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(54) **MAGNETIC ASSEMBLY SYSTEM AND METHOD**

(75) Inventors: **Jayeshkumar Jayanarayan Barve**, Bangalore (IN); **Ramasamy Anbarasu**, Lubeck (DE); **Shishir Chandrasekhar Menon**, Bangalore (IN)

Correspondence Address:
GENERAL ELECTRIC COMPANY
GLOBAL RESEARCH
ONE RESEARCH CIRCLE, BLDG. K1-3A59
NISKAYUNA, NY 12309 (US)

(73) Assignee: **GENERAL ELECTRIC COMPANY**, Schenectady, NY (US)

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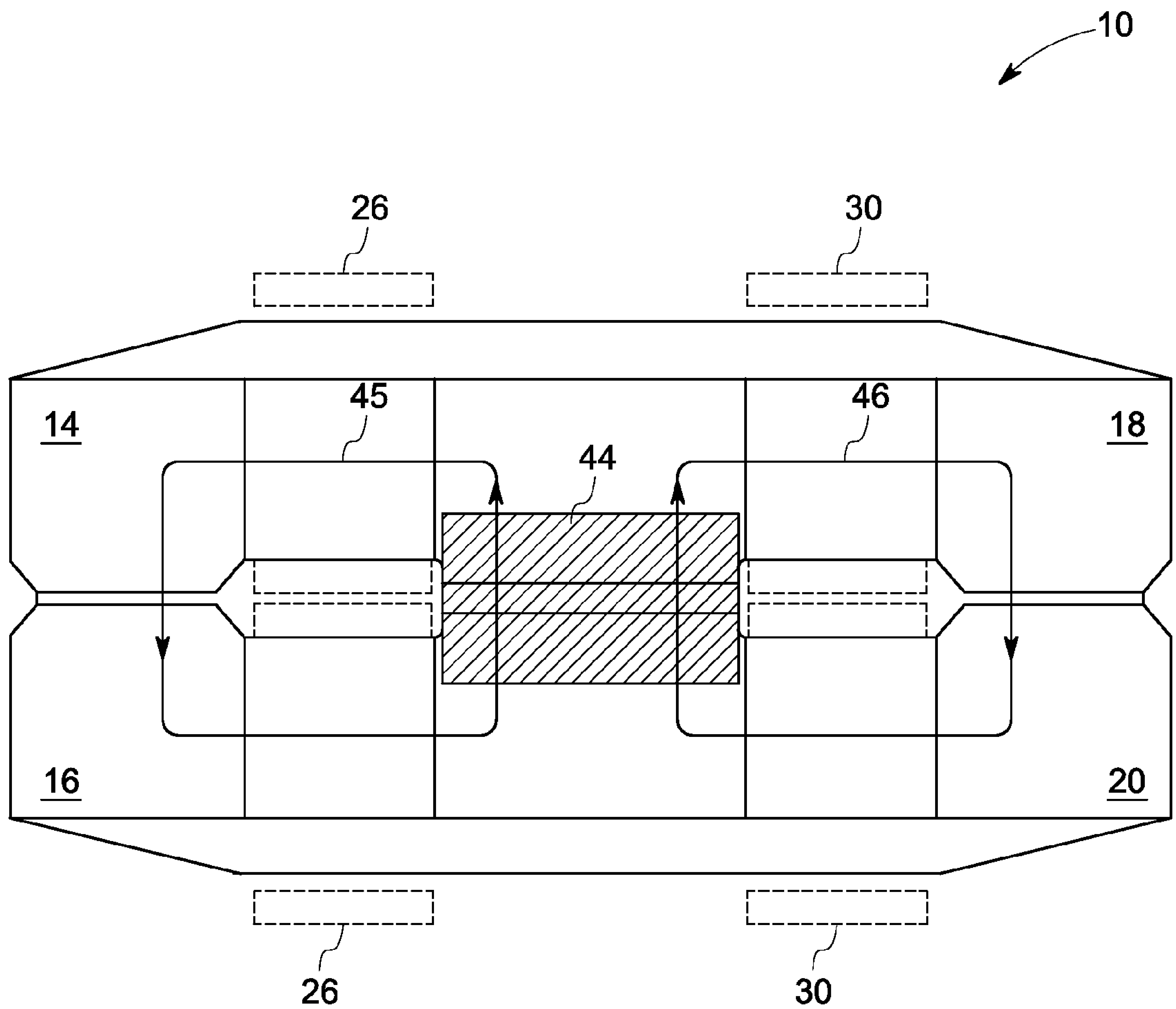
(57) **ABSTRACT**

A magnetic assembly having a magnetic field mechanism is proposed. The magnetic assembly includes a central limb and a top and bottom yoke. At least a first coil is disposed on a first side of one of the top and bottom yoke and at least a second coil is disposed on a second side. The magnetic assembly further includes a first magnetocaloric unit disposed on the first side between the top and bottom yoke and a second magnetocaloric unit disposed on the second side wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.



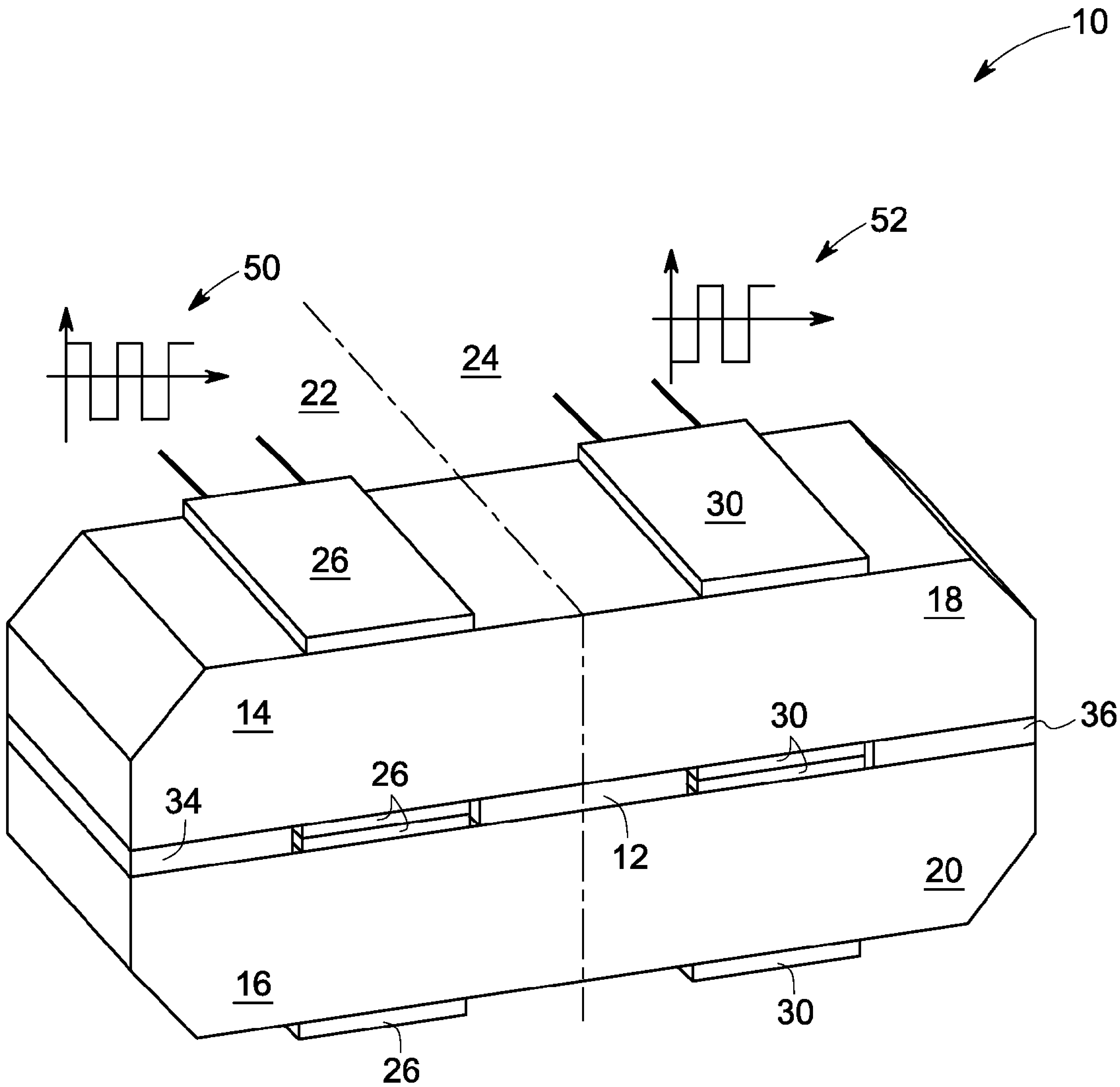


FIG. 1

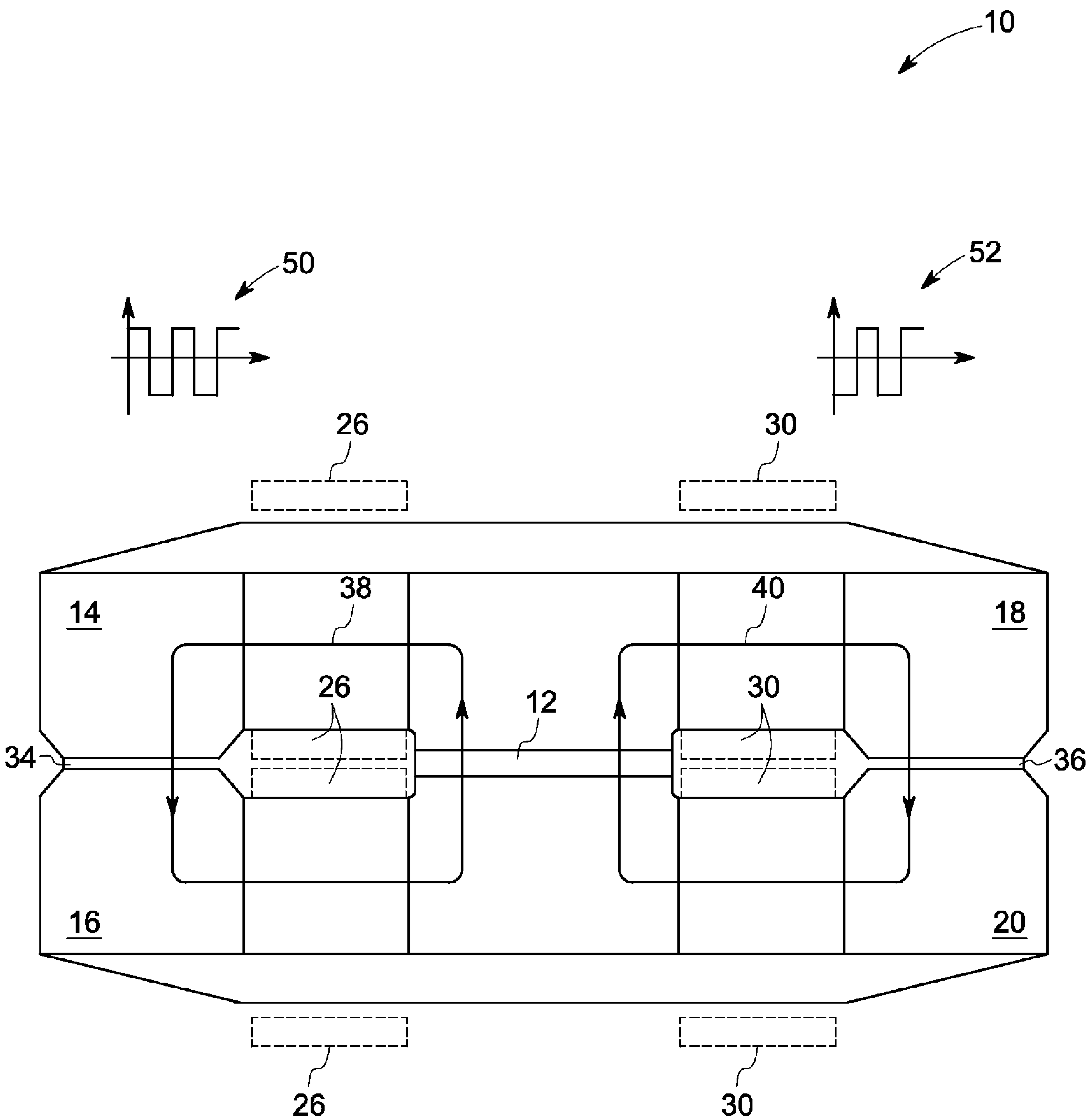


FIG. 2

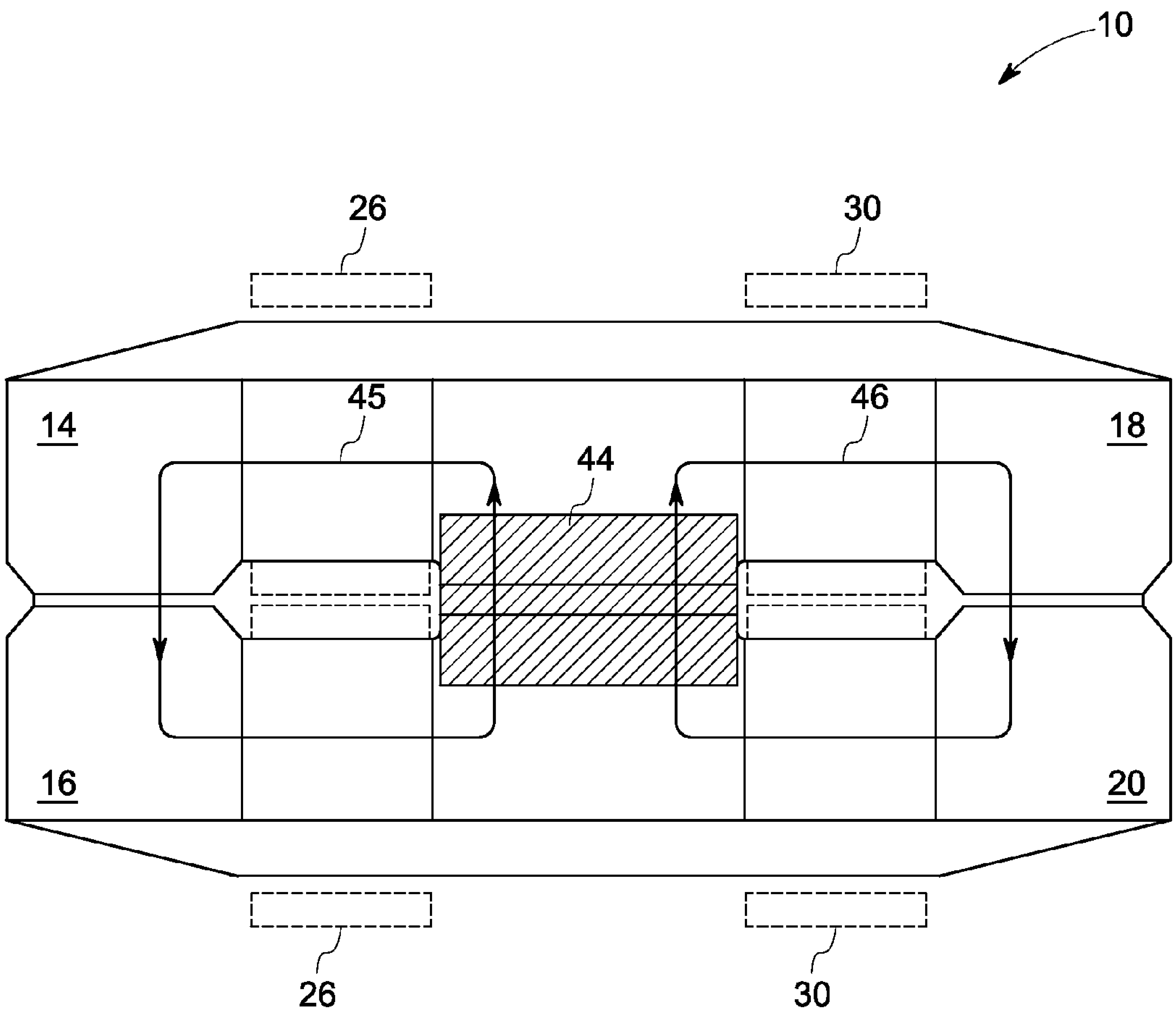


FIG. 3

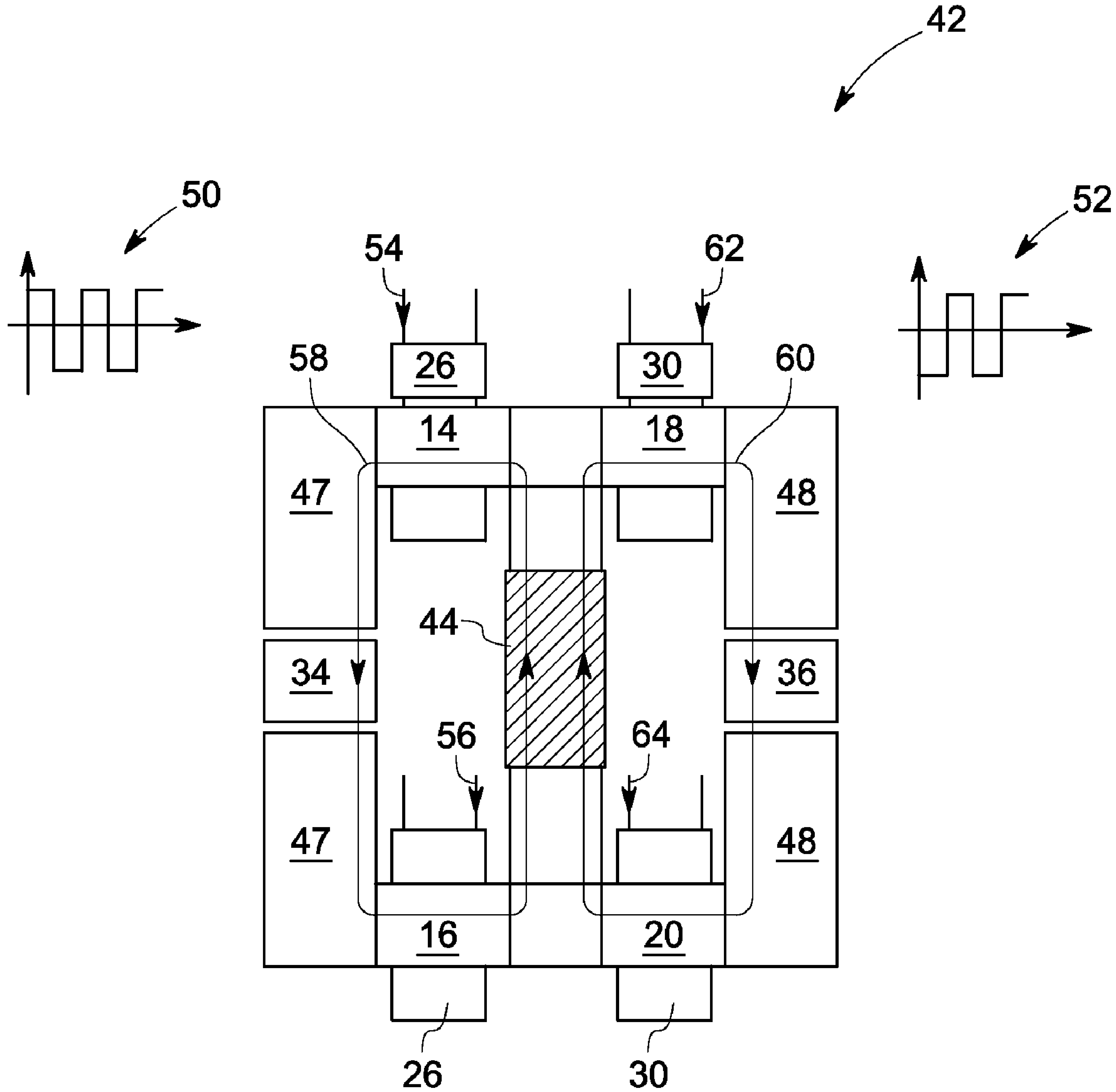


FIG. 4

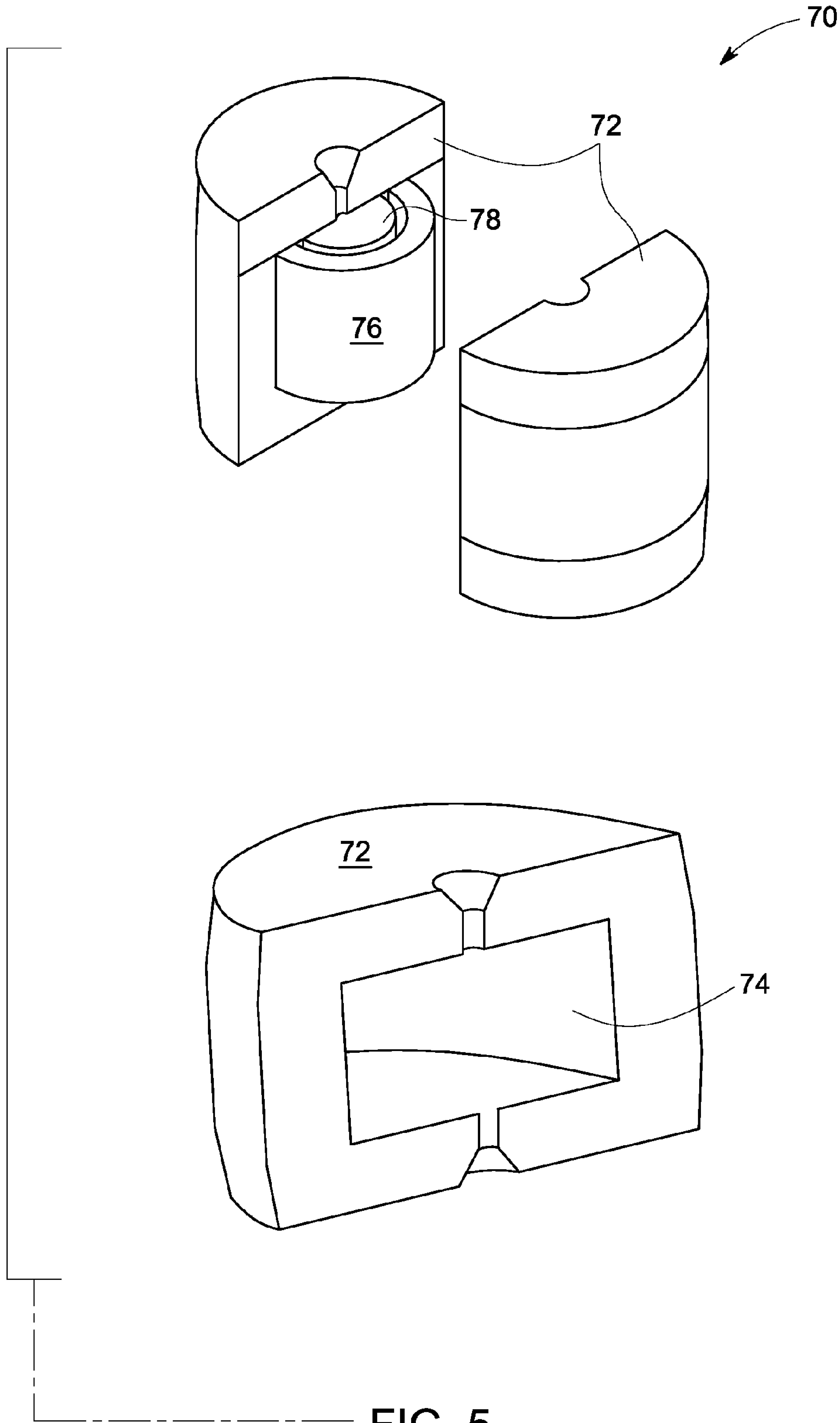


FIG. 5

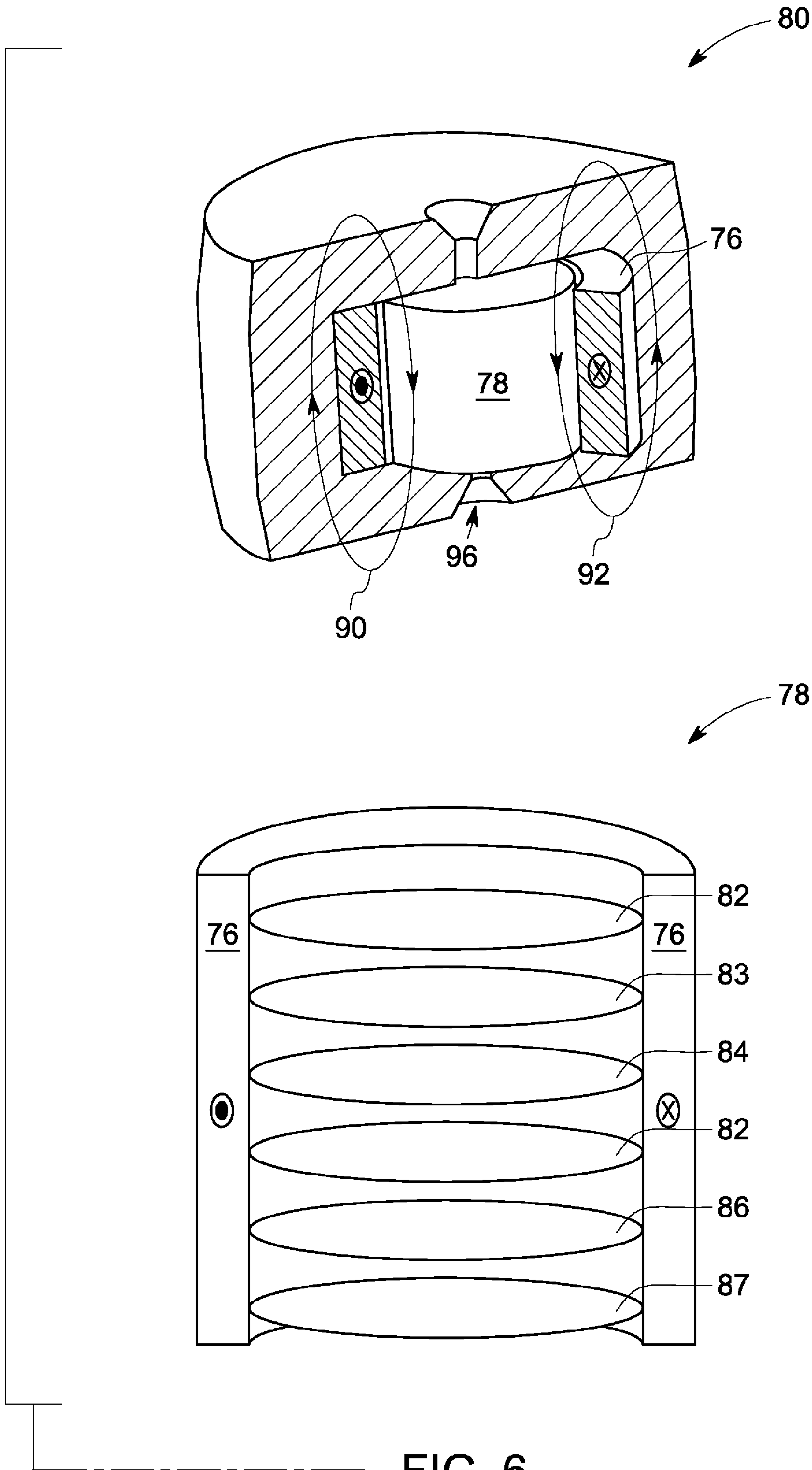


FIG. 6

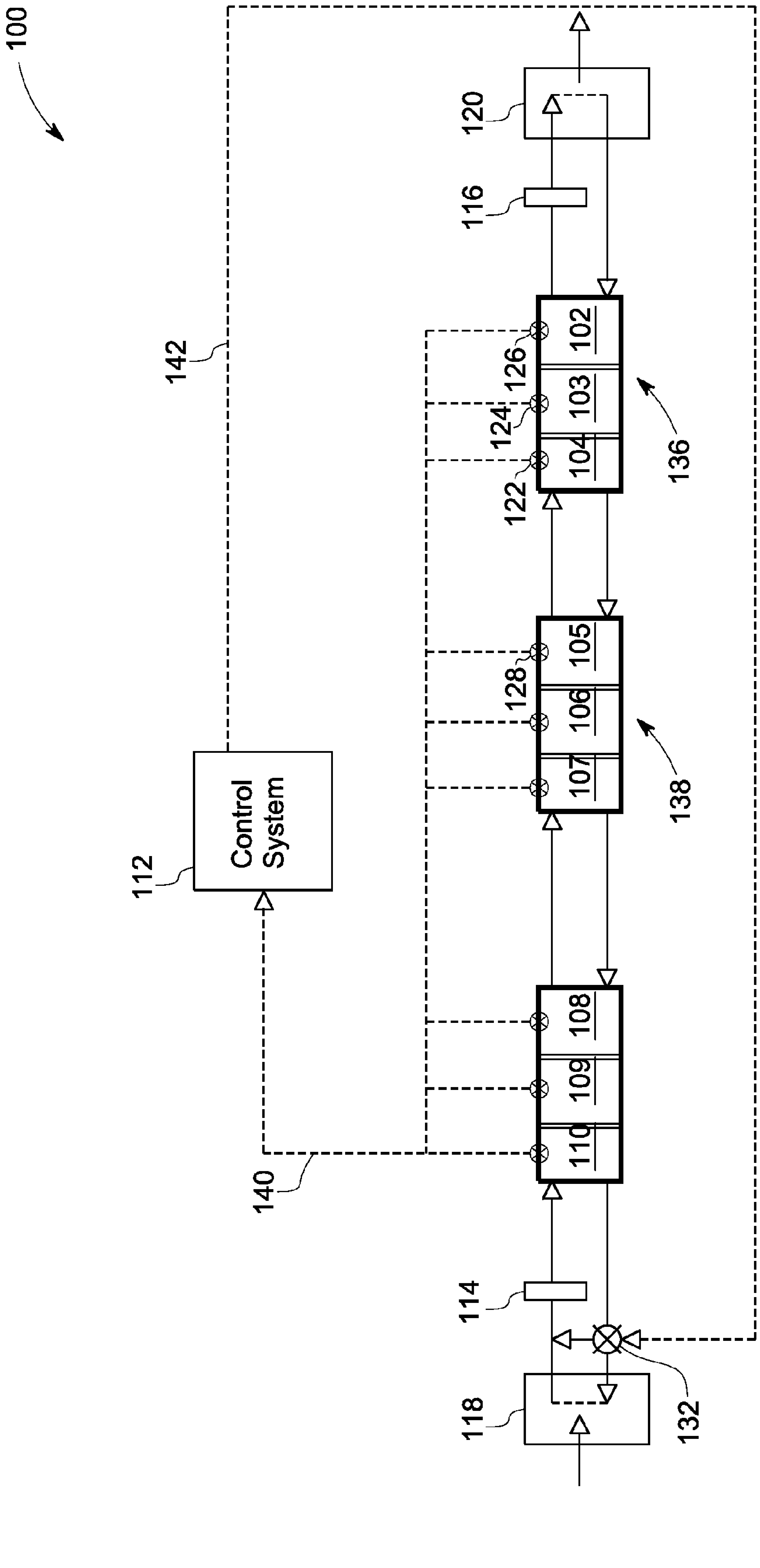

100
142
Control System
112
140
120
116
102
103
104
126
124
122
136
105
106
107
128
138
108
109
110
114
118
132

FIG. 7

MAGNETIC ASSEMBLY SYSTEM AND METHOD

BACKGROUND

[0001] The invention relates generally to magnetic assembly and in particular, to magnetic refrigeration.

[0002] Conventional refrigeration technology has often utilized the adiabatic expansion or the Joules-Thomson effect of a gas. However, such gas compression technology has some drawbacks. First, a Hydro-fluorocarbon (HFC), Hydro-chloroFluorocarbon (HCFC), or chlorofluorocarbon (CFC) gas, a typical refrigerant working material used most commonly in this technology, poses environmental challenges such as global warming or ozone layer depletion. Second, the gas compression technology typically results in low efficiency, thus constituting an obstacle to desired energy savings. To solve these problems, a method that takes advantage of entropy change accompanied by magnetic phase transition, also referred to as magnetic transformation, of a solid has been researched as a high-efficiency refrigeration technique. In the magnetic refrigeration technique, cooling is effected by using a change in temperature resulting from the entropy change of a magnetic material. More specifically, a magnetic material used in this method alternates between a low magnetic entropy state with a high degree of magnetic orientation created by applying a magnetic field to the magnetic material near its Curie temperature, and a high magnetic entropy state with a low degree of magnetic orientation (randomly oriented state) that is created by removing the magnetic field from the magnetic material. Such transition between high and low magnetic entropy state manifests as transition between low and high lattice entropy state, in turn resulting in warming up or cooling down of the magnetocaloric material when exposed to magnetization and demagnetization. This is called the "magnetocaloric effect." Accordingly, significant research has been directed at leveraging the mangetocaloric effect present within certain magnetocaloric materials to develop a magnetic refrigerator.

[0003] In an exemplary system implementing a magnetic refrigeration cycle, the permanent magnets are stationary and magnetic rings are used to move a gadolinium powder, stuffed into pockets of the ring, in and out of magnetic fields generated by the permanent magnets. Typically, a fluid is pumped into and out of the system to carry heat away and to provide a cooling fluid for refrigeration. As evident, such systems require a complex mechanical drive for rotating the ring, pumping the heat-conducting fluids in and out of the system and complex fluid sealing. Further, the movements of the heat-conducting fluids through portions of the rotating ring require synchronizing mechanisms.

[0004] These magnetic refrigerator systems need moving parts and/or advanced fluid flow to absorb or reject heat from the magnetocaloric material. In principle, similar constraints bound the possibility of using electrocaloric (pyroelectric) materials. The complexity of fluidic schemes and the moving parts reduce the efficiency of cascaded coolers and reduce the reliability significantly. Moving parts and advanced fluid flow systems increase the cost of magnetic refrigerators and provide additional sources of failure.

[0005] Thus, it would be beneficial to eliminate moving parts in magnetic refrigerator systems in order to provide simpler and more reliable mechanisms. Moreover, it would be beneficial to provide hybrid mechanisms having electro magnets and permanent magnets to enable magnetic refrigeration systems with increased efficiency.

BRIEF DESCRIPTION

[0006] Briefly, a magnetic assembly having a magnetic field mechanism is proposed. The magnetic assembly includes a central limb and a top and bottom yoke. At least a first coil is disposed on a first side of one of the top and bottom yoke and at least a second coil is disposed on a second side. The magnetic assembly further includes a first magnetocaloric unit disposed on the first side between the top and bottom yoke and a second magnetocaloric unit disposed on the second side wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.

[0007] In one embodiment a magnetic assembly having a magnetic field mechanism is proposed. The magnetic assembly includes a central limb and a top and bottom yoke, wherein the central limb comprises a permanent magnet. At least a first coil is disposed on a first side of one of the top and bottom yoke and a second coil is disposed on an opposite side relative to the first coil. The magnetic assembly further includes a first magnetocaloric unit disposed on the first side between the top and bottom yoke and a second magnetocaloric unit disposed on the opposite side relative the first magnetocaloric unit wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.

[0008] In one embodiment, a magnetic assembly is proposed. The magnetic assembly includes a cylindrical magnetic field mechanism having a core defining a hollow inner surface and at least one coil disposed within the hollow inner surface. At least one magnetocaloric unit is disposed in the hollow inner surface, wherein the magnetocaloric units are alternately magnetized and demagnetized to generate thermal units.

[0009] In one embodiment, a magnetic cooling system is proposed. The magnetic refrigeration system includes a cylindrical magnetic field mechanism having a core defining a hollow inner surface and at least a coil disposed in the hollow inner surface. The coil produce magnetic field upon excitation. At least one magnetocaloric unit is disposed in the hollow inner surface, wherein the magnetocaloric units are alternately magnetized and demagnetized to generate thermal units. A heat exchange fluid is coupled to the magnetocaloric unit to exchange heat.

[0010] In one embodiment, a magnetic cooling system is proposed. The magnetic refrigeration system includes a magnetic field system having a magnetic field mechanism that includes a central limb and a top and bottom yoke. At least a first coil disposed on a first side of one of the top and bottom yoke and a second coil disposed on an opposite side relative to the first coil. The system further includes a first magnetocaloric unit disposed on the first side between the top and bottom yoke and a second magnetocaloric unit disposed on the opposite side relative the first magnetocaloric unit. The first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units. A heat exchange fluid is configured to exchange heat from the generated thermal units. The system further includes a pump to circulate the heat exchange fluid, a thermal sink to remove heat from the heat exchange fluid, and a thermal source configured to refrigerate via the heat exchange fluid.

[0011] In one embodiment, a method to generate magnetic field in a magnet assembly is proposed. The method includes creating an alternating magnetic field by energizing and de-energizing a coil, orienting the alternating magnetic field via a magnetic field mechanism through a magnetocaloric material. Generated thermal units are exchanged via a heat transfer fluid coupled to the magnetocaloric material and a thermal source and a thermal sink.

DRAWINGS

[0012] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0013] FIG. **1** illustrates a perspective view of a magnetic assembly design;

[0014] FIG. **2** is a profile view of the magnetic assembly in FIG. **1**;

[0015] FIG. **3** is a profile view of a hybrid magnetic assembly;

[0016] FIG. **4** is a sectional view of the hybrid magnetic assembly of FIG. **3**;

[0017] FIG. **5** is a perspective view of a cylindrical magnetic assembly;

[0018] FIG. **6** is a sectional view of the cylindrical magnetic assembly in FIG. **5**; and

[0019] FIG. **7** is an exemplary configuration of a cooling device.

DETAILED DESCRIPTION

[0020] FIG. **1** illustrates a perspective view of a magnetic assembly design according to one embodiment of the instant invention. A magnetic assembly generally indicated by the reference numeral **10** includes a magnetic field mechanism to facilitate a magnetic flux path. The magnetic assembly includes a central limb **12**, a top yoke **14**, **18** and a bottom yoke **16**, **20**. It may be noted that the magnetic flux path includes central limb **12**, top yoke **14** (and **18**) and the bottom yoke **16** (and **20**) that are part of the magnetic field mechanism. In one embodiment, the central limb **12**, the top yoke **14** and the bottom yoke **16** form a closed magnetic flux path. In another embodiment, the central limb **12**, the top yoke **18** and the bottom yoke **20** form a closed magnetic flux path. A first side **22** and a second side **24** are designated for the convenience of describing the various embodiments of the magnetic assembly **10**.

[0021] A first coil **26** is disposed on the top yoke **14** and bottom yoke **16** (on the first side **22**). A second coil **30** is disposed on an opposite side (a second side **24**) relative to the first coil **26**on the top yoke **18** and the bottom yoke **20**. A first magnetocaloric unit **34** is disposed on the first side **22** between the top yoke **14** and the bottom yoke **16**. A second magnetocaloric unit **36** is disposed on the second side **24** (opposite side) relative to the first magnetocaloric unit **34** between the top yoke **18** and the bottom yoke **20**. The first magnetocaloric unit **34** and the second magnetocaloric unit **36** are alternately magnetized and demagnetized via the magnetic field to alternately generate a positive (heating) and negative (cooling) thermal units in the magnetocaloric units. The magnetization and demagnetization cycle is outlined in further detail at FIG. **2**.

[0022] FIG. **2** is a profile view of the magnetic assembly **10** in FIG. **1**. During an operation of the magnetic assembly **10**, the first coil **26** and the second coil **30** are energized by a current. In one embodiment, during a first cycle, the first coil **26** is energized to produce magnetic flux that may travel in a closed loop **38** around the central limb **12**, the top yoke **14** via the first magnetocaloric unit **34** and the bottom yoke **16**. The first magnetocaloric unit **34** experiences increased external magnetic field resulting in change in magnetic entropy. Such change in magnetic entropy may result in heating up or cooling down of the magnetocaloric unit based on type of magnetocaloric material. Since the change in total entropy is a constant under adiabatic condition, the net result is the first magnetocaloric unit **34** heating up or cooling down. By de-energizing the first coil **26**, the magnetic flux though the first magnetocaloric unit **34** is removed. During such decreased external magnetic field, internal thermal energy within the magnetocaloric unit **34** acts to overcome the magnetic field. Since the change in total entropy is constant, the net result is the first magnetocaloric unit **34** cools down or heats up. In one embodiment, during a second cycle, the second coil **30** is energized to produce magnetic flux that may travel in a closed loop **40** around the central limb **12**, the top yoke **18** via the second magnetocaloric unit **36** and the bottom yoke **20**. Similarly, second magnetocaloric unit **36** heats up or cools down during the magnetizing cycle described above. By de-magnetizing the second magnetocaloric unit **36** (de-energizing the second coil **30**), the magnetocaloric unit **36** cools down or heats up. It may be noted that, in a dual active magnetocaloric regenerative refrigeration (AMRR) cycle, both the first and second magneto caloric units are functional as described above. However, in a single AMRR cycle either the first magneto caloric unit **34** only or the second magneto caloric unit **36** only functional.

[0023] FIG. **3** is a profile view of a hybrid magnetic assembly having a permanent magnet in the central limb. A hybrid magnetic assembly **42** includes a permanent magnet **44** embedded in the central limb **12**. The permanent magnet **44** helps facilitate magnetic flux in a magnetic path **45** and magnetic path **46**. The first coil **26** is disposed on the top yoke **14** and the bottom yoke **16**. During operation of the hybrid magnetic assembly **42**, the first coil **26** is energized to produce magnetic field that forms a magnetic closed path **45**. The second coil **30** is disposed on the top yoke **18** and the bottom yoke **20**. In one embodiment, the second coil **30** is energized to produce magnetic field that forms a magnetic closed path **46**. Hybrid magnetic assembly structures have advantages such as aided magnetic field along with the electromagnets. Further, such hybrid assembly **42** may require reduced coil size and current to produce the same amount of magnetic field.

[0024] FIG. **4** is a sectional view of the hybrid magnetic assembly of FIG. **3**, illustrating the position and winding direction of coils on the yoke. During operation of the magnetic assembly **42**, the first coil **26** is energized at **54** and **56**. In one embodiment, the excitation current **50** impressed on coil **26** and configured to drive magnetic flux lines **58** along the central limb **12**, the top yoke **14**, a first side limb **47** and the bottom yoke **16**. Along with the flux generated by the permanent magnet **44**, the coil **26** produces magnetic flux **58** that may pass through the first magnetic material **34** to produce thermal units. In another embodiment, the current **52** is impressed on coil **30** while current **50** energize the coil **26**. Such excitation orients the magnetic flux **60** towards flux **58** along with the magnetic flux from the permanent magnet **44**. In one embodiment, the magnetic flux **58** orients towards flux **60** along with the magnetic flux from the permanent magnet **44**.

[0025] In another embodiment, the excitation current **52** is impressed on the second coil **30** at **62** and **64** configured to drive magnetic flux lines **60** along the central limb **12**, the top yoke **18**, a second side limb **48** and the bottom yoke **20**. Correspondingly, along with the flux generated by the permanent magnet **44**, the second coil **30** produces magnetic flux **60** that may pass through the second magnetocaloric unit **36** to produce thermal units.

[0026] FIG. **5** is a perspective view of a cylindrical magnetic assembly. The cylindrical magnetic assembly **70** is configured to facilitate cylindrical magnetic field mechanism. The cylindrical magnetic assembly includes a core **72** defining a hollow inner surface **74**. The core **72** is generally made of, but not limited to, a magnetic material such as soft iron. A field winding **76** is disposed within the hollow inner surface **74**. A magnetocaloric unit **78** having a plurality of magnetocaloric discs is disposed adjacent to the field winding **76** within the hollow inner surface **74**. The magnetocaloric unit **78** is subjected to magnetic field magnetizing and demagnetizing alternately to generate thermal units. A cut section of the cylindrical magnetic assembly and working is discussed in detail at FIG. **6**.

[0027] FIG. **6** illustrates a cross-sectional view of the cylindrical assembly in FIG. **5**. The cut section **80** illustrates the field windings **76** and the magnetocaloric unit **78** disposed adjacent to the field winding. The magnetocaloric unit **76** includes multiple magnetocaloric discs **82-87** stacked one below the other.

[0028] In operation, the field winding **76** is energized via an external source such as a current drive. The field windings **76** produce magnetic flux within the core **72** that facilitates a closed loop magnetic flux transmission **90**, **92** through the magnetocaloric unit **78**. The magnetocaloric discs **82-87**, by virtue of its properties, heats up or cools down during magnetization cycle. In one embodiment, a heat exchange fluid, for example an aqueous solution of glycols is made to pass through the central conduit **94**. The heat exchange fluid along its flow between **94** and **96**, comes in contact with the magnetocaloric disks **82-87** facilitating heat exchange. Similarly, the magnetic assembly **80** may be used for a cooling cycle wherein the heat exchange fluid is configured to exchange heat with magnetocaloric disks **82-87**. The heat exchange fluid may be coupled through various stages in refrigeration cycle.

[0029] FIG. **7** illustrates an exemplary configuration **100** of a cooling device. As illustrated, the cooling device **100** includes a plurality of thermally coupled magnetocaloric elements such as represented by reference numerals **102-110** that are configured to provide cooling in a variety of environments. Examples of such environments include a refrigeration system, a chiller, a gas liquefaction plant, a cryocooler, a magnetic bearing device, an electronic device, an automotive, an air conditioning system and a rotating machine. In one embodiment, the magnetocaloric elements **102-110** may comprise materials including, but not limited to, gadolinium alloys, lanthanum alloys, manganese alloys, samarium alloys, cobalt alloys, tin alloys, and combinations thereof. It may be noted that, magnetocaloric elements **102-110**, may represent the magnetocaloric units **34**, **36**, **78** as referenced in FIG. **1** and FIG. **5** respectively.

[0030] In this embodiment, the cooling device **100** includes a control system **112** that is configured to regulate the temperature of each of the plurality of magnetocaloric elements **102-110**. The plurality of magnetocaloric elements **102-110** may be heated or cooled through isentropic magnetization, or isentropic demagnetization and through transfer of heat using a fluid medium for regulating the temperature of each of the plurality of magnetocaloric elements **102-110**. In this exemplary embodiment, the cooling device **100** includes the first and second reservoirs **114** and **116** containing the fluid medium for transferring the heat between the magnetocaloric elements **102-110** and the environment. Examples of fluid medium suitable for use in the first and second reservoirs **114** and **116** include ethylene glycol, water, propylene glycol, helium, nitrogen and dynalene or other suitable heat transfer mediums.

[0031] Further, the cooling device **100** also includes first and second heat exchangers **118** and **120** thermally coupled to the magnetocaloric elements **102-110** and to the first and second reservoirs **114** and **116** for transferring heat between the magnetocaloric elements **102-110** and the environment through the fluid medium. In the illustrated embodiment, the control system **112** is configured to control operation for selectively heating or cooling the plurality of magneto-caloric elements **102-110** based on a measured or an estimated temperature of the plurality of magnetocaloric elements **102-110**.

[0032] In this exemplary embodiment, the cooling device **100** includes a plurality of temperature sensors for measuring temperature of at least one of the magnetocaloric elements **102-110**. For example, the cooling device **100** includes a plurality of temperature sensors such as represented by reference numerals **122**, **124**, **126** and **128** for measuring the temperature of at least one of the magnetocaloric elements **102-110**. Further, the control system **112** is configured to estimate the temperature of each of the plurality of magnetocaloric elements **102-110** based upon factors such as a Curie temperature of a respective magnetocaloric element **102-110**, a MCE curve of the respective magnetocaloric element **102-110**, intensity of an applied magnetic flux **38**, **40** (see FIG. **2**) and so forth. In certain embodiments, the cooling device **100** includes a bypass valve **132** for bypassing a cooling load such as a freezer load as desired during the operation of the cooling device **100**.

[0033] In the illustrated embodiment, the plurality of magneto-caloric elements **102-110** may be grouped in a plurality of magnetocaloric blocks. Each of the plurality of magnetocaloric blocks may include a logical grouping of magnetocaloric elements **102-110** based upon the temperature of each of the plurality of magnetocaloric elements **102-110**. For example, the number of the magnetocaloric elements in each of the magnetocaloric blocks may be determined based upon factors such as the isentropic MCE temperature change of different MCE elements **102-110**, difference in Curie temperatures of the MCE elements **102-110**, number of sensors employed for temperature sensing and so forth. However, a greater or lesser number of magnetocaloric elements may be envisaged. Moreover, the first and second magnetocaloric blocks **136** and **138** may include a different number of magneto-caloric elements.

[0034] As described above, the magnetocaloric elements **102-110** in the first magnetocaloric block **136** are subjected to magnetic regenerative refrigeration cycle. In particular, the magnetocaloric elements **102-110** are isentropically magnetized causing an increase in temperature of the magnetocaloric elements **102-110**. The fluid medium flow through the magnetocaloric elements **102-104** from the first reservoir **114** toward the second reservoir **116** absorbs the heat from the magnetocaloric elements **102-110** and transfers the heat to a heat sink (not shown) through the heat exchanger **120**. Further, the magnetocaloric elements **102-110** are isentropically demagnetized causing the temperature of the magnetocaloric elements **102-110** to decrease. Further, the fluid medium that flows through the magnetocaloric elements **102-110** from the second reservoir **116** toward the first reservoir **114** is cooled by the magnetocaloric elements **102-110** via heat absorption from magnetocaloric elements **102-110** and to absorb a heat load at the cold side through the heat exchanger **118**.

[0035] Referring back to FIG. **7**, the control system **112** is configured to receive measured temperatures from the temperature sensors **122**, **124**, **126** and **128**, as represented by reference numeral **140**. Further, the control system **112** is configured to estimate the temperature of each of the plurality of magnetocaloric elements **102-110**. In one embodiment, the control system **112** is configured to transmit a bypass command **142** to the bypass valve **132** for bypassing the cooling load such as a freezer load as desired during the operation. In certain embodiments, the control system **112** may include a processor (not shown) to process the temperature measurements **140** from the temperature sensors **122**, **124**, **126** and **128**.

[0036] In one embodiment, a method to generate magnetic field in a magnet assembly is proposed. The method includes creating an alternating magnetic field by energizing and de-energizing a coil. The alternating magnetic field may be derived from a phase shifted current pulse (such as **50**, **52** described in FIG. **4**). The alternating magnetic field is oriented via a magnetic field mechanism to pass through a magnetocaloric material. Alternating magnetic field, when impressed on the magnetocaloric material, produces thermal units. Generated thermal units are exchanged via a heat transfer fluid coupled to the magnetocaloric material and a thermal source (from where heat is extracted to cool/refrigerate) and a thermal sink (where the heat is rejected out to external ambient temperature).

[0037] Advantageously, embodiments of the instant invention, such as multiple coils on yoke and limb, would enable generation of thermal units with substantial improvement in Carnot efficiency over conventional vapor compression cooling devices. Further, the cylindrical design and the hybrid magnetic assembly produces compact magnetic field with decreased ampere turn requirement for producing magnetic field intensity. Reduced ampere-turn requirement have advantages such as increased efficiency and efficient magnetic coupling. Furthermore, overall increased efficiency may be achieved by reduced power requirement and effective heat exchange schemes.

[0038] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

1. A magnetic assembly comprising:
a magnetic field mechanism comprising a central limb and a top and bottom yoke;
at least a first coil disposed on a first side of one of the top and bottom yoke;
at least a second coil disposed on a second side;
a first magnetocaloric unit disposed on the first side between the top and bottom yoke; and
a second magnetocaloric unit disposed on the second side wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.

2. The magnetic assembly of claim **1**, wherein the first coil and the second coil is energized by an excitation current.

3. The magnetic assembly of claim **2**, wherein the energized coils produce a magnetic flux.

4. The magnetic assembly of claim **3**, wherein the magnetic flux passes through the first magnetocaloric unit and the second magnetocaloric unit.

5. The magnetic assembly of claim **4**, wherein the first magnetocaloric unit and the second magnetocaloric unit are configured for a heating cycle or a cooling cycle.

6. The magnetic assembly of claim **1** further comprising a permanent magnet on the central limb.

7. The magnetic assembly of claim **1**, wherein the first magnetocaloric unit is configured for a heating or a cooling cycle.

8. The magnetic assembly of claim **1**, wherein the second magnetocaloric unit is configured for a heating or a cooling cycle.

9. The magnetic assembly of claim **1**, wherein the generated thermal units effects a heat transfer.

10. The magnetic assembly of claim **9**, wherein a refrigeration cycle is provided via the generated thermal units.

11. A magnetic assembly comprising:
a magnetic field mechanism comprising a central limb and a top and bottom yoke, wherein the central limb comprises a permanent magnet;
at least a first coil disposed on a first side of one of the top and bottom yoke;
a second coil disposed on an opposite side relative to the first coil;
a first magnetocaloric unit disposed on the first side between the top and bottom yoke; and
a second magnetocaloric unit disposed on the opposite side relative the first magnetocaloric unit wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.

12. A magnetic assembly comprising:
a cylindrical magnetic field mechanism having a core defining a hollow inner surface and at least one coil disposed within the hollow inner surface;
at least one magnetocaloric unit disposed in the hollow inner surface, wherein the magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units.

13. The magnetic assembly of claim **12**, wherein the coil is energized by a current.

14. The magnetic assembly of claim **13**, wherein current carrying coil produces magnetic field.

15. The magnetic assembly of claim **14**, wherein the magnetic field magnetize the at least one magnetocaloric unit.

16. The magnetic assembly of claim **12**, wherein the generated thermal units effects a heat transfer.

17. A magnetic cooling system comprising:
a cylindrical magnetic field mechanism having a core defining a hollow inner surface and at least a coil disposed in the hollow inner surface, wherein the coil produce magnetic field upon excitation;

at least one magnetocaloric unit disposed in the hollow inner surface, wherein the magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units;

a heat exchange fluid coupled to the magnetocaloric unit to exchange heat.

18. A magnetic cooling system comprising:

a magnetic field system comprising:

a magnetic field mechanism comprising a central limb and a top and bottom yoke;

at least a first coil disposed on a first side of one of the top and bottom yoke;

a second coil disposed on an opposite side relative to the first coil;

a first magnetocaloric unit disposed on the first side between the top and bottom yoke;

a second magnetocaloric unit disposed on the opposite side relative the first magnetocaloric unit wherein the first magnetocaloric unit and the second magnetocaloric unit are alternately magnetized and demagnetized to generate thermal units;

a heat exchange fluid configured to exchange heat from the generated thermal units;

a pump to circulate the heat exchange fluid;

a thermal sink to remove heat from the heat exchange fluid; and

a thermal source configured to refrigerate via the heat exchange fluid.

19. A method to generate magnetic field in a magnet assembly, the method comprising:

creating an alternating magnetic field by energizing and de-energizing a coil;

orienting the alternating magnetic field via a magnetic field mechanism through a magnetocaloric material;

generating thermal units via the alternating magnetic field; and

exchanging the generated thermal units via a heat transfer fluid coupled to the magnetocaloric material and a thermal source and a thermal sink.

* * * * *