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(54) **DOWNHOLE TOOL MEASUREMENT DEVICE MOUNTING SYSTEM AND METHOD**

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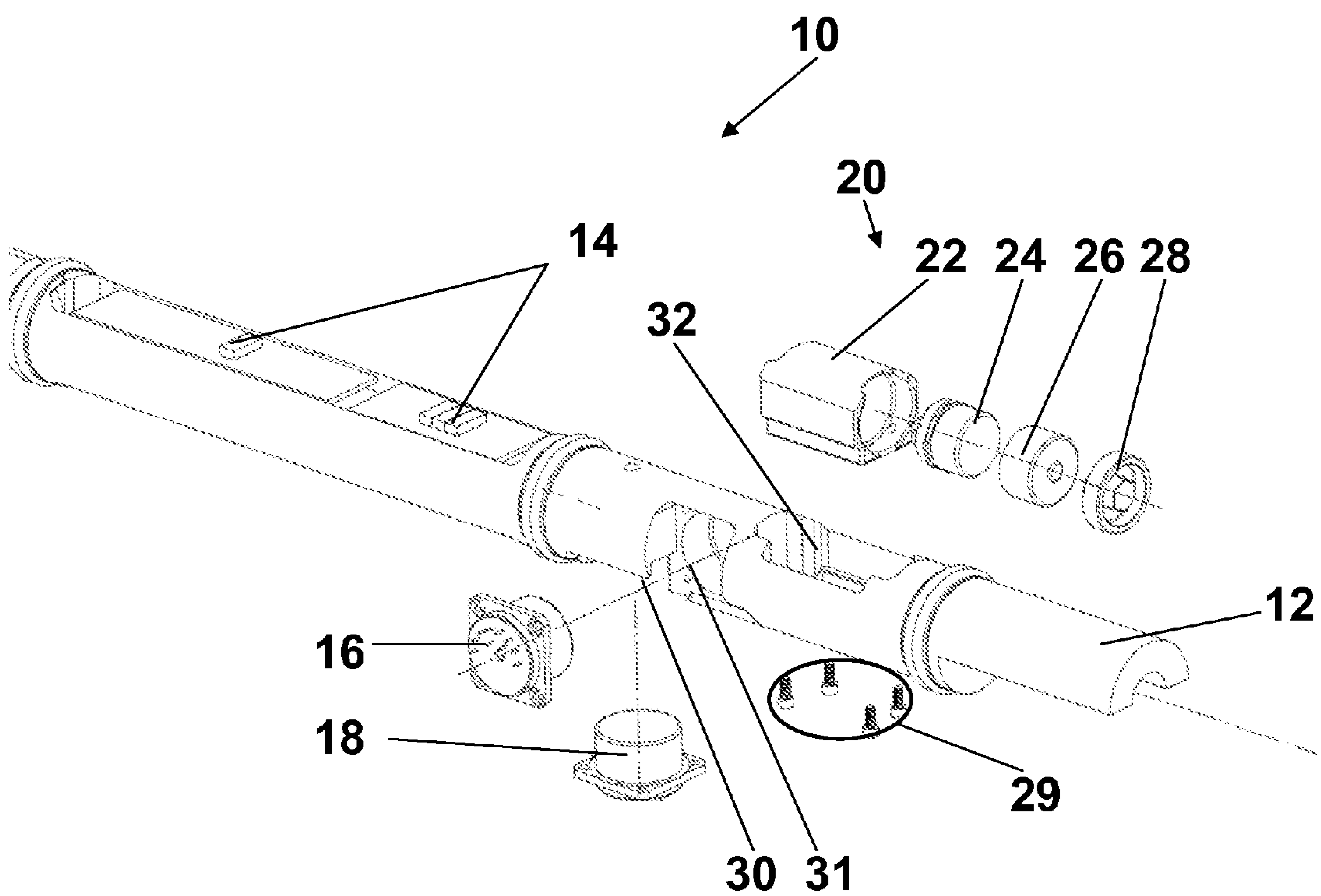
(57) **ABSTRACT**

A downhole tool measurement device mounting system and method and provided.



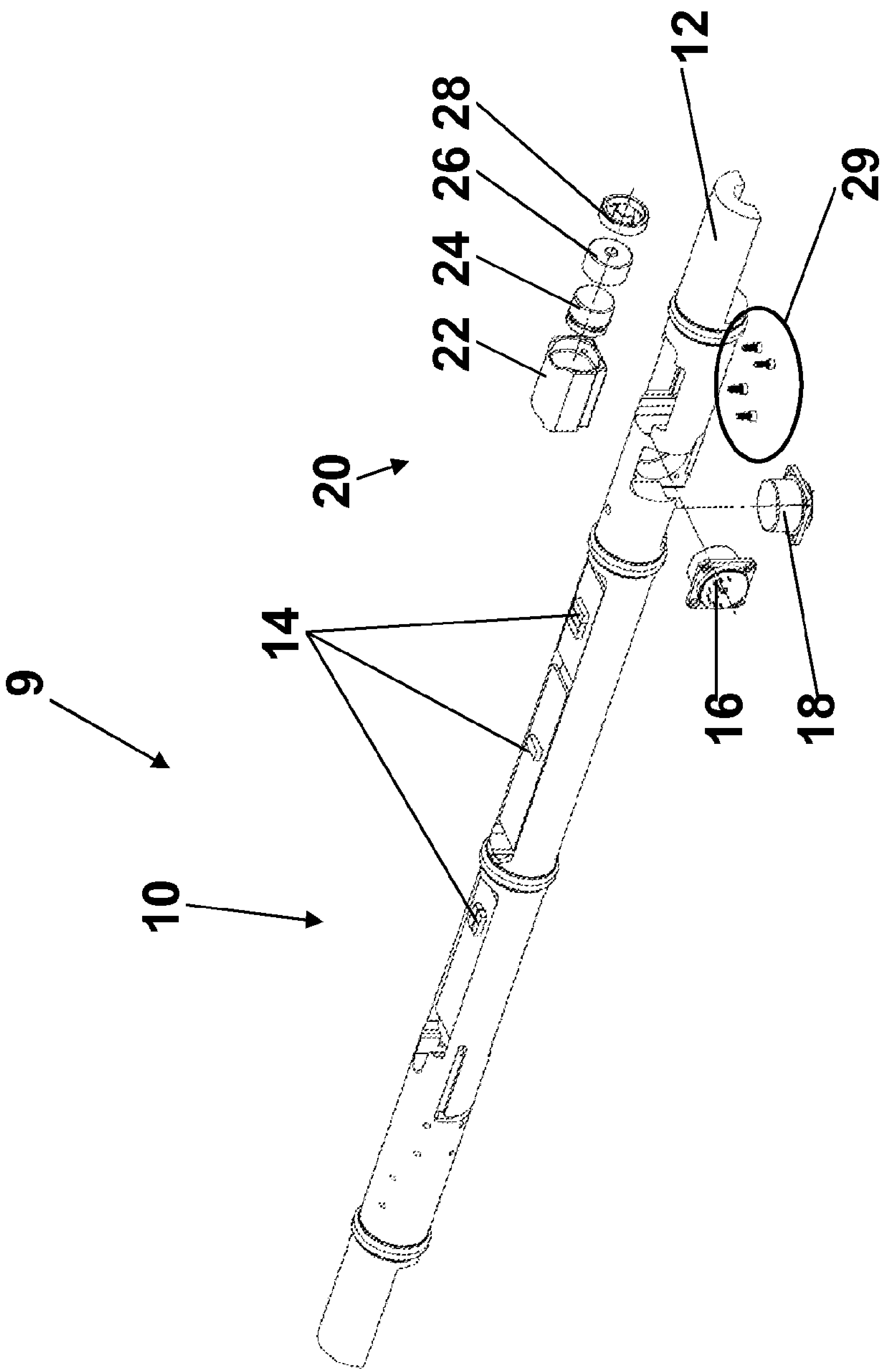


FIGURE 1

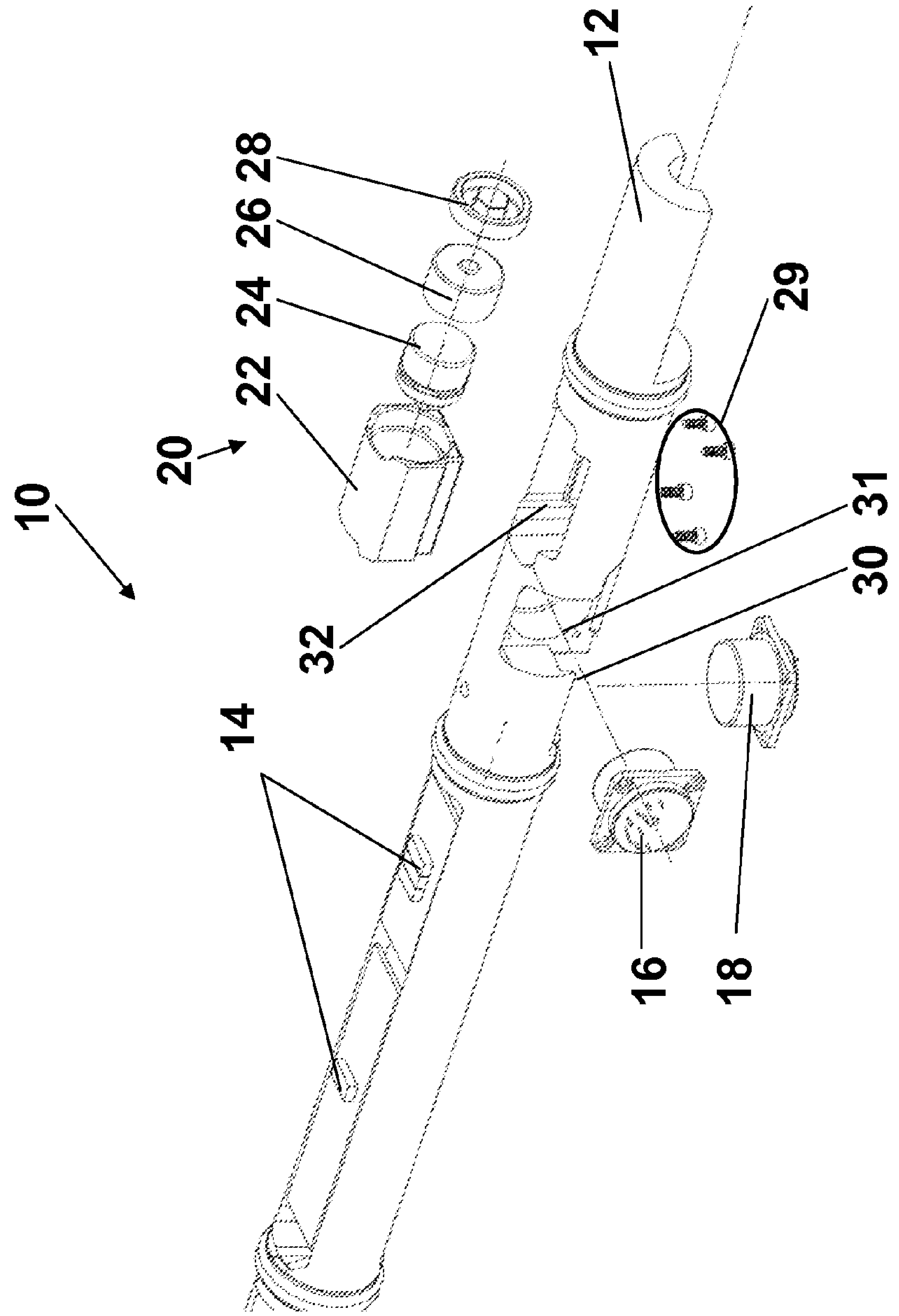


FIGURE 2

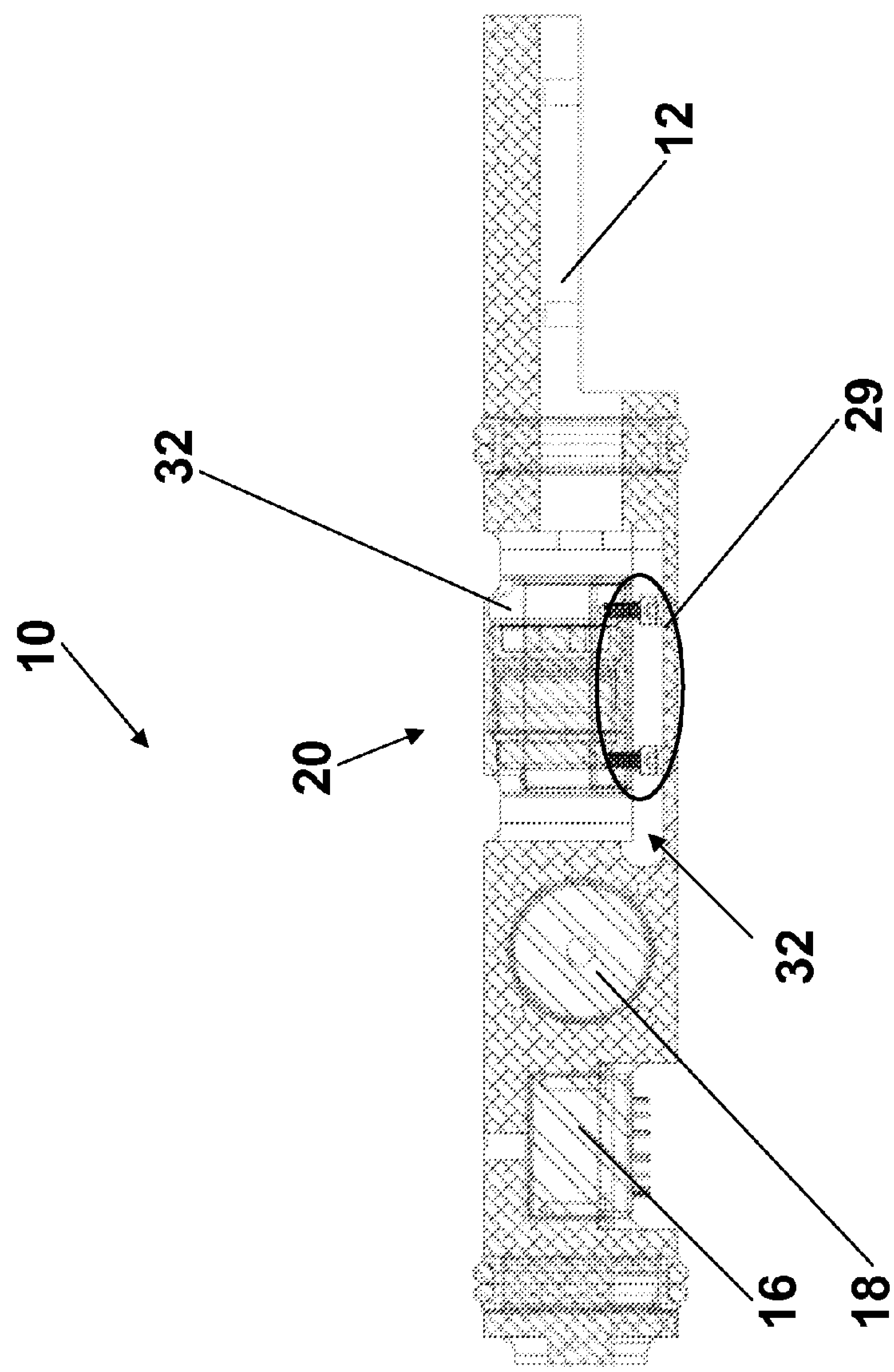


FIGURE 3

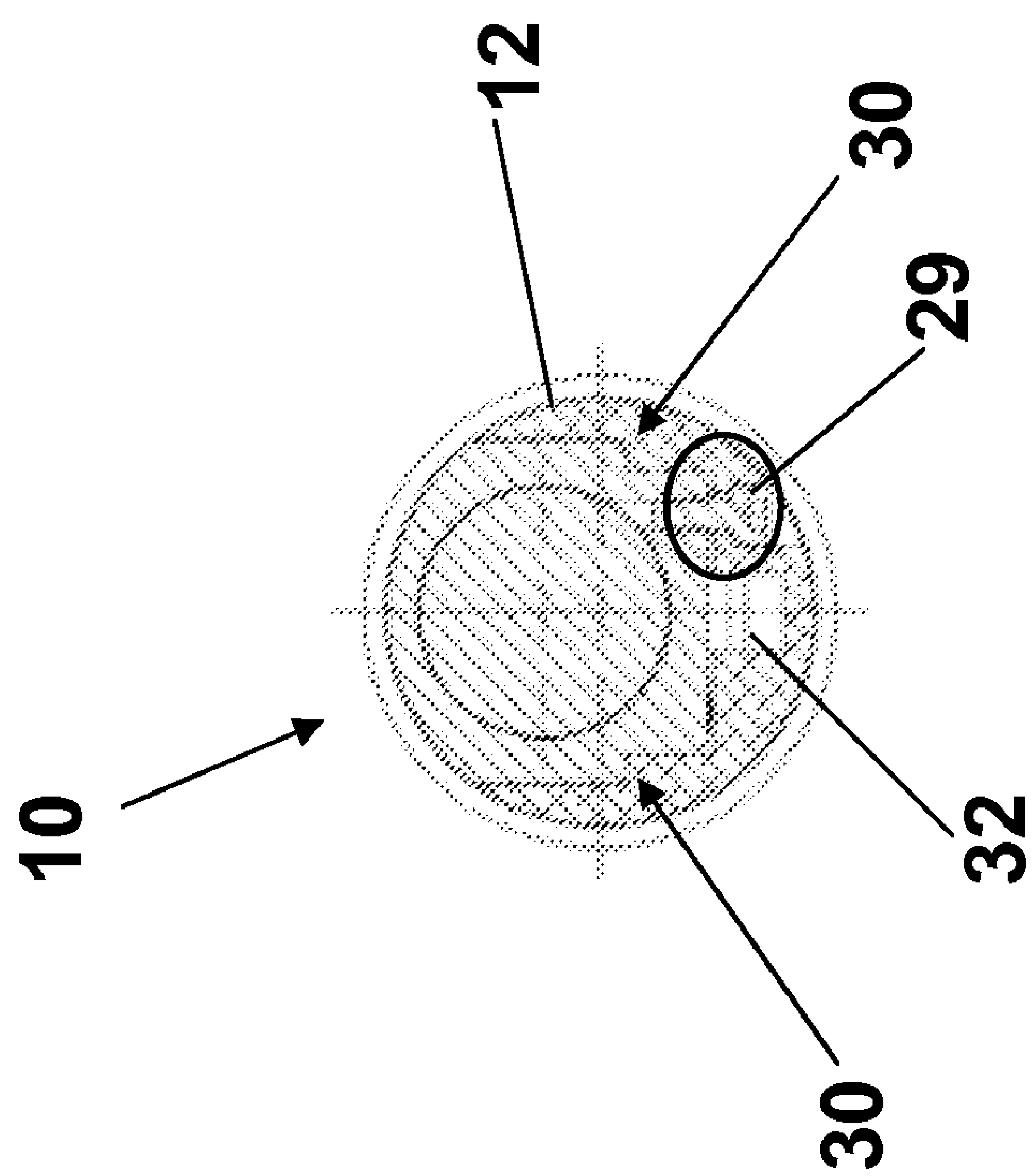


FIGURE 4

DOWNHOLE TOOL MEASUREMENT DEVICE MOUNTING SYSTEM AND METHOD

PRIORITY CLAIMS/RELATED APPLICATIONS

[0001] This application claim the benefit under 35 USC 119(e) to U.S. Provisional Patent Application Ser. No. 61/330,187, filed on Apr. 30, 2010 and entitled "Downhole Tool Measurement Device Mounting System And Method", the entirety of which is incorporated herein by reference.

FIELD

[0002] The disclosure relates generally to downhole tools and in particular to downhole survey sensors.

BACKGROUND

[0003] A downhole survey instrument typically consists of electronics and various sensors packaged within a chassis usually machined from a cylindrical piece of non-magnetic material. The downhole survey instrument is usually a long, slender, assembly, due to the form factor of drilling sensor apparatus in which it is used. These typical instruments also have features that retain and ruggedize the sensors and electronics due to the harsh downhole environment. The survey assemblies typically include an inclinometer which sometimes consists of three or more, typically orthogonally positioned, accelerometers. An accelerometer pair is usually mounted normal to the elongated chassis axis, and a third accelerometer, usually called the Z axis accelerometer, is typically coaxial to the instrument chassis long axis.

[0004] In most typical systems, the 'Z' axis accelerometer for a downhole survey sensor is installed at one end of the elongated chassis since the cross-section of the accelerometer consumes a large percentage of the available chassis cross section. Furthermore, the chassis material cross-section must provide the structural integrity needed to maintain the relative positions of the sensors in the assembly through handling and use in the harsh downhole environment.

[0005] The typical configuration consists of installing an accelerometer into a coaxial pocket machined into one end of the instrument chassis and then retaining it with a threaded member or members that clamp the accelerometer in place. The disadvantage of this scheme is that it 1) limits placement of the 'Z' axis accelerometer near one end of the assembly; 2) If the 'Z' axis accelerometer is not located at the end of the chassis, additional members may need to be attached which complicates the sensor; 3) it makes routing of conductors difficult as not much cross-section remains for thru-wireways in the chassis; and 4) it takes more time to replace accelerometer due to the complexity of the assembly so that, for example, end components would need to be removed/unwired to access the accelerometer.

[0006] Another configuration simply uses an elastomeric compound to 'glue' the accelerometer in place. This has the disadvantage of poor stability (since the accelerometer may be able to move) and difficult replacement/rework since the "glue" must be removed.

[0007] Thus, it is desirable to provide a mount for downhole survey sensor that overcomes the limitations and drawbacks of typical systems and it is to this end that the disclosure is directed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates an example of an implementation of a mounting for a survey sensor;

[0009] FIG. **2** illustrates more details of the distal end of the mounting for a survey sensor;

[0010] FIG. **3** is a sectional side view of the mounting for a survey sensor; and

[0011] FIG. **4** is a sectional end view of the mounting for a survey sensor.

DETAILED DESCRIPTION OF ONE OR MORE EMBODIMENTS

[0012] The disclosure is particularly applicable to a downhole survey sensor with accelerometers and it is in this context that the disclosure will be described. It will be appreciated, however, that the mounting system and method has greater utility since it can be used to mount other types of sensors and may be used for a variety of different industries in addition to the drilling/boring examples described below.

[0013] In one implementation, an accelerometer may be mounted, but the mounting device and mounting method may be used for other sensors and the mounting of other sensors is within the scope of this disclosure. In one implementation, an accelerometer subassembly may be mounted into/onto features machined on/in a chassis body **12** as shown in FIGS. **1** and **2**. However, using the mounting device and method, the accelerometer assembly may be installed along axes (the x axis and/or the y axis) other than the typical z axis. In general terms, the accelerometer may be mounted into a 'block' that contains features for rigidly attaching the accelerometer. For example, the "block" may be a configuration in which a flange of the accelerometer is captured between a shoulder within the block and the shoulder of a threaded member or intermediate member that is captured by a threaded member. The block may be fastened to the chassis, such that the accelerometer has its sensing axis parallel to the chassis axis. The block and chassis may both have machined features, in this case shoulders/ledges, that, when the sensor is fully assembled, ensures a stable relative position between them and hence between other sensors and the Z accelerometer.

[0014] FIG. **1** illustrates an example of an implementation of a mounting **10** for a survey sensor which is also shown in more detail in FIG. **2**. As shown in FIGS. **1** and **2**, an implementation of the mounting **10** may include the chassis **12** into which a sensor, such as an accelerometer, may be mounted. The chassis **12** of the sensor body may have one or more circuits or printed circuit boards **14** attached to the chassis body as shown adjacent to the sensors. In one example, the circuits/printed circuit boards **14** may be mounted on a side of the chassis that is the same side on which at least one of the sensors are installed. As shown in FIG. **1**, a tool **9** into which the mount **10** is connected/attached/affixed/part of may be significantly larger than the mount and the mount **10** may be used with various different types of tools. In the example in FIGS. **1** and **2**, the mount **12** may house a first sensor **16** and a second sensor **18**, such as an X axis accelerometer and a Y axis accelerometer when the two accelerometers are mounted on different sides of the chassis **10** as shown. As shown in FIG. **2**, each of the sensors **16**, **18** may be mounted and secured into a cavity **30**, **31** in the chassis. The mount may be used for various downhole sensors. For example, as described below in more detail, the sensor may be a magnetometer or gyroscope

[0015] In the example in FIGS. **1** and **2**, the mount **12** also may house a third sensor assembly **20**, such as a Z axis accelerometer assembly, that mounts in and is secured in a third cavity **32** in the chassis **12**. The third accelerometer assembly **20** may further comprise a block **22** into which an accelerometer **24** is mounted. The third accelerometer assembly **20** may further comprise a retaining cap **26** that sits on top of the accelerometer **24** inside of the block **22**. The third accelerometer assembly **20** may further comprise a retainer member **28**, that may be threaded or may use another mechanism to secure the accelerometer in the block, that releasably secures the accelerometer **24** and the retaining cap **26** into the block **22** to create a monolithic accelerometer assembly. Alternatively, the block **22** may be a configuration in which a flange of the accelerometer **24** is captured between a shoulder within the block (not shown) and a shoulder of a retainer member **28** of the retainer cap **26** that is captured by the retainer member **28**. The monolithic accelerometer assembly may then be inserted into the cavity **32** and secured or fastened into the cavity so that, for example, the accelerometer **24** has its sensing axis parallel to the chassis axis. The monolithic accelerometer assembly may be secured to/fastened to the cavity/chassis by various mechanisms. For example, the block **22** and chassis cavity **32** may both have machined features, such as shoulders/ledges **30** (one of which is shown in FIG. **4**), that, when the sensor is fully assembled, ensures a stable relative position between them and hence between other sensors and the accelerometer **24**. Alternatively, as shown in FIGS. **1** and **3**, the mount may have one or more securing mechanisms **29**, such as screws, that secure the block **22** to the chassis.

[0016] FIG. **3** is a sectional side view of the mounting **10** for a survey sensor. In this example, the sensors **16**, **18**, **20** are mounted on sides of the chassis **12** so that acceleration in the X axis, acceleration in the Y axis and acceleration in the Z axis can be measured. It is important to note that the third sensor assembly **20** does not need to be coaxial to the chassis **12** or the other sensors **16**, **18**. In particular, the ability to measure each different axis signal is based on the sensor axes being orthogonal and the configuration shown in FIGS. **1-4** satisfies this requirement while having the third sensor assembly **20** that is not coaxial to the chassis **12** or the other sensors **16**, **18**. The configuration shown in FIG. **1-4** is possible due to an offset that allows the mount to utilize a typically sized mini accelerometer. The configuration allows for the close grouping of the sensors (the inclinometer or accelerometers) if desired. In addition, the configuration enables and permits the placement of the third sensor at any location along the length of the survey sensor while maintaining a rugged, rigid, one-piece, chassis. For example, locating the sensors closer to the magnetometer and having a more rigid structure between them is important to survey accuracy and stability.

[0017] Returning to FIG. **3**, the figure also shows the securing mechanisms **29** passing through the chassis **12** and securing the third sensor assembly **20** to the chassis **12**. FIG. **4** is a sectional end view of the mounting **20** for a survey sensor in which the securing mechanisms **29** passing through the chassis **12** can be seen.

[0018] The mount, as shown in FIGS. **3** and **4**, has a passageway **32** underneath the sensor assembly **20**. The passageway may be used as a wireway for conductors that need to pass through this region of the assembly. Using this configuration, the sensor assembly **20** can be removed and re-installed without needing to remove these conductors.

[0019] In an alternative embodiment, the mount may mount a magnetometer sensor or a fluxgate magnetometer sensor. The magnetometer sensor or a fluxgate magnetometer sensor embodiment may also have an accelerometer or a group of accelerometers that are mounted on the downhole assembly. The magnetometer sensor or a fluxgate magnetometer sensor is an independent sensor commonly used in downhole assemblies. A magnetometer is a sensor system that measures a magnetic field. In a guidance system used in downhole assemblies, the common magnetic fields are from the earth's field or from other sources of magnetic fields such as interfering magnetic assemblies or adjacent wells with magnetic material in the well bores. Flux gate magnetometers are commonly used in downhole applications and all known downhole applications of flux gates use Permalloy material. Further details of magnetometers and flux gate magnetometers may be found in U.S. Pat. No. 6,972,563 which is incorporated herein by reference.

[0020] For a fluxgate magnetometer sensor, most modern fluxgate designs rely on a tape wound ring core approach which typically allows the combination of two orthogonal measurement axes on the same structure. The traditional material used is commonly known as Supermalloy, with a fairly high squareness BH loop index of some 0.75. Amorphous materials can offer improvements in squareness BH loop index to exceed 0.85 and much higher initial permeabilities, coupled with lower excitation current. All these qualities allow for a fluxgate structure which is smaller in size for equivalent sensitivity when compared with the traditional approach, plus lower drive current needs, which is highly beneficial since the typical measurement while drilling (MWD) string is battery operated. Amorphous material also exhibits lower magnetostriction effects, which produces better signal to noise ratios. The lower core losses verses temperature also allow the use of thicker ribbon, leading to a larger effective cross sectional area for a given OD/ID, which further improves the volumetric efficiency. An example of improved amorphous materials include Magnetic Metals DC annealed 9001.

[0021] While the foregoing has been with reference to a particular embodiment of the invention, it will be appreciated by those skilled in the art that changes in this embodiment may be made without departing from the principles and spirit of the disclosure, the scope of which is defined by the appended claims.

1. A mounting device for at least one sensor, comprising:
a chassis;
a first sensor area and a second sensor area in the chassis capable of housing a first sensor and a second sensor that measure a characteristic along a first axis and a second axis, respectively; and
a sensor assembly mounted in a cavity of the chassis in a third sensor area wherein a sensing axis of the sensor assembly is orthogonal to the first and second axes, the sensor assembly having a block and an orthogonal sensor mounted in the block to form a monolithic assembly that is secured into the cavity.

2. The mounting device of claim **1** further comprising a first sensor housed in the first sensor area and a second sensor housed in the second sensor area.

3. The mounting device of claim **2**, wherein the first, second and orthogonal sensors are accelerometers.

4. The mounting device of claim **1** wherein the sensor assembly further comprises a retaining cap that is adjacent the orthogonal sensor and a retainer wherein the retainer secures the retainer cap and the orthogonal sensor to the block.

5. The mounting device of claim **4**, wherein the retainer is a threaded retainer that screws into the block.

6. The mounting device of **1**, wherein the orthogonal sensor has a flange that is captured by the block to secure the orthogonal sensor to the block.

7. The mounting device of **2** further comprising one or more circuit boards mounted on the chassis wherein at least one circuit board is mounted on a side of the chassis on which one of the first sensor, second sensor and orthogonal sensor are mounted.

8. The mounting device of **1**, wherein the first sensor area and the second sensor area are each a cavity in the chassis.

9. The mounting device of **2**, wherein each of the first, second and orthogonal sensors are one of a magnetometer and a gyroscope.

10. The mounting device of **1**, wherein the third sensor area is located at any place along a length of the chassis.

11. The mounting device of **1** further comprising a passageway underneath the cavity in the chassis in the third sensor area for a set of wires connected to the orthogonal sensor.

12. The mounting device of **2**, wherein each of the first, second and orthogonal sensors are one of a magnetometer sensor and a fluxgate magnetometer sensor.

13. The mounting device of **2**, wherein the fluxgate magnetometer sensor is manufactured from an amorphous material.

14. The mounting device of **13**, wherein the fluxgate magnetometer sensor is manufactured from a material having a BH loop index that exceeds 0.85.

15. A method for mounting one or more sensors to a chassis, the method comprising:

mounting a first sensor and a second sensor to a chassis, wherein each sensor is capable of measuring a characteristic along a first axis and a second axis, respectively;/

mounting a third sensor assembly in a cavity of the chassis wherein a sensing axis of the third sensor assembly is orthogonal to the first and second axes; and

wherein mounting the third sensor assembly further comprises mounting a third sensor into a block to form a monolithic assembly that is mounted into the cavity of the chassis.

16. The method of claim **15**, wherein mounting a third sensor assembly further comprising inserting a retainer cap into the block after the third sensor and securing a retainer to the block to secure the retainer cap and the third sensor to the block.

17. The method of claim **15**, wherein mounting the third sensor further comprises capturing a flange of the third sensor by the block to secure the orthogonal sensor to the block.

18. The method of claim **15**, wherein mounting the third sensor assembly further comprising mounting the third sensor assembly along a length of the chassis.

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