Aug. 21, 1962 P. P. CAREY 3,050,032

PERCUSSION-TYPE DRILL

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Fig. 1A

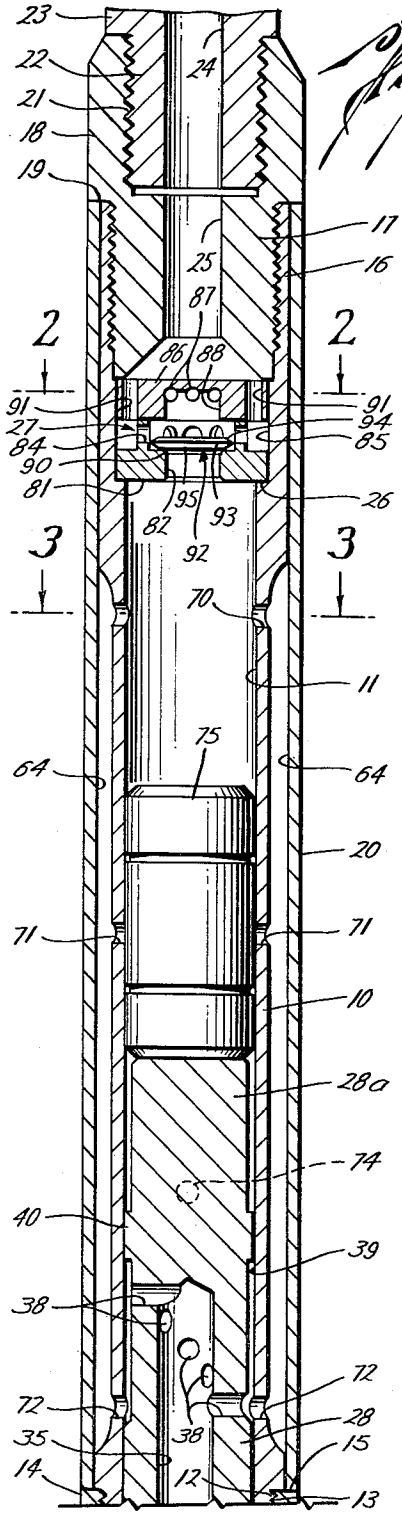
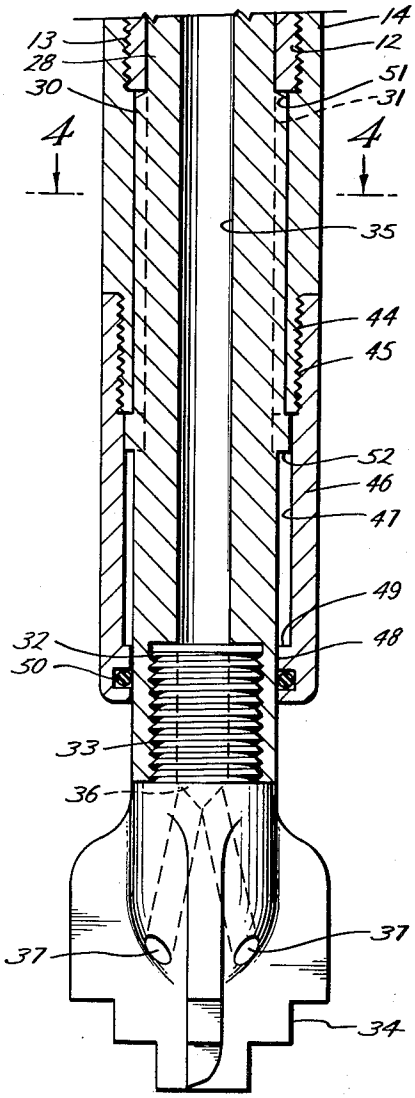


Fig. 1B



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Fig. 5

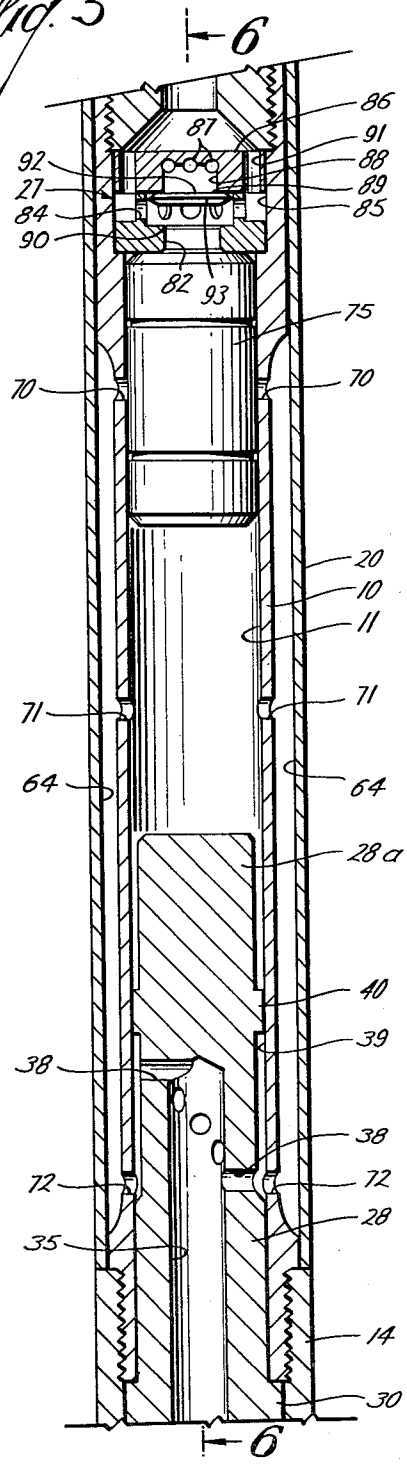


Fig. 2

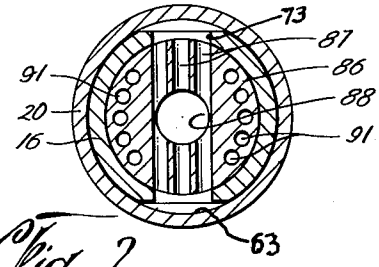


Fig. 3

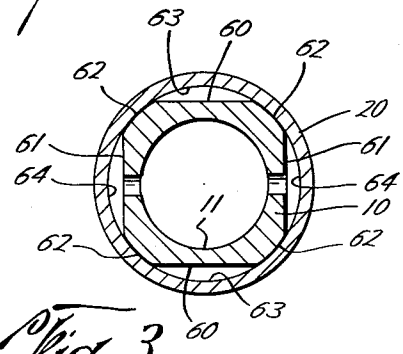
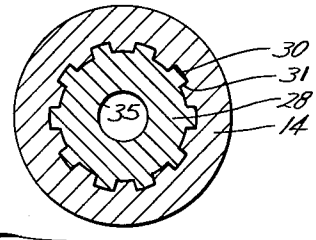


Fig. 4



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Fig. 6

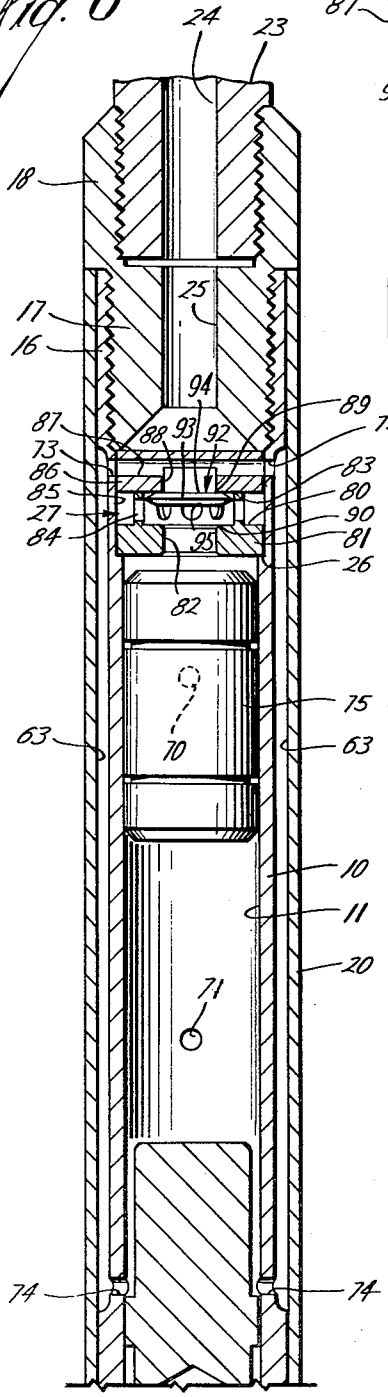


Fig. 7

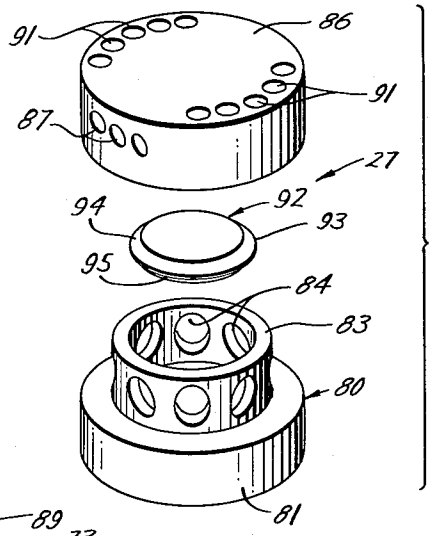
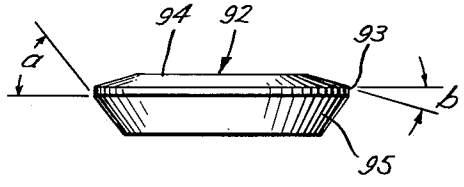


Fig. 8



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3,050,032

PERCUSSION-TYPE DRILL

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Filed Dec. 30, 1960, Ser. No. 79,891
6 Claims. (Cl. 121—28)

This invention relates to percussion-type drills for use in drilling holes in the earth and more particularly to percussion-type drills actuated by pneumatic pressure fluids.

Conventional pneumatic fluid actuated percussion drills all employ generally similar arrangements of an anvil member secured to a drill bit or earth-boring tool and a hammer movably disposed relative to the anvil so as to strike repeated downwardly directed impacts against the anvil, to thereby drive the bit or cutting tool through the earth formations. These tools vary widely in their efficiency, that is, in making most effective use of the energy in the power fluid to maximize the impactive energy of the hammer.

It is, therefore, a primary object of this invention to provide a percussion-type drill having improved features of construction adapted to provide a drill which is of relatively simple but rugged construction, and which is exceptionally efficient in operation.

An important object is to provide a percussion-type drill employing pneumatic power fluid and adapted to deliver maximum energy from the power fluid to the percussion stroke.

Another object is the provision of a novel valve arrangement for controlling the flow of pressure fluid so as to maximize the energy applied to the percussion stroke while reducing the pressure required for effecting the return stroke of the hammer element of the tool.

A more specific object is to provide a highly efficient form of valve for pneumatic-pressure actuated percussion drills.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIGS. 1A and 1B, together, comprise a longitudinal sectional view through a tool in accordance with one embodiment of this invention, the hammer element being shown in the position occupied at completion of a percussion stroke;

FIGS. 2 and 3 are cross-sectional views taken generally along lines 2—2 and 3—3, respectively, of FIG. 1A.

FIG. 4 is a cross-sectional view taken generally along line 4—4 of FIG. 1B;

FIG. 5 is a view similar to FIG. 1A, showing the hammer element at substantially the completion of its return stroke;

FIG. 6 is a view similar to FIG. 5, showing the hammer element at the position occupied at an early stage in the percussion stroke;

FIG. 7 is an exploded perspective view of the valve elements of the tool; and

FIG. 8 is an enlarged elevational view of the valve.

Referring to the drawing, the tool comprises a generally tubular barrel 10 having an axial bore 11, and is provided at its lower end with an externally threaded pin member 12 which is threadedly received in an internally threaded box 13 provided in the upper end of a tubular coupling 14 somewhat larger in external diameter than the external diameter of barrel 10, thereby providing the annular upwardly facing external shoulder 15 about the exterior of the lower end of barrel 10. At its upper end barrel 10 is provided with an internally threaded socket 16 which is

adapted to receive an externally threaded pin 17 formed on the lower end of a tubular drill head 18 somewhat larger in external diameter than barrel 10. The enlarged diameter of drill head 18 provides the downwardly facing annular shoulder 19 about the upper end of barrel 10. A tubular casing 20 is mounted about the exterior of barrel 10 and is securely clamped in position about the barrel between shoulders 15 and 19 when the tool is assembled. Drill head 18 has an internally threaded socket 21 at its upper end adapted to receive the externally threaded pin 22 on the lower end of the tubular drill stem 23, having an axial bore 24 which is in communication with an axial bore 25 extending through the drill head and communicating with the interior of barrel 10. The bottom of socket 16 is counterbored to provide an upwardly facing annular shoulder 26 which forms a seat for a valve mechanism, designated generally by the numeral 27, the valve mechanism being held in place against seat 26 by the inner end of pin 17 of the drill head when the latter is screwed down into socket 16.

Slidably disposed in the bore of barrel 10, below the valve mechanism 27, is a generally cylindrical anvil 28. An intermediate portion of the latter is provided with longitudinal splines 30 (see FIG. 4) which engage corresponding spline grooves 31 formed in the bore wall of coupling 14, whereby to permit longitudinal movement of the anvil relative to the barrel while preventing relative rotation therebetween. At its lower end anvil 28 is provided with an internally threaded socket 32 adapted to receive the threaded shank 33 of a percussion bit 34 which may be of any generally conventional construction. An axial bore 35 extends through anvil 28 from a point spaced a short distance from the upper end thereof to its lower end where it is adapted to communicate with a registering bore 36 extending through the body of bit 34 and communicating with discharge orifices 37 for exhausting fluid from the bit. Anvil 28 is provided with a plurality of radial ports 38 communicating the upper end of bore 35 with the interior of barrel 10, the ports opening to a clearance space 39 between an upper portion 28*a* of the anvil, which is reduced somewhat in diameter to provide the annular clearance space 39 between portion 28*a* and the bore wall of barrel 10. An annular enlargement 40 is provided about reduced diameter portion 28*a* intermediate ports 38 and the upper end of the anvil and functions as a slidable closure for annular space 39.

The lower end of coupling 14 is provided with a reduced diameter externally threaded pin 44 which is received in an internally threaded socket 45 provided in the upper end of a tubular extension sleeve 46 having an internal bore 47 somewhat larger than the external diameter of splines 30, bore 47 being further restricted at its lower end to provide an axial opening 48 adapted to closely receive the exterior of the anvil. The reduction in diameter of opening 48 relative to bore 47 provides an upwardly facing annular shoulder 49 about the exterior of the anvil. A seal ring 50 is mounted in the wall of opening 48 to form a slidable fluid-tight seal between the lower end of extension sleeve 46 and the exterior of the anvil. The upper ends 51 of splines 30 extend radially outwardly beneath the lower end of pin 12 and by engagement with the latter serve to limit upward movement of the anvil relative to barrel 10. The lower ends 52 of the splines are adapted to engage shoulder 49 in the lower end of sleeve 46 to thereby limit downward movement of the anvil relative to the barrel.

The exterior of barrel 10 is planed off longitudinally at substantially 90° intervals to provide two pairs of flats 60—60 and 61—61 on diametrically opposite sides of the barrel, the flats being separated by the rounded corners 62 forming portions of the external periphery of the bar-

rel. The flats so-provided on the exterior of the barrel cooperate with the surrounding wall of casing **20** to define longitudinal passages **63—63** and **64—64** therebetween, while the round portions **62** of the barrel, which have close fitting engagement with the inner wall of casing **20**, form seals preventing communication between adjacent passages **63** and **64**. To assure fluid-tight seals between the rounded portions **62** and the wall of casing **20**, the latter is dimensioned to form a press-fit about the exterior of barrel **10**. Passages **64—64** extend longitudinally from a point just above pin **12** to a point below shoulder **26** in the barrel, as best seen in FIGS. 1A and 5. Passages **63—63** extend longitudinally from a point somewhat above the lower ends of passages **64** to a point just below the inner end of pin **17**, as best seen in FIG. 6.

Three sets of longitudinally spaced ports **70**, **71** and **72** provide communication between passages **64** and the interior of barrel **10**. Ports **70** and **72** are located near the upper and lower ends of passages **64**, while ports **71** are located at an intermediate point along the wall of the barrel. Two pairs of ports **73** and **74** (FIG. 6) provide communication between the upper and lower ends of passages **63** and the interior of barrel **10**.

A generally cylindrical piston or hammer element **75** is slidably mounted in bore **11** of barrel **10**, having a close sliding fit therein, and is adapted to reciprocate in the barrel to effect impactive engagement with the upper end of anvil **28** in response to the flow of pneumatic fluid through the several passages and ports under the control of valve mechanism **27**.

Valve mechanism **27** comprises a valve cage **80** which includes a base ring **81** having an axial port **82** therein, base ring **81** being adapted to fit on seat **26** in the bottom of socket **16**. Intermediate the inner and outer periphery of base ring **81**, cage **80** is provided with an upstanding annular flange **83** having a plurality of radial openings **84** therethrough. Flange **83**, being spaced inwardly from the outer periphery of base ring **81**, defines an annular space **85** between the outer periphery of flange **83** and the inner wall of socket **16**. Mounted on top of flange **83** is a cap **86** which is held in place on the cage by the inner end of pin **17** of the drill head when the latter is screwed down into socket **16**, thereby securing the valve mechanism firmly against seat **26**. Cap **26** is provided with a plurality of passages **87** which extend transversely across the cap and communicate at their outer ends with ports **73** (FIG. 6). A cylindrical recess **88**, co-axial with port **82**, provides communication between the several passages **87** and the interior of flange **83**, the inner edge of recess **88** defining a valve seat **89**, while the opposed inner edge of port **82** defines a valve seat **90**. Cap **86** is also provided on opposite sides thereof, at substantially right angles to the direction of passages **87**, with a plurality of vertically extending passages **91** which provide communication through the cap between bore **25** of the drill head and annular space **85**, and thence through radial openings **84** and port **82** with the interior of barrel **10**, or through recess **88** and passages **87** with ports **73** and passages **63**, depending on the position of a valve **92**.

Valve **92** is of a specialized structure which contributes most significantly to the efficiency of the drill. As best seen in FIG. 8, the valve body is a generally circular disk mounted in the bore of flange **83** for vertical movement between seats **89** and **90**. The valve has a peripheral edge **93** which is generally V-shaped in longitudinal section, being defined by converging upper and lower tapered surfaces **94** and **95**, respectively. Edge **93** has a diameter providing a close but free fit within the bore of flange **83** and is located non-symmetrically with respect to the ends of the valve, being off-set slightly toward the upper end. The thickness of valve **92** from end-to-end is made appreciably less than the diameter of ports **84**, so that when the valve is in engagement with either seat **89** or **90**, edge **93**, which is termed the "leading edge" for purposes of this description, will be off-set vertically with respect to the centers of ports **84**, as will be best seen in FIGS. 1, 5 and 6. Moreover, in its preferred form, the lower tapered surface **95** will function as an airfoil, for purposes which will appear more fully hereinafter.

By way of example, in a 1½ inch drill, the dimensions of valve **92** will be as follows:

Diameter at leading edge **93**	inch	1.000
Thickness of leading edge **93**	do	1/32
Total thickness of valve	do	7/32
Axial thickness—surface **94**	do	3/64
Axial thickness—surface **95**	do	9/64
Angle *a* (FIG. 8)	degree	51.5
Angle *b* (FIG. 8)	do	16.7

In operation, pneumatic fluid, such as compressed air or gas, will be delivered through the bores of drill stem **23** and of drill head **17** through passages **91** and ports **84** into the interior of the valve cage. With the valve in the down position (FIG. 1A) closing port **82** and the hammer at the bottom of its impactive stroke, the pneumatic fluid under pressure will be directed through passages **87** and ports **73** into passages **63**, from which the pressure fluid will enter the bore of barrel **10** through ports **74** into clearance space **39** above shoulder **40** and exert upward pressure on the lower end of hammer element **75**, driving the latter upwardly in its return stroke. As the latter passes ports **71**, the pressure fluid beneath the hammer element is exhausted to passages **64** and thence through ports **72** and **38** into passages **35** and **36** and thence through outlets **37** from the bit. At the same time, the inertia of the hammer element continues to move the hammer element upwardly until it closes ports **70** and pressure fluid trapped between the upper end of the hammer element and the valve cage will be compressed by this continuing upward movement of the hammer element. This pressure momentarily becomes greater than the pressure inside the valve cage above valve **92** and forces the valve upwardly against seat **89**, thereupon closing off passages **87**. Leading edge **93** of the valve will then be above the center of ports **84** and the pressure fluid will thereby be directed through port **82** against the top of the hammer element, thereby supplying the energy for the downwardly directed power stroke on the hammer element. Down stroke power is thus maintained until the hammer element passes ports **70**, whereupon the pressure fluid will be vented into passages **64** whence it will flow through ports **72** and **38** and passages **35** and **36** to bit outlets **37**. As the hammer moves downwardly past ports **71**, on the continuation of its down stroke, pressure fluid will be compressed between the lower end of the hammer and the upper end of anvil **28**, thereby forcing the pressure fluid back through ports **74** and passages **63** to passages **87**, so as to build up pressure on top of valve **92**, which, at that moment, is in its elevated position against seat **89**, and finally forcing the valve back down to its original position on seat **90** to complete the cycle.

By positioning leading edge **93** of the vale so that it will be slightly above the center of ports **84** and by offsetting the leading edge toward the upper end of the valve body, the valve will be dynamically unstable and tend to drop from its uppermost position. At the same time, by its taper, surface **95** acts as an airfoil in response to the flow of air across this surface to produce a negative lift or suction on the valve, which, together with the unbalanced character of the valve, will cause the valve to fall to its down position with the extertion of an absolute minimum of pressure on its upper end.

Since these features of construction of the valve result in a minimum of pressure required to close the valve; that is, to move it to its down position, the amount of compression required by the hammer element at the bottom of its stroke will be a minimum and thereby produce a lesser cushioning action at the bottom of the down stroke, thereby enabling the hammer to deliver maximum impactive energy to the anvil.

The air delivered through exhaust ports 71 and 72 and discharged through the bit outlets will aid in removing cuttings by blowing them back upwardly through the drill hole.

The sliding connection formed between sleeve 46 and anvil 28 as limited by shoulders 51 and 52, permits relative longitudinal movement between the anvil carrying the bit and the casing of the drill, as may necessarily occur during operation of the drill.

It will be understood that instead of the percussion-type bit illustrated in FIG. 1B, a rotary-type bit may be secured to the lower end of anvil 28 and percussive force supplied thereto while the drill string is rotated to increase the cutting action of the rotary-type bit.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiments within the scope of the appended claims, but without departing from the spirit of this invention.

What I claim and desired to secure by Letters Patent is:

1. In an earth-boring drill, the combination comprising a tubular body having an axial bore, an anvil member mounted for limited longitudinal movement in the lower end of said bore and adapted to be secured to an earth-cutting bit member, a hammer member reciprocable in said bore relative to the anvil member for percussive engagement therewith, a valve chamber in the upper end of said bore, inlet port means extending radially through the wall of said chamber providing communication between the interior thereof and a source of pneumatic pressure fluid, first outlet port means at one end of said chamber below said inlet port means communicating with the interior of said bore above said hammer member, second outlet port means from the chamber above said inlet port means and coaxial with said first outlet port means, passage means connecting said second outlet port means with the interior of said bore at a level below that attained by the lower end of the hammer member in its downward travel, exhaust ports from said bore at longitudinally spaced points along the path of movement therein of said hammer member, and disk-shaped valve means horizontally disposed in said chamber for vertical movement between positions opening and closing the respective outlet port means and operable in response to reciprocation of the hammer member to direct pneumatic fluid from said inlet port means alternately to said first and second outlet port means, and valve means being dynamically unbalanced in the direction of said first outlet port means.

2. In an earth-boring drill, the combination comprising a tubular body having an axial bore, an anvil member mounted for limited longitudinal movement in the lower end of said bore and adapted to be secured to an earth-cutting bit member, a hammer member reciprocable in said bore relative to the anvil member for percussive engagement therewith, a valve chamber in the upper end of said bore, inlet port means extending radially through the wall of said chamber providing communication between the interior thereof and a source of pneumatic pressure fluid, first outlet port means at one end of said chamber below said inlet port means communicating with the interior of said bore above said hammer member, second outlet port means from the chamber above said inlet port means and coaxial with said first outlet port means, passage means connecting said second outlet port means with the interior of said bore at a level below that attained by the lower end of the hammer member in its downward travel, exhaust ports from said bore at longitudinally spaced points along the path of movement therein of said hammer member, and valve means movable in said chamber between said outlet port means and operable in response to reciprocation of the hammer member to direct pneumatic fluid from said inlet port means alternately to said first and second outlet port means, said valve means comprising a circular valve body horizontally disposed in said chamber, said valve body having a peripheral edge generally V-shaped in vertical cross-section and axially off-set toward the upper end of the valve body, the upper and lower ends of the valve body defining closures respectively for said second and first outlet port means.

3. In an earth-boring drill, the combination comprising a tubular body having an axial bore, an anvil member mounted for limited longitudinal movement in the lower end of said bore and adapted to be secured to an earth-cutting bit member, a hammer member reciprocable in said bore relative to the anvil member for percussive engagement therewith, said body having fluid passage means for conducting pressurized fluid from a source into and out of opposite ends of said bore for reciprocating said hammer member, and valve means mounted in the upper end of said bore for alternately directing said pressurized fluid into the passage means leading into opposite ends of said bore in response to reciprocation of said hammer member, said valve means comprising a tubular cage coaxial with said bore and having a plurality of radial passages through the wall thereof, a lower end wall on said cage having a first axial outlet port communicating with the upper end of the bore, a circular cap member closing the upper end of said cage, said cap member having a first passage means therethrough providing communication between said source of pressurized fluid and the outer ends of said radial passages, a second outlet port in said cap member co-axial with said first outlet port and vertically spaced therefrom, said cap member having second passage means providing communication between said second outlet port and the passage means in said body leading to the lower end of said bore, and a valve member mounted in said valve cage for movement alternately into and out of closing engagement with said first and second outlet ports in response to reciprocation of said hammer member, said valve member comprising a circular disk-shaped body horizontally disposed in said cage, said body having a peripheral edge V-shaped in axial section and offset toward the upper end of the body.

4. In an earth-boring drill, the combination comprising a tubular outer casing, a tubular inner barrel coaxially mounted within the casing, an anvil member mounted for limited longitudinal movement in the lower end of the barrel and adapted to be secured to an earth-cutting bit member, a hammer member reciprocable in the bore of the barrel above the anvil member for percussive engagement therewith, a valve cage mounted in the upper end of said barrel, inlet port means through the wall of the cage providing communication between the interior thereof and a source of pneumatic pressure fluid, first outlet port means at one end of said cage below said inlet ports communicating with the interior of said barrel above said hammer member, second outlet port means from the cage above said inlet port means, first passage means defined between the outer casing and said barrel connecting said second outlet port means with the interior of the barrel at a level below that attained by the lower end of the hammer member in its downward travel, exhaust ports through the wall of said barrel communicating with the interior thereof at longitudinally spaced points along the path of movement therein of said hammer member, second passage means defined between the casing and the barrel connecting said exhaust ports, and valve means mounted in said cage operable by the reciprocation of the hammer member to alternately direct pneumatic fluid to said first and second outlet port means, said valve means being dynamically unbalanced in the direction of said first outlet port means.

5. The combination as defined in claim 4, wherein said valve means comprises a circular disk-shaped body horizontally disposed in said cage for axial movement into and out of closing engagement with the respective outlet port means, said valve body having a peripheral edge V-shaped in axial section and offset toward the upper end of the valve body, the opposite ends of said valve body defining closures for the respective outlet port means.

6. A valve-and-cage construction for pneumatic motors, comprising, a generally tubular cage having longitudinally spaced coaxial outlet ports, and having inlet ports communicating with the interior of the cage through the wall thereof at points intermediate the outlet ports, and a valve member movable in said cage, said valve member comprising a disk-shaped body horizontally disposed in said cage for axial movement into and out of closing engagement with the respective outlet ports, said valve body having a peripheral edge V-shaped in axial section and offset toward one end of the valve body to dynamically unbalance the valve member, the opposite ends of said valve body defining closures for the respective outlet ports.

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