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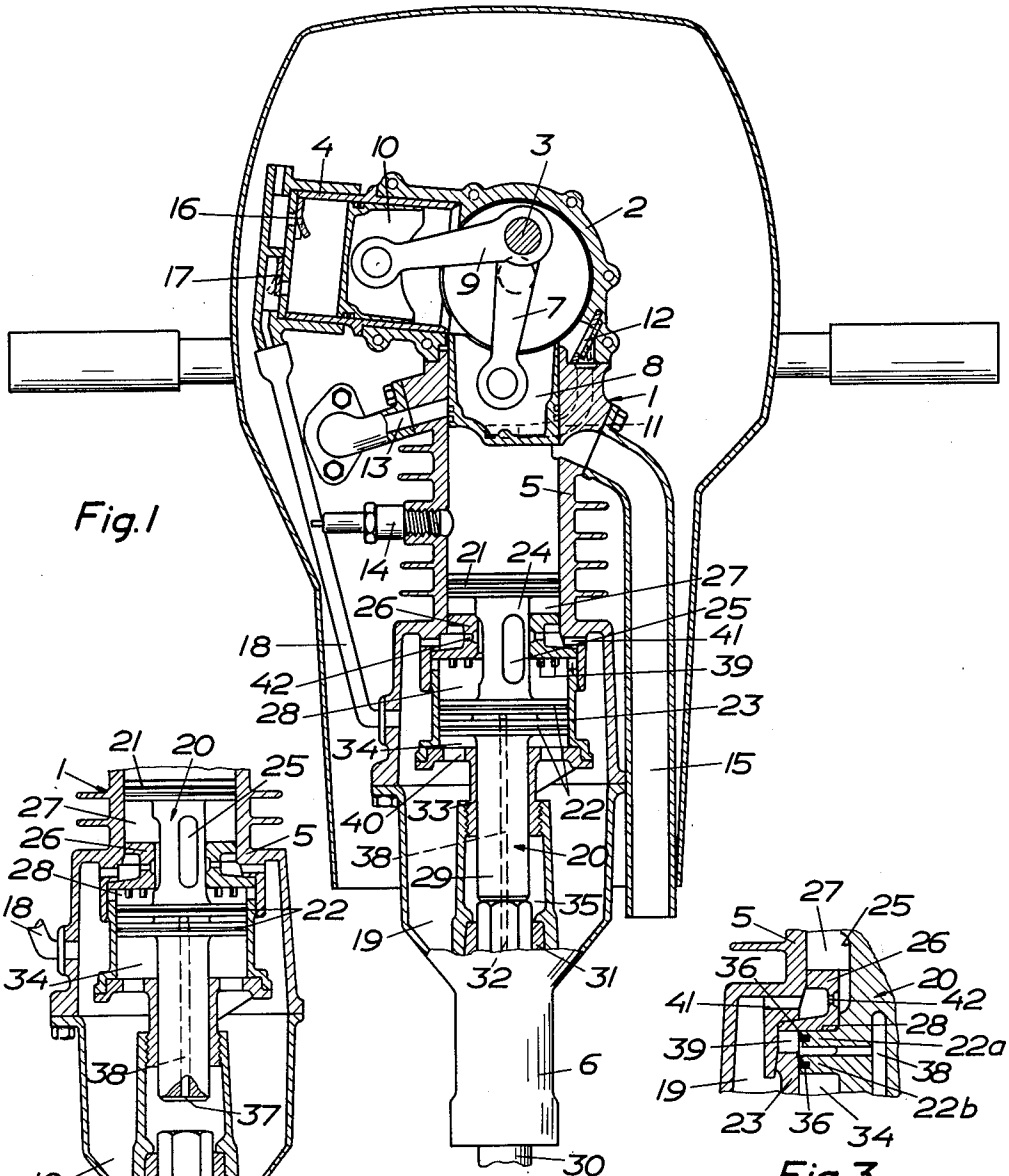


Fig. 1

Fig. 2

Fig. 3

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PERCUSSION TOOLS INCORPORATING A COMBUSTION CYLINDER FOR DRIVING A RECIPROCABLE HAMMER PISTON

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This invention relates to internal combustion percussion tools of the type having a housing, a combustion cylinder forming part of said housing, and a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to the combustion cylinder. In such tools usually a captive piston movable in the housing defines gas expansion and fluid compression in the combustion cylinder and regulates the movement of the free working hammer piston, a portion of which is actuated by combustion gases in the combustion cylinder to produce the percussion stroke. For efficient performance of the tool the cylinder clearance i.e. the minimum distance between the captive piston and the hammer piston during their reciprocation should be kept as small as possible. During the return stroke or subsequent thereto, however, the hammer piston encounters a rapidly increasing fluid pressure in the combustion cylinder caused by the captive piston producing its compression stroke. In conventional percussion tools of the above type this counterpressure results in a considerable reduction of the return stroke of the hammer piston, giving a cylinder clearance well above the value necessary for top performance of the engine and the hammer piston.

One object of the invention is to provide a percussion tool of the aforementioned character having an improved impact delivering capacity. Another object of the invention is to provide a percussion tool of the aforementioned character in which the cylinder clearance may be kept at a small value during operation of the tool to give better performance of the engine and the hammer piston. A further object of the invention is to provide a percussion tool of the aforementioned character having improved means for venting off pressure fluid in connection with the reciprocation of the hammer piston for purposes such as cleansing the drill hole when the percussion tool is used for drilling. A still further object of the invention is to provide in a percussion tool of the abovementioned character a free working hammer piston with improved impact delivering capacity and a long operable life.

The above and other objects of the invention will become obvious from the following description and from the accompanying drawing in which one embodiment of the invention is illustrated by way of example. It should be understood that these embodiments are only illustrative of the invention and that various modifications may be made within the scope of the claims without departing from the scope of the invention.

In the drawing, FIG. 1 shows a longitudinal sectional view through a percussion tool according to the invention with the hammer piston in the impact position, FIG. 2 is a fragmental sectional view corresponding to FIG. 1 but showing the hammer piston near the upper limit of its reciprocation, and FIG. 3 is an enlarged fragmental sectional view corresponding to FIG. 1 and showing a portion of the piston in the upper limit of the reciprocation of the hammer piston.

The percussion tool illustrated in the drawing comprises a housing 1 incorporating a crank case 2 in which a crank shaft 3 is journalled for rotation. A laterally extending compressor cylinder 4 is carried by the crank case 2, which latter is mounted on a combustion or motor

cylinder 5 closed at its downward end by a lower casing 6. A connecting rod 7 is journalled on the crank pin of the crank shaft 3 and connected to the piston pin of the captive motor piston 8 which is reciprocably arranged in the combustion cylinder 5. Another connecting rod 9 journalled adjacent to the connecting rod 7 on the crank shaft 3 is connected to the piston pin of a compressor piston 10 reciprocable in the compressor cylinder 4. The capative piston 8 controls in conventional manner ports in the combustion cylinder 5 through which scavenging air and fuel is supplied to the combustion cylinder 5 through opposed passages 11 via check valves 12 from the crank case 2. Through a passage 13, which is controlled by the captive piston 8, scavenging air mixed with fuel is drawn into the crank case 2 and compressed therein by the combined motion of the motor and compressor pistons 8, 10. After having been compressed in the combustion cylinder 5 the air-fuel mixture is ignited by means of a spark plug 14 and the combustion products are after expansion subsequently exhausted through an exhaust manifold 15 uncovered by the captive piston 8.

The compressor piston 10 draws air through an opening controlled by a valve 16 into the compressor cylinder 4, compresses the air contained therein and delivers it over a valve 17 through a conduit 18 to a chamber 19 in the housing 1. The chamber 19 forms a pressure receiver or source in the lower casing 6 and the lower portion of the cylinder 5.

A free working hammer piston 20 of tandem piston type, having an upper piston head 21 and a lower piston head 22, is free to reciprocate with its upper piston head 21 tightly and slidingly fitted in the combustion cylinder 5. The lower piston head 22 reciprocates tightly and slidingly in a hammer piston cylinder 23 inserted coaxially to form a downward continuation of the combustion cylinder 5. Between the tandem heads 21, 22 the hammer piston 20 is formed with a reduced cylindrical portion 24 having a number of axially extending valving grooves 25 thereon and being tightly and slidingly received in an axially divided collar portion 26. Between the piston heads 21, 22 and the collar portion 26 there are formed cylinder chambers 27 and 28, respectively. A striking rod 29 is formed at the downward end of the hammer piston 20 for striking blows on the neck of an instrument such as a drill 30 tightly received in a chuck 31 in the lower casing 6. The drill is formed with an axial passage therethrough for purposes of cleansing the drill hole. The striking rod 29 is guided in a tubular portion of a cylinder cover 33 for the hammer piston cylinder 23. A cylinder chamber 34 is formed between the cover 33 and the lower piston head 22. In the lower casing 6 between the drill chuck 31 and the tubular portion of the cylinder cover 33 there is formed a chamber 35 for receiving the presure fluid intended for cleansing the drill hole.

The lower piston head 22 is preferably formed by two spaced apart flanges 22*a*, 22*b*, FIG. 3, each carrying at least one circumferential seal member 36 tightening against the hammer piston cylinder 23. A vent opening 37, FIG. 2, is provided centrally on the free end of the striking rod 29 and is connected by means of an internal passage 38 in the hammer piston 20 to the space between the two flanges 22*a*, 22*b*. Adjacent the collar portion 26 there are provided a number of recesses 39 in the hammer piston cylinder 23 which are arranged in order to lead fluid from the cylinder chamber 28 past the upper of the seal members 36 to the space between the flanges 22*a*, 22*b* at the end of the return stroke of the hammer piston 20. The opposed faces of the lower piston head 22 may be of about equal area.

Perforations 40 are provided in the cylinder cover 33 by which a permanent communication between the pressure source 19 and the cylinder chamber 34 below the lower piston head 22 is established. Via passages 41 the pressure source 19 is also connected to radial openings 42 centrally in the collar portion 26, the openings 42 coacting with the valving grooves 25 for feeding pressure fluid to the cylinder chambers 27 and 28.

During operation of the percussion tool the captive piston 8 is reciprocated in well known manner as a result of the explosions in the combustion cylinder 5 simultaneously driving the compression piston 10 for loading the pressure source 19 with pressure fluid. During the impact stroke preceding the position of the hammer piston shown in FIG. 1, the hammer piston 20 will be driven downward by the combustion pressure in the cylinder 5. The downward movement of the hammer piston 20 is counteracted by an upward thrust produced by pressure fluid in the cylinder chamber 27 below the piston head 21 supplied thereto from the pressure source 19 via the passages 41, the radial openings 42 and the valving grooves 25. The pressure fluid simultaneously producing an upward thrust on the piston head 22 in the cylinder chamber 34 is more or less completely counteracted by pressure fluid fed from the source 19 through the openings 42 and valving grooves 25 to act on the upper side of the piston head 22 in the cylinder chamber 28. From the position in FIG. 1 the hammer piston 20 produces its return stroke as a result of the upward thrust thereon produced by the pressure fluid acting in the cylinder chamber 27. As soon as the hammer piston 20 during its return stroke reaches the position of FIG. 2, the valving grooves 25 through cooperation with the collar portion 26 cut off the connection between the pressure source 19 and the cylinder chamber 28. During continued upward movement of the hammer piston 21 the pressure fluid trapped in the cylinder portion 28 receives an additional compression until the upper seal member 36 is bypassed by the recesses 39 in the cylinder 23, whereupon the cylinder chamber 28 is vented via the recesses 39, the space between the piston flanges 22*a*, 22*b*, the passage 38, the vent opening 37, the receiving chamber 35 and on through the passage 32 in the drill 30 to flush the drill hole. With the venting completed the hammer piston 20 reaches its upper limit, FIG. 3 in which position the cylinder clearance between the piston head 21 of the hammer piston 20 and the captive piston 8 has a minimum value and the fluid or combustible mixture in the cylinder 5 has reached its maximum compression. As a result of the venting of the cylinder chamber 28 the pressure fluid producing an upward thrust on the hammer piston 20 in the cylinder chamber 34 is no longer counteracted, and thus actuates the hammer piston 20 by an upward thrust during the transition from the return stroke to the percussion stroke. This thrust is additional to the upward thrust produced on the piston head 21 in the cylinder chamber 27 and overcomes efficiently the tendency of the compressed fluid or combustible mixture in the cylinder 5 to cause during said transition a reduction of the return stroke of the hammer piston 20, i.e. undesired increase of the cylinder clearance. During the pressure peak in the combustion chamber 5 after ignition the hammer piston 20 is thrown downwardly to begin with against the added action of the upward thrusts produced in the cylinder chambers 27 and 34. Shortly thereafter, however, as soon as the valving grooves 25 slide downward past the position of FIG. 2, pressure fluid from the pressure fluid source 19 is again admitted to the cylinder chamber 28. This causes immediately a more or less full balancing of the upward thrust on the piston head 22 through a downward thrust thereon produced by the pressure fluid acting in the cylinder chamber 28. After impact the described cycle of operation is repeated.

In case the drill 30 is removed from the chuck 31 the hammer piston 20 is prevented from striking against the collar portion 26 and the cylinder cover 33 by means of pressure fluid trapped and compressed under the piston head 21. Such trapping is produced by interaction between the valving grooves 25 and the collar portion 26 near the lower limit of reciprocation of the hammer piston 20.

The embodiment of the invention above described and illustrated in the drawings should only be considered as an example and the invention may be modified in several different ways within the scope of the following claims.

What I claim is:

1. In an internal combustion percussion tool, a housing, a combustion cylinder forming part of said housing, a captive piston in said housing reciprocable to define gas expansion and fluid compression in said combustion cylinder, a free working hammer piston in said housing reciprocable to define gas expansion and fluid compression in said combustion cylinder, a free working hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a portion of said hammer piston being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a cylinder chamber in said housing between said hammer piston and said housing for actuating the hammer piston by an upward thrust thereon to produce the return stroke, a pressure fluid source, means for feeding pressure fluid from said source to said cylinder chamber, means separate from said cylinder chamber for giving said hammer piston an additional upward thrust during its reciprocation, and means for substantially reducing or eliminating said additional upward thrust during the percussion stroke and the return stroke except during the transition of the hammer piston from the return stroke to the percussion stroke to counteract during said transition the pressure in said combustion chamber caused by said fluid compression.

2. In an internal combustion percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a portion of said hammer piston being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a first cylinder chamber in said housing between said hammer piston and said housing for actuating the hammer piston by an upward thrust thereon to produce the return stroke, a second cylinder chamber in said housing between said hammer piston and said housing for giving said hammer piston an additional upward thrust during its reciprocation, a pressure fluid source, means for feeding pressure fluid from said source to said first and said second cylinder chamber, and means for substantially reducing or eliminating said additional upward thrust during the percussion stroke and the return stroke except during the transition of the hammer piston from the return stroke to the percussion stroke.

3. In an internal combustion percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a portion of said hammer piston being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a first cylinder chamber in said housing between said hammer piston and said housing for actuating the hammer piston by an upward thrust thereon to produce the return stroke, a second cylinder chamber in said housing between said hammer piston and said housing for giving said hammer piston an additional upward thrust during its reciprocation, a pressure fluid source, means for feeding pressure fluid from said source to said first and said second cylinder

chamber, a third cylinder chamber in said housing between said hammer piston and said housing for giving said hammer piston a downward thrust for substantially reducing or eliminating said additional upward thrust, means for venting said third cylinder chamber during the transition of the hammer piston from the return stroke to the percussion stroke, and means for feeding pressure fluid from said source to said third cylinder chamber during the remainder of the percussion stroke and the return stroke.

4. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said tool reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a first piston head on said hammer piston, a portion of said first piston head actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a second piston head on said hammer piston having opposed faces of substantially equal area, a hammer piston cylinder in said housing forming opposed upper and lower cylinder chambers adjacent the faces of said second piston head, cylinder chamber means separate from said opposed cylinder chambers between said hammer piston and said housing for actuating the hammer piston to produce the return stroke, a pressure fluid source, means for feeding pressure fluid from said source to said separate cylinder chamber means and said opposed cylinder chambers during reciprocation of said hammer piston, and means for venting said upper cylinder chamber during the transition of the hammer piston from the return stroke to the percussion stroke.

5. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a first piston head on said hammer piston having opposed faces, the upper face of said first piston head being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a second piston head on said hammer piston having opposed faces, a hammer piston cylinder in said housing forming opposed upper and lower cylinder chambers adjacent the faces of said second piston head, a cylinder chamber separate from said opposed cylinder chambers formed in said housing adjacent the lower face of said first piston head for actuating the hammer piston to produce the return stroke, a pressure fluid source, means for feeding pressure fluid from said source to said separate and said opposed cylinder chambers during reciprocation of said hammer piston, and means for venting said upper cylinder chamber during the transition of the hammer piston from the return stroke to the percussion stroke.

6. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a first and a second piston head on said hammer piston, a portion of said first piston head actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a reduced portion on said hammer piston between said piston heads, a hammer piston cylinder in said housing forming a cylinder chamber below and adjacent said second piston head, a partition in said housing slidably surrounding said reduced portion and defining upper and lower cylinder chambers adjacent said first and said second piston head, respectively, a pressure fluid source, a connection between said source and said cylinder chamber below said second piston head, a radial passage through said partition in communication with said source, grooves on said reduced portion for connecting said radial passage to said upper and lower cylinder chambers adjacent said partition during the percussion stroke and the return stroke and for closing off said upper and lower cylinder chamber, respectively, from said source with said first and second piston head, respectively, reaching proximity of said partition, and venting means for venting said lower cylinder chamber adjacent said partition during the transition of the hammer piston from the return stroke to the percussion stroke.

7. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a portion of said hammer piston being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a piston head on said hammer piston, a hammer piston cylinder forming opposed upper and lower cylinder chambers adjacent said piston head, a pressure fluid source, means for actuating the hammer piston to produce the return stroke, spaced apart circumferential sealed portions on said piston head providing a seal between said piston head and said piston cylinder, a vent opening on said hammer piston, passage means in said hammer piston connecting the space between said sealed portions to said vent opening, a fluid inlet conduit connected to one of said cylinder chambers, means for closing said conduit and trapping fluid in said one cylinder chamber during one of the strokes of said hammer piston, and means in said housing for leading fluid from said one cylinder chamber past one of said sealed portions to the space between said sealed portions at the end of said one stroke.

8. In a percussion tool according to claim 7, said piston head being formed by two spaced apart flanges, each of them carrying one of said sealed portions.

9. In a percussion tool according to claim 7, said closing and trapping means consisting of cut-off means on said hammer piston.

10. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a portion of said hammer piston being actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, an intermediate piston head on said hammer piston, a hammer piston cylinder forming opposed upper and lower cylinder chambers adjacent said piston head, a pressure fluid source, means for actuating the hammer piston to produce the return stroke, spaced apart circumferential sealed portions on said piston head providing a seal between said piston head and said piston cylinder, a vent opening on said hammer piston, passage means in said hammer piston connecting the space between said sealed portions to said vent opening, a fluid inlet conduit connected to said upper cylinder chamber, means for closing said conduit and trapping fluid in said upper cylinder chamber during the return stroke of said hammer piston, and means in said housing and for leading fluid from said upper cylinder chamber past the upper of said sealed portions to the space between said sealed portions at the end of the return stroke.

11. In an internal combustion percussion tool having a self-contained combustion chamber and a free working hammer piston the combination which comprises a first piston head at one end of said hammer piston, a second piston head on said hammer piston intermediate thereof, a striking rod at the opposite end of said hammer piston, axially spaced apart circumferential sealing portions having substantially equal diameters and disposed on said second piston head, a vent opening on said striking rod, and passage means in said hammer piston connecting the space between said sealing portions to said vent opening.

12. A free working hammer piston according to claim 11, in which said second piston head is formed by two spaced apart flanges, each of them carrying one of said sealed portions.

13. In an internal combustion percussion tool having a self-contained combustion chamber and a free working hammer piston the combination which comprises a first piston head at one end of said hammer piston and having opposite transverse faces, a second piston head on said hammer piston having opposite transverse faces, a reduced diameter portion on said hammer piston and disposed between said piston heads, a striking rod at the opposite end of said hammer piston from said first piston head, axially spaced apart circumferential sealing portions of equal diameter and disposed on said second piston head, a vent opening through said striking rod, and passage means in said hammer piston connecting the space between said sealing portions to said vent opening.

14. In an internal combustion percussion tool having a self-contained combustion chamber, a free working hammer piston comprising a first piston head, forming one end of said hammer piston and having opposite faces, a second piston head on said hammer piston having opposite faces, a reduced portion between said piston heads, valving grooves on said reduced portion, a striking rod forming the opposite end of said hammer piston, spaced apart circumferential sealed portions on said second piston head, a vent opening on the striking rod, and passage means in said hammer piston connecting the space between said sealed portions to said vent opening.

15. In a percussion tool, a housing, a combustion cylinder forming part of said housing, a hammer piston in said housing reciprocable to perform a downward percussion stroke and an upward return stroke with respect to said combustion cylinder, a first piston head on said hammer piston, a portion of said first piston head actuated by combustion gases in said combustion cylinder to produce the percussion stroke of the hammer piston, a second piston head on said hammer piston, a hammer piston cylinder in said housing forming opposed upper and lower cylinder chambers adjacent said second piston head, cylinder chamber means separate from said opposed cylinder chambers between said hammer piston and said housing for actuating the hammer piston to produce the return stroke, a pressure fluid source, means for feeding pressure fluid from said source to said separate cylinder chamber means and said opposed cylinder chambers during reciprocation of said hammer piston, and means for venting said upper cylinder chamber during the transition of the hammer piston from the return stroke to the percussion stroke, said venting means comprising a vent radially through said second piston head.

16. In internal combustion and self-contained percussion tool apparatus of the character described having a housing including an internal combustion cylinder and a hammer piston reciprocable in said housing for performing a downward percussion stroke and an upward return stroke therein, the combination which comprises a first piston head on said hammer piston for actuation by a combustion in said combustion cylinder to produce said percussion stroke, a second piston head on said hammer piston and axially spaced from said first piston head, a hammer piston cylinder in said housing separate from said combustion cylinder and defining with said second piston head upper and lower fluid pressure chambers on opposite sides of said second piston head, a source of pressure fluid, means for intermittently feeding pressure fluid from said source into one of said fluid pressure chambers for reaction with said second piston head to urge said hammer piston through said upward return stroke, additional fluid pressure chamber means separate from both said upper and lower fluid pressure chambers and associated with said first piston head, means for feeding pressure fluid to said separate fluid pressure chamber for reaction with said first piston head during said upward return stroke of said hammer piston, vent passage means radially through said second piston head for venting said upper fluid pressure chamber during transition of said hammer piston from said return stroke to a subsequent percussion stroke, and flow passage means communicating between said upper fluid pressure chamber and said separate additional fluid pressure chamber during a predetermined portion of movement of said hammer piston for equalizing fluid pressure in said chambers.

17. In self-contained internal combustion percussion tool apparatus of the character described having a housing including a combustion cylinder and a captive air-compressing piston and a free-working hammer piston reciprocable in said cylinder upon combustion therein with said captive piston producing compressed air and said hammer piston performing a downward percussion stroke and an upward return stroke, the combination which comprises fluid pressure cylinder means in said housing for producing said upward return stroke of said hammer piston upon introduction of pressure fluid against said hammer piston, additional fluid pressure cylinder means separate from said first mentioned fluid pressure cylinder means for introducing additional pressure fluid against at least a portion of said hammer piston for producing an additional upward thrust during said upward return stroke and at a predetermined portion thereof during transition of said reciprocal movement of said hammer piston from said upward return stroke to downward percussion stroke for counteracting residual compression pressure in said combustion cylinder during said upward return stroke of said hammer piston, and pressure fluid passage means responsive to the axial position of said hammer piston at said predetermined portion of said upward return stroke and transition thereof in flow communication with said additional pressure fluid cylinder means for nullifying said additional upward thrust on said hammer piston.

18. Apparatus as defined in claim 17 in which said hammer piston includes separate piston head surfaces against which fluid pressure in the said separate pressure fluid cylinder means acts, and in which said additional upward thrust is provided by intermittent action of pressure fluid against one of said separate piston head surfaces and said nullifying of said additional upward thrust is provided by venting said pressure fluid from beneath said one piston head surface.

19. Apparatus as recited in claim 18 in which said venting of said pressure fluid and nullifying of said additional upward thrust on said hammer piston is provided by flow passages communicating between said separate pressure fluid cylinder means and movable with said hammer piston whereby said additional upward thrust on said one piston head surface is provided during only a portion of said return stroke and fluid pressure beneath said surface and above the other said piston head surface in said separate pressure fluid cylinder means is equalized during other portions of said upward return stroke of said hammer piston.

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