

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 January 2007 (04.01.2007)

PCT

(10) International Publication Number
WO 2007/001290 A1

(51) International Patent Classification:

F25B 21/00 (2006.01) **F25B 7/00** (2006.01)
F25B 21/02 (2006.01)

(21) International Application Number:

PCT/US2005/022376

(22) International Filing Date: 24 June 2005 (24.06.2005)

(25) Filing Language: English

(26) Publication Language: English

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

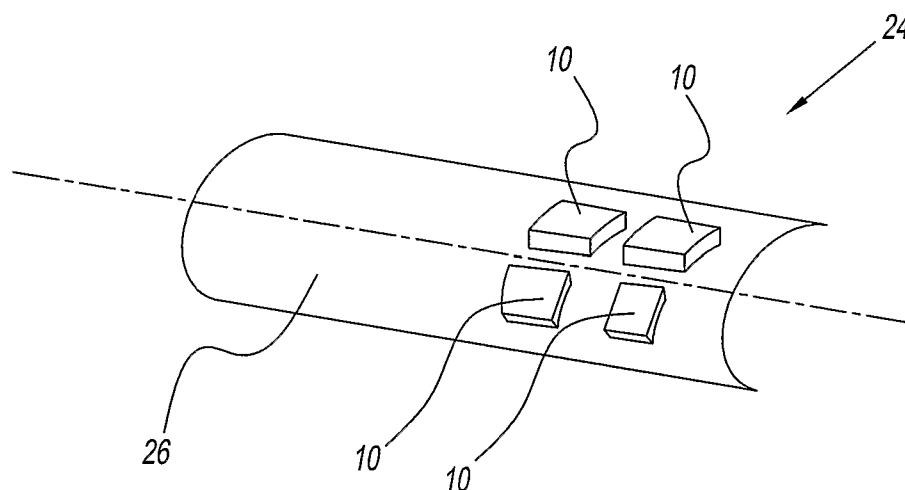
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A COMBINATION THERMO-ELECTRIC AND MAGNETIC REFRIGERATION SYSTEM



(57) Abstract: A refrigeration system has a compartment and a first cooling device. The first cooling device cools the compartment and generates a magnetic field. The refrigeration system also has a second device. The second device uses the generated magnetic field for additional cooling to the compartment.

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A COMBINATION THERMO-ELECTRIC AND MAGNETIC REFRIGERATION SYSTEM

BACKGROUND OF THE INVENTION

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1. Field of the Invention

[0001] The present invention relates to a temperature control for a compartment. More particularly, the present invention relates to a
10 magnetic refrigeration system that uses a magnetic field generated from a number of thermo-electric elements that are wound in a configuration.

2. Description of the Related Art

[0002] Temperature control systems for heating and cooling
15 devices are known in the art. Such known systems use a vapor compression cycle to provide cooling. Typically the refrigerant in vapor phase is pumped from the evaporator by a compressor. The refrigerant is then compressed to a superheated vapor. The high-pressure gaseous
20 refrigerant that absorbs the heat is sent to a condenser. The refrigerant vapor is condensed to high-pressure liquid by transferring heat from the refrigerant to a heat sink that has lower temperature. The condensed refrigerant liquid is circulated to a throttling valve. The throttling valve reduces the pressure to a low level and the refrigerant enters the
25 evaporator. The reduced pressure decreases the boiling temperature of the refrigerant to below the temperature of the heat source. In the evaporator, the evaporation of the low-pressure refrigerant absorbs heat from the heat source that is cooled. Then the refrigerant is circulated to the compressor to start the next refrigeration cycle. Due to the complex
30 mechanical operations associated with the vapor compression cycle, the system response to varied demand is typically slow.

[0003] A thermo-electric device is also known and preferred over other temperature control devices for the applications where compactness

and a quiet operation are needed. This thermo-electric device avoids the use of any atmosphere destroying refrigerants and is thus environmentally friendly. In one known configuration thermo-electric devices are wound around, for example, a conduit. The thermo-electric devices also provide
5 both selective cooling and/or heating around, and in the conduit.

[0004] However, a known problem in the art is that the one or more thermo-electric devices generate a magnetic field. This magnetic field is known in the art as being harmful to electronic components. This magnetic
10 field is also harmful for other reasons and generally is disfavored. This magnetic field may disrupt the operation of electrical systems and is typically shielded against contacting an individual and/or components. Often, a manufacturer will provide an amount of shielding in the system. This shielding prevents the generated magnetic field from entering,
15 penetrating or contacting components or anything else located close by.

[0005] Accordingly, there is a need for a cooling system that productively uses the generated magnetic field. There is also a need for a cooling system that uses the magnetic field to provide additional cooling
20 and for a more productive operation of the refrigeration system.

[0006] There is also a need for such a system that eliminates one or more of the aforementioned drawbacks and deficiencies of the prior art.

25 SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to provide a system for refrigeration.

30 **[0008]** It is another object of the present invention to provide a system for refrigeration that uses a number of thermo-electric devices and a magnetic field that is generated from the number of thermo-electric devices.

[0009] It is yet another object of the present invention to provide a system for refrigeration that uses a number of thermo-electric devices wound in a tubular or cylindrical manner and that uses a magnetic field that is generated from the number of thermo-electric devices by periodically passing a magnet in the magnetic field to complete an appropriate thermodynamic cycle such as a Carnot cycle or a Stirling cycle.

[0010] It is still another object of the present invention to provide a system for refrigeration with the system using a magnetic field for cooling with the magnetic field being generated from a number of thermo-electric devices. The system periodically passes a magnetic material in the magnetic field and uses a change in the magnetic entropy of the magnet when the magnetic field is applied to or removed from the magnetic material.

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[0011] It is still yet another object of the present invention to provide a system for refrigeration that does not use any ozone destroying refrigerants.

[0012] It is a further object of the present invention to provide a system that uses a number of thermo-electric elements that are wound in a cylindrical manner and a second magnetic refrigeration system. The second system uses a working fluid having fine magnetic particles therein.

[0013] It is a further object of the present invention to provide a system that uses a number of thermo-electric elements and a generator that recaptures energy and converts it to electricity from the magnetic field applied to a magnetic cooling system. These and other objects and advantages of the present invention are achieved by a system for refrigeration of the present invention. The refrigeration system has a compartment, and a first cooling device with the first cooling device cooling the compartment and generating a magnetic field. The refrigeration system also has a second magnetic refrigerator. The second magnetic refrigerator has a magnetic material and the magnetic material is periodically

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introduced in the generated magnetic field for additional cooling or an external magnetic field that is applied to a magnetic material.

DESCRIPTION OF THE DRAWINGS

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[0014] Fig. 1 shows a thermo-electric device.

[0015] Fig. 2 is a perspective view of a number of thermo-electric devices being wound in a cylindrical manner around a conduit.

10

[0016] Fig. 3 is a front view of the conduit of Fig. 2.

[0017] Fig. 4 is a perspective view of a first embodiment of the refrigeration system of the present invention.

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[0018] Fig. 4a shows another embodiment of the refrigeration system of Fig. 4.

[0019] Fig. 4b shows another embodiment of the refrigeration system of Fig. 4.

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[0020] Fig. 4c shows another embodiment of the refrigeration system of Fig. 4 in a first position.

[0021] Fig. 4d shows the embodiment of the refrigeration system of Fig. 4c in a second position opposite the first position.

25

[0022] Fig. 5 is a perspective view of an another embodiment of the refrigeration system of the present invention.

30

[0023] Fig. 6 is a diagram of still another embodiment of the refrigeration system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Referring to Fig. 1, there is shown a cross sectional view of a thermo-electric element shown as reference numeral 10. The thermo-electric element or device 10 is preferably a solid state device. The device 10 has a first P type semiconductor 12 and a second N type semiconductor 14 with an electron as a charge carrier. Current from a power supply is passed through the N type semiconductor 14 to the P type semiconductor 12.

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[0025] When current passes therethrough as indicated by reference arrow 16, heat is removed from surface 20 and transferred through the thermo-electric device 10, and then deposited to a second surface 18 of the thermo-electric device as indicated by arrow 22. The heat removal from the surface 20 causes the absorption of heat from the adjacent environment through a working fluid in contact with the cold surface 20. Likewise, the heat generated at surface 18 is ejected through a heat transfer medium. This thermo-electric device 10 is well known and is understood by those in the art and requires no further explanation. One skilled in the art will also appreciate that the thermo-electric device 10 may have another or a different configuration and the present invention is not strictly limited to the embodiment shown in Fig. 1. For example, the thermo-electric device 10 may be tubular shaped.

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[0026] Referring now to Fig. 2, a number of thermo-electric devices 10 may be placed in a series 24 as shown and substantially or completely surround a cylindrical conduit 26. Referring to Fig. 3, there is shown a view of the cylindrical conduit 26 having the series 24 of thermo-electric devices 10 substantially surrounding the conduit 26.

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[0027] One skilled in the art will appreciate that once the number of thermo-electric devices 10 surround the conduit 26, a working fluid 28 such as ethylene glycol may be pumped or otherwise caused to traverse through the conduit. The working fluid 28 will be cooled as it is passed through the

interior of the conduit. Similarly, another working fluid flowing through the exterior surface of the conduit either in co-flow or counter-flow pattern with respect to that first working fluid 28 flowing through an interior of the conduit 26 will be heated. This second working fluid will carry the heat out
5 of the device for further ejection.

[0028] Although shown as being used with ethylene glycol, the working fluid 28 may be any working fluid known in the art or known in the future and the present invention is not limited to any specific working fluid.
10 The number of thermo-electric devices 10 surrounding the conduit 26 will then transfer heat from the working fluid 28 or alternatively transfer heat to the working fluid depending upon the desired application. Then the working fluid 28 can circulate away from the number of thermo-electric devices 10 to traverse into a refrigeration compartment, cabin, or any other
15 desired location to provide a desired cooling and/or heating. As is understood (and is well known in the art) the working fluid 28 will transfer heat from the compartment to another external compartment location and deposit the heat at that location.

[0029] One aspect of placement of the thermo-electric devices 10 in the cylindrical configuration as shown in Fig. 3 is that the cylindrical configuration has a number of benefits. These benefits include enhanced heat transfer, high efficiency, compact configuration, and ease of manufacture. One significant aspect of the use of such thermo-electric
25 devices 10 in the cylindrical configuration is that a magnetic field is generated. Great care in the prior art has been taken to provide a thick member or a shielding to prevent this magnetic field from contacting components and/or individuals.

[0030] The prior art also has taught that the magnetic field should be contained or handled and is generally a detriment to the operation of a system. However, the inventors of the present invention have observed that this energy or magnetic field is wasted. The inventors instead of simply shielding and wasting this energy, have instead used this energy to
30

increase refrigeration capacity and increase productivity of an existing system in a very unexpected manner and have yielded unexpected benefits from this wasted energy.

5 **[0031]** Referring now to Fig. 4, there is shown a perspective view of the system 30 of the present invention. It has been observed and reported that the application of a magnetic field to magnetic material near a Curie temperature of the specific magnetic material heats the magnetic material. Conversely, it has been observed that this same magnetic material will cool
10 upon removal of the magnetic field. This phenomenon is known in the art as the Magneto-Caloric effect that requires no further explanation because it is considered to be well known in the art. Referring now to again Fig. 4, the system 30 preferably has a concentrator 32. The concentrator 32 may be any device or apparatus that preferably concentrates, modulates or
15 amplifies the existing magnetic field generated by the number of thermo-electric devices 10 in the preferred cylindrical configuration.

[0032] The concentrator 32 in one embodiment is a resilient first core 34 and a second resilient core 36 made from a preselected material.
20 As is shown, both the first core 34 and the second core 36 are substantially "C" shaped members but are not limited to this configuration. The first core 34 preferably traverses through an interior space of the conduit 26. The conduit 26 has a number of thermo-electric devices 10 or a first thermo-electric device assembly 38. The second core 36 preferably traverses
25 through a second thermo-electric device assembly 40 having, again, the number of thermo-electric devices 10. The cores 34, 36 are made of materials with high permeability to guide the magnetic field.

[0033] The possible materials for the core 34, 36 may be but not
30 limited to a ferrite U 60, a ferrite M33, a nickel, a ferrite N41, iron, a ferrite T38, a silicon steel, and a super alloy or a super-conducting magnetic material, or other suitable materials. The cores 34, 36 can have one or multiple individual plates or one or more rods that are bundled together. One skilled in the art will appreciate that the number of thermo-electric

devices 10 are wound around a cylindrical surface or conduit 26 as shown in both the first thermo-electric device assembly 38 and the second thermo-electric device assembly 40.

5 **[0034]** Preferably, in this embodiment each of the cores 34, 36 are made from materials with high permeability and concentrate the magnetic field being emitted from the first thermo-electric device assembly 38 and the second thermo-electric device assembly 40 so the magnetic field has a first intense region and a second low or zero region. Since the field
10 generated is proportional to the permeability of the materials, the cores 34 and 36 are preferably made with a suitable permeability.

[0035] Preferably, the magnetic field 42 has a first high intensity shown as reference numeral 44 and a second low or zero intensity shown
15 as reference numeral 46. The first intensity 44 is greater than the second intensity 46 and is maximized using available materials. The system 30 further has a rotatable member 48 having a rim 50 and a channel 52 in the rim.

20 **[0036]** Referring now to an embodiment of the rotatable magnetic cooling member 48 shown as Figure 4a, preferably, a channel 33 has working fluid therein. The rim 50 is made from preferably gadolinium, a pure material, an alloy and any other combinations thereof depending on the design requirements such as operating temperature and temperature
25 range. Some known and possible materials are gadolinium or a compound thereof such as $Gd_5(Si_xGe_{1-x})_4$ (with a magneto-caloric effect), alloys of Gd and Dy, and any other suitable alloy known in the art. The rim 50 is preferably made from any paramagnetic material, ferromagnetic material, or more preferably the material with a suitable magneto-caloric effect
30 (MCE). Preferably, the rotatable member 48 rotates so the working fluid in the rim 50 traverse periodically from the first intensity 44 to the second intensity 46. In this manner, the rim 50 of the rotatable member 48 heats when the rim is in the first intensity 44 and then cools when the rim is away from the first intensity or in the second intensity 46. Thus, the working fluid

in a channel 33 is cooled and is placed in spaced relation to another second working fluid or device that can transfer heat thereto and then communicates with a compartment for cooling (not shown).

5 **[0037]** Referring to Figure 4a, the system 30 may have a rotating member 48 with the rim 50 having a number of channels 33 therein. The channels 33 are generally cylindrically shaped and are located around the rim 50 of the rotating member 48. Alternatively, the channels 33 may have another shape other than generally cylindrical such as oblong or
10 rectangular shaped or may be one discrete channel. Each of the channels 33 preferably has the working fluid therein. The rotating member 48 preferably rotates the channels 33 having the working fluid therein in a cycle 51 as shown. The cycle 51 preferably ejects heat shown as letter Qh with a first heat exchanger at a first location 35. The cycle 51 also has
15 a pumping mechanism and another second heat exchanger 37 for cooling as letter Qc to provide cooling. The rotating member 48 rotates at a rate sufficient to transfer heat and to provide cooling from the magneto-caloric effect when rotating. Thus, the magnetic field 44 provides an additional amount of cooling to the compartment. It has been observed that an
20 additional cooling system with a high Carnot efficiency of about sixty percent can be realized by the magnetic refrigeration cycle using a moderately strong magnetic field.

[0038] Referring now to still another embodiment of the present
25 disclosure shown in Fig. 4b, the rotating member 50 may be spaced between two loops, or a first loop 61 and a second loop 63 to more adequately transfer heat. Each of the loops has a pump 65. Preferably, the first loop 61 may be disposed on a first side of the rotating member 50 and have a first heat exchanger 67 for heat ejection. In this manner, the working fluid
30 in the channel 33 in the rotating member 50 preferably transfers or ejects heat into the first loop 61, that is in turn ejected to ambient. Thereafter, upon rotation a predetermined radial amount the working fluid in the channel 33 provides cooling to the second loop 63. The second loop 63 is spaced from the rotating member 50. The second loop 63 will then

thermally communicate to a second heat exchanger 69 and transfer heat from the desired compartment.

[0039] In another preferred embodiment of the present invention, system 30 has a ferromagnetic or paramagnetic material in a first member that is axially or laterally moved to and from the magnetic field 44 to provide cooling. The first member 71 preferably has a cylindrical piston configuration and reciprocates from a first location 73 to a second location 75. The first member 71 may also have the channel 52 with a working fluid therein as discussed above. Referring now to Fig. 4c, there is shown another exemplary embodiment of the system 30. Preferably, the first location 71 is a complementary location to a relatively high magnetic field and thus ejects heat to a first loop 77 that is communicating with a heat exchanger 79. The second location 75 or down stroke of the first member 71 is communicating with a second loop 81 with a second heat exchanger 83. This second loop 81 provides cooling to for example a compartment. Referring now to Fig. 4d, as shown the first member 71 moves from the first position 73 to the second position 75, the first member will removes heat from the second location 75 where the magnetic field is weaker relative to the first position. Once removed from the strong magnetic field (as shown in Fig. 4c) the first member 71 draws heat therein from the second loop 81 for the cooling phase. The first member 71 preferably reciprocates a number of different times in order to provide additional cooling to the compartment or other desired location.

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[0040] Alternatively, referring to another embodiment of the present invention shown in Fig. 5. The system 30 may alternatively recapture the energy from the magnetic field in the form of electricity to be stored in a battery or to power the number of thermo-electric devices 10. In this embodiment, the system 30 has a magnetic cooling system 59 with a first heat ejection loop 56 and a second cooling loop 58. An alternating magnetic field is applied to a magnetic cooling component 59 and generates cooling. The system 30 also has a generator 54 that recovers and converts part of the magnetic energy from 90 to electricity. The

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generator 54 preferably generates and conditions electricity for powering a thermo-electric assembly 57. The system 30 preferably has a thermoelectric assembly 57 with a first heating loop 95 and a second cooling loop 98. The number of thermoelectric devices 10 in the assembly 57 have the thermo-electric devices 10 in a planar or cylindrical configuration. In this embodiment, the otherwise wasted energy from the magnetic field is recaptured. One skilled in the art should appreciate that the electric current produced may be directly connected to the number of thermo-electric devices 10 or alternatively may be stored for later usage. One significant aspect of the present invention is that the energy is recaptured during heating or cooling for an increased productivity.

[0042] Referring now to Fig. 6, there is shown another preferred embodiment of the present invention. In this preferred embodiment, the system 30 has the conduit 26 with the number of thermo-electric devices 10 wound around the conduit. The system 30 also has a second conduit 60. The second conduit 60 is formed in a loop configuration. The conduit 26 preferably has any number of thermo-electric devices 10 being wound in a cylindrical configuration. This configuration provides the requisite cooling and/or heating desired and has the second conduit 60 traversing through an interior space of the conduit 26. The thermo-electric devices 10 are preferably wound around the second conduit 60 through the conduit 26 at a discrete point. The thermo-electric devices 10 preferably form a magnetic field 62. The magnetic field 62 is at a discrete point of the loop, and preferably intense at that discrete point while the loop also has a portion of the loop located at a less intense other weaker point. One skilled in the art should appreciate that the thermo-electric devices 10 may be placed at any number of discrete points along the loop so long as the number of thermo-electric devices are wound in the tubular or substantially cylindrical fashion.

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[0043] Preferably, the second conduit 60 has a working fluid 28 therein that is preferably ethylene glycol or alternatively any other working fluid known in the art. The working fluid 28 in the second conduit 60 further preferably has a number of fine magnetic particles 64 disposed therein in a

suspension. One skilled in the art will appreciate that the fine magnetic particles 64 have a size that does not prevent or impair any fluid flow properties of the working fluid 28 in the second conduit 60.

5 **[0044]** Once the working fluid 28 having the number of fine magnetic particles 64 disposed therein traverses into the magnetic field 62 and is magnetized, the fine suspended magnetic particles 64 will be heated. Once the working fluid 28 having the number of fine magnetic particles 64 disposed therein traverses through the magnetic field 62 the
10 heat generated will be deposited to a heat sink through a heat exchanger 85, thus the temperature of the magnetic particles containing working fluid initially increases and then decreases after it is passed through the heat exchanger. After exiting the heat exchanger 85, the magnetic particles will then cool at another second location 66 with low or zero magnetic field.
15 The system 30 further has another heat exchanger 68 that will then transfer heat from the third loop to the working fluid 28 in the second conduit 60. The third loop 68 will then traverse into the desired compartment for additional cooling and for use as an auxiliary or second cooling system. The magnetic particles are preferably made from the materials with large
20 magneto-caloric effect as those previously indicated.

[0045] It should be understood that the foregoing description is only illustrative of the present invention. Various alternatives and modifications can be devised by those skilled in the art without departing from the
25 invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances.

WHAT IS CLAIMED IS:

Claim 1: A refrigeration system comprising:

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a compartment;

a first cooling device, said first cooling device cooling said
compartment and generating an magnetic field; and

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a second device, wherein said second device uses said generated
magnetic field for additional cooling.

Claim 2: The refrigeration system of claim 1, wherein said first
15 cooling device has at least one thermo-electric element connected to a
power source.

Claim 3: The refrigeration system of claim 1, wherein said first
cooling device has a plurality of thermo-electric elements connected in
20 series to a power source.

Claim 4: The refrigeration system of claim 1, wherein said first
cooling device has a plurality of thermo-electric elements connected in
series to a power source, said plurality of thermo-electric elements being
25 wound in a cylindrical configuration.

Claim 5: The refrigeration system of claim 4, wherein said second
device comprises a rotating member, said rotating member having a
channel, said channel having a working fluid therein, said rotating member
30 having at least a portion being made from a material selected from the
group consisting of a paramagnetic material, a ferromagnetic material, and
any combinations thereof.

Claim 6: The refrigeration system of claim 5, wherein said magnetic field has a first intensity at a first area and has a second intensity at a second different area, wherein second device has said rotating member rotates from said first area to said second area, wherein said rotating member is disposed periodically in said magnetic field for heat exchanging with said working fluid.

Claim 7: The refrigeration system of claim 4, wherein said second device comprises a movable member, said movable member having a channel therein, said channel having a working fluid therein, said moving member having at least a portion being made from a material selected from the group consisting of a paramagnetic material, a ferromagnetic material, and any combinations thereof.

Claim 8: The refrigeration system of claim 7, wherein said magnetic field has a first intensity at a first area and has a second intensity at a second different area, wherein second device has said movable member or said magnetic field moving relative to the other, wherein said movable member is disposed periodically in said magnetic field for communicating heat with said working fluid therein.

Claim 9: The refrigeration system of claim 4, wherein said second device comprises a coil, said being disposed in said magnetic field, said magnetic field inducing a current in said coil, said current for powering at least said first device.

Claim 10: The refrigeration system of claim 4, wherein said first device has a working fluid through a conduit, wherein said second device comprises a plurality of fine magnetic particles, said plurality of fine magnetic particles being disposed in said working fluid.

Claim 11: The refrigeration system of claim 10, wherein said first cooling device has said plurality of thermo-electric elements connected in series to said power source, said plurality of thermo-electric elements being

wound in said cylindrical configuration and forming an interior path therethrough, and wherein said working fluid in said conduit is disposed through said interior path with said fine magnetic particles therein.

5 Claim 12: The refrigeration system of claim 11, wherein said plurality of fine magnetic particles are suspended in said working fluid.

 Claim 13: The refrigeration system of claim 12, wherein said plurality of fine magnetic particles suspended in said working fluid, said
10 plurality of fine magnetic particles suitable to substantially not adversely affect a flow rate of said working fluid.

 Claim 14: The refrigeration system of claim 12, wherein said working fluid comprises ethylene glycol.

15

 Claim 15: A temperature control system comprising:

 a compartment;

20 a first cooling and heating device, said first cooling and heating device cooling and/or heating said compartment and generating an magnetic field as a waste energy; and

 a second magnetic device, wherein said second magnetic device
25 comprises a magnetic material, said magnetic material periodically being introduced in a generated magnetic field for recapturing said waste energy from said magnetic field and using said waste energy to power the temperature control system.

30 Claim 16: A refrigeration system comprising:

 a compartment;

a first cooling device, said first cooling device cooling said compartment and generating an magnetic field; and

5 a second magnetic refrigerator, wherein said second magnetic refrigerator comprises a magnetic material, said magnetic material periodically being introduced in said generated magnetic field, wherein said second magnetic refrigerator has a working fluid being thermally connected to said second magnetic refrigerator, wherein said working fluid is connected to said compartment for additional cooling.

10

Claim 17: A method of cooling a compartment using a magnetic field as herein before described with reference to any one of Figures 1 through 6 of the accompanying drawings.

15 Claim 18: An apparatus for cooling a compartment using a magnetic field as herein before described with reference to any one of Figures 1 through 6 of the accompanying drawings.

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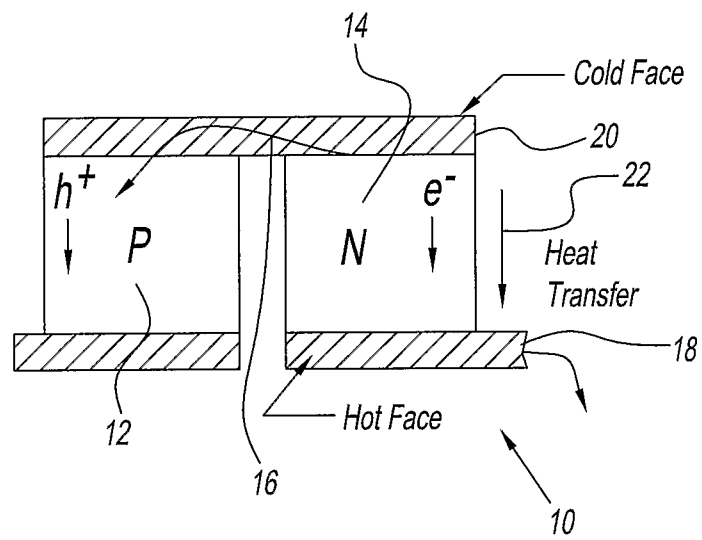


Fig. 1

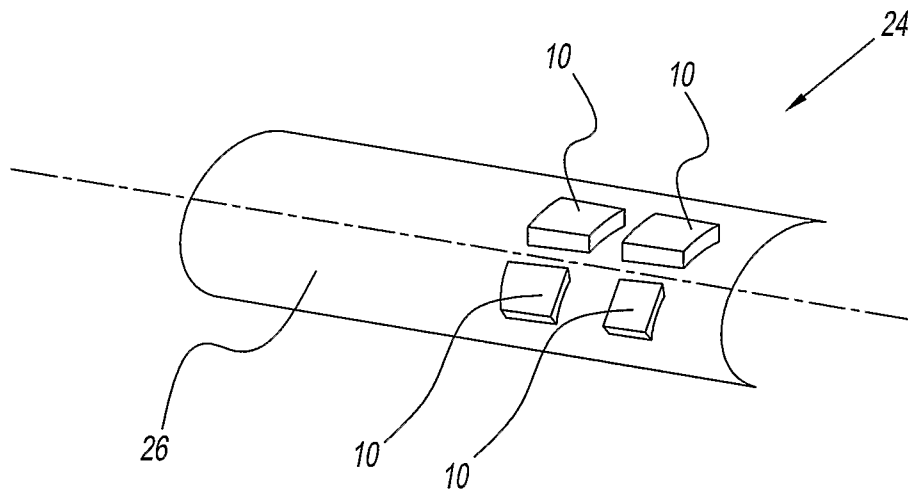


Fig. 2

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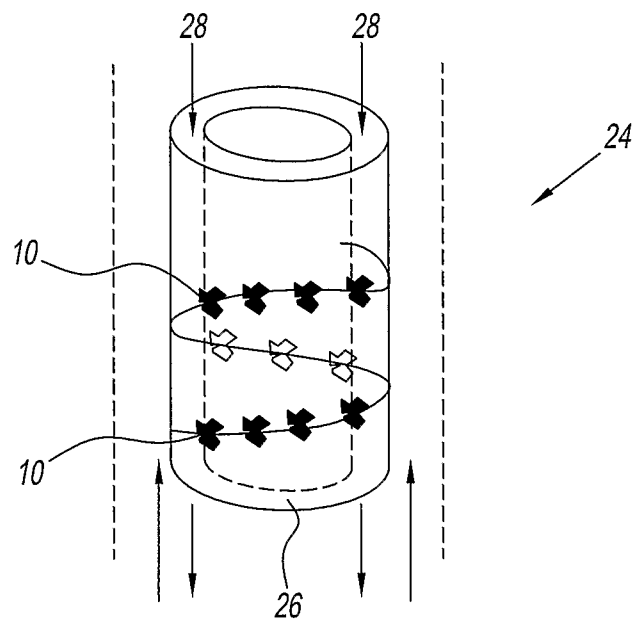


Fig. 3

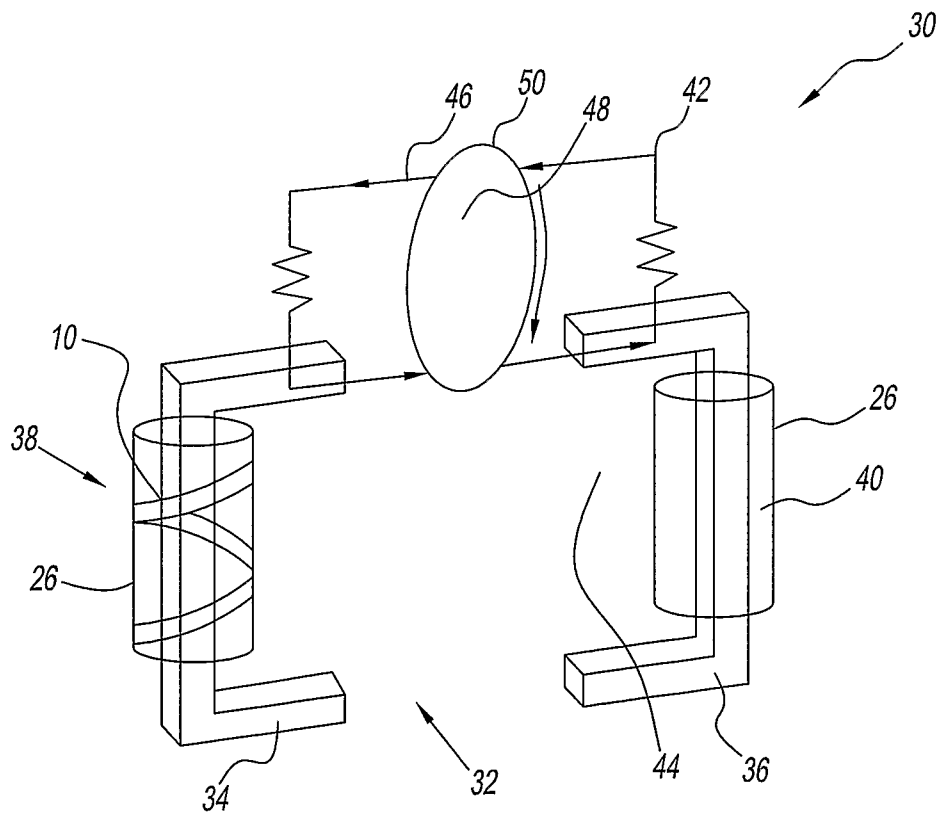


Fig. 4

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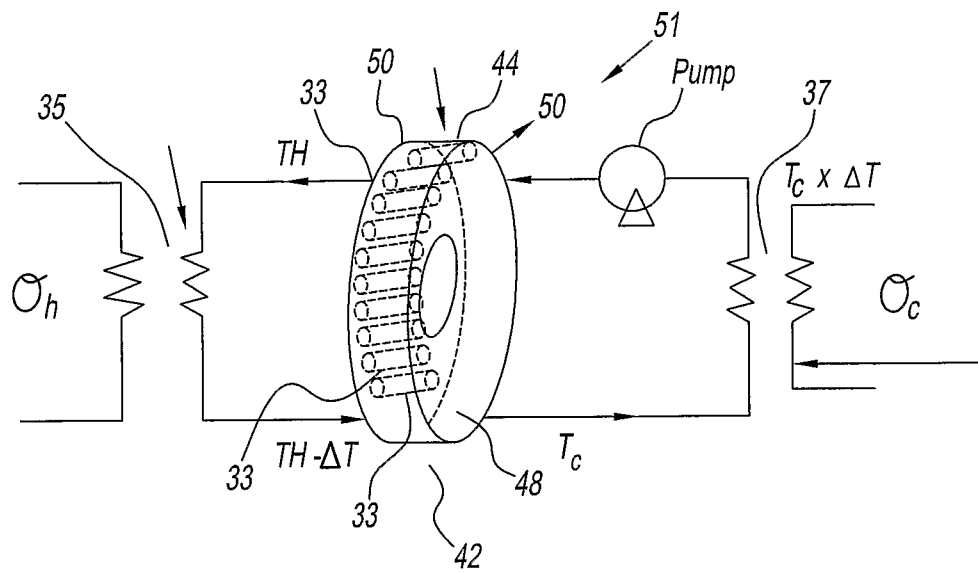


Fig. 4a

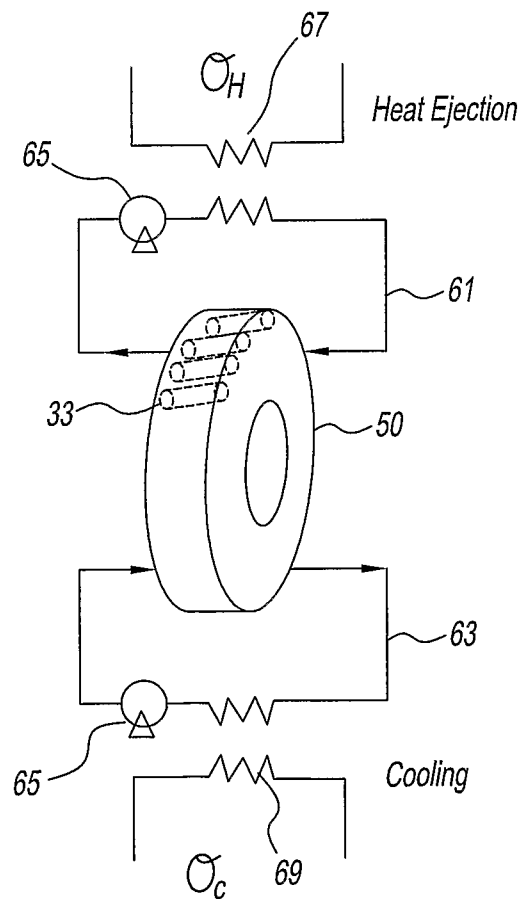


Fig. 4b

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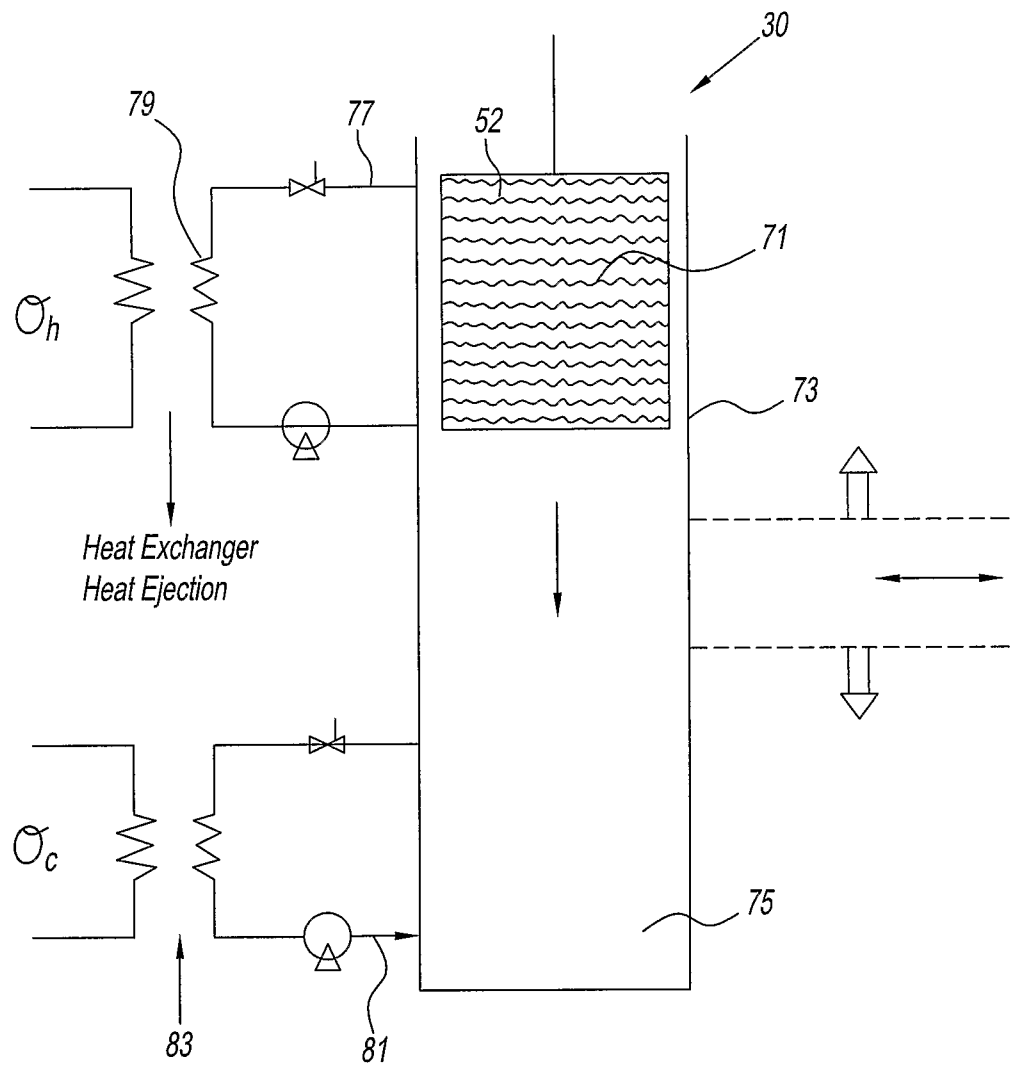


Fig. 4c

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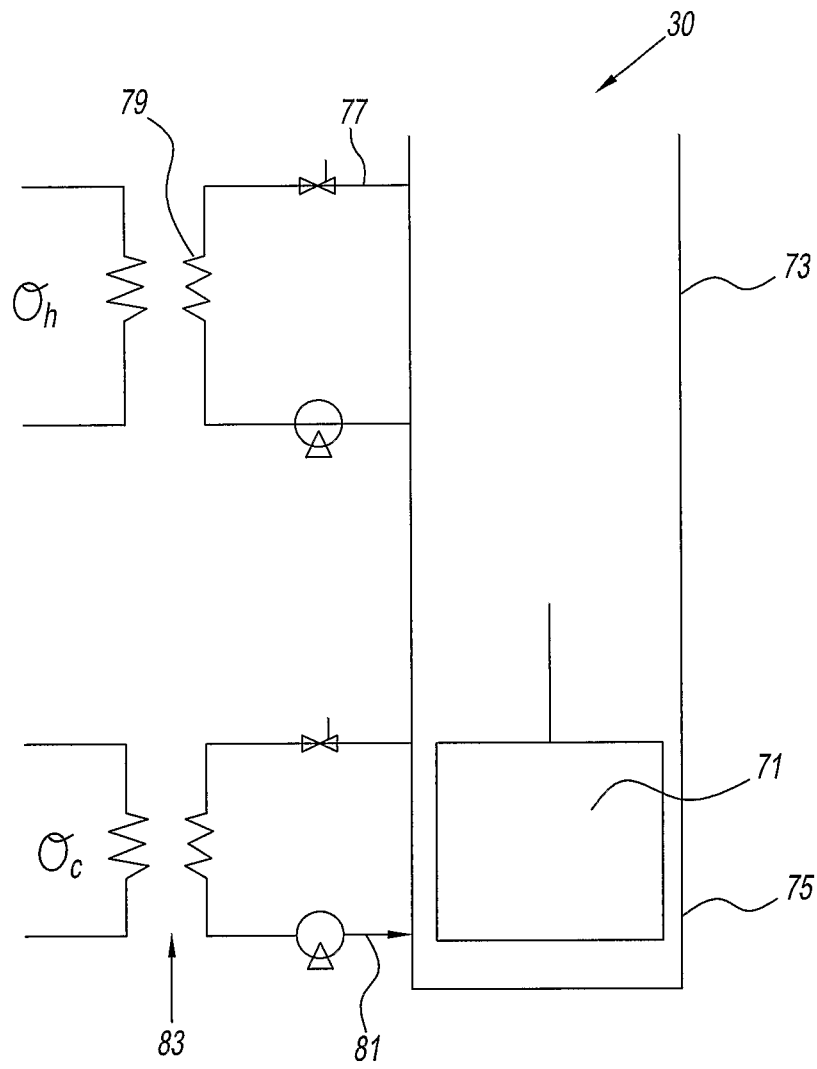


Fig. 4d

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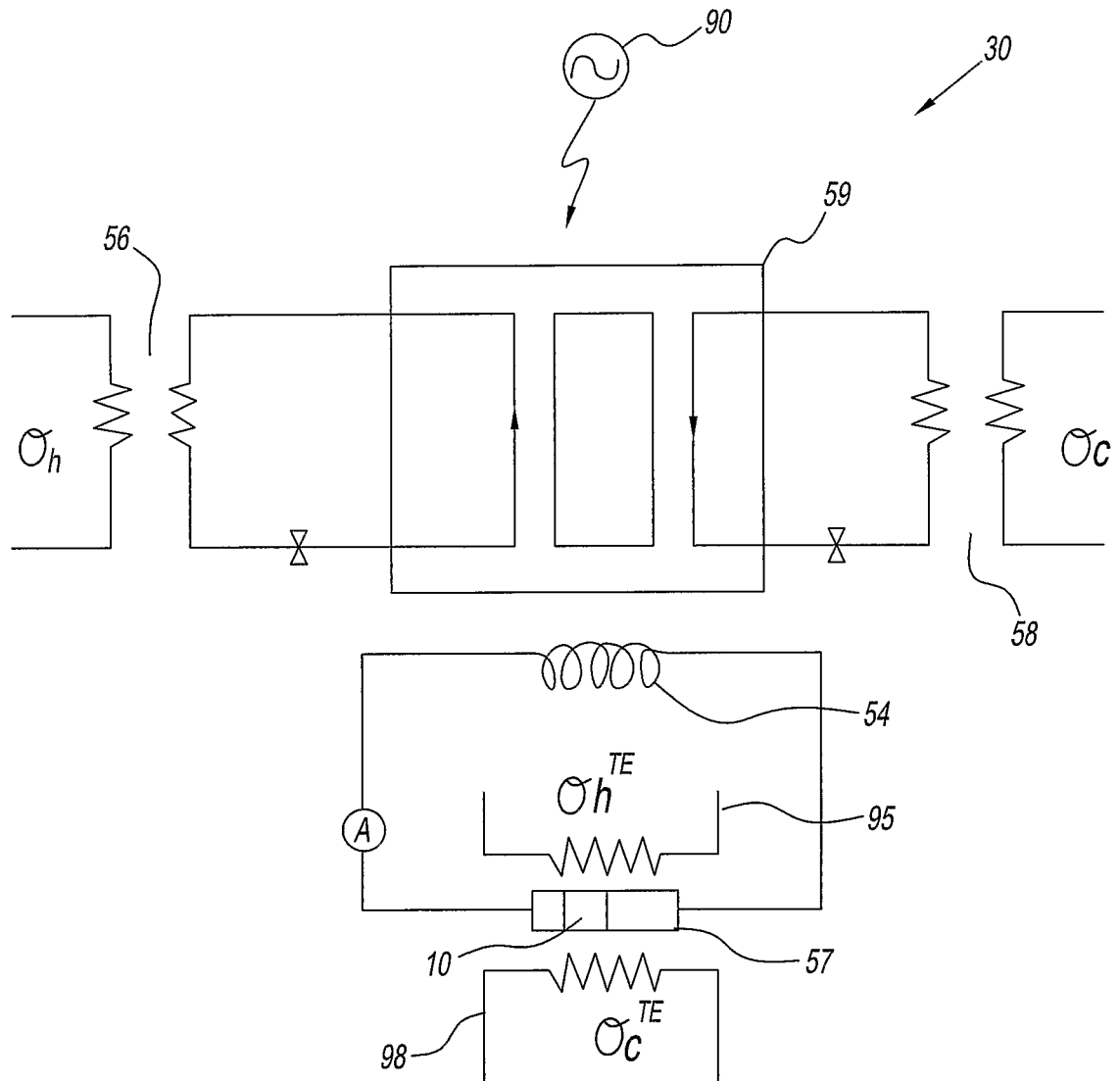
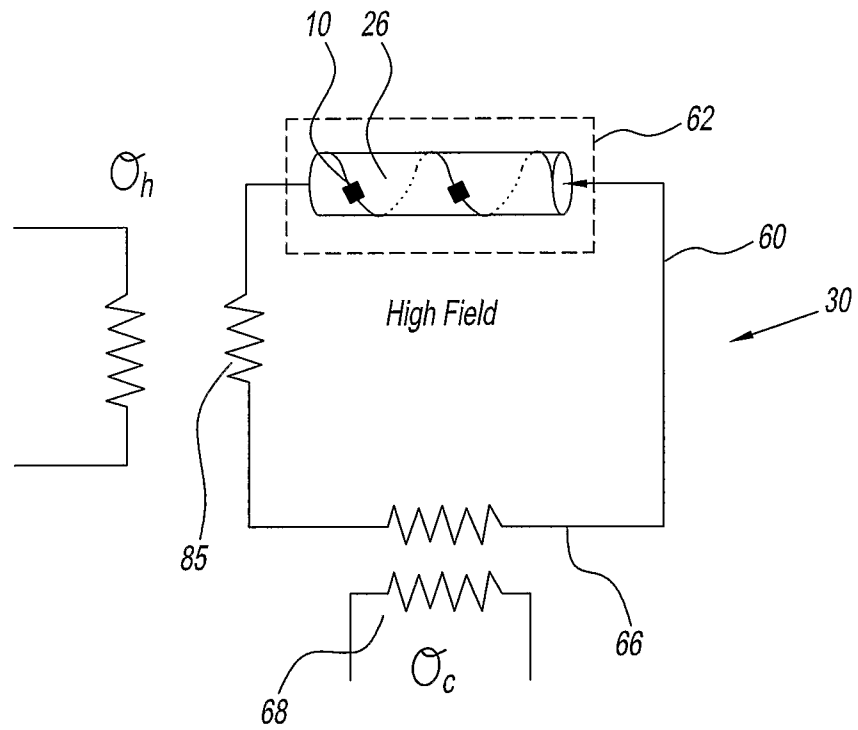


Fig. 5

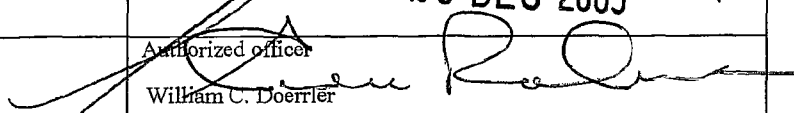
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*Fig. 6*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US05/22376

A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : F25B 21/00, 21/02, 7/00 US CL : 62/3.1, 3.2, 335 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 62/3.1, 3.2, 335, 3.7 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched None Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) None		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,483,341 A (WITTELES) 20 November 1984 (20.11.1984), see entire document.	1-3
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Y		4
A	US 6,595,004 B1 (GHOSHAL) 22 July 2003 (22.07.2003), see entire document.	1-16
A	US 6,588,215 B1 (GHOSHAL) 08 July 2003 (08.07.2003), see entire document.	1-16
A	US 5,597,976 A (SCHROEDER) 28 January 1997 (28.01.1997), see entire document.	1-16
A	US 5,393,350 A (SCHROEDER) 28 February 1995 (28.02.1995), see entire document.	1-16
A	US 3,547,705 A (HEARD) 15 December 1970 (15.12.1970), see entire document.	1-16
A	US 3,319,457 A (LEONE) 16 May 1967 (16.05.1967), see entire documents.	1-16
A	US 2,980,860 A (MACDONALD) 18 April 1961 (18.04.1961), see entire document.	1-16
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family	
Date of the actual completion of the international search 06 December 2005 (06.12.2005)		Date of mailing of the international search report 29 DEC 2005
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201		Authorized officer  William C. Doerrler Telephone No. (571) 272-3750

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US05/22376

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 17 and 18
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 17 and 18 refer to the drawings which is contrary to PCT rule 6.2.
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

- Remark on Protest**
- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.