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## Description

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This invention relates to rock drilling equipment and is particularly concerned with rock drills of the down-the-hole type where the drill is secured to a first tube down which compressed air is passed to activate the drill, as many tubes as are required being successfully secured to a preceding tube to allow a hole to be drilled to the depth required.

Still more particularly, the present invention relates to the type of drill disclosed for example in U.S. Patent Specifications 3085555 and 3198264 incorporating a flap valve to allow the application of compressed air through appropriate porting to one side or the other of a piston which can thus be reciprocated within its cylinder to repeatedly strike the end of a drill bit secured to the drill.

- 10 reciprocated within its cylinder to repeatedly strike the end of a drill bit secured to the drill. Hitherto such drills have been designed to operate at a particular air pressure and accordingly there are currently available drills intended for operation with either a low pressure or a high pressure air supply. This has the disadvantage that if on a particular site the compressed air availability does not suit the particular drill, then the effectiveness of the drill is considerably reduced.
- 15 It is therefore one objective of the present invention to provide a drill of the type defined capable of being successfully operated over a wide range of air pressures. Rock drilling is by its very nature a particularly expensive exercise because of the need to employ such cost capital plant, and obviously the more rapidly can a hole be drilled the less expensive does rock drilling become on a cost per hole basis. Considerable attention has been given to increasing the speed at which a
- 20 hole of a required diameter can be cut and despite the extensive attention that this problem has been given over a considerable number of years, drilling speeds, for practical purposes, have not been increased to any noticeable extent.

It is therefore a second object of the present invention to provide a drill capable of cutting holes at a considerably greater rate than has been possible hitherto.

- 25 According to the present invention an air operated down-the-hole drill comprises a backhead for the connection of a drill to a source of compressed air, a wear sleeve secured to the backhead and a chuck adapted to retain a drill bit secured to the opposite end of the wear sleeve, there being within the wear sleeve an inner cylinder with a valve seat at one (inner) end of the cylinder having a valve stem extending into the cylinder and a piston within the cylinder reciprocable therein from one position where the valve
- 30 stem engages in a bore in the piston to a second position where a stem on the piston enters a bearing located in the cylinder and strikes a drill bit held within the chuck, characterised in that the dimensions of the piston are such that the ratio of the piston head diameter to its bore diameter is in the range 9.9/9.95 to 1, the ratio of the piston head length to the piston stem length is in the range 1.5/1.52 to 1, the ratio of the piston stem diameter is in the range 1.4/1.43 to 1 and the ratio of the piston
- 35 stem length to the length of the piston stem within the bearing at the point at which the piston strikes the drill bit is 1.4/1.45 to 1.

The weight of piston is obviously dictated by its size but the piston weight is believed to be equally critical. Thus, for example, with a 75 mm rock drill the piston weight should be in the range 2.5 kg to 2.53 kg. According to a further feature of the invention a rock drill of the type defined comprises a valve seat

- 40 wherein the ratio of the cross-sectional area of the part of the valve seat within the cylinder to the cross-sectional area of the stem of the valve seat is in the range 0.09/0.10 to 1, the ratio of the stroke length of the piston to the length of the stem of the valve seat is 0.87/0.88 to 1 and the ratio of the net internal length of the bearing to the stroke length of the piston is in the range 0.56/0.57 to 1.
- It has been found that with a down-the-hole drill constructed as defined above the drill has been successfully and unpredictably useable over a wide range of air pressures from as low of 6 to 7 bar to as high as 17 bar. Not only that, the cutting speeds of such drills in comparison with comparable drills known hitherto have shown a dramatic and unforseeable increase in cutting speed which during independent testing was from 30% to 60% faster than conventional drills. To exemplify this the following are three examples of comparative test hole drilling where, as is usual, two drills were run simultaneously as close
- 50 together as practical conditions would allow so that each drill was running through substantially identical substrate.

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Example 1

In a test drilling through granite having a crushing strength of 3522 kg/cm<sup>2</sup> using a compressed air pressure of 17 bar, a drill bit in accordance with the invention and carrying a 90 mm bit was compared with a conventional drill of U.S. origin carrying a 104 mm bit. In the test nine successive six foot lengths of tube were coupled on to each drill to drill a hole 16.46 m deep, and the time taken by each drill to cut the final 9.14 m taken. This experiment was conducted by the quarry operatives. The drill of the invention was found to cut the final 9.14 m of hole in 35 minutes whereas the drill of the prior art was found to take 53.6 minutes,

60 a breakdown of time per tube being given below:

| Tube No. | The drill of the invention | The drill of the prior art |
|----------|----------------------------|----------------------------|
| 5        | 8.8                        | 12.0                       |
| 6        | 6.5                        | 12.0                       |
| 7        | 6.1                        | 6.30                       |
| 8        | 7.3                        | 10.00                      |
| 9        | 6.3                        | 13.30                      |
|          | 35.0                       | 53.60                      |

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This showed the drill of the invention to be running 53.1% faster than the conventional drill.

### Example 2

In a test drilling through rock limestone having a crushing strength of 1409 kg/cm<sup>2</sup> to 2395 kg/cm<sup>2</sup> using a compressed air pressure of 11.5 bar a drill in accordance with the invention and carrying a 90 mm bit was compared with a second conventional drill also of U.S. origin also carrying a 90 mm bit. In tests six successive tubes of the lengths detailed below were coupled on to each drill to drill a hole 16.5 m deep and the time taken to drill the full length of the hole. This experiment was conducted by the quarry operatives. The drill of the invention was found to cut the hole in 41.5 minutes whereas the drill of the prior art was found to take 56.8 minutes. A breakdown of time per tube being given below:

|    | Tube No. | Length  | The drill of the invention | The drill of the prior art |
|----|----------|---------|----------------------------|----------------------------|
| 30 | - 1      | 3.34 m  | 8.8                        | 11.8                       |
|    | 2        | 3.04 m  | 8.0                        | 11                         |
|    | 3        | 3.04 m  | 8.2                        | 11.2                       |
| 35 | 4        | 3.04 m  | 8.0                        | 11                         |
|    | 5        | 3.04 m  | 7.2                        | 10.2                       |
| 40 | 6        | 0.61 m  | 1.3                        | 1.6                        |
|    |          | 16.11 m | 41.5                       | 56.8                       |

This showed the drill of the invention to be running 36.86% faster than the conventional drill.

45 Example 3

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In a test drilling through talc in a matrix of hard abrasive granite having a crushing strength of 3522 kg/cm<sup>2</sup> using a compressed air pressure of 5.7 bar a drill bit in accordance with the invention and carrying a 90 mm bit was compared with a conventional drill of German origin carrying a 83 mm button bit. In the test each drill was used to cut a hole of 5 metre depth with the successive application of standard tube lengths to each drill. This experiment was conducted by the quarry operatives, and the time for each drill to cut the hole to the required depth taken. With the drill of the invention the time was 42.8 minutes and with the drill of the prior art the time was 68.5 minutes. This showed the drill of the invention to be running 60.04% faster than the conventional drill.

One embodiment of the invention is illustrated in the accompanying drawing which is an exploded perspective view of a drill in accordance with the invention.

In the drawing a rock drill comprises a wear sleeve 1 at one (bottom) end of which is provided a chuck 2 to receive a drill bit (not shown), the drill bit being held by a retaining ring 3. Within the wear sleeve is a cylinder 4 having upper and lower ports 5, 6 the outer diameter of the cylinder and the inner diameter of the wear sleeve 1 being such that an annular gap is provided between them. At the bottom end of the cylinder there is provided an integral bearing 7 and within the cylinder is a piston 8, the piston having a stem 9 which engages in and is a close sliding fit with the bearing. At the opposite end of the cylinder there is provided an integral valve-seat 10 on which rests a flap valve 11 held in place by a pin 12, the integral seat 10 having a stem 13 which extends into the cylinder to be engaged by the bore 14 of the piston 8 which bore extends to ports 15 emerging in the piston stem 9. Through the valve seat 10 are two sets of passageways

16, 17 for selective closing by the flap valve 11, the passageways 16 extending directly through the valve seat to emerge in the cylinder alongside the stem 13, and the passageways 17 emerging at the side wall of the integral seat. Above the flap valve is a valve chest 18 having a through bore partially closed by an air metering plug 19 the valve chest being held in place by a spring 20 on which rests a check valve 21, the whole assembly being held in place with sealing rings 22 and a spacer 23 by a backhead 24 secured to the

- whole assembly being held in place with sealing rings 22 and a spacer 23 by a backhead 24 secured to the (top) end of the wear sleeve. At rest and in the absence of pressure air, and with the rock drill lifted clear of the ground, a drill bit secured in the chuck 2 slides downwardly until its inner end contacts the bit retaining ring. In this condition the piston is at rest with the shoulder between the piston 8 and its stem 9 resting on the bearing 7, and the
- 10 flap valve 11 is in a neutral position.

On the application of compressed air, air passes through the backhead 24 and passed the check valve 21, through the valve chest 18 and around both sides of the flap valve such that part of the air passes through the passageways 16 and into the inner cylinder, the remaining air passing through the passageways 17 to pressurise the annulus between the inner cylinder 4 and the wear sleeve 1, the ports 6 in

- 15 the inner cylinder in this condition being closed at the inner side by the piston head 8. The drill is then lowered until the bit contacts the ground thus pushing the bit rearwardly with respect to the chuck 2 until it contacts the piston stem 9 and lifts the piston 8 to open the ports 6 to provide air below the piston for the up stroke. Further relative movement causes the piston stem 9 to clear the integral bearing 7 when air passes down through the bearing 7 to emerge around the bit. The sudden drop in pressure below one side of the
- 20 flap valve causes the flap valve to tilt to close the passageways 17 such that all the incoming air then passes through the passageways 17 and into the cylinder as the piston, on its up stroke, is approaching top dead centre. The bore 14 in the piston then engages the stem 13 on the valve seat. The continued upward movement of the piston to top dead centre and the incoming air through the passageways 16 producing a pressure above the cylinder to generate the down stroke. During the down stroke and as the piston head
- 25 clears the valve seat stem 13, the air above the piston chases down through the piston bore causing a pressure drop and a tilting of the flap valve 11 to close the passageways 16, open the passageways 17 thereby causing pressure air to pass down the annulus between the cylinder 4 and the wear sleeve 1 to enter the cylinder through the ports 6 to load the cylinder below the piston. As the piston approaches bottom dead centre the pressure air has a cushioning effect not sufficient to prevent the piston from
- *so* reaching bottom dead centre and striking by its stem 9 the drill bit in the chuck 2. After it has struck the drill bit, it rebounds and the pressure below the piston generates the up stroke and when the cycle is repeated for so long as pressure air is maintained.

By constructing the piston 8 and the integral valve seat 11 in accordance with the invention such a rock drill as has been demonstrated earlier in respect of the Examples operates at speeds which could not have

35 been predicted and these totally unexpected speeds result in a rock drill that operates with considerably greater cost efficiency than has been possible hitherto, and more than that is capable of operation over a range of air pressures which again has not been possible hitherto.

## Claims

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1. An air operated down-the-hole drill comprising a backhead (24) for the connection of a drill to a source of compressed air, a wear sleeve (1) secured to the backhead (24) and a chuck (2) adapted to retain a drill bit secured to the opposite end of the wear sleeve (1), there being within the wear sleeve (1) an inner cylinder (4) with a valve seat (10) at one (inner) end of the cylinder (4) having a valve stem (13) extending

- 45 into the cylinder (4) and a piston (8) within the cylinder (4) reciprocable therein from one position where the valve stem (13) engages in a bore (14) in the piston (8) to a second position where a stem (9) on the piston enters a bearing (7) located in the cylinder and strikes a drill bit held within the chuck (2), characterised in that the dimensions of the piston are such that the ratio of the piston head (8) diameter to its bore (14) diameter is in the range 9.9/9.95 to 1, the ratio of the piston head (8) length to the piston stem (9) length is in the range 1.5(4) 50 401.
- 50 the range 1.5/1.52 to 1, the ratio of the piston head (8) diameter to the piston stem (9) diameter is in the range 1.4/1.43 to 1 and the ratio of the piston stem (9) length to the length of the piston stem within the bearing (7) at the point at which the piston strikes the drill bit is 1.4/1.45 to 1.

2. An air operated down-the-hole drill as in Claim 1, wherein for a 75 mm rock drill the piston weight is in the range 2.5 kg to 2.53 kg.

3. An air operated down-the-hole drill as in Claim 1 or Claim 2, characterised by a valve seat (10) wherein the ratio of the cross-sectional area of the part of the valve seat (10) within the cylinder (4) to the cross-sectional area of the stem (13) of the valve seat is in the range 0.09/0.10 to 1, the ratio of the stroke length of the piston (8) to the length of the stem (13) of the valve seat is 0.87/0.88 to 1 and the ratio of the net internal length of the bearing (7) to the stroke length of the piston is in the range 0.56/0.57 to 1.

# Patentansprüche

1. Eine luftbetätigte Abwärts-Gesteinsbohrmaschine mit einem hinteren Kopfteil (24) für den Anschluß einer Bohrmaschine an eine Druckluftquelle, mit einer am Kopfteil (24) befestigten Verschleißhülse (1) und 65 einem Bohrfutter (2) zum Festhalten eines Bohrmeißels am entgegengesetzten Ende der Verschleißhülse

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(1), wobei innerhalb der Verschleißhülse (1) ein Innenzylinder (4) mit einem an seinem einen (inneren) Ende ausgebildeten Ventilsitz (10) mit einem in den Zylinder (4) hineinragenden Ventilschaft (13) und einem im Zylinder (4) sitzenden Kolben (8) vorgesehen ist, wobei der Kolben im Zylinder zwischen einer Stellung, in welcher der Ventilschaft (13) in eine Bohrung (14) im Kolben (8) eingreift, und einer zweiten Stellung

- verschiebbar ist, in welcher ein am Kolben sitzender Schaft (9) in ein im Zylinder angeordnetes Lager (7) eintritt und auf einem im Bohrfutter (2) festgehaltenen Bohrmeißel auftritt, dadurch gekennzeichnet, daß der Kolben derartige Abmessungen hat, daß das Verhältnis des Kopfdurchmessers des Kolbens (8) zum Durchmesser der Kolbenbohrung (14) 9,9 bis 9,95:1 beträgt, das Verhältnis der Länge des Kolbenkopfes zur Länge des Kolbenschaftes (9) 1,5 bis 1,52:1 beträgt, das Verhältnis des Durchmessers des Kolbenkopfes (8)
- 10 zum Durch messer des Kolbenschaftes 1,4 bis 1,43:1 beträgt und das Verhältnis der Länge des Kolbenschaftes (9) zur Eindringtiefe des Kolbenschaftes in das Lager (7) an dem Punkt, in welchem der Kolben auf den Bohrmeißel auftrifft 1,4 bis 1,45:1 beträgt.
  - 2. Eine luftbetätigte Abwärts-Gesteinsbohrmaschine nach Anspruch 1, dadurch gekennzeichnet, daß bei einem 75 mm-Gesteinsbohrer das Kolben gewicht 2,5 bis 2,53 kg beträgt.
  - 3. Eine luftbetätigte Abwärts-Gesteinsbohrmaschine nach Anspruch 1 oder 2, gekennzeichnet durch einen Ventilsitz (10), bei welchem das Verhältnis der Querschnittsfläche des Teiles des Ventilsitzes (10)
- innerhalb des Zylinders (4) zur Querschnittsfläche des Schaftes (13) des Ventilsitzes 0,09 bis 0,10:1 beträgt, das Verhältnis der Hublänge des Kolbens (8) zur Länge des Schaftes (13) des Ventilsitzes 0,87 bis 0,88:1 und das Verhältnis der Netto-Innenlänge des Lagers (7) zur Hublänge des Kolbens 0,56 bis 0,57:1 beträgt.

#### 20 Revendications

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Perforatrice de fond de trou de forage à air comprimé, comprenant une tête arrière (24) destinée à raccorder la perforatrice à une source d'air comprimé, un manchon d'usure (1) fixé à la tête arrière (24) et un mandrin (2) adapté pour retenir un outil de forage fixé à l'extrémité opposée du manchon d'usure (1), et dans laquelle il est prévu, à l'intérieur du manchon d'usure (1), un cylindre intérieur (4) muni d'un siège de soupape (10) placé à une extrémité (extrémité intérieure) du cylindre (4) et possèdant une tige de soupape (13) qui s'engage dans le cylindre (4) et un piston (8) logé dans le cylindre (4) et pouvant se déplacer alternativement dans ce dernier entre une position, dans laquelle la tige (13) de la soupape est engagée

- 30 dans un alésage (14) du piston (8) et une deuxième position dans laquelle une tige (9) du piston est engagée dans une portée (7) logée dans le cylindre et frappe un outil de forage tenu dans le mandrin (2), caractérisée en ce que les dimensions du piston sont telles que le rapport du diamètre de la tête (8) du piston au diamètre de son alésage (14) est compris dans l'intervalle de 9,9 à 9,95/1, le rapport de la longueur de la tête (8) du piston à la longueur de la tige (9) du piston est compris dans l'intervalle de 1,5 à
- 1,52/1, le rapport du diamètre de la tête (8) du piston au diamètre de la tige (9) du piston est compris dans l'intervalle de 1,4 à 1,43/1 et le rapport de la longueur de la tige (9) du piston à la longueur de la tige de ce piston qui est contenue dans la portée (7), au point où le piston frappe l'outil de forage, est de 1,4 à 1,45/1.
  2. Perforatrice de fond de trou de forage à aîr comprimé selon la revendication 1, dans laquelle, pour un outil de forage du rocher de 75 mm, le poids du piston est compris dans l'intervalle de 2,5 kg à 2,53 kg.

3. Perforatrice de fond de trou de forage à air comprimé selon la revendication 1 ou la revendication 2, caractérisée par un siège de soupape (10) dans lequel le rapport de l'aire de la section de la partie du siège de soupape (10) contenue dans le cylindre (4) à l'aire de la section de la tige (13) du siège de soupape est compris dans l'intervalle de 0,09 à 0,10/1, le rapport de la longueur de la course du piston (8) à la longueur de la tige (13) du siège de soupape est de 0,87 à 0,88/1 et le rapport de la longueur intérieure nette de la portée (7) à la longueur de la course du piston est compris dans l'intervalle de 0,56 à 0,57/1.

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