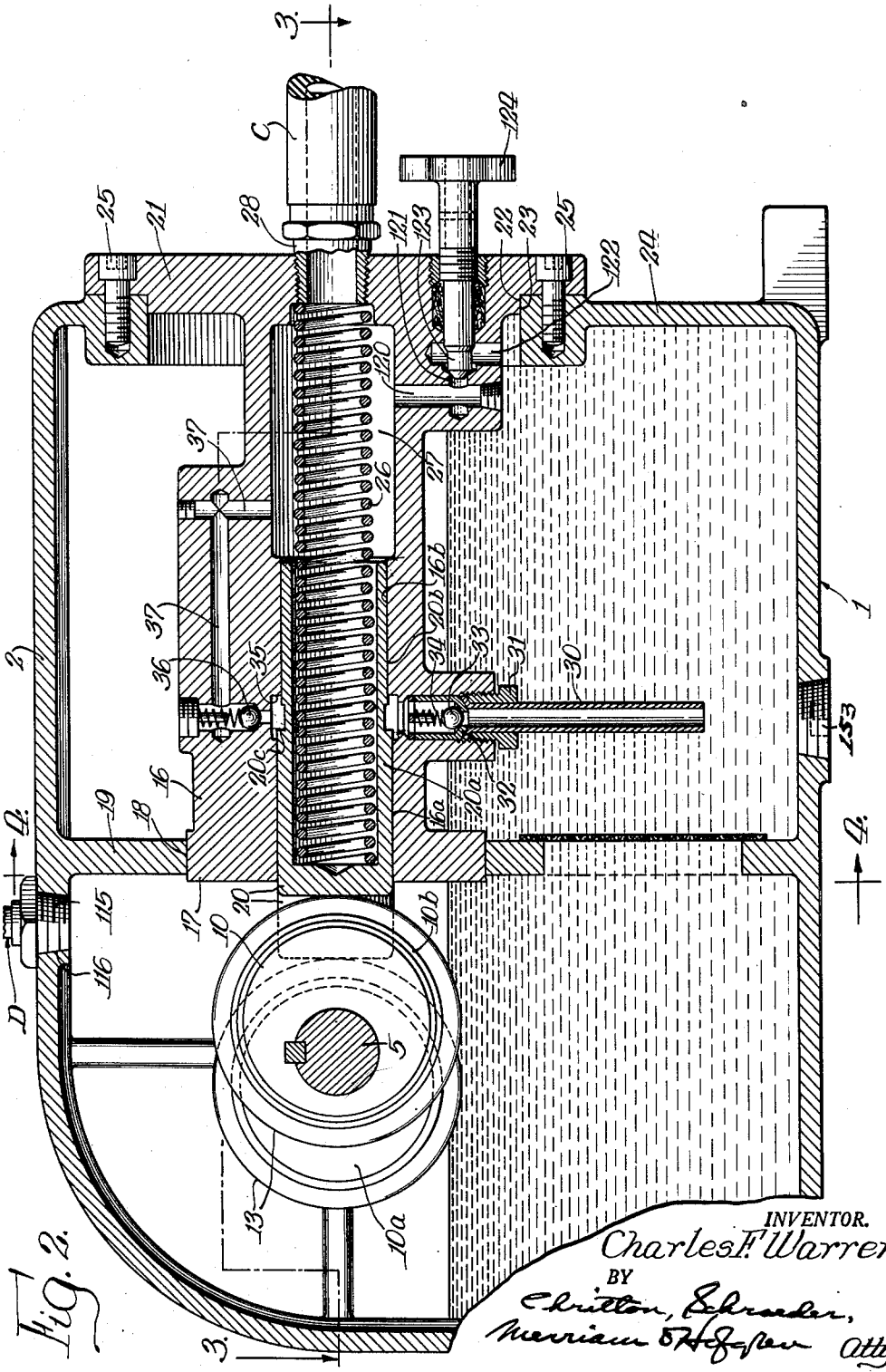


Fig. 2.

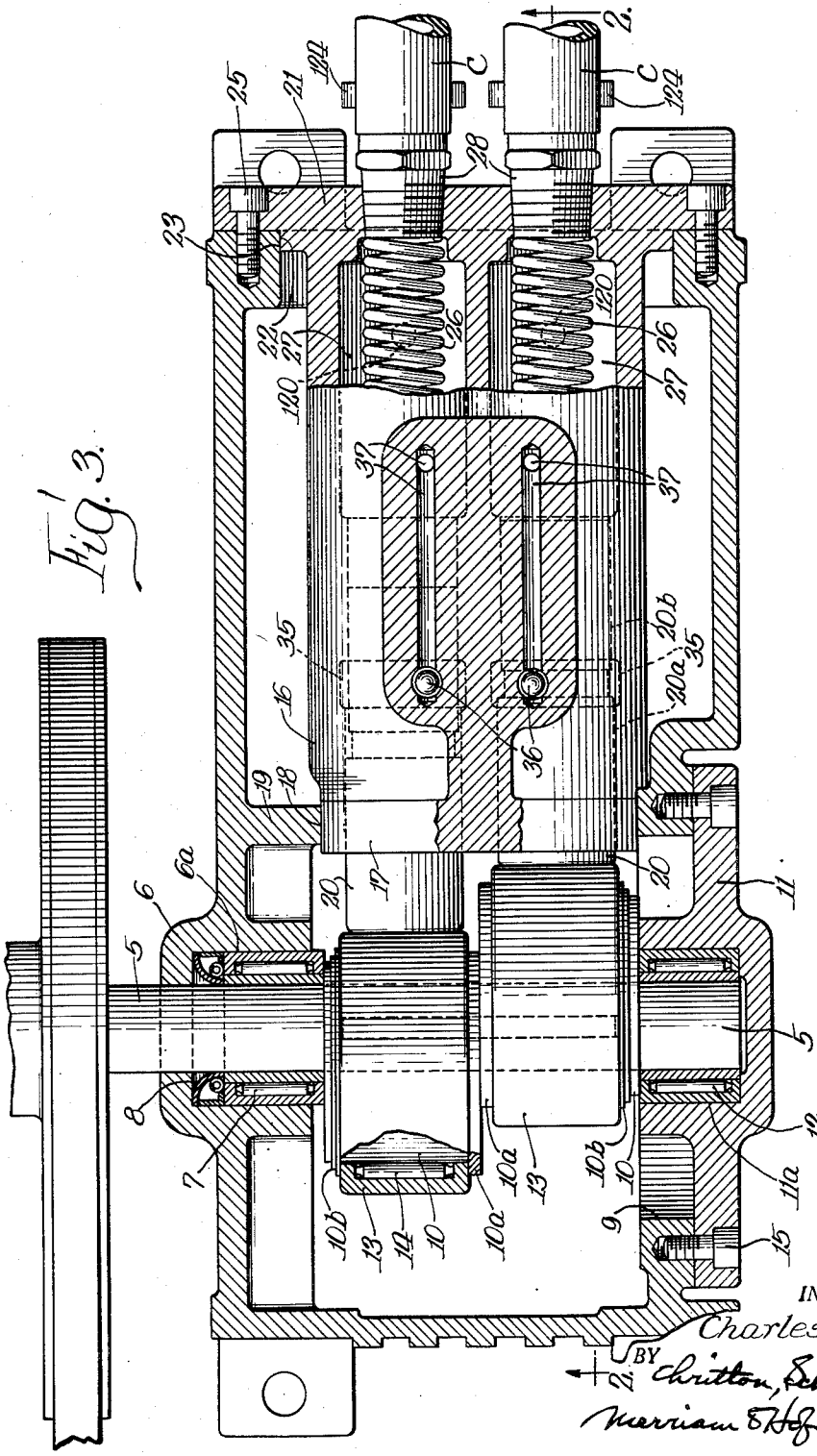
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HYDRAULIC IMPACT PULSATOR TRANSMISSION SYSTEM

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Fig. 3.



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HYDRAULIC IMPACT PULSATOR TRANSMISSION SYSTEM

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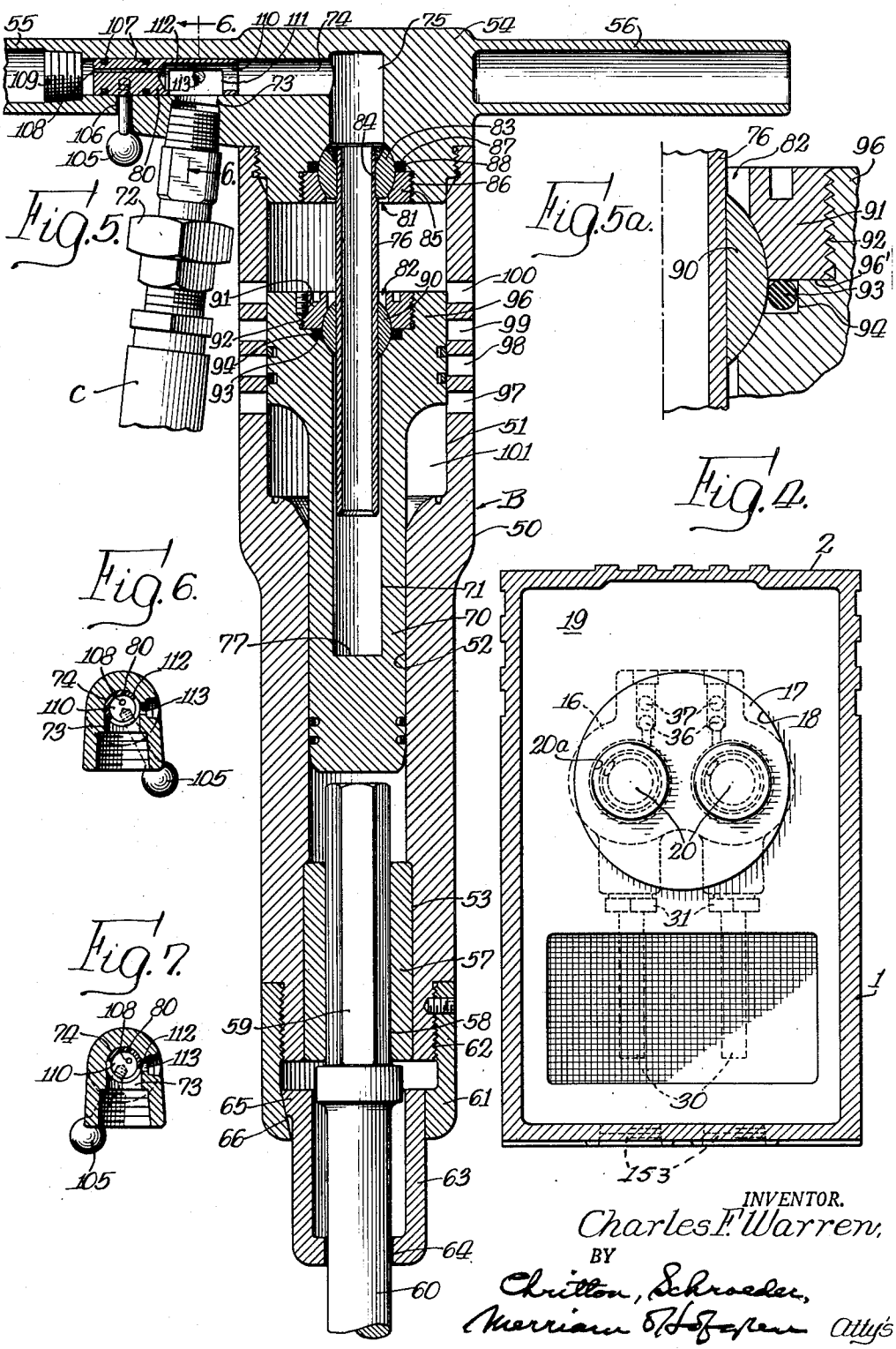


Fig. 5.

Fig. 5a.

Fig. 6.

Fig. 7.

Fig. 4.

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UNITED STATES PATENT OFFICE

2,676,464

HYDRAULIC IMPACT PULSATOR TRANSMISSION SYSTEM

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Application April 12, 1946, Serial No. 661,542

13 Claims. (Cl. 60—54.5)

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The invention relates generally to hydraulic impact transmission systems and more particularly to a system adapted to transmit impacts by means of a reciprocating column of fluid. It is the general object of the invention to provide a new and improved system of this character.

Another object is to provide a hydraulic impact transmission system for use with portable impact tools; and particularly one having a conduit between an impact producing unit and an impact tool unit, means in the impact unit for filling the conduit with a fluid (as for example, oil or other suitable liquid) and for maintaining a column of fluid in the conduit under static pressure, means for imparting rapid reciprocating movement to the rigid column so formed, and means at the impact tool unit end of the conduit forming a restricted return outlet for excess fluid supplied to the conduit. A further object is to provide such a system with manually operable means at the impact tool unit for enlarging the return outlet for the fluid so as to relieve the pressure on the column and stop the operation of the tool.

Another object is to provide an impact transmission system with an impact producing unit, an impact tool unit and pressure fluid supply and return conduits connecting the impact unit with the impact tool unit, together with control means carried on the tool unit for starting and stopping the operation of the tool when the impact unit is in operation.

Another object is to provide a new and improved impact tool unit for transmission system.

A further object is to provide a new and improved hydraulic impact transmission system embodying a reciprocable rigid column of fluid, means for reciprocating the column, means connected to one end of the column for supplying fluid thereto at a rate in excess of the leakage therefrom, and means at the other end of the column for controlling the discharge of excess fluid therefrom.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 is a perspective view of a preferred form of the invention. Fig. 1a is a perspective view thereof on a reduced scale with two impact tool units. Fig. 2 is a vertical section approximately along the line 2—2 of Fig. 3 of the pumping unit thereof. Fig. 3 is a plan section along the line 3—3 of Fig. 2. Fig. 4 is a vertical section on

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a reduced scale along the line 4—4 of Fig. 2. Fig. 5 is a vertical central section through the impact tool unit. Fig. 5a is an enlarged fragmentary view of a portion of Fig. 5. Fig. 6 is a fragmentary section along the line 6—6 of Fig. 5. Fig. 7 is a similar fragmentary section with the control valve in an alternative position.

While my invention is susceptible of embodiment in many different forms, I have shown in the drawings and will herein describe in detail one such embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

In the form selected for purposes of disclosure this invention is embodied in a hydraulically actuated impact tool system comprising generally a pumping or impact producing unit A (Fig. 1), an impact tool B, a supply conduit C connecting the pumping unit to the impact tool for conducting a fluid (such as oil) under pressure to operate the impact tool and a return conduit D for returning the operating fluid to the pumping unit. As shown in Fig. 1a a pair of impact tool units B are connected to an impact producing unit A, the unit A and a drive motor E therefor being mounted on a common frame F. As shown, a belt G runs from a pulley on the motor to a pulley H on the drive shaft of the unit A.

Impact tools of the character to which this invention relates are in the nature of hammers, drills and tampers, which are similar in function to corresponding pneumatically driven tools. However, such tools of the pneumatic type require the provision of an air compressor unit accompanied by an internal combustion motor or other prime mover of substantial power, whereas the combination of an impact unit or pump and an impact tool directly connected to the pump by means of a flexible conduit which confines a continuous and rigid column of fluid under pressure extending from the pump to the tool, constitutes a much more efficient mechanism and employs only a fraction of the power of the pneumatic system for driving the pump and operating the tool. The present invention is an improvement in hydraulic impact transmitting systems of the type embodying a rigid reciprocable column of oil (or other liquid) and constitutes an improvement in the system of Patent No. Re. 22,122, is-

sued to Charles F. Warren and William R. Smith, dated June 16, 1942.

In the form illustrated the pumping unit is adapted to operate two impact tool units. The operating elements of the pumping unit are mounted in a housing 1 which serves also as a reservoir for the hydraulic fluid, and as seen in Fig. 1 is of substantially rectangular form except that the top wall 2 and one end wall 3 are connected by a curved portion 4 substantially concentric with the axis of a drive shaft 5. This shaft extends through a hollow boss 6 in one side wall of the housing, and the boss 6 provides a pocket or recess 6a which seats the roller bearing 7 for the shaft together with a packing element 8. A circular opening 9 in the opposite side wall of the housing is large enough to permit insertion or withdrawal of the shaft 5 with its driving eccentrics 10, 10 together with the bearing assembly; and this opening 9 is closed by a cover plate 11, which includes an inwardly open pocket or recess 11a to support a roller bearing 12 for the inner end of the shaft 5. Each of the eccentrics 10 carries a ring 13 confined between a flange 10a and a retainer ring 10b with interposed bearing rollers 14, so that the eccentric may turn freely within the ring 13. Thus in the process of assembly, the shaft 5, with its bearings 7 and 12 in place and with its eccentrics 13 fitted with their rings 14, may be inserted as a unit through the opening 9, and its mounting in the housing will be completed by application of the cover plate 11 and securement thereof by means of fastening screws 15. It may be understood that the projecting end of the shaft 5 will be fitted with any suitable pulley or gear for operative connection with a prime mover such as an electric motor or internal combustion engine.

The pumping device proper is contained in a cylinder block or casting 16 having a circular inner end portion 17 which fits snugly into a circular opening 18 in a diaphragm or partition wall 19 extending across the housing 1, as seen in Figs. 2 and 3. This provides support for the inner end of the casting 16 and locates the closed ends of the pistons 20, 20 in operative relation to the rings 13 on the driving eccentrics 10, 10. At its outer end the casting 16 is formed with a flange 21 having a circular shoulder 22 which fits into a circular opening 23 in the end wall 24 of the housing 1. The pumping device is secured in place by screws 25 extending through said flange 21 and into the end wall 24 adjacent its opening 23. Thus the insertion of the unit 16, with the pistons 20 and other operative parts already assembled in it, completes the assembly of the pumping device.

Each of the pistons 20 is hollow and open at one end to accommodate a spring 26 which reacts against the end wall of a chamber 27 formed in the casting 16; and each piston includes a larger portion 20a and a slightly smaller portion 20b, the casting 16 being formed with corresponding bores 16a and 16b in which these portions of the piston reciprocate respectively. The bore 16b communicates directly with the chamber 27, and said chamber terminates in a threaded opening into which the terminal 28 of the flexible conduit or hose C is secured, as seen in Fig. 2. Thus, when the hollow piston 20 and chamber 27 and conduit C are filled with hydraulic fluid under pressure, the reciprocatory movements of the piston are transmitted longitudinally by the rigid column of fluid to the impact tool B, as hereinafter more fully described.

The lower portion of the housing 1 serves as a reservoir for the fluid which will be maintained always at a level considerably above the lower end of the supply pipe 30 which depends from the pump casting 16 and is secured therein by a gland 31 which also supports the valve seat 32 for a ball check valve 33 normally seated by its spring 34. The check valve 33 controls access to an annular passage 35 formed in the casting 16 at the junction of the bores 16a and 16b. The shoulder 20c of the piston 20 which defines the outer end of the larger portion 20a operates as a secondary piston head as said larger portion 20a of the piston reciprocates in the bore 16a. As the piston moves toward the axis of the shaft 5, the suction or partial vacuum operating in the annular passage 35 lifts the check valve 33 from its seat and tends to draw fluid through the supply pipe 30 into the passage 35 and into the bore 16a adjacent the shoulder 20c of the piston. Then, upon the return stroke of the piston, the shoulder 20c forces the fluid past a second check valve 36 and through a passage 37 which leads into the chamber 27.

In the construction herein illustrated, with the two eccentrics 10, 10 set 180° apart on the shaft 5, the mechanism is in the nature of a duplex pump with the two pistons 20, 20 operating alternately and thus transmitting separate impulses through two conduits C which are connected respectively to the two chambers 27.

In operation it is most convenient to use oil for the impact transmitting medium and to employ the same oil for lubrication of the mechanism; accordingly, the web or partition 19 is formed with an opening in its lower portion which affords communication between the space in the housing directly under the drive shaft 5 and the space extending below the pump cylinder casting 16. Preferably this opening is covered by a screen. A connection device 115 for the return conduit D is removable from the top wall above the shaft 5 for adding oil as required. The fluid returned through the conduit D is discharged onto the operating parts to lubricate them. Although the feed tubes 30 and check valve assemblies 31, 32, 33, 34 can be originally attached to the cylinder casting 16 and entered with it through the opening 23, it may be desirable to remove these parts occasionally without withdrawing the cylinder units and to facilitate this the bottom wall of the housing is formed with threaded openings directly below the tubes 30, these openings being normally closed by screw plugs 153, as shown in Fig. 2.

As illustrated in the drawings, the impact tool B (Figs. 1 and 5 to 7) comprises a tubular barrel 50 having a cylinder 51 formed in the upper portion thereof, a bore 52 in the middle portion thereof, and a slightly larger bore 53 in the lower end thereof. A head member 54 is screw threaded to the upper end of the barrel and has handle portions 55 and 56 adapted to facilitate use of the tool. At its lower end, a bushing 57 is pressed into the bore 53 and has a hexagonal opening 58 therethrough in which the shank 59 of a tool 60 is slidably guided. A tool retainer is shown as comprising a collar 61 screw threaded on to the barrel at 62 and a cup-shaped retaining member 63. The cup-shaped member has an opening 64 through which the tool extends and is formed at its upper end 65 to interengage a beveled portion 66 on the collar 61.

For striking or imparting impacts to the tool 60 a plunger or impact member 70 is reciprocably

mounted in the bore 52 of the barrel and is formed with a longitudinally extending bore 71. Fluid supplied to the impact tool unit B through the conduit C passes through a connection 72 to a bore 73 in the head member 54 and thence through a horizontal bore 74 to a vertical bore 75 positioned in the head member axially of the barrel 50. A tube 76 communicates at its upper end with the bore 75 in the head member and at its lower end with the bore 71 in the impact member 70 so that fluid supplied to the tool unit acts upon the end surface 77 of the bore 71 to move the impact member 70 downwardly through a stroke and to cause said member to strike the upper end of the tool shank 59. The flow of fluid to the impact member 70 is controlled by a valve 80 hereinafter more fully described.

Although the tube 76 may be secured rigidly to the head member 64 and have a sliding and sealing fit in the bore 71, in the form shown a flexible ball and socket joint 81 is provided between the upper end of the tube 76 and the head member 54 and a ball and socket joint 82 is provided between the upper end of the impact member 70 and the lower portion of the tube 76. The upper joint 81 comprises a ball member 83 sealed tightly on a reduced portion 84 of the tube 76, a socket formed partly on the head member 54 and partly on a collar 85 which is screw threaded at 86 into a recess in the head member, and an annular sealing ring 87 of resilient material such as rubber or synthetic rubber positioned in an annular recess 88 formed by the head member and collar 85. The lower joint 82 comprises a ball member 90 having a sliding fit on the tube 76, a socket formed partly in the piston member 70 and partly in the collar member 91 screw threaded at 92 into a recess in the piston member, and a sealing ring 93 positioned in a recess 94 in the piston member. As shown more clearly in Fig. 5a, the sealing ring is positioned in the upper portion of the recess 94 and is slightly compressed between the right hand surface of the recess and the surface of the ball member 90. The surface 96' against which the collar member 91 seats is preferably in the same plane as the center of the ball member 90. If the fluid under pressure in the tube 76 has a tendency to pass between said tube and the bore 71 of the impact member 70 and leak across the lower spherical surface of the ball member 90, any fluid reaching the recess 94 and creating a pressure therein serves to distort or flatten the sealing ring 93 and increase the sealing contact thereof with the ball member and the surface of the recess 94. The joint between the bottom of the collar 91 and the surface 96' is therefore on the low pressure side of the sealing ring and the sealing ring serves to seal that joint as well as the spherical joint between the lower portion of the ball and the socket. The upper ball and socket joint 81 is similarly arranged so that the joint between the collar 85 and the head member 54 is on the low pressure side of the sealing ring 87. These ball and socket joints are more fully disclosed and claimed in my co-pending application Serial No. 595,016, filed May 21, 1945, on Flexible Pipe Joints, now Patent No. 2,564,938, dated August 21, 1951.

By providing flexible joints intermediate the tube 76 and the parts 54 and 70, it is possible to obtain smooth and efficient operation even though the bores 75 and 71 are not in alinement.

The impact member 70 may be returned upwardly through the return stroke of its movement by resilient means acting upwardly thereon. As shown herein, this means comprises an air cushion created in a chamber 101 in the bore 51 of the barrel below a piston 96 which is formed integrally with the upper end of the impact member 70 and slides in the bore 51. The barrel is provided with a series of horizontally extending ports 97, 98, 99, 100, in the side wall thereof and which communicate with the bore 51 to admit air therethrough during the upward stroke of the piston 96. During the downward stroke of the piston, a quantity of air is trapped in the chamber 101 and is compressed during the final downward movement of the impact member 70 to form the air cushion. An impact tool of this type is more fully disclosed and claimed in my co-pending application Serial No. 576,767, filed February 8, 1945, entitled Hydraulic Impact Tool, now Patent No. 2,624,177, dated January 6, 1953.

In the preferred form disclosed herein, my invention differs in part from the hydraulic impact tool system of U. S. Letters Patent, Re. 22,122 of June 16, 1942, and that of the co-pending application of Charles F. Warren and Karl F. Kuehn, Serial No. 442,730, filed May 13, 1942, now Patent No. 2,397,174, dated March 26, 1946, by providing in the head member 54 of the impact tool unit, a control for the output fluid pressure of the pumping unit A. As illustrated herein, this control comprises the rotary valve 80 located in the bore 74 and provided with an operating handle 105 projecting downwardly from the handle 55 through a slot 106 therein. Preferably, seal rings 107 are provided in the rotary valve member to prevent leakage through the slot 106, and a port 108 extends longitudinally through the valve member to equalize the pressure on both ends thereof. A plug 109 closes the left hand end (Fig. 5) of the bore 74. The right hand end of the valve member 80 has a bore 110 therein and a recess 111 cut in the side wall thereof so that an edge 112 of the recess controls a fluid return port 113 in the head member. The port 113 communicates with a fitting 114 (Fig. 1) to which the adjacent end of the fluid return conduit D is connected. The other end of the return conduit is connected to the fitting 115 secured in a threaded bore 116 (Fig. 2) in the upper wall of the housing of the pumping unit, so that oil returned to the pumping unit from the tool is discharged on to the projecting ends of the pistons 20, the eccentric devices on the drive shaft 5 and the shaft bearings. In this way, the operating parts are continuously lubricated.

In operating the form of the invention illustrated in the drawings, it is contemplated that the drive shaft 5 of the pumping unit will be driven from a suitable prime mover such as an electric motor E by means of a belt G operating on a pulley H on the shaft 5 and which may be started when the system is to be used and stopped when the system is to be shut down completely for an extended period of time. As shown in Fig. 1a the motor and pumping unit are mounted on a support F which is generally portable. Upon starting such prime mover and driving the shaft 5, the pistons 20 are reciprocated in their cylinders, the power strokes being produced by the eccentric devices on the shaft and the return strokes by the coiled springs 26 (Fig. 2). During such reciprocation of the pistons, the secondary pistons 20c function as makeup pumps to draw oil from the reservoir in the bottom of the housing chamber, through the tubes 30 and past the check valves 33 and to force such fluid past the check valves 36 and through the passages 37 into

the chambers 27. This fluid, assuming the system is being started initially, then proceeds to fill the conduits C and the passages in the impact tools B. Once the conduits are filled with oil the makeup pumps formed by the secondary pistons 20c operate continuously to supply fluid to the hydraulic columns formed between the pistons 20 and the tool impact members 70. This fluid is pumped at a rate in excess of leakage from the system. In a system utilizing a conduit of three-quarters inch internal diameter, a rate of eleven gallons per hour has resulted in successful operation, although the quantity may readily be varied.

Referring now to one system, with the hydraulic column formed in the conduit C between a piston of the pumping and one impact tool unit B, the control for the operation of that impact tool unit is in the valve 80. When this valve is in its open position as shown in Figs. 5 and 6, the return port 113 is wide open and permits a quantity of fluid, equal to that pumped by the make-up pump, to return freely to the conduit D. Under such conditions the fluid in the hydraulic column between the pistons 20 and 70, is not under sufficient pressure to actuate the impact member 70. The impact tool B is therefore idle.

Upon shifting the valve 80 from the position of Figs. 5 and 6 to that illustrated in Fig. 7, the return port 113 is almost closed with the result that the pressure in the hydraulic column builds up to a maximum value effective to actuate the tool impact member 70 through its impact producing strokes, the member 70 and the hydraulic column being moved through a return stroke by the operation of the air cushion in chamber 101, the air cushion functioning as a resilient backing for the impact member. Under these conditions, the impact member 70 reciprocates at a high rate of speed and in unison with the reciprocations of the pump piston 20, the hydraulic column of fluid between the pump piston and the tool impact member then being under such high pressure (preferably 400 or more pounds per square inch) that it is in effect, a rigid reciprocable column. This column imparts to the impact tool 60 substantially the full force exerted by the prime mover on the pistons 20.

The force of the blows produced by the tool impact member 70 on the tool 60 may be controlled by the valve 80 by moving the valve to various positions intermediate the wide open and closed positions to vary the pressure in the conduit. The return port 113 thus forms a controllable orifice through which the makeup fluid (in quantities in excess of leakage) must pass before reaching the return conduit D. The fluid passing through the orifice is at a substantially constant volume but varying pressure. Valve 80, by opening or restricting the return port 113 thus controls the effective pressure of the fluid in the hydraulic column and serves to determine the strength of the blows imparted to impact tool.

As the pressure in the column increases from the idle condition (in which the valve 80 is wide open) to the normal operating condition (in which the valve 80 is in the position of Fig. 7), the strokes of the impact member are first short and confined to the lower portion of the bore 52 (Fig. 5) and the column is relatively long. As the pressure and therefore the rigidity of the column increases, the column shortens slightly as the stroke lengthens until the stroke reaches a maximum determined by the stroke of the pump piston and the relative cross sectional areas of the pump piston and the impact member.

By locating a pressure control valve in the handle of the impact tool, advantages accrue in addition to the convenient control for an operator. Since an impact tool is generally in use about 50% of the time the pumping unit is in operation, the continued circulation of fluid through the supply and return conduits when the tool is not in operation functions to cool the fluid and thereby keep the temperature of the conduits and other parts which confine the hydraulic column at a minimum. If during operation of the tool unit the conduit should have vibrational movements due to the reciprocation of the rigid hydraulic column, such movements of the conduit stops when the tool unit is inoperative, thus saving wear and tear on the conduit. The rigidity of the column is built up (or destroyed) under the control of the valve 80 at the impact tool unit end of the system and generally takes place after the impact producing unit is in operation.

When a single impact tool unit is used with an impact producing unit of the type herein disclosed (having two pump pistons 20) means is preferably provided to bypass the fluid in the system which is not in use. As shown in Fig. 2 such a bypass means comprises a port 120 leading from chamber 27 to a valve port 121 which discharges through a passage 122 into the reservoir in the housing 1. A valve 123 controls the port 121 and is adjustable from exteriorly of the casing by means of a hand device 124. This valve is closed (as shown) when the system is in use, and is opened to bypass fluid from the chamber 27.

I claim:

1. A hydraulic impact transmitting system comprising, in combination a flexible conduit adapted to contain a column of fluid, an impact producing unit connected to one end of the conduit and comprising means for imparting forward strokes to a reciprocable rigid column of fluid therein, an impact tool unit connected to the other end of said conduit and comprising means including an impact member reciprocable in the other end of said conduit by said column of fluid, means for supplying make-up fluid to said conduit in a quantity substantially in excess of the leakage therefrom, and a valve at the impact tool unit end of the conduit operable to control an orifice through which the excess make-up fluid escapes from the conduit, and a return conduit for conducting such excess make-up fluid back to the make-up fluid supply means.

2. A hydraulic impact transmitting system comprising in combination, a flexible conduit, a column of fluid therein, an impact producing unit connected to one end of the conduit and comprising means for imparting forward strokes to said column of fluid, an impact tool unit connected to the other end of said conduit and comprising means including an impact member driven in the other end of said conduit by said column of fluid, means for imparting return strokes to said column, means for supplying fluid to said conduit in a quantity substantially in excess of the leakage therefrom, and a valve at the impact tool unit end of the conduit operable to control an orifice through which the excess fluid escapes from the conduit.

3. A hydraulic impact transmitting system comprising, in combination, a conduit adapted

to contain a column of fluid, a first closure reciprocably mounted on one end of the conduit and sealing that end of the fluid column, an impact producing unit connected to said end of the conduit and comprising means for actuating said closure to impart strokes thereto, an impact tool unit connected to the other end of said conduit and including an impact member reciprocable in the other end of said conduit and sealing the other end of the fluid column, means for supplying make-up fluid to said conduit at a rate in excess of the leakage therefrom to form a rigid column of fluid between said closures, valve controlled means at the impact tool unit end of the conduit operable to control the size of an orifice through which the excess make-up fluid escapes from the conduit, and a return conduit for conducting such excess make-up fluid back to the make-up fluid supply means.

4. A hydraulic impact transmitting system comprising, in combination, a conduit, a first closure reciprocably mounted in one end of the conduit, a relatively stationary impact producing unit connected to said end of the conduit and comprising means for actuating said closure to impart strokes thereto, means for driving said actuating means, a portable impact tool unit connected to the other end of said conduit and including an impact member forming a closure reciprocable in the other end of said conduit, means in said impact producing unit for supplying fluid to said conduit at a rate in excess of the leakage therefrom to fill the conduit and form a rigid column of fluid between said closures, valve controlled means at the impact tool unit end of the conduit operable to control an orifice through which the excess fluid escapes from the conduit, and a return conduit for conducting such excess make-up fluid back to the fluid supply means.

5. A hydraulic impact transmitting system comprising, in combination, a conduit, a first closure in one end of the conduit and reciprocable between spaced positions, a second closure in the other end of the conduit, means for supplying fluid to said conduit at one end thereof in a quantity in excess of the leakage therefrom when the system is in operation, means for reciprocating said closures and the column of fluid therebetween as an integral unit, a second conduit extending from said first conduit at a point adjacent said second closure to said fluid supply means for returning excess fluid to the supply means, and valve means located adjacent the junction of said conduits for controlling the passage of fluid from the first conduit to the second conduit.

6. A hydraulic impact transmitting system comprising, in combination, a flexible conduit, a first closure reciprocable in one end of the conduit, an impact member reciprocable in the other end of the conduit, a rigid reciprocable fluid column occupying said conduit and having its ends in direct contact with said closure and impact member and operable to transmit motion therebetween, means for imparting strokes in one direction to said column comprising an actuating device for said closure, means for imparting return strokes to said column operable on said impact member, means connected to the closure end of said conduit operable to supply make-up fluid to the conduit in quantities in excess of leakage therefrom, an orifice in said conduit adjacent said impact member and operable when open to discharge the excess make-up fluid and relieve the pressure of the fluid in said column and operable when partially closed to permit the pressure of the fluid in the column to build up to an operating value, and a return conduit for conducting excess fluid from the orifice to the make-up fluid supply means.

7. A hydraulic impact transmitting system comprising, in combination, a conduit, a first closure reciprocable in one end of the conduit, an impact member reciprocable in the other end of the conduit, a rigid reciprocable column of liquid occupying said conduit and having its ends in direct contact with said closure and impact member and operable to transmit motion therebetween, means for imparting strokes in one direction to said column comprising an actuating device for said closure, means for imparting return strokes to said column operable on said impact member, means operable to supply liquid to the conduit in quantities in excess of leakage therefrom, an orifice in said conduit adjacent said impact member operable when open to exhaust the excess liquid and relieve the pressure of the liquid in said column and operable when partially closed to permit the pressure of the liquid in the column to build up to an operating value and means for controlling said orifice.

8. A power transmission system comprising, in combination, a conduit, a column of liquid therein, closures reciprocably mounted at the ends of the conduit and forming the ends of the column, means for imparting strokes in one direction to the closure at one end of the column, means at said one end operable to supply liquid continuously to the conduit to maintain the column of liquid therein, means backing the closure at the other end of the column operable to impart return strokes to the closures and column, a return conduit leading from an outlet orifice in said other end of the column to return liquid to said supply means, and means at said other end of the column operable to control the pressure of the liquid in the first mentioned conduit by controlling the outlet orifice through which liquid passes therefrom to the return conduit.

9. A power transmission system comprising, in combination, a conduit, a column of liquid therein, closures reciprocably mounted at the ends of the conduit and forming the ends of the column, means for imparting strokes in one direction to the closure at one end of the column, means at said one end operable to supply liquid continuously to the conduit in a quantity in excess of that necessary to maintain the column of liquid therein, resilient means backing the closure at the other end of the column operable to impart return strokes to the closures and column, and means at said other end of the column operable to control the pressure of the liquid in said conduit by varying an outlet orifice for liquid therefrom.

10. In a hydraulic system comprising a hydraulic column, a power actuator at one end of the column, a sump associated with said actuator, and a constantly operating makeup pump having connections for delivering hydraulic fluid from said sump into said column; a tool comprising a cylinder with which such column communicates, a plunger reciprocable in the cylinder subject to motion transmitted thereto by said column from said actuator, a return passage in said tool in communication with said sump for the return of excess makeup fluid to said sump, and a valve for which said tool provides a seat and which is operatively disposed in said passage for the

control of return fluid, whereby to regulate the pressure in said column.

11. In a device of the character described, a tool having a hydraulic cylinder, piston, and hydraulic operating connection for use with an actuator which includes a makeup pump for supplying hydraulic fluid to said connection, and an impactor for transmitting hydraulic shock through such fluid when the fluid is under compression, said tool being provided with a fluid relief port and a valve controlling the discharge of fluid therethrough, said valve regulating the pressure of the hydraulic fluid and the effect of said impactor on the tool.

12. In a system comprising a hydraulic conduit and an impact mechanism including liquid storage means, a makeup pump for delivering liquid from said storage means into said conduit and an impactor for delivering successive shocks to a column of liquid under pressure in said conduit; a tool operated by shocks thus delivered and comprising a piston, a cylinder with which said conduit communicates and in which said piston operates, and means for controlling hydraulic pressure in said conduit, said means comprising a relief valve at said tool capable when open of discharging liquid at least approximately as fast as such liquid is supplied to the conduit.

13. A hydraulic impact transmitting system comprising, in combination, a sump for hydraulic liquid, conduits including an outgoing section and a return section connected to each other and to said sump to comprise a circulatory system for the hydraulic liquid, a pump for delivering liquid from said sump under pressure into the outgoing section, an impact transmitter comprising a reciprocable face exposed to the liquid in one of said sections, an impact receiver comprising a reciprocable face exposed to the liquid in one of said sections, and a restrictor controlling flow of liquid from the returning section to the sump and disposed beyond the point in said system where impacts delivered to the liquid therein are communicated to said impact receiver, whereby to maintain between the impact transmitter and the impact receiver pressure on such liquid adequate for the transmission of impact, while permitting liquid circulation through said system for the cooling thereof and the relief of excess pressure developed by said pump.

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2,227,279	Smith	Dec. 31, 1940
2,389,654	Werff	Nov. 27, 1945
2,397,174	Warren et al.	Mar. 26, 1946
2,413,380	Rush	Dec. 31, 1946
2,414,519	Greene	Jan. 21, 1947
2,420,406	Andrews et al.	May 13, 1947
2,437,821	Hughes	Mar. 16, 1948