

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 May 2006 (04.05.2006)

PCT

(10) International Publication Number
WO 2006/046902 A1

(51) International Patent Classification:
F01P 7/02 (2006.01) *E21B 7/00* (2006.01)

(21) International Application Number:
PCT/SE2005/001549

(22) International Filing Date: 18 October 2005 (18.10.2005)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Data:
0402593-8 27 October 2004 (27.10.2004) SE

(71) Applicant (for all designated States except US): **ATLAS COPCO ROCK DRILLS AB** [SE/SE]; S-701 91 Örebro (SE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **JACOBSSON, Henrik** [SE/SE]; Getingeberg, S-694 95 Vretstorp (SE).

(74) Agent: **DR. LUDWIG BRANN PATENTBYRÅ AB**; Box 171 92, S-104 62 Stockholm (SE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

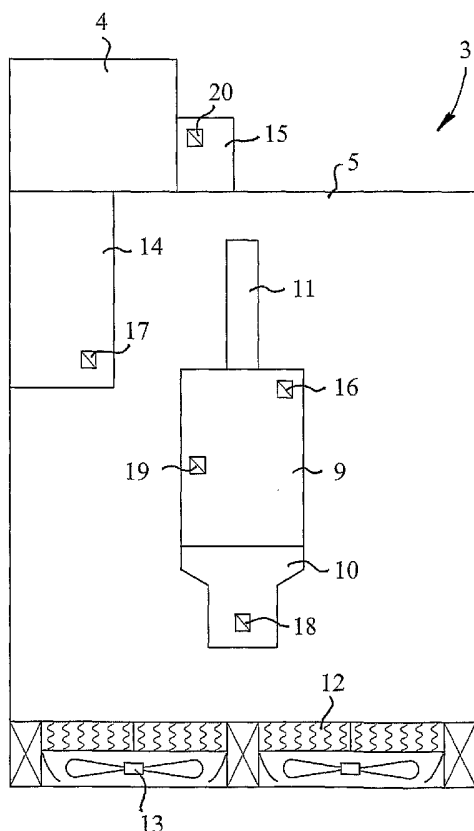
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

[Continued on next page]

(54) Title: A DRILL RIG AND A METHOD FOR CONTROLLING A FAN THEREI



(57) Abstract: The invention relates to a method for controlling at least one fan (13) for the regulation of the cooling demand of at least two cooling elements (12) comprised in a drill rig (1), the cooling demand of each one of the cooling elements (12) being determined, that the determined cooling demands are weighted together and that the fan (13) is controlled based on said weighting together. The invention is characterized in that at least one cooling element is equipped with a safety thermostat, which, if required, prevents undercooling by the fact that the fluid in question is not allowed to circulate in this cooling element. Furthermore, the invention also relates to a drill rig for the execution of the above-mentioned method.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A DRILL RIG AND A METHOD FOR CONTROLLING A FAN THEREIN

Technical Field of the Invention

This invention relates to a method for controlling at least one fan for the regulation of the cooling demand of at least two cooling elements comprised in a drill rig, the cooling demand of each one of the cooling elements being determined, that the determined cooling demands are weighted together and that the fan is controlled based on said weighting together.

10 The invention also relates to a drill rig comprising an engine, at least two cooling elements and at least one fan, a control unit being arranged to control the fan based on a weighting together, executed in the control unit, of current cooling demands in the cooling elements.

15

By drill rigs, in particular drill rigs for drilling in rock are intended and above all drill rigs for drilling in rock above ground.

20 Background of the Invention and Prior Art

The background of the present invention is the need of being able to provide cooling in a drill rig, or in a drilling unit, which is an established synonymous concept in the technical field, to all the cooling-dependent components that are arranged therein. By cooling-dependent components, for instance, engine, compressors and hydraulic-oil pumps are intended, as well as the fluids that circulate in the above-mentioned system and that run the risk of accumulating too much heat upon use. Said components with the appurtenant cooling elements and fans associated therewith are accommodated in an engine house arranged in the drill rig. The cooling elements consist, for instance, of an engine water cooler, a charge-air cooler, a hydraulic-oil cooler and a compressor cooler.

35 A generally recognized way to solve the above-mentioned problems is to place one or more fans, which presses or sucks air through cooling elements intended for the purpose. Previously, the fans have rotated at the highest rotation speed, highest

power, all the time the drill rig has been in operation, without regulation of the same and independently of the cooling demand of the components of the drill rig.

5 Frequently or always, the different cooling elements have different instantaneous needs of cooling air, which makes the fan, consequently more or less all the time, operating more than necessary in relation to the need for either of the cooling elements or even all cooling elements.

10

The problem with the above-mentioned way of controlling, or to be precise, not controlling the fans, is that the cooling elements that have lower cooling demand than what the fans provide run the risk of becoming overcooled, above all when the drill
15 rig is used in cold climates.

20

An additional disadvantage of letting the fan operate at a constantly high rotation speed (highest power) is that the sound level from the fans and thereby also the sound level in the driver's cab is pronounced.

Objects and Features of the Invention

25

The present invention aims at obviating the above-mentioned disadvantages of previously known fan controls and presenting an improved solution. A primary object is to present a fan control, which provides a more efficient and more adapted cooling for the cooling elements of the drill rig. A second object is to present a fan control, which allows drill rigs to be used in colder climates without the components included in the drill
30 rig running the risk of becoming overcooled. An additional object is to provide a drilling unit having closer-to-optimal temperature of the fluids that are in need of cooling. Still another object is to present a fan system being more silent in operation.

35

In a first aspect, this invention relates to a method of the type defined by way of introduction, which is characterized in that at least one cooling element is equipped with a safety thermostat, which, if required, prevents undercooling by the

fact that the fluid in question is not allowed to circulate in this cooling element. Preferred embodiments of the inventive method are further seen in the dependent claims 2 to 6.

5 In a second aspect, the invention also relates to a drilling unit according to claim 7 for execution of the method. Preferred embodiments of the inventive drill rig are further seen in the dependent claims 8 to 16. The advantage of said method and device is that the speed of rotation/effect of the fan is
10 adjustable, which entails that the air flow that passes through the cooling elements at each instant of time in a better way corresponds to the cooling demand that the same have at said instant of time. Thanks to the closer-to-optimal fluid temperatures with reduced temperature variations, the stress on the
15 components of the systems decreases, which increases the service life of the same. By regulating the rotation speed of the fan, so that it does not operate with constantly high rotation speed (highest power), also the sound level in and around the drill rig is lowered. A lower rotation speed of the fan further
20 entails a smaller power output from the engine and accordingly reduced fuel consumption.

Additional advantages and features of the invention are seen in the following, detailed description of preferred embodiments.

25

Brief Description of the Appended Drawings

Hereinafter, the invention will be described with an exemplifying purpose, reference being made to the accompanying drawings, in which:

30

Fig. 1 is a side view of a drill rig according to the invention,

35

Fig. 2 is a schematic, partially cut view from above of a carrier included in the drill rig, and

Fig. 3 is an alternative embodiment of the carrier corresponding to Figure 2.

Detailed Description of Preferred Embodiments

In Figure 1, a drill rig according to the invention is shown, generally designated 1. The drill rig 1 comprises a carrier 3 carried by a pair of caterpillars 2, or the like, and comprising a driver's cab 4 and an engine house-forming chassis 5. The engine house 5 is in no way tight but comprises holes and openings so that good circulation of air therein is allowed. In the front part of the carrier 3, a feeder 6 is arranged, which is carried by one or more bars 7 and which comprises a drilling equipment 8, which is carried by the bars 7. The radius of working and accessibility of the drill rig 1 is determined by the bars 7 and the drilling equipment 8, which are of conventional type.

Now reference is made primarily to Figure 2, in which a partially cut view from above of the carrier 3 of the drill rig 1 (a plurality of components are eliminated for the sake of clarity) is schematically shown. Centrally in the engine house 5, an engine 9 is arranged, preferably an internal combustion engine and in particular a diesel engine, which is connected to a compressor 10 and one or more hydraulic-oil pumps 11 for the supply of power to, for instance, the drilling equipment 8 of the drill rig 1. As these components or fluids associated therewith have substantial cooling demands, cooling elements 12 or coolers are further arranged in the rear part of the engine house 5, which coolers, for instance, consist of engine water coolers, charge-air coolers, hydraulic-oil coolers and compressor-oil cooler. The cooling elements 12 are connected to the respective unit in such a way that the fluids used in the units can circulate between the cooling elements 12 and the units. At the cooling elements 12, one or more fans 13 are arranged, which, in a preferred embodiment, are hydraulically driven, but alternatively they may, for instance, be driven pneumatically or electrically, i.e., the fans 13 may be arranged to be driven by a suitable power system present on the drill rig 1. Furthermore, a hydraulic-oil tank 14 is arranged in the engine house 5 and in a suitable way connected to the

hydraulic-oil pump 11 and remaining parts of the hydraulic-oil system.

In the embodiment shown, the fans 13 are located downstreams of the cooling elements 12, since it from a flow point of view, at a short distance, is easier to suck than press air between closely located cooling flanges. However, from a space point of view, it may be preferred to place the fans 13 upstreams of the cooling elements 12. In the same way, the design of the engine house 5 entails that the cooling elements 12 in the embodiment shown are divided into groups, more precisely two by two, with an individual fan 13 for each group. The cooling elements 12 may advantageously be divided into groups including cooling elements 12 having similar cooling demand in the respective group. In the embodiment example according to Figure 2, hence, it is advantageous to place the cooling elements 12 for the hydraulic oil and the compressor oil together and for the engine water and the charge air together.

Now reference is made also to Figure 3, in which an alternative embodiment of the carrier 3 of the drill rig 1 is shown. In this alternative embodiment, in contrast to Figure 2, the engine 9, the compressor 10 and the hydraulic-oil pumps 11 are transverse to the longitudinal direction of the drill rig 1 and placed in the rear part of the engine house 5. Furthermore, the cooling elements 12 are placed centrally in a group and with a common fan 13, located downstreams of the cooling elements 12. In addition, the location of the hydraulic-oil tank 14 has also been changed.

30

Common to the two alternative configurations in Figures 2 and 3 is that they comprise a control unit 15, which in the figures is outlined to be located near the driver's cab 4. The control unit 15 should be programmable and comprise a plurality of inputs and outputs for signal transfer. The control unit 15 may consist of an ordinary control unit in the drill rig 1 or of a specific control unit only for the control of the fan(s) 13. In addition, the control unit 15 may be located on any another suitable location than the one shown in the figures, for

instance on the proper engine 9. Furthermore, the drill rig 1 comprises a plurality of sensors to measure operating parameters, such as preferably temperatures, but also other quantities may be measured, such as power output or the like. The temperatures are measured, for instance, of the cooling fluids on suitable places in the respective system. A first sensor 16 is, for instance, located in the engine 9 or in the vicinity thereof in order to measure the temperature of the engine cooling water. A second sensor 17 is arranged to measure the temperature of the hydraulic oil, said second sensor 17 preferably being located in the hydraulic-oil tank 14. A third sensor 18 is located at the compressor 10 in order to measure the compressor-oil temperature. A fourth sensor 19 is located on a suitable place in order to measure the temperature of the charge air and a fifth sensor 20 is located in such a way that the same can measure the temperature of the surrounding air around the drill rig 1. Preferably, the measurement of the ambient temperature is carried out in front of the engine house 5, such as is outlined in the drawings, in order to get as correct and true a measuring as possible. This as a consequence of the warm air that is generated in the engine house 5 being blown out rearward from the same. All sensors 16-20 are in a suitable way operatively connected to the control unit 15 that controls the fans 13 in a suitable way. In the preferred embodiment, the sensors 16-20 are connected to the control unit 15 via electrical cabling (not shown), but also wireless or optic communication between the units is feasible.

In prior art, the fan that creates an air flow through the cooling elements is switched on if the drill rig is in operation. In other words, when the drill rig operates, the fan operates at a constantly high rotation speed (highest power). Characteristic of the drill rig 1 according to the invention is that the rotation speed of the fan 13 can be varied, within a range of from 0 % to 100 % of the requisite rotation speed, by the control of the same. The fan 13 according to the invention operates all the time when there is a cooling demand, but at a low rotation speed and only exceptionally at the highest rotation speed. The sound that arises during the operation of the

fans propagates through the construction and into the driver's cab 4 and creates, at highest rotation speed, noise inside the same, but by means of a regulated fan at a low rotation speed the noise decreases markedly, and furthermore the wear on the same decreases. A decreased power output also entails reduced fuel consumption.

The rotation speed of the fan is controlled or regulated by the control unit 15 based on the determined cooling demands or the temperatures in the cooling elements 12. More precisely, by the fact that the control unit 15 compares or weights together the cooling demands of the cooling elements 12 that constitute a group of cooling elements, after which the individual fan 13 is controlled based on the occurring cooling demand of the cooling elements 12 associated with the respective fan. It is advantageous to control the individual fan 13 that co-operates with the individual group of cooling elements 12 based on the greatest cooling demand among the cooling elements 12 in the group. However, it should be pointed out that also other suitable ways of weighting together the cooling demands are feasible in order to control the fans 13.

In order to determine the cooling demand of the charge-air cooler, also the ambient temperature is measured, since the maximally allowable the charge-air temperature is closely dependent on the ambient temperature, which gives better determination of the cooling demand and further additionally better precision in the control of the fan 13. Furthermore, also the cooling demand of the other cooling elements 12 can be more exactly defined with the knowledge about the ambient temperature.

Said sensors 16-20 need necessarily not consist of sensors specific to the object discussed above with the purpose of providing temperatures only for the fan control, but in certain applications and embodiments of the inventive drill rig 1, values from existing sensors may be used in the determination of the cooling demand of the various cooling elements 12. For in-

stance, the engine water temperature is frequently measured by already existing sensors.

In spite of the fans 13 providing a closer-to-optimal cooling of the cooling elements 12 according to the present invention, some kind of safety thermostats (not shown) should be comprised that make it impossible for the fluids in the different systems to be cooled below a certain limit value, more precisely by the fact that the fluid in question is not allowed to circulate in the cooling element of the same.

Feasible Modifications of the Invention

The invention is not only limited to the embodiments described above and shown in the drawings. Thus, the method as well as the drill rig may be modified in miscellaneous ways within the scope of the subsequent claims. It should be especially mentioned that the drill rig not necessarily has to comprise a cab but may still be controlled from a position outside the same. It should also be appreciated that each fan may consist of one or more fan elements. It should also be pointed out that even if the cooling elements are divided into groups, the individual fans do not need to have separate control but the fans may be mutually controlled. By way of introduction, it is mentioned that by drill rigs, in particular drill rigs for the drilling in rock above ground are intended, yet the invention is not limited to this but also drilling in other materials and operation below ground are feasible. It should be pointed out that by the expression, regulation of the cooling demand, both in the claims and in the detailed description, it is meant that the cooling demand of the cooling element can be regulated by letting the fan operate, for instance, at different rotation speed. More precisely, by the fact that a high fan speed entails a lower instantaneous cooling demand and a low fan speed entails a higher instantaneous cooling demand. Thus, the cooling demand should neither be too high or too low but is regulated to a suitable level.

Claims

1. Method for controlling at least one fan (13) for the regulation of the cooling demand of at least two cooling elements (12) comprised in a drill rig (1), the cooling demand of each one of the cooling elements (12) being determined, that the determined cooling demands are weighted together and that the fan (13) is controlled based on said weighting together, **characterized** in that at least one cooling element is equipped with a safety thermostat, which, if required, prevents under-cooling by the fact that the fluid in question is not allowed to circulate in this cooling element.
2. Method according to claim 1, **characterized** in that the at least one fan (13) is controlled based on the cooling demand of the cooling element (12) that has the greatest cooling demand.
3. Method according to claim 1 or 2, **characterized** in that the rotation speed of the fan (13) is controlled based on the cooling demand of the cooling element (12) that has the greatest cooling demand.
4. Method according to any one of claims 1-3, **characterized** in that the temperature is measured in order to determine the cooling demand in each one of the cooling elements (12).
5. Method according to any one of claims 1-4, **characterized** in that the ambient temperature is measured and constitutes input data to the determination of the cooling demand of at least one cooling element (12).
6. Method according to any one of the preceding claims, **characterized** in that the drill rig (1) comprises at least two fans (13), each one of which is arranged to co-operate with a group of cooling elements (12) associated therewith, and that each individual fan (13) is controlled based on the weighted-together cooling demand of the cooling elements (12) associated with the same.

7. Drill rig comprising an engine (9), at least two cooling elements (12) and at least one fan (13), a control unit (15) being arranged to control the fan (13) based on a weighting together, executed in the control unit (15), of current cooling demands in the cooling elements (12), **characterized** in that at least one cooling element is equipped with a safety thermostat in order to, if required, prevent undercooling by not allowing circulation of the fluid in question in this cooling element.

8. Drill rig according to claim 7, **characterized** in that the control unit (15) is arranged to control the at least one fan (13) based on the cooling demand of the cooling element (12) that has the greatest cooling demand.

9. Drill rig according to claim 7 or 8, **characterized** in that the same comprises at least four cooling elements (12).

10. Drill rig according to any one of claims 7-9, **characterized** in that the cooling elements (12) consist of engine water cooler, charge-air cooler, hydraulic-oil cooler and compressor-oil cooler.

Drill rig unit according to any one of claims 7-10, **characterized** in that the cooling elements (12) are arranged in groups, at least one fan (13) being arranged to co-operate with each group of cooling elements (12).

12. Drill rig according to claim 11, **characterized** in that the hydraulic-oil cooler and the compressor-oil cooler constitute one of the groups of cooling elements (12), and the engine water cooler and the charge-air cooler constitute the second group of cooling elements (12).

13. Drill rig according to claim 11 or 12, **characterized** in that the control unit (15) is arranged to control the at least one fan (13), which is arranged to co-operate with one of the groups of cooling elements (12), based on a weighting together of the present cooling demand of the cooling elements (12) associated with said fan (13).

14. Drill rig according to any one of claims 7-13, **characterized** in that the engine (9) is an internal combustion engine and that the same comprises a compressor (10) and a hydraulic-oil pump (11).

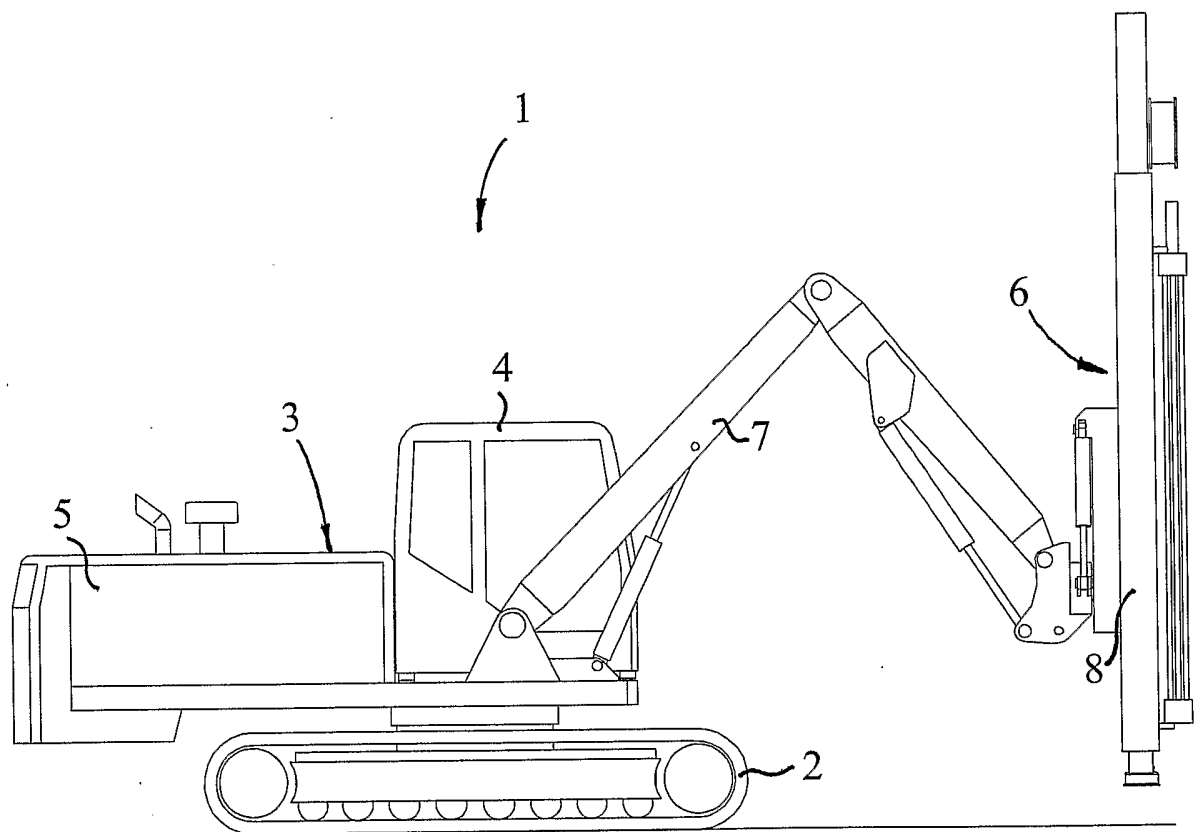
5

15. Drill rig according to any one of claims 7-14, **characterized** in that the same comprises sensors (16-20) in order to measure temperatures, which correspond to the cooling demand of each one of the cooling elements (12).

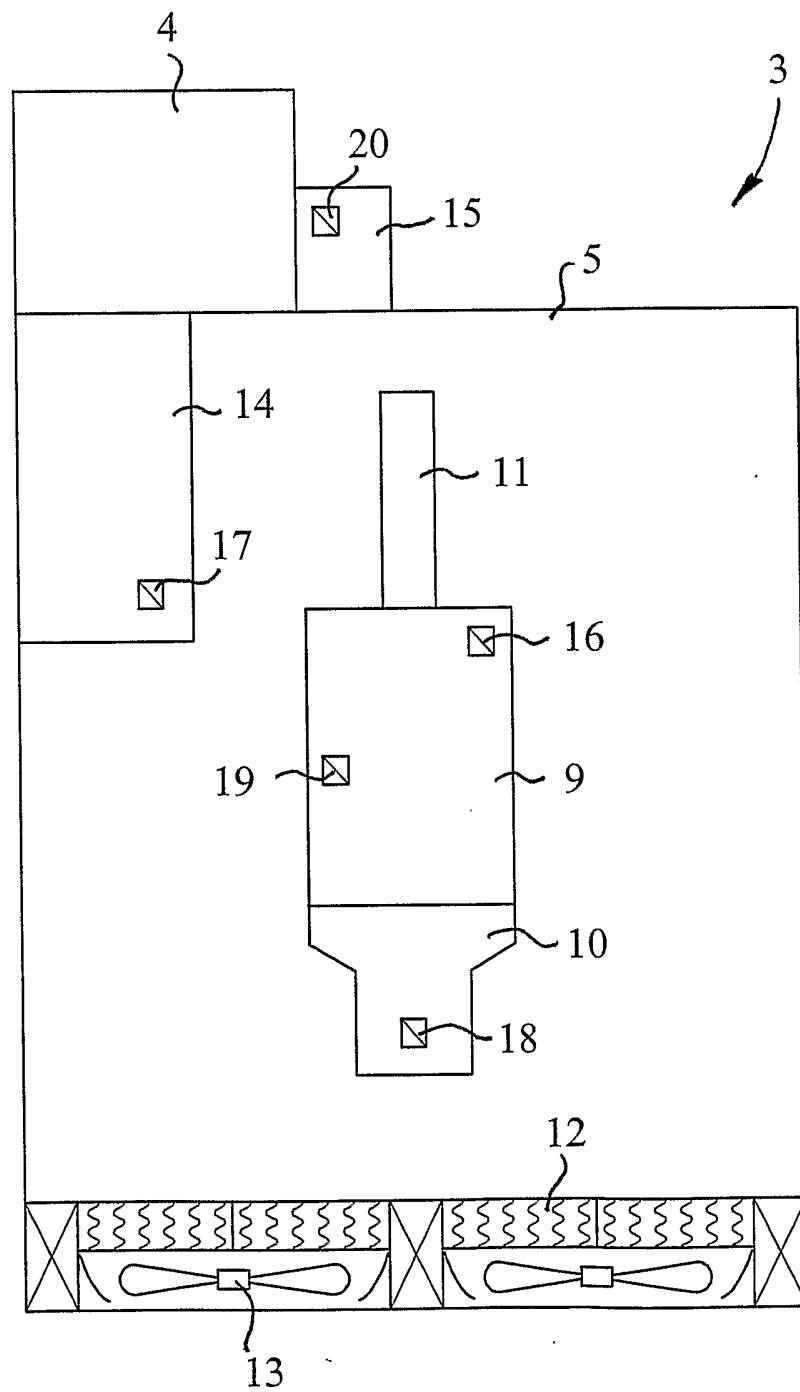
10

16. Drill rig according to any one of claims 7-15, **characterized** in that the same comprises a sensor (20) in order to measure the ambient temperature, which constitutes input data to the determination of the cooling demand of at least one
15 cooling element (12).

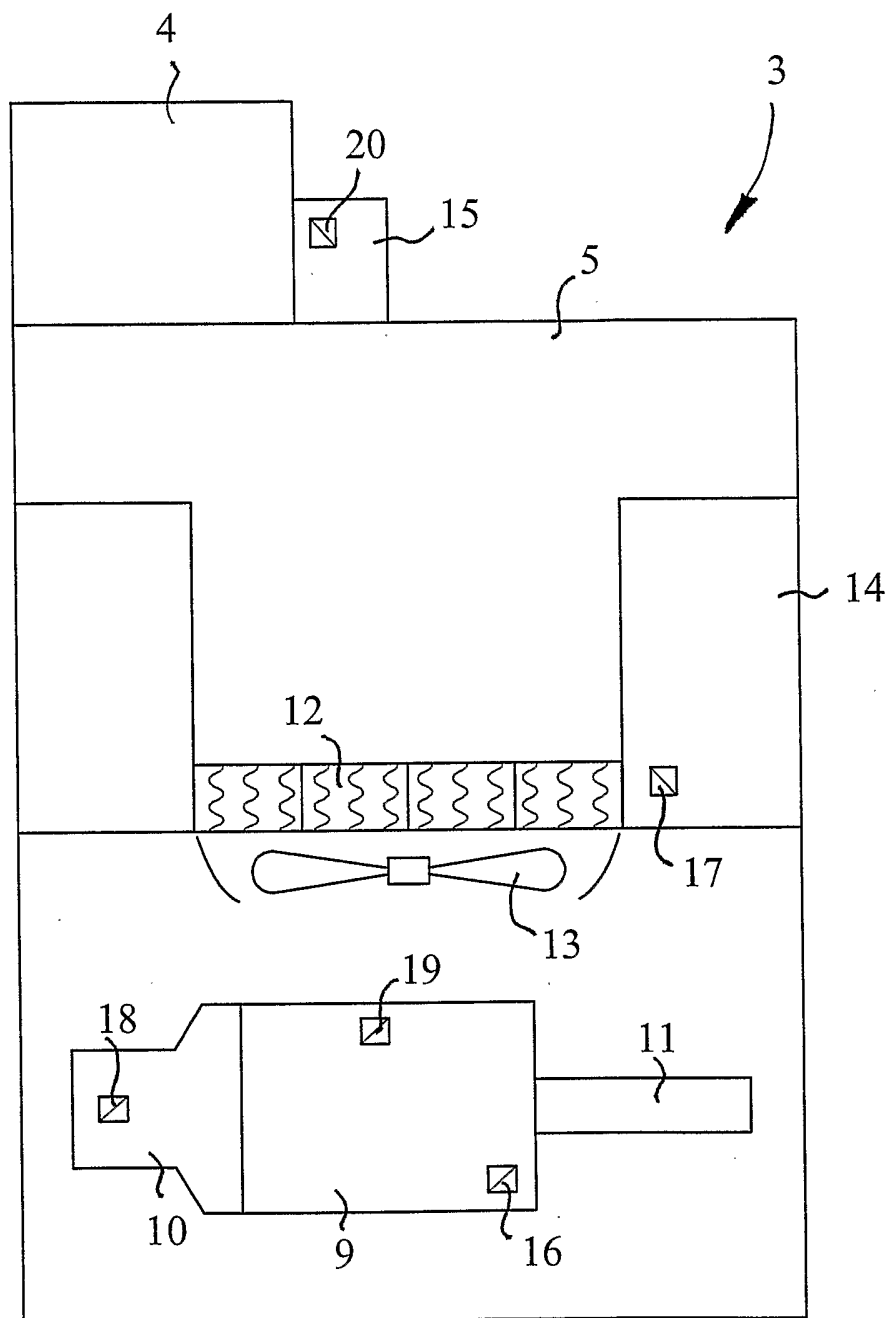
1 / 3

**Fig 1**

2 / 3

*Fig 2*

3 / 3

*Fig 3*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 2005/001549

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E21B, F01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0369148 A2 (ROBERT BOSCH GMBH), 23 May 1990 (23.05.1990), abstract --	1-16
A	US 4998510 A (ROGNON, A), 12 March 1991 (12.03.1991), abstract --	1-16
A	US 4479532 A (WATANABE, M), 30 October 1984 (30.10.1984), abstract --	1-16
A	DE 19520122 A1 (FA J EBERSPÄCHER), 12 May 1996 (12.05.1996), abstract --	1-16

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 January 2006

Date of mailing of the international search report

19-01-2006

Name and mailing address of the ISA/

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

Tomas Erlandsson /LR

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 2005/001549

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5692467 A (SAHM, W C ET AL), 2 December 1997 (02.12.1997), abstract -- -----	1-16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2005/001549

INTERNATIONAL PATENT CLASSIFICATION (IPC):

F01P 7/02 (2006.01)

E21B 7/00 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

26/11/2005

International application No.

PCT/SE 2005/001549

EP	0369148	A2	23/05/1990	DE	3838404 A	17/05/1990
				DE	58901992 D	00/00/0000
US	4998510	A	12/03/1991	DE	68903686 D,T	01/07/1993
				EP	0345144 A,B	06/12/1989
				FR	2632356 A,B	08/12/1989
US	4479532	A	30/10/1984	JP	1517512 C	07/09/1989
				JP	57109221 U	06/07/1982
				JP	57109232 A	07/07/1982
				JP	61026585 Y	09/08/1986
				JP	63066015 B	19/12/1988
DE	19520122	A1	12/05/1996	WO	9638692 A	05/12/1996
US	5692467	A	02/12/1997	BE	1005917 A	08/03/1994
				WO	9303938 A	04/03/1993