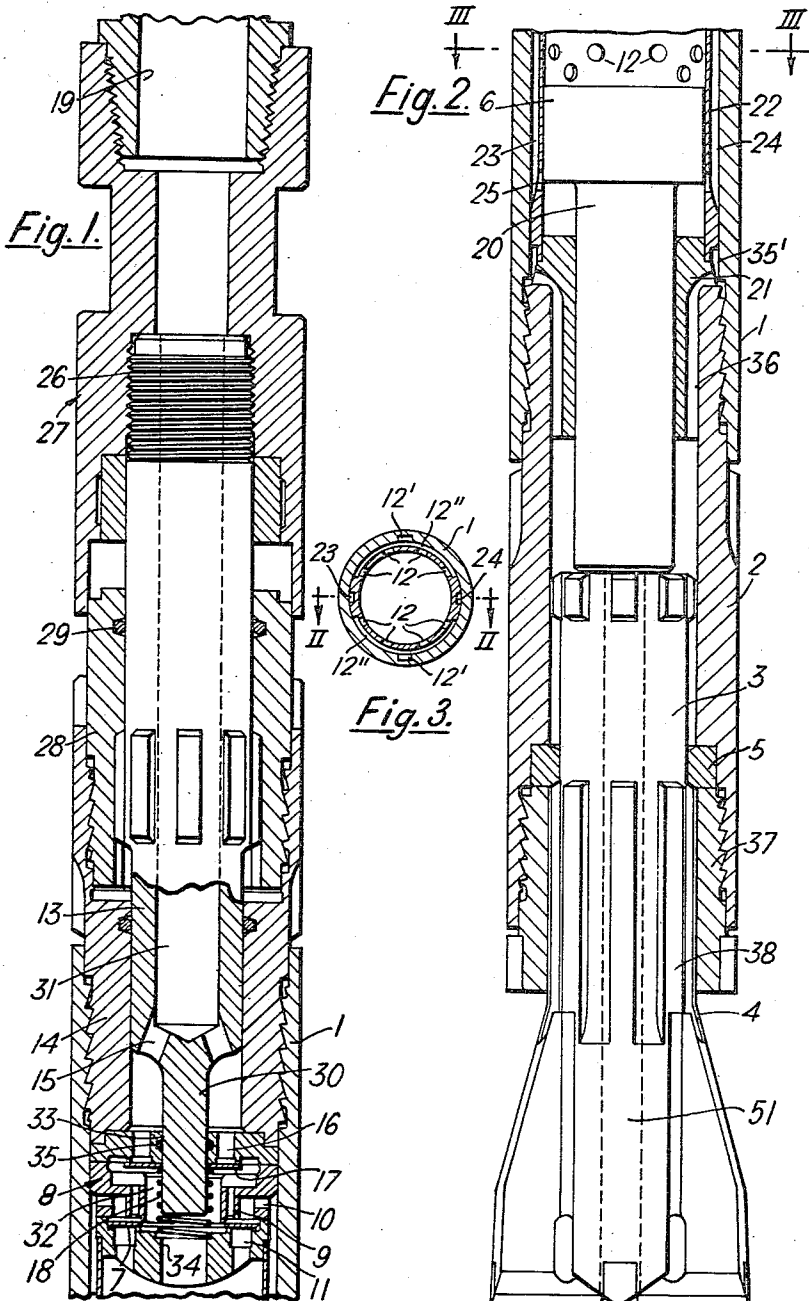


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A. P. C. STENUICK
ROCK DRILLING APPARATUS

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Inventor

ANDRE PIERRE CAMILLE STENUICK

By *Kurt Zelman*
AGENT

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ROCK DRILLING APPARATUS

Andre Pierre Camille Stennick, Fontaine l'Evêque, Belgium, assignor to Halifax Tool Company Limited, Halifax, England, a British company

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This invention concerns a pneumatically operated percussive hammer for rock drilling or like boring apparatus or rigs, such hammer being of the kind (hereinafter referred to as "the kind specified") comprising a cylinder having at its operative end a part or chuck (hereinafter called a "chuck") adapted to receive the shank of a bit axially reciprocable in said chuck to an extent limited by retaining means (e.g. a retaining ring, pin or key) and the inner end of which bit is adapted to be struck repeated blows by a piston located within said cylinder and reciprocable axially therein by compressed air alternately applied to opposite ends of the piston under the control of a distributor valve located in a valve chest disposed towards that end of the cylinder remote from the said chuck, said distributor valve controlling at least two ports or sets of ports, one for supplying compressed air to one end of said piston and the other for supplying compressed air to the other end of the piston and the distributor valve being adapted to close these ports or sets of ports alternately automatically as the said piston reciprocates in the cylinder of the hammer and opens one or more exhaust ports alternately to the opposite ends of the piston.

It is desirable when using a hammer of the type specified to lead air, e.g. exhaust air or live air or both, under pressure continuously or pulsatingly to the bit-end of the hammer for discharge into a bore hole being drilled thereby to keep cuttings or debris (hereinafter called "debris") clear of the bit and to discharge it from the bore hole.

The requisite compressed air is conveniently supplied to the said hammer from a suitable compressor through appropriate conduit means which may include one or more drill tubes by which the hammer is carried.

The invention is especially applicable to down-the-hole drilling equipment of the form described in U.S. Patent No. 2,823,013.

The said retaining means permits an axial movement of the bit in its chuck considerably greater than the bit makes in normal operation, and when a pneumatically operated percussive hammer of the kind specified is in normal use, the resultant reaction thrust of the ground on which the bit is acting plus the forward or downward thrust of the hammer, maintains the bit in proper relation with the hammer cylinder and the reciprocable piston by which repeated impacts are applied to the bit. However, should the hammer be withdrawn or raised with respect to the ground for any reason, the bit may move outwardly with respect to the chuck until arrested by the said retaining means so that, as the hammer piston reciprocates inside the hammer cylinder, it will, on its repeated forward movements, travel further down the cylinder (i.e. towards the bit-end of the latter) than it normally should and will be liable to strike, and so damage, internal parts of the hammer which it would not ordinarily strike: this will particularly be the case where the hammer has been in use for some time and some degree of wear has taken place whereby air, which would otherwise form a cushion to retard the latter portion of the advance movement of the piston, may escape. Thus where the piston is, as it usually will be, furnished at the head of a shank which is guided in an internal bush within the cylinder, the head of the piston will be liable to strike the inner end of the bush and damage the same.

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The same sort of trouble may also arise should a substantial cavity in the rock or ground be met during the drilling operation (particularly in the case of vertical drilling) so that the hammer meets no resistance and tends to advance and so that the bit advances freely from the chuck until it is stopped by the said retaining means.

Furthermore where the hammer is withdrawn or lifted or a cavity is met as aforesaid, there is a tendency, due to vibration, for the bit to "bounce about" so that it may be struck occasional blows by the reciprocating piston which will drive the bit against the bit retaining means (e.g. the retaining ring, pin or key) and cause failure of this part with the consequential loss of the bit down the hole.

It is an object of this invention to provide, in a pneumatically operated percussive hammer of the kind specified, means for automatically arresting the reciprocation of the hammer piston should the normal thrust on the bit be relieved and the bit be permitted to move freely forwardly relatively to the chuck of the hammer to an extent greater than that which is customary in the normal functioning of the hammer.

According to this invention there is provided a pneumatically operated percussive hammer for rock drilling or like boring apparatus and of the kind specified, such hammer including by-pass valve means for by-passing compressed air past the distributor valve of the hammer to one end of the cylinder of the latter, and means adapted automatically to open said by-pass valve means so that compressed air will automatically be supplied to or predominantly to one end of the said hammer piston so as to retain such piston at one end of the said cylinder and against reciprocation in such cylinder whenever the bit of the hammer is, during operation, relieved of the normal resultant thrust thereon and until normal operating conditions are restored.

The bit will usually be relieved of the normal resultant thrust during the operation of the hammer if the latter is withdrawn or lifted with respect to a bore hole or if the hammer encounters a cavity during the drilling operation.

Should abnormal conditions such as above referred to arise during normal working operations and it should thus become necessary automatically to arrest the reciprocation of the hammer piston, it is very desirable that the supply of air under pressure to the bit-end of the hammer for discharging debris from the bore hole should nevertheless be maintained in order to prevent the debris falling back into the bore hole and causing a blockage. Therefore, according to a further feature of the invention, provision is made whereby even when the compressed air supplied to the hammer is by-passed primarily to one end of the hammer piston to retain it in an end position against reciprocation, some compressed air will also be delivered to the bit-end of the hammer for debris clearing purposes.

Preferably it is to the back end (i.e. the end remote from the bit) of the hammer piston to which the said by-passed compressed air is supplied so that the piston will be maintained in its advanced position by such air.

The invention is especially applicable to a pneumatically operated percussive hammer of the kind specified and in which a shock absorber piston is provided coaxially in, or coaxial with, that end of the hammer cylinder remote from the bit and for axial sliding movement with respect to such cylinder, the said valve chest thus being located between the shock absorber piston and the hammer piston and the shock absorber piston having port means through which compressed air may be supplied to the valve chest, preferably via a non-return or check valve independent of the distributor valve, said shock absorber piston being adapted, when the hammer is in use, for attachment to

the leading end of the said drill tube or tubes by which the hammer is carried.

According to a further feature of the invention, where the hammer is furnished with a shock absorber piston as above described, the said by-pass valve may be so associated therewith that, on relative axial withdrawal movement taking place between the shock absorber piston and the hammer cylinder due to the initiation of the withdrawal of the drill tubes immediately preparatory to the withdrawal of the hammer from the bore hole, or due to the uncontrolled advancement or falling of the hammer due to it meeting a cavity during drilling, the said by-pass valve means are automatically opened to admit compressed air to the hammer cylinder in order to retain the hammer piston inactive at one end, preferably the forward end thereof as above described.

In order that the nature of the invention may be more readily understood, the same will now be described, by way of example, as applied to a pneumatically operated percussive hammer for rock drilling and like boring purposes and of the kind specified, such hammer being described with reference to the accompanying drawings in which:

FIGURE 1 shows mainly in axial section the upper part of a pneumatic percussive hammer constructed in accordance with this invention;

FIGURE 2 is a similar view to FIGURE 1 but shows the lower part of the same hammer as is shown partly in FIGURE 1, the view being in section on the line II—II in FIG. 3; and FIGURE 3 shows the apparatus of FIG. 2 in section on the line III—III.

In describing this embodiment of the invention and in the claims the apparatus will be regarded as being in such a position that the pneumatic percussive hammer and the drill tube or tubes by which it is carried occupy a vertical position with the percussive hammer at the lower end of the lowermost drill tube.

Referring to the drawings it will be seen that the pneumatically operated percussive rock drilling hammer illustrated in FIGURES 1 and 2 comprises a cylinder 1 having at its operative end a chuck 2 adapted to receive the shank 3 of a bit 4 axially reciprocable in said chuck to an extent limited by a split retaining ring 5 or by a retaining pin or key (not shown). The inner end of the shank 3 of the bit 4 is adapted to be struck repeated blows by a piston 6 located within the cylinder 1 and reciprocable axially therein by compressed air alternately applied to opposite ends of the piston under the control of a distributor valve 7 located in a valve chest 8 disposed toward that end of the cylinder 1 remote from the chuck 2, said distributor valve controlling outlet ports 9 and 10 for supplying compressed air to the lower end of the piston 6 and another set of outlet ports 11 for supplying compressed air to the upper end of the piston 6, the distributor valve 7 being adapted to close these sets of outlet ports alternately automatically as the said piston reciprocates in the cylinder of the hammer and opens exhaust ports 12 in turn to the opposite ends of the pistons 6. A tubular shock absorber piston 13 is provided coaxially in a shock absorber case 14 screwed coaxially into the upper end of the hammer cylinder 1, the shock absorber piston being axially slidable with respect to the cylinder 1 and being located at the opposite end of the valve chest 8 to the hammer piston 6 and having port means 15 through which compressed air may be supplied to the valve chest 8 through inlet ports 16 in the latter controlled by a check valve 17 which is independent of the distributor valve 7 and which is urged to its closed position by a compression spring 18 within the valve chest, said shock absorber piston 13 being adapted, when the hammer is in use, for attachment to the leading end of a drill tube 19 or string of such drill tubes by which the hammer is carried and the upper end of which tube or tubes is connected to a hammer rotating motor (not shown) mounted on a carriage for vertical adjustment

on the mast of the drilling apparatus as described for example in U.S. Patent No. 2,823,013 or U.S. Patent No. 2,895,715.

The hammer piston 6 has a coaxial shank 20 at its lower end which slides through a bush 21 mounted in the lower end of the hammer cylinder 1 above the bit shank 3 and the hammer piston 6 reciprocates in a cylindrical liner 22 within the hammer cylinder 1 and along the outer surface of which liner are formed axially elongated passages 23 and 24 communicating at their lower ends with radial inlet ports 25 located in the lower part of the said liner, and at their upper ends with lateral portions of the ports 10 leading from the valve chest 8 secured in the upper portion of the hammer cylinder between the liner 22 and the tubular shock-absorber case 14.

The upper end 26 of the shock absorber piston 13 is screw-threaded to screw into the lower part of an adaptor 27 for connection to the lower end of the drill tube 19.

An internally splined shock absorber bush 28 is screwed into the upper end of the shock absorber case 14 and the shock absorber piston 13 (which is corresponding splined) has its upper part passing through a fluid-tight seal 29 in the upper end of this bush. The splines of the shock absorber piston in co-operation with those in the shock absorber bush 28 serve to ensure that the hammer cylinder 1 rotates with the drill tube 19 and also to limit the axial movement permitted to the shock absorber piston with respect to its case and consequently with respect to the hammer cylinder and valve chest.

At its lower end, the shock absorber piston is of reduced diameter so as to provide a coaxial cylindrical plunger valve 30 which constitutes the male part of a by-pass valve. The aforementioned ports 15 of the shock absorber piston lead from the bore 31 of the latter and diverge downwardly, the arrangement thus being such that compressed air supplied through the rotating motor shaft and down the drill tube or tubes 19 and axially through the bore 31 of the shock absorber piston, will be discharged from the latter through the ports 15 around the plunger valve 30 and above the valve chest 8.

The valve chest 8 comprises a generally cylindrical body formed in a plurality of parts shaped to define between them a central cavity 32 and the hereinbefore mentioned ports 9, 10, 11 and 16 and the upper and lower ends of the chest are respectively furnished with a central coaxial bore 33 and a coaxial bypass bore 34 in which bores the plunger valve 30 on the shock absorber piston is a close sliding fit and the lower of these bores constituting a valve seat for the plunger valve which is fluid-tightly sealed in the central bore 33 by a surrounding O-ring 35 or equivalent means.

The ports 16 are arranged as a series around, but radially spaced from, the central bore 33 in the upper end of the valve chest, the lower ends of the ports 16 being closable by the check valve 17 which is of annular form and is slidable upwardly and downwardly along that portion of the plunger valve 30 which protrudes axially into the cavity 32, the spring 18 for closing this check valve being arranged around the said plunger valve and bearing at one end on the underside of the check valve and at the other end upon the bottom of the major cavity 32 of the valve chest. The check valve 17 serves to prevent the reverse flow of air from the valve chest through said ports 16.

When the hammer is operating normally with a resultant thrust applied to the bit, the plunger valve 30 projects into and closes the central bore 34 in the lower end of the valve chest 8. Compressed air passing down the centre of the shock absorber piston and through the ports 15 depresses the check valve 17 and passes into the cavity 32 in the valve chest for distribution alternately to the upper and lower ends of the hammer cylinder. The distributor valve 7 is of annular form and coaxial with the bore 34 of the valve chest 8, the valve being free for free rising and falling within the valve chest.

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The valve 7 is adapted to open and close the ports 9 and 10 alternately with the ports 11 as the piston 6 rises and falls, the compressed air flowing into the hammer cylinder to the space above the hammer piston head via the ports 11 when the distributor valve is raised due to the pressure below the valve exceeding that above it, and flowing into the hammer cylinder below the hammer piston head through the ports 9 and 10, when the distributor valve moves to its lower position on the air pressure above it exceeding that below it. As above explained the ports 10 communicate, via the aforementioned passages 23 and 24 in the liner 22 of the cylinder, with series of radial inlet ports 25 at the lower part of the liner 22 and which serve to admit air to the interior of the liner below the lower end of the hammer piston 6.

It will be appreciated that compressed air is alternately admitted to opposite ends of the piston 6 so that the piston rises and falls in rapid succession, the lower end of the shank 20 of the piston striking the upper end of the shank 3 of the bit 4 of the hammer each time the piston descends.

In the cylinder liner are arranged ports 12 connected by ducts 12' through which air in the hammer cylinder is exhausted from the cylinder respectively towards the end of the downward and upward strokes of the hammer piston, this exhaust air being conducted through axial channels 12' in the walls of the hammer cylinder from the ducts 12', the channels communicating with an annular space 35' around the piston shank guide bush 21 and along longitudinal channels 36 in the outer wall of the latter, down the interior of the bit chuck 2, and down an axial bore 51 in the bit 4 to the vicinity of the operating end of the bit in order to clear debris from the bore hole during the drilling operations.

Alternatively, or additionally, the exhausted air may be conducted to the vicinity of the operating end of the bit by passing it between splines around the shank 3 of the bit and via channels through an internally splined chuck bush 37 screwed into the lower end of the bit chuck 2. This chuck bush 37 retains the split ring 5 in position in the latter as well as co-operating with the splines 38 along the bit shank 3.

Should the shock absorber piston 13 be withdrawn with respect to the hammer cylinder, e.g. by the shock absorber piston being raised with the drill tube or tubes 19 or by reason of the hammer entering a cavity during drilling and falling with relation to the shock absorber piston, the plunger valve 30 on the shock absorber piston will be withdrawn from its valve seat or bore 34 in the lower end of the valve chest so that the distributor valve 7 will be, as it were, short circuited so that compressed air will then be permitted free flow from the major cavity 32 of the valve chest 8 directly into the upper end of the hammer cylinder effectively to hold the hammer piston down in its lower position and to stop it reciprocating, only a relatively restricted flow of compressed air being permitted in these conditions through the exhaust ports 12 for discharge at the operating end of the hammer for maintaining debris evacuation at the bit and for preventing the sucking of such debris, sludge or the like into the hammer.

It will be appreciated that even with the movement of the hammer piston arrested as above described a sufficient flow of air to the vicinity of the operating end of the hammer will be available to maintain the bit of the hammer clear of debris in normal conditions and so prevent the blocking of the operation of the hammer whilst this is not operating and until the plunger valve 30 is returned into the valve seat or bore 34 and the normal operation of the hammer is resumed.

I claim:

1. A pressure-fluid operated percussive boring apparatus comprising, in combination

(a) drill tube means having an axis;

(b) hammer cylinder means mounted on said drill

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tube means for limited movement relative to said drill tube means in the direction of said axis, said hammer cylinder means defining therein a cavity elongated in said direction and carrying drill bit means, said drill tube means and hammer cylinder means constituting the support members of said apparatus;

(c) hammer means in said cavity and dividing the same into two longitudinal portions, said hammer means being reciprocable in said cavity in said direction for actuating movement of said drill bit means away from said drill tube means in said direction;

(d) a source of fluid under pressure;

(e) distributor valve means secured to one of said support members and formed with an inlet conduit communicating with said source, and with two outlet conduits respectively communicating with said portions of said cavity, said valve means being responsive to pressure differences in said conduits for alternately connecting said inlet conduit with a respective outlet conduit;

(f) by-pass valve means communicating with said inlet conduit and one of said outlet conduits, said by-pass valve means including two members respectively connected to said support members for joint movement therewith toward and away from an open position of said by-pass valve means members in which said by-pass valve means connects said inlet conduit and said one outlet conduit; and

(g) exhaust means for exhausting said cavity.

2. An apparatus as set forth in claim 1, wherein said exhaust means include an exhaust conduit having an orifice in said cavity and another orifice in said drill bit means for discharge of pressure fluid from one of said cavity portions through said drill bit means.

3. Apparatus according to claim 1 wherein the drill bit means carried by said hammer cylinder means includes a chuck adapted to receive and retain a bit, said reciprocable hammer means includes a piston arranged for striking a bit received by said shank, said hammer cylinder means includes a valve chest above said piston, said distributor valve means being mounted in said valve chest and adapted to control the admission of said fluid alternately to the upper and lower sides of said piston to reciprocate the latter, a shock absorber piston located above said valve chest and capable of limited axial movement relative to said hammer cylinder means, said shock absorber piston having passage means for the flow of said fluid therethrough, and adaptor means connecting the shock absorber piston to said drill tube means for supporting the hammer and supplying said fluid to the latter, and wherein said by-pass valve means members are constituted by said shock absorber piston and said valve chest.

4. Apparatus according to claim 3 wherein said members of said by-pass valve means include a plunger valve on said shock absorber piston and a by-pass bore portion of the said valve chest adapted to receive said plunger valve.

5. Apparatus according to claim 4, wherein said plunger valve comprises a coaxial reduced extension of said shock absorber piston and projecting centrally into said valve chest for axial sliding movement therein, sealing means around said plunger valve adjacent its entrance to said valve chest, said by-pass bore portion being formed with an axial bore located in the end of said valve chest remote from said shock absorber piston and adapted to sealingly receive said plunger valve, said axial bore connecting said inlet conduit with said one portion of said cavity, and the discharge of said fluid from said inlet conduit to said cavity being controlled solely by said distributor valve means when said plunger valve is sealingly received in said axial bore.

6. Apparatus according to claim 3, wherein the valve chest includes a non-return check valve through which said fluid may pass from said source to said valve chest

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but which bars the return of fluid to the shock absorber piston.

7. For use in a pressure fluid operated percussive boring apparatus including drill tube means, hammer cylinder means mounted on said drill tube means for limited axial movement thereon, said hammer cylinder means defining a cavity therein and carrying drill bit means, hammer means in said cavity and dividing the same into two portions, said hammer means being reciprocable in said cavity for actuating movement of said drill bit means in a direction away from said drill tube means, a source of fluid under pressure communicating with said drill tube means, said drill tube means and hammer cylinder means constituting the supporting members of said apparatus, and means for exhausting said cavity; in combination,

- (a) first valve means formed with an inlet conduit and two outlet conduits, and responsive to pressure differences in said conduits for alternately connecting said inlet conduit with respective outlet conduits;
- (b) means for securing said first valve means to one of said support members for communication of said

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inlet conduit with said source, and for respective communication of said outlet conduits with said portions of said cavity;

- (c) second valve means communicating with said inlet conduit and one of said outlet conduits, said second valve means having two portions movable relative to each other toward and away from a position in which said second valve means connects said inlet conduit to said one outlet conduit; and
- (d) means for respectively securing said portions of said second valve means to said support members for movement toward and away from said position when said hammer cylinder means moves on said drill tube means.

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