This invention relates to pressure fluid operated drills of the percussion type, more particularly to drills which enter the hole being drilled so that the percussive forces of the drill are transmitted directly to the drill bit. In drills of this type there are dimensional limitations in that the dimensions of the drill housing must be less than the effective cutting diameter of the drill bit. Therefore, in order to provide a drill of maximum power, it is desirable that the walls of the housing be as thin as possible, consistent with the strength and ruggedness required of the drill. To accomplish this, it is desirable to eliminate any longitudinal passages in the tool housing. In drills of this type, it is desirable to provide maximum flow of hole cleaning air, or other operating pressure fluid, when the drill is lowered into the hole or raised out of the hole. Also, during these periods, it is desirable to prevent reciprocation of the hammer within the drill housing since the drill bit is not bearing against a work surface and the force of the hammer blows may damage the tool. An object of this invention is to provide a percussion drill of novel and simple construction. Another object of this invention is to provide an improved percussion drill that will enter the hole being drilled as the drilling progresses. A further object of this invention is to provide an improved percussion drill of the type described wherein the drill hammer is automatically set into operation when the bit bottoms on a work surface. A still further object of this invention is to provide an improved percussion drill of the type described wherein a maximum flow of hole cleaning air is provided when the drill bit is not in engagement with a work surface. A still further object of this invention is to provide an improved percussion drill of the type described wherein adjacent transverse faces of the drill and bit are substantially parallel receiving therebetween the cuttings from the bit to reduce the size of the cuttings and facilitate their removal from the hole. A drill which accomplishes the above described objects includes an elongated tubular housing. A reciprocable tappet, having a central longitudinal bore, is mounted in a retainer housing at the forward end of the tool. The tappet is adapted for direct connection to a bit. A backhead and valve assembly are mounted at the rearward end of the housing. The valve assembly and tappet define a chamber within the housing for a reciprocating hammer having a central longitudinal bore. A tube extends from the backhead through the hammer bore and into the tappet for conducting air directly to the bit. A larger concentric tube extends from the valve assembly through the hammer bore for conducting air from the valve to the chamber forward of the hammer. The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a longitudinal sectional view of a preferred form of the invention showing the relationship of parts when the drill bit is engaging a work surface;

FIGURE 2 is an enlarged fragmentary sectional view of the drill of FIGURE 1 showing the relationship of parts when the bit is not in engagement with a work surface;

FIGURE 3 is an enlarged, fragmentary, sectional view of the upper valve assembly shown in FIGURE 1.

Referring now to the accompanying drawings, the drill housing 10 comprises an elongated tubular member. A tappet retainer bushing 18 is threaded into the forward end of the housing 10 and is provided interiorly with a plurality of parallel longitudinal ribs 19 extending from the forward end of the bushing to a point intermediate its ends. A tappet 13, retained within the bushing 18, is generally cylindrical in shape and is provided with a plurality of peripheral, parallel, longitudinal grooves 15 extending from its forward end rearwardly along a portion of its length. The tappet is further provided with a stepped axial bore comprising a small bore 14 at its forward end, a large bore 14a intermediate its ends, and an intermediate bore 14b at its rearward end. A plurality of radial slots 16 are provided in the rearward end face of the tappet. A threaded projection extends from the forward end of the tappet and is adapted for the reception of a drill bit 17 of a known type.

When the tappet 13 is mounted in the retainer bushing 18, the ribs 19 are received in the grooves 15 to form a spline connection permitting longitudinal movement of the tappet. The ribs and grooves limit forward movement of the tappet and bit. When a bit is secured to the tappet, the rearward face of the bit opposes the forward annular end face of the bushing 18 to limit rearward movement of the tappet and bit. During operation of the drill these faces serve to crush cuttings which fall between them, thereby facilitating removal of the cuttings from the hole.

A backhead 23 is threaded centrally to the rearward end of the housing 10 and clamps an automatic valve assembly 20 in the housing. In order to prevent undue strain on the threads at the rearward end of the housing 10 the backhead 23 is provided with an annular shoulder 23a which bears against the rearward end of the housing. A spring washer 20c is seated against the housing shoulder 20a and opposes the clamping force of the backhead 23 to secure the valve assembly within the housing. The backhead is provided, at its rearward end, with internal threads adapted to receive a drill pipe 22 which supports and feeds the drill into the hole and through which air is conducted to the drill backhead. Lengths of pipe are added as the drill progresses into the hole.

A reciprocating piston or hammer 11 is disposed within a cylindrical chamber 21 defined by the housing 10, the tappet 13 and bushing 18, and the valve assembly 20. The forward end of the hammer is of reduced diameter to pass within the retainer bushing 18 and to engage the rearward end of the tappet 13. The hammer is provided with an axial bore 12.

A tube 25 extends from the backhead 23 through the valve assembly 20, the chamber 21, the hammer bore 12, and into the small bore 14 of the tappet 13 to conduct air from the backhead directly to the drill bit, which is provided with a suitable bore and passages. This tube communicates with backhead passage 24. The diameter of the small bore 14 is substantially the same as the outside diameter of the tube 25 to provide an effective seal between these members so that all of the air passing through the tube 25 is conducted to and through the bit 17 to agitate the bit cuttings and blow the cuttings from the hole.

A larger tube 30, concentric with the tube 25, extends from the valve assembly 20 through the chamber 21, the hammer bore 12, and into the larger bore 14a retained within the bushing 18. When the tappet is in its rearwardmost position during drilling operation of the drill, indicated in FIGURE 1, the forward end of the tube 30 lies within the large bore 14a. The intermediate bore 14b is of a diameter substantially the same as that of the outer diameter of the tube 30. The tube 30, however, has a reduced diameter portion 30a.
adjacent to its forward end which coincides axially with the tappet bore 14b when the tappet is in the aforementioned rearwardly most position. The tube 30 is provided with radial ports 41 at its end forward of the reduced diameter portion 36a. With the tappet in the indicated position, air flowing forwardly through the tube 30 passes into the tappet bore 14a, from the ports 41 and the open end of the tube, then flows rearwardly through the tappet bore 14b and slots 16, and into the chamber 21 at the forward end of the hammer 11.

The rearward end of the body 30 is formed into a flange which is supported within the automatic valve assembly 20, best shown in FIGURE 3. The valve assembly is made up of stacked members which define an annular valve chamber 28 within which an annular automatic valve 27 is disposed for limited reciprocating movement, passages 26 for communicating live air to the valve chamber 28, and passages 29 for communicating the chamber 28 with the tube 30. The chamber 28 opens from the forward end of the valve assembly, communicating with the chamber 21 rearwardly of the hammer. At the rearward end of the valve assembly, the passages 26 communicate with the passages 26a in the backhead 23.

The valve chamber 28 defines opposing forward and rearward valve seating surfaces, which are engaged alternately by the valve 27 and limit the reciprocating movement of the valve. The valve 27 defines opposing forward and rearward seating surfaces which are exposed, respectively, to the chamber 21 and to the passages 29, and which cooperate with the chamber seating surfaces to communicate the passages 26 alternatively with the passages 29 and the chamber 21. Since the drill is operated in an upright position, as shown in FIGURE 1, the valve 27 normally assumes the forward position shown in FIGURES 1 and 3. When air is supplied to the drill, the valve 27 functions automatically to operate the drill in a manner to be described. The above described automatic valve assembly 20 is identical to a valve assembly shown and described in U.S. Patent 2,942,578, issued June 28, 1960.

The housing 10 is provided with axially spaced rows of exhaust ports communicating the chamber 21 with the exterior of the housing. Rearward ports 31 are provided to exhaust the chamber 21 rearwardly of the hammer when the hammer moves to a forward position indicated in FIGURE 1. Forward ports 32 are provided to exhaust the chamber 21 forwardly of the hammer when the hammer moves to a rearward position indicated in FIGURE 1. All of the ports 31 and 32 are disposed to direct the air rearwardly as it passes from the housing 10 to provide additional hole cleaning assistance in carrying the cuttings out of the hole. The tube 30 is provided with radial ports 42 disposed to be closed by the hammer during drilling operation of the drill. The diameter of the hammer bore is substantially the same as the outside diameter of the tube 30 so that effective sealing is provided.

In operation, the drill is suspended vertically by one or more sections of drill pipe 22 and air is supplied to the backhead 23 of the drill through the drill pipe 22. The drill may be rotated by external rotation means, above the ground, rotation being applied to the drill pipe 22. If it is assumed that, at the start of a drilling operation, the bit 17 is resting on the work surface to be drilled, the various parts of the drill structure are in the positions shown in FIGURES 1 and 3. The valve 27 is in its forwardmost position, to direct air through the passages 29 and the tube 30. The tappet 13 is positioned so that air flowing through the tube 30 may pass through the tappet bore 14b and slots 16, enter the chamber 21 at the forward end of the hammer. The hammer is in a forward position engaging the tappet 13.

The ports 32 are covered, or closed, by the hammer and the ports 31 are uncovered, or open, so that the chamber 21 rearwardly of the hammer is exhausted, or open to atmosphere.

With the parts in the above described positions, when air is directed through the drill pipe by means of a control valve (not shown) the air is directed to the drill backhead and to the passages 24 and 26a. A portion of the air passes through the passage 24 and the tube 25 directly to the drill bit 17; and a portion of the air passes through the passages 26a and 26b to the valve chamber 28. The valve 27 is positioned to direct air from the passages 26 through the passages 29 and the tube 30 to the chamber 21 forwardly of the hammer. As the hammer begins to move rearwardly, the ports 31 are closed to seal the chamber rearwardly of the hammer and the hammer compresses the air therein. With further hammer movement, this compressed air acts on the forward surface of the valve 27 to shift the valve rearwardly, and the valve is then positioned to direct air from the passages 26 to the chamber 21 rearwardly of the hammer. The rearward movement of the hammer uncovers the ports 32 to exhaust air from the chamber 21 forwardly of the hammer.

The hammer then begins to move forwardly to provide the impact blow to the tappet 13. As the hammer moves forwardly, the ports 32 are again closed and the hammer compresses the air in the chamber 21 forwardly of the hammer. This compressed air acts, through the tube 30 and passages 29, on the rearward surface of the valve 27 to shift the valve forwardly, and the valve is again positioned to direct air through the tube 30 to the forward face of the hammer. Before the hammer strikes the tappet 13, the ports 31 are again opened releasing pressure at the rearward face of the hammer and the cycle repeats itself. The air exhausted through the ports 31 and 32 assists in blowing the cuttings from the hole.

During operation of the drill, the bit 17 and drill housing 10 move away from each other as a result of the impact blows. When this occurs, the opposing faces of the bit and the retainer bushing 18 alternately separate and come together to crush larger cuttings which fall between these surfaces. This, of course, facilitates the removal of these cuttings by the hole cleaning air.

Referring now to FIGURE 2 of the drawing, when the drill is lifted off the bottom of the hole, the bit 17 and the tappet 13 move forwardly with respect to the drill housing and the retainer bushing due to their weight. The tappet will drop a distance permitted by the ribs 19 and grooves 15. The hammer, due to its weight, will drop a distance permitted by the retainer bushing or the tappet, the reduced diameter portion passing within the retainer bushing. When this occurs, the tappet bore 14b is moved forwardly from the reduced diameter portion 36b to the forward end of the tube 30, and provides an effective tappet bore and through passage 26a to the chamber 21 forwardly of the hammer. This prevents air flowing through the tube 30 from passing into the chamber 21 forwardly of the hammer, hence further reciprocation of the hammer is prevented. The hammer is now positioned to uncover the ports 42 in the tube 30. The valve 27 remains in its forwardmost position to direct air continuously through the tube 30. This air passes through the ports 42 into the chamber 21, rearwardly of the hammer, and through the exhaust ports 31 to provide continuous hole cleaning air in addition to that which passes through the tube 25 and the bit 17.

This flow of air also prevents chips or dust from entering the tool throat of the drill.

Since the air seal between the tube 30 and the tappet bore 14b may not be completely effective, the retainer bushing 18 is provided with an internal annular groove 43, immediately rearward of the ribs 19, which is now adjacent to the upper end of the tappet. This provides for the release of any gas passing through the tappet bore 14b and forwardly of the hammer. This air passing through the spline connection of the tappet bushing and to the forward end of the drill. This prevents the hammer from being raised by air leaking into the chamber 21.

When the drill is lowered into a partially drilled hole, the relation of parts will be the same and the air will be prevented from reciprocating. When the drill bottoms in the hole, the tappet and hammer will assume normal op-
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Operating positions shown in FIGURE 1, closing the ports 42 and opening the ports 41 in the tube 30. The drill will then operate automatically in the manner described. It will be apparent that the drill may be raised off the work surface at any time to stop the drilling action and merely provide hole cleaning air.

There has been described an in-the-hole drill of simple construction and which is automatic in operation in that the drill hammer does not reciprocate until the bit engages a work surface. Because of its construction, maximum power is available in a drill housing of minimum size. Means are provided for crushing the cuttings to a smaller size and for providing and directing hole cleaning air for blowing the cuttings out of the hole. Hole cleaning air is provided when the drill is engaging and drilling the work surface and when the drill is lifted off the work surface.

What is claimed is:

1. In a pressure fluid operated tool of the percussion type, an elongated hollow housing adapted for connection at its rearward end to a source of pressure fluid, valve means disposed adjacent to the rearward end of said housing, a tappet having an axial bore mounted at the forward end of said housing for limiting axial movement and adapted to receive a drill bit, a hammer having an axial bore therethrough reciprocable in said housing wherein in a chamber defined by said valve means and said tappet to engage the rearward end of said tappet, means for exhausting pressure fluid from said chamber, a tube supported at its rearward end by said valve means and extending through said hammer bored into said tappet bore, said valve means being pressure fluid operated to direct pressure fluid alternatively to said chamber rearwardly of said hammer and through said tube, said tappet disposed to assume a rearwardmost position during drilling operation of said tool and a forwardmost position when said tool is removed from a work surface, and said exhaust port bore being uncovered by said hammer as it approaches the limits of its forward and rearward strokes.

2. A tool as set forth in claim 1 wherein said exhaust means comprises at least one port directly communicating said chamber with the exterior of said housing and disposed to direct pressure fluid rearwardly along the exterior of said housing, said exhaust port bore being uncovered by said hammer as it approaches the limits of its forward and rearward strokes.

3. A tool as set forth in claim 1 wherein a bushing is secured to the forward end of said housing, said bushing serving to guide and support said tappet, means defining a transverse face at the forward end of said bushing, said face adapted to be contacted by a complementary face of a bit attached to said tappet to crush cuttings falling between said faces.

4. A tool as set forth in claim 1 wherein said tube is provided with at least one port intermediate its ends disposed to be closed by said hammer in its normal operating stroke, said hammer disposed to move forwardly of its normal stroke position when said tool is removed from a work surface wherein said tube port is uncovered and pressure fluid directed through said tube passes through said port, said chamber rearwardly of said hammer, and said exhaust means to provide continuous hole cleaning air.

5. A tool as set forth in claim 1 wherein said exhaust means comprises at least two axially spaced ports directly communicating said chamber with the exterior of said housing and disposed to direct pressure fluid rearwardly along the exterior of said housing, said exhaust ports being uncovered respectively by said hammer as it approaches the limits of its forward and rearward strokes.

6. A tool as set forth in claim 5 wherein said tube is provided with at least one port intermediate its ends disposed to be closed by said hammer in its normal operating stroke, said hammer disposed to move forwardly of its normal stroke position when said tool is removed from a work surface wherein said tube port is uncovered and pressure fluid directed through said tube passes through said tube port, said chamber rearwardly of said hammer, and the rearwardmost of said exhaust ports to provide continuous hole cleaning air.

7. In a pressure fluid operated tool of the percussion type comprising a tubular housing adapted for connection at its rearward end to a source of pressure fluid, valve means disposed adjacent to the rearward end of said housing, a tappet mounted at the forward end of said housing for limited axial movement and adapted to receive a drill bit, a hammer having an axial bore therethrough reciprocable in said housing within a chamber defined by said valve means and said tappet, means for exhausting pressure fluid from said chamber, said tappet having a stepped axial bore comprising a small bore at its rearward end and a large bore forward of said small bore, a tube having a diameter corresponding to that of said hammer bored into said small tappet bore, said tappet bore being uncovered by said valve means and extending through said hammer bore into the tappet bore, said valve means being pressure fluid operated to direct pressure fluid alternatively to said chamber rearwardly of said hammer and through said tube, said tube having a reduced diameter portion adjacent its forward end, said tappet disposed to assume a rearwardmost position during drilling operation of said tool wherein said small bore coincides axially with said reduced diameter portion of said tube to permit pressure fluid directed through said tube to flow to said chamber forwardly of said hammer, and said tappet disposed to assume a forwardmost position when said tool is removed from a work surface wherein said small tappet bore seals the end of said tube to prevent reciprocation of said hammer.

8. A pressure fluid operated tool of the percussion type comprising a tubular housing adapted for connection at its rearward end to a source of pressure fluid, valve means including a reciprocable valve member supported adjacent to the rearward end of said housing, a tappet mounted at the forward end of said housing for limited axial movement and adapted to receive a drill bit, a hammer having an axial bore therethrough reciprocable in said housing within a chamber defined by said valve means and said tappet to engage the rearward end of said tappet, means for exhausting pressure fluid from said chamber, said tappet having a stepped axial bore comprising a small bore at its rearward end and a large bore forward of said small bore, a tube having a diameter corresponding to that of said hammer bore and said small tappet bore supported at its rearward end by said valve means and extending through said hammer bore into the tappet bore, said valve means being pressure fluid operated to direct pressure fluid alternatively to said chamber rearwardly of said hammer and through said tube, said tube having a reduced diameter portion adjacent its forward end, said tappet disposed to assume a rearwardmost position during drilling operation of said tool wherein said small bore coincides axially with said reduced diameter portion of said tube to prevent reciprocation of said hammer.
prevent flow of pressure fluid to said chamber forwardly of said hammer.

9. A pressure fluid operated tool of the percussion type comprising a tubular housing adapted for connection at its rearward end to a source of pressure fluid; valve means including a reciprocable valve member supported adjacent to the rearward end of said housing; a tappet mounted at the forward end of said housing for limited axial movement and adapted to receive a drill bit; a hammer having an axial bore therethrough reciprocable in said housing within a chamber defined by said valve means and said tappet to engage the rearward end of said tappet; said housing having a plurality of exhaust ports disposed to direct pressure fluid directly from said chamber and rearwardly along the exterior of said housing; some of said exhaust ports disposed to be uncovered by said hammer as it approaches its rearward stroke limit, and some as it approaches its forward stroke limit; said tappet having a stepped axial bore comprising a small bore at its forward end, and intermediate bore at its rearward end and a large bore intermediate its ends; a first tube, having a diameter corresponding to that of said hammer bore and said intermediate tappet bore, supported at its rearward end by said valve means and extending through said hammer bore into the tappet bore; said first tube having a reduced diameter portion adjacent its forward end and having a plurality of ports intermediate its ends; said tube ports disposed to be closed by said hammer in its normal operating stroke; said valve member disposed in one position thereof, to direct pressure fluid to said chamber rearwardly of said hammer and, in another position thereof, to direct pressure fluid to said first tube; a second tube secured at the rearward end of said housing and extending through said first tube into said small tappet bore for conducting hole cleaning pressure fluid to said bit; said tappet disposed to assume a rearwardmost position, during drilling operation of said tool, wherein said intermediate bore coincides axially with said reduced diameter portion of said first tube to permit pressure fluid directed through said first tube to flow into said large tappet bore, through said intermediate tappet bore, and into said chamber forwardly of said hammer; said tappet disposed to assume a forwardmost position, when said tool is removed from a work surface, wherein said intermediate bore seals the end of said first tube to prevent normal operation of said hammer; and said hammer disposed to move forwardly of its normal stroke position, when said tool is removed from a work surface, wherein said tube ports are uncovered and pressure fluid directed through said first tube passes through said tube ports and said chamber rearwardly of said hammer to provide continuous hole cleaning pressure fluid through some of said exhaust ports.

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