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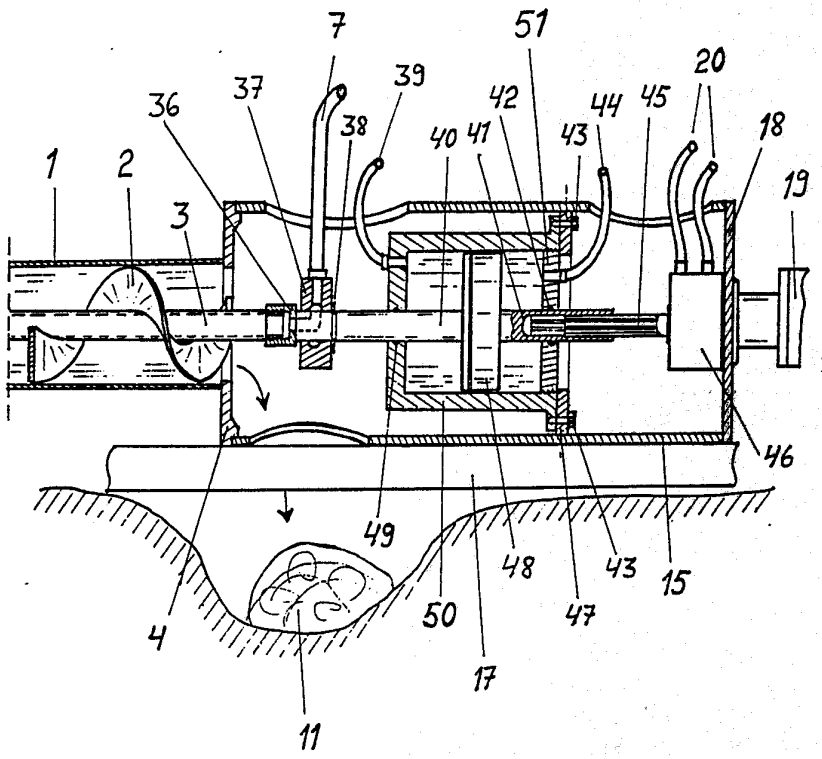

(57) Abstract

The invention relates to a tunnel drilling method by means of which a protecting (1) tube, which is to be installed in the tunnel, and a tunnel drilling tool are driven forward by one and the same power unit in the tunnel working pit so that the driving power of the unit is divided into a force driving the protecting tube and, over a rotating unit (3), into a force driving the drilling tool and that distribution of said force to the rotating unit is effected by a power transmitting thrust bearing (50).

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METHOD AND APPARATUS FOR DRILLING A TUNNEL

The invention relates to a method and apparatus for drilling a tunnel, wherein there are two independent forces; the one driving the protecting tube and the other driving the drilling apparatus by means of a rotating spiral tube.

Previously known drilling apparatus is a.o. the one in the applicant's former patent application No. FI-891706, by means of which the protecting tube is forced into the excavated tunnel portion as the tunnel advances. Also the force for the tool in the drilling head is transmitted over the protecting tube. The conveying drum rests against the inner surface of the protecting tube and moves foward along with the protecting tube. There is a thrust bearing in the drill head, and so the force over the protecting tube is transmitted entirely through the thrust bearing as a force for the tool forward drive.

In the solution presented in the US-patent 2,669,441 the tools and the thrust bearing are in the working pit. No protecting tube is driven into the tunnel but the force into the drill head is simply brought forward by a rotating conveyor pipe.

The disadvantage of the former solutions is lack of control of the force. On driving the drill head forward with the protecting tube, the required force changes as the length of the protecting tube grows and because of friction from different soil types. This means that the farther the drilling advances the more the information diminishes about the impact of tool force against he front wall of the tunnel and possible obstacles cannot then be detected. Therfore, the risk of tool damages is great. In the solution as per the US-patent publication No. 2,669,441 drilling is possible only in rock or soil that needs no protecting tube to support the tunnel.

By means of the method according to this invention a crucial improvment of the said disadvatages has been achieved. In order to put this into practice, the method and apparatus of this invention are characterized in what has been presented in the enclosed patent claims.

It can be considered the main advantage of this invention that the tool driving force, which is smaller than the force driving the protecting tube, is separated as an independent easily adjustable force. When the force has been separated by means of a hydraulic cylinder, which can yield because of pressure adjustment while functioning also as thrust bearing and therefore move freely in the longitude, the hit of tool in an obstacle can be detected immediately as rise of pressure in the hydraulic system.

In the following the invention is more closely described with reference to the enclosed drawings where

Fig. 1 is a driving and rotating unit in the working pit where the hydraulic cylinder functions as thrust bearing.

Fig. 2 is an optional driving and rotating unit placed in the working pit where the hydraulic cylinder functions as thrust bearing.

The solution in fig. 1 provides a hydraulic cylinder which functions as a thrust bearing (23) comprised of a piston (24) and a piston rod (26). The piston rod is a pipe through which the hydraulic pressure hoses (30,29) can be taken to the piston and conduct the pressure fluid to the chamber space on both sides of the piston. The cylinder is closed with a threaded ring flange (35). The cylinder itself is a rotating

drumlike part. The rotation is transmitted from the fluid motor (16) by means of a gear (25) which is attached to the cylinder with a broad gear (31). The pressure fluid enters the fluid motor (16) along the hoses (20). The cylinder (23) is encircled with an immobile annular part (22), inside of which the cylinder can rotate and also slide lengthwise. Part (22) is fixed to the actual frame (27) that conduits the driving force. The connecting surface between cylinder (23) and part (22) is a bearing area which also comprises an annular chamber space (32) into which compressed air is conducted through the air channels in the cylinder frame (23) over a hose (7) and further to rotating tubes (3). Tube (3) is fixed to the flange (21) by screwing. This flange transmits the rotation from cylinder (23) to the conveying tube (3). The bellow rubber (34) fixed to part (22) prevents the cylinder sliding surface from getting dirty. The oil in the compressed air lubricates the sliding surface and leakeage of compressed air is prevented with a retaining ring (33). The driving force to the tool from the conveying tube (3), which has a system of spiral ribs, is in this case transmitted over a hydraulic cylinder (24), which functions as thrust bearing, and can therefore be detected as hydraulic pressure in the hoses (29,30). Drilling waste (11) is removed through the openings in the frame (27) and between the frame beams (17) under the drilling unit.

The force driving the protecting tube (1) into the tunnel is transmitted from the power unit (19,28) direct over the rear frame (27) and its end flanges (18,4) to the protecting tube (1).

In figure 3 the cylinder part (50) in the thrust bearing is fixed to the frame (15) with a flange (47) and screws (43). Therefore the cylinder does not rotate but the piston (48) and

the piston rod (40) are rotating. The fluid motor (46) comprises a grooved shaft (45) which can move longitudinally in chamber (41) formed inside the piston rod (40). Correspongdingly, the chamber is also grooved to allow rotation. At piston rod rear end there is a threaded part(36) by means of which the tube (3) is fixed to the piston rod. Around the piston rod there is a not-rotating part (37) that comprises an annular chamber groove around the piston rod. Compressed air conducted to this chamber enters the piston rod through a pick-up hole at the chamber and then the conveying drum (3) from where it reaches the tool in the drill head. Lateral movement of part (37) on the piston rod is prevented by a ring spring (38) in the piston rod groove. The cylinder is closed with a flange (51) attached to the cylinder by screwing and joined to the piston rod with a packing (42) allowing its rotation and sliding. The lines (39,44) are hydraulic hoses and the other cylinder end is sealed with a retaining ring (49).

The rotating motion of the fluid motor can also easily be transmitted as a rotating motion for the piston rod (40) by connecting the motor shaft e.g. by means of a flange joint to a corresponding flange in the piston rod. The fluid motor must then be secured with respect to the frame (15) so that it can slide but not rotate. This can be done with conductors arranging them parallel to the frame and using them also as support for the motor.

This invention is not restricted to the embibodiments of prior art but it can be modified within the limits of the enclosed patent claims. The frame construction of the driving unit can be drumlike but, advantageously, also a beam construction.

PATENT CLAIMS

1. A method for drilling a tunnel, wherein the protecting tube (1) that has to be installed in the tunnel and the tunnel drilling tool/tools are driven forward with one or more power units (19) at the tunnel opening, the driving power of which is divided into a force driving the protection tube (1) and another force driving the tool by means of rotating means **characterized** in that the distribution of the driving power is provided in the hydraulic cylinder (23,50) which has the function of a thrust bearing.

2. A method according to patent claim 1 **characterized** in that at least the rotating part (23,48) of the thrust bearing can both rotate and move to the protecting tube (1) parallel with its longitudinal axis with respect to the frame (15,27) that transmits the driving force to the protecting tube.

3. A method according to patent claims 1 or 2 **chracterized** in that the shell surface of the hydraulic cylinder functioning thrust bearing works as bearing surface for both the rotation and the longitudinal movement.

4. A method according to one or more of the patent claims 1-3 **characterized** in that the outer shell surface of the hydraulic cylinder (23) is lubricated by the oil contained in the compressed air when said cylinder funtions also as a rotating connection for conduction of compressed air to the rotating tube (3).

5. An apparatus for ef cting the method according to claim 4, which is provided witn a driving power unit (19) placed in the tunnel working pit, protecting tubes (1), which are to be forced into the tunnel, and conveying tubes (3,2) to

drive and rotate the tool inside the protecting tubes and and also comprising a spiral ribbing (2), a center tube (3) and a thrust bearing, by means of which the driving force is transmited to the conveying tubes **characterized** in that the thrust bearing transmitting the rotating force is a hydraulic cylinder (23,50) yielding longitudinally against the hydraulic pressure.

6. An apparatus according to patent claim 5 **characterized** in that the rotating portion (23,40) of the thrust bearing is provided with a pick-up hole with air channels for conducting compressed air over an immobile tube (7) to the rotating tube (3).

7. An apparatus according to patent claims 5 and 6 **characterized** in that the hydraulic cylinder with its thrust bearing function (23) is provided with a hollow piston rod (26) along which the pressure hoses (29,30) are taken to the cylinder discharge chambers.

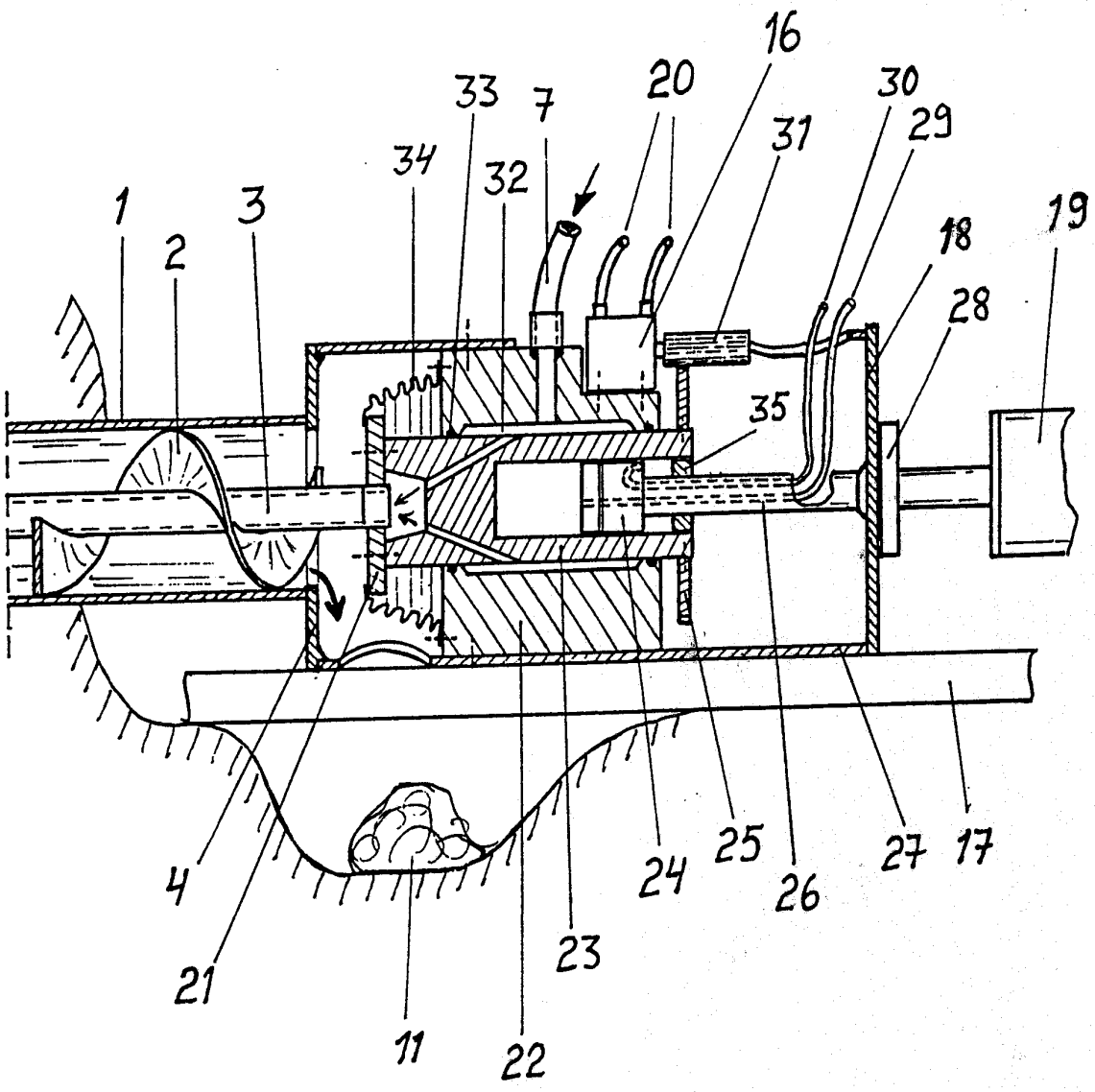

Fig. 1

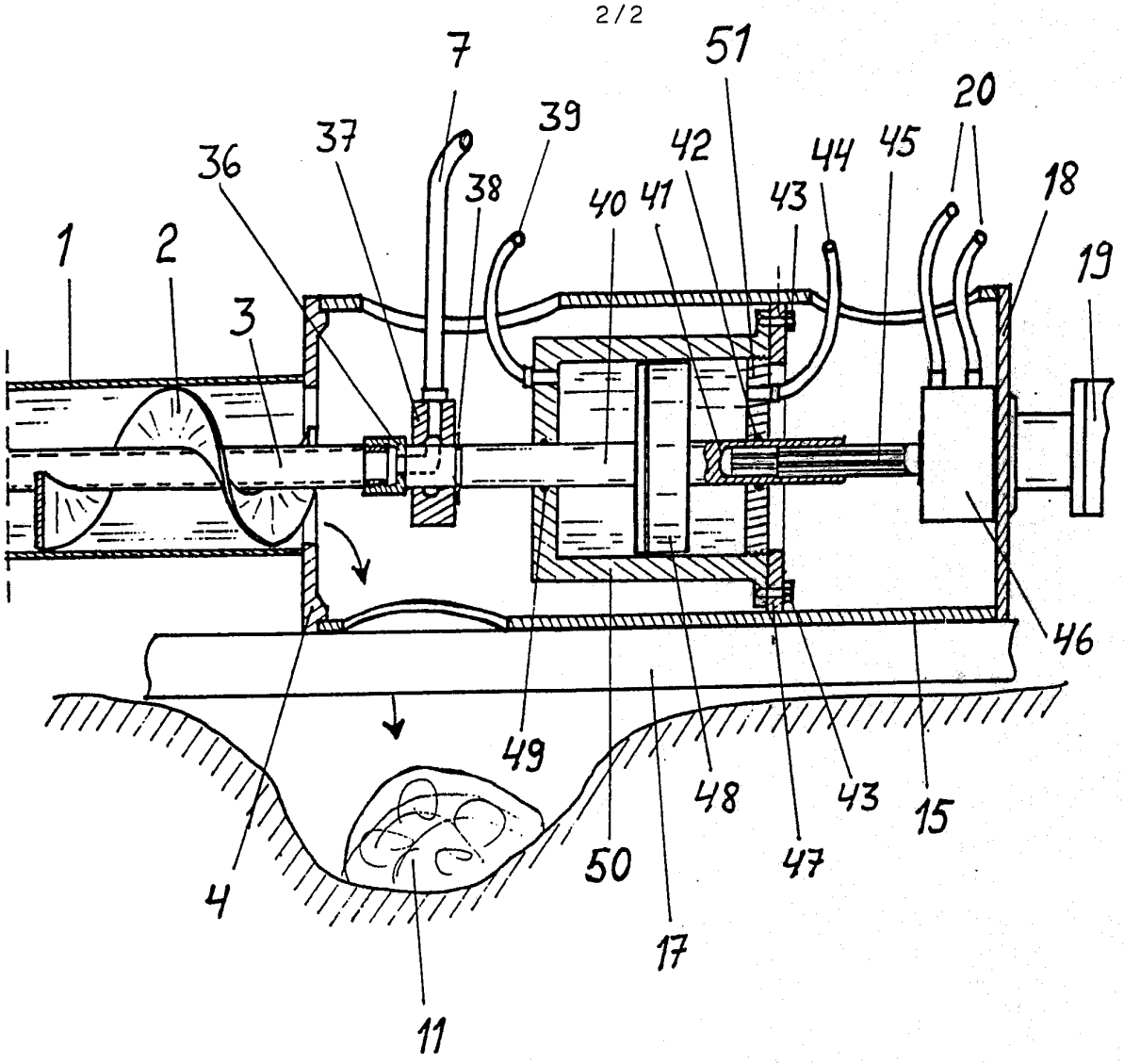
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Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 90/00231

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: E 21 D 9/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	E 21 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	US, A, 2669441 (A.F. CASTANOLI ET AL) 16 February 1954, see the whole document --	1-7

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th December 1990	1990 -12- 21
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Åke Olofsson

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 90/00231

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 90-11-01 The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2669441	54-02-16	NONE	