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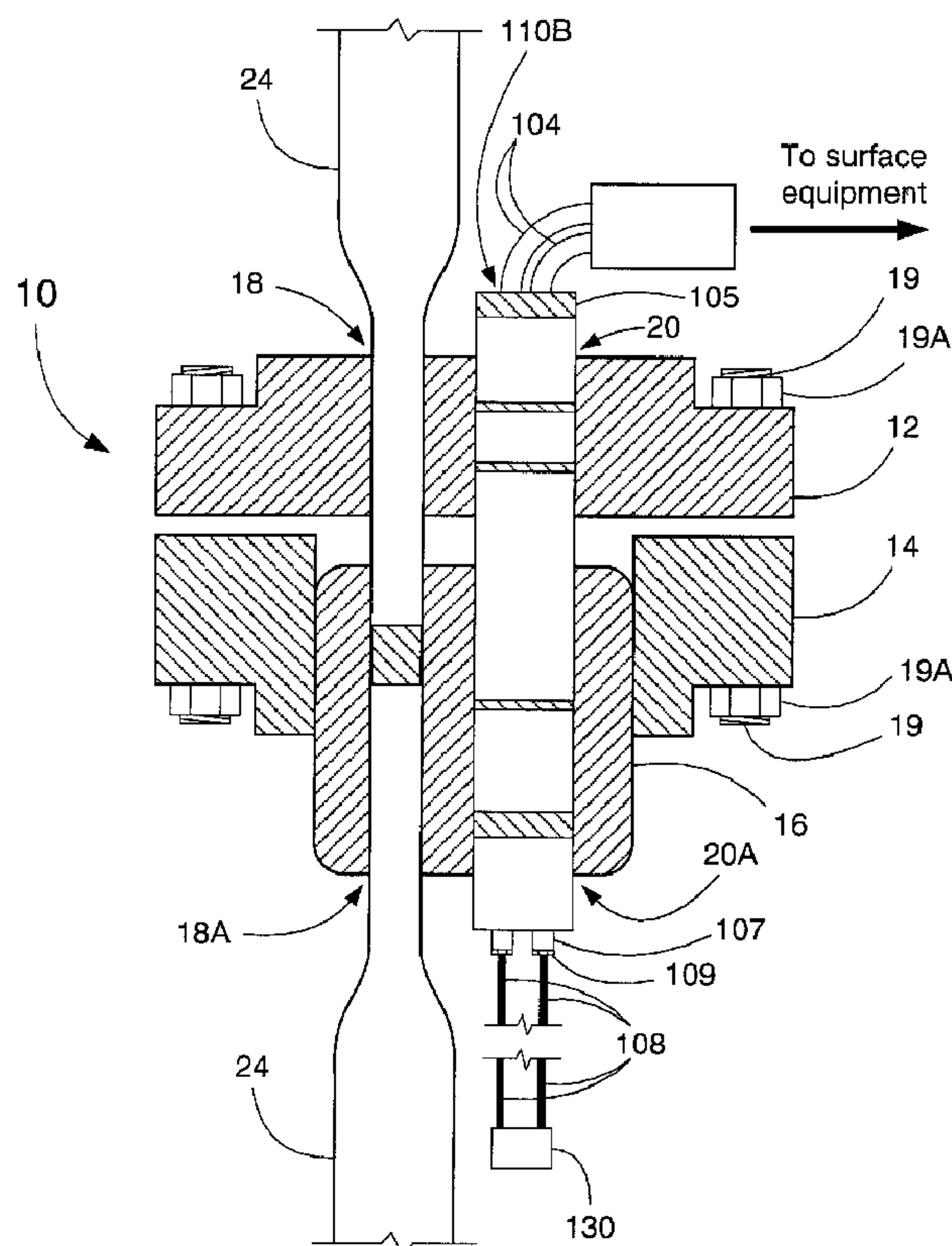
(71) **Demandeur/Applicant:**
HAWK OILFIELD SERVICES INC., CA

(72) Inventeur/Inventor:
ABOUELDAHAB, HAZEM, CA...

(74) Agent: NA

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(54) Title: A WELLHEAD ELECTRICAL FEEDTHROUGH SYSTEM



(57) **Abrégé/Abstract:**

A hollow feedthrough system is insertable into a feedthrough port of a wellhead. The system comprises a wellhead component, a sealing arrangement and a cable- connecting sub. The wellhead component comprises a cable conduit for housing encapsulated

(57) **Abrégé(suite)/Abstract(continued):**

cables, which are electrically connectible to a source of electrical power. The wellhead component includes a hollow feedthrough mandrel with a first end, a second end and a plenum. The first end has one or more nipples for receiving a portion of the encapsulated cables therethrough. The plenum for receiving the one or more encapsulated cables from the cable conduit through the second end of the mandrel. The mandrel is sealingly insertable within the feedthrough port. The sealing arrangement comprises metal-to-metal seals between the one or more nipples and the received portion of the encapsulated cables. The cable-connecting sub for electrically connecting the encapsulated cables with a motor-lead cable.

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ABSTRACT

A hollow feedthrough system is insertable into a feedthrough port of a wellhead. The system comprises a wellhead component, a sealing arrangement and a cable-connecting sub. The wellhead component comprises a cable conduit for housing encapsulated cables, which are electrically connectible to a source of electrical power. The wellhead component includes a hollow feedthrough mandrel with a first end, a second end and a plenum. The first end has one or more nipples for receiving a portion of the encapsulated cables therethrough. The plenum for receiving the one or more encapsulated cables from the cable conduit through the second end of the mandrel. The mandrel is sealingly insertable within the feedthrough port. The sealing arrangement comprises metal-to-metal seals between the one or more nipples and the received portion of the encapsulated cables. The cable-connecting sub for electrically connecting the encapsulated cables with a motor-lead cable.

A WELLHEAD ELECTRICAL FEEDTHROUGH SYSTEM

TECHNICAL FIELD

This disclosure generally relates to equipment for the production of hydrocarbons. In particular, the disclosure relates to a wellhead electrical feedthrough
5 system for providing an electrical conductor through a wellhead.

BACKGROUND

A wellhead provides physical support and pressure seals for the casing that is fixed within the oil or gas well below. The weight of the casing is transferred to the ground by suspending the casing from the wellhead, which in turn is fixed to the ground.
10 Typically further equipment is also positioned within the well and suspended from the wellhead, such as production tubing. The wellhead also provides pressure seals that contain the pressure within the well so that production of oil or gas can be controlled. Above the ground, the wellhead provides a connection point for blowout preventers during drilling operations and Christmas trees during the production phase of the well.

15 When oil and/or gas are being produced from a well artificial-lift systems are often used to facilitate movement of the produced fluids from lower sections of the well to the surface. Artificial-lift systems can be situated on the surface or they can be inserted within the wellbore. The later of these systems are also referred to as downhole artificial-lift systems. A common example of a downhole artificial-lift system is an electrical
20 submersible pump (ESP).

ESPs require electrical power to operate the electric motor. The electric power is often provided from a source on the surface. As such, power-conducting cables that conduct the electrical power to the ESP must pass through the wellhead. Additionally, the functionality of many ESPs can be monitored by downhole sensors that provide the
25 pressure and/or temperature information to the surface by information-conducting cables. However, the power-conducting cables and the information-conducting cables must pass through the wellhead without interfering with either of the physical-support functionality or pressure-seal functionality of the wellhead.

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In some known applications, the power-conducting cables require three splicing-sites: i) one above the wellhead to connect a power-conducting cable from the power-source on the surface to a trans-wellhead conductor; ii) below the wellhead from the trans-wellhead conductor to an intermediate conductor that extends into the well; and iii) from the intermediate conductor to a primary conductor that is directly connected to the ESP. These splicing sites are also referred to as pig-tails, with an upper pigtail, an electrical feedthrough mandrel, and a lower pigtail, respectively.

Because each wellhead can be customized to a particular well or operator's specifications, installing the three pigtails is often a customized work-order that requires trained electricians to perform. Furthermore, anytime there is a work-over of the well, for whatever reason, the power-conducting cables often must be replaced, which again requires the services of a trained electrician. Because the electrical feedthrough mandrel and the lower pigtail may come into contact with conductive fluids these electrical connections are often sealed with insulating seals, such as rubber or silicon seals. The insulating seals are susceptible to failure in the face of a pressure surge within the well. If one or both of the lower pigtail connection or the downhole pigtail connection fail the ESP will lose power and the power-conducting cables must be replaced, which requires further production-downtime of the well.

SUMMARY

Embodiments of the present disclosure relate to an electrical feedthrough system that is insertable into a feedthrough port of a wellhead. The feedthrough system comprises a wellhead component, a sealing arrangement and a cable-connecting sub. The wellhead component comprises a cable conduit for housing a first portion of one or more encapsulated cables therein. The one or more encapsulated cables are electrically connectible to a source of electrical power. The wellhead component also includes a hollow feedthrough mandrel with a first end, a second end and a plenum therebetween. The plenum for receiving a second portion of the one or more encapsulated cables from the cable conduit through the second end of the hollow feedthrough mandrel. The first end has one or more nipples for receiving a third portion of the one or more encapsulated cables therethrough. The feedthrough mandrel is sealingly insertable within the

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feedthrough port of the wellhead. The sealing arrangement comprises one or more metal-to-metal seals that provide a fluid-tight seal between the one or more nipples and the third portion of the one or more encapsulated cables. The cable-connecting sub for electrically connecting the one or more encapsulated cables with a motor-lead cable
5 forming a complete electrical circuit between the source of electrical power and the motor-lead cable.

Embodiments of the present disclosure relate to an electrical feedthrough system that provides a hollow feedthrough mandrel with metal-to-metal seals between the mandrel and an outer layer of encapsulated cables. The hollow mandrel extends through
10 and is sealingly engaged with the wellhead, which allows the encapsulated cables to extend uninterrupted from the source of electrical power, through the wellhead and down into the wellbore. The metal-to-metal seals provide a robust fluid-tight seal at the end the location where each of the encapsulated cables exit the feedthrough mandrel and enter into the wellbore. The cable-connection sub forms an electrical connection between the
15 wellbore end of the encapsulated cables and a motor-lead cable. Without being bound by any particular theory, the electrical feedthrough system may reduce the time and cost of forming multiple pigtail-connections between sections of encapsulated cable and between a second of encapsulated cable and the motor-lead cable. The feedthrough mandrel may be of any dimension and so it can be used in most wellheads, including
20 slimhole wells, and it can be retrofit into most wellheads. Furthermore, during any well workovers the encapsulated cables and the feedthrough cables may be preserved and used again after the well workover rather than discarding them as is the common practice.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the present disclosure will become more apparent in the following detailed description in which reference is made to the appended drawings.
25 FIG. 1 is mid-line elevation view of an example of a wellhead with one embodiment of the present disclosure inserted therein; and

FIG. 2 is a mid-line elevation, partially-exploded view of one example of a downhole splice-arrangement in accordance with embodiments of the present disclosure.

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DETAILED DESCRIPTION

As used herein, the term “casing” refers to any type of tubular that is installed within an oil and/or gas well and that is physically supported by a wellhead at that surface. This includes tubulars that provide structural support to well bore and any
5 tubulars that are used to conduct oil and/or gas to the surface.

Embodiments of the present disclosure relate to a feedthrough 100 for use with oil and/or gas wells. The feedthrough 100 may also be referred to as a wellhead penetrator or a penetrator or an electrical feed through or a power feed through or an electrical connector or an electrical penetrator. As shown in FIG. 1, the feedthrough 100
10 is insertable through a wellhead 10 that comprises a flange 12, a casing head 14 and a casing hanger 16. Because each wellhead 10 can be built to the specifications of each different well, this discussion is not limited to these named components of a wellhead 10. It is understood, that the wellhead 10 may include further components such as, but not limited to: further hangers for supporting further downhole tubulars, one or more
15 annulus-access valves, a blowout preventer or a Christmas tree. While not shown in FIG. 1, further seals are also provided between various abutting surfaces of the wellhead to provide the sealing functionality of the wellhead 10. For example, one or more seals may be provided between the flange 12 and the casing head 14 and between the casing head 14 and the casing hanger 16.

20 The flange 12 and the casing head 14 are connectible together by one or more bolts 19 and nuts 19A. The casing hanger 16 is fixed to the ground surround the wellhead 10 by various means known to those skilled in the art. The flange 12 defines a production port 18 and a feedthrough port 20. The casing hanger 14 defines a wellbore 22 that is in fluid communication with an inner diameter of casing tubulars 24 that are supported
25 therefrom. The casing hanger 16 is insertable into the wellbore 22, within the casing head 14. The casing hanger 16 defines a production port 18A and a feed through port 20A. When the wellhead 10 is assembled, the production ports 18, 18A are in fluid communication with each other and the feedthrough ports 20, 20A are in fluid communication with each other. The production ports 18, 18A and the feedthrough ports
30 20, 20A provide fluid communication from above the flange 12 to the wellbore 22 below

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the casing hanger 16. As shown in FIG. 1, a joint of casing 24 is insertable through the production ports 18, 18A. The casing 24 can be used to physically reinforce the wellbore 22 or it may be a tubular that is a smaller diameter and that is used to conduct oil and/or gas to the surface. It is understood that at any wellhead 10 there may be one or more strings of casing 24 that are supported within the wellbore 22 by the wellhead 10.

The electrical feedthrough system 100 of the present disclosure comprises a wellhead component 102, a sealing arrangement 104 and a cable-connecting sub 130.

The well component 102 comprises a cable conduit 104 and a hollow feedthrough mandrel 110 with one or more encapsulated cables 108 therein.

The cable conduit 104 extends from the wellhead 10 to surface equipment (not shown). The surface equipment can include but is not limited to an electrical power source and/or a device for receiving, recording and displaying any information provided by information-conducting cables, as discussed further below. The cable conduit 104 houses one or more encapsulated cables 108 that extend between the surface equipment and the wellhead 10. The cable conduit 104 can be made of a rigid material to support and protect the encapsulated cables 108 from physical or chemical damage as may occur at a busy wellhead 10 site.

The one or more encapsulated cables 108 may comprise one or more layers that are wrapped around an electrical-conductor cable and/or an information-conductor cable. The electrical-conductor cable is one of a single copper conductor or multiple, smaller copper conductors. The information-conductor cable can be any type of cable that transmits information, including but not limited to optical fibers. The electrical-conductor cable is covered by one or more polymer-based insulation layers. Depending upon the temperatures within the wellbore 22 or at the electrical-conductor cables, the insulation layers may comprise one or more layers of polypropylene, ethylene propylene diene, other synthetic polymers, natural rubbers or blends of natural rubbers and synthetic polymers. The insulation layers are typically covered in a protective layer to protect the insulation layer or the electrical-conductor cables from the environment within the wellbore 22. The protective layer may be covered by a jacket layer to protect against

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mechanical injuries and to fill in any physical gaps within the layers therebelow. The protective layer may then be further protected by a layer of metal or metal-alloy armor.

The feedthrough mandrel 110 is extendible through the feedthrough ports 20, 20A. The feedthrough mandrel 110 is substantially hollow with a substantially closed
5 first-end 110A and a second-end 110B that may be substantially closed. The second-end 110B is connectible to the cable conduit 104 by a connection 105. The connection 105 may be one or more of a threaded connection, a snap-fit connection, a friction fit connection or combinations thereof. The encapsulated cables 108 pass from the cable conduit 104 into the hollow feedthrough mandrel 110 at or proximal to the connection
10 105.

When inserted into the feedthrough ports 20, 20A an external surface of the feedthrough mandrel 110 is sealing engaged with an inner surface of each of the feedthrough ports 20, 20A. In some embodiments of the present disclosure, at least one flange sealing-member 112 is positioned in the feedthrough port 20 to form a fluid-tight
15 seal between the external surface of the feedthrough mandrel 110 and the flange 12. The at least one flange sealing-member 112 may be fixed to either of the flange 12, the feedthrough mandrel 110 or both. FIG. 1 shows two flange sealing-members 112, but embodiments of the present disclosure are not limited to this number. In some embodiments of the present disclosure at least one hanger sealing-member 114 is
20 positioned in the feedthrough port 20A to provide a fluid-tight seal between the external surface of the feedthrough mandrel 110 and the casing hanger 14. In some embodiments of the present disclosure, there is a hanger sealing-member 114 positioned at or proximal to the first end 110A to prevent the incursion of wellbore fluids into the feedthrough port 20A. FIG. 1 shows two hanger scaling-members 114, but embodiments of the present
25 disclosure are not limited to this number.

The flange sealing-member 112 and the hanger-sealing member 114 may be made of deformable materials that will deform when the feedthrough flange 110 is inserted into the feedthrough ports 20, 20A to form a fluid-tight seal that will prevent fluid communication thereacross when exposed to the ambient or the pressures and
30 temperatures that are found at the wellhead 10 and in the wellbore 22. For example,

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pressures from the range of 5,000 psi to 10,000 psi. For example, temperatures from the range of -40° C to 250 ° C.

The one or more encapsulated cables 108 extend through the hollow feedthrough mandrel 110 and into the wellbore 22. The sealing arrangement 104 is positioned at or proximal to the first-end 110A of the feedthrough mandrel 110. The sealing arrangement 104 provides a fluid-tight seal against the outer most layer of the one or more encapsulated cables 108 at the location where the one or more encapsulated cables 108 exit the first-end 110A. In some embodiments of the present disclosure, the sealing arrangement 104 includes at least one nipple 107 that extends away from the closed first-end 110A external to the feedthrough mandrel 110. In some embodiments of the present disclosure there may be a nipple 107 for each encapsulated cable 108 that extends from the surface equipment and through the feedthrough mandrel 110. In some embodiments, there may be a predetermined number of nipples, for example at least 2. However, if there are less encapsulated cables 108 than nipples 107, then the unused nipples 107 can be sealed, as described further below. In some embodiments of the present disclosure there are three nipples 107 and three encapsulated cables 108.

In some embodiments of the present disclosure, the outermost layer of the one or more encapsulated cables 108 is a metal armor-layer. The sealing arrangement 104 includes a metal-to-metal seal 109 that forms a fluid-tight seal between the metal armor-layer and the nipple 107. The metal-on-metal seal 109 is a fluid-tight seal that prevents fluid communication thereacross when exposed to the ambient or the pressures and temperatures that are found at the wellhead 10 and in the wellbore 22. For example, the metal-to-metal seal 104A can be a soldered connection, a welded connection, a metal-on-metal compression seal or combinations thereof. In some embodiments of the present disclosure, an example of a suitable metal-to-metal seal 104 is commercially available from the Swagelok Company of Ohio, USA. In the instances where there is at least one more nipple 107 than encapsulated cables 108 being used, then the nipple 107 can also be sealed closed by a metal-on-metal seal.

The one or more encapsulated cables 108 extend beyond the sealing arrangement 104 further down the wellbore 22 until they reach the cable-connecting sub 130. The

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cable-connecting sub 130 electrically connects the one or more encapsulated cables 108 to a motor-lead cable 120.

FIG. 2 shows one embodiment of the present disclosure that relates to the cable-connecting sub 130. The cable-connecting sub 130 electrically connects the one or more encapsulated cables 108 to the motor-lead cable 120 so that electric current can be delivered to the ESP from the surface equipment. In some embodiments of the present disclosure, the cable-connecting sub 130 comprises a housing 131 wherein are enclosed a cable splice kit 136, 138, 140 and a hollow mini-mandrel with a first end 130A, a second end 130B and a plenum 132 is defined therebetween. The cable-connecting sub 130 is positionable within the wellbore 22 and relatively proximal to the ESP (not shown). When positioned in the wellbore 22, the first end 130A can receive the one or more encapsulated cables 108, which terminate within the plenum 132 at a sealing member 134. Opposite to the one or more encapsulated cables 108 the sealing member 134 receives one or more grips 136. The one or more grips 136 are electrically connected to the one or more encapsulated cables 108 and one or more pins 138. The one or more pins 138 connect with a cable peek seal 140. In some embodiments of the present disclosure, there may be an equal number of encapsulated cables 108, grips 136 and pins 138. The cable peek seal 140 is positioned proximal the second end 130B for connecting with the motor-lead cable 120 that can enter the plenum 132 via the second end 130B. The motor-lead cable 120 may be held in position by a nut 144. The nut 144 can form a fluid-tight seal around the motor-lead cable 120 and sealingly close the second end 130B. A similar nut 144 can be employed at the first end 130A to form a fluid-tight seal around the one or more encapsulated cables 108 and to sealingly close the first end 130A. The motor-lead cable 120 then electrically connects to the ESP by a receptacle 122 that physically and electrically connects to the ESP. At least the one or more grips 136, the one or more pins 138 and the cable seal can conduct electric current. The cable peek seal 140 will eliminate fluid communication with the electrical splice kit. When the cable-connecting sub 130 is electrically connected with both the one or more encapsulated cables 108 and the motor-lead cable 120 an electric circuit is completed from the surface equipment, through the wellhead 10, along the one or more encapsulated cables 108, through the cable-connecting sub 130 to the ESP.

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I claim

1. An electrical feedthrough system that is insertable into a feedthrough port of a wellhead, the electrical feedthrough system comprising:
 - (a) a wellhead component comprising:
 - (i) a cable conduit for housing a first portion of one or more encapsulated cables therein, the one or more encapsulated cables are electrically connectible to a source of electrical power;
 - (ii) a hollow feedthrough mandrel with a first end, a second end and a plenum therebetween for receiving a second portion of the one or more encapsulated cables from the cable conduit through the second end, the feedthrough mandrel sealingly insertable within the feedthrough port of the wellhead, the first end having one or more nipples for receiving a third portion of the one or more encapsulated cables therethrough;
 - (b) a sealing arrangement that comprises one or more metal-to-metal seals that provide a fluid-tight seal between the one or more nipples and the third portion of the one or more encapsulated cables; and
 - (c) a cable-connecting sub for electrically connecting the one or more encapsulated cables with a motor-lead cable forming a complete electrical circuit between the source of electrical power and the motor-lead cable.

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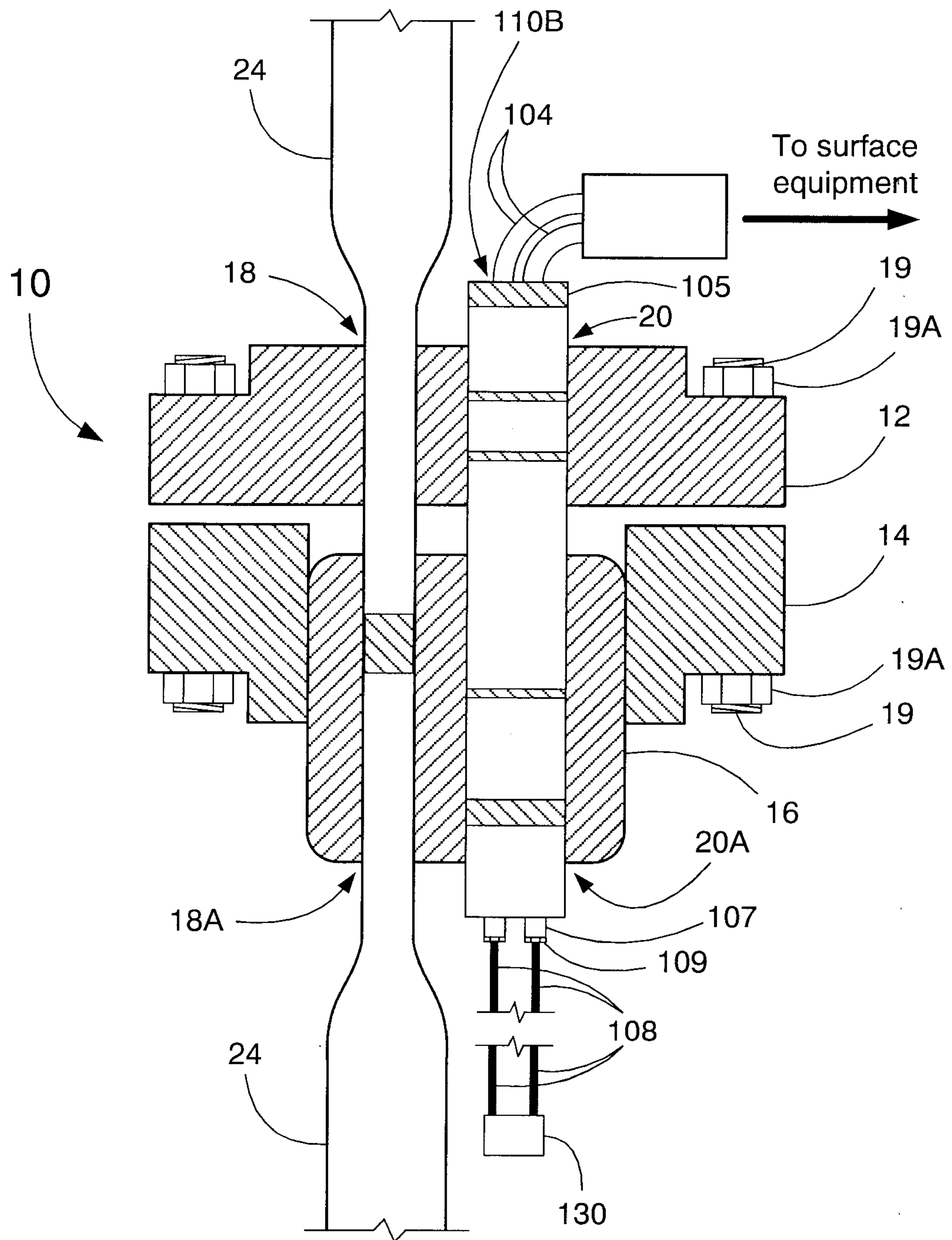


FIG. 1

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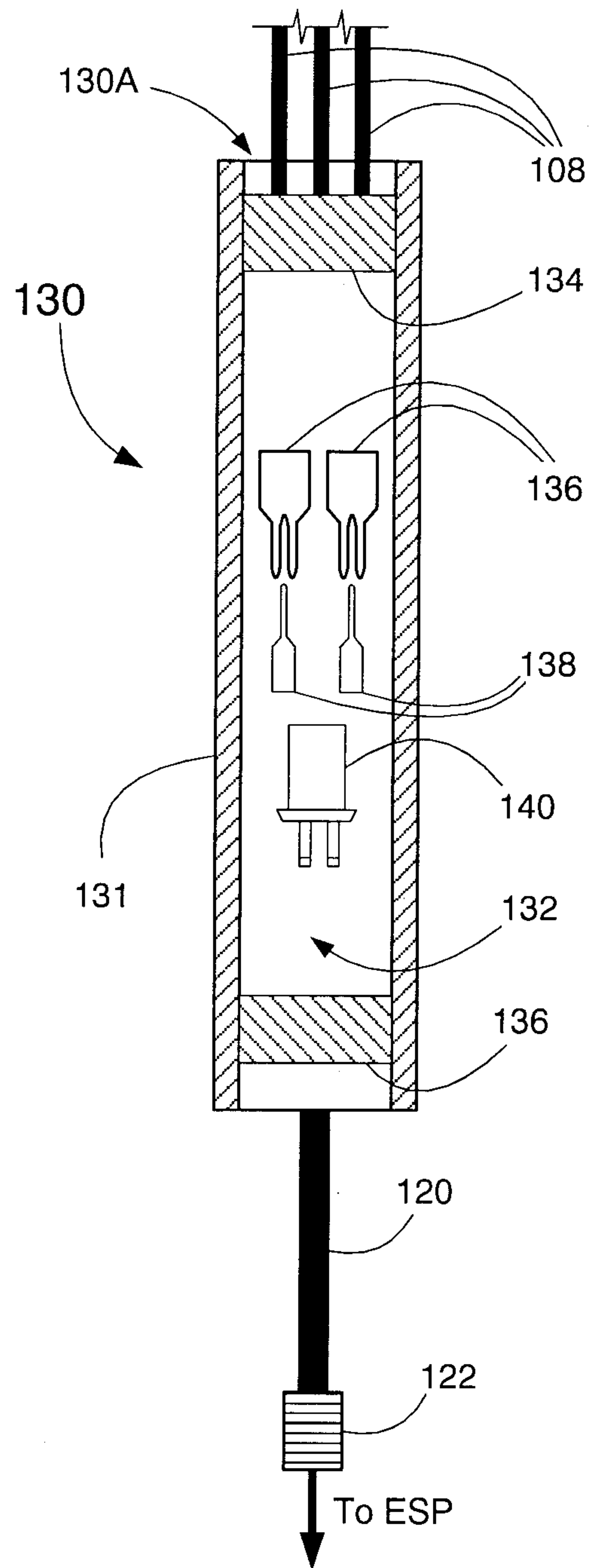


FIG. 2

