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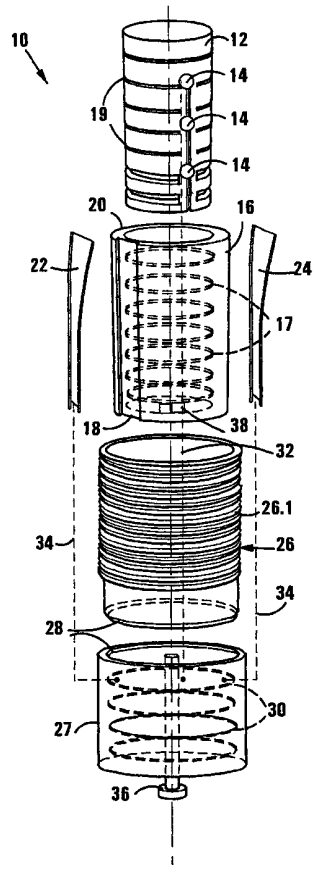
[Continued on next page]

(54) Title: MONITORING ARRANGEMENT FOR A WEAR PART



(57) Abstract: A monitoring device (10) for monitoring a parameter of a wear part (42) which is embeddable in the wear part includes a monitor for monitoring the parameter of the wear part and for providing a parameter signal representative thereof and an internal transmitter for transmitting the parameter signal externally of the wear part. The invention further includes an internal receiver for receiving a power signal from an external transmitter and a transducer for converting energy inherent into electrical energy.

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Published:

— *With international search report.*

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

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.

MONITORING ARRANGEMENT FOR A WEAR PART

This invention relates to an arrangement for monitoring a wear part, a method of monitoring a wear part, and a monitoring device for monitoring the wear part. In particular, the wear part may be a millball.

According to a first aspect of the invention there is provided a monitoring device for monitoring a parameter of a wear part and which is embeddable in the wear part, which includes a monitor for monitoring the parameter of the wear part and for providing a parameter signal representative thereof; and an internal transmitter for transmitting the parameter signal externally of the wear part.

The device may be electrically operable and may be externally or internally powered. Thus, it may include an internal receiver for receiving a power signal from an external transmitter and a transducer for converting energy inherent in the power signal into electrical energy. An energy storage component may also be provided. Instead, the device may include an internal generator.

The device may include an antenna for transmitting the parameter signal. If the device is externally powered, the antenna for transmitting the parameter signal may also be operable to receive the power signal.

The parameter being monitored may be the size of the wear part or its temperature.

Conveniently, the device may be receivable in a cavity in the wear part.

The device may include a sensor for sensing variations in the parameter being monitored. The antenna and the sensor may be the same component.

The device may further include a cylindrical casing and the said component may be located in the casing. In one embodiment the component may be comprised of two parts that are spaced apart in the casing. In the case where the size of the wear part is being monitored, the sensor may be arranged such that it wears away as the part wears.

The device may have a frequency variable oscillator, the frequency of oscillation being representative of the value of the parameter being monitored. The frequency may be varied by variations in the resistance of the sensor caused by variations in its length, in the case where the size of the wear part is being monitored, or as a result of temperature variations, in the case where temperature is being monitored. In another embodiment, in which the size of the wear part is being monitored and in which the sensor and the antenna are the same component, the frequency may be determined by the length of the component, the component being

worn shorter as the wear part wears.

As indicated above, the wear part may, in particular, be a millball.

According to a second aspect of the invention there is provided an arrangement for monitoring a parameter of a wear part, which comprises a monitoring device as described above and an external unit which includes an external receiver for receiving the parameter signal from the internal transmitter.

As described above, the monitoring device may be embedded in the wear part.

The external unit may also include an external transmitter for supplying a power signal to the monitoring device, if the monitoring device is externally powered.

According to a third aspect of the invention there is provided a wear part with a monitoring device as described above embedded therein. As indicated above, the wear part may, in particular, be a millball.

According to a fourth aspect of the invention there is provided a mill which includes an external receiver for receiving the parameter signal from the internal

transmitter of a monitoring device embedded in millballs to be used therewith. The mill may also include at least one millball.

According to a fifth aspect of the invention there is provided a method of monitoring a parameter of a wear part, which includes

monitoring the parameter of the wear part by means of a monitor embedded in the wear part;

transmitting a parameter signal representative of the parameter by means of an internal transmitter embedded in the wear part; and

receiving the transmitted parameter signal externally of the wear part.

As indicated above, the monitoring device may be supplied with power from an external source or from an internal generator.

Further as indicated above, the frequency of the parameter signal may be varied in accordance with variations in the parameter.

The invention is now described in more detail with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of a first embodiment of a monitoring device for monitoring a parameter of a wear part according to the invention;

Figure 2 is a schematic representation of a monitoring arrangement according

to the invention; and

Figure 3 is a sectioned side view of a second embodiment of a monitoring device for monitoring a parameter of a wear part according to the invention.

In Figure 1, a first embodiment of a monitoring device 10 for monitoring the diameter of a millball according to the invention is shown to include a rubber plug 12 which houses three T-shaped ferrite antennae 14. The plug 12 locates within a holder 16 which includes longitudinally opposed slots 18 and 20 respectively.

The holder 16 includes key formations 17 which key into circumferential grooves 19, formed in the plug 12 to retain the plug firmly located in the holder 16. Two elongate resistive sensors 22 and 24 locate in slots 16 and 18 in the sides of the holder 16.

An external, hardened steel casing 26 with a serrated outer surface 26.1 is provided to enclose the plug 12 and plug holder 16.

A steel electronics housing 27 is attachable by way of a screw thread arrangement 28 to the end of the casing 26 as shown in the drawing. The housing 27 houses electronic circuitry on PC boards 30. The electronic circuitry includes a transducer (not shown) for receiving a power signal from an external transmitter, as is explained below, a storage capacitor (also not shown) for storing energy supplied

via the external transmitter, and a frequency variable oscillator (also not shown) for supplying a parameter signal to the antennae 14. The oscillation frequency of the oscillator is determined by the resistance of the sensors 22 and 24, and is in the order of 200 kHz.

When assembled, the rubber plug 12 locates within the plug holder 16, which in turn locates within the casing 26 with the sensors 22 and 24 sandwiched between the outer surface of the plug holder 16 and the inner surface of the casing 26. The antennae 14 and the sensors 22 and 24 are connected to the PC boards 30 by way of electrical conductors, schematically represented as lines 32 and 34 respectively. A bolt 36 and nut 38 arrangement holds the monitoring device in its assembled configuration.

In Figure 2, a monitoring arrangement 40 for a millball 42 is shown schematically. In the drawing, a coal mill 44 is shown to include a plurality of millballs 42 comprising hollow, spherical steel balls having walls 46 of measurable thicknesses. In use, the balls 42 rotate in a horizontal plane along troughs 48 to mill coal (not shown).

Monitoring devices 10, in their assembled configuration, are located within pre-drilled, radially orientated cavities in the walls 46 of balls 42 as shown in the drawing.

An external unit 50 according to the invention includes an external transmitter 50.1 and an external receiver 50.2. An antenna 52 is provided for the unit 50.

In use, the unit 50 powers the monitoring devices 10 continuously by transmitting a power signal at a suitable frequency. This power signal is received by the antennae 14 and directed to the transducer located on the PC boards 30 in the housing 27 (see Figure 1). The capacitor is provided which is charged by the power signal from the unit 50 to provide power, in use.

Referring now to Figures 1 and 2 generally, the outer ends 10.1 of the monitoring devices 10 are located flush with the outer surfaces of the millballs 42. As the balls 42 wear down, the monitoring devices wear down with them, effectively reducing the lengths of the sensors 22 and 24 as this process takes place. The sensors 22 and 24 continuously determine the oscillation frequency of the oscillator on the PC boards 30. The oscillator then generates a parameter signal at a frequency determined by the resistance of the sensors 22 and 24. As the lengths of the sensors 22 and 24 are reduced as a result of wear, their resistance changes and the frequency of the parameter signal changes accordingly. The antennae 14 of the monitoring device are supplied with the parameter signal which is transmitted to the external receiver 50.2. In use, the antennae 14 also wear down, hence the necessity of providing a plurality (three in this embodiment) of antennae for the monitoring device.

The external unit 50 is connected to a microprocessor and database (not shown) wherein the minimum wall thickness values of the millballs to be monitored are electronically stored. The wall thicknesses of the millballs are incrementally associated with pre-determined frequencies of the parameter signals anticipated from the monitoring device. Accordingly, it is possible to determine and continuously monitor the millball wall thicknesses as a function of the frequency of the parameter signals received from the monitoring device 10.

A second embodiment of a monitoring device 10 for monitoring the size of a millball is shown in Figure 3. Like parts in Figure 3 are given like numbers as shown in Figures 1 and 2.

The monitoring device 10 in Figure 3 is shown to include a rubber plug 12 in which an antenna 14 is located. The antenna 14 is made of steel and also acts as the sensor, as the frequency of oscillation is determined by the length of the antenna 14.

The plug 12 locates within a steel housing 54. An outer portion of the housing 54 is provided with external screw threading 72 which locates the monitoring device 10 in the wall 46 of the millball 42.

The housing 54 extends past the wall 46 into the millball 54 as shown

in Figure 3. The electronic circuitry on a PC board 30, a section of co-axial cable 56 and a generator 58 are also housed in the housing 54.

The antenna 14 is connected to the PC board 30 by way of the co-axial cable 56 and the generator 58 is connected to the PC board 30 by way of wires 60. The PC board 30 is held in place by spacers 62 and the rubber plug 12 is held in place in the housing 54 by a bolt 64. A teflon disc 66 is located between the rubber plug 12 and the bolt 64.

The generator 58 has a counterweight 68 attached by an arm 67. The counterweight 68 moves under the influence of gravitational force when the millball 42 turns, in use. This movement causes the arm 67 to rotate, which in turn causes the generator 58 to produce electrical energy. The generator 58 then powers the PC circuitry.

An external receiver 50.2 is provided in a wall 70 of the mill 44. As the length of the antenna 14 is reduced as a result of wear, the frequency of the parameter signal that is transmitted to the external receiver 50.2 varies.

Similarly, the external receiver 50.2 is connected to a microprocessor and database (not shown) and it is thereby possible to determine and continuously monitor the millball wall thicknesses as a function of the frequency of the parameter signals

received from the monitoring device 10.

It will be appreciated that many variations and modifications of the invention are possible without departing from the spirit of the disclosure. For example, with little modification, the arrangement as described with reference to the drawings can monitor other parameters such as temperature.

The applicant believes that with the arrangement as described with reference to the drawings, the disadvantages associated with the conventional methods of monitoring millball sizes are to a large extent minimised. The conventional methods involve stopping the mill and physically measuring the circumference of the balls with large callipers or by way of ultrasonic equipment or the like. Accordingly, unnecessary mill down-time (to measure millball sizes) can be eliminated with a resultant reduction in operating costs.

CLAIMS:

1. A monitoring device for monitoring a parameter of a wear part and which is embeddable in the wear part, which includes

a monitor for monitoring the parameter of the wear part and for providing a parameter signal representative thereof; and

an internal transmitter for transmitting the parameter signal externally of the wear part.

2. The device as claimed in Claim 1, which includes an internal receiver for receiving a power signal from an external transmitter and a transducer for converting energy inherent in the power signal into electrical energy.

3. The device as claimed in Claim 2, which includes an energy storage component.

4. The device as claimed in Claim 1, which includes an internal generator.

5. The device as claimed in any one of the preceding claims, which includes an antenna for transmitting the parameter signal.

6. The device as claimed in Claim 3, which includes an antenna for transmitting the parameter signal and which is also operable to receive the power

signal.

7. The device as claimed in any one of the preceding claims, in which the parameter being monitored is the size of the wear part.

8. The device as claimed in any one of Claims 1 to 6, in which the parameter being monitored is the temperature of the wear part.

9. The device as claimed in any one of the preceding claims, which is receivable in a cavity in the wear part.

10. The device as claimed in Claim 5, which includes a sensor for sensing variations in the parameter being monitored.

11. The device as claimed in Claim 10, in which the antenna and the sensor are the same component.

12. The device as claimed in Claim 11, which further includes a cylindrical casing and the said component is located in the casing.

13. The device as claimed in Claim 12, in which the said component is comprised of two parts.

14. The device as claimed in any one of the preceding claims, in which the monitor has a frequency variable oscillator, the frequency of oscillation being representative of the value of the parameter being monitored.

15. The device as claimed in any one of the preceding claims, in which the wear part is a millball.

16. An arrangement for monitoring a parameter of a wear part, which comprises a monitoring device as claimed in any one of Claims 1 to 14 and an external unit which includes an external receiver for receiving the parameter signal from the internal transmitter.

17. An arrangement as claimed in Claim 16, in which the monitoring device is embedded in the wear part.

18. An arrangement for monitoring a parameter of a wear part, which comprises a monitoring device as claimed in Claim 2 and an external unit which includes an external receiver for receiving the parameter signal from the internal transmitter and an external transmitter for supplying a power signal to the monitoring device.

19. A wear part with a monitoring device as claimed in any one of Claims 1

to 14, embedded therein.

20. A millball which has a monitoring device as claimed in any one of Claims 1 to 14 embedded therein.

21. A mill which includes at least one millball as claimed in Claim 20 and an external unit which has an external receiver for receiving the parameter signal from the internal transmitter of the monitoring device.

22. A mill which includes an external receiver for receiving a parameter signal from the internal transmitter of a monitoring device of a millball as claimed in Claim 20.

23. A method of monitoring a parameter of a wear part, which includes

monitoring the parameter of the wear part by means of a monitor embedded in the wear part;

transmitting a parameter signal representative of the parameter by means of an internal transmitter embedded in the wear part; and

receiving the transmitted parameter signal externally of the wear part.

24. The method as claimed in Claim 23, in which the monitoring device is supplied with power from an external source.

25. The method as claimed in Claim 23, in which the monitoring device is supplied with power from an internal generator.

26. The method as claimed in any one of Claims 23 to 25, in which the parameter being monitored is the size of the wear part.

27. The method as claimed in any one of Claims 23 to 25, in which the parameter being monitored is the temperature of the wear part.

28. The method as claimed in any one of Claims 23 to 27, in which the frequency of the parameter signal is varied in accordance with variations in the parameter.

29. The method as claimed in any one of Claims 23 to 28, in which the wear part is a millball.

30. A monitoring device substantially as herein described with reference to the accompanying drawings.

31. A method of monitoring a wear part substantially as herein described with reference to the accompanying drawings.

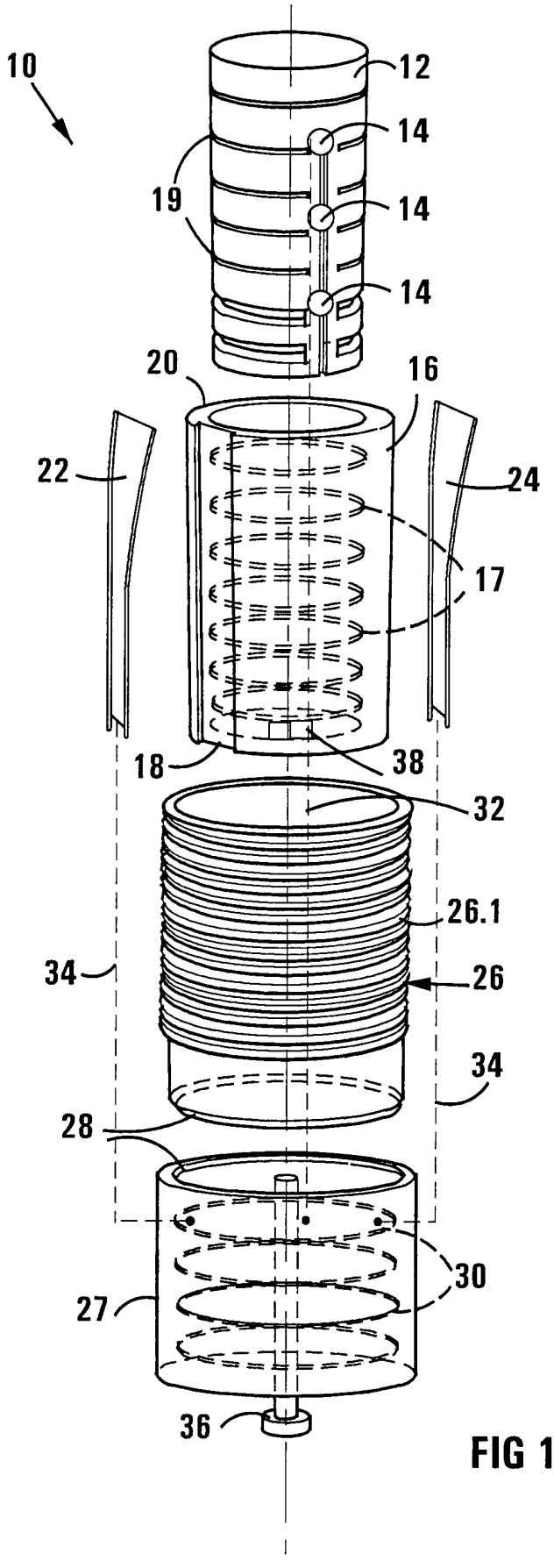

FIG 1

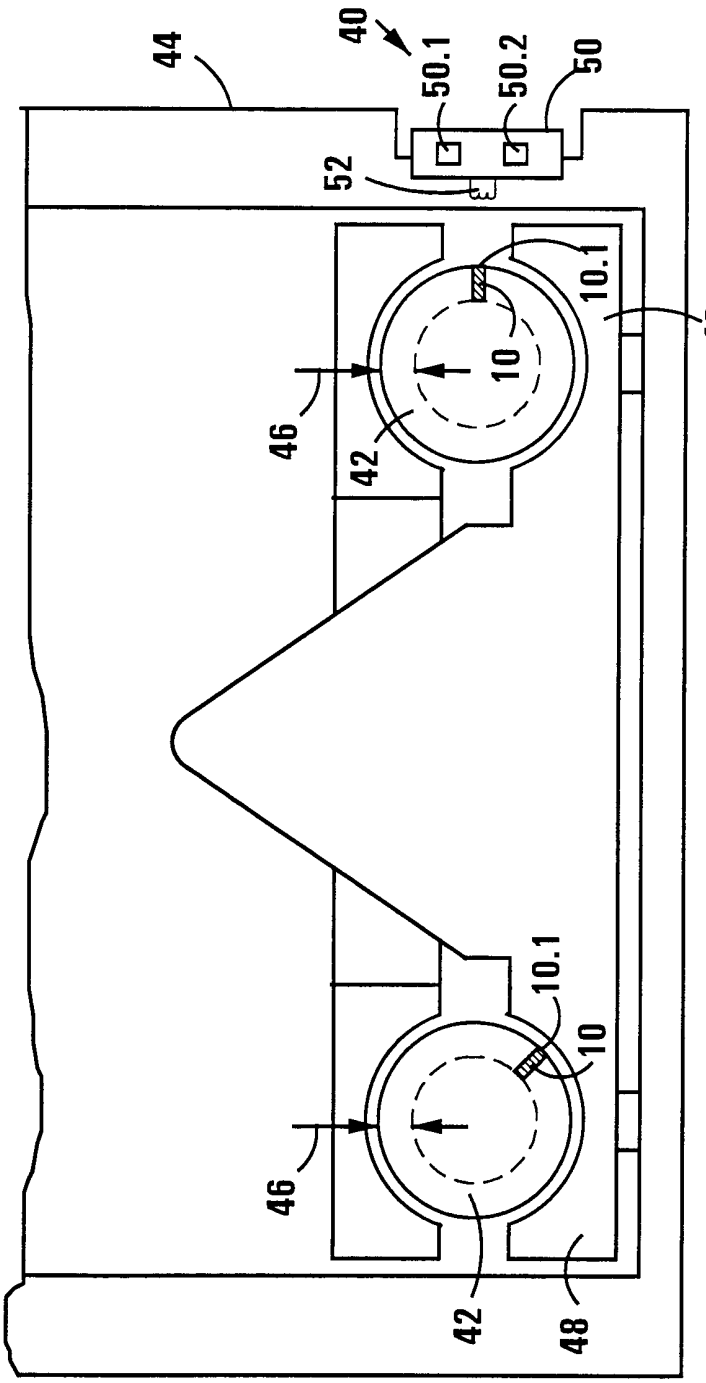

FIG 2

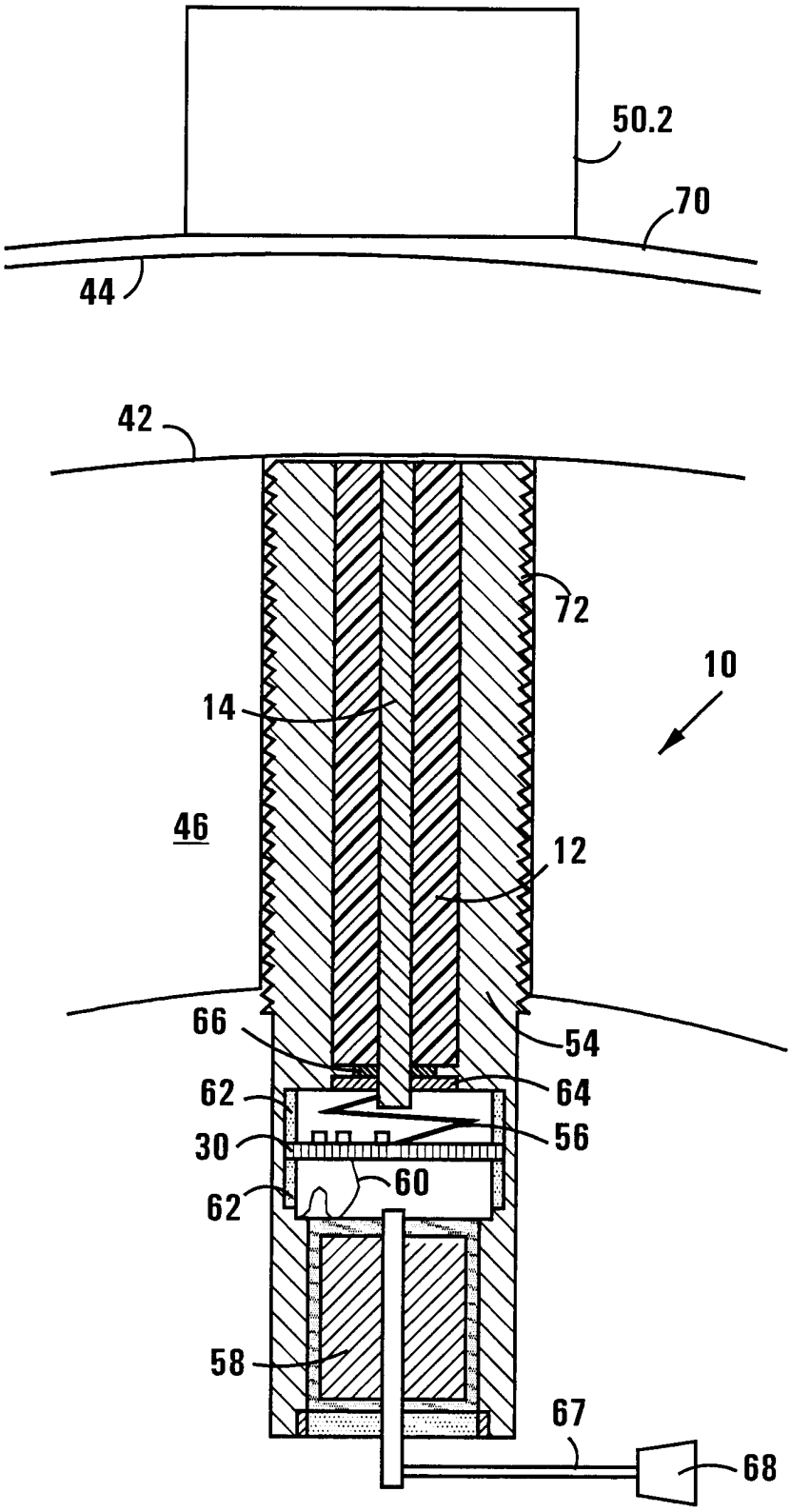

FIG 3

INTERNATIONAL SEARCH REPORT

Int. tional Application No
PCT/IB 00/00987

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01B7/06 B02C15/12 B02C17/20 G01N3/56

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 7 G01B B02C F16D G01N

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

Electronic data base consulted during the international search (name of data base and, where practical, 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.
X Y A	WO 93 00997 A (SKEGA AB) 21 January 1993 (1993-01-21) page 4, line 5 -page 5, line 29 figure 2 ---	1,5,7,9, 16,17,19 8,10 20
X Y A	GB 2 270 383 A (BOWMAN MARTIN ROBIN) 9 March 1994 (1994-03-09) the whole document ---	1,7,9, 23,26 10,27 4,25
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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 document 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	Date of mailing of the international search report
11 October 2000	17. 11. 2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	**Authorized officer** Wennborg, J

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/IB 00/00987

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 637 794 A (HANISKO JOHN-CYRIL P) 10 June 1997 (1997-06-10) abstract column 3, line 45 - line 57 column 4, line 47 - line 61 figures 1-3	8,27
A	WO 98 16407 A (WEANT BOB R ;DANGSON HENRY T (US); INDIAN HEAD INC (US); LESESKY A) 23 April 1998 (1998-04-23) abstract page 6, line 14 - line 17	2,18
A	US 4 153 209 A (FRASER DONALD S) 8 May 1979 (1979-05-08) abstract figures 1,2	15, 20-22,29

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 00/00987

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 30,31
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
Claims 30 and 31 have not been searched in accordence with Rule 6.2 PCT.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 30,31

Claims 30 and 31 have not been searched in accordence with Rule 6.2 PCT.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/IB 00/00987

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