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(54) **SUPERCONDUCTING MAGNETIC ENERGY STORAGE**

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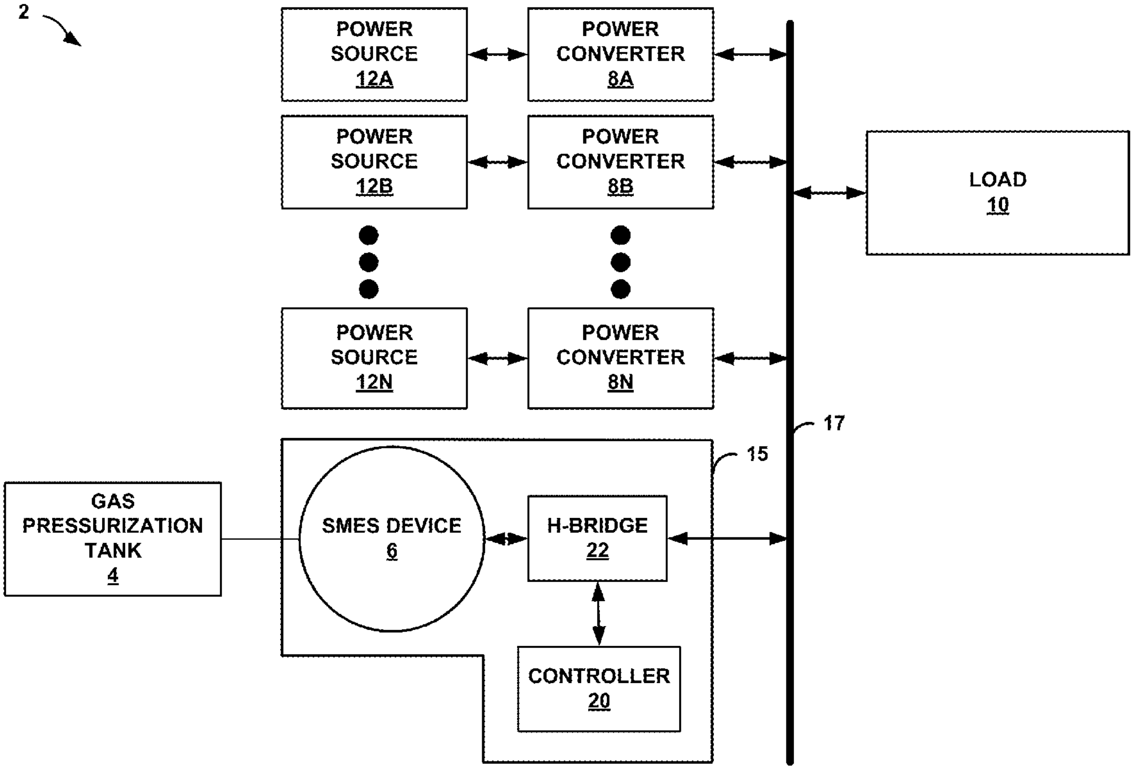
(57) **ABSTRACT**

A superconducting magnetic energy storage (SMES) device including a toroidal housing and a coil. The toroidal housing is configured to store a cryogenic fluid that cools the SMES to a superconducting state. The coil is configured to be in the superconducting state from cooling from the cryogenic fluid. The coil is also configured to store power for delivery to one or more external devices.



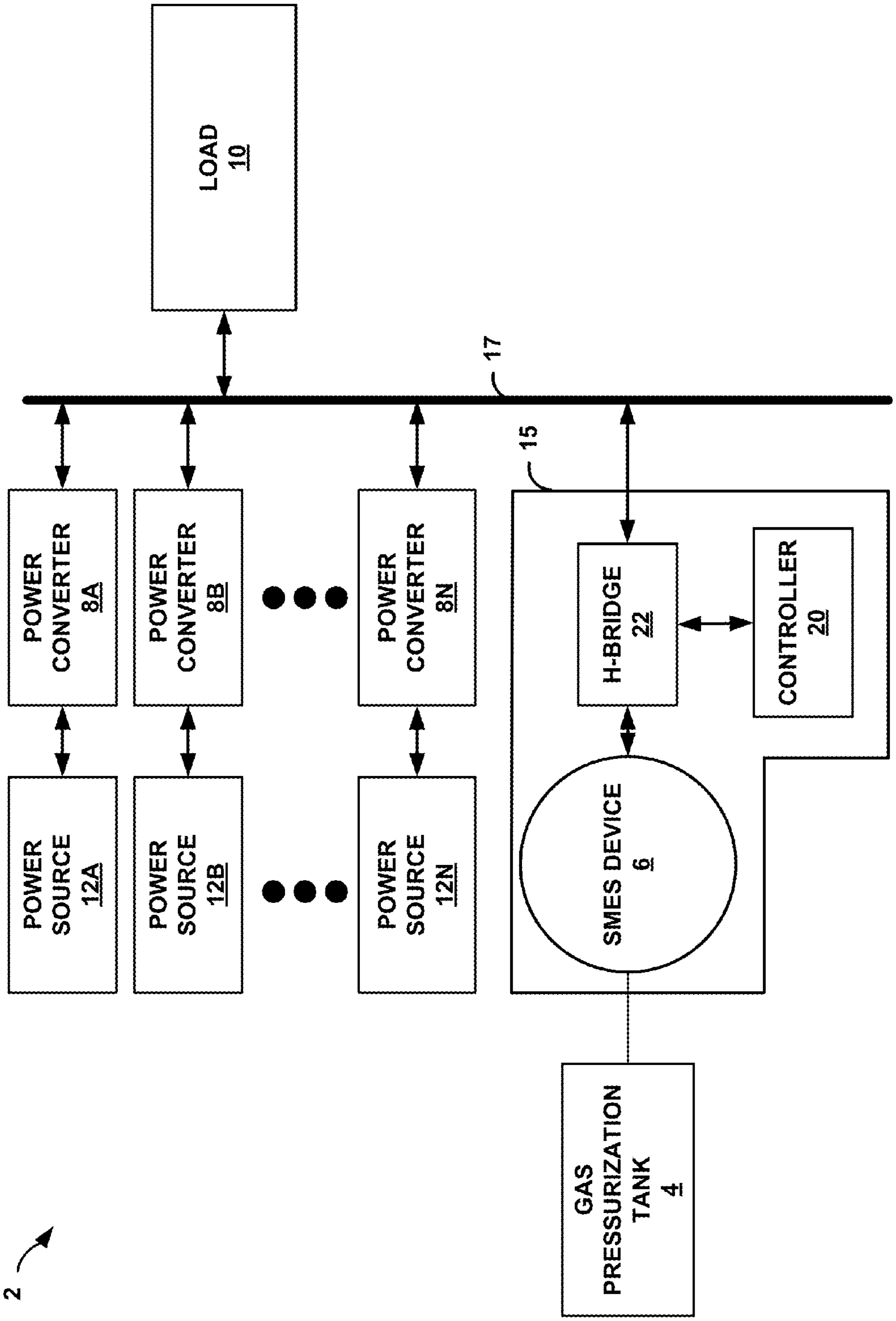

2
LOAD 10
17
POWER SOURCE 12A
POWER CONVERTER 8A
POWER SOURCE 12B
POWER CONVERTER 8B
POWER SOURCE 12N
POWER CONVERTER 8N
15
H-BRIDGE 22
CONTROLLER 20
SMES DEVICE 6
GAS PRESSURIZATION TANK 4

FIG. 1

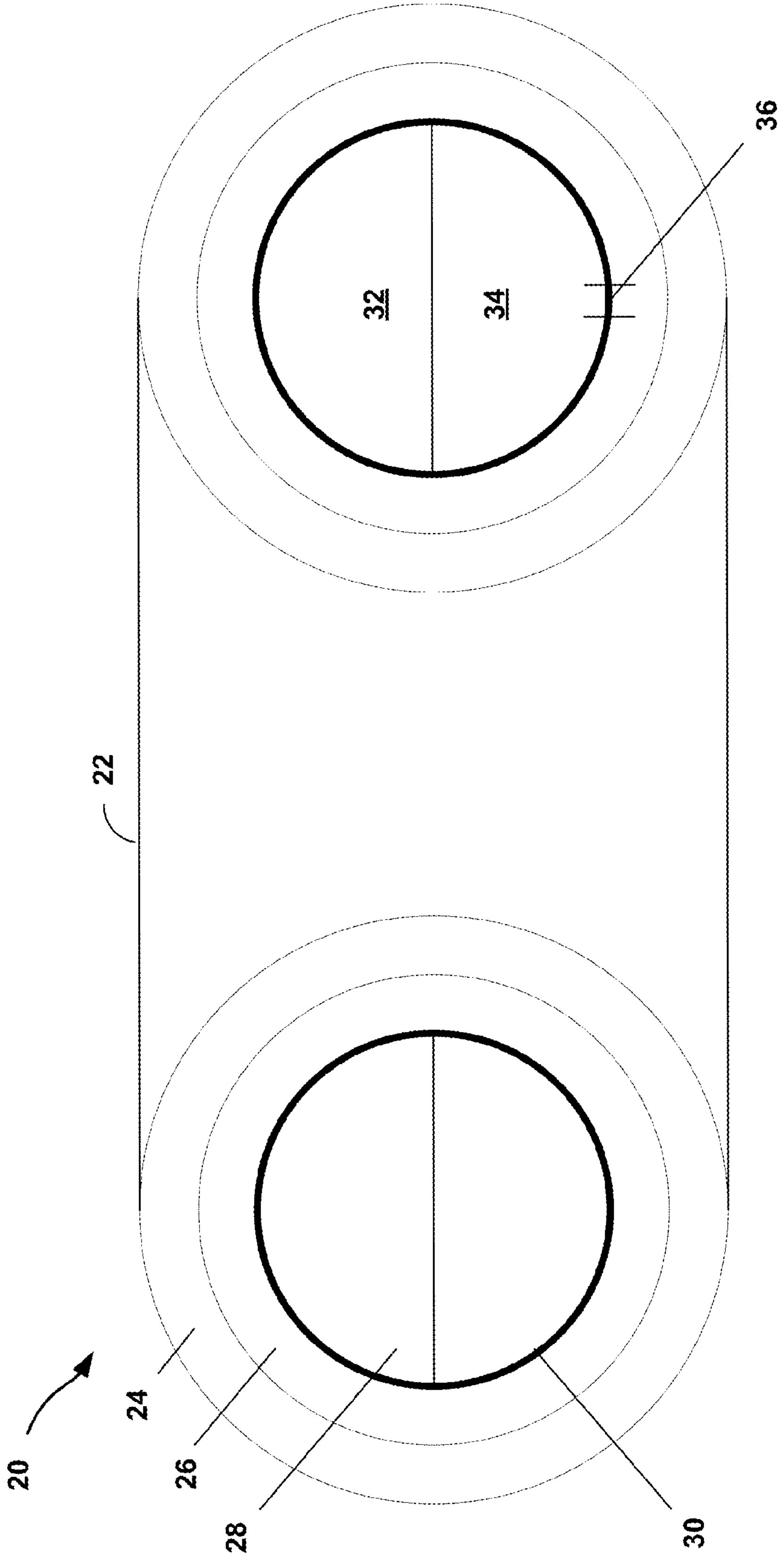


FIG. 2A

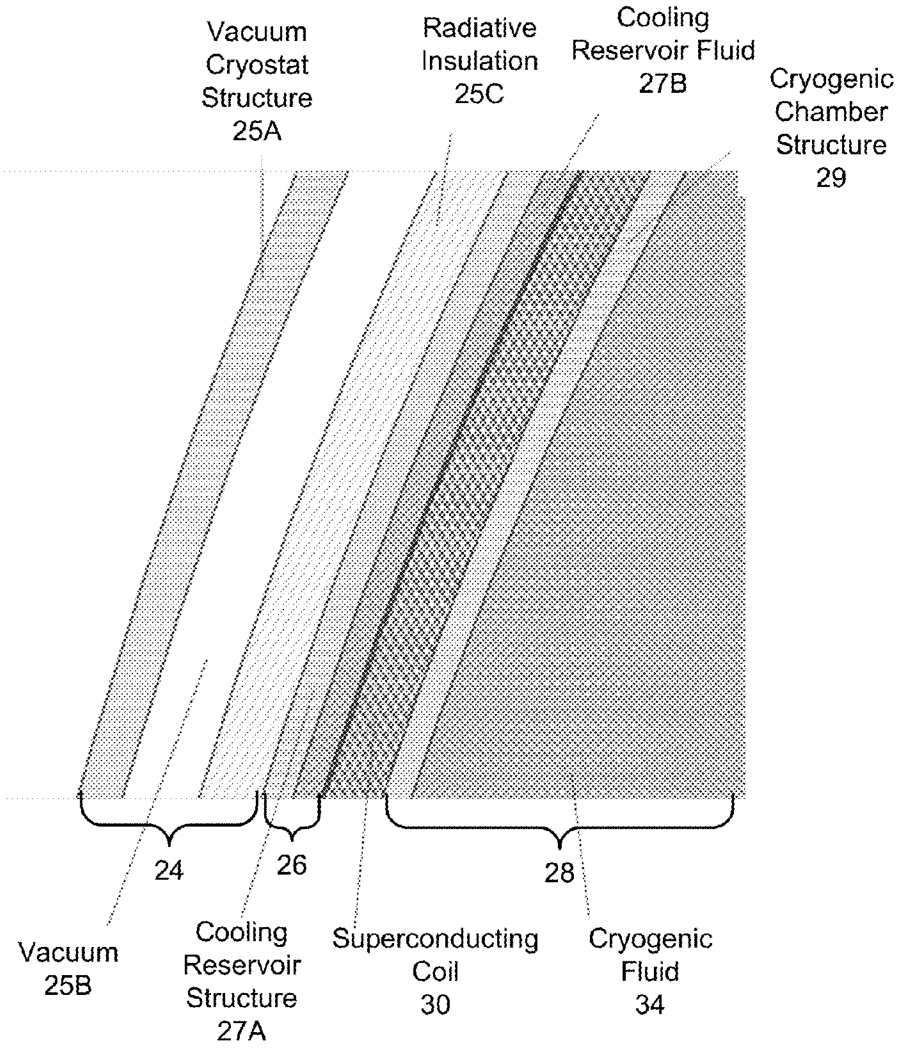

Vacuum
Cryostat
Structure
25A
Radiative
Insulation
25C
Cooling
Reservoir Fluid
27B
Cryogenic
Chamber
Structure
29
24
26
28
Vacuum
25B
Cooling
Reservoir
Structure
27A
Superconducting
Coil
30
Cryogenic
Fluid
34

FIG. 2B

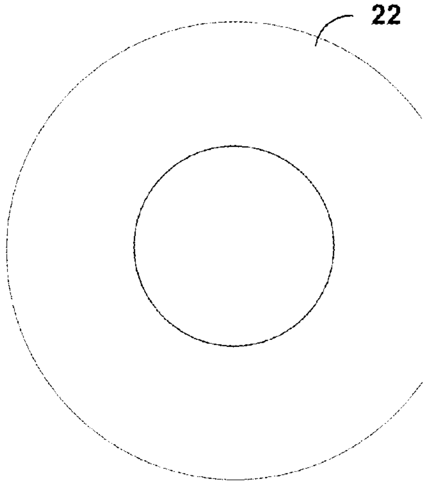

22

FIG. 2C

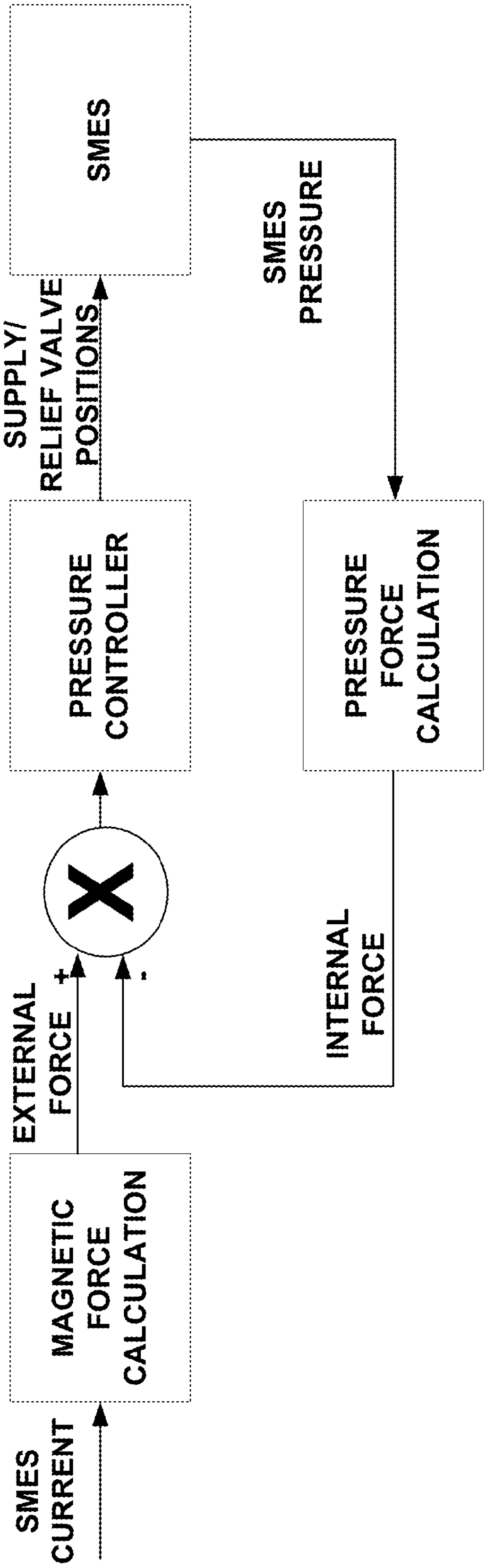

SMES CURRENT
MAGNETIC FORCE CALCULATION
EXTERNAL FORCE
+
-
X
INTERNAL FORCE
PRESSURE CONTROLLER
SUPPLY/ RELIEF VALVE POSITIONS
SMES
SMES PRESSURE
PRESSURE FORCE CALCULATION

FIG. 3

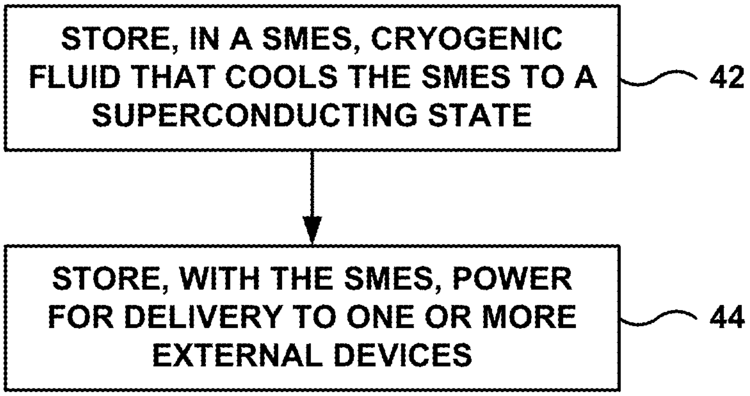

STORE, IN A SMES, CRYOGENIC FLUID THAT COOLS THE SMES TO A SUPERCONDUCTING STATE
42
STORE, WITH THE SMES, POWER FOR DELIVERY TO ONE OR MORE EXTERNAL DEVICES
44

FIG. 4

SUPERCONDUCTING MAGNETIC ENERGY STORAGE

[0001] This application claims the benefit of U.S. Provisional Application No. 62/174,076 filed Jun. 11, 2015, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to energy storage devices, and more particularly, to superconducting magnetic energy storage devices (SMES).

BACKGROUND

[0003] Superconducting magnetic energy storage (SMES) devices store energy in a magnetic field. The SMES includes a coil that is cooled below the superconducting temperature and functions in a superconducting state at such a temperature. The magnetic field is created by the flow of direct current in the superconducting coil.

SUMMARY

[0004] In some examples, the disclosure describes a superconducting magnetic energy storage (SMES) device including a toroidal housing and a coil. The toroidal housing is configured to store a cryogenic fluid that cools the SMES to a superconducting state. The coil is configured to be in the superconducting state from cooling from the cryogenic fluid. The coil may also be configured to store power for delivery to one or more external devices.

[0005] In some examples, the disclosure describes a system including a controller, a gas pressurization tank, a power converter, and a superconducting magnetic energy storage (SMES) device. The SMES includes a cryogenic fluid, a toroidal housing, and a coil. The cryogenic fluid cools the SMES to a superconducting state. The toroidal housing is configured to store the cryogenic fluid. The coil is configured to be in the superconducting state from cooling from the cryogenic fluid. The coil is further configured to store power for delivery to one or more external devices.

[0006] In some examples, the disclosure describes a method for operating a superconducting magnetic energy storage (SMES) device. The method includes storing, in the SMES device, a cryogenic fluid that cools the SMES to a superconducting state. The method also includes storing, with the SMES device being in the superconducting state, power for delivery to one or more external devices.

[0007] The details of one or more examples of this disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of this disclosure will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a block diagram illustrating an example energy delivery system.

[0009] FIGS. **2**A and **2**B are cross-sectional diagrams illustrating an example superconducting magnetic energy storage (SMES) device.

[0010] FIG. **2**C is a plan view diagram illustrating an example superconducting magnetic energy storage (SMES) device.

[0011] FIG. **3** is a schematic block diagram illustrating an example superconducting magnetic energy storage (SMES) device.

[0012] FIG. **4** is a flow diagram illustrating example techniques for superconducting magnetic energy storage (SMES).

DETAILED DESCRIPTION

[0013] Superconducting magnetic energy storage (SMES) devices store energy in a magnetic field. SMES devices include a superconductor wound around a core, to form a coil, and at cryogenic temperatures the coil functions in a superconducting state. For example, the superconducting coil is cryogenically cooled bringing it into the superconducting state, such that the resistivity of the wire approaches zero (i.e., the coil has virtually no electrical resistance) and does not lose energy in the form of heat.

[0014] The SMES device operates in three modes set by the operation of power electronics equipment (e.g., a controller as described in more detail below). The SMES device stores energy in a magnetic field in a charge mode and a maintain mode, and dissipates the energy in a discharge mode. In a charge mode, current flows from a positive node to a negative node (or ground) via the winding of the SMES device. In a maintain mode, the current is diverted to circulate through the winding of the SMES device. In a discharge mode, the current is outputted to deliver power.

[0015] The flow of current through the winding during the charge mode creates a magnetic field. In the superconducting state, there is little loss in the current flowing through the winding meaning that the magnetic field is preserved in the maintain mode through the circulation of current in the winding. In this manner, the SMES device stores energy in a form of a magnetic field. Then, in the discharge mode, current flows out of the SMES device collapsing the magnetic field.

[0016] As a result, SMES devices allow virtually lossless energy storage in the superconducting state, while allowing for extremely fast charge and discharge capability. Because of these benefits of SMES devices, including the benefit that SMES devices function at cryogenic temperatures, SMES devices may be utilized to store relatively high amounts of energy and for rapid delivery of such energy.

[0017] SMES devices are typically cooled by bathing the SMES device in a tank of cryogenic fluid. The external tank of cryogenic fluid requires a large volume of space. Because space may be limited in potential SMES applications, the size of a SMES device and the energy stored in the SMES device is also limited.

[0018] The techniques described in this disclosure describe examples of SMES devices that reduce the total volume of space required to store a given amount of energy. In examples described in this disclosure, an SMES device may itself internally store the cryogenic fluid, rather than being placed in the tank of cryogenic fluid. Storing cryogenic fluid inside an SMES device may reduce the physical space required by the SMES device because it does not require a tank of cryogenic fluid. Likewise, storing cryogenic fluid inside a SMES device may allow use of a larger SMES in the same physical space that would otherwise be used by a tank of cryogenic fluid, thus storing more energy.

[0019] As described in more detail, in some examples, the cryogenic fluid stored inside the SMES device may include a cryogenic fuel such as liquid hydrogen such that the SMES device may also be used as a fuel tank. As a result, the SMES device may be used for dual purposes, namely storing energy in a magnetic field and in liquid form, thus storing more energy in a given physical space. Further, storing cryogenic fluid within the SMES device may counter the stress created by the superconducting coil on the surface of the SMES device by supporting the structure of the SMES device from the interior of the SMES device. This may further reduce the physical space required to store both electrical and chemical energy by combining the two storage systems.

[0020] FIG. **1** is a block diagram illustrating an example energy delivery system. Energy delivery system **2** includes gas pressurization tank **4**, power sources **12**A-**12**N, power converters **8**A-**8**N, supplemental power source **15** that includes superconducting magnetic energy storage (SMES) device **6** and controller **20**, DC bus **17**, and load **10**. Energy delivery system **2** may be part of a jet engine of an airplane or part of an engine of a ship such as a jet engine or ship engine configured to function in a super cooled, superconducting state.

[0021] Power sources **12**A-**12**N (collectively referred to as power sources **12**) may provide electrical power to devices of energy delivery system **2** and more generally to the other devices on the airplane or ship via power converters **8**. Power sources **12** may each deliver a respective fraction of the needed power (e.g., half if only two power sources), but may be capable of delivering all of the needed power. In this way, if one of power sources **12** is unable to provide power (e.g., due to a malfunction), the other ones of power sources **12** can still power all devices, including in the case where all but one power source **12** malfunctions. In some examples, one of power sources **12** may be the primary power source, and the others the redundant power sources. In such examples, in response to the primary power source being unable to provide power, the redundant power sources provide power. In some examples, multiple power sources **12** may not be necessary, and a single power source **12** may be sufficient. Examples of power sources **12** include batteries, solar panels, gas generators, and any other type of devices or utilities that can provide power.

[0022] Power converters **8**A-**8**N (collectively referred to as power converters **8**) may receive AC power from respective power sources **12** and output DC power (e.g., a DC current) to DC bus **17**. Load **10** and SMES device **6** receive the DC current from DC bus **17**. In examples where power sources **12** output DC power, power converters **8** may not be needed.

[0023] Examples of load **10** include a motor used to drive a propeller. In general, load **10** may be any device that receives electrical current from power converter **14** and for which supplemental power source **15** provides supplemental power. Load **10** may include any device that consumes power, such as motors of vehicles or aircraft, computing devices, lighting, or any other type of device that requires a voltage or current to operate. In some examples, load **10** may include hydrogen powered automobiles, spacecraft, rockets, or other hydrogen powered device.

[0024] If one of power sources **12** were to not be able to deliver power, there is a delay before the other one of power sources **12** can deliver all the power needed by the components (e.g., by load **10**). Supplemental power source **15** may be configured to deliver the needed power to load **10** during such a switch over time. Because load **10** may consume a relatively large amount of power, supplemental power source **15** may be configured to deliver such a relatively large amount of power in a relatively short amount of time.

[0025] For instance, as illustrated, supplemental power source **15** (also referred to as an uninterruptible power supply (UPS)) includes SMES device **6** and controller **20**. SMES device **6** stores energy in form of a magnetic field, and that energy can be delivered as a current to power load **10**. Controller **20** is configured to cause SMES device **6** to store the energy and cause SMES device **6** to deliver the current.

[0026] In some examples, in addition to or instead of acting as UPS, SMES device **6** acts as a ‘peaking’ unit where during short durations SMES device **6** is used to augment existing power sources (e.g., power from one or both of power sources **12**). For example, power sources **12** may be formed as gas turbines that provide the main source of power, but during certain maneuvers SMES device **6** provides a short, temporary source of power rather than trying to extract power from the gas turbine (e.g., one or more of power sources **12**). This would allow the gas turbine to avoid harsh transients, and may also be useful for examples of load **10** that come on/off quickly or for times when propulsion has to increase for only a short time.

[0027] Controller **20** may include any of a various types of discrete or analog circuitry (including integrated circuitry and/or programmable circuitry) for controlling components in different electrical paths through SMES device **6**. SMES device **6** may be well suited for storing large amounts of energy that needs to be delivered in a relatively short amount of time. For example, SMES device **6** may be configured to store greater than or equal to approximately tens mega-Joules (MJ), and possibly hundreds of MJ, of energy in a compact package that can be rapidly discharged, but storage of less or more energy is also contemplated.

[0028] Moreover, the components of energy delivery system **2** may be cryogenically cooled to a temperature dependent on the cryogen selected and the superconducting material to function in a superconducting state. It has been found that in a superconducting state the mass and/or size of various components such as power sources **12** and load **10** can be reduced, which may be beneficial for airplanes or ships.

[0029] SMES device **6** stores energy when SMES device **6** is configured in a superconducting state, which occurs when the wires of SMES device **6** are cooled to cryogenic temperatures. Because load **10** is, in some examples, already cooled to function at cryogenic temperatures, load **10** may directly interface with SMES device **6**, which is also cryogenically cooled. For instance, rather than SMES device **6**, if a battery backup that functions at room temperature were utilized for backup power, then additional interface components may be needed to interface load **10** to such a battery backup, which increases weight and cost.

[0030] As described above, SMES device **6** stores energy in the form of a magnetic field. For instance, SMES device **6** includes a superconductor wound around a core to form a winding around the core. SMES device **6** receives electrical power from power converter **14** and stores the power in the form of electromagnetic energy for purposes of delivering backup power or peaking power. The term “supplemental power” is used to refer generically to backup power or peaking power.

[0031] Power converter **14** may provide a direct current to the winding of SMES device **6**. Controller **20** configures electrical paths through SMES device **6** to a charge mode to allow current to flow through SMES device **6** causing SMES device **6** to create a magnetic field which is produced as the direct current flows through the winding. After a current is induced in the superconducting coil, controller **20** configures electrical paths through SMES device **6** to a maintain mode to short the winding and allow the current to circulate within the winding (e.g., no new electrons enter the winding). Thus SMES device **6** acts as a battery, storing energy in the magnetic field until the energy is required at some point in the future. Also, due to SMES device **6** being in the superconducting state, little to no current is lost and no power is lost from heat.

[0032] Later, when the stored energy is required by load **10**, controller **20** configures electrical paths through SMES device **6** to a discharge mode to interrupt the direct current circulating in the winding and cause the current to flow to load **10** (e.g., via power converter **14** or possibly directly to load **10**). In this way, during the charge mode, SMES device **6** creates a magnetic field, and in the maintain mode (also referred to as a steady-state mode), SMES device **6** stores energy in form of the magnetic field, and then in the discharge mode, the magnetic field collapses and the current flows out of SMES device **6**.

[0033] In some examples, controller **20** may control the states of the SMES device **6** using an H-bridge configuration (i.e., H-bridge **22**) that includes diodes and switches. For example, controller **20** may selectively open and close switches in such an H-bridge **22** to transition SMES device **6** from the charge mode to the maintain mode and from the maintain mode to the discharge mode.

[0034] For instance, after a current is induced in the superconducting winding, controller **20** may short H-bridge **22** so that the direct current circulates in the winding of SMES device **6**. When there is a need for the energy stored in SMES device **6**, controller **20** may open H-bridge **22** such that there is no longer a short in the circuit. Current from SMES device **16** may then flow to load **18**. In this way, SMES device **16** is configured to deliver the stored energy to load **18** (e.g., a motor) in response to one of power sources **12**A-**12**N turning off or in response to a need for peaking power (e.g., controller **20** may control SMES device **16** through the charge, maintain, and discharge modes for peaking power for short durations). In other words, SMES device **16** is configured to provide supplemental power as needed.

[0035] Gas pressurization tank **4** may include pressurized gas that may be input to SMES device **6**. The pressurized gas may be chosen based on the cooling requirements of power system **2** and the boiling point for a particular element. For example, if SMES device **6** is to be cooled below approximately **23** Kelvin, the pressurized gas may include helium (since helium's boiling point is approximately 4 K). Other gases may be chosen depending on the temperature required to maintain superconductivity in power system **2**. Gaseous pressurization may provide benefits to cryogenic fuel storage and SMES. First, it may provide a mechanism for reducing the forces on the SMES structure imposed by the magnetic field. Additionally, gaseous pressurization may be used to force delivery of the cryogenic fuel from the SMES tank without relying on fuel boil-off

[0036] In some examples, it may be beneficial to transport cryogenic fluid from SMES device **6** to load **10** and power source **12** (e.g., SMES device **6** provides power to a cryo-cooled generator). Thus, the electrical wires connecting SMES device **6** and load **10** may include superconducting wires. For example, the superconducting electrical wires may be bathed in cryogenic fluid. As a result, the electrical wires may provide simultaneous electrical and cryogenic fluid distribution, which may enable efficient distribution of current between SMES device **6** and load **10** while enabling flow of a cryogenic fluid along the same distribution path.

[0037] FIGS. **2**A and **2**B are cross-sectional diagrams illustrating an example superconducting magnetic energy storage (SMES) device. FIG. **2**C is a plan view diagram illustrating an example superconducting magnetic energy storage (SMES) device. SMES **20** may include housing **22**, superconducting coil **30**, and cryogenic fluid **34**.

[0038] Housing **22** may include high strength metals, such as high strength steel alloys (e.g., ferrite, austenite, graphite, etc.). Housing **22** may include a composite material, such as a high strength, low temperature composite (e.g., zylon fiber epoxy composite). Housing **22** may include a variety of shapes, such as a toroid, donut-shape, or any other shape suitable for generating and storing a magnetic field. In some examples, SMES **20** may include a hollow interior. At least a portion of toroid housing **22** may be hollow such that housing **22** may be used as a storage device. The interior of SMES **20** may include a vacuum. In some examples, the interior may include fluid and/or pressurized gas. For example, where housing **22** includes a hollow toroid, housing **22** may be used to store fluid.

[0039] SMES **20** may include a plurality of chambers. For example, SMES **20** may be partitioned to include vacuum cryostat **24** and cryogenic chamber **28**. In some examples, SMES **20** may include cooling reservoir **26**. In some examples, the plurality of chambers may be positioned in concentric shapes within housing **22**. As illustrated in FIG. **2**A, vacuum cryostat **24** and cooling reservoir **26** have approximately the same thickness. However, FIGS. **2**A-**2**C are not necessarily drawn to scale, such that cryogenic chamber **28** may occupy more volume than shown in FIGS. **2**A-**2**B while cooling reservoir **26** may occupy less volume than shown in FIGS. **2**A-**2**B. For example, cooling reservoir **26** may be approximately the same thickness as vacuum cryostat **24**, may include a thin layer of cryogenic fluid **34**, or may be any suitable thickness to assist in cooling superconducting coil **30**.

[0040] Vacuum cryostat **24** includes a vacuum cryostat structure **25**A, which may include high strength metals or a composite material, as described above with reference to housing **22**. Vacuum cryostat structure **25**A may include the outer layer of housing **22**. Vacuum cryostat **24** includes vacuum (or near vacuum) region **25**B that is used to prevent external heat sources from heating cryogenic fluid **34** and superconducting coil **30**. Vacuum cryostat **24** may include radiative insulation **25**C including radiation resistant material, such as mylar, which may help reduce heat transfer from radiation. Vacuum cryostat **24** may not be necessary in every example.

[0041] In some examples, cryogenic chamber **28** includes cryogenic chamber structure **29**., which may include high strength metals or a composite material, as described above with reference to housing **22**. Cryogenic chamber **28** may include pressurized gas **32** and cryogenic fluid **34**. Cryogenic chamber **28** may include sub-chambers, for example, pressurized gas **32** and cryogenic fluid **34** may be separated by a physical barrier. Pressurized gas **32** may include gaseous helium, gaseous hydrogen, or gaseous nitrogen. Cryogenic fluid **34** may be pressurized, and may include liquid helium. In some examples, cryogenic fluid **34** may include fuel that may be used to power an engine (e.g., load **10**). For example, cryogenic fluid **34** may include liquid hydrogen, liquid helium, or liquid natural gas. In some instances, cryogenic fluid **34** may include liquid helium and pressurized gas **32** may include gaseous helium. In some examples, cryogenic fluid **34** may include liquid hydrogen and pressurized gas **32** may include gaseous helium or gaseous hydrogen. Cryogenic fluid **34** may boil to produce pressurized gas **32**. However, in some examples, pressurized gas **32** may include gas from gas pressurization tank **4**.

[0042] For illustration purposes only, FIG. **2**A shows equal volume of pressurized gas **32** and cryogenic fluid **34**. However, it is to be understood that cryogenic chamber **20** does not necessarily include a physical barrier between pressurized gas **32** and cryogenic fluid **34**, nor are there necessarily equal volumes of pressurized gas **32** and cryogenic fluid **34**. Instead, cryogenic chamber **28** may be filled almost entirely with cryogenic fluid **34** and may not include any, or a relatively small amount of, pressurized gas **32**. If cryogenic fluid **34** is used as fuel, the volume of cryogenic fluid **34** decreases as the fuel is consumed such that space occupied by pressurized gas **32** increases. In some examples, additional pressurized gas **32** may be pumped into cryogenic chamber **28** as cryogenic fluid **34** is consumed (e.g., by gas pressurization tank **4**).

[0043] In some examples, SMES **20** may include cooling reservoir **26** and a transfer port **36**. Cooling reservoir **26** includes cooling reservoir structure **27**A and cooling reservoir fluid **27**B. Cooling reservoir fluid **27**B cools superconducting coil **30**. Transfer port **36** may include an opening between cryogenic chamber **28** and cooling reservoir **26**, which may enable cryogenic fluid **34** to flow between cryogenic chamber **28** and cooling reservoir **26**. For example, where cryogenic fluid **34** includes liquid hydrogen, cooling reservoir fluid **27**B may include cryogenic fluid **34** that drains from cryogenic chamber **28** to cooling reservoir **26** to cool superconducting coil **30**. Cooling reservoir fluid **27**B may then be transported from cooling reservoir **26** to an engine (e.g., load **10**). In some examples, transfer port **36** may be situated so as to evacuate pressurized gas **32** from cryogenic chamber **28** to cooling reservoir **26**, such that cooling reservoir fluid **27**B may include pressurized gas **32**.

[0044] Superconducting coil **30** may be located within SMES **20**. For example, superconducting coil **30** may be affixed on the outer surface of cryogenic chamber **28** (e.g., cryogenic chamber structure **29**). Cryogenic fluid **34** within cryogenic chamber **28** may cool the interior surface of cryogenic chamber **28**, which in turn may cool superconducting coil **30**. In some examples, where SMES **20** includes cooling reservoir **26**, cryogenic fluid **34** may drain from cryogenic chamber **28** into cooling reservoir **26**, such that superconducting coil **30** is also cooled via direct contact with cryogenic fluid **34** (labeled as cooling reservoir fluid **27**B once fluid **34** flows into cooling reservoir **26**) inside cooling reservoir **26**.

[0045] In operation, cryogenic fluid **34** stored in cryogenic chamber **28** cools superconducting coil **30**. A current may be induced in superconducting coil **30** by an outside power source, which generates a magnetic field in SMES **20**. Once sufficient current is generated in superconducting coil **30**, superconducting coil **30** may be disconnected from the outside power source, for example, by shorting H-bridge **22**. As a result, current may flow through superconducting coil **30** indefinitely.

[0046] Further, in some examples, cryogenic chamber **28** may be used as a fuel tank and cryogenic fluid **34** may provide fuel to an engine or fuel cell. For example, SMES **20** may act as a cryogenic fuel tank, storing liquid hydrogen in cryogenic chamber **28**, such that the liquid hydrogen may fuel an engine.

[0047] As a result, the liquid hydrogen may, in some examples, cool superconducting coil **30** to a superconducting state in order to store energy in a magnetic field, while simultaneously providing fuel to an engine (e.g., load **10** that is also in a superconducting state from the cooling from the liquid hydrogen). Thus, SMES **20** may store two forms of energy (e.g., electromagnetic and fuel) in the same volume of space, which may allow for smaller fuel tanks or more energy storage in a given volume of space.

[0048] FIG. **3** is a schematic block diagram illustrating an example superconducting magnetic energy storage (SMES) device. A controller balances the pressure inside SMES **6** with the magnetic forces created by superconducting coil **30**. The internal pressure may be managed proportionally to the current in the superconducting coil **30**, or proportionally to the field strength, to counteract the magnetic force and reduce the require mass of the structure.

[0049] FIG. **4** is a flow diagram illustrating example techniques for a superconducting magnetic energy storage (SMES). In some examples, SMES **6** of FIG. **2** may be configured to store cryogenic fluid **34** (**42**). Cryogenic fluid **34** may include liquid helium or liquid hydrogen. Cryogenic fluid **34** may cool SMES **6** to a superconducting state. SMES **6** may receive power from power source **12** of FIG. **1**. When SMES **6** is in a superconducting state, SMES **6** may store power from power source **12** for delivery to one or more external devices (e.g., load **10**) (**44**). The external devices may include the motor of a vehicle, rocket, or spacecraft, or any other device that consumes power. In some examples, SMES **6** may output cryogenic fluid **34** to the one or more external devices which may provide fuel and/or cooling to the one or more external devices. In some examples, SMES **6** may output electric power to power converter **8** or output power directly to the one or more external devices.

[0050] Various examples of this disclosure have been described. These and other examples are within the scope of the following claims.

What is claimed is:

1. A superconducting magnetic energy storage (SMES) device comprising:

a toroidal housing configured to store a cryogenic fluid that cools the SMES to a superconducting state; and

a coil, wherein the coil is configured to be in the superconducting state from cooling from the cryogenic fluid and configured to store power for delivery to one or more external devices.

2. The SMES device of claim **1**, wherein the cryogenic fluid cools the one or more external devices to a superconducting state.

3. The SMES device of claim **1**, wherein the toroidal housing further comprises a plurality of chambers, wherein at least one chamber in the plurality of chambers stores the cryogenic fluid.

4. The SMES device of claim **3**, wherein the coil is wrapped around a chamber of the plurality of chambers.

5. The SMES device of claim **3**, wherein the plurality of chambers comprise concentric chambers.

6. The SMES device of claim **3**, wherein a first chamber of the plurality of chambers includes a vacuum cryostat and a second chamber of the plurality of chambers includes the cryogenic fluid.

7. The SMES device of claim **3**, wherein the plurality of chambers includes a cooling reservoir, wherein the cooling reservoir provides the cryogenic fluid to the one or more external devices.

8. The SMES device of claim **1**, wherein the cryogenic fluid is provided to one or more external devices as fuel, wherein the cryogenic fluid comprises one or more of:

liquid hydrogen, liquid helium or liquid natural gas.

9. The SMES device of claim **1**, wherein the toroidal housing further comprises a pressurized gas.

10. The SMES device of claim **9**, wherein the pressurized gas comprises one or more of:

helium, hydrogen, or nitrogen.

11. A system comprising:

a controller;

a gas pressurization tank;

a power converter; and

a superconducting magnetic energy storage (SMES) device comprising:

a cryogenic fluid that cools the SMES to a superconducting state; and

a toroidal housing configured to store the cryogenic fluid;

a coil, wherein the coil is configured to be in the superconducting state from cooling from the cryogenic fluid and configured to store power for delivery to one or more external devices.

12. The system of claim **11**, wherein the cryogenic fluid cools the one or more external devices to a superconducting state.

13. The system of claim **11**, wherein the toroidal housing further comprises a plurality of chambers, wherein at least one chamber in the plurality of chambers stores the cryogenic fluid.

14. The system of claim **13**, wherein the coil is wrapped around a chamber of the plurality of chambers.

15. The system of claim **13**, wherein the plurality of chambers comprise concentric chambers.

16. The system of claim **13**, wherein a first chamber of the plurality of chambers includes a vacuum cryostat and a second chamber of the plurality of chambers includes the cryogenic fluid.

17. The system of claim **13**, wherein the plurality of chambers includes a cooling reservoir, wherein the cooling reservoir provides the cryogenic fluid to the one or more external devices.

18. The system of claim **11**, wherein the cryogenic fluid is provided to one or more external devices as fuel, wherein the cryogenic fluid comprises one or more of: liquid hydrogen, liquid helium, or liquid natural gas, wherein the gas pressurization tank includes a pressurized gas, and wherein the pressurized gas comprises one or more of: helium, hydrogen, or nitrogen.

19. A method for a superconducting magnetic energy storage (SMES) device comprising:

storing, in the SMES device, a cryogenic fluid that cools the SMES to a superconducting state; and

storing, with the SMES device being in the superconducting state, power for delivery to one or more external devices.

20. The method of claim **19**,

wherein storing the cryogenic fluid comprises storing the cryogenic fluid in a toroidal housing, and

wherein storing power comprises storing in a coil wrapped around a chamber within the toroidal housing, wherein the coil is configured to be in the superconducting state from cooling from the cryogenic fluid.

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