Jan. 6, 1953 C. F. WARREN 2,624,177

HYDRAULIC IMPACT TOOL

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Fig. 4.

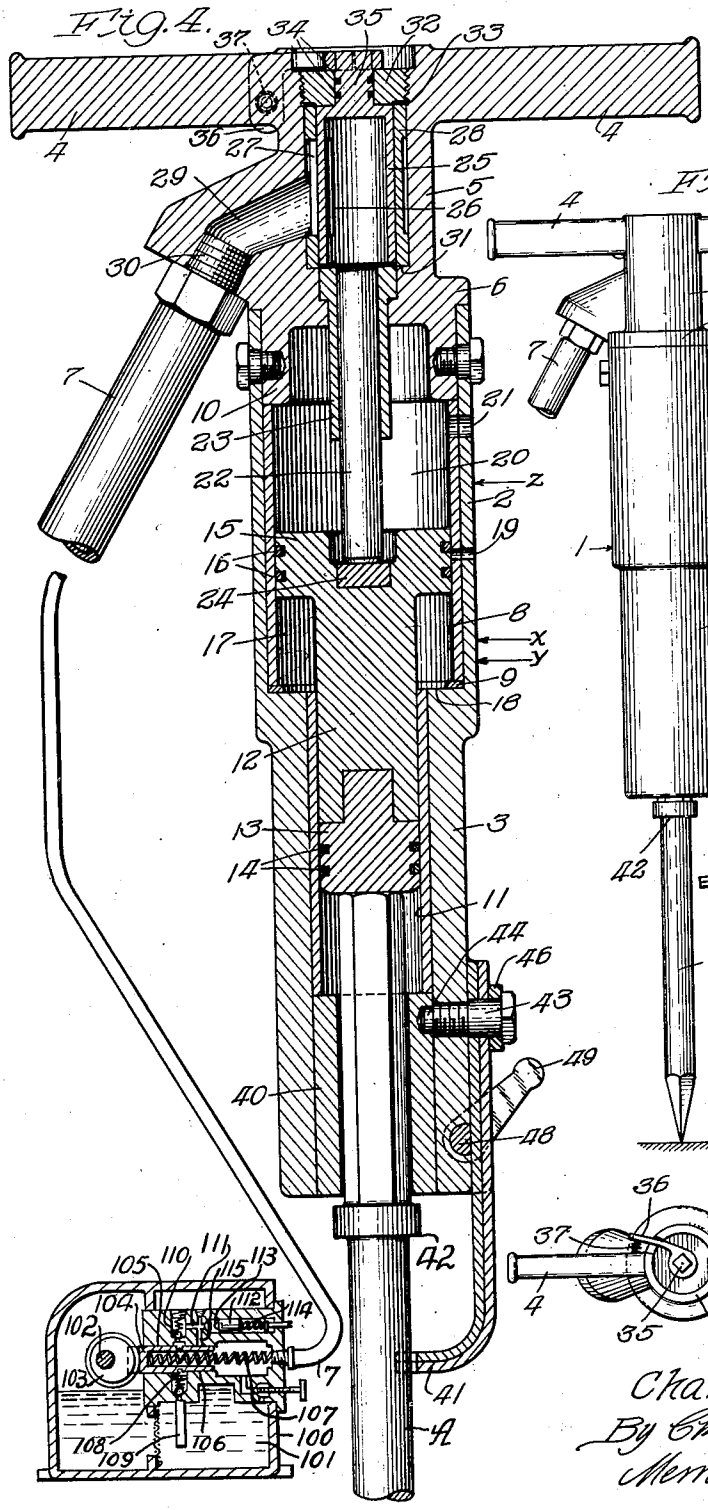

Fig. 1.

Fig. 2.

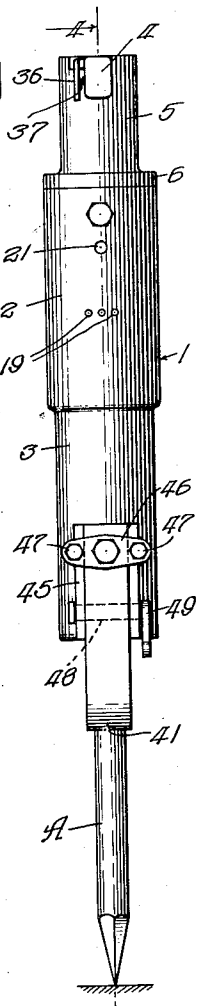

Fig. 3.

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Fig. 5.

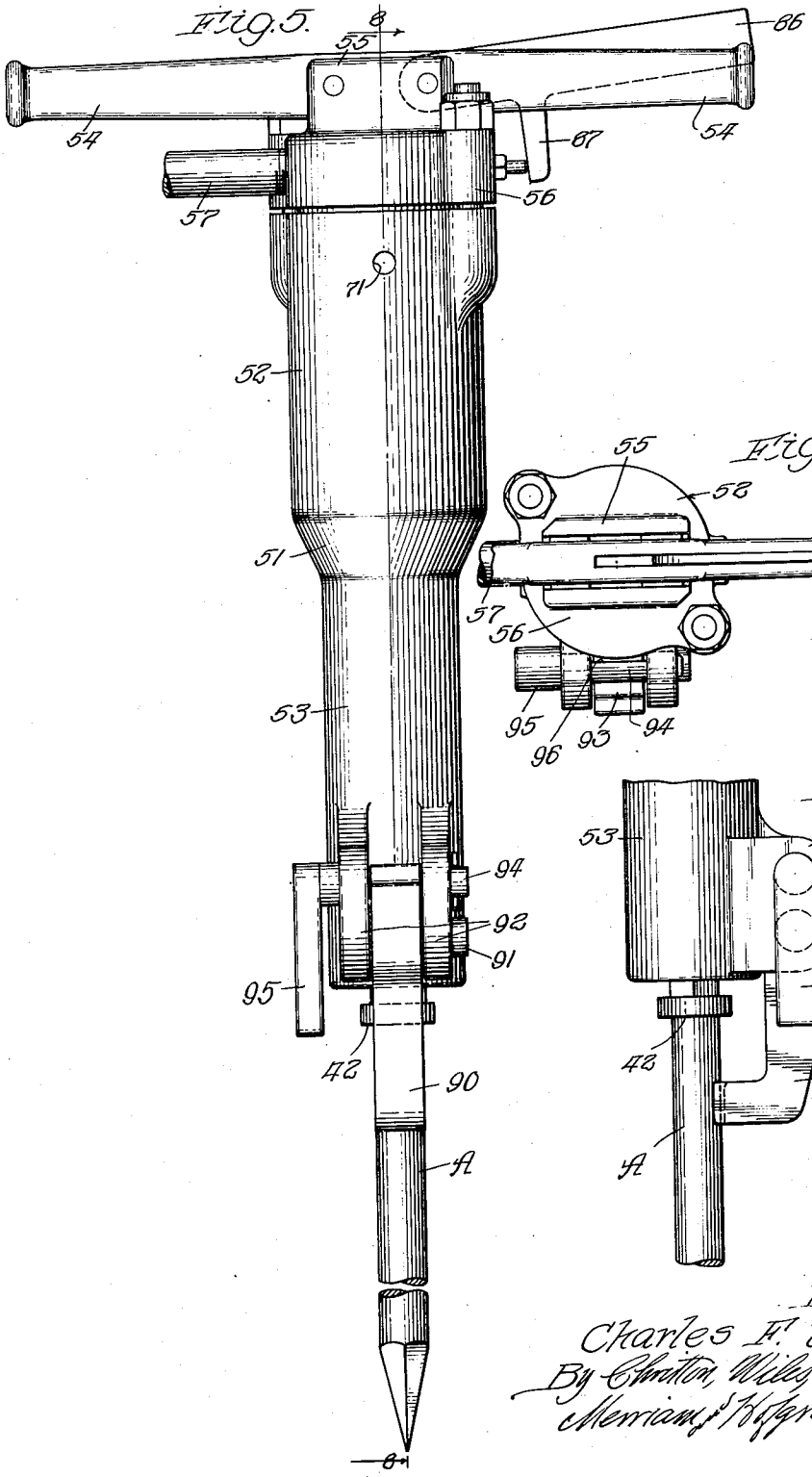

Fig. 6.

Fig. 7.

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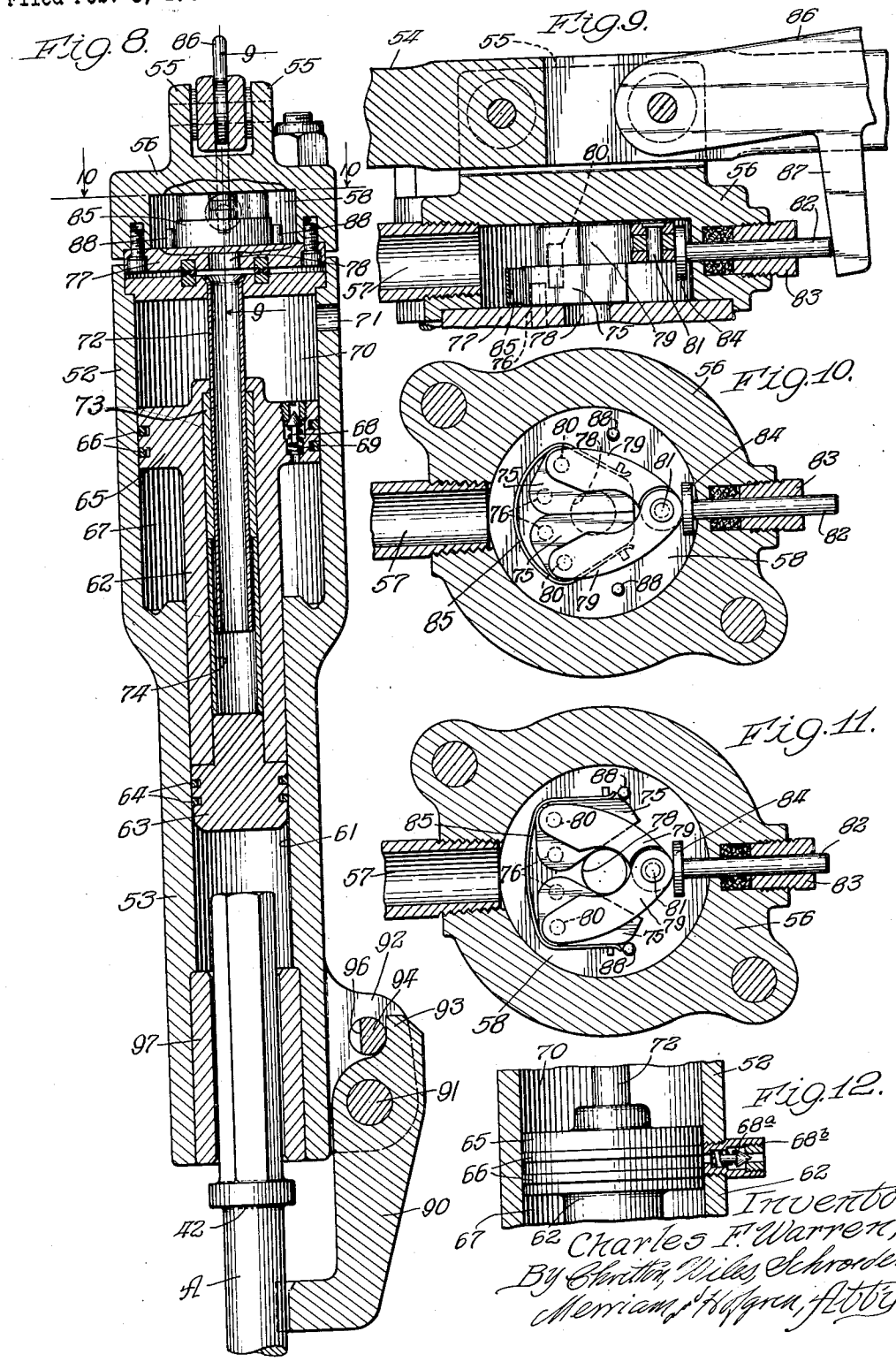

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2,624,177

UNITED STATES PATENT OFFICE

2,624,177

HYDRAULIC IMPACT TOOL

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Application February 8, 1945, Serial No. 576,767

11 Claims. (Cl. 60—54.5)

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This invention relates to a driving mechanism designed for transmitting a series of blows to percussively actuated tools, and it is particularly concerned with the type of apparatus in which the tool driving impulses are transmitted from a power driven pump through a liquid column acting against a rigid reciprocating plunger which operates as a hammer against thhe tool.

One object of the invention is to provide a new and improved impact tool for the purpose indicated.

Another object of the invention is to provide an impact tool of improved design in which an air spring or air cushion is employed to assist the return strokes of the driving plunger.

It is also an object of the invention to provide an impact tool actuated by a pre-loaded column of liquid and having a quantity of trapped air serving as a return spring which is placed initially under precompression and automatically replenished as needed during operation of the tool.

More specifically the invention includes a cylinder with a piston therein and a driving plunger smaller than the piston and rigidly extending therefrom through one end of the cylinder in air-tight relation thereto so that a quantity of air is trapped in the chamber between the piston and that end of the cylinder to serve as a cushion or air spring for assisting the return stroke of the plunger, together with hydraulic driving means extending from the other side of the piston through the other end portion of the cylinder for actuating the piston and the plunger, and means for automatically replenishing the trapped air at substantially atmospheric pressure in the event of leakage or loss of a portion thereof.

Other objects and advantages of the invention will appear from the following description taken in connection with the drawings in which:

Fig. 1 is a front elevation of an impact tool embodying this invention.

Fig. 2 is a side elevation of the same.

Fig. 3 is a top plan view of said tool.

Fig. 4 is a substantially axial vertical section taken as indicated at line 4—4 on Fig. 2 and on a larger scale, its impulse generator means being shown on a reduced scale.

Fig. 5 is a side elevation of a tool embodying a modification of the invention.

Fig. 6 is a top plan view of the same with one of the handles broken away.

Fig. 7 is a fragmentary side elevation of the lower portion of the tool illustrating the steel retainer.

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Fig. 8 is a vertical axial section taken substantially as indicated at line 8—8 on Fig. 5.

Fig. 9 is a fragmentary vertical section taken as indicated at line 9—9 on Fig 8 and on a larger scale.

Fig. 10 is a plan section taken as indicated at line 10—10 on Fig. 8 showing the fluid control valve in closed position.

Fig. 11 is a plan sectional view similar to Fig. 10 but showing the valve at open position.

Fig. 12 is a fragmentary detail section showing an alternative location of a check valve.

While there are illustrated in the drawings and will hereinafter be described in detail a preferred embodiment of the invention and certain modifications thereof, it is to be understood that the invention is not limited to the particular forms illustrated, but that on the contrary it is contemplated that various changes and rearrangements may be made by those skilled in the art without departing from the scope of the invention as defined in the appended claims.

The devices illustrating this invention are shown herein equipped with pointed steels indicated in each instance at A as of the type adapted for drilling or breaking concrete structures or pavements, and for like work, but it may be understood that the hammers and driving mechanisms of these devices may be employed for various other purposes and with other steels, each adapted to its own class of work. As shown in Fig. 1, the driving mechanism includes a casing 1 which comprises a cylinder 2 and a cylindrical guide portion 3 extending from the lower end thereof. A cross bar type of handle is shown at 4 extending from a portion 5 which connects the handle with the head 6 of the cylinder 2 and, as indicated in Fig. 4, this connecting portion 5 serves as a valve chamber for a valve controlling the operation of the reciprocating column of liquid through which power is transmitted to the tool or steel A in apparatus of this type. A fragment of the conduit through which the liquid column acts is shown at 7 and may be understood as extending from a suitable pumping device such as that shown and described in Patent No. 2,397,174, granted March 26, 1946, so as to be embodied in a system of the type disclosed in U. S. Letters Patent Re. 22,122 dated June 16, 1942. The mechanisms of said patents include means for keeping the liquid column pre-loaded at a predetermined pressure to insure that it shall act as a rigid element in transmitting rapid

reciprocation to the hammer or other tool which it operates.

As shown in Fig. 4, the cylinder 2 is provided with a liner sleeve 8 fitted between a packing washer or gasket 9 at its lower end and the depending skirt 10 of the cylinder head 6 which engages the upper end of the sleeve 8. The guide portion 3 of the casing 1 includes a guide bore provided with a liner sleeve or bushing 11 of smaller diameter than the interior of the cylinder 2 and the driving plunger 12 is fitted slidably in the sleeve 11 being provided with a hammer head 13 preferably having circumferential grooves with packing rings 14 therein. The upper end of the driving plunger 12 carries rigidly a piston 15 which may be integral with the plunger 12, if desired, and which is also circumferentially grooved to receive packing rings 16. Thus, the space or chamber 17 between the piston 15 and the lower end wall 18 of the cylinder 2 is substantiially air-tight, and the air trapped therein is adapted to serve as a cushion or spring for returning the plunger 12 upwardly after each downward driving stroke thereof. Eventually, however, the repeated compression of the air in the space 17 will result in some loss or leakage past the packing rings 14 or the rings 16, and to provide for the constant replacement of this loss the cylinder 2 is formed with an air admission port 19 which is positioned to be uncovered by the piston 15 at the upper limit of its normal stroke so that momentarily the space 17 is placed in communication with the outer atmosphere, whereby any deficiency of air in the lower end of the cylinder will be supplied by atmospheric air entering port 19 to be trapped beneath the piston 15 as the piston moves downwardly in its next power stroke. The opposite end of the cylinder is also in communication with the outer atmosphere through a relief port 21 to avoid compression of the air in the space 20 to such an extent as to retard or impair the operation of the plunger 12.

The plunger 12 is actuated by means of the hydraulically operated piston 22 which is shown in the form of a rod considerably smaller in diameter than the air piston 15. The piston 22 fits snugly and slidably in an elongated bushing 23 secured in the cylinder head 6 and depending therefrom into the cylinder 2. At its lower end the piston 22 impinges upon a slug 24 of hardened steel pressed into the piston 15 so that the reciprocation of the piston 22 is transmitted directly to the plunger 12, and although the reciprocations of the liquid column acting through the conduit 7 are quite rapid, the pre-loading of the column, as explained in said Patent 2,397,174, and Letters Patent Re. 22,122 insures that contact between the piston 22 and the plunger 12 will be maintained throughout the driving and return strokes of the plunger; this precompression of the liquid in the system results in a precompression of the air in the chamber 17, sufficient to force the piston 15 approximately to the position indicated at x on Fig. 4. During its working stroke the piston will travel slightly farther, to the position denoted at y, and the return stroke will carry it upward to the point marked z, at which the air inlet port 19 is uncovered by the piston.

The fluid controlling valve is in the form of a hollow cylinder 25 having a single oblong port 26 adapted to be registered with a like port 27 of a bushing 28 which is secured fixedly in the cylindrical bore of the connecting portion 5 between the cylinder head 6 and the handle 4. The bushing 28 is so positioned that its port 27 provides communication with the inlet passage 29 into which the conduit 7 is coupled by its threaded terminal 30. The lower end of the bushing 28 rests upon a shoulder 31 of the valve chamber and the bushing is secured in place by a threaded gland 32 clamped against its upper end with suitable packing 33 interposed. The valve member 25 is formed with a central stem 35 extending through a bore in the gland 32 and provided with suitable packing rings 34 to render it fluid-tight. The upper end of the stem 35 is squared, as seen in Fig. 3, and carries an operating lever 36 which is held normally in valve closing position by means of a spring 37, but which is disposed where it is easily accessible to the thumb of the operator's right hand while grasping the handle 4 so that operation of the tool itself is under the control of the operator at all times. When the handle 36 is swung to position for registering the port 26 with the port 27 the reciprocations of the fluid column in the conduit 7 are transmitted to the piston 22, it being understood that the passage 29 and the space within the hollow valve member 25 are already filled with liquid constituting an extension of the conduit in the column 7. The movements of the column originating in the pumping device, hereinafter described, produce rapid reciprocation of the piston 22 and corresponding movement of the plunger 12 with its hammer head 13 whereby rapidly repeated impacts are delivered to the upper end of the steel A while its lower end is held in contact with the material to be worked upon.

The shank of the steel A is guided somewhat loosely in a bushing 40 secured in the lower end of the guide 3 and when the tool is lifted away from the work the steel is prevented from falling out of the bushing 40 by means of a retainer 41 which engages a shoulder 42 formed on the steel A. The retainer 41 is shown as composed of a pair of spring arms with their upper end portions secured in position by a screw 43 engaged in the wall of the guide portion 3 of the casing and having a reduced inner end portion 44 which serves to anchor the bushing 40 therein. The spring members are disposed between parallel flanges 45 projecting from the side of the guide cylinder 3 and additional securement is provided in the form of a cleat 46 which extends under the head of the screw 43 and is clamped against the retainer springs by screws 47. The lower ends of the springs are bent toward the steel A and may be arcuately notched to fit around the body of the tool at one side to insure engagement with the shoulder 42 when the steel A is lowered out of operative engagement with the hammer head 13. At operative position the retainer 41 rests against the flat side of a cam member 48 journaled in the guide cylinder 3 and to release the steel A it is only necessary to rotate the cam through a limited angle by means of its lever arm 49 swinging the latter to the position illustrated in Fig. 1 and thus bringing the lower end of the retainer 41 out of the path of the shoulder 42. The pumping or impulse generating device more particularly shown in said Patent 2,397,174 comprises a casing 100 providing in a floor portion a sump 101 for a liquid in which the hydraulic column is constituted. The power drive shaft 102 carries a cam 103 which reciprocates the differentially diametered piston 104 in cylinder 105 and cylinder 106. The piston is urged toward

the cam by a heavy compression spring 107. The pipe 7 which carries the hydraulic column from the impulse generating device to the tool communicates with cylinder 106.

Adjacent the shoulder 108 which provides a working face for piston 104 is an annular channel with which communicates the check valve-controlled intake pipe 109 from the sump. This piston supplies makeup liquid to replenish system losses. The makeup liquid displaced by the piston face 108 passes check valve 110 into conduit 111 to displace a spring-loaded piston valve 112 to permit excess liquid to escape under pressure through port 113 back to the sump. The compression of spring 114 is adjustable to predetermine the pressure at which makeup liquid will be admitted to duct 115 into cylinder 106 behind the smaller end of piston 104 in the advanced position of the latter.

The modified structure shown in Figs. 5 to 11 operates on the same principles as that already described, but differs in detail therefrom. The casing 51 includes a cylinder 52 and a cylindrical guide portion 53, together with a cross bar handle 54 secured between lugs 55 which project from the cylinder head 56. The actuating column of liquid is enclosed in a conduit 57 shown entering the cylinder head 56 at one side and communicating with a valve chamber 58 which is formed in the cylinder head. The shank of the steel A projects into the guideway 61 in which the plunger 62 is mounted for reciprocation with a hammer head 63 at its lower end. The latter is provided with packing rings 64 and the upper end of the plunger 62 carries the piston 65 having packing rings 66 so that the air space 67 between the piston 65 and the lower end of the cylinder 62 will be substantially air-tight. The piston 65 is shown provided with a check valve 68 normally seated by spring 69 but adapted to open toward the space 67 for admitting air thereto so as to replace any loss or leakage of air and maintain a sufficient quantity therein to serve as a pneumatic spring or cushion to assist in the return of the plunger 62 after each of the driving strokes. The space 70 above the piston 65 in the cylinder 52 is provided with a relatively large port 71 which affords constant communication with the atmosphere and maintains a supply of air from which the air in the space 67 may be replenished through the check valve 68 during the return stroke of the plunger 62.

Instead of a metallic piston like that of the structure already described the present form, as shown in Fig. 8, includes a tube 72 communicating with the valve chamber 58 at its upper end and at its lower end telescopically engaged in a bushing 73 set into the piston 65. The bore in the piston 65 which accommodates the bushing 73 extends through the plunger 62, the reduced end of the hammer 63 being secured in the lower end of said bore. The bushing 73 is made long enough to insure a substantially fluid-tight slidable connection with the tube 72 and a spacer sleeve 74 is disposed between the lower end of the bushing 73 and the reduced end of the hammer head 63, said sleeve 74 having a slightly larger bore than the bushing 73. This insures easy working clearance for reciprocation of the plunger 62 in response to reciprocation of the column of liquid extending through the tube 72 and sleeve 74 into contact with the upper or inner end of the hammer head 63. Thus, when the valve in the valve chamber 58 is open the movements of the column of liquid in the conduit 57 actuate the plunger 62 and deliver rapidly repeated hammer blows against the upper end of the steel A.

The valve in the chamber 58 consists of twin gate members 75, 75 attached by pivots 76 to the upper face of a plate 77 having a central port 78 therein which registers with the passage in the tube 72. A pair of links 79 are connected respectively to the valve members 75 by pivots 80 and the opposite ends of said links are connected together by a pivot 81 so that they form a toggle. A plunger 82 mounted in a guide bushing 83 is arranged with its head 84 in contact with the connected ends of the links 79 so that, as seen in Fig. 11, inward movement of the plunger 82 swings the valve gates 75 to open position at which they uncover the port 78 thus placing the column of fluid from the tube 72 in operative communication with the column in the conduit 57 so that movements of the latter will be transmitted to the plunger 62 and its hammer head 63. A bent spring member 85 embracing the valve members 75 urges them yieldingly to closed position and serves to close them whenever pressure on the outer end of the plunger 82 is relieved. For opening the valve such pressure is applied by means of a hand lever 86 pivotally mounted in a slot in one end of the handle 54 and having a depending arm 87 which engages the end of the plunger 82. The opening movement of the gates or valve members 75 is limited by stop pins 88 upstanding from the plate 77.

The steel retainer for holding the tool member A in position is shown in Fig. 8 as a dog 90 pivoted at 91 between lugs 92 formed on the side of the guide cylinder 53. The tail portion 93 of the dog 90 is shown engaging the concentric portion of the cam 94 which is also pivoted in the lugs 92 but by swinging the lever arm 95 of the cam its flat portion 96 may be brought opposite the tail 93 of the dog 90 permitting the latter to be swung clear of the shoulder 42 on the steel A so that the steel may be removed from the guide bushing 97 of the guide cylinder 53.

As shown in Fig. 12 instead of mounting the check valve 68 in the piston 65, the check valve 68^a may be provided in a fitting 68^b secured in the side wall of the cylinder 52 and affording access to the space 67 below the piston 65. This arrangement will render the check valve somewhat more accessible if it should require cleaning or other servicing.

It will be understood that when an impact tool of either form herein described is employed in a hydraulic impact transmitting system of said Letters Patent Re. 22,122 and with a pump unit like that, above described and shown more particularly in Patent 2,397,174, the pre-loading of the liquid column which is maintained by the pump unit will result in a pre-compression of the air which serves as a pneumatic spring in the impact tool. Thus, the automatic replenishment of this air during the return strokes of the impact plunger, as already described, insures that a substantially constant quantity of air will be subjected to pre-compression by the liquid column acting through the piston of the tool and that uniform behavior of the tool will be thus insured.

I claim as my invention:

1. In a high speed reciprocable fluid-operated tool, a first cylinder, a first piston therein, a tool driving plunger connected with the piston

and extending from one end of the piston through one end of the cylinder in bearing relation to the cylinder, whereby air trapped between the end of the first cylinder and the first piston provides a pneumatic spring for returning the plunger and the first piston from their driving stroke, and hydraulic driving means for said first piston comprising a second cylinder and a second displacement piston of materially smaller cross section than the first piston and hydraulic impulse connections to said second cylinder; said second piston having means connecting it with the first piston, said means having a portion of materially smaller cross sectional area than the first piston and extending through the end of the first cylinder, the space between the first piston and the end of the first cylinder about said means being in open communication with the atmosphere, said first cylinder having an opening of sufficient capacity so that air trapped behind the first piston can escape without substantial obstruction, thereby permitting the free piston return by the trapped air constituting said pneumatic spring.

2. The device of claim 1 in further combination with means for automatically replacing leakage of air from the space about said piston connecting means between said first piston and first cylinder for maintaining in such space a sufficient volume of air to serve effectively as a pneumatic spring.

3. The device of claim 2 in which the means for automatically replacing air leakage comprises a port with which said first cylinder is provided in its side wall in a position to be uncovered by said first piston as said first piston approaches its extreme retracted position.

4. In a fluid operated tool, a cylinder, a piston therein, a tool driving plunger rigid with the piston and extending from one end of the cylinder in substantially air-tight relation thereto, whereby the air in the space between said end of the cylinder and the piston provides a pneumatic spring for returning the plunger from its driving stroke, means automatically replacing leakage of air from said space, a second piston of smaller diameter than the first extending slidably through the other end of the cylinder in fluid-tight relation thereto, a hydraulic pressure chamber surmounting said end of the cylinder, one end of said smaller piston being exposed to the pressure in said chamber and the other end engaging the first piston, the other end of the cylinder having a port communicating with the atmosphere and of sufficient capacity to pass air freely from about the smaller piston, whereby to facilitate the rapid reciprocation of said piston and plunger subject alternately to pressure in said chamber and to said pneumatic spring.

5. In a fluid operated tool, a cylinder, a piston therein, a tool driving plunger rigid with the piston and extending from one end of the cylinder in substantially air-tight relation thereto, whereby the air in the space between said end of the cylinder and the piston provides a pneumatic spring for returning the plunger from its driving stroke, a second piston of smaller diameter than the first extending slidably through the other end of the cylinder in fluid-tight relation thereto, a hydraulic pressure chamber surmounting said end of the cylinder, one end of said smaller piston being reciprocable in said pressure chamber in response to reciprocation of the fluid therein and the other end engaging the first piston, the said other end of the cylinder having a port communicating substantially directly to the atmosphere and of sufficient capacity to permit substantially unimpeded reciprocation of the piston and plunger.

6. In the combination defined in claim 5, a pair of telescoped cylindrical valve members defining said pressure chamber and having ports adapted to be registered, one of said members being fixed and the other rotatable for effecting registration of said ports, the innermost of said members constituting a chamber in which the second piston is reciprocable, and a pressure fluid supply conduit opening laterally into said chamber by way of said ports when they are registered.

7. The device of claim 6 in which the innermost member is rotatable and has an end wall with a stem extending therefrom, in further combination with a pair of handle bars extending from opposite sides of the pressure chamber, and an operating lever for said inner valve member attached to said stem and extending alongside one of said handle bars.

8. In a fluid operated tool, a casing, a tool driving plunger and a piston both mounted for reciprocation in the casing with one end of the piston operatively engaged with the plunger, the casing including a hydraulic pressure chamber constituting a cylinder for said piston and in which the other end of the piston is exposed, a pair of sleeves defining said pressure chamber, said sleeves being telescopically engaged and having ports adapted to be registered, one of said sleeves being adjustable relatively to the other for effecting registration of said ports, a pressure fluid supply passage opening laterally into said chamber through said ports to provide force for the driving strokes of the piston and plunger, and resilient means acting thereon in the opposite direction, said piston telescoping into the inner sleeve in its return strokes.

9. In a hydraulic impact transmitting system which includes a conduit confining a rigid, reciprocable column of liquid with an impulse producing pump having a cylinder and a piston therein closing one end of said conduit and means maintaining the liquid column under a predetermined initial pressure: a fluid operated tool having a work delivering piston closing the other end of the conduit, an air compressing piston of materially greater diameter than the work delivering piston and in pressure transmitting connection therewith, a cylinder in which the latter piston reciprocates, an impact delivering plunger rigid with said air compressing piston and extending from one end of its cylinder in substantially air-tight relation thereto, whereby the air in the space between said end of the cylinder and said piston provides a pneumatic spring for returning the plunger from its impact stroke, and means automatically replacing leakage of air from said space, the end of the last mentioned cylinder behind the air compressing piston having a vent opening communicating with the atmosphere and having sufficient capacity to pass air without substantial obstruction to permit the free return of the air compressing piston in response to the reaction of said pneumatic spring.

10. In a hydraulic impact transmitting system which includes a conduit confining a rigid, reciprocable column of liquid with an impulse producing pump having a cylinder and a piston therein closing one end of said conduit and means maintaining the liquid column under a predetermined initial pre-loading pressure: a fluid op-

erated tool comprising a work delivering piston closing the other end of the conduit, an air compressing piston of materially greater diameter than the work delivering piston and in pressure transmitting connection therewith, a cylinder in which the latter piston reciprocates, an impact delivering plunger rigid with said air compressing piston and of smaller diameter and extending from one end of said last-mentioned cylinder in substantially air-tight relation thereto, the initial pre-loading of the liquid column placing the air under pre-compression in the space between said end of said cylinder and the piston therein, providing resilient means for returning the plunger from its impact stroke, and said last mentioned cylinder having a port comprising means automatically exposing said space to atmospheric pressure during the return strokes of the plunger for replacing leakage of air from said space, the end of the last mentioned cylinder behind the air compressing piston having a vent opening communicating with the atmosphere and having sufficient capacity to pass air without substantial obstruction to permit the free return of the air compressing piston in response to the reaction of said pneumatic spring.

11. In a hydraulic impact transmitting system which includes a conduit confining a rigid, reciprocable column of liquid with an impulse producing pump having a cylinder and a piston therein closing one end of said conduit and means maintaining the liquid column under a predetermined initial pre-loading pressure: a fluid operated tool comprising a work delivering piston closing the other end of the conduit, an air compressing piston of materially greater diameter than the work delivering piston and in pressure transmitting connection therewith, a cylinder in which the latter piston reciprocates, an impact delivering plunger rigid with said air compressing piston and of smaller diameter and extending from one end of said last-mentioned cylinder in substantially air-tight relation thereto, the initial pre-loading of the liquid column placing the air under pre-compression in the space between said end of said cylinder and the piston therein, providing resilient means for returning the plunger from its impact stroke, said last mentioned cylinder having a port through which air is admitted to said space during the return stroke of the plunger to replace leakage and maintain a uniform quantity of air in said space subject to the pressure of the liquid column, the end of the last mentioned cylinder behind the air compressing piston having a vent opening communicating with the atmosphere and having sufficient capacity to pass air without substantial obstruction to permit the free return of the air compressing piston in response to the reaction of said pneumatic spring.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
489,757	Reilly	Jan. 10, 1893
722,179	Keller	Mar. 3, 1903
872,885	Anderson	Dec. 3, 1907
1,494,030	Slater	May 13, 1924
1,771,672	Degenhardt	July 29, 1930
1,857,624	Degenhardt	May 10, 1932
1,938,860	Renfer	Dec. 12, 1933
1,969,798	Hultquist	Aug. 14, 1934
2,168,806	Reilly	Aug. 8, 1939
2,260,268	Warren et al.	Oct. 21, 1941
2,397,174	Warren et al.	Mar. 26, 1946
2,429,390	Case	Oct. 21, 1947

FOREIGN PATENTS

Number	Country	Date
389,318	Great Britain	Mar. 16, 1933