

Description

This invention relates generally to downhole tools energized by self-contained power supply apparatus and, in particular, to an electrical power supply apparatus for use in a downhole tool.

In drilling and completing oil or gas wells, various activities need to be performed downhole. For example, downhole pressure and temperature readings need to be taken when conducting a drill stem test, and perforating guns need to be activated when perforating a casing prior to fracturing a formation. These two specific operations, as well as many others, are performed by tools which need to be energized when the tools are at their downhole locations. This energization is typically electrical energization, at least during some phase of the downhole operation.

In the past and at present, such electrical energization has been and is provided through a wireline from a source at the surface or through a self-contained battery pack located within the downhole tool. The cells in the battery pack have been chemical batteries, such as silver oxide or lithium types. The use of fuel cells (e.g. containing liquid hydrogen and oxygen) in a self-contained pack has been contemplated, but we believe the use of such cells has not been commercially implemented.

One shortcoming of the wireline energization technique is the relative difficulty in using the wireline rather than merely using a "slick line" or retaining cable, which relative difficulty is well recognized in the industry. Additionally, because of the length of the wireline, electrical losses occur which would not occur if the power supply were wholly contained within the downhole tool. Finally, the requirement of a wireline does not lend itself to long-term tests, as the wireline truck or skid and power supply must remain at the well site. Moreover, the presence of a wireline or any cable in the well bore prohibits quickly closing off the well in an emergency unless one is willing to cut the wireline or cable and then "fish" it out at a later time.

Although battery packs overcome the two aforementioned shortcomings of wireline energization, the battery packs have relatively limited operating lives and electrical capacities whereby the operation of the downhole tool, both as to how much can be driven by a battery pack and as to how long energization can be sustained, is limited. When testing multiple parameters or conducting a long-term test, e.g. weeks or months, such limitations become particularly apparent. Although more batteries can be added to provide more capacity, such additional batteries at some point can no longer be accommodated because of the size constraints which are imposed upon all downhole tools

by the size of the well bore and other known factors. Also, even though batteries can be replaced so that operations can be continued, such replacement requires a trip of the pipe string in which the battery packs are incorporated out of and back into the well bore, thereby increasing the expense of the operation. Such battery packs also have limitations as to the types of wells in which they can be readily used; this is specifically referring to deep wells (e.g. wells from two to five miles (3 to 8 km) deep) because of the high pressures and temperatures which are encountered in these wells and which can detrimentally affect the chemical operations within the battery cells.

US-A-3666030 describes an electrical energy source for a downhole tool, which source comprises housing means, means disposed in the housing means for providing mechanical motion; conversion means disposed in the housing means for converting the mechanical motion to energy usable by the tool, and connecting means for connecting the energy from the conversion means to the tool. In the particular arrangements described, a magnet is moved relative to a coil to generate electrical energy.

We have now devised an improved such power supply apparatus. In accordance with the present invention, such apparatus is characterised in that said housing means is adapted to be received within a receptacle of the downhole tool; a fuel capsule is removably retained inside said housing means, said fuel capsule including a radioisotope for generating thermal energy; said means is a Stirling cycle engine means for converting said thermal energy to mechanical motion; and wherein said connecting means communicate externally of said housing means.

The invention also includes a method of energizing an electrical circuit contained in a downhole tool used in an oil or gas well, comprising initiating mechanical motion in a housing and converting said motion into electrical energy; characterised by inserting a fuel capsule into said housing in heat transfer relationship with a Stirling cycle engine retained in said housing; said fuel capsule including a radioisotope; inserting said housing into the downhole tool; and electrically connecting the electrical circuit to a linear alternator disposed in said housing and mechanically connected to said Stirling cycle engine.

The invention further comprises a downhole tool for an oil or gas well which tool includes a system requiring energy from a power supply, characterised in that the tool has a receptacle therein which contains a power supply apparatus of the invention.

The invention thus provides an improved long-term, power supply apparatus for a downhole tool;

which apparatus is self contained and wholly mounted within the downhole tool for obviating the necessity of a wireline, thereby achieving an advantage similar to that of the battery packs. Furthermore, however, the apparatus can overcome the shortcomings of battery packs by providing for a longer operating life and by providing for more output capacity within a smaller volume than are provided by the known battery packs, and by providing for reliable usage even in deep wells where temperatures are greater than those in which presently available batteries can operate.

The present invention can combine nuclear, mechanical and electrical aspects into an overall combination having the following features and advantages: very high power density, stable operation, long operating life, and minimal moving parts which neither rotate nor require a lubricating system or valves. The apparatus of the present invention can be simple, reliable and relatively inexpensive.

In one embodiment of the apparatus of the invention, the electrical energy generator includes a linear alternator.

In the method of the invention, there can be generated, at the output of the linear alternator and in response to the radioisotope, an electrical output within the range between approximately 0.5 watts and approximately 2.5 watts; for example, for application to the electrical circuit of the downhole tool. In a preferred embodiment, this output is achieved while constraining the linear displacement of a movable member of the linear alternator to approximately 3.2mm (1/8 inch) relative to a stator of the linear alternator. The step of inserting the housing into the downhole tool includes retaining the housing within a receptacle region having a diameter of approximately 25.4mm (one inch) and a length of not greater than approximately 610mm (twenty-four inches).

In order that the invention may be more fully understood, embodiments thereof will now be described by way of illustration only, with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic illustration of a well having a downhole tool including a power supply constructed in accordance with the present invention;

FIG. 2 is a diagram of a preferred embodiment of the power supply apparatus of the present invention.

Schematically illustrated in FIG. 1 is a well 2, particularly an oil or gas well, at the mouth of which is disposed a conveyancing means 4, such as a winching system of a more complex design than is schematically shown in FIG. 1, for lowering and raising a downhole tool 6. Conveyancing means 4 is also contemplated to include a pipe or tuning

string in which downhole tool 6 is incorporated or disposed.

The downhole tool 6 has an electrical circuit or system 8 for performing a function of whatever type might be needed in the downhole environment of the well 2. Specific examples of the downhole tool 6, but not by way of limitation, are an electronic pressure and temperature gauge or an electrically-actuated perforating gun. The electrical circuit 8 is disposed or contained in a suitable housing 10 of a type known to the art.

The housing 10 has a receptacle 12 for receiving a power supply 14 which provides the electrical energization to which the electrical circuit 8 responds, thereby enabling the function to be performed. In the preferred embodiment subsequently described, the power supply 14 is a radioisotope thermomechanical electrical generator (thus the label R.T.E.G. used in FIG. 1).

In the preferred embodiment the receptacle 12 is sized to accommodate the size of the power supply 14 subsequently more particularly specified. The size specifications or limitations are important in the preferred embodiment of the present invention in that they provide a more compact self-contained power supply than is provided by battery packs known for similar applications. This is of considerable significance to a downhole tool designer who must work within some absolute size constraints imposed by the size of the well bore, the tubing disposed in the well bore, and the formation with which the tool is to be used, for example.

With reference to FIG. 2, the preferred embodiment of the power supply 14 will be described. Broadly, the power supply 14 includes housing means 16 for being received within the receptacle 12 of the housing 10 of the downhole tool 6. The power supply 14 also includes thermal energy source means 18, disposed in the housing 16, for generating thermal energy which powers an external combustion engine means 20, also disposed within the housing 16, for converting the thermal energy into mechanical motion. The external combustion engine means 20 is a Stirling cycle engine having a driving output coupled to conversion means 22, also disposed within the housing 16, for converting the mechanical motion from the engine 20 to energy usable by the system 8 within the downhole tool 6. Since the system 8 is an electrical system in the illustrated preferred embodiment, this energy is, of course, electrical energy; however, other suitable output energies could be derived in correspondence with the nature of some other type of functional system which might be used in the downhole tool 6 in place of the electrical system 8. Also included in the power supply 14 are transfer means for transferring thermal energy from the

thermal energy source 18 to the engine 20 and means for connecting the output from the conversion means 22 to the system 8.

The housing 16 of the preferred embodiment is defined by a tubular member 24 having a cylindrical side wall 25 with a maximum outer diameter of, preferably, not greater than approximately 2.54cm (one inch) and an outer length of, preferably, not greater than approximately 61cm (twenty-four inches). More broadly, the maximum outer diameter is less than the inner diameter of the downhole tool 6 and the outer length is less than the length of the downhole tool so that the housing 16, and thus the entire power supply 14, can be fully received entirely within the downhole tool 6. The specific dimensions are particularly advantageous because they are significantly less than typical dimensions of battery packs which are now accommodated in downhole tool designs. Thus, with the present invention a more compact overall downhole tool is provided, thereby saving material and fabrication costs.

At one end of the tubular member 24 there is an opening 26 through which the thermal energy source 18 can be moved into and removed from the housing 16. In the FIG. 2 embodiment, this opening 26 is defined through an end wall 28 of the tubular member 24. This end wall 28 is disposed transversely to the cylindrical side wall 25 of the tubular member 24. The opening 26 is closable by means of a closure cap 30 which is connected by mating threads within the opening 26. Because the thermal energy source 18 is received in this end of the tubular member 24, the interior surface of the end wall 28 and this portion of the tubular member 24 are lined with a suitable insulation material 32.

Alternatively, the tubular member 24 can be constructed in two sections which are threadedly connected as at reference numeral 33 shown in FIG. 2. With this construction no end opening 26 and closure cap 30 are needed so that the end wall 28 is continuous across the entire end area of that portion of the tubular member 24; this permits better insulating of the thermal energy source 18. Other suitable constructions of the housing 16 and other suitable techniques for inserting and removing the thermal energy source 18 can, of course, also be used as would be well known in the art.

The other end of the tubular member 24 has an end wall 34 disposed transversely to the side wall 25. This end wall 34 is spaced linearly from the end wall 28 at the opposite end of the cylindrical side wall 25.

The thermal energy source 18, movable into and out of the housing 16 through the opening 26 (or other suitable alternative construction), is in the preferred embodiment a unitary member constructed in the form of a fuel capsule 36 made of, at

least in part, a suitable radioisotope having a half-life sufficient to provide a sufficiently long-lived primary energy source for the power supply 14 so that power source replacements are not needed once an operation commences, thereby making extra trips out of and into the well unnecessary. There is a sufficient quantity of the radioisotope in the fuel capsule 36 so that the power supply 14 has an overall electrical output within the range of approximately 0.5 watt to approximately 2.5 watts. In the preferred embodiment it is specifically contemplated that the electrical output from the conversion means 22 need be only something less than approximately one watt, which output is ultimately the result of the capacity of the radioisotope primary power source contained in the fuel capsule 36. The fuel capsule 36 is removable from the housing 16 independently of any of the other components of the power supply 14 so that this primary fuel source can be readily replaced if ultimately needed. The fuel capsule 36 is surrounded by a suitable heat transfer medium, such as a heat pipe, defining the transfer means for transferring the thermal energy generated by the radioactive decay of the radioisotope within the fuel capsule 36 to the external combustion engine 20.

As previously mentioned, the external combustion engine means 20 is a Stirling cycle engine. The Stirling cycle is a well known thermodynamic cycle and various engines operating in accordance with this cycle are well known. In general, these engines have two pistons: one of which is referred to as a displacer for moving a working gas between hot and cold chambers, and the other of which is referred to as a power piston for providing a mechanical motion output. The movements of these pistons are in response to thermal energy, or heat, from the radioisotope of the fuel capsule 36. As shown in FIG. 2, the Stirling cycle engine is disposed adjacent the fuel member 36 so that the heat generated by the radioactive decay of the radioisotope in the fuel capsule 36 is transferred to the Stirling cycle engine through the heat transfer medium within the volume surrounding the capsule 36. In FIG. 2 the Stirling cycle engine is specifically identified by the reference numeral 38, and the mechanical motion is provided through a coupling member 40, such as the piston rod of the power piston known to be contained within the Stirling cycle engine 38.

The conversion means 22 is connected to the coupling member 40 so that the conversion means 22 is actuated by that motion, which motion is derived in response to the thermal energy from the thermal energy source means 18. In the preferred embodiment shown in FIG. 2, the conversion means 22 is an electrical energy generator (specifically identified as a linear alternator 42)

which generates a voltage across two terminals 44, 46. For the specific embodiment including a linear alternator, this form of the conversion means 22 includes a stator with which the two terminals 44, 46 are associated and a movable member connected to the coupling member 40 so that relative movement between the stator and the movable member is achieved when the Stirling engine 38 operates. That is, the stator is fixed in a stationary manner relative to the housing 16 and the movable member is fixed relative to the power piston within the Stirling engine 38 so that movement of the power piston moves the movable member relative to the stator. This relative movement generates the electrical voltage by the electromagnetic relationship between the stator and the movable member as is well known in linear alternators. In the preferred embodiment wherein size constraints are important factors, the Stirling engine 38 and the linear alternator 42 are constructed so that this relative movement is constrained to not more than approximately 3.2mm (1/8 inch), but also so that such limited displacement still generates an electrical output sufficient to provide power within the range between approximately 0.5 watt and approximately 2.5 watts. As shown in FIG. 2, the linear alternator 42 is disposed on the side of the Stirling cycle engine 38 opposite the fuel member 36.

The electrical output from the linear alternator 42, which is provided across the terminals 44, 46, is communicated externally of the housing 16 by the connecting means, schematically illustrated in FIG. 2 as including conductive members 48, 50 and output contacts or terminals 52, 54. These elements can be included in a single unitary member which provides both mechanical and electrical coupling of a suitable type for connecting with the circuit 8 to be energized by the power supply 14. This connecting, or coupling, means is preferably connected to or through the end wall 34 of the housing 16 so that the connection is made within the confines of the maximum outer diameter of the tubular member 24.

The above-described preferred embodiment of the apparatus defining the power supply 14 is also comprehended within a method of energizing an electrical circuit contemplated by the present invention. This method comprises inserting the fuel capsule 36 into the housing 16 in heat transfer relationship with the Stirling cycle engine 38, inserting the housing 16 into the downhole tool 6, and electrically connecting the electrical circuit of the downhole tool to the linear alternator 42. The importance of this method is in utilizing the fuel capsule 36, having the radioisotope, with a Stirling cycle engine in a downhole tool so that an improved technique of energizing such a downhole tool is provided. In particular, this method includes

within the step of inserting the housing into the downhole tool the step of retaining the housing within a receptacle region having a diameter of approximately 2.54cm (one inch) and a length of not greater than approximately 61cm (twenty-four inches). This method also comprises generating, at the output of the linear alternator 42 and in response to the radioisotope in the fuel capsule 36, an electrical output within the previously defined range of between approximately 0.5 watt and approximately 2.5 watts for application to the electrical circuit of the downhole tool. This power generating is achieved in the preferred embodiment of the method in conjunction with constraining the movement of the movable member of the linear alternator 42 relative to the stator of the linear alternator 42 to not more than approximately 3.2mm (1/8 inch). Although one may consider these specific design parameters to be merely matters of design choice, as comprehended within the method of the present invention these parameters are specific critical limitations of the preferred methodology by which an improved power supply technique is achieved within the constricted downhole environment to which the method is limited.

In summary, the radioisotope thermomechanical electrical generator of the preferred embodiment power supply 14 utilizes the energy released by the decay of the radioisotope within the fuel capsule 36 to provide heat to operate the Stirling engine 38 which will in turn drive the linear alternator 42 to provide a suitable electrical power output, such as in the specific embodiment an output of less than approximately one watt of AC or DC power for use in oil field instrumentation. The power supply 14 will operate for a long period of time, depending upon the half-life of the radioisotope, and over a wide temperature range, from less than 0°C to over 200°C because of the constant energy output of the radioactive source. These operating parameters define the invention in a manner which is particularly useful in deep oil or gas wells.

Additional or alternative specific design criteria contemplated for a specific implementation of the preferred embodiment include an approximately 2.54cm (one-inch) maximum outer diameter and a maximum length of preferably not greater than approximately 61cm (two-feet), an approximately 13mm (1/2 inch) diameter by approximately 15cm (six inch) length well at the heat source end of the housing for receiving a similarly sized fuel capsule, a suitable heat transfer mechanism, such as a heat pipe, to transfer heat from the radioisotope capsule to the head of the Stirling engine with suitable insulation as needed in the side wall and end of this section of the housing, a threaded end cap in a 13mm (1/2 inch) well to secure the fuel capsule in place and to provide maximum thermal contact

between the surfaces of the fuel capsule and the wall, an overall efficiency of 15% or better at 200°C; isolated electrical output terminals across which approximately 10-20 vac rms are provided from DC to as high a frequency as possible with a power output between approximately 0.5 watt and approximately 2.5 watts, and with a power drain two times normal for two seconds out of 100 seconds.

Claims

1. A power supply apparatus (14) for an oil or gas well downhole tool (6) having a system requiring energy from said power supply, which apparatus comprises housing means (16), means (20) disposed in said housing means for providing mechanical motion; conversion means (22), disposed in said housing means, for converting said mechanical motion to energy usable by the system within the downhole tool; and connecting means (52,54), for connecting said energy from said conversion means to the system of the downhole tool; characterised in that said housing means (16) is adapted to be received within a receptacle (12) of the downhole tool; a fuel capsule (18) is removably retained inside said housing means, said fuel capsule including a radioisotope for generating thermal energy; said means (20) is a Stirling cycle engine means for converting said thermal energy to mechanical motion; and wherein said connecting means (52,54) communicate externally of said housing means.
2. Apparatus according to claim 1, wherein said housing means has a first end through which a closable opening (26) is defined for receiving said fuel capsule into said housing means and for removing said fuel capsule from said housing means.
3. Apparatus according to claim 1 or 2, wherein: said housing means has a second end spaced linearly from said first end; said conversion means includes an electrical energy generator means (42) for generating a voltage across two terminals (44,46) of said electrical energy generator means in response to said mechanical motion from said Stirling cycle engine means; and said connecting means includes a coupling means (48,50), connected to said second end of said housing means, for coupling said two terminals to the system of the downhole tool.
4. Apparatus according to claim 1, 2, or 3, wherein said housing means includes a tubular mem-

ber (24) having a maximum outer diameter less than an inner diameter of the downhole tool and having an outer length less than the length of the downhole tool so that said tubular member is fully received entirely within the downhole tool.

5. Apparatus according to claim 4, wherein: said tubular member includes: a cylindrical side wall (25) across which said maximum outer diameter is defined; a first end wall (28) disposed transversely to said side wall at one end thereof, said first end wall having an opening (26) defined therethrough for receiving a closure cap (30) so that when said closure cap is removed from said opening said fuel capsule can be inserted into or removed from said tubular member through said first end thereof; and a second end wall (34) disposed transversely to said side wall at another end thereof; said conversion means includes linear alternator means for generating an electrical voltage in response to said Stirling cycle engine means; and said connecting means includes terminal means (52,54), disposed through said second end wall, for providing said electrical voltage externally of said housing.
6. A method of energizing an electrical circuit contained in a downhole tool (6) used in an oil or gas well, comprising initiating mechanical motion in a housing (16) and converting said motion into electrical energy; characterised by inserting a fuel capsule (18) into said housing (16) in heat transfer relationship with a Stirling cycle engine (20) retained in said housing, said fuel capsule including a radioisotope; inserting said housing into the downhole tool (6); and electrically connecting the electrical circuit to a linear alternator (22) disposed in said housing and mechanically connected to said Stirling cycle engine.
7. A method according to claim 6, further comprising generating, at the output of said linear alternator and in response to said radioisotope, an electrical output within the range between approximately 0.5 watts and approximately 2.5 watts for application to the electrical circuit of the downhole tool.
8. A method according to claim 6 or 7, wherein the step of inserting said housing into the downhole tool includes retaining said housing within a receptacle region having a diameter of approximately 2.5 cm (one inch) and a length of not greater than approximately 61 cm (twenty-four inches).

between the surfaces of the fuel capsule and the cell, an overall efficiency of 15% or better at 200°C, isolated electrical output terminals across which approximately 10-20 vac rms are provided from DC to as high a frequency as possible with a power output between approximately 0.5 watt and approximately 2.5 watts, and with a power drain two times normal for two seconds out of 100 seconds.

Claims

1. A power supply apparatus (14) for an oil or gas well downhole tool (6) having a system requiring energy from said power supply, which apparatus comprises housing means (16), means (20) disposed in said housing means for providing mechanical motion; conversion means (22), disposed in said housing means, for converting said mechanical motion to energy usable by the system within the downhole tool; and connecting means (52,54), for connecting said energy from said conversion means to the system of the downhole tool; characterised in that said housing means (16) is adapted to be received within a receptacle (12) of the downhole tool; a fuel capsule (18) is removably retained inside said housing means, said fuel capsule including a radioisotope for generating thermal energy; said means (20) is a Stirling cycle engine means for converting said thermal energy to mechanical motion; and wherein said connecting means (52,54) communicate externally of said housing means.
2. Apparatus according to claim 1, wherein said housing means has a first end through which a closable opening (26) is defined for receiving said fuel capsule into said housing means and for removing said fuel capsule from said housing means.
3. Apparatus according to claim 1 or 2, wherein: said housing means has a second end spaced linearly from said first end; said conversion means includes an electrical energy generator means (42) for generating a voltage across two terminals (44,46) of said electrical energy generator means in response to said mechanical motion from said Stirling cycle engine means; and said connecting means includes a coupling means (48,50), connected to said second end of said housing means, for coupling said two terminals to the system of the downhole tool.
4. Apparatus according to claim 1, 2, or 3, wherein said housing means includes a tubular mem-

ber (24) having a maximum outer diameter less than an inner diameter of the downhole tool and having an outer length less than the length of the downhole tool so that said tubular member is fully received entirely within the downhole tool.

5. Apparatus according to claim 4, wherein: said tubular member includes: a cylindrical side wall (25) across which said maximum outer diameter is defined; a first end wall (28) disposed transversely to said side wall at one end thereof, said first end wall having an opening (26) defined therethrough for receiving a closure cap (30) so that when said closure cap is removed from said opening said fuel capsule can be inserted into or removed from said tubular member through said first end thereof; and a second end wall (34) disposed transversely to said side wall at another end thereof; said conversion means includes linear alternator means for generating an electrical voltage in response to said Stirling cycle engine means; and said connecting means includes terminal means (52,54), disposed through said second end wall, for providing said electrical voltage externally of said housing.
6. A method of energizing an electrical circuit contained in a downhole tool (6) used in an oil or gas well, comprising initiating mechanical motion in a housing (16) and converting said motion into electrical energy; characterised by inserting a fuel capsule (18) into said housing (16) in heat transfer relationship with a Stirling cycle engine (20) retained in said housing, said fuel capsule including a radioisotope; inserting said housing into the downhole tool (6); and electrically connecting the electrical circuit to a linear alternator (22) disposed in said housing and mechanically connected to said Stirling cycle engine.
7. A method according to claim 6, further comprising generating, at the output of said linear alternator and in response to said radioisotope, an electrical output within the range between approximately 0.5 watts and approximately 2.5 watts for application to the electrical circuit of the downhole tool.
8. A method according to claim 6 or 7, wherein the step of inserting said housing into the downhole tool includes retaining said housing within a receptacle region having a diameter of approximately 2.5 cm (one inch) and a length of not greater than approximately 61 cm (twenty-four inches).



9. A downhole tool (6) for an oil or gas well which tool includes a system requiring energy from a power supply, characterised in that the tool has a receptacle (12) therein which contains a power supply apparatus (14) as claimed in any of claims 1 to 5.

Patentansprüche

1. Energieversorgungsvorrichtung (14) für ein in einer Öl- oder Gasbohrung befindliches Bohrlochwerkzeug (6) mit einem Energie von der Energieversorgungsvorrichtung benötigten System, enthaltend Gehäusemittel (16), in den Gehäusemitteln angeordnete Mittel (20) zur Erzeugung mechanischer Bewegung, in den Gehäusemitteln angeordnete Wandlermittel (22) zur Umwandlung der mechanischen Bewegung in eine von dem System in dem Bohrlochwerkzeug nutzbare Energie, und Verbindungsmittel (52, 54) zur Verbindung der Energie aus den Wandlermitteln mit dem System des Bohrlochwerkzeugs,

dadurch gekennzeichnet, daß die Gehäusemittel (16) zum Einsatz in eine Aufnahme (12) des Bohrlochwerkzeugs eingerichtet sind; daß in den Gehäusemitteln eine Brennstoffkapsel (18) auswechselbar gehalten ist, die ein Wärmeenergie erzeugendes Radioisotop enthält; daß die Mittel (20) einen Heißgasmotor zur Umwandlung von Wärmeenergie in mechanische Bewegung bilden; und daß die Verbindungsmittel (52, 54) außerhalb der Gehäusemittel angeschlossen sind.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Gehäusemittel ein erstes Ende haben, in dem eine verschließbare Öffnung (26) zum Einsetzen der Brennstoffkapsel in die Gehäusemittel und zum Entfernen der Brennstoffkapsel aus den Gehäusemitteln bestimmt ist.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Gehäusemittel ein geradlinig von dem ersten Ende entferntes zweites Ende haben; daß die Wandlermittel Generatormittel (42) zur Erzeugung elektrischer Energie enthalten, mittels derer als Folge der mechanischen Bewegung des Heißgasmotors an zwei Klemmen (44, 46) der Generatormittel eine elektrische Spannung erzeugbar ist; und daß die Verbindungsmittel mit dem zweiten Ende der Gehäusemittel verbundene Kuppelungsmittel (48, 50) zum Anschluß der beiden Klemmen an das System des Bohrlochwerkzeugs enthalten.

4. Vorrichtung nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß die Gehäusemittel ein rohrförmiges Glied (24) mit einem maximalen Außendurchmesser, der kleiner ist als der Innendurchmesser des Bohrlochwerkzeugs, und einer Außenlänge enthalten, die kleiner ist als die Länge des Bohrlochwerkzeugs, so daß das rohrförmige Glied vollständig in das Bohrlochwerkzeug aufgenommen ist.

5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß das rohrförmige Glied eine zylindrische Seitenwand (25) enthält, über die der maximale Außendurchmesser bestimmt ist, sowie eine erste Stirnwand (28), die quer zu der Seitenwand an deren einem Ende angeordnet ist und eine darin bestimmte Öffnung (26) zur Aufnahme einer Verschlusskappe (30) enthält, so daß nach Entfernung der Verschlusskappe aus der Öffnung die Brennstoffkapsel durch dessen erstes Ende in das rohrförmige Glied eingesetzt oder aus diesem entfernt werden kann, und eine zweite, quer zu der Seitenwand an deren anderem Ende verlaufende Stirnwand (34); daß die Wandlermittel einen linearen Wechselstromerzeuger enthalten, durch den unter Ansprechen auf den Heißgasmotor eine elektrische Spannung erzeugbar ist; und daß die Verbindungsmittel durch die zweite Stirnwand verlaufende Anschlußmittel (52, 54) zur Bereitstellung der elektrischen Spannung außerhalb des Gehäuses enthalten.

6. Verfahren zur Energieversorgung einer elektrischen Schaltung in einem Bohrlochwerkzeug (6), das in einer Öl- oder Gasbohrung verwendet wird, bei dem in einem Gehäuse (16) mechanische Bewegung eingeleitet und diese Bewegung in elektrische Energie umgewandelt wird,

gekennzeichnet durch Einsetzen einer ein Radioisotop enthaltenden Brennstoffkapsel (18) in das Gehäuse (16) in wärmeübertragender Beziehung zu einem in dem Gehäuse gehaltenen Heißgasmotor (20); Einsetzen des Gehäuses in das Bohrlochwerkzeug (6); und Herstellen einer elektrischen Verbindung der elektrischen Schaltung mit einem linearen Wechselstromerzeuger (22), der in dem Gehäuse angeordnet und mechanisch mit dem Heißgasmotor verbunden ist.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß ferner am Ausgang des linearen Wechselstromerzeugers und unter der Wirkung des Radioisotops eine elektrische Ausgangsleistung im Bereich von ungefähr 0,5 W bis un-



gefähr 2,5 W zum Anlegen an die elektrische Schaltung in dem Bohrlochwerkzeug erzeugt wird.

8. Verfahren nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß beim Einsetzen des Gehäuses in das Bohrlochwerkzeug das Gehäuse in einem Aufnahmebereich mit einem Durchmesser von ungefähr 2,5 cm (1 Zoll) und einer Länge von nicht mehr als ungefähr 61 cm (24 Zoll) gehalten wird.
9. Bohrlochwerkzeug (6) für eine Öl- oder Gasquelle, das ein System enthält, welches Energie aus einer Energieversorgung benötigt, dadurch gekennzeichnet, daß das Werkzeug eine Aufnahme (12) aufweist, die eine Energieversorgungsvorrichtung (14) nach einem der Ansprüche 1 bis 5 enthält.

Revendications

1. Dispositif d'alimentation (14) pour un outil de fond de puits de pétrole ou de gaz (6) possédant un système nécessitant de l'énergie du dispositif d'alimentation, lequel dispositif comprend des moyens de boîtier (16), des moyens (20) disposés dans lesdits moyens de boîtier pour fournir un mouvement mécanique; des moyens de conversion (22), disposés dans lesdits moyens de boîtier, pour convertir ledit mouvement mécanique en énergie utilisable par le système à l'intérieur de l'outil de fond de puits; et des moyens de connexion (52,54), pour relier ladite énergie desdits moyens de conversion au système de l'outil de fond de puits, caractérisé en ce que lesdits moyens de boîtier (16) sont adaptés pour être logés à l'intérieur d'un réceptacle (12) de l'outil de fond de puits, une capsule de combustible (18) est retenue d'une manière amovible à l'intérieur desdits moyens de boîtier, ladite capsule de combustible contenant un isotope radioactif pour générer de l'énergie thermique, lesdits moyens (20) sont des moyens de moteur à cycle de Stirling pour convertir ladite énergie thermique en mouvement mécanique, et dans lequel lesdits moyens de connexion (52,54) communiquent à l'extérieur desdits moyens de boîtier.
2. Dispositif suivant la revendication 1, dans lequel lesdits moyens de boîtier possèdent une première extrémité à travers laquelle une ouverture obturable (26) est définie pour recevoir ladite capsule de combustible dans lesdits moyens de boîtier et pour enlever ladite capsule de combustible desdits moyens de boî-

tier.

3. Dispositif suivant la revendication 1 ou 2, dans lequel :
lesdits moyens de boîtier possèdent une seconde extrémité espacée linéairement de ladite première extrémité, lesdits moyens de conversion comprennent des moyens de génération d'énergie électrique (42) pour générer une tension entre deux bornes (44,46) desdits moyens de génération d'énergie électrique en réponse audit mouvement mécanique provenant desdits moyens de moteur à cycle de Stirling et lesdits moyens de connexion comprennent des moyens de couplage (48,50), reliés à ladite seconde extrémité desdits moyens de boîtier, pour coupler lesdites deux bornes au système de l'outil de fond de puits.
4. Dispositif suivant la revendication 1, 2 ou 3, dans lequel lesdits moyens de boîtier comprennent un élément tubulaire (24) ayant un diamètre extérieur maximum inférieur à un diamètre intérieur de l'outil de fond de puits et ayant une longueur extérieure inférieure à la longueur de l'outil de fond de puits de telle manière que ledit élément tubulaire est entièrement contenu à l'intérieur de l'outil de fond de puits.
5. Dispositif suivant la revendication 4, dans lequel: ledit élément tubulaire comprend: une cloison latérale cylindrique (25) à partir de laquelle ledit diamètre extérieur maximum est défini; une première cloison d'extrémité (28) disposée transversalement à ladite cloison latérale à une extrémité de celle-ci, ladite première cloison d'extrémité ayant une ouverture (26) définie à travers celle-ci pour recevoir un bouchon de fermeture (30) de manière à ce que lorsque ledit bouchon de fermeture est enlevé de ladite ouverture ladite capsule de combustible puisse être insérée ou enlevée dudit élément tubulaire à travers ladite première extrémité de celui-ci; et une seconde cloison d'extrémité (34) disposée transversalement à ladite cloison latérale à une autre extrémité de celle-ci, lesdits moyens de conversion comprennent un alternateur linéaire pour générer une tension électrique en réponse aux moyens de moteur à cycle de travers ladite seconde cloison d'extrémité, pour fournir ladite tension électrique à l'extérieur dudit boîtier.
6. Procédé d'alimentation en énergie d'un circuit électrique contenu dans un outil de fond de puits (6) utilisé dans un puits de pétrole ou de gaz, comprenant le déclenchement d'un mou-



vement mécanique dans un boîtier (16) et la conversion dudit mouvement mécanique en énergie électrique, caractérisé par l'insertion d'une capsule de combustible (18) dans ledit boîtier (16) en relation de transfert de chaleur avec un moteur à cycle de Stirling (20) contenu dans ledit boîtier; ladite capsule contenant un isotope radioactif, l'insertion dudit boîtier dans l'outil de fond de puits (6), et la connexion électrique du circuit électrique à un alternateur linéaire (22) disposé dans ledit boîtier et relié mécaniquement audit moteur à cycle de Stirling.

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7. Procédé suivant la revendication 6, comprenant en outre la génération, à la sortie dudit alternateur linéaire et en réponse audit isotope radioactif, d'une énergie électrique de sortie dans la gamme comprise entre 0.5 watt environ et 2.5 watts environ pour son application au circuit électrique de l'outil de fond de puits.

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8. Dispositif suivant la revendication 6 ou 7, dans lequel l'étape d'insertion dudit boîtier dans l'outil de fond de puits comprend le maintien dudit boîtier à l'intérieur d'une zone de réceptacle ayant un diamètre de 2.5cm (un pouce) environ et une longueur inférieure à 61cm (vingt-quatre pouces) environ.

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9. Outil de fond de puits (6) pour un puits de pétrole ou de gaz, lequel outil comprend un système nécessitant de l'énergie d'une alimentation, caractérisé en ce que l'outil possède un réceptacle (12) à l'intérieur de celui-ci qui contient un dispositif d'alimentation (14) suivant l'une quelconque des revendications 1 à 5.

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