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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) Title: SHOCK ABSORPTION FOR A LOGGING INSTRUMENT

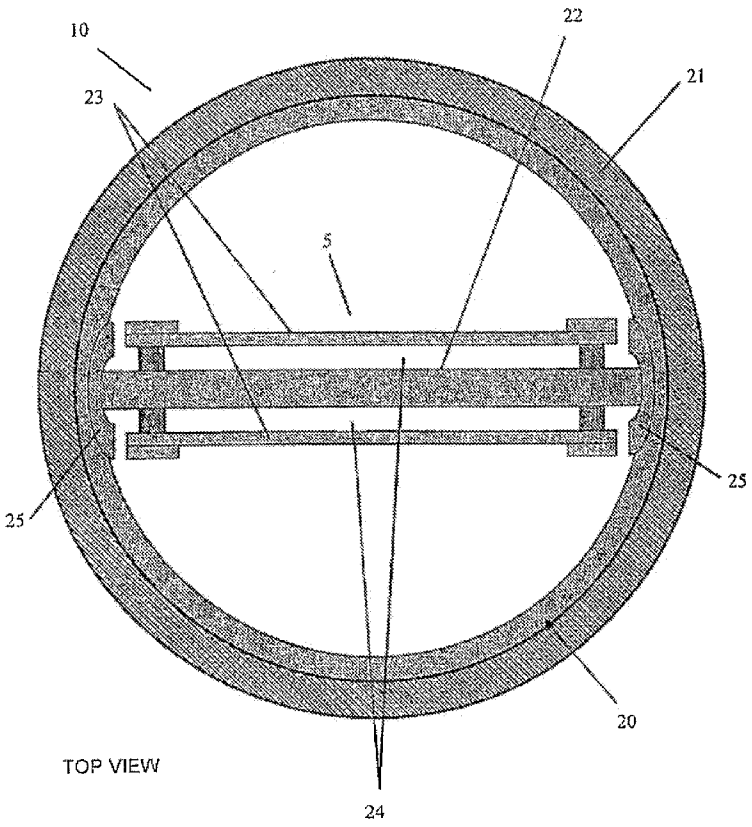

FIG. 2

(57) Abstract: A logging instrument including an instrument housing; an instrument assembly; and shock absorbing material disposed between the instrument housing and the instrument assembly to provide for absorbing shock to the instrument assembly.

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report*

— *with amended claims*

SHOCK ABSORPTION FOR A LOGGING INSTRUMENT

John Cheeseborough

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention disclosed herein relates to well logging instruments.

2. Description of the Related Art

[0002] In exploration for hydrocarbons, it is important to make accurate measurements of geologic formations. The geologic formations below the surface of the earth may contain reservoirs of oil and gas. The geologic formations may include formation layers and various structures. In a quest for oil and gas, it is important to know about the location and composition of the formation layers and the various structures. In particular, it is important to know about the geologic formations with a high degree of accuracy so that resources are not wasted. Measuring properties of the geologic formations provides information that can be useful for locating the reservoirs of oil and gas. Typically, the oil and gas are retrieved by drilling boreholes into the subsurface of the earth. The boreholes also provide access for taking measurements of the geologic formations.

[0003] Well logging is a technique used to take measurements of the geologic formations from the boreholes. In one embodiment, a "logging instrument" is lowered on the end of a wireline into the borehole. The logging instrument sends data via the wireline to the surface for recording. In another embodiment, the logging instrument may be dropped inside of a drill pipe without the wireline to the surface. Such a logging instrument can then be retrieved with the drill string and its data extracted at the surface. Output from the logging instrument comes in various forms and may be referred to as a "log." Many types of measurements are made to obtain information about the geologic formations. Some examples of the measurements include gamma ray logs, nuclear magnetic resonance logs, resistivity logs, pressure logs, seismic logs, and sonic or acoustic logs. The different types of logging instruments need to survive the rigors of the environment in the borehole.

[0004] Boreholes are typically not straight but may have various curvatures. As the logging instrument traverses a borehole with various curvatures, the logging instrument may be subject to transverse accelerations or shocks in addition to axial accelerations. The logging instrument must be built to withstand the shocks or the logging instrument may lose accuracy or fail. An inaccurate or failed logging instrument can result in wasted resources.

[0005] The logging instrument can include some delicate components such as circuit boards and sensors. The logging instrument must either be built with components that can with stand the shocks or be built to protect the components from the shocks. Typically, it is less expensive in design time and money to protect the components from the shocks.

[0006] Various attempts have been made to reduce the shock experienced by the components. These attempts have focused on packaging the components into a cylindrical assembly. The assembly is then protected from the shocks with various shock absorbing devices. The diameter of the assembly must be less than the diameter of an instrument housing. The diameter of the assembly must also account for the thickness of the shock absorbing device. These attempts have resulted in some problems. For example, the volume required by the shock absorbing device subtracts from the volume available to the components. Large shock absorbing devices may result in large components being unable to fit within the assembly. Additional problems relate to maintaining the components. Maintaining the components typically requires that the assembly be disassembled. Components that are glued into the assembly may have to be unglued. Ungluing and disassembly can result in increased risk of damage to the components.

[0007] Therefore, what are needed are an apparatus and method to protect components within the logging instrument from extreme accelerations.

BRIEF SUMMARY OF THE INVENTION

[0008] The shortcomings of the prior art are overcome and additional advantages are provided through a logging instrument including an instrument housing; an instrument assembly; and shock absorbing material disposed between the instrument housing and the instrument assembly for absorbing shock to the instrument assembly.

[0009] Also disclosed is a method for producing a logging instrument with shock protection for an instrument assembly, the logging instrument including an instrument housing, the method including selecting a shock absorbing material; placing the shock absorbing material about at least one of the instrument assembly and an interior of the instrument housing; and inserting the instrument assembly into the instrument housing, wherein the shock absorbing material is disposed between the instrument assembly and the instrument housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates an exemplary embodiment of a logging instrument in a borehole penetrating the earth;

FIG. 2 illustrates an exemplary embodiment of the logging instrument with a shock absorbing material;

FIG. 3A and **3B**, collectively referred to as **FIG. 3**, depict aspects of interaction of side rails of an instrument chassis with the shock absorbing material;

FIG. 4 illustrates an exemplary embodiment of the logging instrument with axial shock protection; and

FIG. 5 illustrates an exemplary method of producing the logging instrument with the shock absorbing material.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The teachings provide for using a shock absorbing material to protect components internal to a logging instrument from accelerations or shocks. As used herein, "shock" refers to acceleration and other mechanical forces likely to cause

damage to unprotected components. Shock absorbing material may be disposed between a component and the interior of an instrument housing. Shocks imposed upon an exterior surface of the instrument housing are transmitted to an interior surface of the instrument housing. At the interior surface, the shock is at least partially decreased or "absorbed" by the shock absorbing material. The shock absorbing material reduces the shock transmitted to the component.

[0012] Referring to **FIG. 1**, a well logging instrument **10** is shown disposed in a borehole **2**. The borehole **2** is drilled through earth **7** and penetrates formations 4, which include various formation layers **4A-4E**. The logging instrument **10** is generally, but not always, lowered into and withdrawn from the borehole **2** by use of an armored electrical cable **6** or similar conveyance as is known in the art. An instrument assembly **5** is shown disposed within the logging instrument **10**. As used herein, the instrument assembly **5** can include at least one of a chassis, electronics, wiring, and a sensor. Components such as the electronics, wiring and sensors can be secured to the chassis. The teachings provide for protecting the instrument assembly **5** from shock.

FIG. 2 illustrates an exemplary embodiment of the logging instrument **10** with the shock absorbing material. In **FIG. 2**, the logging instrument **10** includes an instrument housing **21** that contains the instrument assembly **5**. Referring to **FIG. 2**, a shock absorbing material **20** is shown disposed about an interior circumference of the instrument housing **21**. The instrument assembly **5** is shown disposed within a space formed interior to the shock absorbing material **20**. In the embodiment shown in **FIG. 2**, the instrument assembly **5** is superimposed approximately upon an inside diameter of the instrument housing **21**. The instrument assembly **5** includes a chassis **22**, printed circuit boards **23** and wiring channels **24**. The wiring channels **24** may be oriented in any or combination of three dimensions. The chassis **22** can include side rails **25** that interact with the shock absorbing material **20**. The side rails **25** can be attached to the chassis **22** or formed from the chassis **22**.

FIG. 3 depicts aspects of interaction of the side rails **25** with the shock absorbing material **20**. Referring to **FIG. 3A**, a diameter "D" is selected to ensure that the side rails **25** compress the shock absorbing material **20**. The shock absorbing material **20** is compressed an amount to provide for holding the instrument assembly **5** in place

during shock producing events. Holding the instrument assembly **5** in place provides for the instrument assembly **5** not slipping with respect to the shock absorbing material **20**. The side rail **25** includes at least one surface **36** that interacts with the shock absorbing material **20**. The surface **36** may include a rough texture. The rough texture has a roughness that is suitable for holding the instrument assembly **5** in place during shock producing events. In other embodiments, the surface **36** may be attached to the shock absorbing material **20**. Methods of attachment can include at least one of adhesive and mechanical. One example of mechanical attachment is a mechanical fastener.

FIG. 3A also illustrates a brace **37** that supports the shock absorbing material **20**. The brace **37** can be derived from a shape of the instrument housing **21**. The brace **37** can also be at least one of other components in the logging instrument **10** and a bracket.

FIG. 3B depicts aspects of an edge of the side rail **25** interacting with the shock absorbing material **20**. Referring to **FIG. 3B**, an angle θ measures the angle formed by the edge of the side rail **25** with respect to the shock absorbing material **20**. Generally, angles of about ninety degrees or less provide better support of the instrument assembly **5** than angles greater than about ninety degrees.

The shock absorbing material **20** can absorb shock at least one of transverse and axial to the logging instrument **10**. Referring to **FIG. 3A**, transverse shocks are in the X-Y plane while axial shocks are parallel to the Z-axis. The transverse shocks are absorbed by compression in the X-Y plane of the shock absorbing material **20**. The axial shocks are absorbed by compression of the shock absorbing material **20** parallel to the Z-axis.

In some embodiments, the shock absorbing material **20** may be attached to the interior of the instrument housing **21**. In these embodiments, the axial shocks may also be absorbed by stretching of the shock absorbing material **20** in a direction parallel to the Z-axis.

The axial shocks may also be absorbed by placing the shock absorbing material **20** at least one of above and below the chassis **22**. **FIG. 4** illustrates an exemplary embodiment of the shock absorbing material **20** placed below the instrument assembly **5**.

Many types of material can be used for the shock absorbing material **20**. An exemplary embodiment of the shock absorbing material **20** includes an expanded closed cell silicone sponge material that can endure temperatures up to about 300°C or greater. The expanded closed cell sponge material is available from Ipotec, Inc. of Exeter, New Hampshire. Another exemplary embodiment of the shock absorbing material **20** includes silicone sheeting that can endure temperatures up to about 260°C or greater. The silicone sheeting is available from Rubber-Cal, Inc. of Santa Ana, California. The shock absorbing material **20** may be one of extruded and molded into shapes adapted for insertion into the instrument housing **21** and preventing shocks to the instrument assembly **5**.

The shock absorbing material **20** can be built in several shapes. In one embodiment, the shock absorbing material **20** is in a hollow cylindrical shape. The instrument assembly **5** is inserted into the interior of the shock absorbing material **20** with the hollow cylindrical shape. The instrument assembly **5** and the shock absorbing material **20** are then inserted into the instrument housing **21**. The shock absorbing material **20** is typically compressed during insertion into the instrument housing **21**. In another embodiment, the shock absorbing material **20** is in a sheet form that is wrapped around the instrument assembly **5**. In yet another embodiment, the shock absorbing material is in a strip form. Strips of the shock absorbing material **20** are placed about the side rails **25**. The diameter D of the instrument assembly **5** and the thickness of the shock absorbing material **20** are selected so that the shock absorbing material **20** is compressed when inserted into the instrument housing **21**. In a further embodiment, the shock absorbing material includes a shape that surrounds the instrument assembly **5** in three dimensions.

[0013] FIG. 5 illustrates an exemplary method **50** for producing the logging instrument **10** using the shock absorbing material **20** for shock absorption. A first step **51** calls for selecting the shock absorbing material **20**. A second step **52** calls for placing the shock absorbing material **20** about at least one of the instrument assembly **5** and an interior of the instrument housing **21**. A third step **53** calls for inserting the instrument assembly **5** into the logging instrument, wherein the shock absorbing material **20** is disposed between the instrument assembly **5** and the instrument housing **21**.

Various components may be included and called upon for providing for aspects of the teachings herein. For example, a lubricant may be used to allow the shock absorbing material **20** to slide into the instrument housing **21**. As another example, various brackets may be used to hold the shock absorbing material **20** in place in at least one of about the instrument assembly **5** and within the instrument housing **21**. As another example, a sensor, an optical unit, an electrical unit, or electromechanical unit may be used to measure at least one of compression of the shock absorbing material **20** and displacement of the instrument assembly **5** within the logging instrument **10** to measure the shocks subjected to the instrument assembly **5**. The various components may be included in support of the various aspects discussed herein or in support of other functions beyond this disclosure.

[0014] One skilled in the art will recognize that the various components or technologies may provide certain necessary or beneficial functionality or features. Accordingly, these functions and features as may be needed in support of the appended claims and variations thereof, are recognized as being inherently included as a part of the teachings herein and a part of the invention disclosed.

While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications will be appreciated by those skilled in the art to adapt a particular instrument, situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A downhole instrument comprising:
   (a) a housing;
   (b) an instrument assembly; and
   (c) shock absorbing material removably disposed between the housing and the instrument assembly for substantially an entire length of the instrument assembly.

2. The instrument as in claim 1, wherein the housing comprises a brace to support the shock absorbing material.

3. The instrument as in claim 2, wherein the housing comprises at least one of a shape, a bracket, and a component to provide the brace.

4. The instrument as in claim 1, wherein the instrument assembly comprises a side rail.

5. The instrument as in claim 4, wherein the side rail comprises a texture on a surface to prevent slipping of the assembly with respect to the shock absorbing material.

6. The instrument as in claim 4, wherein the side rail comprises an edge of about ninety degrees or less to prevent slipping of the assembly with respect to the shock absorbing material.

7. The instrument as in claim 1, wherein the shock absorbing material is attached to the instrument assembly.

8. The instrument as in claim 1, further comprising an adhesive to attach the shock absorbing material to the instrument assembly.

9. The instrument as in claim 1, further comprising a mechanical fastener to attach the shock absorbing material to the instrument assembly.

10. The instrument as in claim 1, wherein the shock absorbing material comprises a thickness to provide for compressing the shock absorbing material when the shock absorbing material and the instrument assembly are disposed in the logging instrument.

11. The instrument as in claim 1, wherein the shock absorbing material comprises at least one of silicone sheet material and expanded closed cell silicone sponge material.

12. The instrument as in claim 1, wherein the shock absorbing material is attached to the housing.

13. A method for producing a downhole instrument with shock protection for an instrument assembly, the downhole instrument comprising a housing, the method comprising:

(a) removably placing a shock absorbing material about at least one of the instrument assembly and an interior of the housing for substantially an entire length of the instrument assembly; and

(b) inserting the instrument assembly into the housing, wherein the shock absorbing material is disposed between the instrument assembly and the housing.

14. The method as in claim 13, wherein inserting comprises compressing the shock absorbing material.

15. The method as in claim 13, further comprising:

(a) removing the instrument assembly from the housing;

(b) removing the shock absorbing material from the at least one of the instrument assembly and the interior of the housing;

(c) removably placing the shock absorbing material about at least one of the instrument assembly and the interior of the housing for substantially the entire length of the instrument assembly; and

(d) inserting the instrument assembly into the housing, wherein the shock absorbing material is disposed between the instrument assembly and the housing.

16. A downhole instrument comprising:

(a) a housing;

(b) an instrument assembly; and

(c) a material removably disposed between the housing and the instrument assembly for substantially an entire length of the instrument assembly, wherein the material at least one of compresses and stretches to reduce acceleration of the instrument assembly.

AMENDED CLAIMS
received by the International Bureau on 30 October 2008 (30/10/08)

What is claimed is:

1. An apparatus for measuring a property of an earth formation, the apparatus comprising:

(a) a logging instrument configured to be conveyed through a borehole penetrating the earth formation and configured to measure the property;

(b) a housing disposed at the logging instrument;

(c) an instrument assembly disposed at the logging instrument; and

(d) shock absorbing material removably disposed between the housing and the instrument assembly for substantially an entire length of the instrument assembly.

2. The apparatus as in claim 1, wherein the housing comprises a brace to support the shock absorbing material.

3. The apparatus as in claim 2, wherein the housing comprises at least one of a shape, a bracket, and a component to provide the brace.

4. The apparatus as in claim 1, wherein the instrument assembly comprises a chassis comprising a side rail, and wherein the side rail is configured to interact with the shock absorbing material.

5. The apparatus as in claim 4, wherein the side rail comprises a texture on a surface to prevent slipping of the assembly with respect to the shock absorbing material.

6. The apparatus as in claim 4, wherein the side rail comprises an edge of about ninety degrees or less to prevent slipping of the assembly with respect to the shock absorbing material.

7. The apparatus as in claim 1, wherein the shock absorbing material is attached to the instrument assembly.

8. The apparatus as in claim 1, further comprising an adhesive configured to attach the shock absorbing material to the instrument assembly.

9. The apparatus as in claim 1, further comprising a mechanical fastener configured to attach the shock absorbing material to the instrument assembly.

10. The apparatus as in claim 1, wherein the shock absorbing material comprises a thickness to provide for compressing the shock absorbing material when the shock absorbing material and the instrument assembly are disposed in the.

11. The apparatus as in claim 1, wherein the shock absorbing material comprises at least one of silicone sheet material and expanded closed cell silicone sponge material.

12. The apparatus as in claim 1, wherein the shock absorbing material is attached to the housing.

13. A method for producing an apparatus for measuring a property of an earth formation, the method comprising:

(a) removably placing a shock absorbing material about at least one of an instrument assembly and an interior of a housing for substantially an entire length of the instrument assembly, wherein the instrument assembly and the housing are disposed at a logging instrument configured to be conveyed through a borehole penetrating the earth formation and configured to measure the property; and

(b) inserting the instrument assembly into the housing, wherein the shock absorbing material is disposed between the instrument assembly and the housing.

14. The method as in claim 13, wherein inserting comprises compressing the shock absorbing material.

15. The method as in claim 13, further comprising:

(a) removing the instrument assembly from the housing;

(b) removing the shock absorbing material from the at least one of the instrument assembly and the interior of the housing;

(c) removably placing the shock absorbing material about at least one of the instrument assembly and the interior of the housing for substantially the entire length of the instrument assembly; and

(d) inserting the instrument assembly into the housing, wherein the shock absorbing material is disposed between the instrument assembly and the housing.

16. An apparatus for measuring a property of an earth formation, the apparatus comprising:

(a) a logging instrument configured to be conveyed through a borehole penetrating the earth formation;

(b) a housing disposed at the logging instrument;

(b) an instrument assembly disposed at the logging instrument; and

(c) a material removably disposed between the housing and the instrument assembly for substantially an entire length of the instrument assembly, wherein the material at least one of compresses and stretches to reduce acceleration of the instrument assembly.

17. The apparatus as in claim 4, wherein the instrument assembly further comprises a printed circuit board.

18. The apparatus as in claim 1, wherein the logging instrument is configured to be conveyed in the borehole by at least one of a wireline and gravity.

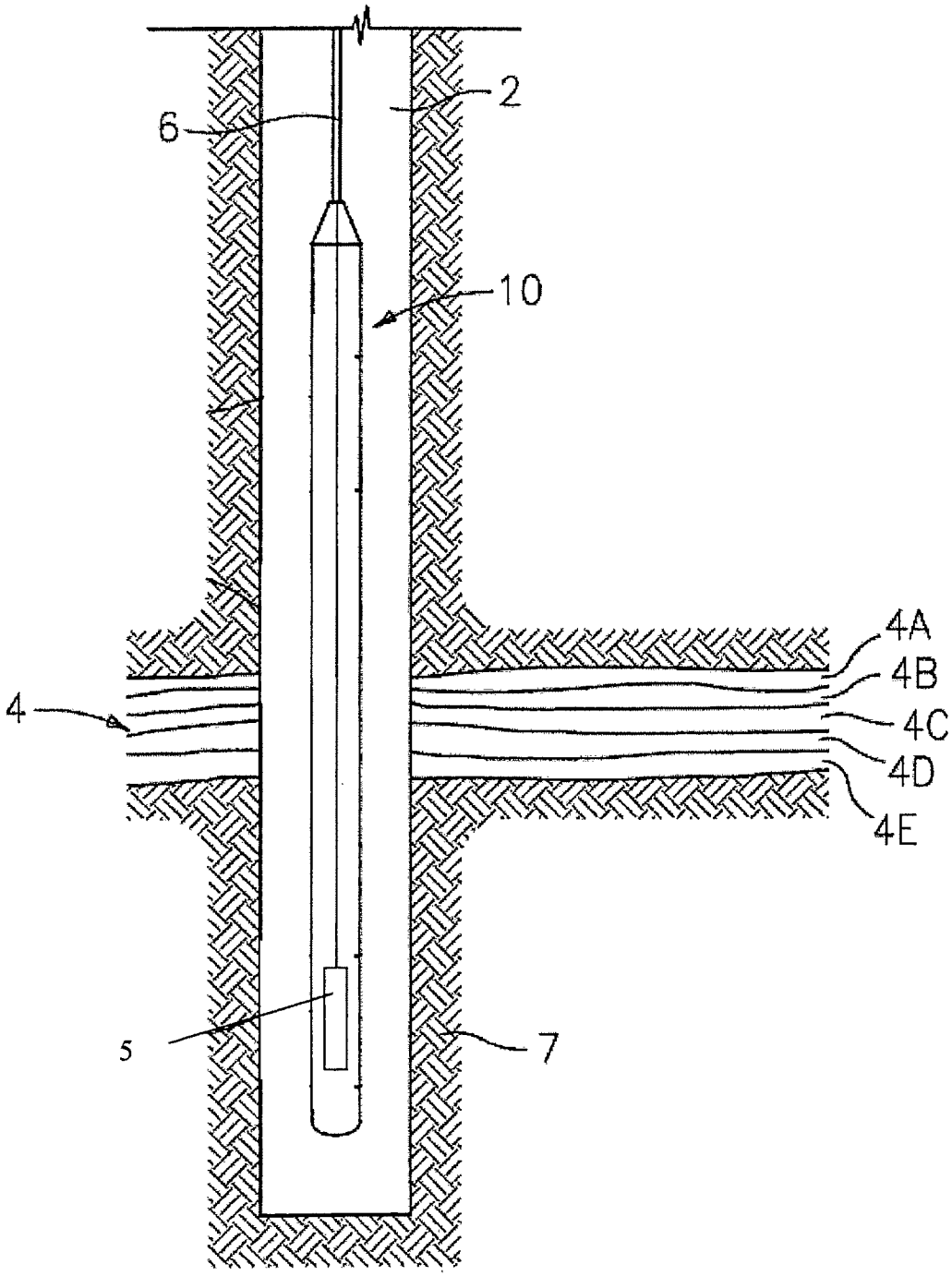


FIG. 1

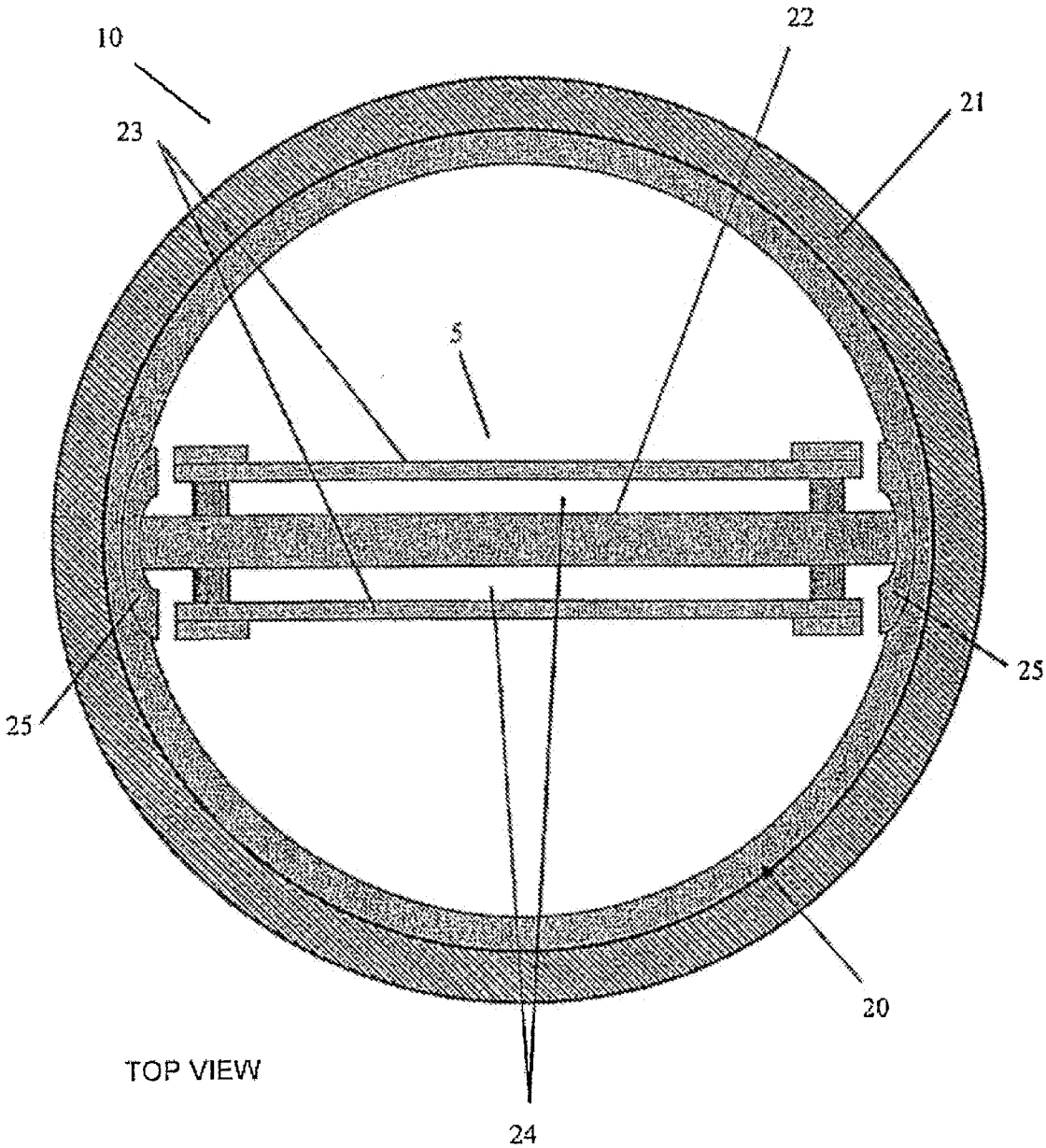


FIG. 2

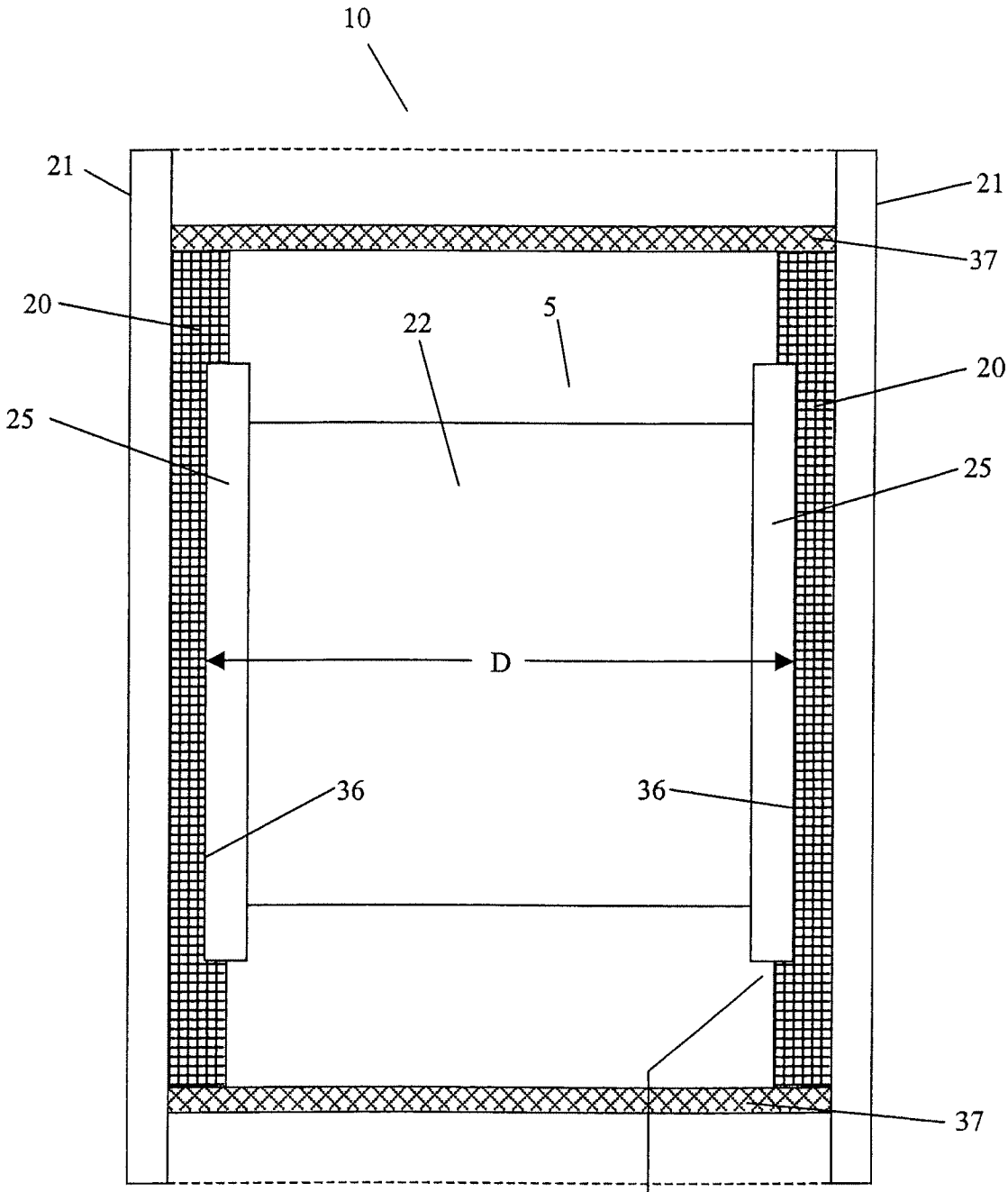


FIG. 3A

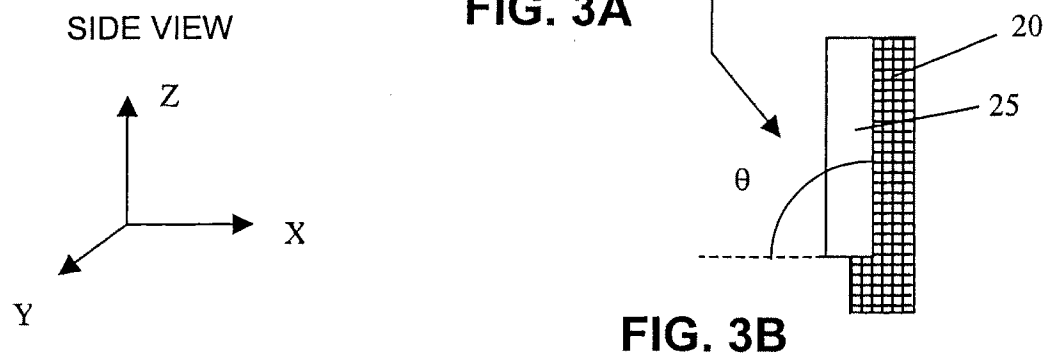
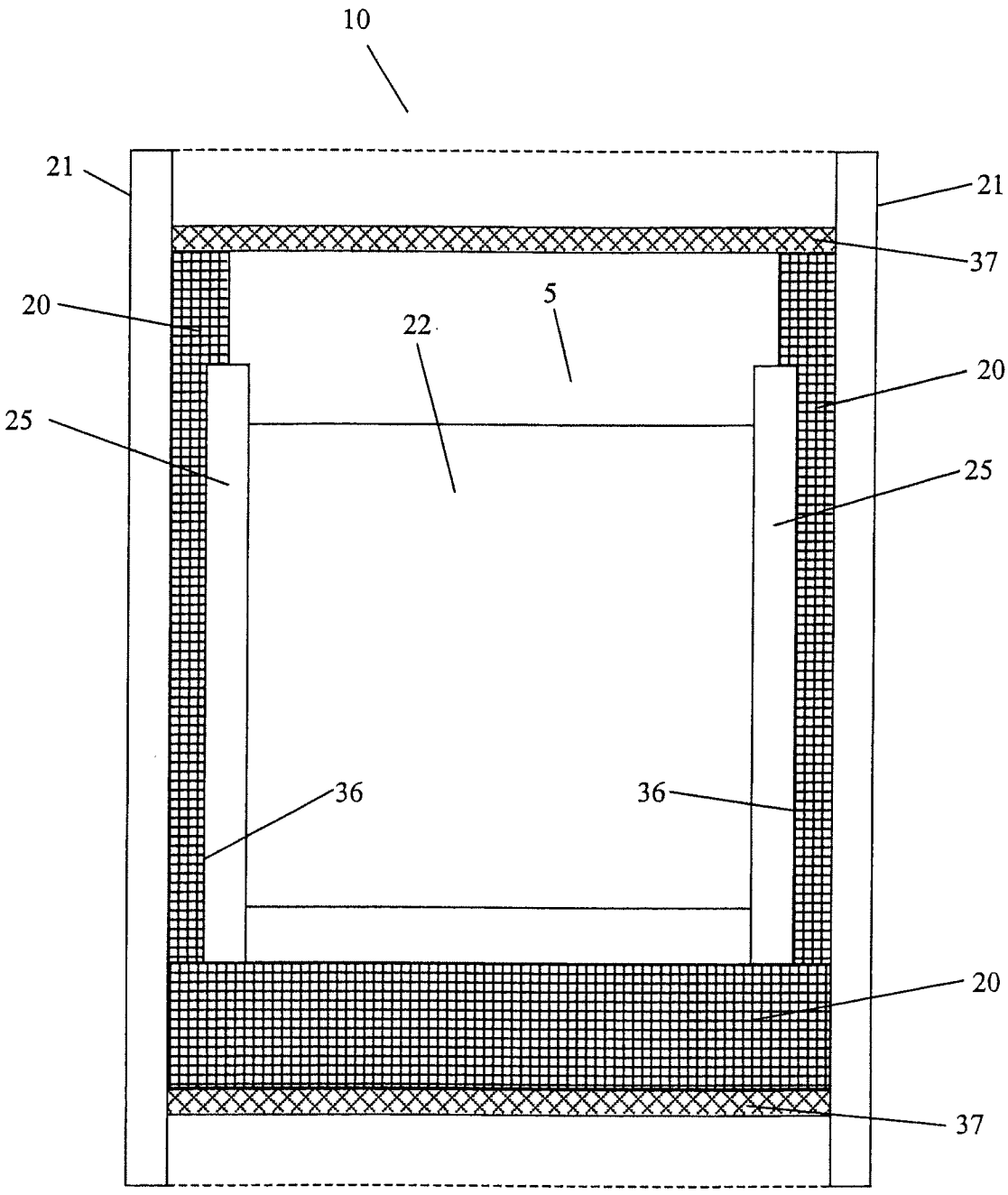


FIG. 3B



SIDE VIEW

FIG. 4

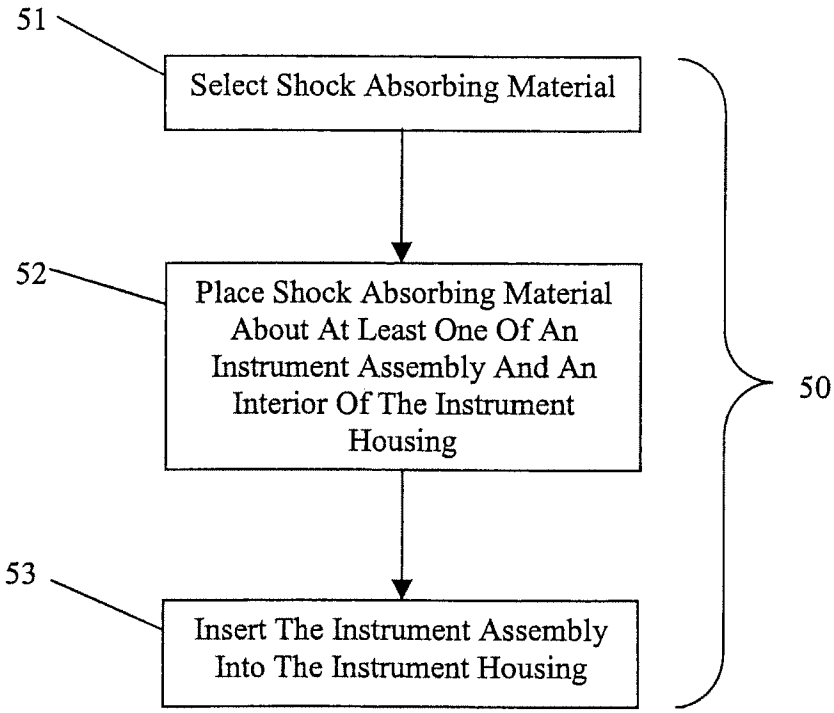

51
Select Shock Absorbing Material
52
Place Shock Absorbing Material About At Least One Of An Instrument Assembly And An Interior Of The Instrument Housing
53
Insert The Instrument Assembly Into The Instrument Housing
50

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/069310

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 47/01 (2008.04)
USPC - 166/254.2
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(8) - E21B 47/01 ((2008.04)
USPC - 73/430; 166/254.2; 174/544; 175/50; 181/102; 250/256

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 practicable, search terms used)
PatBase and Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 5,869,836 A (LINDEN et al) 09 February 1999 (09.02.1999) entire document	1-3, 7-11, 13-16 --- 4-6, 12
Y	US 4,158,773 A (NOVAK) 19 June 1979 (19.06.1979) entire document	4-6
Y	US 6,134,892 A (TURNER et al) 24 October 2000 (24.10.2000) entire document	12

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
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"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
28 August 2008	03 SEP 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774