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(56) Documents Cited:
EP 2505937 A2
WO 2006/096833 A2
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US 6931879 A
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US 20100236749 A

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INT CL **F24J**
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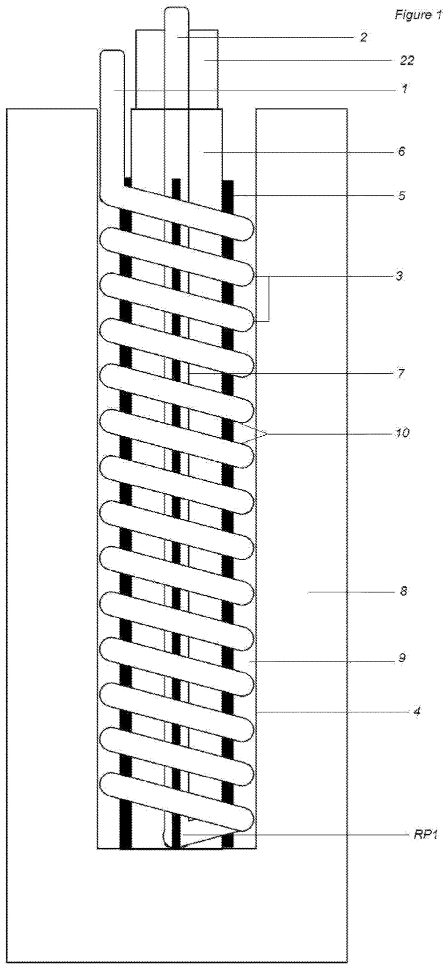
(54) Title of the Invention: **Geothermal ground loop heat exchanger for closed circulating systems**
Abstract Title: **Geothermal Ground Loop Heat Exchanger for Circulating Heat Pump Systems**

(57) A heat exchanger for a circulating geothermal ground loop has an inlet 1, an outlet 2 and a coil 3 arranged therebetween. The coil can be of helical form, and the heat exchanger is installed in a geothermal borehole 4. The helical coil arrangement is formed around a core of thermally insulated material 6, and the outlet pipework is also encased within a thermally insulated material 22 throughout the rising length of the return pipework in the borehole. The arrangement can further include a support frame structure 5 which maintains a defined separation between the helical coil and the core of thermally insulated material. In use, the insulated core provides a heat transfer barrier between the helical coil and the fluid return pipework, but yet the support frame structure provides space between the coil helix and the insulated core to permit contact with a geothermal grout or borehole backfill material and the coil. The heat exchanger can be a part of a geothermal energy system, such as a closed loop ground-source heat pump.

Figure 1



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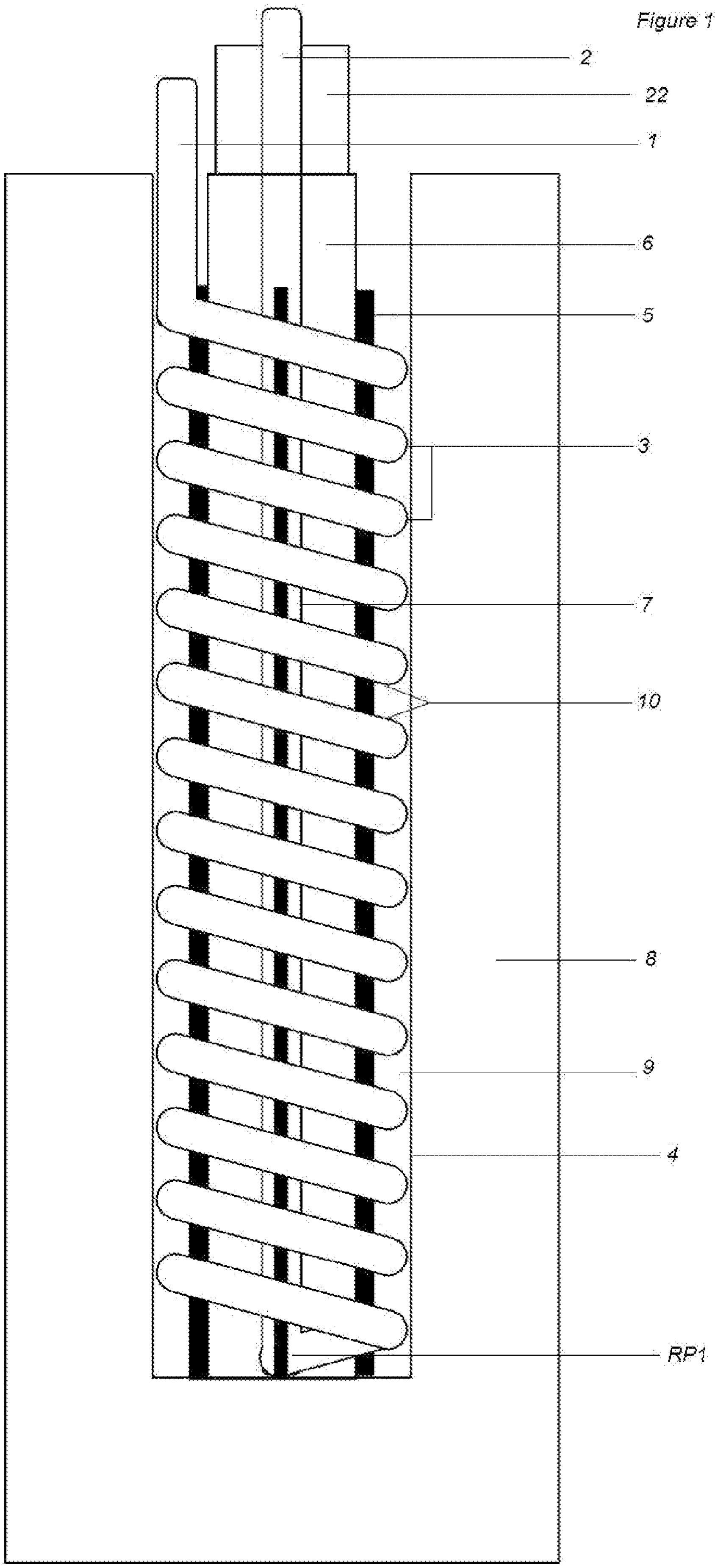
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Figure 1



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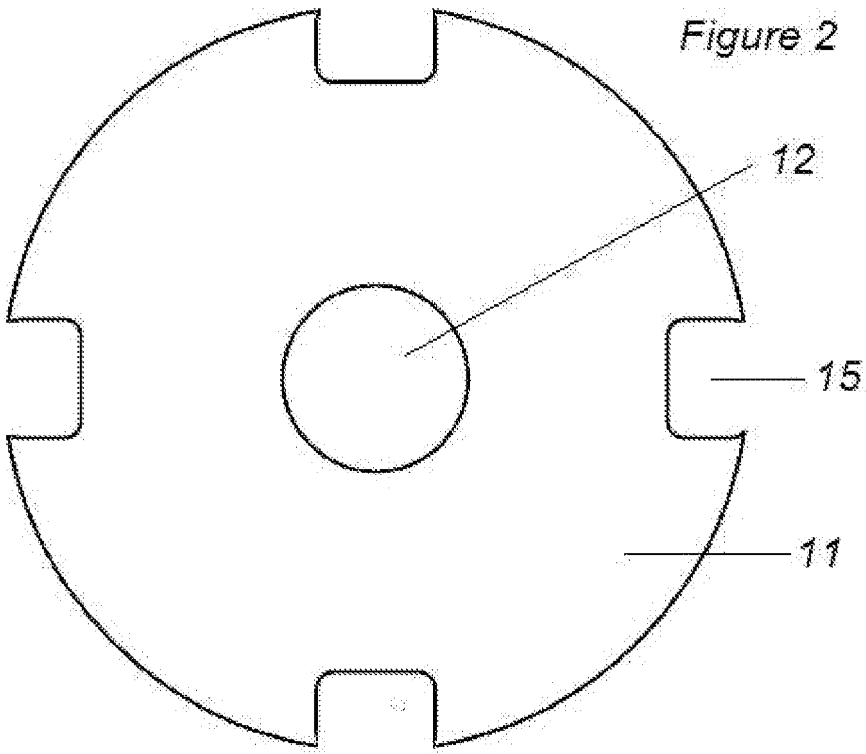

Figure 2

14 01 13

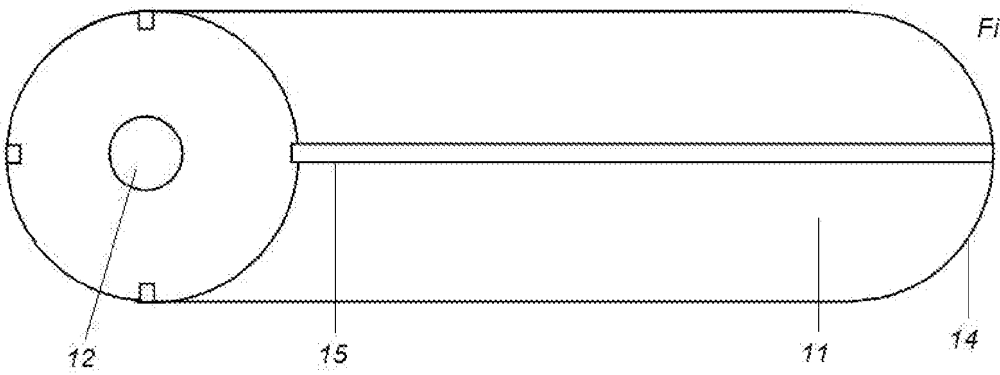

Figure 3

14 01 13

14 01 13

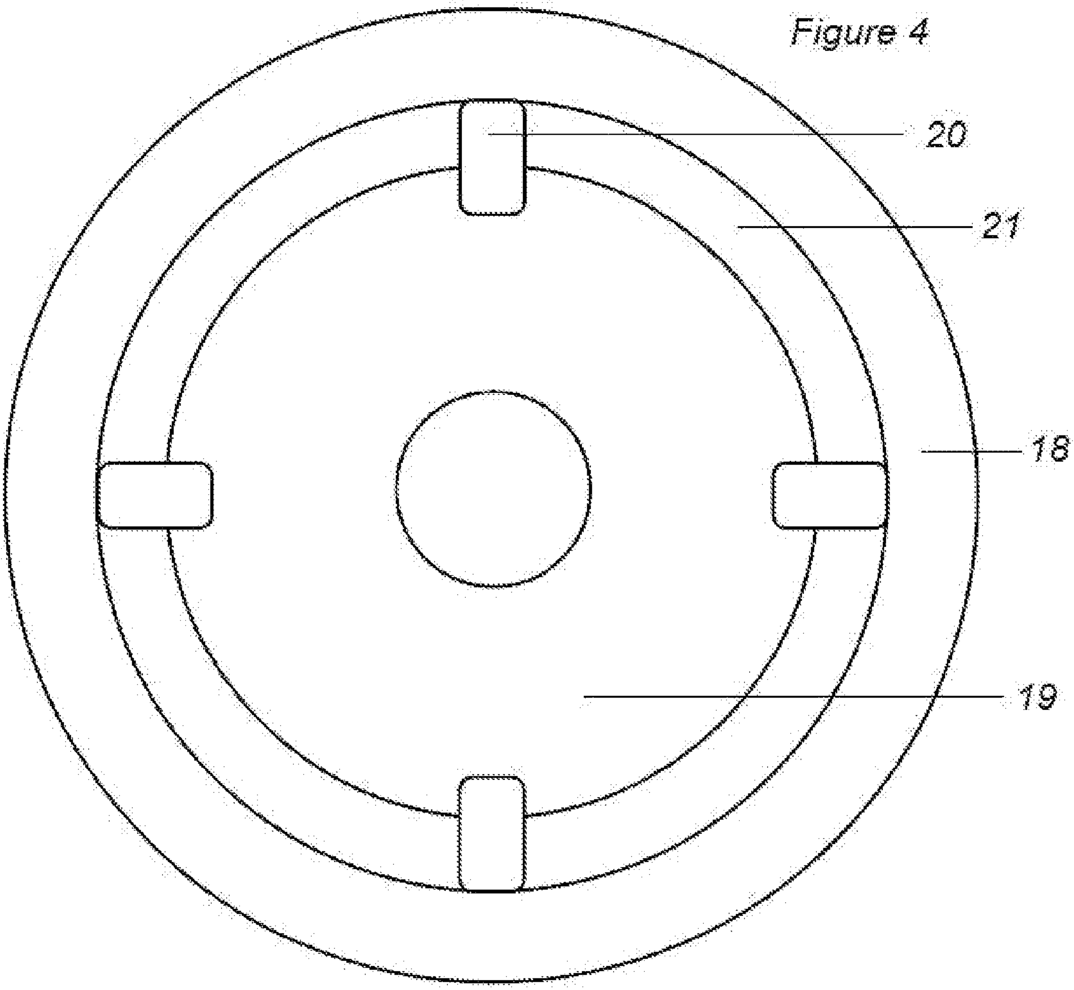

Figure 4

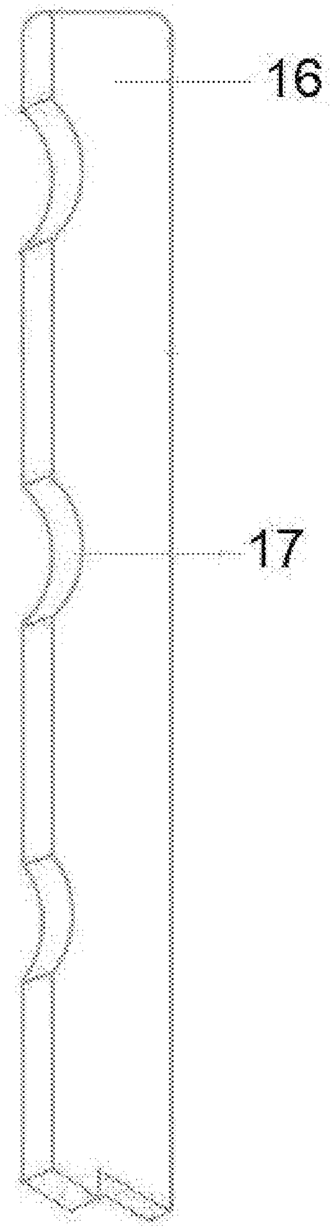

Figure 5

14 01 13

DESCRIPTION

GEOTHERMAL GROUND LOOP HEAT EXCHANGER FOR CLOSED CIRCULATING HEAT PUMP SYSTEMS:

THE FIELD OF THE INVENTION:

The present invention relates to a vertical closed circulation geothermal ground loop unit which is installed in to a geothermal borehole for the purpose of collecting geothermal heat energy when connected to a ground source heat pump installation.

BACKGROUND:

Ground source heat pumps function by utilising heat energy from the Earths ground mass, heat energy is collected by installing an array of horizontal or vertically laid collection pipes in the ground.

Geothermal heat energy collection pipe work is called the ground loop.

There are various types of ground loops used for collecting geothermal heat energy however the proposed invention is designed for systems known as vertical closed circulating or closed loop.

Thermal fluid inside the ground loop is pumped round the closed circulating pipe work and absorbs the naturally occurring heat energy stored in the earths ground mass.

The thermal fluid then enters the heat pump where the temperature of the thermal fluid is raised and the heat generated is then transferred in a heat exchanger unit to heat water that supply's space heating or hot water.

Following this process of thermal transference the thermal fluid cools and passes back into the closed circulating ground loop where the process of heat energy collection/absorption from the Earths ground mass starts again, this is a continuous process as long as there is a requirement for heating or hot water.

Closed circulating ground loops may be installed horizontally in trenches a few metres deep or vertically in geothermal boreholes at depths ranging between 20 to 100 plus meters dependent on the geothermal conditions of the installation site. Both installation styles have their advantages and disadvantages however it is generally recognised that a well installed vertical closed circulating ground loop will supply greater operating efficiencies than that of its horizontal counterpart.

Greater efficiencies are achieved due to the depth of the borehole engaging higher ground temperatures thus increasing the temperature of the thermal transfer fluid. Furthermore vertical borehole installations are less susceptible to fluctuating changes in ground temperature. Both of these points will assist in increasing the operating efficiencies of the heat pump.

However that said even through a vertical ground loop may offer increased operating efficiencies over its horizontal counterpart it is well documented that in many domestic installations neither styles achieve acceptable operating efficiencies and in many cases offer very little or no beneficial cost savings over a modern fossil fuel boiler.

There can be a number of reasons why poor coefficients of performance transpire the most commonly accepted cause in a vertical geothermal borehole installation is the inadequate design and capabilities of the present vertical ground loop.

A closed circulating ground loop is a relatively simplistic unit, it is constructed with a flow thermal fluid inlet pipe, a return thermal fluid pipe and a U shape connector joining both pipes together at the end of the ground loop installed in the borehole. The cold thermal fluid enters the inlet pipe and is warmed by the Earths heat energy as it circulates through before returning back to the ground source heat pump.

The inadequate design of the current vertical closed circulating ground loop limits the effective collection of geothermal heat energy thus reducing the co-efficiencies of performance of the heat pump installation. Key design issues include;

- A straight thermal fluid inlet pipe design minimises the time the thermal fluid is able to be in contact with the ground mass to absorb heat energy.
- The return pipe that carry's the warmed thermal fluid is aligned next to the cold inlet pipe in the geothermal borehole therefore as the cold spent thermal fluid enters the ground loop it cools the returning warm thermal fluid.
- The return pipe that carry's the warmed thermal fluid has no thermal divide between the cold inlet pipe work and the reduced ground temperatures at shallow levels.

The proposed invention successfully addresses the above issues and significantly increases the co-efficiencies of performance of a heat pump installation.

SUMMARY OF THE INVENTION:

The proposed invention as (Fig 1) is intended to overcome the drawbacks of the current closed circulating vertical ground loop system and to improve on the present design to achieve significant increases in the coefficients of performance of a ground source heat pump installation.

The proposed invention as (Fig 1) is installed in a geothermal borehole (Fig 1) (4) which has a drill circumference of up to circ 500mm and a drill depth whereas to an acceptable geothermal temperature can be achieved for heat exchange. The unique design of the proposed invention as (Fig 1) permits the proposed invention as (Fig 1) to be installed at shallower depths than the current traditional vertical ground loop systems.

Key features of the proposed invention are:

- A unique thermal fluid transport pipe helix coil design (Fig 1) (3)
- A cylindrical thermally insulated material core (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19)
- A support frame structure (Fig 1) (5) (Fig 4) (20) (Fig 5) (16)

The proposed invention (Fig 1) has at least one surface inlet thermal fluid transport pipe (Fig 1) (1) via which the spent thermal fluid enters the ground loop from a heat pump assembly.

The inlet thermal fluid transport pipe (Fig 1) (1) enters the geothermal borehole (Fig 1) (4) and extends down to a depth whereas an optimal temperature can be achieved for the collection of heat energy by the circulating thermal fluid. It is at this depth where the main body of the ground loop unit as (Fig 1) is positioned.

The main body of the ground loop unit (Fig 1) is produced by the thermal fluid transport pipe (Fig 1) (1) being formed in to a helix coil arrangement (Fig 1) (3) on the outer circumference of the unit. The helix coil arrangement (Fig 1) (3) is formed around a thermally insulated material core (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19) and a frame structure (Fig 1) (5) (Fig 4) (20) (Fig 5) (16) bears and secures the thermal fluid transport pipe helix coil (Fig 1) (3) by a formation (Fig 5) (17) which guides and secures the thermal fluid transport pipe helix coil (Fig 1) (3) (Fig 4) (18).

The frame structure (Fig 1) (5) (Fig 5) (16) (Fig 4) (20) additionally spaces the helix coil thermal fluid transport pipe (Fig 1) (3) (Fig 4) (18) up to 100mm away from the cylindrical thermally insulated material core (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19) thus permitting the geothermal grout or suitable backfill material (Fig 1) (9) (Fig 4) (21) to sufficiently encase the helix coil thermal fluid transport pipe (Fig 1) (3) (Fig 4) (18) providing suitable contact with the earths ground mass (Fig 1) (8) for high-quality heat energy transfer.

The frame structure (Fig 1) (5) (Fig 5) (16) (Fig 4) (20) consists of four or more moulded shafts (Fig 1) (5) (Fig 4) (20) (Fig 5) (16) secured along the length the thermally insulated core material (Fig 1) (6) (Fig 2) (11) (Fig 3) (11) (Fig 4) (19) affixed within a channel formation (Fig 2) (15) (Fig 3) (15) in the thermally insulated material core (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19).

The thermal fluid transport pipe (Fig 1) (1) that forms the helix coil (Fig 1) (3) continues throughout the extent of the unit as (Fig 1) (3) and may be manufactured in spans up to 8 meters.

At the end point of the helix coil (Fig 1) (3) the thermal heat energy collecting process ceases and the thermal fluid transport pipe turns back upwards (Fig 1) (RP1) (Return Pipe 1) to run centrally through the helix coil ground loop unit (Fig 1) carrying the warmed thermal fluid back to the heat pump via the return thermal fluid transport pipe (Fig 1) (2). The unit design during this process is focused on maintaining the peak temperature of the thermal transfer fluid.

Maintaining the temperature of the thermal fluid in the return thermal fluid transport pipe (Fig 1) (2) is vital to providing improved coefficients of performance of the installation and this is achieved by encasing the return thermal fluid transport pipe (Fig 1) (2) in a thermally insulated material (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19).

The thermally insulated core material (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19) surrounding the returning thermal fluid transport pipe (Fig 1) (2) limits cold contamination of the thermal fluid by shielding the thermal transport pipe from shallow ground temperatures and from the cold thermal fluid flowing in the helix coil transport pipe (Fig 1) (3) (Fig 4) (18).

As the return thermal fluid transport pipe (Fig 1) (2) exits the main body of the helix ground loop unit (Fig 1) it is vital that the temperature of the thermal fluid flowing in the return thermal fluid transport pipe (Fig 1) (2) is maintained as it rises through the borehole (Fig 1) (4) and ground mass (Fig 1) (8) back to the heat pump.

This is achieved by encasing the return thermal fluid transport pipe (Fig 1) (2) within a thermally insulated material (Fig 1) (22) of a minimum thickness of twice the diameter of the thermal fluid transfer pipe (Fig 1) (1) throughout the rising length of the geothermal borehole (Fig 1) (4) and ground mass.

CLAIMS:

1. A closed circulating geothermal ground loop unit (Fig 1) which has at least one surface inlet thermal fluid transport pipe (Fig1) (1) and at least one surface return thermal fluid transport pipe (Fig 1) (2). Where at least one thermal fluid transport pipe (Fig1) (1) is formed in to a helix coil (Fig 1) (3) and the said helix coil is installed in a geothermal borehole (Fig 1) (4) in the earths ground mass (Fig 1) (8). The thermal fluid transport pipe helix coil (Fig 1) (3) shall be installed around a frame/structure (Fig 1) (5) and thermally insulated material (Fig 1) (6). Where as said thermally insulated material (Fig 1) (6) shall encase at least one fluid transport pipe (Fig 1) (7) as to provide an isolative barrier for the returning thermo transfer fluid. The frame/structure (Fig 1) (5) shall be installed to bear the thermal fluid transport pipe helix coil (Fig 1) (3) and establishes a separation space between said thermal fluid transport pipe helix coil (Fig 1) (3) and the thermally insulated material (Fig 1) (6) to permit the thermal fluid transport pipe helix coil (Fig 1) (3) to be sufficiently encased by the geothermal grout or suitable backfill material (Fig 1) (9).

2. A closed circulating geothermal ground loop unit as (claim 1) which has installed a thermally insulated material (Fig 2) (Fig 3) (11) which provides an insulation covering for at least one thermal fluid transport pipe (Fig 1) (7) (Fig 2) (Fig 3) (12).

3. A closed circulating geothermal ground loop unit as (claim 1) that has a thermally insulated material (Fig 2) (Fig 3) (11) which is cylindrical in form (Fig 3) (14).

4. A closed circulating geothermal ground loop unit as (claim 1) that utilises thermally insulated material (Fig 1) (6) (Fig 2) (Fig 3) (11) and such has a formation (Fig 2) (15) (Fig 3) (15) to receive a frame, structure or fixing (Fig 5) (16) to bear, secure or attach a thermal fluid transport pipe helix coil (Fig 1) (3).

5. A closed circulating geothermal ground loop unit as (claim 1) which has a thermally insulated material as claim 2 (Fig 1) (6) (Fig 2) (Fig 3) (11) where the thermally insulated material (Fig 2) (Fig 3) (11) has a minimum thickness of twice the diameter of the thermal fluid transfer pipe (Fig 1) (1) when measured from one side to the other side.

6. A closed circulating geothermal ground loop unit as (claim 1) which has a thermally insulated material as claim 2 (Fig 1) (6) (Fig 2) (Fig 3) (11) which has more than one thermal fluid transfer pipe therefore the thermally insulated material (Fig 2) (Fig 3) (11) is increased in size to a minimum thickness of twice the diameter of the combined thermal fluid transfer pipes when measured from one side to the other side.

7. A closed circulating geothermal ground loop unit as (claim 1) which has a thermally insulated material as claim 2 (Fig 1) (6) (Fig 2) (Fig 3) (11) (Fig 4) (19) where as the thermally insulated material (Fig 1) (6) (Fig 2) (fig 3) (11) extends in a cylindrical form as claim 3 (Fig 1) (6) (Fig 3) (14) throughout the length of the thermal transfer pipe helix coil (Fig 1) (3) and said thermally insulated material (Fig 1) (6) (Fig 2) (Fig 3) (11) is position centrally of the thermal transfer pipe helix coil (Fig 1) (3).

8. As (claim 4) a closed circulating geothermal ground loop unit which has a frame or structure (Fig 5) (16) (Fig 1) (5) that bears, secures or attaches to a thermal fluid transport pipe helix coil (Fig 1) (3).

9. A closed circulating geothermal ground loop unit which has a frame or structure (Fig 5) 16 (Fig 1) (5) that provides separation of up to 150mm between said thermal fluid transport pipe helix coil (Fig 1) (3) and the thermally insulated material (Fig 2) (Fig 3) (11).

10. A closed circulating geothermal heat exchange unit as claim 1 (Fig 1) where the thermal insulation material (Fig 1) (6) (Fig 2) (11) (Fig 3) (11) (Fig 4) (19) separates at least one thermal fluid transport pipe (Fig 1) (7) from any surrounding suitable back fill material (Fig 1) (9) (Fig 4) (21) .

11. Where as a thermal fluid transport pipe is formed in to a helix coil (Fig 1) (3) (Fig 4) (18) and installed in a borehole (Fig 1) (4) for the purpose of extracting geothermal energy from the earths ground mass (Fig 1) (8) where by the helix coil (Fig 1) (3) (Fig 4) (18) is separated from the thermally insulated material (Fig 2) (Fig 3) (11) (Fig 4) (19) by a frame, structure or fixing (Fig 5) (16) (Fig 4) (20) to permit a geothermal grout or suitable backfill material (Fig 1) (9) (Fig 4) (21) to sufficiently encase the helix coil thermal fluid transport pipe (Fig 1) (3) (Fig 4) (18).

12. A geothermal ground loop unit which has a frame or structure (Fig 5) 16 (Fig 1) (5) that has a formation (Fig 5) (17) to receive guide or secure the thermal fluid transport pipe helix coil (Fig 1) (3).

13. A geothermal ground loop unit as claim 1 which has at least one thermal fluid transport pipe formed in to a helix coil arrangement (Fig 1) (3) where as each wound return of the helix shall measures no greater than 300mm between each pipe coil (Fig 1) (10).

14. A geothermal ground loop unit which has a thermally insulated material (Fig 2) (Fig 3) (11) to provide an insulation covering for at least one thermal fluid transport pipe (Fig 1) (7) (Fig 2) (Fig 3) (12) and the said pipe is installed in a geothermal borehole (Fig 1) (4) and connected to a heat pump assembly.

15. A geothermal ground loop unit as (Fig 1) where as at least one thermal fluid transport pipe (Fig 1) (7) is accommodated within the thermally insulated material (Fig 1) (6) to reduce heat loss / energy transfer and or to maintain an ambient temperature of a thermal exchange fluid.

16. A closed circulating ground loop unit (Fig 1) where as the thermal fluid transport pipe is formed in to a helix coil (Fig 1) (3) for the purposes of collecting geothermal energy when installed within a borehole (Fig 1) (4).

17. A closed circulating ground loop unit (Fig 1) which has a the thermal fluid transport pipe (Fig 1) (1) which is formed in to a helix coil (Fig 1) (3) and said has a minimum of one thermal fluid delivery pipe (Fig 1) (1) and a minimum of one thermal fluid return pipe (Fig 1) (7).

18. A closed circulating geothermal ground loop unit (Fig 1) where as the thermal fluid transport pipe is formed in to a helix coil (Fig 1) (3) inside which a thermal exchange fluid and or gas flows.

19. A closed circulating geothermal ground loop unit as claim 1 (Fig 1) where as the thermal fluid transport pipe (Fig 1) (1) is fashioned in to a helix coil (Fig 1) (3) from a continuous length pipe.

20. A closed circulating geothermal ground loop unit as claim 1 (Fig 1) where as the thermal fluid transport pipe is fashioned in to a helix coil (Fig 1) (3) angled between 0 and 180 degrees.

21. A closed circulating geothermal ground loop unit as claim 1 (Fig 1) where as at least one thermal fluid transfer pipe (Fig 1) (2) remains encased in a thermal insulating material (Fig 1) (22) of a minimum thickness of twice the diameter of the thermal fluid transfer pipe (Fig 1) (1) throughout the rising length of the geothermal borehole (Fig 1) (4).

22. The closed circulating geothermal heat exchange unit as claim 1 (Fig 1) wherein the said geothermal heat exchange unit is connected by means of common inlet and return thermal fluid pipes (Fig 1) (1) (2) to a ground source heat pump.

Application No:	GB1300254.8	**Examiner:**	Mr Brian A Woods
Claims searched:	1, at least	**Date of search:**	28 January 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, at least	US2011/272054 A (YANG) See whole document.
X	1, at least	EP2505937 A2 (YANG) See whole document.
X	1, at least	US2011/094719 A (YANG) See whole document.
X	1, at least	WO2006/096833 A2 (KELIX HEAT TRANSFER SYSTEMS) See whole document, but in particular paragraphs [0240] to [0331].
X	1, at least	US5816314 A (BICKFORD et al) See whole document noting insulating material 2 and helical coil 1.
X	1, at least	US2010/236749 A (STOJANOWSKI) See whole document, but in particular paragraph [0040].
X	1, at least	US6931879 A (WIGGS) See whole document noting a ground-source heat pump system which has a ground based heat exchanger with the fluid return line 2 surrounded by insulation 3.
X	1, at least	EP2503262 A2 (ORIENT) See whole document noting a geothermal heat exchanger which has a return section of pipework being preferably coated with a layer of insulating material.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

F24J

The following online and other databases have been used in the preparation of this search report

WPI;EPODOC;TXTE

International Classification:

Subclass	Subgroup	Valid From
F24J	0003/08	01/01/2006