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(54) [DOWNHOLE TOOLS WITH A STIRLING COOLER SYSTEM]

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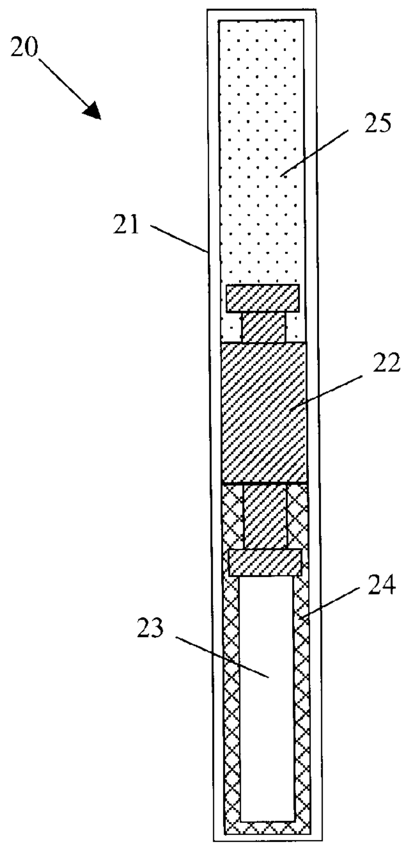
(57) **ABSTRACT**

A cooling system for a downhole tool includes an insulating chamber disposed in the tool, wherein the chamber is adapted to house an object to be cooled; a Stirling cooler is disposed in the tool, the cooler has a cold end configured to remove heat from the chamber and a hot end configured to dissipate heat; and an energy source to power the Stirling cooler. A downhole tool includes: a tool body, and a cooling system with an insulating chamber; wherein the chamber is adapted to house an object to be cooled; a Stirling cooler is disposed in the tool, the cooler has a cold end configured to remove heat from the chamber and a hot end configured to dissipate heat; and an energy source to power the Stirling cooler.



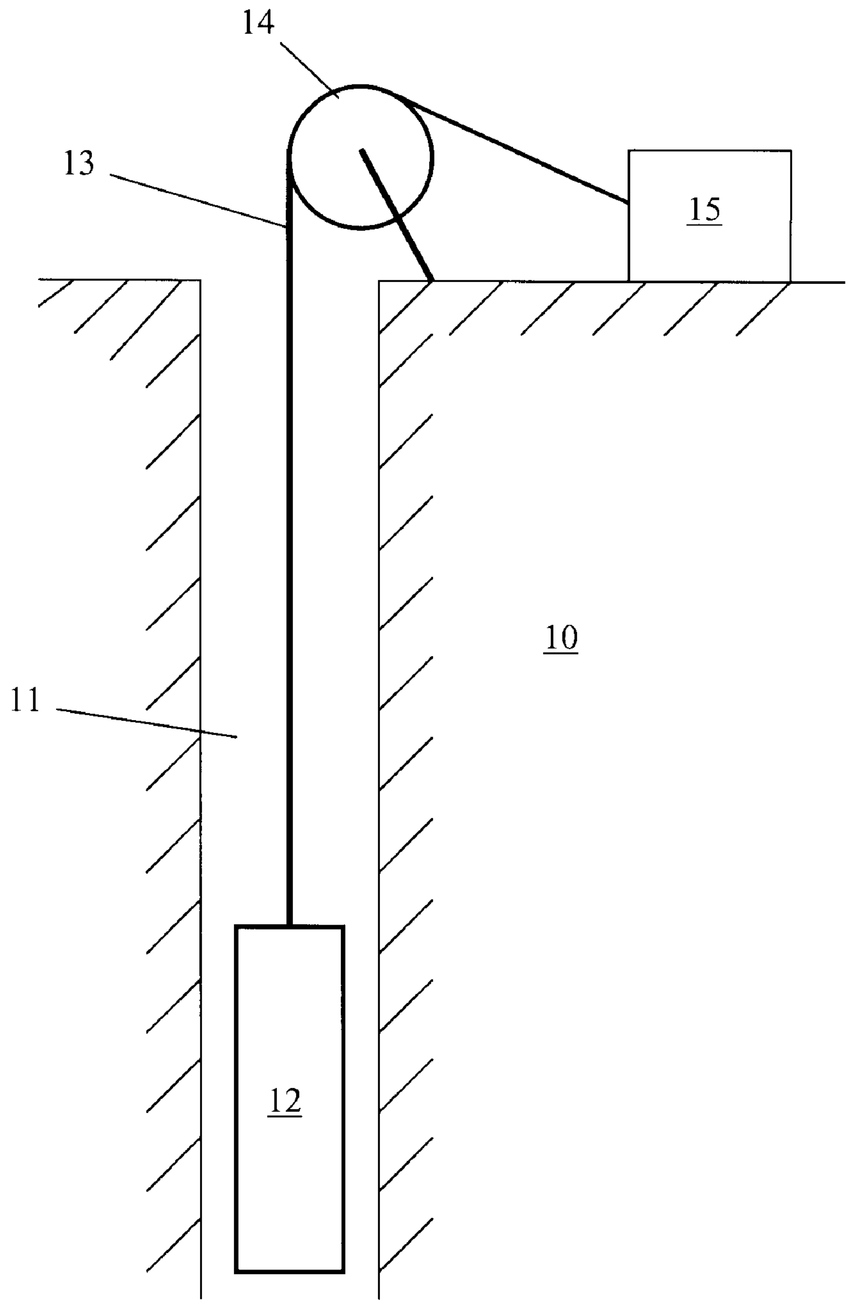


FIG. 1
(Prior Art)

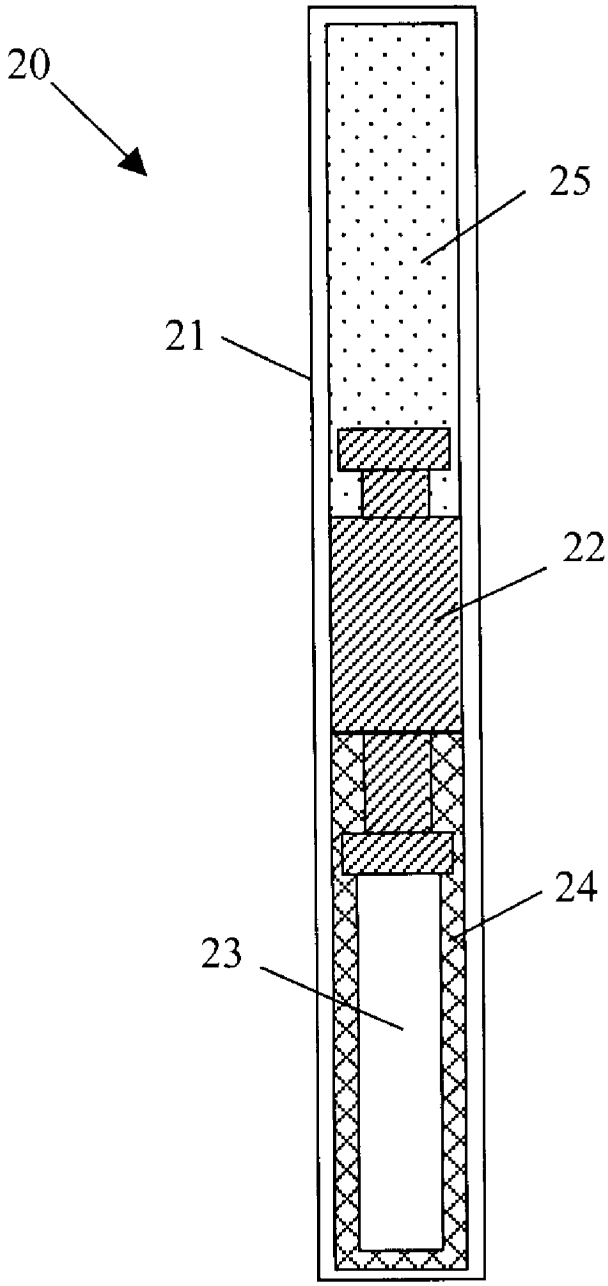


FIG. 2

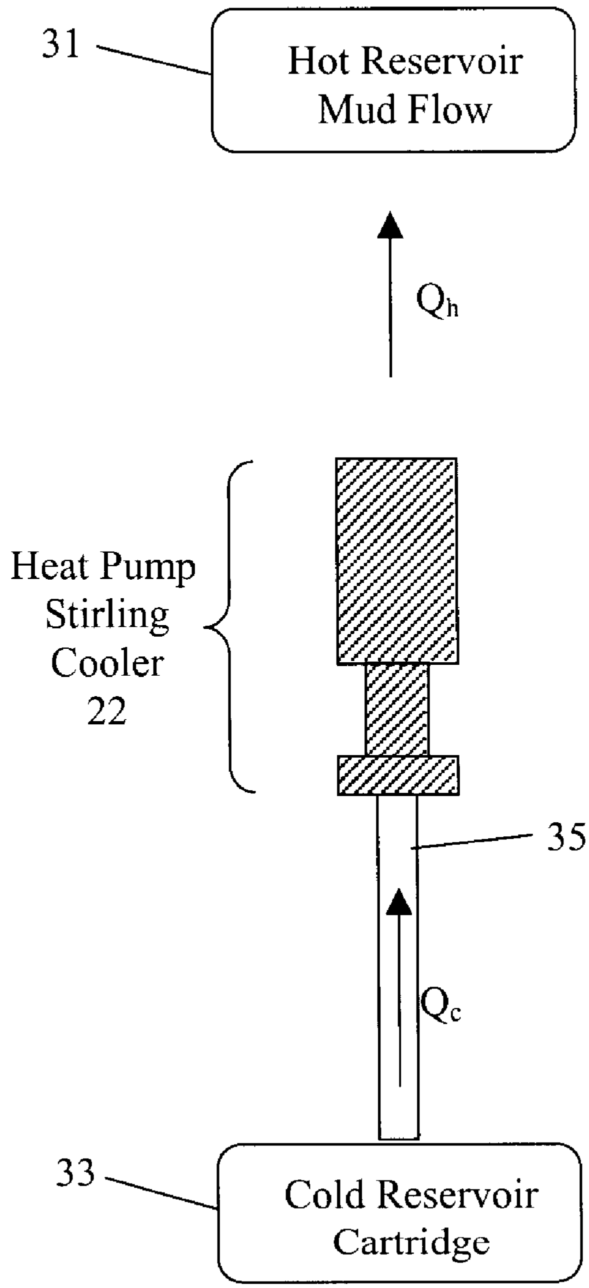

31
Hot Reservoir
Mud Flow
Q_h
Heat Pump
Stirling
Cooler
22
35
Q_c
33
Cold Reservoir
Cartridge

FIG. 3

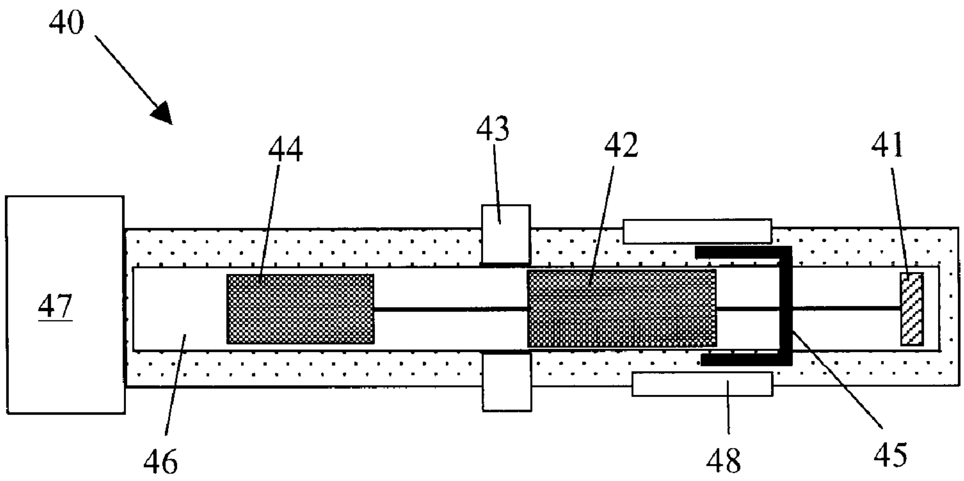


FIG. 4

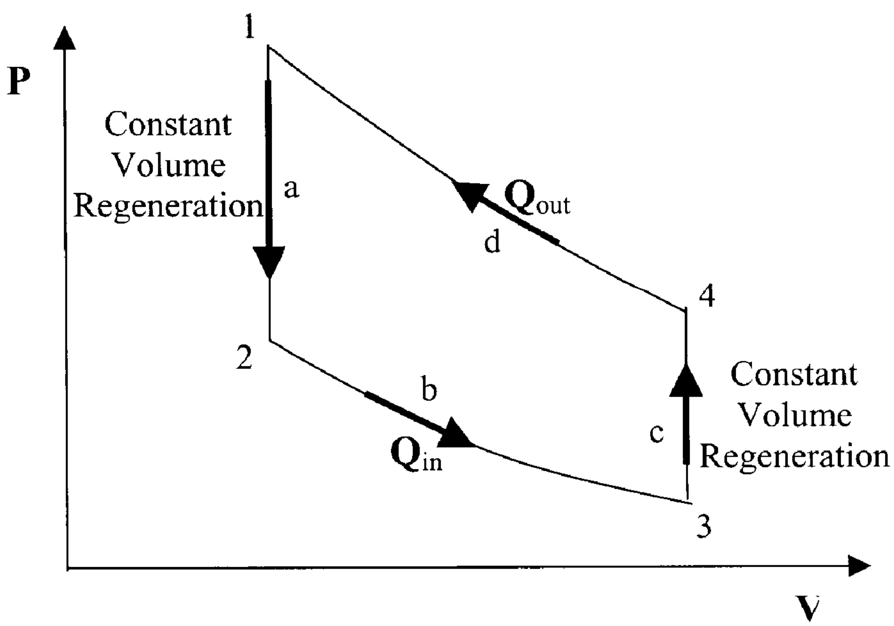


FIG. 5
(Prior Art)

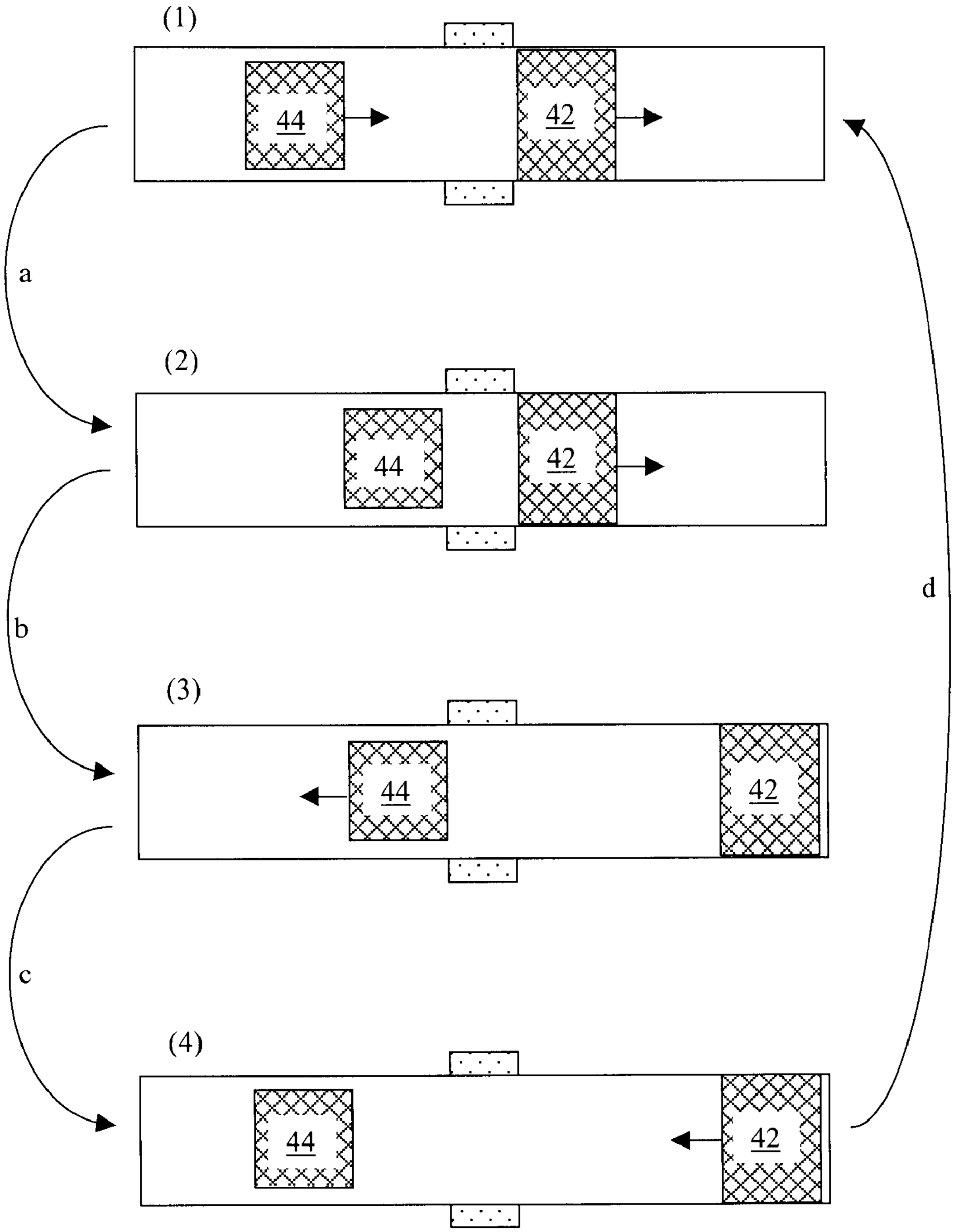


FIG. 6

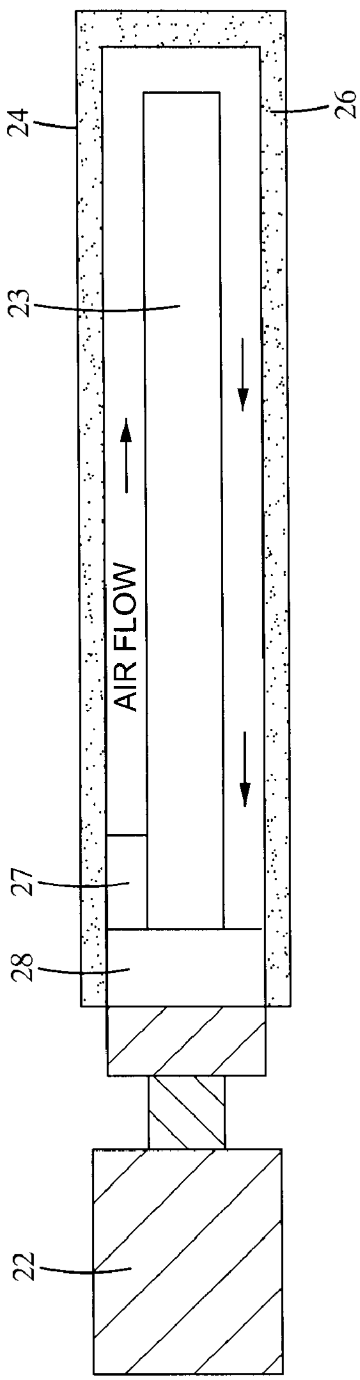


FIG. 7

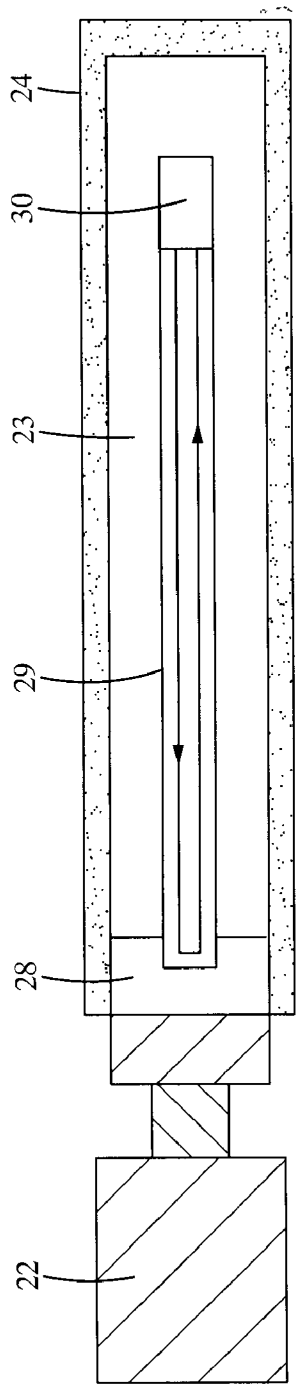


FIG. 8

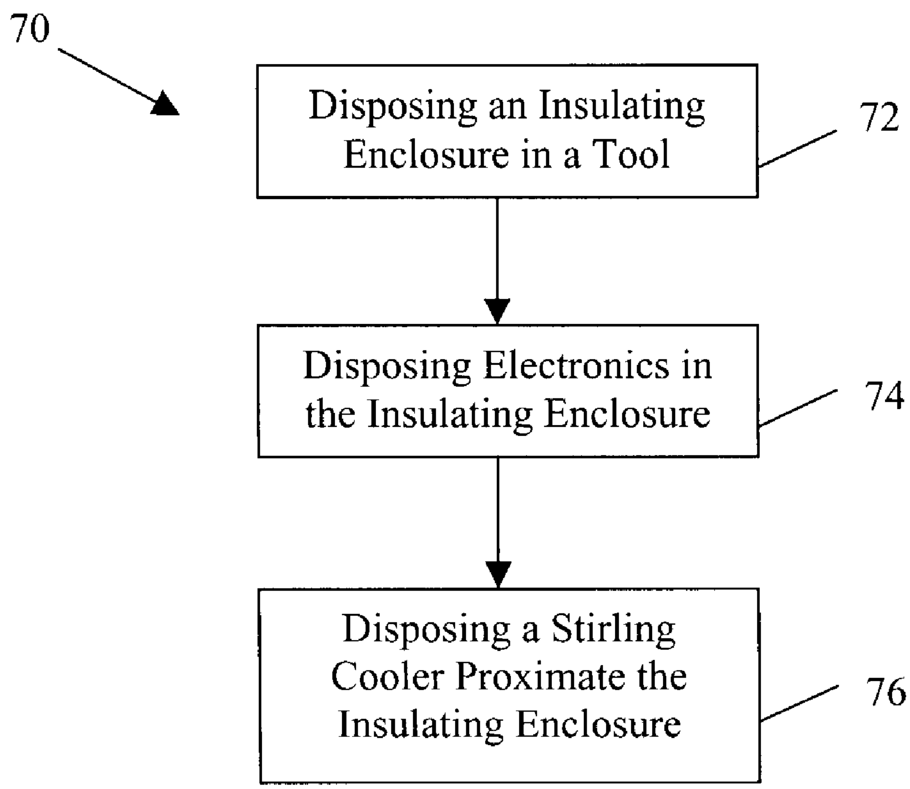

70
Disposing an Insulating Enclosure in a Tool
72
Disposing Electronics in the Insulating Enclosure
74
Disposing a Stirling Cooler Proximate the Insulating Enclosure
76

FIG. 9

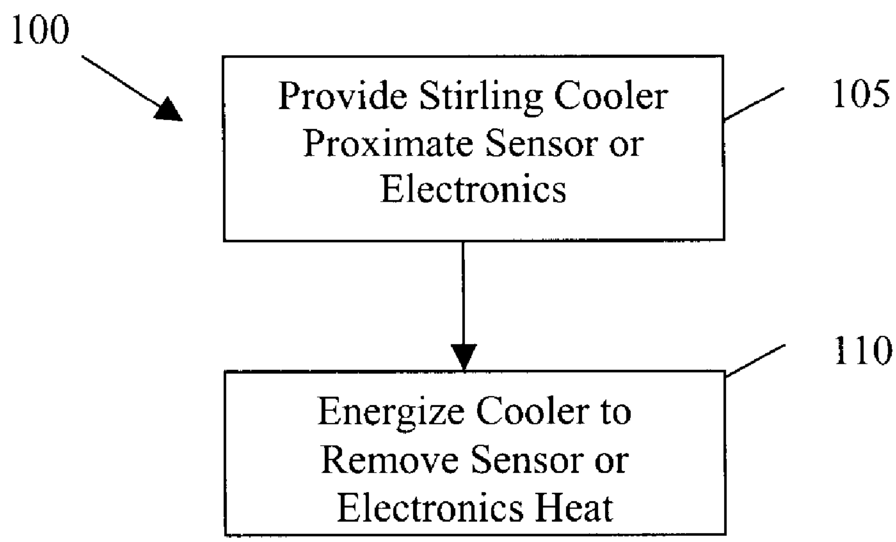

100
Provide Stirling Cooler Proximate Sensor or Electronics
105
110
Energize Cooler to Remove Sensor or Electronics Heat

FIG. 10

[DOWNHOLE TOOLS WITH A STIRLING COOLER SYSTEM]

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority, under 35 U.S.C. §119, to Provisional Application Ser. No. 60/517,782, filed on Nov. 6, 2003, incorporated by reference in its entirety.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates generally to techniques for maintaining downhole tools and their components within a desired temperature range in high-temp environments, and, more specifically, to a Stirling-Cycle cooling system for use with downhole tools.

[0004] 2. Background Art

[0005] Various well logging and monitoring techniques are known in the field of hydrocarbon and water exploration and production. These techniques employ downhole tools or instruments equipped with sources adapted to emit energy through a borehole traversing the subsurface formation. The emitted energy passes through the borehole fluid ("mud") and into the surrounding formations to produce signals that are detected and measured by one or more sensors, which typically are also disposed on the downhole tools. By processing the detected signal data, a profile of the formation properties is obtained.

[0006] A downhole tool, comprising a number of emitting sources and sensors for measuring various parameters, may be lowered into a borehole on the end of a cable, a wireline, or a drill string. The cable/wireline, which is attached to some sort of mobile processing center at the surface, provides the means by which data are sent up to the surface. With this type of wireline logging, it becomes possible to measure borehole and formation parameters as a function of depth, i.e., while the tool is being pulled uphole.

[0007] An alternative to wireline logging techniques is the collection of data on downhole conditions during the drilling process. By collecting and processing such information during the drilling process, the driller can modify or correct key steps of the operation to optimize performance. Schemes for collecting data of downhole conditions and movement of the drilling assembly during the drilling operation are known as Measurement While Drilling (MWD) techniques. Similar techniques focusing more on measurement of formation parameters than on movement of the drilling assembly are know as Logging While Drilling (LWD). Logging While Tripping (LWT) is an alternative to LWD and MWD techniques. In LWT, a small diameter "run-in" tool is sent downhole through the drill pipe, at the end of a bit run, just before the drill pipe is pulled. The run-in tool is used to measure the downhole physical quantities as the drill string is extracted or tripped out of the hole. Measured data is recorded into tool memory versus time during the trip out. At the surface, a second set of equipment records bit depth versus time for the trip out, and this allows the measurements to be placed on depth. **FIG. 1** shows a conventional logging tool **12** disposed in a borehole **11** that penetrates a subsurface formation **10**. The logging tool **12** may be deployed on a wireline **13** via a wireline control mechanism **14**. In addition, the logging tool **12** may be connected to surface equipment **15**, which may include a computer (not shown).

[0008] Downhole tools are exposed to extreme temperatures (up to 260° C.) and pressures (up to 30,000 psi and possibly up to 40,000 psi in some instances). These tools are typically equipped with sensitive components (e.g. electronics packages) that often are not designed for such harsh environments. The trend among manufacturers of electronic components is to address the high-volume commercial market, making it difficult to find components for downhole tools that function effectively at these elevated temperatures. At the same time, the oilfield industry is moving toward the exploration of deeper and hotter reservoirs. As a result, there is an urgent need for methods or devices that permit the sensitive electronic components to be operated at high temperatures. Redesigning silicon chips to operate at high temperatures (e.g., above 150° C.) is costly and has a significant impact on the development time and thus the time to market. The alternative is to have systems to protect the electronic components from the high temperature environments. Conventional techniques include those that insulate the sensitive components from the hot environments, such as putting them in Dewar flasks. This technique protects the tool only for a certain amount of time, and the nature of the flasks makes them intrinsically fragile. A better approach is to use an active cooling system.

[0009] A cooling system capable of providing multi-watt refrigeration for thermally protected electronic components in downhole tools would enable the use of electronic and sensor technologies that are otherwise not suitable for high temperature applications. This would reduce the ever-increasing costs associated with the development and implementation of high-temperature electronics, and make it possible to introduce new technologies to subsurface exploration and production.

[0010] A cooling system for use in a downhole tool needs to fit in the limited space within the tool. Several miniature cooling systems suitable for use in downhole tools have been proposed. See e.g., Aaron Flores, "Active Cooling for Electronics in a Wireline Oil-Exploration Tool," Ph.D. dissertation, MIT, 1996. This technique was based on a once-through vapor compression cycle. However, this approach requires very careful sealing and lubrication due to high pressure in the condenser part.

[0011] Gloria Bennett proposed an active cooling system for downhole tools based on a miniature thermoacoustic refrigerator, "Active Cooling for Downhole Instrumentation: Miniature Thermoacoustic refrigerator," 1991, University of New Mexico, Ph.D. dissertation, UMI 1991.9215048. This approach is promising, but the components used are relatively bulky, and the performance of a miniature thermoacoustic refrigerator is uncertain.

[0012] Although cooling systems for use in downhole tools have been proposed, a need remains for improved cooling/refrigeration techniques for downhole tools.

SUMMARY OF INVENTION

[0013] One aspect of the invention relates to cooling systems for downhole tools. A cooling system in accordance with one embodiment of the invention includes an insulating chamber disposed in the downhole tool, wherein the insulating chamber is adapted to house an object to be cooled; a Stirling cooler disposed in the downhole tool, wherein the Stirling cooler has a cold end configured to remove heat from the insulating chamber and a hot end configured to dissipate heat; and an energy source to power the Stirling cooler.

[0014] One aspect of the invention relates to downhole tools. A downhole tool in accordance with one embodiment of the invention includes a tool body; and a cooling system comprising: an insulating chamber disposed in the downhole tool, wherein the insulating chamber is adapted to house an object to be cooled; a Stirling cooler disposed in the downhole tool, wherein the Stirling cooler has a cold end configured to remove heat from the insulating chamber and a hot end configured to dissipate heat; and an energy source to power the Stirling cooler.

[0015] One aspect of the invention relates to methods for manufacturing downhole tools. A method in accordance with one embodiment of the invention includes disposing a sensor or electronics in an insulating chamber in the downhole tool; and disposing a Stirling cooler in the downhole tool proximate the insulating chamber such that the Stirling cooler is configured to remove heat from the insulating chamber.

[0016] One aspect of the invention relates to methods for cooling a sensor or electronics included in downhole tools. A method in accordance with one embodiment of the invention includes providing a Stirling cooler in the downhole tool proximate the sensor or electronics; and energizing the Stirling cooler such that heat is removed from the sensor or electronics.

[0017] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0018] **FIG. 1** shows a conventional downhole tool disposed in a borehole.

[0019] **FIG. 2** shows a downhole tool including a Stirling cooler in accordance with one embodiment of the invention.

[0020] **FIG. 3** shows a schematic illustrating heat transfer using a Stirling cooler in accordance with one embodiment of the invention.

[0021] **FIG. 4** shows a free-piston Stirling cooler in accordance with one embodiment of the invention.

[0022] **FIG. 5** shows a diagram illustrating a Stirling cycle.

[0023] **FIG. 6** shows a schematic illustrating various states of the pistons in the Stirling cooler in a Stirling cycle.

[0024] **FIG. 7** shows a schematic of an active air-flow cooling system in accordance with an embodiment of the invention.

[0025] **FIG. 8** shows a schematic of a liquid-fluid cooling system in accordance with an embodiment of the invention.

[0026] **FIG. 9** illustrates a method for manufacturing a downhole tool in accordance with one embodiment of the invention.

[0027] **FIG. 10** illustrates a method for cooling sensors or electronics within downhole tools in accordance with the invention.

DETAILED DESCRIPTION

[0028] Embodiments of the invention relate to cooling systems for use in downhole tools. These cooling systems are based on Stirling cycles that can function efficiently in a closed system, require no lubrication, and can function at relatively lower pressures as compared to a vapor compression system. A Stirling engine or cooler is based on the Stirling (also referred to as "Sterling") cycle, which is a well known thermodynamic cycle. A Stirling engine uses heat (temperature difference) as the energy source to provide mechanical work. A Stirling cooler operates in reverse; it uses mechanical energy to produce a temperature difference e.g., as a cooler or refrigerator.

[0029] Various configurations of Stirling engines/coolers have been devised. These can be categorized into kinematic and free-piston types. Kinematic Stirling engines use pistons attached to drive mechanisms to convert linear piston motions to rotary motions. Kinematic Stirling engines can be further classified as alpha type (two pistons), beta type (piston and displacer in one cylinder), and gamma type (piston and displacer in separate cylinders). Free-piston Stirling engines use harmonic motion mechanics, which may use planar springs or magnetic field oscillations to provide the harmonic motion.

[0030] Due to daunting engineering challenges, Stirling cycle engines are rarely used in practical applications and Stirling cycle coolers have been limited to the specialty field of cryogenics and military use. The development of Stirling engines/coolers involves such practical considerations as efficiency, vibration, lifetime, and cost. Using Stirling engines/coolers on downhole tools presents additional difficulties because of the limited space available in a downhole tool (typically 3-6 inches [7.5-15 cm] in diameter) and the harsh downhole environments (e.g., temperatures up to 260° C., pressures up to 30,000 psi or more, and shock up to 250 g or more). Stirling engines have been proposed for use as electricity generators for downhole tools (See U.S. Pat. No. 4,805,407 issued to Buchanan).

[0031] Embodiments of the present invention may use any Stirling cooler designs. Some embodiments use free-piston Stirling coolers. One free-piston Stirling cooler embodiment of the invention makes use of a moving magnet linear motor.

[0032] **FIG. 2** shows a downhole tool (such as **12** in **FIG. 1**) in accordance with one embodiment of the invention. As shown, a downhole tool **20** includes an elongated housing **21** that protects various components **23** of the instrument. These components **23** may include electronics that need to be protected from high temperatures. The components are disposed in an insulating enclosure or chamber **24** and connected to a Stirling cooler **22**. Other components **25** of the downhole tool **20** may be included at the other end of the Stirling cooler **22**. The components **25** may include other electronics for controlling the Stirling cooler **22** or mechanisms to remove heat from the hot end of the Stirling cooler **22**.

[0033] **FIG. 3** shows a schematic of a system for heat removal using a Stirling cooler in accordance with one embodiment of the invention. As shown, a Stirling cooler **22** functions as a heat pump, removing heat from the cold reservoir cartridge **33** to the mud flow (hot reservoir) **31**. In this manner, the heat removed from the object to be cooled (the cold cartridge **33**) is effectively "pumped" to the other end (the hot end) of the Stirling cooler and dissipated into the mud flow **31**, for example. Note that the Stirling cooler **22** may be in direct contact with the object to be cooled. Alternatively, the Stirling cooler **22** may be placed at a distance from the object to be cooled with a heat transport mechanism **35** disposed therebetween to transfer the heat. Those skilled in the art will appreciate that the heat transport mechanism **35** may be any suitable heat transport device (e.g., a heat pipe), including those implemented with circulating fluids. Embodiments of the invention may also be implemented with heat transport mechanisms on the cold side and the hot side (not shown).

[**0034**] **FIG. 4** shows a schematic of a free-piston Stirling cooler that may be used with embodiments of the invention. As shown, the Stirling cooler **40** is attached to an object **47** to be cooled. As noted above, in some embodiments, a heat transport device may be used to transport heat between the object **47** and the Stirling cooler **40**. The Stirling cooler **40** includes two pistons **42**, **44** disposed in cylinder **46**. The cylinder **46** is filled with a working gas, typically air, helium or hydrogen at a pressure of several times (e.g., 20 times) the atmospheric pressure. The piston **42** is coupled to a permanent magnet **45** that is in proximity to an electromagnet **48** fixed on the housing. When the electromagnet **48** is energized, its magnetic field interacts with that of the permanent magnet **45** to cause linear motion (in the left and right directions looking at the figure) of piston **42**. Thus, the permanent magnet **45** and the electromagnet **48** form a moving magnet linear motor. The particular sizes and shapes of the magnets shown in **FIG. 4** are for illustration only and are not intended to limit the scope of the invention. One skilled in the art will also appreciate that the locations of the electromagnet and the permanent magnet may be reversed, i.e., the electromagnet may be fixed to the piston and the permanent magnet fixed on the housing (not shown).

[**0035**] The electromagnet **48** and the permanent magnet **45** may be made of any suitable materials. The windings and lamination of the electromagnet are preferably selected to sustain high temperatures (e.g., up to 260° C.). In some embodiments, the permanent magnets of the linear motors are made of a samarium-cobalt (Sm—Co) alloy to provide good performance at high temperatures. The electricity required for the operation of the electromagnet may be supplied from the surface, from conventional batteries in the downhole tool, from generators downhole, or from any other means known in the art.

[**0036**] The movement of piston **42** causes the gas volume of cylinder **46** to vary. Piston **44** can move in cylinder **46** like a displacer in the kinematic type Stirling engines. The movement of piston **44** is triggered by a pressure differential across both sides of piston **44**. The pressure differential results from the movement of piston **42**. The movement of piston **44** in cylinder **46** moves the working gas from the left of piston **44** to the right of piston **44**, and vice-versa. This movement of gas coupled with the compression and decompression processes results in the transfer of heat from object **47** to heat dissipating device **43**. As a result, the temperature of the object **47** decreases. In some embodiments, the Stirling cooler **40** may include a spring mass **41** to help reduce vibrations of the cooler resulting from the movements of the pistons and the magnet motor.

[**0037**] While **FIG. 4** shows a Stirling cooler having a magnet motor that uses electricity to power the Stirling cooler, one skilled in the art will appreciate that other energy sources (or energizing mechanisms) may also be used. For example, operation of the Stirling cooler (e.g., the back and forth movements of piston **42** in **FIG. 4**) may be implemented by mechanical means, such as a fluid-powered system that uses the energy in the mud flow coupled to a valve system and/or a spring (not shown). The hydraulic pressure of the mud flow could be used to push the piston in one direction, while the spring is used to move the piston in the other direction. A conventional valve system is used to control the flow of mud to the Stirling piston in an intermittent fashion. Thus the coordinated action of a hydraulic system, a spring, and a valve system results in a back and forth movement of the piston **42**.

[**0038**] The movement of gas to the right and to the left of piston **44**, coupled with compression and decompression of the gas in cylinder **46** by piston **42**, creates four different states in a Stirling cycle. **FIG. 5** depicts these four states and the transitions between these states in a pressure-volume diagram. **FIG. 6** illustrates the four states and the direction of the movements of the pistons **42** and **44** in a Stirling cycle.

[**0039**] In process a (from state 1 to state 2), piston **44** moves from left to right in **FIG. 6**, while piston **42** remains stationary. Therefore, the volume in cylinder **46** (see **FIG. 4**) is unchanged. The working gas in the cylinder is swept from one side of piston **44** to the other side.

[**0040**] In the second process b (from state 2 to state 3), piston **42** moves to the right, increasing the volume in the cylinder (shown as **46** in **FIG. 4**). The magnet motor drives the movement of piston **42**. Due to the increased volume in the cylinder, the gas expands and absorbs heat.

[**0041**] In process c (from state 3 to state 4), piston **44** moves to the left, forcing the working gas to move to its right. The volume of the gas remains unchanged.

[**0042**] In process d (from state 4 back to state 1), piston **42** moves to the left, driven by the magnet motor. This compresses the working gas. The compression results in the release of heat from the working gas. The released heat is dissipated from the heat dissipater **43** into the heat sink or environment (e.g., the drilling mud). This completes the Stirling cycle. The net result is the transport of heat from one end of the device to the other. Thus, if the Stirling device is in thermal contact (either directly or via a transport mechanism) with the object to be cooled (shown as **47** in **FIG. 4**), heat can be removed from the object. As a result, the temperature of the object is lowered or heat generated at the object can be removed.

[**0043**] **FIG. 7** shows a schematic of a system for heat removal using a Stirling cooler in accordance with another embodiment of the invention. As shown, a Stirling cooler **22** is coupled to an insulating enclosure or chamber **24**. The chamber **24** is configured with an internal cavity **26** formed therein and adapted to provide an path over the component(s) **23** housed therein. The cavity **26** may be formed using any conventional materials known in the art. A fan **27** is disposed within the chamber **24** to circulate air around the component **23** to be cooled, thereby actively transferring heat dissipating from the component(s) to the cold side of the Stirling cooler **22**. The fan **27** may be powered by the electrical supply feeding the Stirling cooler or by an independent power network (e.g. separate battery) as known in the art. This particular embodiment is further equipped with a heat exchanger **28** disposed at one end of the chamber **24** to increase cooling efficiency across the cooler/chamber interface and cool the recirculating air. The heat exchanger **28** may be a conventional heat sink or another suitable device as known in the art. Other embodiments may be implemented with multiple fans **27** to increase the cooling air flow.

[**0044**] **FIG. 8** shows a schematic of another system for heat removal using a Stirling cooler in accordance with an embodiment of the invention. As shown, a Stirling cooler **22** is coupled to an insulating enclosure or chamber **24**. The chamber **24** is configured with an internal liquid-coolant system **29** disposed therein. The coolant system **29** is adapted with a flow loop that allows a liquid to flow in a closed loop from the housed component(s) **23** to a heat exchanger **28** attached to the cold side of the Stirling cooler **22**. The coolant system **29** may be constructed using conventional materials known in the art (e.g., via multiple tubes). The heat exchanger **28** may be a conventional heat sink or another suitable device as known in the art. The coolant liquid, which may be water or any suitable alternative, is circulated in the flow loop via a pump **30** coupled to the flow lines and powered by the Stirling cooler **22** power network or using independent power means.

[**0045**] The Stirling cooler system of **FIG. 8** is shown with the liquid-coolant system **29** centrally disposed within the chamber **24**, such that the component(s) **23** to be cooled surround the coolant system. Those skilled in the art will appreciate that other embodiments of the invention may be implemented with the liquid-coolant system **29** in various configurations and lengths depending on space constraints. For example, embodiments of the invention may be implemented with the liquid-coolant system configured within, or forming, the walls of the insulating chamber (not shown). In such embodiments the liquid-coolant system would not be centrally disposed within the chamber **24**. Embodiments comprising the liquid-coolant system **29** render increased cooling efficiency as the liquid collects the heat dissipated in the component **23** chamber and transfers it to the cold side of the Stirling **22** via the heat exchanger **28**. In addition the use of liquid coolant, and, if desired in some embodiments, insulated coolant lines, allows a larger spatial separation between the Stirling cooler and the component to be cooled.

[**0046**] While the above description uses a free-piston Stirling cooler to illustrate embodiments of the invention, those skilled in the art will appreciate that other types of Stirling coolers may also be used, including those based on kinematic mechanisms—e.g., double-piston Stirling coolers and piston-and-displacer Stirling coolers.

[**0047**] In accordance with embodiments of the invention, Stirling coolers are used to cool electronics, sources, sensors or other heat sensitive parts that need to function in the harsh downhole environment. In these embodiments, the component(s) to be cooled is disposed in an insulating chamber (e.g., a Dewar flask) and the cold end of the Stirling cooler is coupled to (either directly or via a heat transport mechanism) one side of the chamber. It has been found that a substantial amount of heat (e.g. 150 W) could be removed with the cooler embodiments of the invention. Thus, it is possible to maintain an environment below 125° C. for the housed component, even when the temperature in the borehole may be 175° C. Model studies also indicate that the Stirling cooler embodiments of the invention are capable of removing heat at a rate of up to 400 W.

[**0048**] Some aspects of the invention relate to methods for producing a downhole tool having a cooling system in accordance with the invention. A schematic of a portion of a downhole tool including a Stirling cooler embodiment of the invention is illustrated in **FIG. 2**. It will be appreciated by those skilled in the art that embodiments of the invention are not limited to any particular type of downhole tool. Thus, the invention may be implemented with any tool or instrument adapted for subsurface disposal, including wireline tools, LWD/MWD/LWT tools, coiled tubing tools, casing drilling tools, and with long-term/permanently disposed tubulars used in reservoir monitoring.

[**0049**] **FIG. 9** shows a process for producing a downhole tool in accordance with one embodiment of the invention. As shown, the process **70** includes disposing an insulating chamber in a downhole tool (step **72**). The insulating chamber may be a Dewar flask or a chamber made of an insulating material suitable for downhole use. In some embodiments, the insulating chamber may be formed by a cutout on the insulating tool body (not shown). Then, electronics that need to function at relative low temperatures are placed into the insulating chamber (step **74**). Alternatively, the electronics, sources, or sensors may be placed in the insulating chamber before the latter is placed in the downhole tool. Then, a Stirling cooler is disposed in the downhole tool (step **76**). Note that the relative order of placement of the Stirling cooler and the insulating chamber is not important, i.e., the Stirling cooler may be placed in the tool before the insulating chamber. Preferably, the Stirling cooler is placed proximate the insulating chamber. However, if space limitations do not permit placement of the Stirling cooler proximate the insulating chamber, the Stirling cooler may be placed at a distance from the insulating chamber and a heat transport mechanism may interposed therebetween to conduct heat from the chamber to the Stirling cooler.

[**0050**] **FIG. 10** shows a process for cooling a sensor or electronics disposed in a downhole tool in accordance with the invention. The process **100** includes providing a Stirling cooler in the downhole tool proximate the sensor or electronics (step **105**); and energizing the Stirling cooler such that heat is removed from the sensor or electronics (step **110**).

[**0051**] Advantages of the present invention include improved cooling/refrigeration techniques for downhole tools. A cooling system in accordance with embodiments of the invention can keep downhole components at significantly lower temperatures, enabling these components to render better performance and longer service lives. Cooling systems in accord with embodiments of the invention have closed systems, with minimal moving parts, ensuring smooth and quiet operation as well as providing a major advantage in qualifying the instruments for shock and vibration.

1. A cooling system for a downhole tool, comprising:

an insulating chamber disposed in the downhole tool, wherein the insulating chamber is adapted to house an object to be cooled;

a Stirling cooler disposed in the downhole tool, wherein the Stirling cooler has a cold end configured to remove heat from the insulating chamber and a hot end configured to dissipate heat; and

an energy source to power the Stirling cooler.

2. The cooling system of claim 1, wherein the Stirling cooler is a free-piston Stirling cooler.

3. The cooling system of claim 2, wherein the free-piston Stirling cooler comprises a permanent magnet.

4. The cooling system of claim 1, wherein the energy source is one selected from a surface electrical source, a downhole battery, a hydraulic power source, and a downhole power generator.

5. The cooling system of claim 1, further comprising a heat transport mechanism disposed between the cold end of the Stirling cooler and the insulating chamber, wherein the heat transport mechanism is adapted to conduct heat from the insulating chamber to the cold end of the Stirling cooler.

6. The cooling system of claim 1, wherein the insulating chamber is adapted to provide an airflow near the object to be cooled.

7. The cooling system of claim 1, wherein the insulating chamber is adapted to provide a liquid fluid flow near the object to be cooled.

8. A downhole tool, comprising:

a tool body; and

a cooling system comprising:

an insulating chamber disposed in the downhole tool and adapted to house an object to be cooled; and

a Stirling cooler disposed in the downhole tool, wherein the Stirling cooler has a cold end configured to remove heat from the insulating chamber and a hot end configured to dissipate heat.

9. The downhole tool of claim 8, wherein the Stirling cooler is a free-piston Stirling cooler.

10. The downhole tool of claim 9, wherein the free-piston Stirling cooler comprises a permanent magnet.

11. The downhole tool of claim 8, further comprising an energy source to power the Stirling Cooler, the source selected from one of a surface electrical source, a downhole battery, a hydraulic power source, and a downhole power generator.

12. The downhole tool of claim 8, further comprising a heat transport mechanism disposed between the cold end of the Stirling cooler and the insulating chamber, wherein the heat transport mechanism is configured to conduct heat from the insulating chamber to the cold end of the Stirling cooler.

13. The downhole tool of claim 8, wherein the insulating chamber is adapted to provide an airflow near the object to be cooled.

14. The downhole tool of claim 8, wherein the insulating chamber is adapted to provide a liquid fluid flow near the object to be cooled.

15. A method for constructing a downhole tool, comprising:

disposing a sensor or electronics in an insulating chamber in the downhole tool; and

disposing a Stirling cooler in the downhole tool proximate the insulating chamber such that the Stirling cooler is configured to remove heat from the insulating chamber.

16. The method of claim 15, wherein the Stirling cooler is a free-piston Stirling cooler.

17. The method of claim 16, wherein the free-piston Stirling cooler comprises a permanent magnet.

18. The method of claim 15, wherein the insulating chamber is adapted to provide an airflow near the sensor or electronics.

19. The method of claim 15, wherein the insulating chamber is adapted to provide a liquid fluid flow near the sensor or electronics.

20. A method for cooling a sensor or electronics disposed in a downhole tool, comprising:

providing a Stirling cooler in the downhole tool proximate the sensor or electronics; and

energizing the Stirling cooler such that heat is removed from the sensor or electronics.

21. The method of claim 20, wherein the Stirling cooler is a free-piston Stirling cooler.

22. The method of claim 21, wherein the free-piston Stirling cooler comprises a permanent magnet.

23. The method of claim 20, wherein the energizing is by supplying electrical power from a source selected from one of a surface electrical source, a downhole battery, a hydraulic power source, and a downhole power generator.

24. The method of claim 20, wherein the sensor or electronics are disposed in an insulating chamber in the downhole tool, the chamber being adapted to provide an airflow or liquid fluid flow near the sensor or electronics.

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