United States Patent

Feucht

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[54] **HYDRAULIC DRIFTER**

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[52] **U.S. Cl.** **173/78,** 173/80, 173/116, 173/121, 173/134

[51] **Int. Cl.**.....**B25d 9/00,** B25d 17/14

[58] **Field of Search**.....173/80, 78, 105, 116, 134, 173/121

[56] **References Cited**

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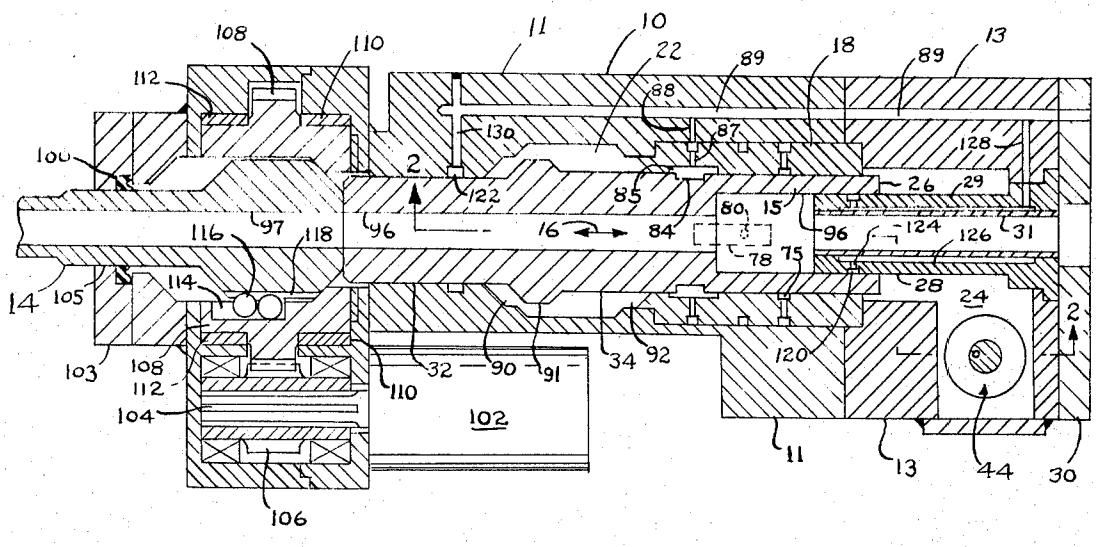
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[57] **ABSTRACT**

A hydraulically-actuated percussion drill having a hydraulic control valve arranged so that hole-cleaner air can be directed through an axial passage in the piston without interference from the hydraulic valve; the piston is annular so that its central bore acts as an air passage. Oil drainage grooves are provided at the piston-housing joints where high pressure oil might otherwise tend to escape into the air passage; air pressure is used to retard leakage of oil past the grooves. Preferably the piston is built to include a cushioner flange which moves into hydraulic snubber cavities to decelerate the piston. The hydraulic supply system is such that high pressure oil is continually washed through the snubber cavities to take away heat developed by the snubbing actions.

8 Claims, 2 Drawing Figures



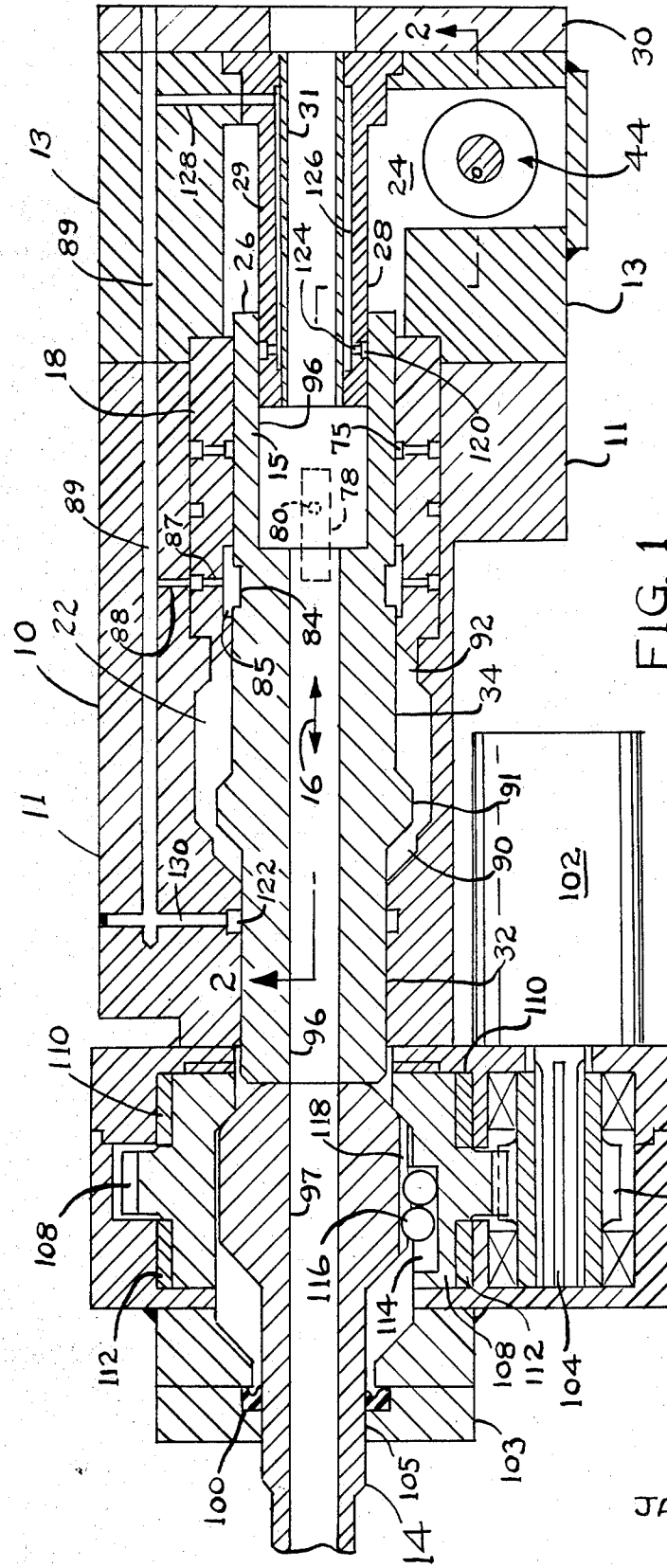


FIG. 1

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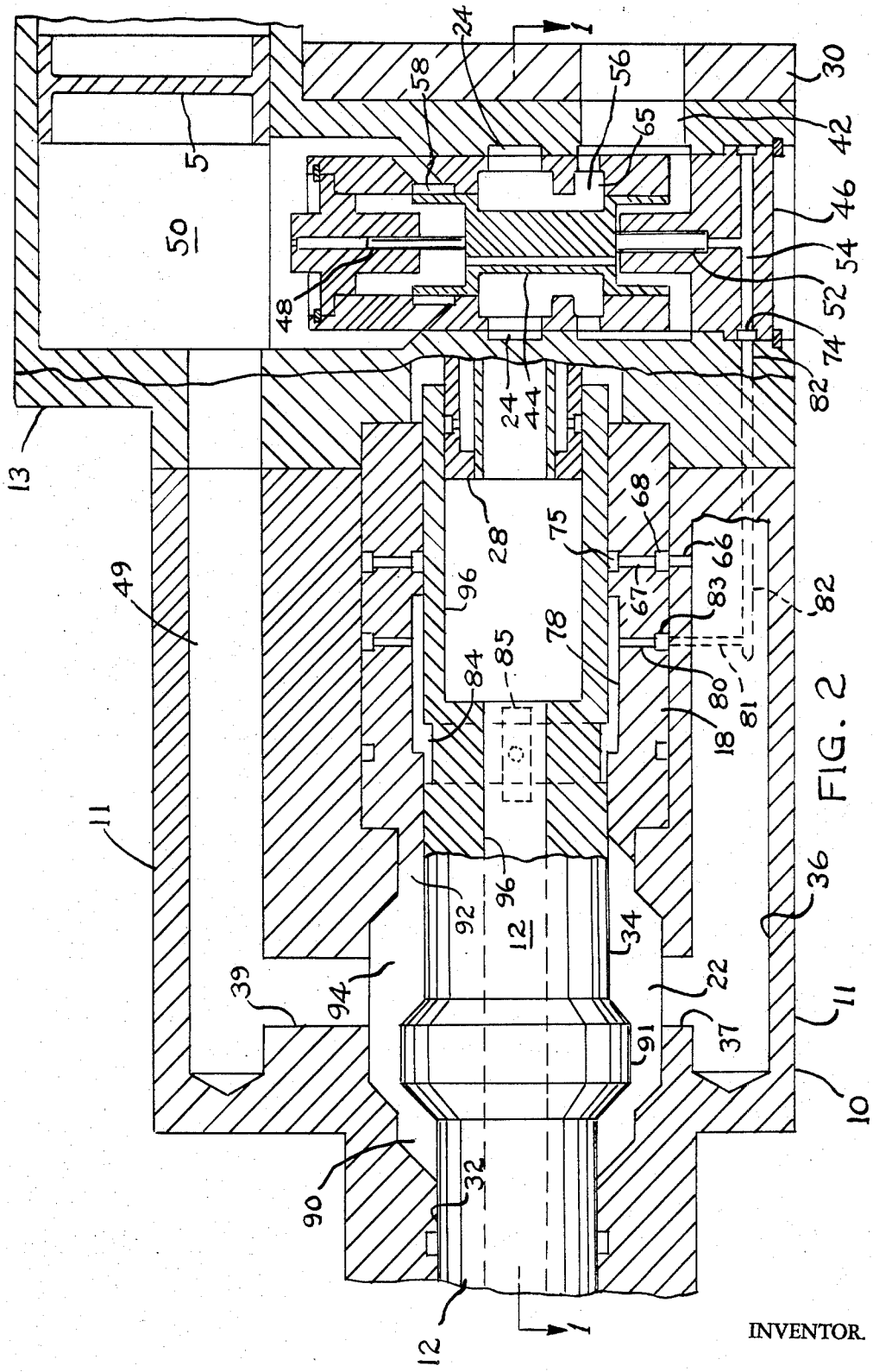


FIG. 2

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HYDRAULIC DRIFTER

THE DRAWINGS

FIG. 1 is a longitudinal sectional view taken through a percussion drill incorporating the invention.

FIG. 2 is a fragmentary sectional view taken on line 2—2 of FIG. 2.

FIG. 1 IN GREATER DETAIL

FIG. 1 shows a percussion drill having a two piece drill housing **10** which slidably confines a striker piston **12** for movement toward and away from a drill steel **14**. The general arrangement is similar to that shown in U.S. Pat. No. 3,490,549 issued to R. D. Catterson on Jan. 20, 1970. Thus, drill steel **14** is positioned in housing **10** for continuous rotary movement about its longitudinal axis, as by means of a fluid motor **102** (generally similar to motor **102** in the above mentioned patent). Piston **12** is suitably mounted within housing **10** for reciprocating motion as denoted by arrow **16**; the piston has no rotational movement. Housing **10** is shown as two block-like housing elements **11** and **13** suitably secured together, as by through bolts (not shown).

Housing **10** contains an annular insert element **18** which separates the housing into two annular hydraulic chambers **22** and **24**. In operation, chamber **22** is continually supplied with high pressure hydraulic fluid (oil), while chamber **24** is intermittently supplied with hydraulic fluid. Chamber **24** is a high work area chamber, while chamber **22** is a low work area chamber so that when chamber **24** is pressurized there is a leftward movement of piston **12** against drill steel **14**; when chamber **24** is depressurized there is a reverse rightward movement of piston **12** away from the drill steel. Such cyclic or reciprocatory movement of the piston is preferably at high velocity, for example twelve hundred to fifteen hundred cycles per minute.

Piston **12** has its right end portion **15** slidably disposed between the inner surface of fixed insert **18** and the outer surface of a two piece tubular air duct **28** which is secured in place by a cap element **30**; the aforementioned bolts (not shown) mount the cap element on housing **10** so that the outer surface of duct **28** constitutes an inner surface of hydraulic chamber **24**. The annular piston end area **26** exposed to chamber **24** constitutes the effective work area of chamber **24**.

The extreme left end portion **32** of piston **12** has a slightly smaller diameter than the main portion **34** of the piston such that hydraulic fluid in chamber **22** acts on the piston differential area (area of **34** minus area of **32**) to bias the piston rightwardly when chamber **24** is depressurized. The differential piston area is the effective work area of chamber **22**.

The various piston diameters are chosen so that chamber **24** has a relatively high effective work area, for example 1.7 square inches, while chamber **22** has a relatively low work area, for example 0.3 square inches. As previously noted, when both chambers **22** and **24** are pressurized the piston **12** is moved leftwardly against drill steel **14**, whereas when only chamber **22** is pressurized the piston is moved rightwardly away from the drill steel. The piston is shown just beginning its rightward motion.

HYDRAULIC FLUID SUPPLY

In the illustrated percussion drill hydraulic fluid for pressurizing chamber **22** is supplied through a longitudinal passage **36** (FIG. 2) drilled into valve housing members **11**, **13** and **30**. The entrance end of passage **36** is at the right face of element **30**, and is suitably threaded for connection of conventional hydraulic hoses (not shown) leading from a remote pump or other hydraulic source.

After the fluid has passed through chamber **22** it flows through a second drilled passage **49** to a cylindrical chamber **50** containing an accumulator piston **51**; the space to the right of piston **51** is gas-charged to provide accumulator pressure for maintaining hydraulic chamber **50** at a suitable value, for example 1,200 p.s.i. Hydraulic fluid intermittently flows from chamber **50** across a shuttle valve **44** into the aforementioned chamber **24** (FIG. 1). Valve **44** is so designed that in its non-illustrated position it permits fluid to flow from chamber **50** into chamber **24**; in its FIG. 2 illustrated position the valve permits fluid to be exhausted from chamber **24** to a drain opening **42**. Drain pressure is usually in the neighborhood of 30 p.s.i.

HYDRAULIC VALVE OPERATION

To intermittently or cyclically pressurize and depressurize work chamber **24** it is necessary to alternately connect said chamber to high pressure space **50** and low pressure drain line **42**. In the illustrated percussion drill this operation is accomplished by a shuttle valve **44** which is slidably positioned in a valve body **46** suitably mounted in housing element **13**. Valve **44** includes a relatively small diameter pilot piston **48** whose upper end face is continually exposed to high pressure hydraulic fluid from space **50**. Valve **44** also includes a larger diameter pilot piston **52** whose end face is intermittently exposed to high pressure hydraulic fluid in drilled chamber **54**.

As shown in FIG. 2, line **54** is depressurized so that fluid pressure on the upper end face of piston **48** is effective to move valve **44** down to its illustrated position wherein valve groove **56** spans chamber **24** and exhaust groove **65**; in this position chamber **24** exhausts to the drain opening **42**.

When both chambers **50** and **54** are pressurized the differential piston area (area of piston **52** minus area of piston **48**) cause valve **44** to be moved upwardly to a non-illustrated position wherein annular groove **56** spans chamber **24** and annular groove **58**. In such a position the valve conducts high pressure fluid from space **50** into chamber **24**.

In general, the position of valve **44** is controlled by the state of pressurization or depressurization of chamber **54**; in the usual case such pressurization-depressurization actions will be cyclic at rates of several hundred cycles per minute, timed by piston **12**. The function of valve **44** is to cyclically connect chamber **24** with alternate ones of grooves **58** and **65** so that chamber **24** may be cyclically pressurized and depressurized.

PRESSURIZATION OF CHAMBER 54

Pressurization of chamber **54** is initially achieved by trapping high pressure fluid in the fluid passage system

comprising slots 78, drilled holes 80, 81 and 82 machined groove 74, and chamber 54. High pressure fluid is initially supplied to groove 78 while piston 12 is in a rightward position wherein its annular groove 84 spans annular housing groove 75 and housing slots 78. The illustrated device uses two diametrically spaced slots 78 which connect with two drilled holes 80 and a surrounding annular groove 83. FIGS. 1 and 2 are taken at right angles to one another so that one of the slots 78 is shown in cross section in FIG. 2 and in dotted plan in FIG. 1. FIG. 2 is on a larger scale than FIG. 1 to show greater detail.

When piston 12 is displaced rightwardly from its illustrated position groove 84 interconnects slots 78 with annular groove 75. High pressure fluid can thereby fill the passage system comprising passage 36, hole 66, annular groove 68, hole 67, annular groove 75, groove 84, slots 78, holes 80, 81 and 82, groove 74 and chamber 54. This action pressurizes chamber 54.

During leftward movement of piston 12 chamber 54 remains pressurized until groove 84 registers with two diammetrically spaced slots 85 formed in the inner face of insert 18. At this time groove 84 spans slots 78 and 85 to form a path for depressurizing chamber 54. Depressurization involves reverse flow from chamber 54 through groove 74, holes 82, 81, and 80, slots 78, groove 84, slots 85, drilled holes 87 and 88, and auxiliary drain passage 89. Passage 89 may connect with main drain port 42, although such a connection is not shown.

In its illustrated position piston 12 has moved to the leftward limit of its motion and is just starting back on its rightward stroke. Groove 84 bridges across housing slots 78 and 85 so that chamber 54 is depressurized. Valve 44 is therefore in its illustrated position wherein chamber 24 is vented to drain 42. Chamber 22 is pressurized, but chamber 24 is not; therefore piston 12 is biased in a rightward direction.

As piston 12 moves rightward to a position wherein groove 84 bridges across slot 78 and groove 75 the control chamber 54 becomes pressurized to move valve 44 upwardly to open port 58 and close port 65. High pressure fluid thereby flows from space 50 through port 58 into chamber 24 to pressurize that chamber and cause a reverse leftward movement of piston 12.

PISTON SNUBBER ACTION

Above mentioned U.S. Pat. No. 3,490,549 shows a striker piston having an enlarged head or flange 134 that moves through a semi-confined mass of hydraulic fluid to cushion or snub the piston movement as the piston nears the limits of its travel, thereby minimizing cavitation effects and reducing shocks, as during overtravel when the drill steel is operating in air or against low resistances resulting from loose soil formations. In the present apparatus piston 12 is provided with a cushioner flange 91 whose diameter is slightly less than the diameters of the annular cavities 90 and 92 located at opposite ends of chamber 22. The central space area 94 of chamber 22 has a much larger diameter than flange 91 so that the flange can move relatively freely through the body of liquid until it reaches cavity 90 or 92. As the piston flange moves into either one of cavities 90 and 92 a mass of liquid is trapped within the respective cavity. The trapped liquid can escape from the cavity only by flowing past the outer edge surface of flange 91; the small clearance between the flange diameter and the cavity diameter produces a flow-throttling action that impedes the escape of the liquid, thereby slowing the piston before it actually strikes the blind end wall surface of the cavity. The snubbing action is achieved at each limit of piston movement; cavity 90 acts to decelerate the piston during its rightward movement and cavity 92 acts to decelerate the piston during its leftward movement.

The snubbing action of cavities 90 and 92 is accompanied by the production of a certain amount of heat in the trapped oil. It is therefore preferred to have a positive continual flow of oil through chamber 22 so that new oil is admitted to the chamber for every successive cycle, such that heat of snubbing is carried away with the spent liquid. In the illustrated construction work chambers 22 and 24 are in series flow relation so that the fluid must flow through chamber 22 and then through chamber 24 in a single path; chambers 22 and 24 are not in parallel flow paths. The arrangement is such that the chamber 22 displacement is entirely exhausted through the single hole 39, thus insuring a positive oil flow through chamber 22 and a positive carry off of the heat developed by the snubbing action of piston flange 91 in the snubbing chambers 90 and 92. Preferably supply hole 37 and exhaust hole 39 connect with opposite face areas of chamber 22 to further insure against stagnation in the chamber.

HOLE CLEANING

In some situations the drilling rate is improved by forcing air into the hollow drill steel which carries the drill rod and bit. The illustrated drill includes an annular piston 12 whose inner surfaces 96 form an air passage extending the length of the piston. The arrangement permits a compressed air hose (not shown) to be connected onto cap 30 so that compressed air can flow through tubular member 28 and thence through piston passage 96 to a registering passage 97 in drill steel 14.

Preferably the piston bore is itself used as the compressed air passage; i.e. there is no separate air tube extending through the piston. A piston-formed air passage can be more generously sized than can a separate air tube; consequently more air flow can be provided for a given supply pressure. Also, the striker piston can have some misalignment with respect to drill steel 14 without loss of air flow. When a separate air tube is employed special seals and clearances must be provided to compensate for the inevitable misalignments or cocking actions that occur when the striker piston bangs down on the drill steel.

In the illustrated construction the air passage is sealed by a flap type seal 100 at the work output end of the drill, and by the fit of piston 12 on the air admission tube 28. The piston is sufficiently guided at its two diameters 32 and 34 so that piston-housing misalignment is minimal at the right end of the piston.

Ordinarily drill steel 14 includes an attached hexagonal drill rod, not shown, on the order of 12 feet long. The entire drill is usually mounted on a feeder chain located in an elongated feed channel; as the drilling proceeds the drill and the drill steel advance as a unit along the feed channel in the direction of the hole being drilled. The drill rod is guided by a bushing

at the forward end of the feed channel so that at the beginning of the feed operation the drill steel is adequately guided at two widely spaced points (the drill and the bushing). However, as the feed operation proceeds the two guide points come closer together, so that any misalignments or transverse vibrations of the guide structures tend to stress or bind the drill steel. It is desirable that the drill steel have a slight wobble or looseness in the drill to relieve the binding tendencies. At the same time the drill steel must have a sealed connection with the drill housing to prevent undue leakage of hole-cleaner air. Flap seal **100** is believed sufficient to seal the pressurized air joint between drill steel **14** and housing element **103** while still allowing sufficient play of the drill steel as is necessary to prevent mechanical stress in the relatively movable component parts. Since the compressed air flows through the striker piston and drill steel rather than through a separate air tube the problems of tube-piston misalignments or tube-drill steel misalignments are avoided.

DRILL STEEL ROTATION

Drill steel rotation can be achieved through any suitable drive means, but as shown in FIG. **1**, the drive system comprises a fluid motor **102** having a splined drive shaft **104** keyed to a gear **106** which drives a second hollow gear **108**. The second gear is rotatably mounted in radial sleeve bearings **110** and **112**, and is provided with a plurality of axial grooves **114**, each of which contains two ball elements **116**. Mating grooves **118** in an enlarged diameter portion of drill steel **14** trap the ball elements, whereby the elements constitute keys or drivers for transmitting gear **108** rotation into drill steel rotation while permitting axial displacement of the drill steel by the hammer action of striker piston **12**. Ball elements **116** reduce friction effects between the gear and drill steel, while enabling the drill steel to have a desirable wobble or looseness relative to the housing.

Flap seal **100** is mounted in an annular cap plate **103** having a central hole **105** which defines a bearing for the reduced diameter shaft portion of the drill steel. The bearing is remote from the drive ball elements **116** so that the bearing does not hamper the aforementioned wobble action.

HYDRAULIC SEALS

The hydraulic pump and reservoir for supplying passage **36** with hydraulic fluid is usually of limited capacity such that leakage of hydraulic fluid is undesirable. Unless piston **12** adequately seals the hydraulic system there is a possibility that hydraulic fluid can leak from high pressure work chambers **22** and **24** into the air passage **96** or out of the housing interior along the joint between housing **10** and drill steel **14**. The illustrated drill is therefore equipped with two annular oil drainage grooves **120** and **122**.

Groove **120** is formed in the outer surface of tubular member **28** so that high pressure liquid in chamber **24** must pass into groove **120** before reaching the compressed air passage defined by surface **96**. Groove **120** communicates with a drilled hole **124** and annular groove **126** formed by the two component tube elements **29** and **31** of air tube **28**. Groove **126** in turn communicates with a drilled hole **128** leading to drain passage **89**. Groove **122** connects with passage **89** via a drilled hole **130**.

The system of grooves and passages serves to drain off high pressure liquid from chambers **22** and **24** before it can escape into the space defined by surfaces **96**. The drain back system is enhanced because the pressure in passage **96** is usually higher than the hydraulic pressure, for example 100 p.s.i. air pressure vs. 30 p.s.i. oil drain pressure. The air pressure, alone or in conjunction with O-ring seals (not shown), promotes drainage of oil back to drain **89** rather than into the compressed air system where it would be non-recoverable.

The ability of the pressurized air to promote oil drainage is due to the fact that the inner surface **96** of the piston is used as the air passage; i.e. there is no separate air tube that would isolate the pressurized air from the piston-housing joints.

PISTON RETURN ASSIST

The left end face area of piston **12** exposed to pressurized air is somewhat greater than the right end face area exposed to pressurized air. Therefore the pressurized air has a continual biasing action on the piston tending to move or return to the right. Because of this constant biasing air force it is possible to make the effective work area of chamber **22** slightly smaller than would otherwise be the case. The smaller hydraulic chamber area or displacement somewhat reduces the total hydraulic fluid requirements.

Contemplated hydraulic pressures are relatively high so that various joints between the component parts must be sealed to properly confine the high pressure fluids to the desired flow paths. Hence in practice O-ring seals should be used between the striker piston and its fixed housing and between the shuttle valve and its housing. Additional seals should be provided between housing elements **11** and **13**, and between valve body **46** and housing element **13**.

I claim:

1. A percussion drill having a housing and a striker piston-drill steel assembly disposed therein; said housing defining separate hydraulic chambers alternately pressurized, one above the other, for reciprocating the piston back and forth in the housing; said drill steel having a reduced diameter shaft portion extending through a bearing at the work output end of the housing and an enlarged impact-receiver portion loosely keyed to a surrounding drive gear within the housing, whereby the drill steel can wobble about the bearing while being rotated by the drive gear.

2. The drill of claim **1** wherein the piston and drill steel are formed with communicating air passages for hole-cleaner air, and the housing is provided with an air seal at the bearing-drill steel joint such that compressed air is prevented from leaking through the work output end of the drill.

3. A percussion drill comprising a striker piston slidably confined within a drill housing; a first low area work chamber continually pressurized with hydraulic liquid for retracting the piston, and a second high area work chamber intermittently pressurized with hydraulic liquid for advancing the piston; said piston having a passage therethrough for conducting high pressure hole-cleaner air to the hole being drilled; said housing

having annular hydraulic drain grooves at the piston-housing joints where hydraulic liquid could otherwise leak from the pressurized work chamber to the piston air passage.

4. The drill of claim 3 and further comprising means for causing the air pressure to be materially higher than the hydraulic drain pressure, whereby the air pressure prevents leakage of hydraulic liquid from the associated drain groove into the piston air passage.

5. The drill of claim 3 wherein the piston air passage comprises a relatively small diameter hole-cleaner air passage extending rearwardly from the striker end of the piston, and a relatively large diameter counterbore extending forwardly from the rear end of the piston; said housing including a fixed air admission tube extending forwardly into the counterbore to deliver air to the small diameter passage.

6. The drill of claim 5 wherein the outside diameter of the piston at its striker end is larger than the diameter of the counterbore, whereby the air pressure continually exerts a rearward bias on the piston.

7. A percussion drill comprising a striker piston slidably confined within a drill housing; a first low area work chamber continually pressurized with hydraulic liquid for moving the piston in one direction, and a second high area work chamber intermittently pressurized with hydraulic liquid for moving the piston in the other direction; said piston having an enlarged cushioner flange arranged within the first continually pressurized chamber; said first chamber comprising a central chamber space materially larger in diameter than the cushioner flange, and reduced diameter end cavity spaces only slightly larger in diameter than the cushioner flange, whereby the piston can move freely while the flange is in the central chamber space but less freely when the flange enters either end cavity.

8. The drill of claim 7 wherein the entire hydraulic supply is initially admitted to the low area work chamber, thereafter to the high area work chamber, and finally to the drain.

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