United States Patent

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[54] VARIABLE STROKE PERCUSSION TOOL
5 Claims, 6 Drawing Figs.

[52] U.S. Cl. 91/277, 91/1, 91/299
[51] Int. Cl. F01l 31/08, F01l 25/04
[50] Field of Search 91/277, 299(Cursory), 330(Cursory), 317(Cursory)

[56] References Cited
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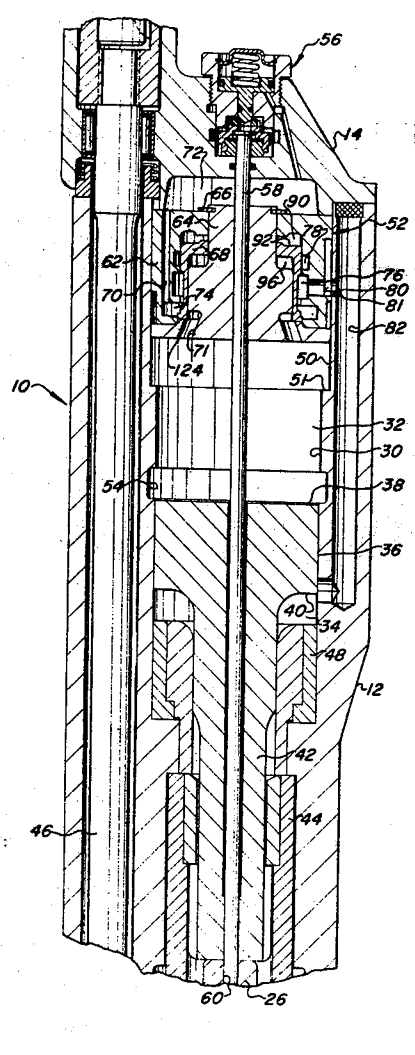
ABSTRACT: A mechanism for varying the stroke length of an expansible chamber percussion tool having a hammer piston reciprocably disposed in a cylinder comprising the expansible chamber. The mechanism comprises a rotatably mounted cam extending radially through the cylinder wall and engaged with a fluid distributing valve housing which is movably disposed in the expansible chamber and forms an abutment at one end of the cylinder. The cam mechanism is operable to be adjusted from the exterior of the tool proper while the tool is in operation whereby the distributing valve is selectively positioned to alter the stroke of the hammer piston.



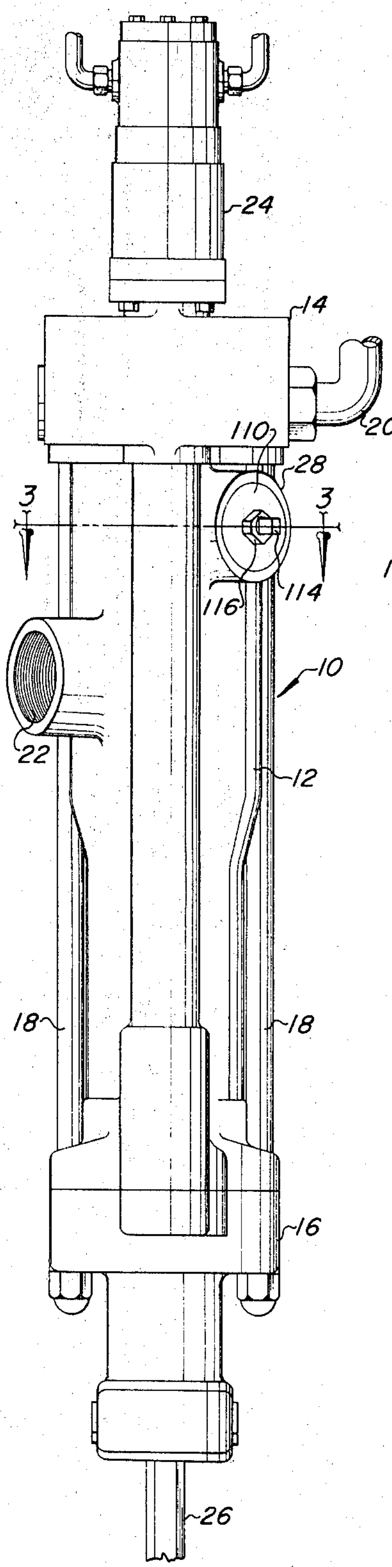


Fig 1

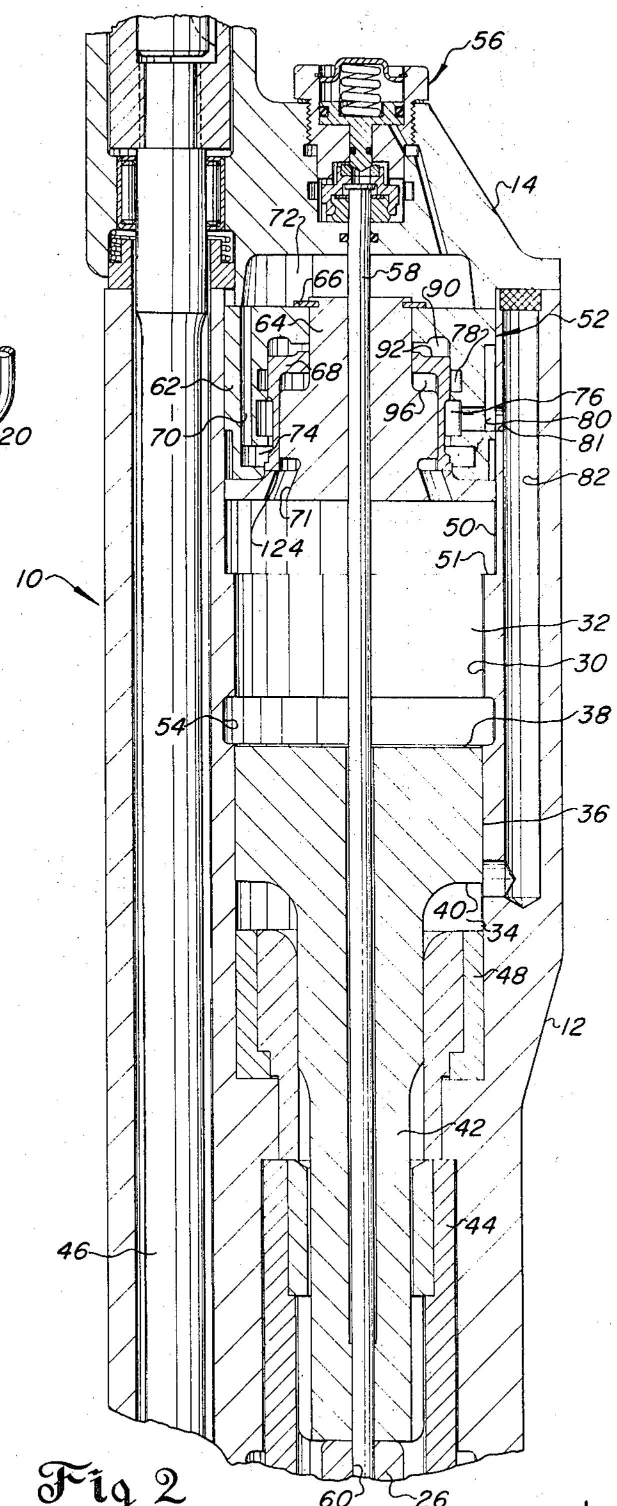


Fig 2

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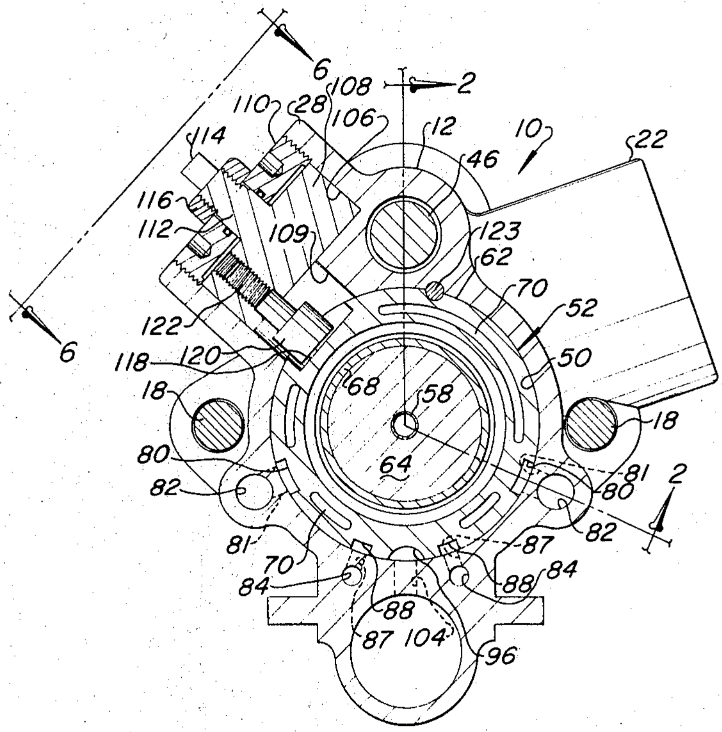

Fig 3

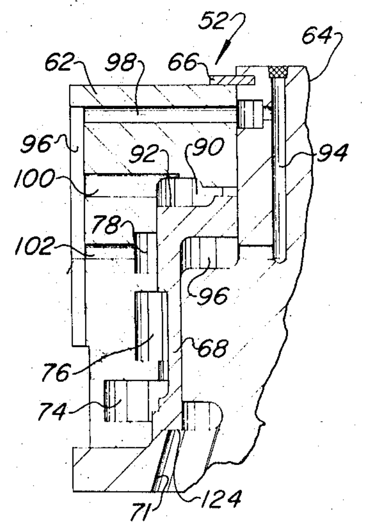

Fig 5

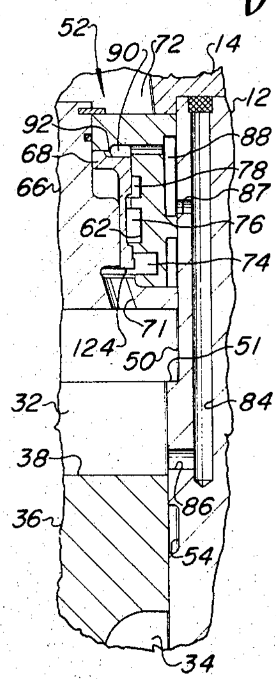

Fig 4

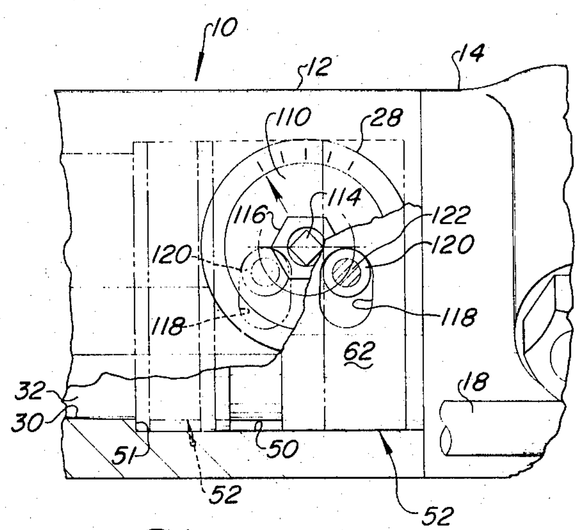

Fig 6

VARIABLE STROKE PERCUSSION TOOL

BACKGROUND OF THE INVENTION

It is known in the art of rock drills, paving breakers and other percussion tools that the optimum penetration rate of a particular rock formation or other workings is dependent on blow intensity and blow frequency delivered to the drill steel or striking member. Generally, a combination of low intensity and high frequency results in more satisfactory performance in penetrating soft material, and high blow intensity and low frequency yield better penetration in hard formations. Applications of rock drills are likely to be quite varied as to what type of rock formation is required to be drilled and often drill workings are composed of layers of rock material of different hardness whereby it is desirable to selectively alter hammer blow frequency and intensity as the drill steel encounters various materials.

In conventional fluid-operated percussion tools an effective way of changing hammer blow intensity and frequency comprises altering the stroke length of the expansible chamber hence the stroke of the hammer itself. A reduction in hammer stroke length results in reduced hammer blow intensity and an increase in hammer reciprocation rate or blow frequency. Increasing the length of stroke of the hammer accordingly increases the blow force and reduces the rate of reciprocation.

Stroke varying means are known in the art which comprise physically altering the expansible chamber volume and length by moving one of the end abutments. An example of a variable stroke percussion tool having means for selectively positioning the fluid-distributing valve to increase or decrease expansible chamber length is disclosed in U.S. Pat. No. 3,032,013 to R.R.Vincent. In the Vincent patent a plurality of ringlike spacer elements are used to selectively position the fluid-distributing valve which forms a movable abutment at one end of the hammer cylinder. German Pat. No. 1,004,560 to N. Wittlich discloses a mechanism operable from the exterior of a percussion tool for variably positioning the fluid-distributing distributing valve at limited selected positions within the cylinder. However, in the design of long hole rock drills, hole cleansing fluid conduits are necessarily designed to extend axially through the drill percussion motor to be in communication with the drill steel thereby precluding use of the arrangement of the stroke varying means disclosed in the Wittlich patent.

Furthermore, it is desirable that an infinite range of stroke lengths be provided between the maximum and minimum limits so that the most favorable hammer blow intensity and frequency combination can be selected to meet the drillability requirements of a particular rock formation.

SUMMARY OF THE INVENTION

The present invention provides for a variable stroke fluid-operated percussion tool which includes a mechanism for selectively varying the blow intensity and frequency of the percussive hammer while the tool is in operation. The invention provides adjustable positioning means for positioning a movable abutment at one end of the cylinder bore of an expansible-chamber percussion tool whereby the stroke length of the tool hammer may be selectively altered.

The present invention further provides a stroke-varying mechanism for a percussion tool which is operable to vary the blow intensity and blow frequency of the percussive hammer over an infinitely variable range between limits to enable selection of the proper hammer stroke commensurate with desired tool performance. A particular advantage of the present invention resides in the stroke-adjusting mechanism which is operable from the exterior of the tool to adjustably position a movable abutment comprising a fluid-distributing valve.

A further advantage of the invention resides in the provision of a compact and structurally simple mechanism for a variable-stroke percussion tool which provides improved penetration rates for rock drills and the like at a savings in motive fluid expenditure.

Further advantages and benefits derived from the present invention will be realized upon reading the description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a conventional fluid-operated percussion rock drill showing the external arrangement of the stroke adjustment mechanism.

FIG. 2 is a partial longitudinal section of the percussion drill of FIG. 1, and is taken along the line 2–2 of FIG. 3.

FIG. 3 is a section view taken along the line 3–3 of FIG. 1 illustrating details of construction of the distributing-valve positioning cam and associated parts.

FIG. 4 is a fragmentary section view of the distributing valve and valve trip porting.

FIG. 5 is a fragmentary section view showing further details of the distributing valve.

FIG. 6 is a fragmentary view from the line 6–6 of FIG. 3, partially broken away, and showing the distributing-valve chest in the limit positions.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a conventional fluid-operated rock drill generally designated by the numeral **10**. The drill **10**, commonly known as a drifter, is adaptable to be mounted on a mast or guide shell, not shown, and is extensively used in mining and construction work. The drill **10** basically comprises a percussion motor housing **12**, a backhead **14** closing one end of the housing **12**, and a chuck end **16** closing the opposite end. Elongated tie rods **18** are employed to hold the aforementioned basic components in assembly. Motive pressure fluid to operate the percussion motor is supplied to the backhead **14** by means of the conduit **20** from a source, not shown. Exhaust fluid from the percussion motor is conducted through the radially extending exhaust port **22** located on the housing **12**. The drill **10** also includes a drill steel rotation motor **24** of the fluid operated type which provides for rotation of the drill steel **26** which is suitably retained in the chuck end **16** in a manner well known to those skilled in the art of percussion tools. Also shown in FIG. 1 located on the percussion motor housing for a stroke-varying mechanism to be explained later herein in detail.

Referring to FIG. 2, a major portion of the drill **10** including the percussion motor is shown in longitudinal section. The percussion motor includes an elongated cylindrical bore **30** in the housing **12** in which a hammer piston **36** is reciprocably disposed forming expansible chambers **32** and **34**. The hammer piston **36** includes opposed pressure surfaces **38** and **40**, and an elongated reduced diameter section **42** adapted for transmitting percussive blows to the drill steel **26**. The section **42** is keyed to a rotatively mounted chuck driver **44** whereby the hammer **36** is rotatively driven with the drill steel **26** by conventional means, not shown, engaged with the rotation motor shaft **46**. Hammer rotation is specifically provided for to prevent uneven wear on the sliding surfaces. The hammer **36** is slidably journaled in a liner and sleeve assembly **48** forming a stationary abutment closing the forward end of the cylinder **30**. The opposite end of the cylinder **30** includes a stepped bore portion **50** and a transverse shoulder **51** formed thereby. A movable abutment comprising a fluid distributing valve **52** is longitudinally slidably disposed in the bore **50**. The cylinder **30** also includes a relieved portion **54** comprising an exhaust passage for conducting spent motive fluid from the percussion motor to the exhaust port **22**, FIG. 1.

FIG. 2 also illustrates the location of a drill hole cleansing fluid valve **56** disposed in the backhead **14** and in fluid flow communication with a tubular element **58** extending longitudinally through the drill **10** into a bore **60** in the drill steel **26**. The tube **58** is desirably located in the position shown in FIG. 2 whereby drill hole cleansing fluid may be communicated to the hollow drill steel for flushing drill cuttings and debris from the drill hole.

Referring to FIGS. 2, 3, 4 and 5 the distributing valve 52 is of a type generally well known in the art of percussion tools comprising basically a cylindrical housing or chest 62, a plug element 64 secured to the chest by a retaining ring 66, and an axially shiftable valve element 68. The valve chest 62 includes longitudinal annular passages 70 (see FIG. 3, also) in communication with the space 72 in the backhead 14 and opening into the annular area 74. The valve chest 62 also includes annular spaces 76 and 78 surrounding the valve element 68. As shown in FIGS. 2 and 3 the annular space 76 opens into longitudinal slots 80 formed on the periphery of the valve chest 62. The slots 80 are in communication with parallel conduits 82 in the cylinder housing 12 by way of apertures 81. The conduits 81 open into the chamber 34 and serve to conduct pressure fluid thereto for lifting the hammer piston 36.

Referring to FIGS. 3 and 4, the housing 12 also includes longitudinal conduit 84 opening through apertures 86 into the chamber 32 and in communication with slots 88 on the periphery of the valve chest 62 by way of apertures 87. The slots 88 open into the area 90 formed between the valve chest 62 and the surface 92 on the valve element 68. The flow passages formed by the conduits 84 and the slots 88 placing the chamber 32 in communication with the area 90 comprise what are known as valve trip passages and operate to deliver a pulse of pressure fluid to the surface 92 on the valve element 68 when the hammer piston 36 moves past the opening 86 as shown in FIG. 4 during the blow-delivering stroke. The pulse of pressure fluid is operable to shift the valve element 68 from the position shown in FIG. 4 to the position shown in FIG. 2 in a manner well known whereby fluid flow to the percussion motor is provided alternately to chambers 32 and 34.

The section view of FIG. 5 illustrates conduit 94 in communication with the area 96 formed between the plug 64 and the valve element 68. The conduit 94 opens to the slot 96 in the valve chest 62 by means of the transverse passage 98. Passages 100 and 102 communicate the areas 90 and 78, respectively, with the slot 96 which as shown in FIG. 3 is vented to the exterior of the drill 10 through the opening 104. The passages illustrated in FIG. 5 are required to vent the respective areas shown in keeping with proper functioning of the valve 52. The purpose of illustration of the construction features of the valve 52 and the slots 80, 88 and 96 which communicate with the respective conduits and passages previously described is to make clear that regardless of the longitudinal position of the valve 52 in the stepped bore 50 the respective conduits will be in flow communication with the valve to assure proper functioning of the drill 10. The slots 80, 88 and 96 are accordingly of sufficient length to provide for positioning of the valve 52 in an infinite number of positions between the backhead 14 and the shoulder 51 formed by the intersection of the bores 30 and 50.

The distributing-valve positioning and retaining means is illustrated in FIG. 3. The radially extending boss 28 on the housing 12 includes a partially threaded bore 106 which rotatably journals a cylindrical member 108 forming a cam-positioning block. The cam block 108 is retained within the bore 106 by the threaded cap 110. The cam block 108 includes a coaxial partially threaded stem portion 112 extending through the cap 110 and having a flat-sided tang 114 formed on the outermost end. A locknut 116 threaded over the stem 112 is operable to retain the cylindrical cam block 108 nonrotatably when properly tightened against the cap 110.

On the periphery of the valve chest 62 is an elongated recess 118 which receives a cylindrical cam element 120 extending inwardly from the cam-positioning block 108 through the opening 109 in the cylinder housing 12. The cam element 120 is secured to the block 108 by a threaded stem portion 122. As can be seen in FIGS. 3 and 6, the cam 120 is mounted eccentric to the rotative axis of the block 108 and is engaged with the recess 118 so that when the block 108 is rotated the cam 120 will move in a circular arc path, FIG. 6, to longitudinally displace the valve assembly 52 axially in the stepped bore 50. The valve chest 62 is prevented from rotating in the bore 50 by a pin 123. In FIG. 6 the valve assembly 52 is shown in the maximum stroke length position as denoted by the solid lines and in the minimum stroke length position as shown by the phantom lines. These respective positions of the valve assembly 52 correspond to the maximum and minimum length and volume of the expansible chamber 32. The valve 52 is suitably placed in the positions shown or in any position between these limits by applying a suitable operating lever or wrench, not shown, to the tang 114, loosening the locknut 116 by suitable means, and rotating the cam block 108 until the desired position of the valve is reached. The locknut 116 may then be retightened to retain the cam block 108 and accordingly the valve 52 in the position corresponding to the desired stroke length of the hammer piston 36.

Suitable indicia may be placed on the circumference of the boss 28 and on the cam block 108 to indicate the position of the valve 52 whereby a predetermined stroke length may be set. Quite advantageously the most favorable position of the valve 52 may be determined while the drill 10 is in operation due to the fact that no interruption of fluid flow to and from the valve occurs even when the positioning means is being operated. Also, the most favorable penetration rate of the drill 10 may be set while the drill is in operation drilling stratified rock formation or in workings in which the drillability of the rock is unknown with respect to the optimum blow intensity and frequency. The adjustable positioning cam is also advantageously located on the side of the cylinder housing 12 where it is easily accessible for adjustment while the drill is in operation.

Although the operation of percussion tools of the type disclosed is generally well known, a brief explanation of the operating cycle is described herein. The basic operation of the drill 10 comprises the alternate valving of pressure fluid to the expansible chambers 32 and 34 to cause reciprocating motion of the hammer piston 36. Referring to FIGS. 2 and 4, pressure fluid supplied to the area 72 in the backhead 14 flows through the passages 70 to the area 74, and with the valve element 68 in the position shown in FIG. 4 through the openings 71 into the expansible chamber 32 to drive the hammer piston 36 to strike the drill steel 26. As the hammer surface 38 passes the openings 86, a pulse of pressure fluid is transmitted through the trip conduits 84, openings 87, the slots 88, and into the area 90 to act on the surface 92 of the valve element 68 causing the same to shift to the position shown in FIG. 2. The pulse of pressure fluid is sufficient to shift the valve element even though the area 90 is vented as previously described. With the valve 68 in the position of FIG, 2, pressure fluid flows from the area 74 to the annular space 76, into the slots 80, through the openings 81 and into the lifting fluid conduits 82 to the expansible chamber 34 whereby the hammer piston 36 after delivering a blow is returned toward the valve assembly 52 by pressure force acting on the surface 40. As the surface 38 of the hammer passes over the exhaust passage 54 and the openings 86, fluid in the chamber 32 becomes compressed as the volume of the chamber is reduced. As the pressure increases in chamber 32 to a predetermined value, pressure force acting on the surface 124 of valve element 68 will cause it to shift to the position of FIG. 4 whereby fluid is again communicated at substantially supply pressure to the chamber 32 to drive the hammer piston 36 on the blow-delivering stroke.

The position of the valve assembly 52 shown in FIGS. 2 and 4 is that which provides for maximum length and volume of the expansible chamber 32. If the valve assembly is adjusted to be positioned close to the shoulder 51 however, the length and volume of the chamber 32 is reduced. Accordingly, a reduced quantity of pressure fluid will be valved into the chamber 32 before the trip opening 86 is uncovered by the surface 38 on the hammer and the valve 68 is shifted. Accordingly, less fluid energy will be expended on the blow-delivering stroke of the hammer and blow intensity will be reduced. Also, on the return stroke of the hammer 36 the volume of chamber 32 being reduced will cause a more rapid pressure rise to the value necessary to trip the valve element 68 back to the blow-delivering position of FIG. 4, the result being that blow frequency is thereby increased.

I claim:

1. An improved pressure fluid actuated percussion tool comprising:

pressure-fluid actuated percussion motor means including a housing having a cylinder bore therein and hammer piston means reciprocably disposed in said cylinder and forming therewith expansible chamber means;

pressure fluid distributing-valve means disposed in said housing and forming a movable abutment at one end of said expansible chamber, said distributing valve means being movable between positions defining the maximum and minimum hammer stroke length of said expansible chamber, and the improvement comprising;

means mounted on said percussion motor housing and operable from the exterior of said tool for positioning said distributing valve means in said motor housing, said means including a member rotatably mounted on said motor housing and having an axis of rotation extending radially with respect to said cylinder, said member being operatively engaged with said distributing valve means whereby in response to rotation of said member said distributing valve means is operable to be positioned in said minimum and maximum stroke length positions and in an infinite number of positions therebetween.

2. The invention set forth in claim 1 wherein said distributing valve means includes a cylindrical valve housing disposed in said cylinder and longitudinally slidable therein, said valve housing having a recess located on its periphery, and said positioning means includes cam means mounted on said rotatable member eccentric to the rotational axis thereof and disposed in said recess in said valve housing whereby in response to rotation of said member said cam means operates to position said valve housing in said cylinder.

3. The invention set forth in claim 1 wherein said rotatable member includes operator means comprising a shaft extending radially outward from said percussion motor housing, said shaft including lock means whereby said distributing valve means may be retained in a position corresponding to the desired stroke length of said expansible chamber.

4. An improved pressure fluid actuated percussion tool comprising:

pressure-fluid actuated percussion motor means including a housing having a cylinder bore therein and hammer piston means reciprocably disposed in said cylinder and forming therewith expansible chamber means, said hammer piston means including opposed pressure surfaces subject to pressure fluid forces;

pressure fluid distributing-valve means disposed in said housing and forming a movable abutment at one end of said expansible chamber, said distributing valve means including a shiftable element operable to valve pressure fluid alternatively to said opposed surfaces of said hammer piston means to cause said hammer piston means to reciprocate in said cylinder bore, said distributing valve means being movable between positions defining the maximum and minimum hammer stroke length of said expansible chamber; and

said percussion motor housing including conduit means in communication with said expansible chamber means and passage means in said distributing valve means, said passage means being disposed in said valve means to be in communication with said conduit means in any of said positions of said distributing-valve means in said motor housing, and the improvement comprising means operable for positioning said distributing-valve means in said minimum and maximum stroke length positions and in an infinite number of positions therebetween.

5. The invention according to claim 4 wherein said distributing-valve means comprises a cylindrical valve housing longitudinally slidably disposed in said cylinder, said passage means comprising longitudinal slots formed on the periphery of said valve housing, and said slots are in flow communication with said conduits in said motor housing in any of said positions of said valve means in said cylinder.