

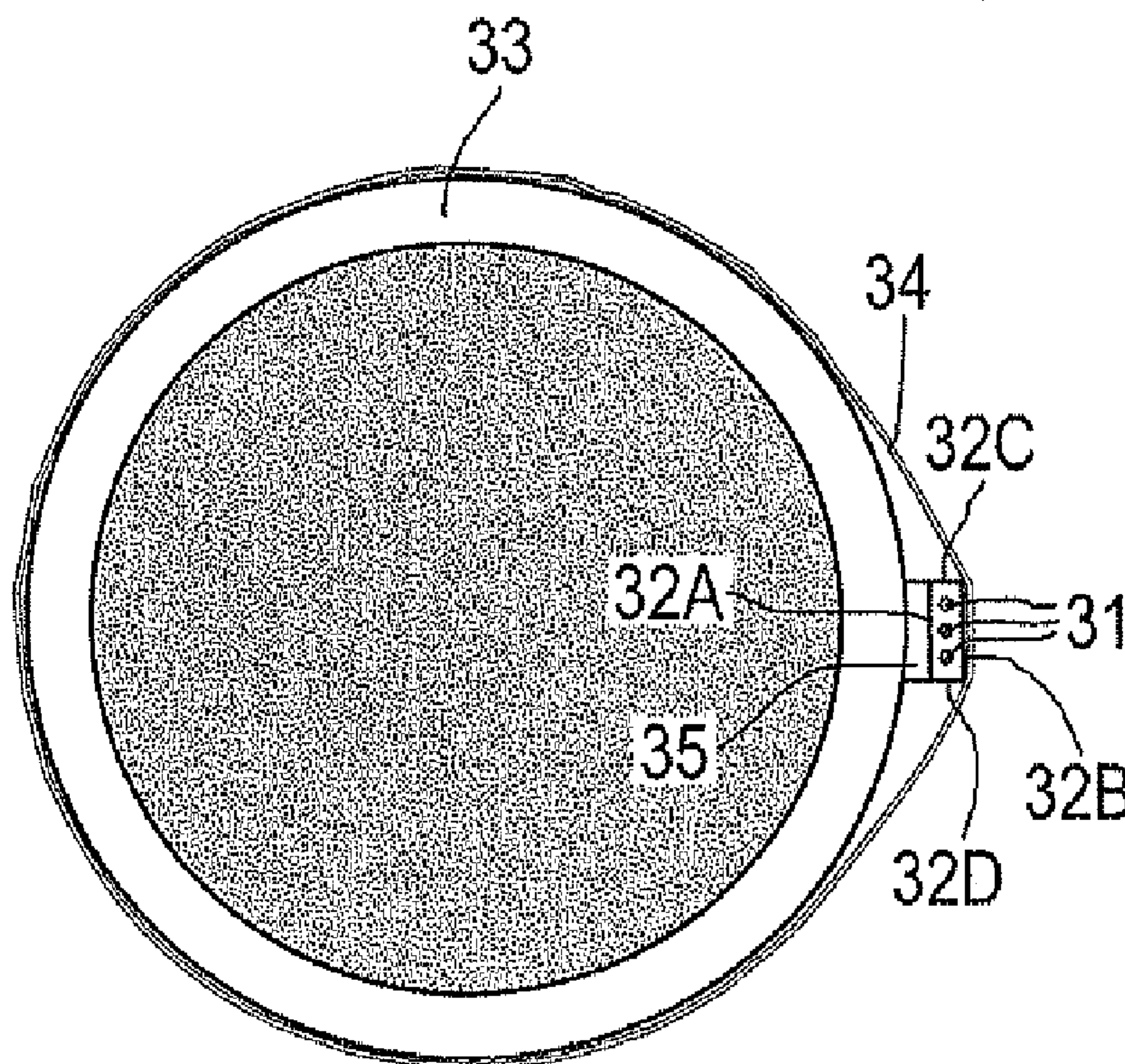


(86) Date de dépôt PCT/PCT Filing Date: 2009/02/12
(87) Date publication PCT/PCT Publication Date: 2009/08/20
(85) Entrée phase nationale/National Entry: 2010/08/10
(86) N° demande PCT/PCT Application No.: EP 2009/051618
(87) N° publication PCT/PCT Publication No.: 2009/101125
(30) Priorité/Priority: 2008/02/15 (EP08101691.7)

(51) Cl.Int./Int.Cl. *E21B 17/02* (2006.01),
E21B 43/10 (2006.01)
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(54) Titre : PROCEDE DE PRODUCTION D'HYDROCARBURES A TRAVERS UN Puits INTELLIGENT
(54) Title: METHOD OF PRODUCING HYDROCARBONS THROUGH A SMART WELL

Fig.3



(57) **Abrégé/Abstract:**

A method is disclosed for producing hydrocarbons through an instrumented smart well containing a well tubular (6,29-32) and an assembly of power, DTS and/or other sensing and/or signal transmission cables (13,40-44) comprising at least one power and/or

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

signal transmission cable, which is bonded along at least part of its length to an outer surface of the well tubular (6,29-32) by an adhesive, which preferably is reusable and/or has a thermal conductive of at least 3W/mK or at most 0.2W/mK.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
20 August 2009 (20.08.2009)

PCT

(10) International Publication Number
WO 2009/101125 A1(51) International Patent Classification:
E21B 17/02 (2006.01) *E21B 43/10* (2006.01)(21) International Application Number:
PCT/EP2009/051618(22) International Filing Date:
12 February 2009 (12.02.2009)

(25) Filing Language: English

(26) Publication Language: English

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

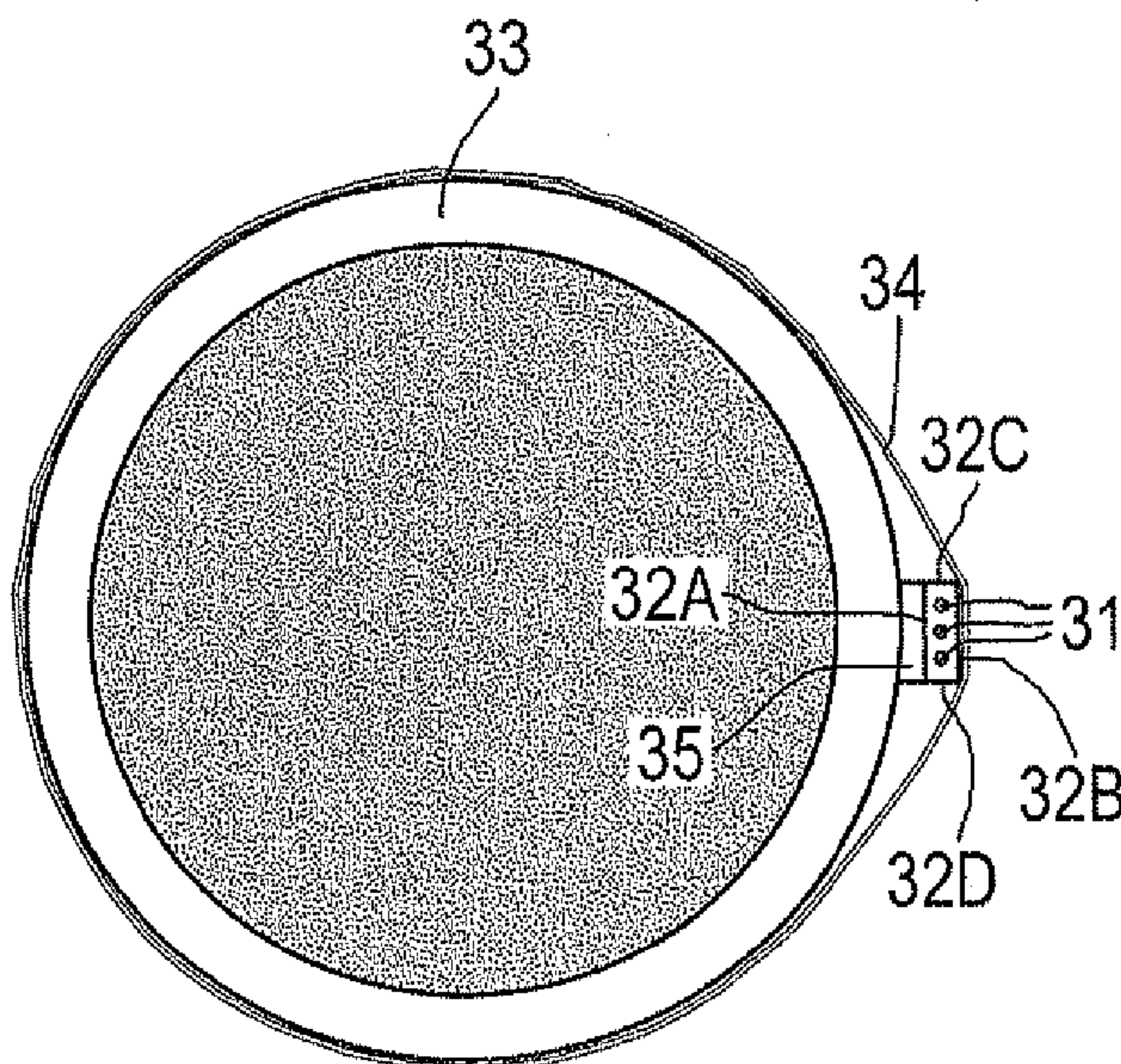
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

[Continued on next page]

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Fig.3



(57) Abstract: A method is disclosed for producing hydrocarbons through an instrumented smart well containing a well tubular (6,29-32) and an assembly of power, DTS and/or other sensing and/or signal transmission cables (13,40-44) comprising at least one power and/or signal transmission cable, which is bonded along at least part of its length to an outer surface of the well tubular (6,29-32) by an adhesive, which preferably is reusable and/or has a thermal conductive of at least 3W/mK or at most 0.2W/mK.

WO 2009/101125 A1



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

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

Published:

— with international search report (Art. 21(3))

- 1 -

METHOD OF PRODUCING HYDROCARBONS THROUGH A SMART WELL

BACKGROUND OF THE INVENTION

The invention relates to a method of producing hydrocarbons through a smart well in which one or more well tubulars and an assembly of power, sensing and/or signal transmission cables is arranged.

5 A smart well is a well in which one or more instruments, such as valves, motors, pumps and/or sensors are arranged downhole and electrical and/or hydraulic power and/or fiber optical, acoustic or other signals are transmitted between a power source or control unit at the
10 earth surface and the downhole instruments.

Installation, connection and protection of a fragile power and/or signal transmission cable assembly in a well is a complex and expensive operation.

UK patent application GB 2433080 discloses a drill
15 pipe, wherein a wire is bonded to an inner surface of the pipe, which requires a complex procedure to insert the wire to the possibly 9 meters long pipe and to firmly bond the wire to the pipe such that it is not detached during the drilling operations.

20 It is an object of the present invention to provide a method of producing hydrocarbons through a smart well in which installation, connection, protection and/or removal of the power and/or signal transmission cable assembly is less complex and the cable assembly is adequately
25 protected.

SUMMARY OF THE INVENTION

In accordance with the invention there is provided a method of producing hydrocarbons through a smart well containing a well tubular and a power, sensing and/or

- 2 -

signal transmission cable assembly comprising at least one power, sensing and/or signal transmission cable, which is bonded along at least part of its length to an outer surface of the well tubular.

5 Preferably, the power, sensor and/or signal transmission cable assembly is encapsulated in a protective layer, which is bonded along at least part of its length to the well tubular by a adhesive, which is reusable and/or has a thermal conductive of at least
10 3W/mK or at most 0.2W/mK.

 Optionally, the assembly comprises a plurality of power, sensor and/or signal transmission cables is encapsulated in a common protective layer with an outer substantially flat side which is bonded along at least
15 part of its length to the well tubular.

The protective layer may be configured as a substantially flat hollow strip with an outer surface having a pair of substantially flat opposite sides with a larger width than other sides of the strip.

20 The protective layer may furthermore at selected intervals be attached to the outer surface of the well tubular by releasable and/or elastic straps, such that one of the flat sides is pressed against the well tubular.

25 The well tubular may be radially expanded after insertion into the wellbore and one of the substantially flat sides of the protective layer is along at least part of its length bonded to the outer surface of the well tubular by a reusable adhesive, which is detached from
30 the outer surface of the well tubular during the expansion process and which is induced to be rebonded to the outer surface of the well tubular after the expansion process.

- 3 -

5 The well tubular may be radially expanded such that one of the flat sides of the protective layer is pressed against along at least part of its length against the outer surface of the expanded tubing and an opposite flat side is pressed along at least part of its length against the inner surface of the surrounding wellbore or well casing and/or against the inner surface of at least one elastic strap.

10 The power, sensing and/or signal transmission cable assembly may comprise a plurality of electrical power cables and a plurality of fiber optical sensing and/or transmission cables and extend between at least two nodes that are longitudinally spaced along the length of the length of the cable assembly, which nodes comprise
15 switches for switching power and/or optical signal transmission to another power, sensing and/or optical cable if a cable is damaged or for another reason.

20 It is preferred that at or near at least one node a wireless power and/or signal transmission device is arranged which is configured to transmit wireless power and/or signals to one or more electrical devices and/or sensors arranged downhole in the well tubular and/or in the space between the tubing and the surrounding wellbore or well casing, and/or in the formation surrounding the
25 wellbore, and/or in a branch wellbore that is connected to the wellbore in which the tubing is arranged.
When used in this specification and claims the term well tubular shall encompass any tubular element in a well, such as a production tubing, well casing, well liner, liner hanger, well packer, well screen and/or an
30 instrumented sleeve.

These and other features, advantages and embodiments of the method according to the present invention are

- 4 -

described in the accompanying claims, abstract and the following detailed description of preferred embodiments in which reference is made to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG.1 is a schematic longitudinal sectional view of a smart well in which a power transmission and/or sensing cable assembly is bonded along at least part of its length to the outer surface of a well tubular;

10 FIG.2 is a schematic longitudinal sectional view of a smart multilateral well in which a series of mutually interconnected power transmission and/or sensing assemblies are bonded along at least part of their length to the outer or inner surfaces of various well tubulars;

15 FIG.3 is a schematic cross-sectional view of an expandable well tubular to which a power strip is bonded along at least part of its length; and

20 FIG.4 is a schematic longitudinal sectional view of a power strip which is at selected intervals along its length bonded to the outer surface of a well tubular by an swellable elastomer.

DETAILED DESCRIPTION OF THE DEPICTED EMBODIMENTS

25 FIG.1 shows a crude oil, natural gas and/or other hydrocarbon fluid production well 1, which traverses a crude oil, natural gas and/or other hydrocarbon fluid containing formation 2.

 The well 1 comprises a well casing 3 which is fixed within an overburden formation 4 by a cement sheath 5.

30 A production tubing 6 is suspended within the well 1 from a wellhead 7 and is sealingly secured to a lower portion of the well casing 3 by a production packer 8. The production tubing comprises a perforated lower inflow section 6A, which comprises perforations 9 and which traverses the hydrocarbon fluid containing formation 2

- 5 -

such that hydrocarbon fluid is induced to flow from the formation 2 through the perforations 9 into the production tubing 6 towards the wellhead 7 as illustrated by arrows 10 and 11. The perforated lower inflow section 5 6A of the production tubing 6 is surrounded by a gravel pack 12 to protect caving in of the formation 2.

A power and/or signal transmission cable assembly 13 comprising at least one power and/or signal transmission cable is bonded to the outer surface of the production 10 tubing 6. The assembly 13 comprises at least one fiber optical Distributed Temperature Sensor (DTS) which is bonded along a substantial part of its length to the outer surface of the production tubing 6 by an adhesive, such as a fast curing high-tack 1K polyurethane adhesive 15 designed for industrial bonding, for example TEROSON ISR 70-03 (TEROSON is a trade mark).

The assembly 13 is connected to a fiber optical signal transmission, reception and interpretation assembly 14, which transmits a pulsed optical signals 20 into the fiber optical DTS and detects the time of arrival and spectrum of the optical reflections that are reflected back when the light pulses travel along the length of the fiber optical DTS and which spectrum contains information about the temperature of the wall of 25 the DTS sensor at the reflection point. It will be understood that by bonding the assembly 13 to the tubing 6 using a thermally conductive adhesive the fiber optical DTS will have a temperature which closely matches that of the wall of the production tubing 6. Since the 30 temperature of the perforated lower section 6A of the tubing 6 in a region with a relatively large influx of hydrocarbon and/or other fluids will be different from the temperature in a region with a relatively small

- 6 -

influx of hydrocarbons and other fluids the temperature profile measured by the fiber optical DTS along the length of the inflow zone along the length of the perforated lower section 6A will give information about the fluid influx. Furthermore influx of gaseous components will result in adiabatic expansion of these components and consequently in a temperature drop, so that the temperature profile measured by the fiber optical DTS will also provide information about the gas content and/or heat capacity of the well effluents, so that information is provided regarding the composition of well effluents flowing into the well 1 and where which well effluents flow into the well 1 along the length of the perforated lower section 6A of the production tubing 6.

FIG.2 shows a multilateral well 20, which comprises a substantially vertical main wellbore 21 and a pair of substantially horizontal well branches 22 and 23, which traverse different crude oil, natural gas and/or other hydrocarbon fluid containing formations 24 and 25. The main wellbore 21 comprises a well casing 26 which is sealingly secured within the overburden 27 and hydrocarbon fluid containing formations 24 and 25 by means of an annular cement sheets 28. The well casing 26 comprises two openings into which curved elbow liners 29 and 30 extend. The curved elbow liners 29 and 30 are connected to horizontal liners 31 and 32 that extend through the horizontal well branches 22 and 23 and that are perforated by e.g. a perforating gun to provide a series of perforations 33 through which hydrocarbon fluids flow from the formations 24 and 24 into the horizontal well branches 22 and 23.

- 7 -

Furthermore a production tubing 34 is suspended from a wellhead 35 within an upper part of the well casing 26 and sealingly secured to the casing 26 by an expandable well packer 36.

5 Each of the horizontal well branches 22 and 23 is provided with pressure, temperature, composition, seismic and/or other sensors 37 and a pair of inflow control valves (ICV's) 38 which monitor the composition of the hydrocarbon and/or other fluids and control the fluid
10 influx into the different well effluent inflow regions upstream of the inflow control valves 38. The sensors 37 and valves 38 are connected to well monitoring and control equipment 39 near the wellhead 35 by a series of backbone cable assemblies 40-44 that are interconnected
15 by four inductive and fiber optical coupler assemblies 45A-D - 47A-D. The backbone cable assemblies 40-44 comprise a primary backbone electrical power and fiber optical sensing cable assembly 40 which is bonded to the outer surface of the well casing 26 and is embedded in
20 the cement sheets 28 and which is connected to a pair of outer annular electrical inductive couplers 45A, 47A and fiber optical couplers 45C, 47C that are also embedded in the cement sheets 28. These outer annular electrical inductive couplers 45A, 47A and fiber optical couplers
25 45C, 47C are co-axially arranged around a pair of inner electrical inductive couplers 45B, 47B and fiber optical couplers 45D, 47D that are arranged in the interior of the curved elbow liners 29 and 30 and that are connected to a pair of curved secondary electrical and fiber
30 optical power and communication backbone cable assemblies 41 and 43 that are bonded to the inner walls of these elbow liners 29 and 30. Each of the curved secondary electrical power and fiber optical communication cable

- 8 -

assembly 41,43 is at its lower end connected to a tertiary electrical power and fiber optical communication cable assembly 42,44 which extends through each of the horizontal well branches 22,23 by means of pairs of coaxial electrical inductive couplers 46A,46B and 48A and 48B and fiber optical couplers 46C, 46D and 48C, 48D. These four inductive and fiber optical coupler assemblies 45A-D - 48A-D allow repair and or replacement of the secondary and tertiary backbone cable assemblies 41-44 in case of damage of these assemblies 41-44 and or of the ICV's 38 and or sensors 36, which may also be connected by releasable inductive and/or fiber optical couplers to these assemblies 41-44. Thus it will be understood that by bonding the primary, secondary and tertiary cable assemblies 40-44 to the inner or outer walls of the well casing 26 and liners 29-32 a versatile and at least partially replacable power and communication backbone cable assembly is provided which enable to install an efficient and powerful electrical power and fiber optical communication network within the main wellbore 21 and well branches 22 and 23.

Currently, smart wells often include a plurality of sensing and control systems including gauges, optical sensors and valves. It is common for multiple vendors to be used to provide the sensing and control systems and for the associated cabling to be unique, proprietary and specific to the system in question. This commonly leads to the requirement for each sensing or control component of the full smart well system to have individual cabling or pipework containing, but not limited to, electrical or optical cables and hydraulic working fluids. The number of cables required causes increased complexity in pressure control and other well construction components,

- 9 -

increased costs associated with the procurement and installation of the cables and increased risk of failure of one or more components during installation due to increased component numbers. Current methods are also
5 inflexible in the sense that the systems (instrumentation and control) are installed when the well is built and that their configuration cannot be altered or systems augmented or serviced without well intervention, which is typically logistically difficult and financially
10 expensive.

In accordance with the invention there is provided a method of producing hydrocarbons through a smart well containing well tubulars and one or more instruments, such as valves, motors, pumps and/or sensors are arranged
15 downhole whereby the instruments are connected to the surface control systems using one or more common backbone cable assemblies 40-44 comprising power and/or electrical communications and/or optical fiber communications and/or sensing (e.g DTS, FBG or other fiber-optic sensing
20 method) capability.

The physical embodiment of each backbone cable assembly 40-44 includes an assembly of power and/or signal transmission cables, which cables are encapsulated in a common protective layer that is releasably secured
25 to the outer or inner surface of a well tubular and has an outer circumference with a larger width than thickness.

FIG.3 illustrates an assembly of power and/or signal transmission cables 31 that is arranged in a common
30 protective layer, which is configured as a substantially flat hollow power strip 32 with an outer surface having a pair of substantially flat opposite sides 32A-B with a

- 10 -

larger width than other sides 32 C-D of the power strip 32.

5 The power strip 32 may at selected intervals be pressed against the outer surface of a well tubular 33 by releasable straps 34, such that one of the flat sides 32A of the power strip 32 is pressed against the outer surface of the well tubular 33 and is bonded to said surface by an adhesive 35.

10 The well tubular 33 may be radially expanded after insertion into the wellbore and one of the flat sides 32A of the power strip 32 may along at least part of its length bonded to the outer surface of the well tubular by a reusable adhesive, such as a fast curing high-tack 1K polyurethane adhesive 35 designed for industrial bonding, 15 for example TEROSON ISR 70-03 (TEROSON is a trade mark), which is detached from the outer surface of the well tubular 33 during the expansion process and which is bonded again to the outer surface of the well tubular 33 after the expansion process.

20 In such case the well tubular 33 may be radially expanded such that the inner flat side 32A of the power strip 32 is pressed against along at least part of its length against the outer surface of the expanded tubing 33 and the outer flat side 32B is pressed along at least 25 part of its length against the inner surface of the surrounding wellbore or well casing or of an elastic strap 34.

30 In terms of the sensing aspects of the invention, the use of an adhesive to bond the cable assembly to the well tubular offers several advantages in the case that the fiber-optic cable is used for distributed temperature sensing (DTS). Currently, a DTS cable is clamped periodically to the well tubular (typically the

- 11 -

production tubing) and typically the position of the fiber is ill defined, tending to contact the production tubing at the clamp points and to bow out and away from, or around, the production tubing between the clamps, as is illustrated in FIG.4. This causes observed fluctuations in the measured temperature along the length of the DTS fiber. By bonding the fiber on to the production tubing over it's whole length, or a least over the minimum length resolvable it is possible to better define the temperature measurement to be that of the production tubing and not the temperature of the fluid in the annular space around the production tubing at an indeterminate distance from the outer surface of the production tubing.

15 The method could be further improved by selecting the adhesive appropriately, loading the adhesive with thermally conductive or insulating materials or using an interstitial insulator (in the sequence: production tubing - adhesive - interstitial insulator - adhesive -
20 DTS fiber) such that the thermal condition of the DTS fiber can be further determined.

 The fiber could be, for example, bonded to the production tubing using an adhesive of high thermal conductivity to give the best tubing temperature measurement. Further, the protective layer could have a
25 lower thermal conductivity, reducing heat flow from the production tubing through the fiber and providing a improved measure of the temperature of fluids flowing inside the production tubing.

30 In another example, the adhesive bonding the DTS fiber to the production tubing could be of low thermal conductivity or include an interstitial insulating layer which would define the local temperature of the fiber as

- 12 -

that of the annular space. This example would be particularly appropriate for temperature monitoring of inflow from the reservoir into the well tubulars, where the well tubular is used as the deployment device, but
5 the required temperature measurement is that of the fluids exiting the reservoir.

The two previous examples could be used in combination to best achieve the desired measurement. Perhaps measuring production tubing temperature over a
10 portion of the well and annular or inflow temperature over another portion. It may also be beneficial in wells which use concentric string production to periodically measure the temperature in the inner string and outer string by alternating the adhesive and insulation
15 arrangement joint by joint.

A further benefit of using an adhesive with a defined thermal characteristic could be applied to ESP (electric submersible pump) cables which carry high currents and are subject to significant heating. An adhesive with high
20 thermal conductivity bonding the ESP cable to the well tubular could aid heat removal from the cable, thus increasing reliability and failures by avoiding 'hot spots' on the cable, which could occur away from clamp positions.

25 In terms of the power and/or signal transmission aspects of the invention, the cable assembly may comprise a plurality of electrical power cables and a plurality of fiber optical transmission or sensing cables and the assembly may extend between at least two nodes , such as
30 the couplers 45-48 shown in FIG.2, that are longitudinally spaced along the length of the length of the cable assembly 40-44, which nodes 45-48 may comprise switches or a fusing arrangement for switching power

- 13 -

and/or optical signal transmission to another power
and/or optical cable if a cable is damaged or for another
reason. It is preferred that several methods can be used
simultaneously, in combination and as required to connect
5 an instrument to the power and/or signal transmission
and/or optical fiber communications or sensing backbone
cable, including, but not limited to, direct electrical
and/or optical connections, wireless connections and
multiple series wireless connections.

10 In the case of direct electrical and/or optical
connections, the connection points can be pre-defined and
prepared and utilise standard connector designs or
techniques and/or be established during installation at
any location or at periodic designated connection points.
15 Also that the electrical and/or optical connection can be
formed by welding, soldering, clamping, piercing or other
means. In this case the design would also include a means
to protect the connection point from the downhole
environmental conditions, including, but not limited to
20 hydraulic and gas pressures, mechanical shock and loading
and corrosive fluids and gasses, in order to maintain the
long-term integrity and performance of the backbone
cable.

25 In the case of wireless connections, the wireless
connection equipment would be connected to the backbone
cable much as a directly connected instrument.

The wireless connections would allow the transmission
of electrical power and/or communication signals to one
or more electrical devices and/or sensors arranged
30 downhole within the well tubular and/or in the annular
space between the production tubing and the surrounding
wellbore or well casing, and/or in the formation
surrounding the wellbore, and/or in a branch wellbore

- 14 -

that is connected to the wellbore in which the tubing is arranged.

5 In the case of multiple wireless connections, more than one wireless stages would be connected in series to allow the transmission of electrical power and/or communication signals to one or more electrical devices and/or sensors arranged downhole within the well tubular and/or in the annular space between the production tubing and the surrounding wellbore or well casing, and/or in 10 the formation surrounding the wellbore, and/or in a branch wellbore that is connected to the wellbore in which the tubing is arranged. This arrangement would be used in the case that the physical arrangement of the well did not allow for a single wireless connection to be 15 used.

It is also preferred that the distribution of direct and wireless connection points be arranged such and provide for instruments to be installed, substituted or recovered for repair using techniques such as slickline, 20 wireline, coiled tubing, downhole tractors or other means at any time during the operating life of the well.

It will be recognised that well known electrical effects such as resistive losses and transfer efficiencies of wireless connections will ultimately 25 limit performance of the system.

It is therefore preferred that the power and/or communications settings be adjustable by manual and/or automatic means in order to allow for improved and/or optimised performance in terms of, but not limited to, 30 power levels, communications data rates and data latency in response to factors such as range from surface to connection point and number of wireless steps.

- 15 -

It is also preferred that a communications protocol is also provided which conforms to the OSI 7 layer model and is optimised for use of the communications channel or channels available. The communications protocol would also include quality of service (QOS) provisions to enable suitable sharing of the communications channel or channels including, but not limited to, the inclusion of emergency high priority channels for the control of safety critical instruments such as safety valves.

It is also preferred that the backbone cable design be such that, where the backbone cable 40 is deployed on the well casing 26 as illustrated in FIG.2, the long term pressure integrity of the well structure be maintained to at least as good a level as it is with current methods. With the inclusion of the primary backbone cable 40 on the outside of the well casing 26, there is potential for the creation of a micro-annulus between the backbone cable 40 and the cement sheath 28 and/or the backbone cable 40 and the well casing 26. The creation of micro-annuli will be combated by including periodic seal points positioned along the length of the backbone cable 40.

As illustrated in FIG.4 these seal points 50 could comprise swellable elastomers 51 formed around the backbone cable power strip 52 such that these elastomers would swell once the well to formation annulus 53 had been cemented or periodic clamp-on devices which provide metal-ceramic-metal seals along the cable metal cores and also provide a good bonding surface to ensure a good cement seal is achieved. Alternatively, the surface finish of the cable could be designed to provide a good cement bond through the use of patterning or moulding.

In such case at least one wireless electrical transmission device that is connected to one of the

- 16 -

electrical backbone cables may be an inductive coupler that is arranged in the vicinity of an inductive coupler that is connected to the downhole electrical device and/or sensor. The inductive coupler connected to the backbone cable may be separated from the inductive coupler connected to the downhole electrical device by the metallic wall of one or more well tubulars or by a non-metallic solid, a liquid or a gas.

At least one wireless electrical transmission device that is connected to one of the fiber optical signal transmission backbone cables may be an electromagnetic transmitter and/or receiver which is configured to transmit and/or receive electromagnetic signals to and/or from one or more downhole sensors.

One or more downhole electrical devices may consist of an electrical motor or generator that is connected to a downhole valve or pump and one or more downhole sensors may consist of a sensor for monitoring downhole pressure, seismic vibrations, temperature and/or the composition of the produced fluids.

- 17 -

C L A I M S

1. A method of producing hydrocarbons through a smart well containing a well tubular and a power, sensing and/or signal transmission cable assembly comprising at least one power, sensing and/or signal transmission cable, which is bonded along at least part of its length to an outer surface of the well tubular.
2. The method of claim 1, wherein the power, sensing and/or signal transmission cable assembly is encapsulated in a protective layer, which is bonded along at least part of its length to the well tubular by an adhesive which is reusable and/or has a thermal conductive of at least 3W/mK or at most 0.2W/mK.
3. The method of claim 2, wherein the assembly comprises a plurality of power, sensing and/or signal transmission cables that are encapsulated in a common protective layer with an outer substantially flat side which is bonded along at least part of its length to the well tubular.
4. The method of claim 3, wherein the protective layer is configured as a substantially flat hollow strip with an outer surface having a pair of substantially flat opposite sides with a larger width than other sides of the strip.
5. The method of claim 3, wherein the protective layer is furthermore at selected intervals attached to the outer surface of the well tubular by releasable and/or elastic straps, such that one of the flat sides is pressed against the well tubular.
6. The method of claim 3, wherein the well tubular is radially expanded after insertion into the wellbore and one of the substantially flat sides of the protective

- 18 -

layer is along at least part of its length bonded to the outer surface of the well tubular by a reusable adhesive, which is detached from the outer surface of the well tubular during the expansion process and which is induced to be rebond to the outer surface of the well tubular after the expansion process.

7. The method of claim 6, wherein the well tubular is radially expanded such that one of the flat sides of the protective layer is pressed against along at least part of its length against the outer surface of the expanded tubing and an opposite flat side is pressed along at least part of its length against the inner surface of the surrounding wellbore or well casing and/or against the inner surface of at least one elastic strap.

8. The method of claim 6 or 7, wherein the tubing is expanded by pushing an expansion cone therethrough and reusably sticky bonding agent is used which is detached from the tubing during the expansion process and which bonds itself again against the expanded tubing.

9. The method of claim 2, wherein the power, sensing and/or signal transmission cable assembly comprises at least one electrical power cable and at least one fiber optical sensing and/or signal transmission cable.

10. The method of claim 9, wherein the power, sensing and/or signal transmission cable assembly comprises a plurality of electrical power cables and a plurality of fiber optical sensing and/or transmission cables and the assembly extends between at least two nodes that are longitudinally spaced along the length of the length of the cable assembly, which nodes comprise switches for switching power and/or optical signal transmission to another power and/or optical cable if a cable is damaged or for another reason.

- 19 -

11. The method of claim 10, wherein at or near at least one node a wireless power and/or signal transmission device is arranged which is configured to transmit wireless power and/or signals to one or more electrical devices and/or sensors arranged downhole in the well tubular and/or in the space between the tubing and the surrounding wellbore or well casing, and/or in the formation surrounding the wellbore, and/or in a branch wellbore that is connected to the wellbore in which the tubing is arranged.

12. The method of claim 11, wherein at least one wireless electrical transmission device that is connected to one of the electrical cables is an inductive coupler that is arranged in the vicinity of an inductive coupler that is connected to the downhole electrical device and/or sensor.

13. The method of claim 11, wherein at least one wireless electrical transmission device that is connected to one of the fiber optical signal transmission cables is an electromagnetic transmitter and/or receiver which is configured to transmit and/or receive electromagnetic signals to and/or from one or more downhole sensors.

14. The method of claim 11, wherein one or more downhole electrical devices comprise an electrical motor or generator that is connected to a downhole valve or pump and one or more downhole sensors consists of a sensor for monitoring downhole pressure, seismic vibrations, temperature, the composition of the produced well fluids and/or movement of fluid in the formation.

15. The method of claim 14, wherein:
- at least downhole sensor is a fiber optical Distributed Temperature Sensor (DTS) cable which is bonded by an

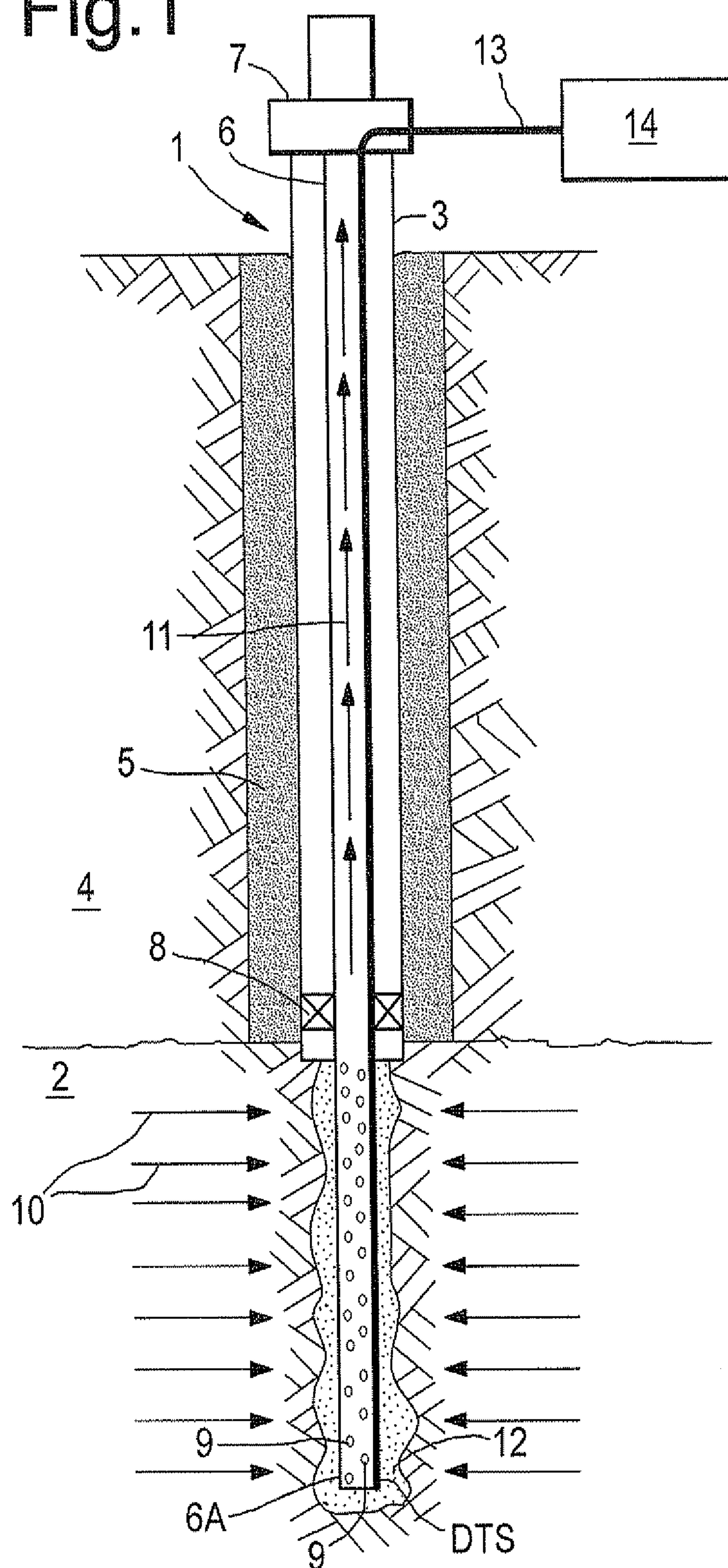
- 20 -

adhesive having a high thermal conductivity to the well tubular;and/or

- 5 - an insulating layer is applied to the outer surface of the fiber optical DTS cable , which layer is bonded to the well tubular to reduce thermal conduction through the fiber optical DTS cable and provide a measure of the temperature of the tubular to which the fiber is bonded and/or the fluids contained within the tubular;or
- 10 - the adhesive has a relatively low thermal conductivity to enable accurate temperature measurement within an annular space surrounding the well tubular to which the fiber optical DTS cable is bonded;and
- 15 - the fiber optical DTS cable is used to monitor the temperature of fluids flowing into the well and/or through the well tubular; and/or
- 20 - the well tubular comprises an inner well tubular, which is surrounded by an outer well tubular, through which tubulars well effluents are produced and an assembly of power and/or signal transmission cables is encapsulated in a relatively flat encapsulation which is bonded to the outer surface of the inner well tubular, which strip comprises one fiber optical DTS cable which is configured to monitor the temperature of the wall of the inner well tubular and another fiber optical DTS cable which is
- 25 configured to monitor the temperature of the well effluents flowing through the annular space between the inner and outer well tubular to obtain temperature traces of the fluxes of well effluents flowing through the interiors of the inner and outer well tubulars.

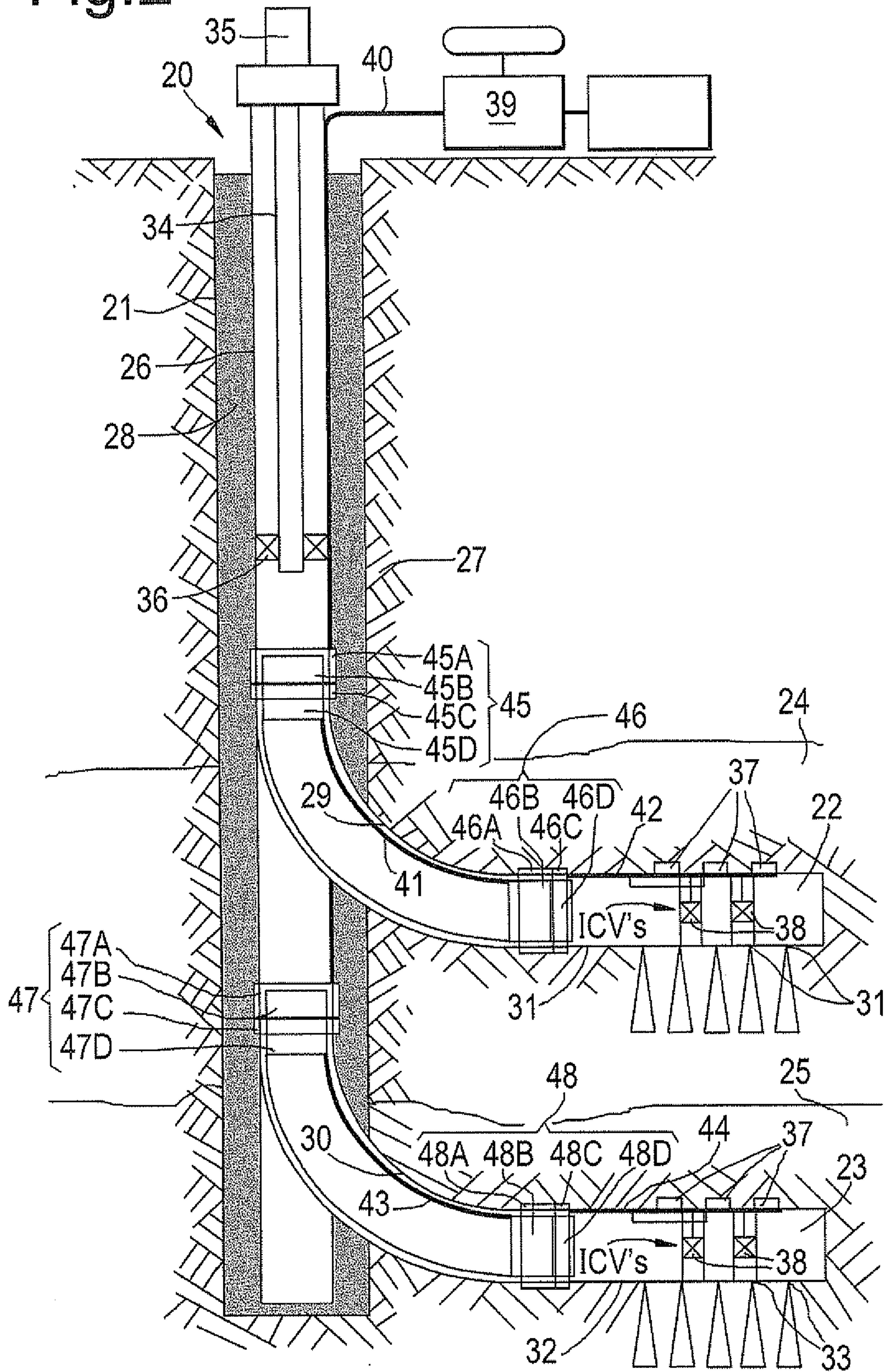
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Fig. 1



2/3

Fig.2



3/3

Fig.4

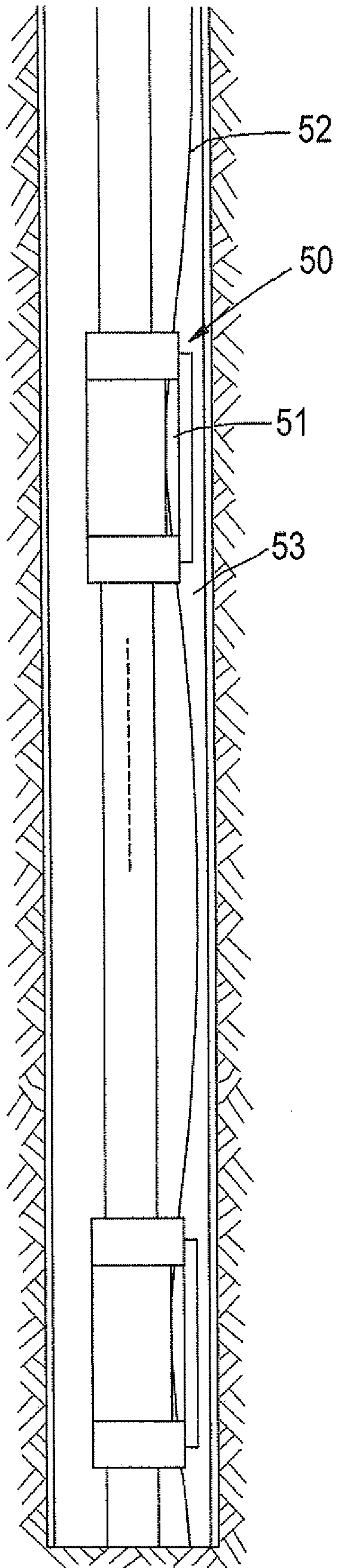


Fig.3

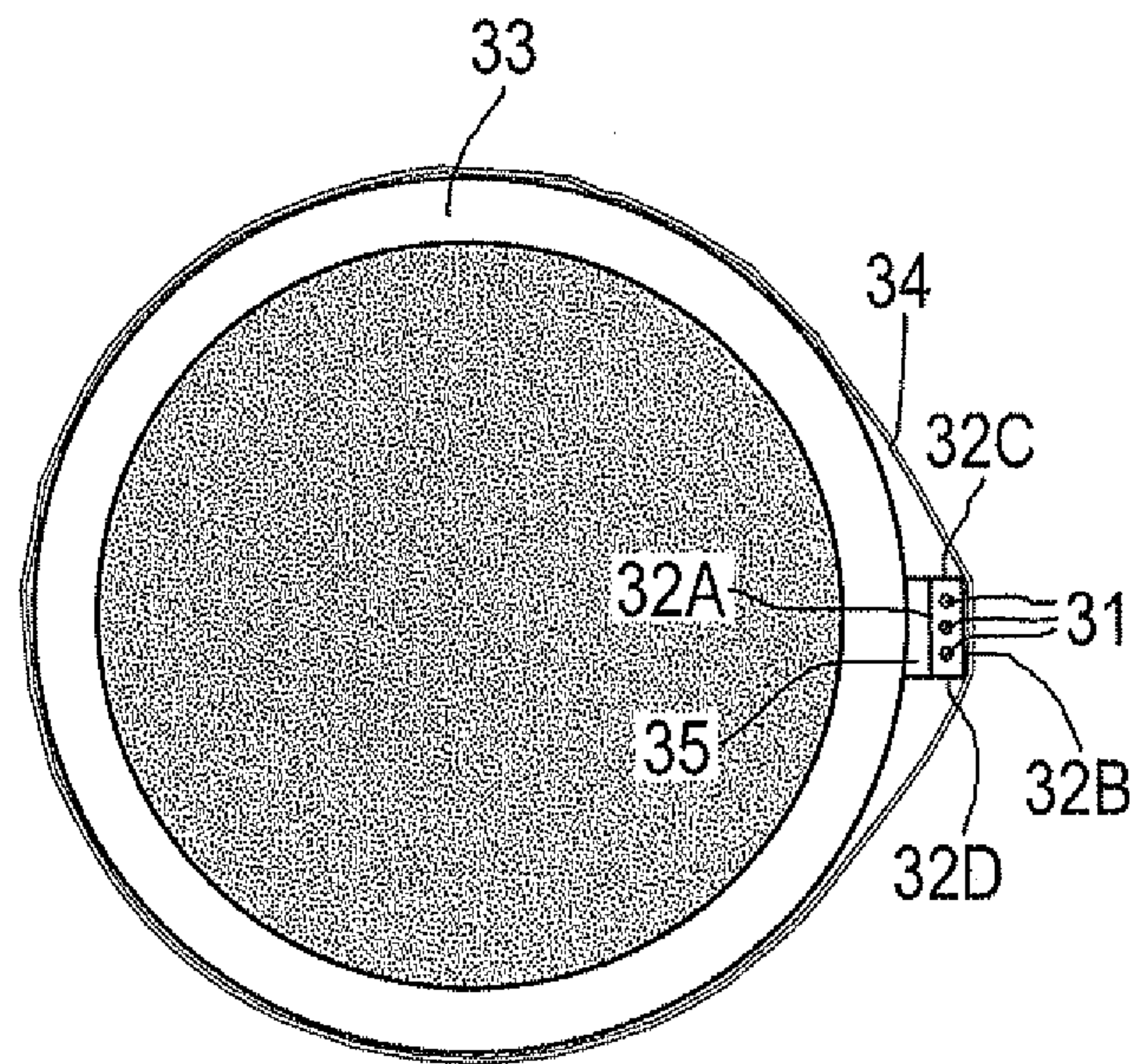


Fig. 3

