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(54) HYDROGEN ENERGY SYSTEMS

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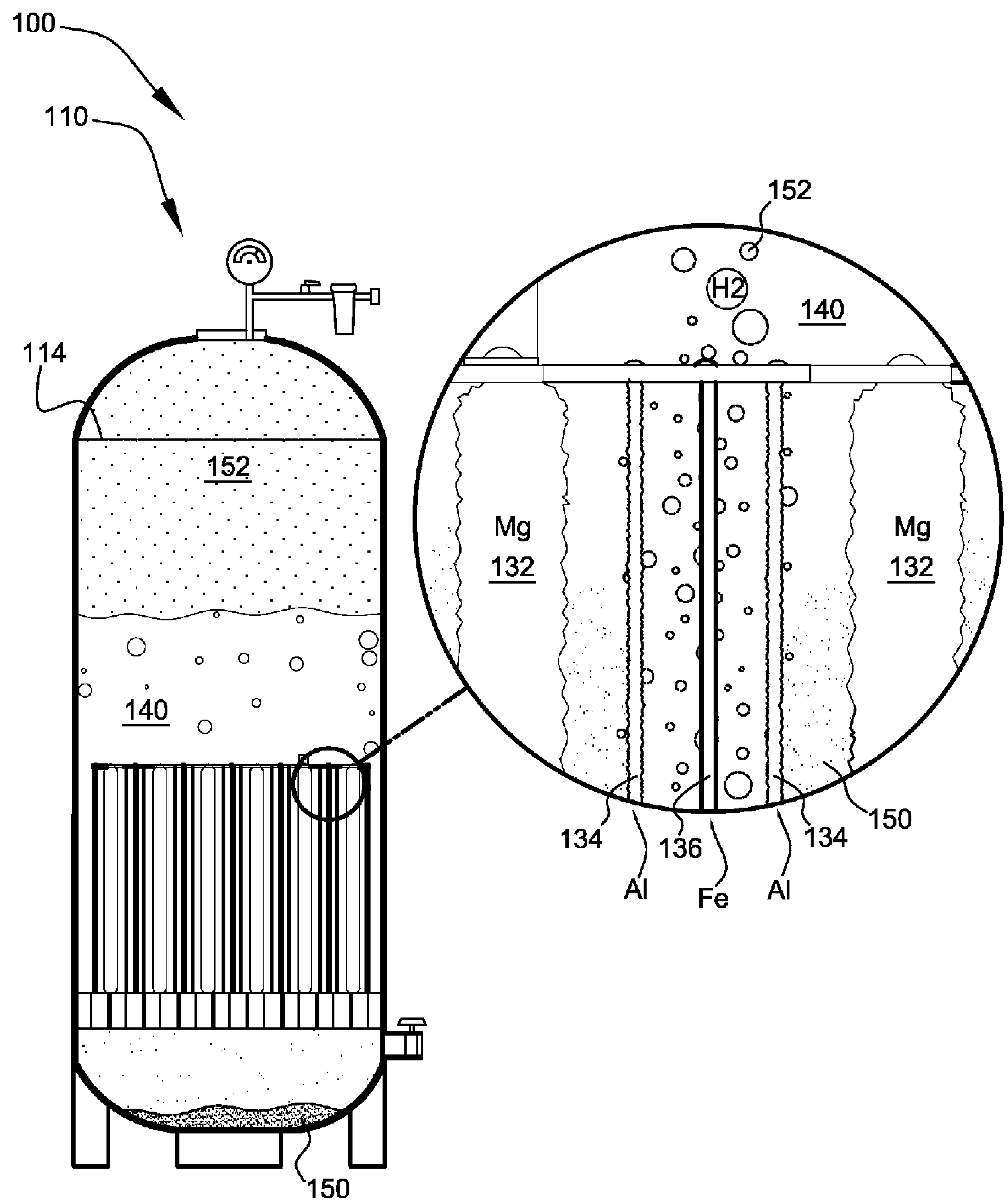
C25B 9/00 (2006.01)

(52) U.S. Cl. 204/242

(57) **ABSTRACT**

A hydrogen energy system comprising galvanic hydrogen generators and hydrogen input manifolds for vehicle engines. The galvanic hydrogen generators generate hydrogen gas, magnesium hydroxide, and heat by the galvanic reaction of magnesium anodes with steel cathodes in salt water. Heat exchangers channel excess heat to a heat sink such as a thermocouple, Stirling engine, hot water system, etc. The hydrogen input manifold is bolted between the engine block and the air intake manifold of a gasoline or diesel engine. Hydrogen gas is injected into the hydrogen input manifold to provide supplementary fuel to the engine, lowering the amount of petroleum that is used.



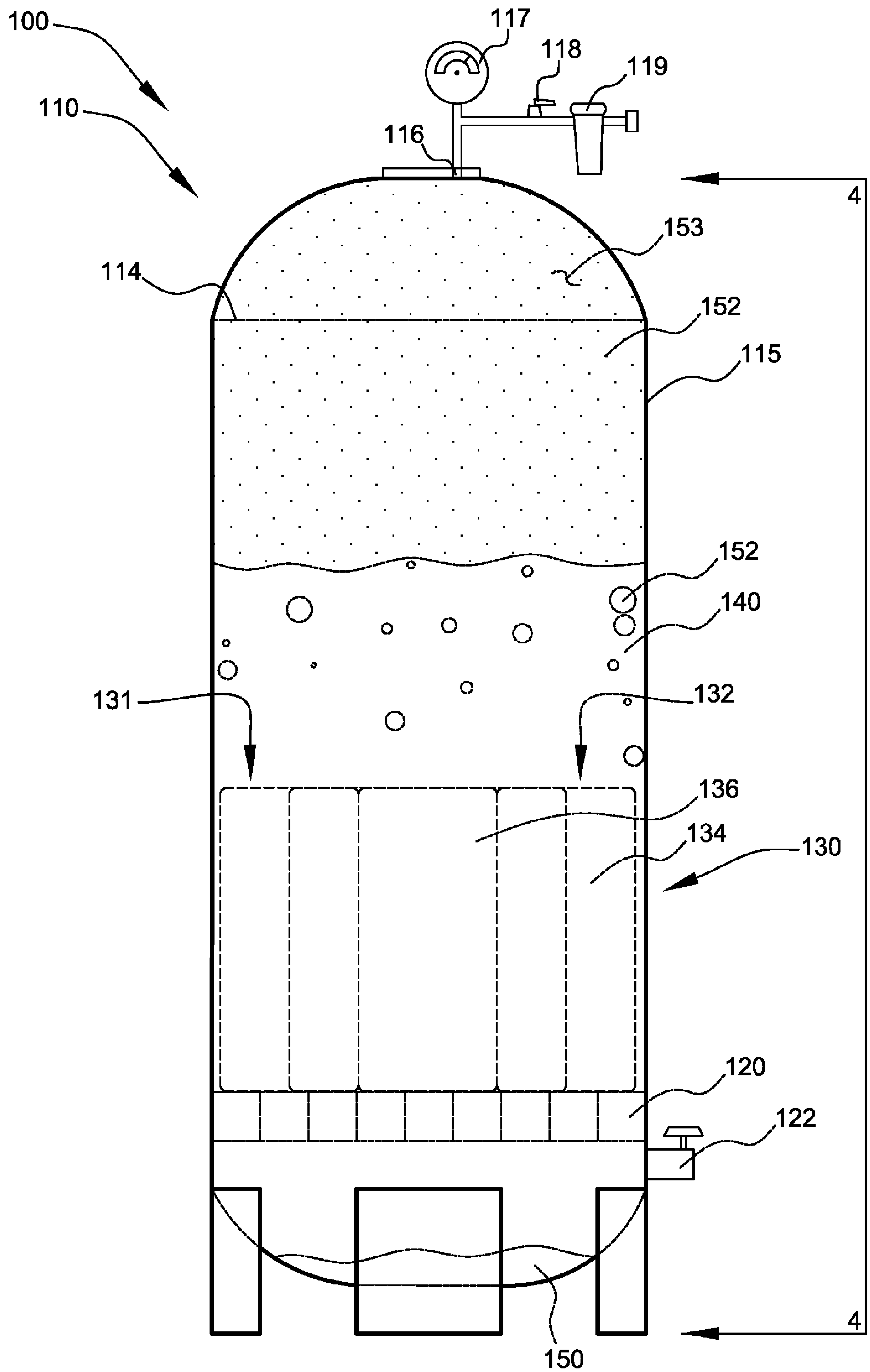

100
110
117
118
119
116
153
114
152
115
152
140
131
132
136
134
130
120
122
150
4
4

FIG. 1

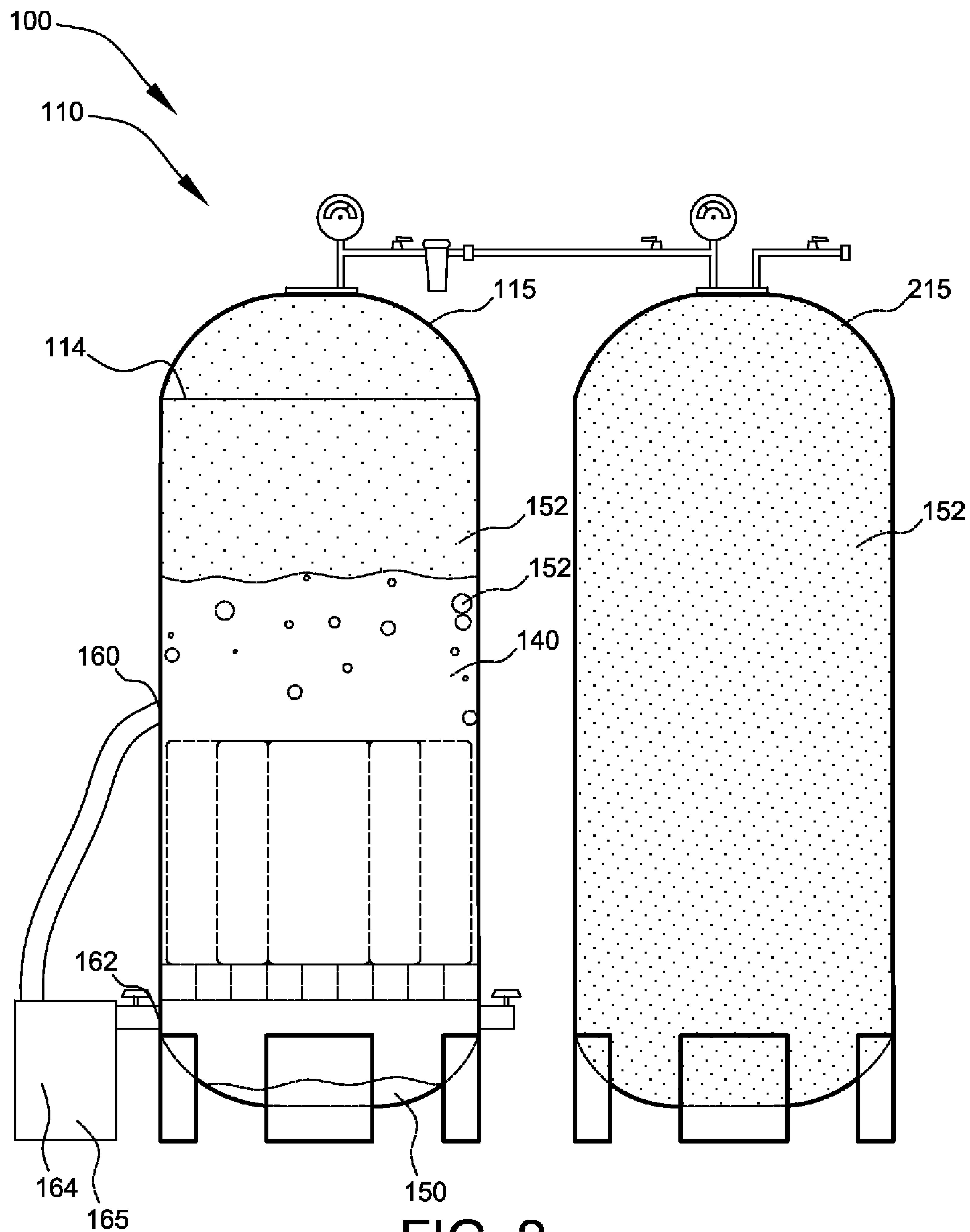


FIG. 2

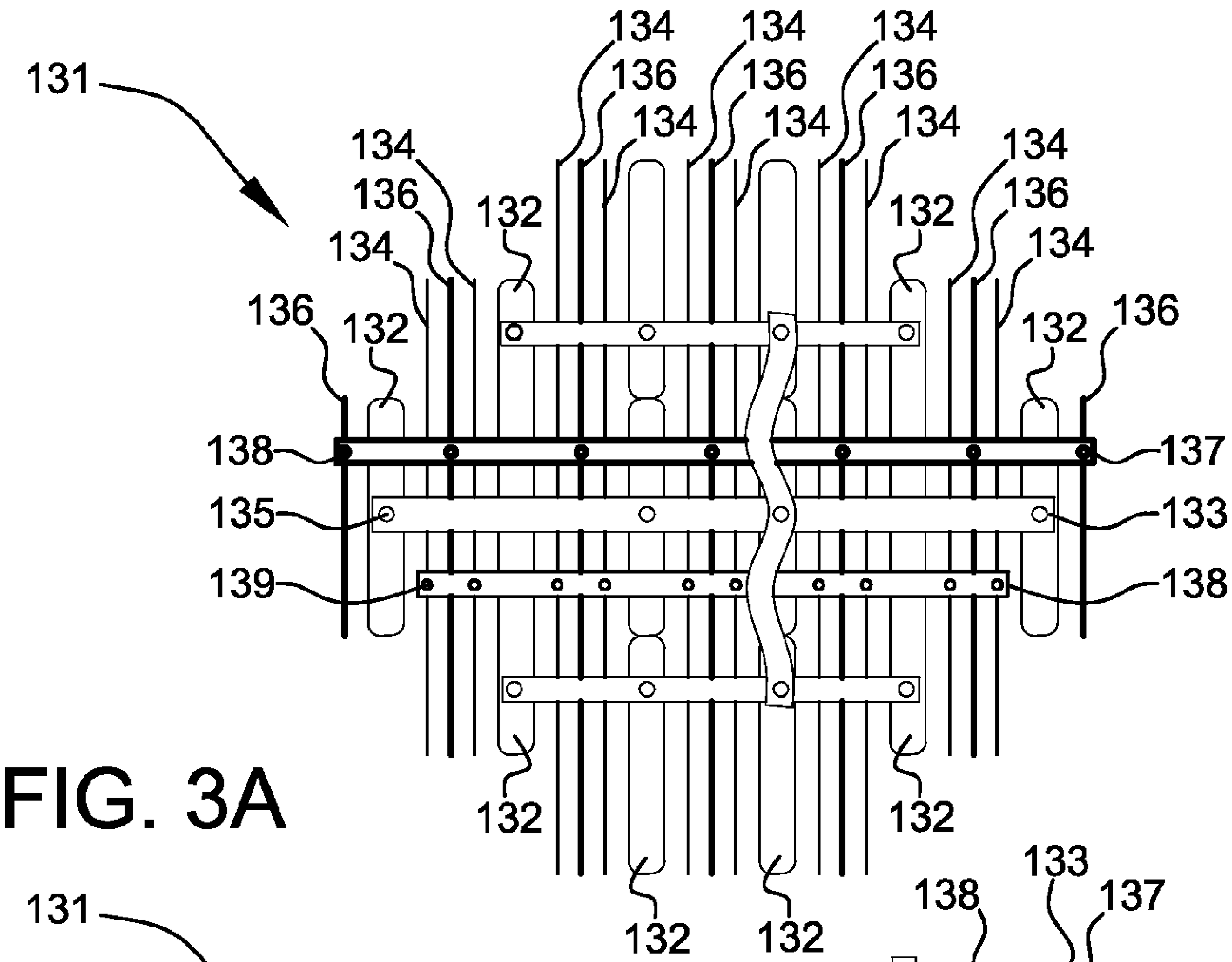


FIG. 3A

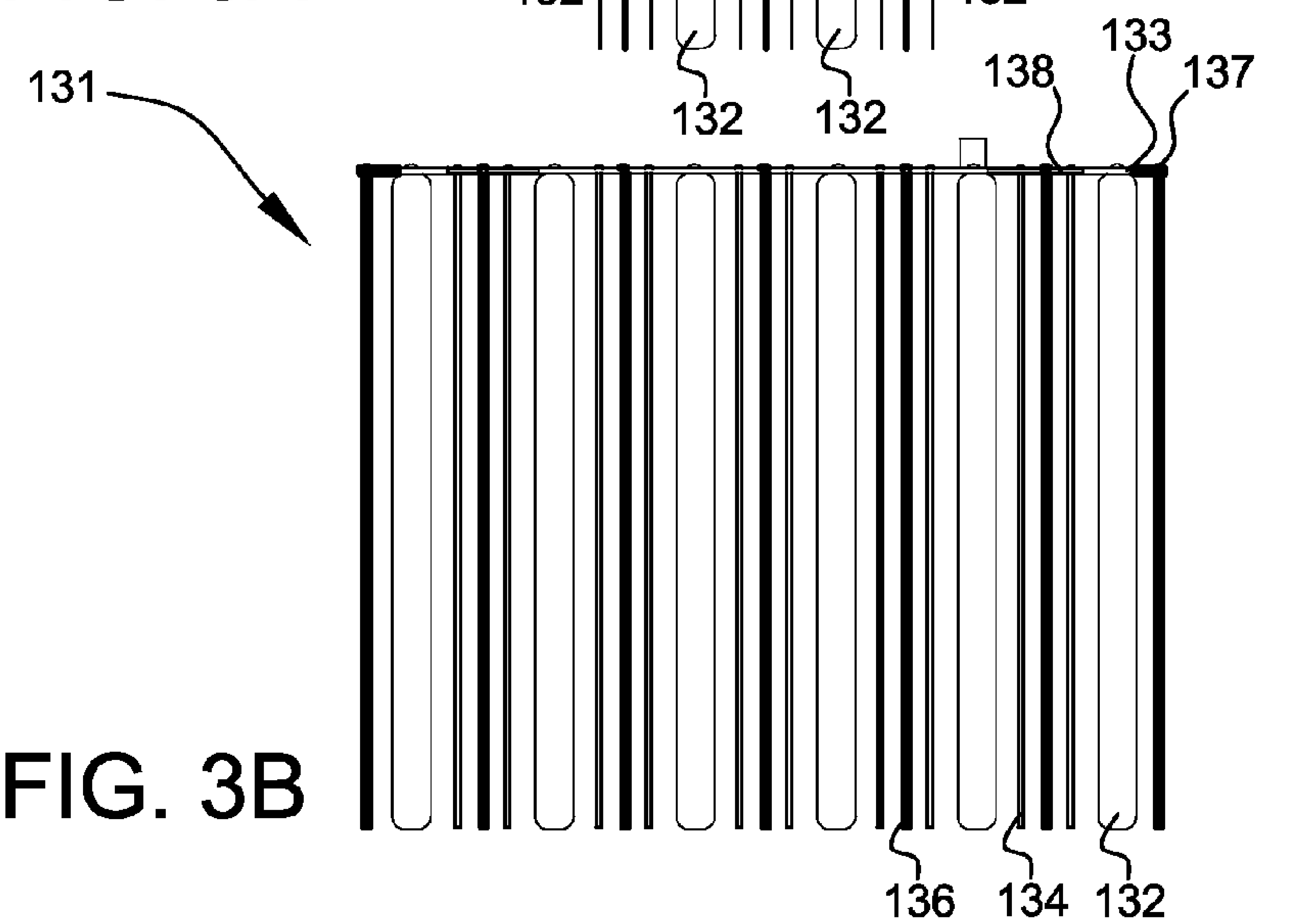


FIG. 3B

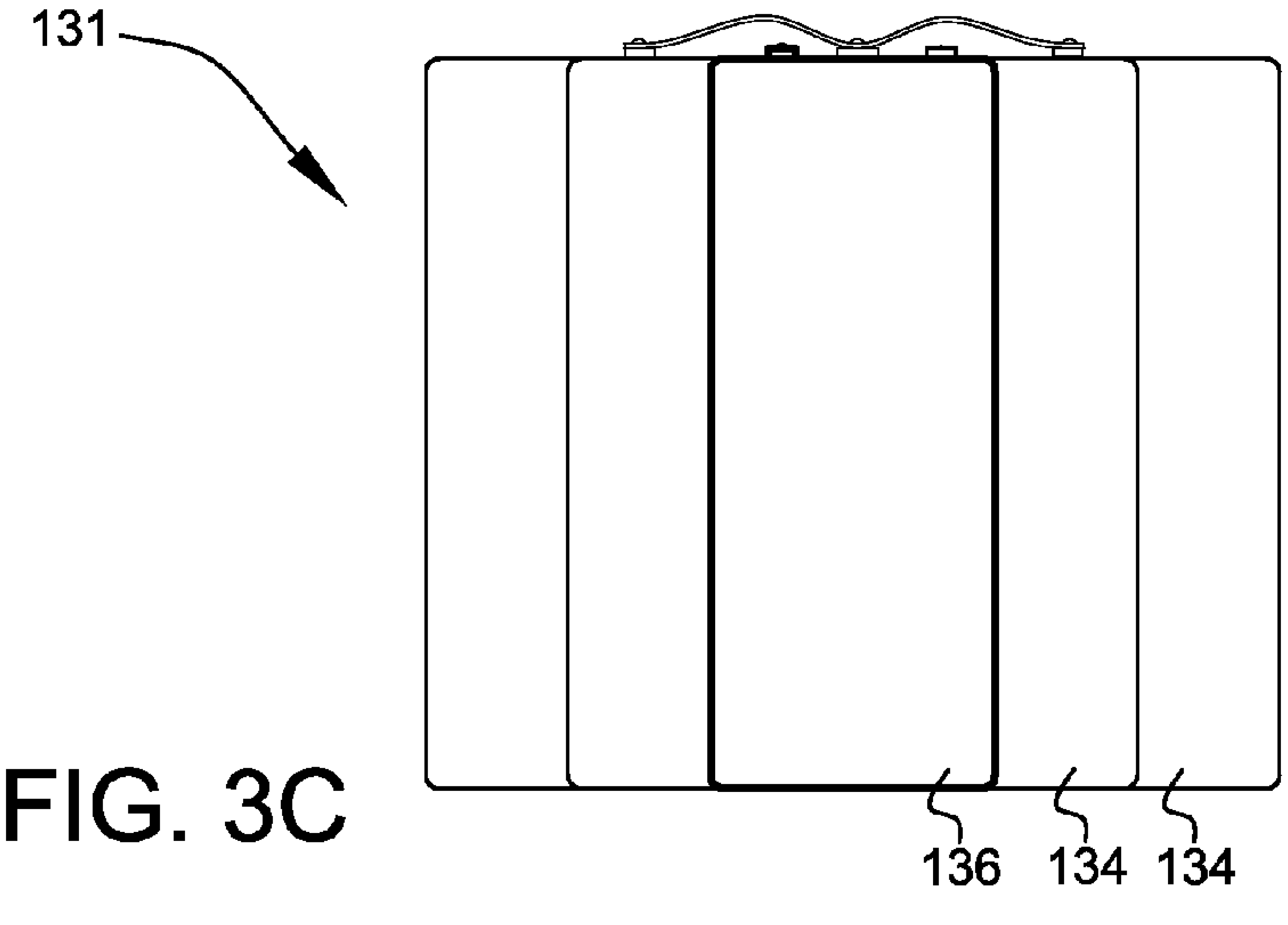


FIG. 3C

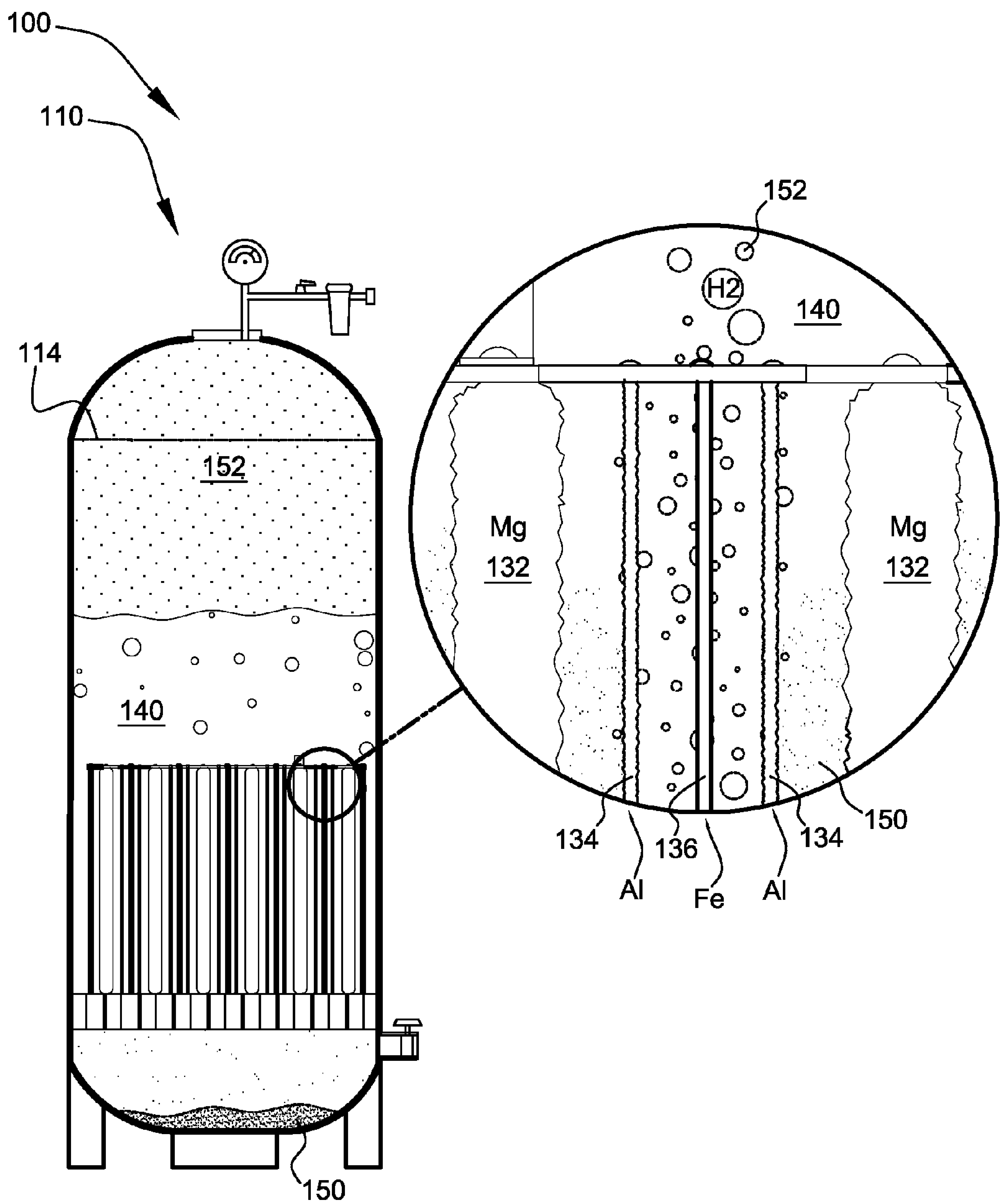

100
110
114
152
140
150
152
H2
140
Mg
132
Mg
132
134
136
134
150
Al
Fe
Al

FIG. 4

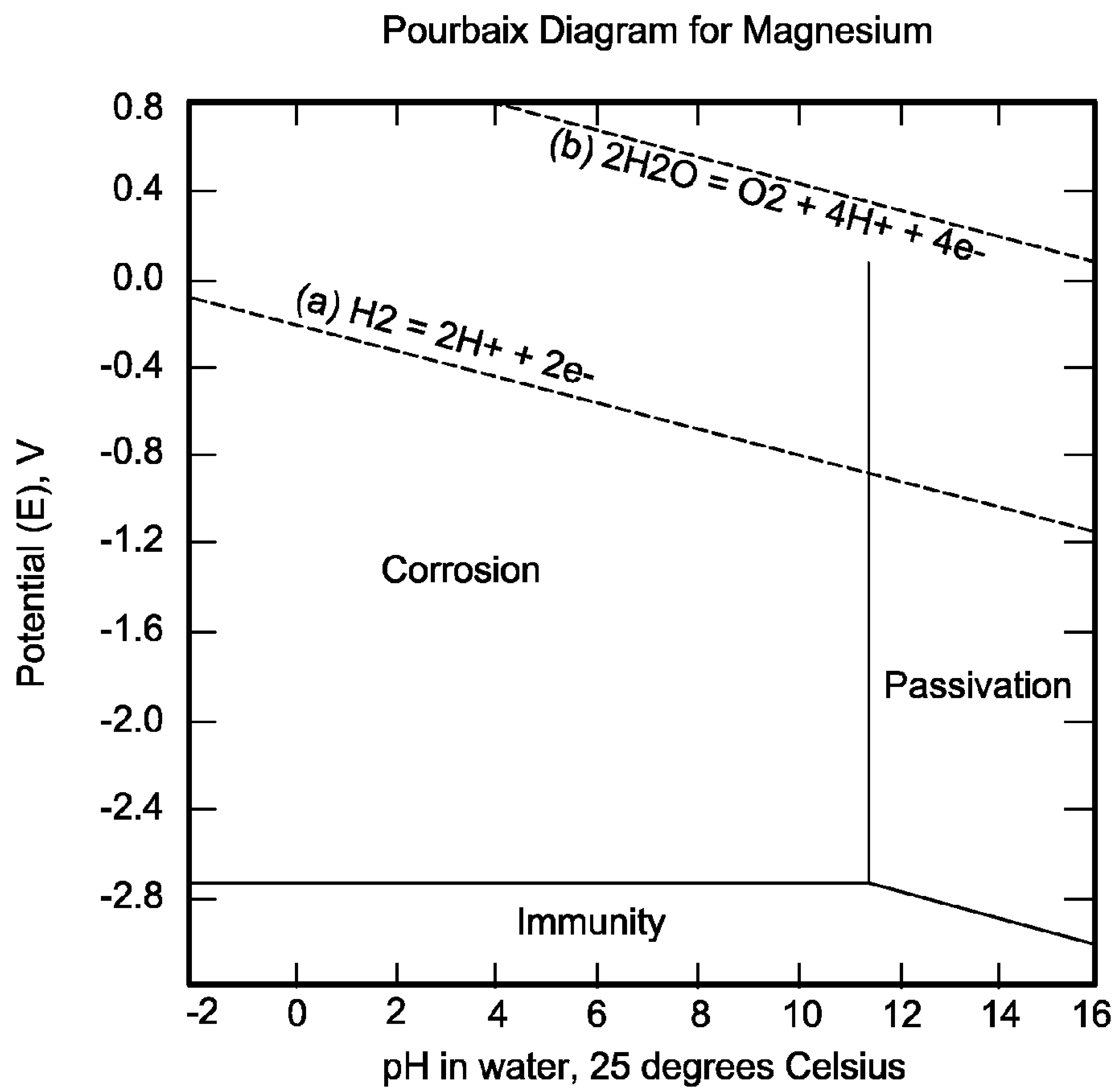

Pourbaix Diagram for Magnesium
(b) 2H2O = O2 + 4H+ + 4e-
(a) H2 = 2H+ + 2e-
Corrosion
Passivation
Immunity
Potential (E), V
0.8
0.4
0.0
-0.4
-0.8
-1.2
-1.6
-2.0
-2.4
-2.8
-2
0
2
4
6
8
10
12
14
16
pH in water, 25 degrees Celsius

FIG. 5

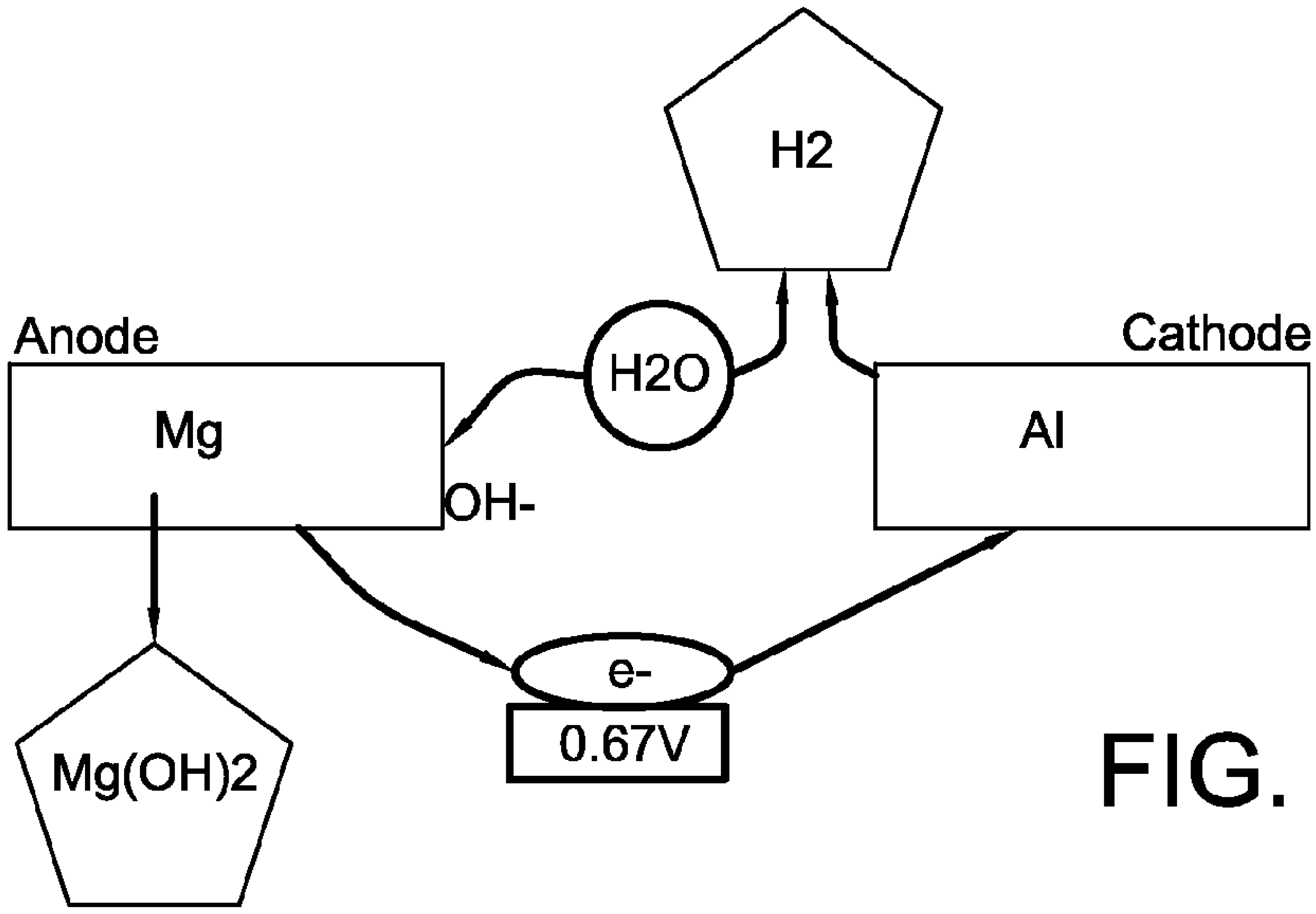


FIG. 6A

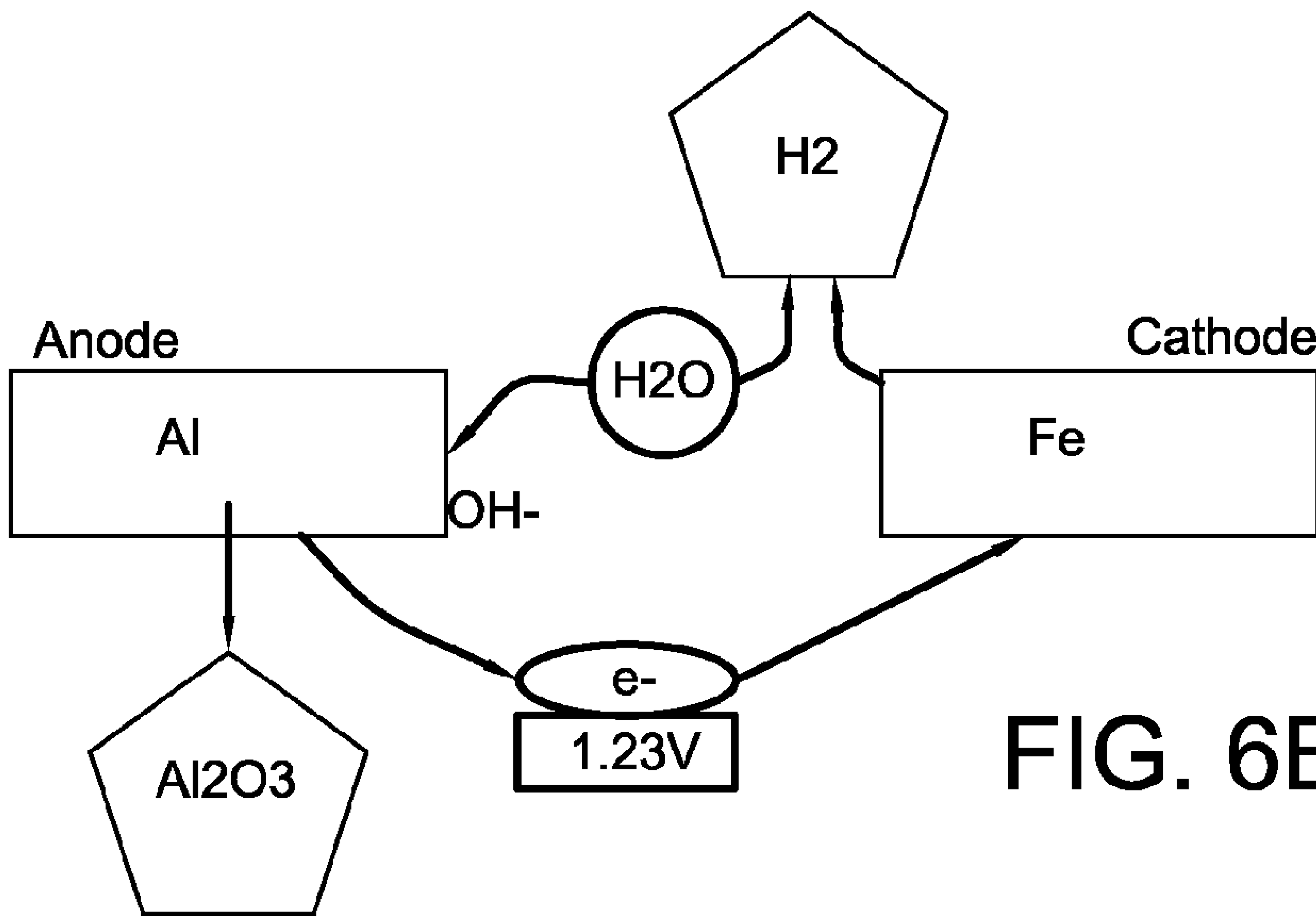


FIG. 6B

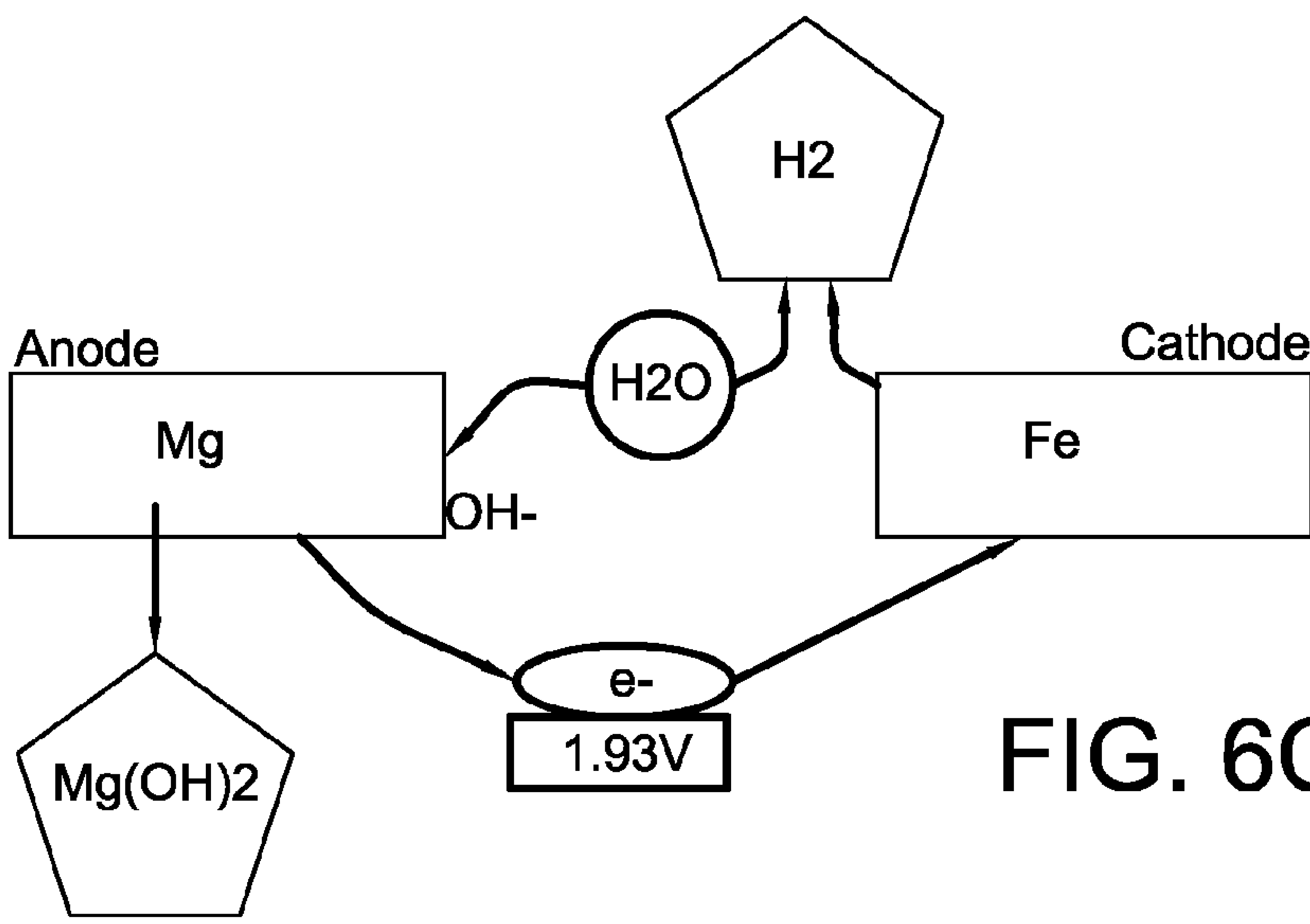


FIG. 6C

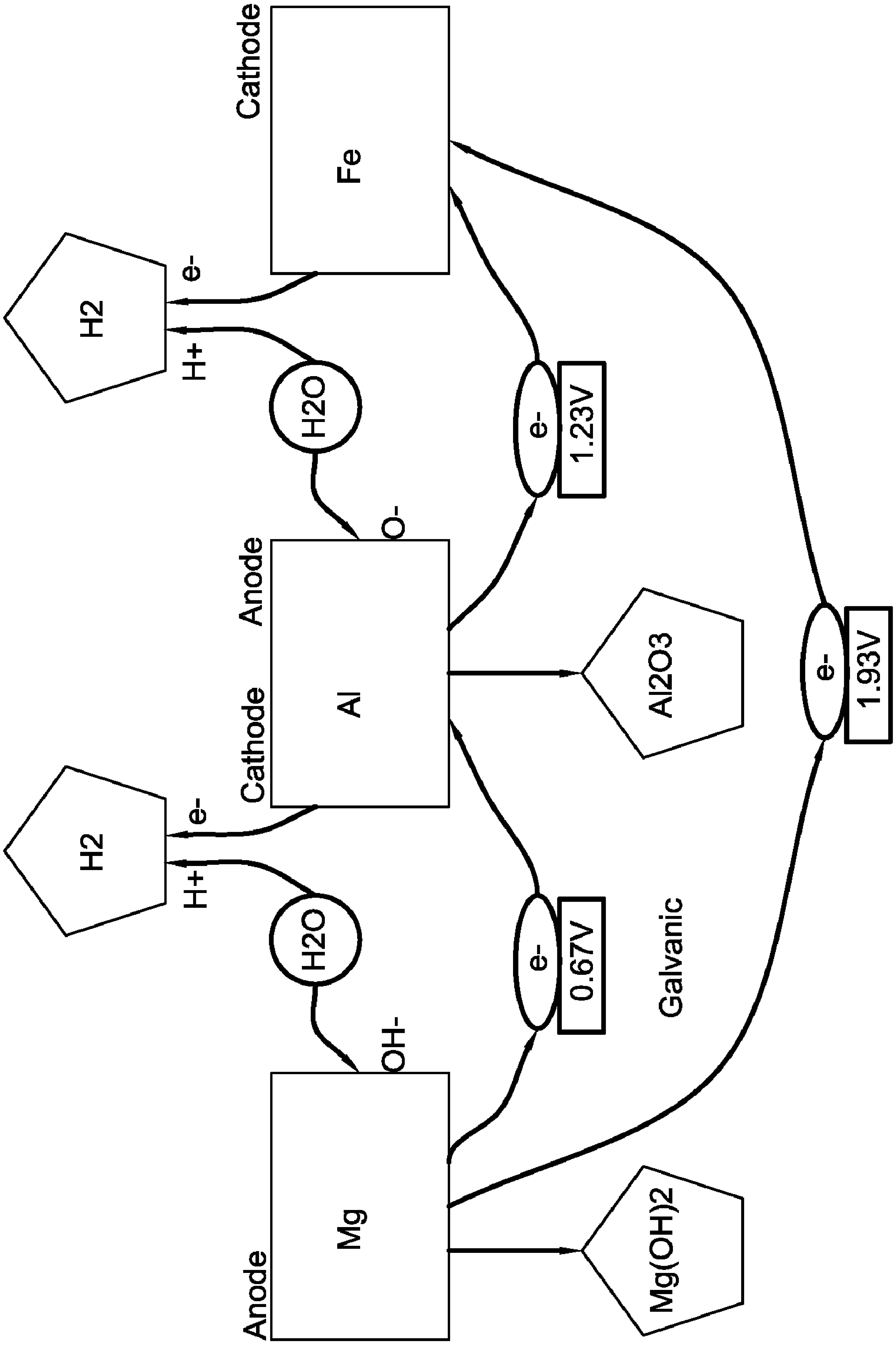

Cathode
Fe
H2
e-
H+
H2O
O-
e-
1.23V
Anode
Cathode
Al
Al2O3
e-
1.93V
H2
e-
H+
H2O
OH-
e-
0.67V
Galvanic
Anode
Mg
Mg(OH)2

FIG. 7

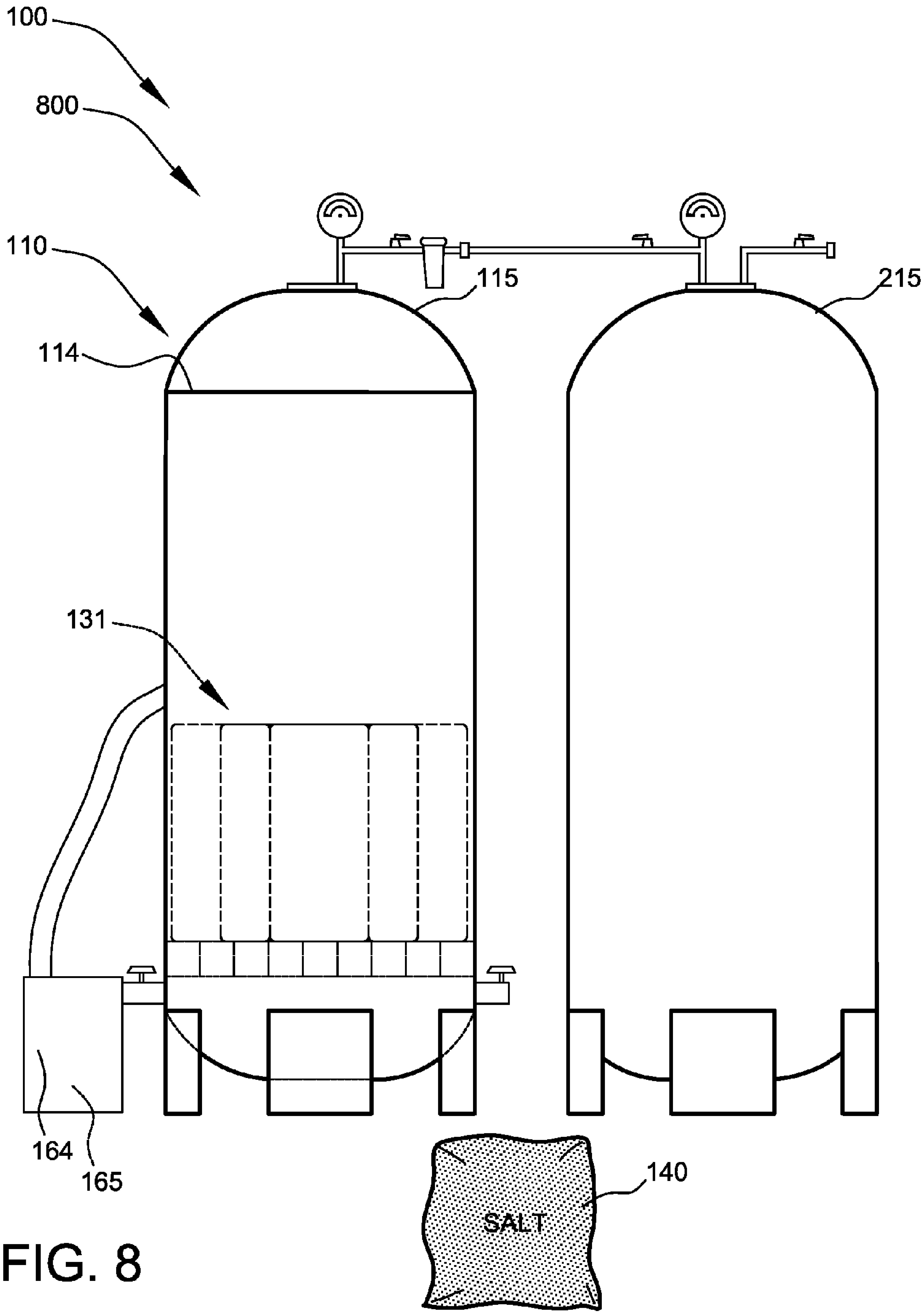


FIG. 8

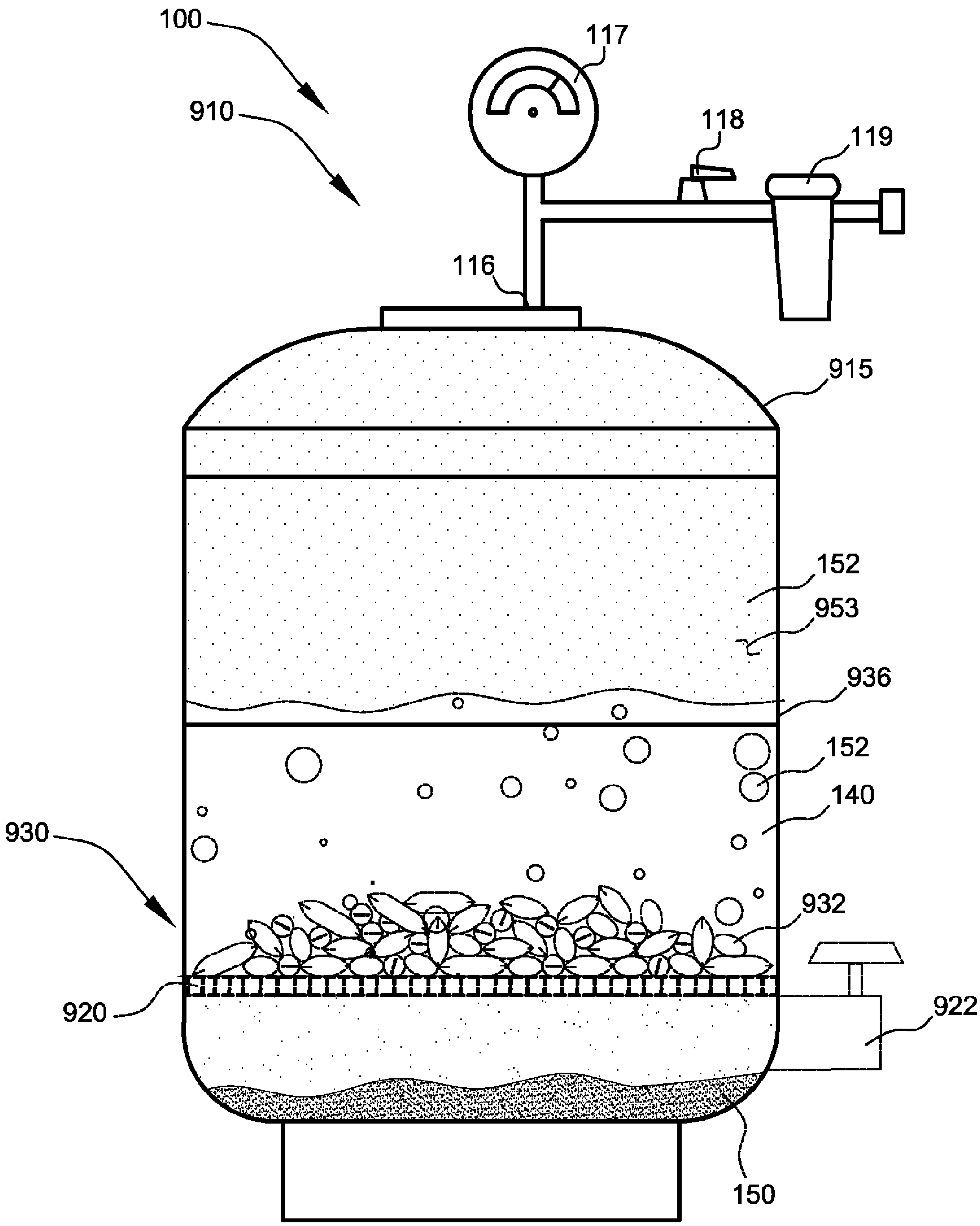

100
910
117
118
119
116
915
152
953
936
152
140
930
932
920
922
150

FIG. 9

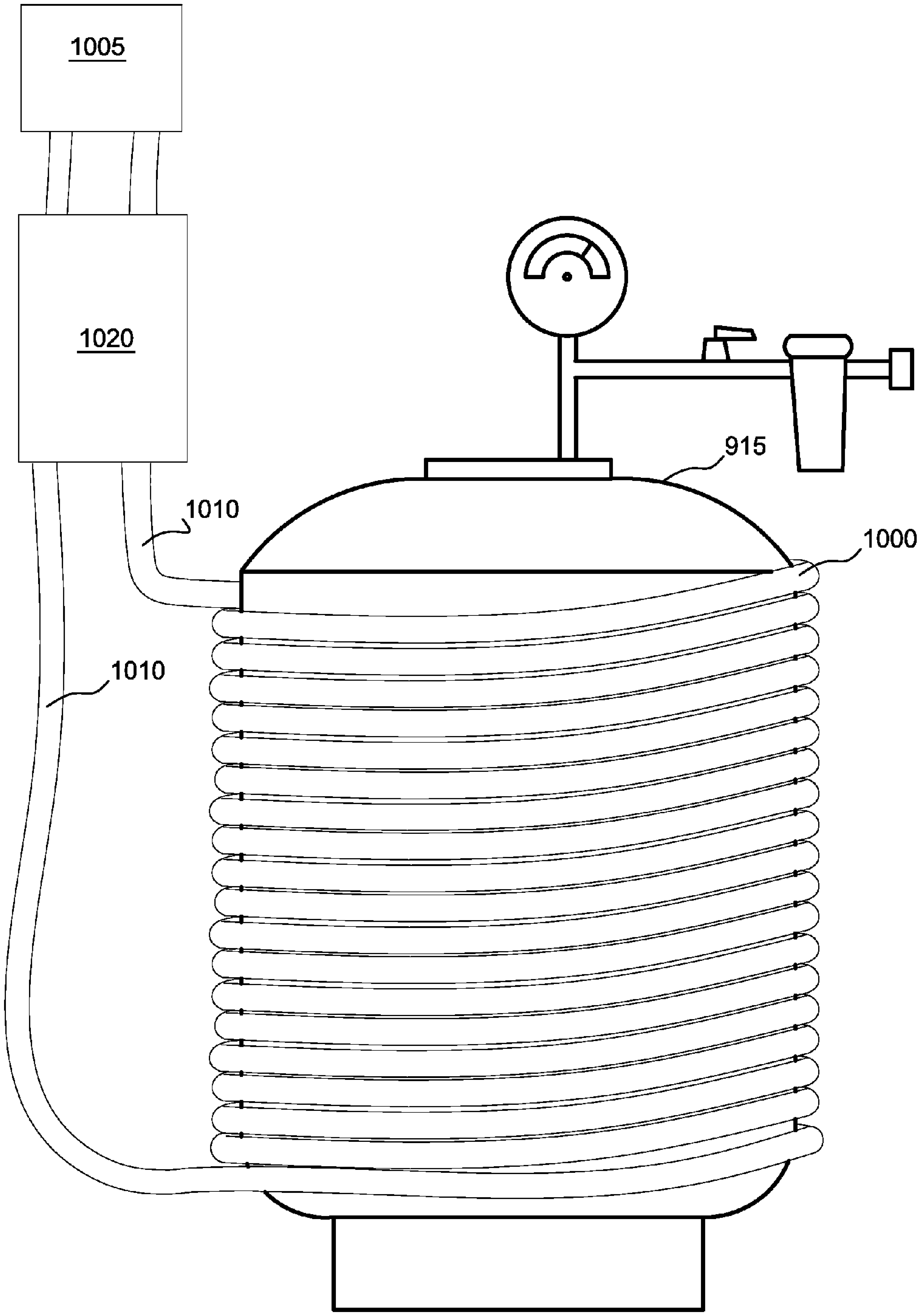


FIG. 10

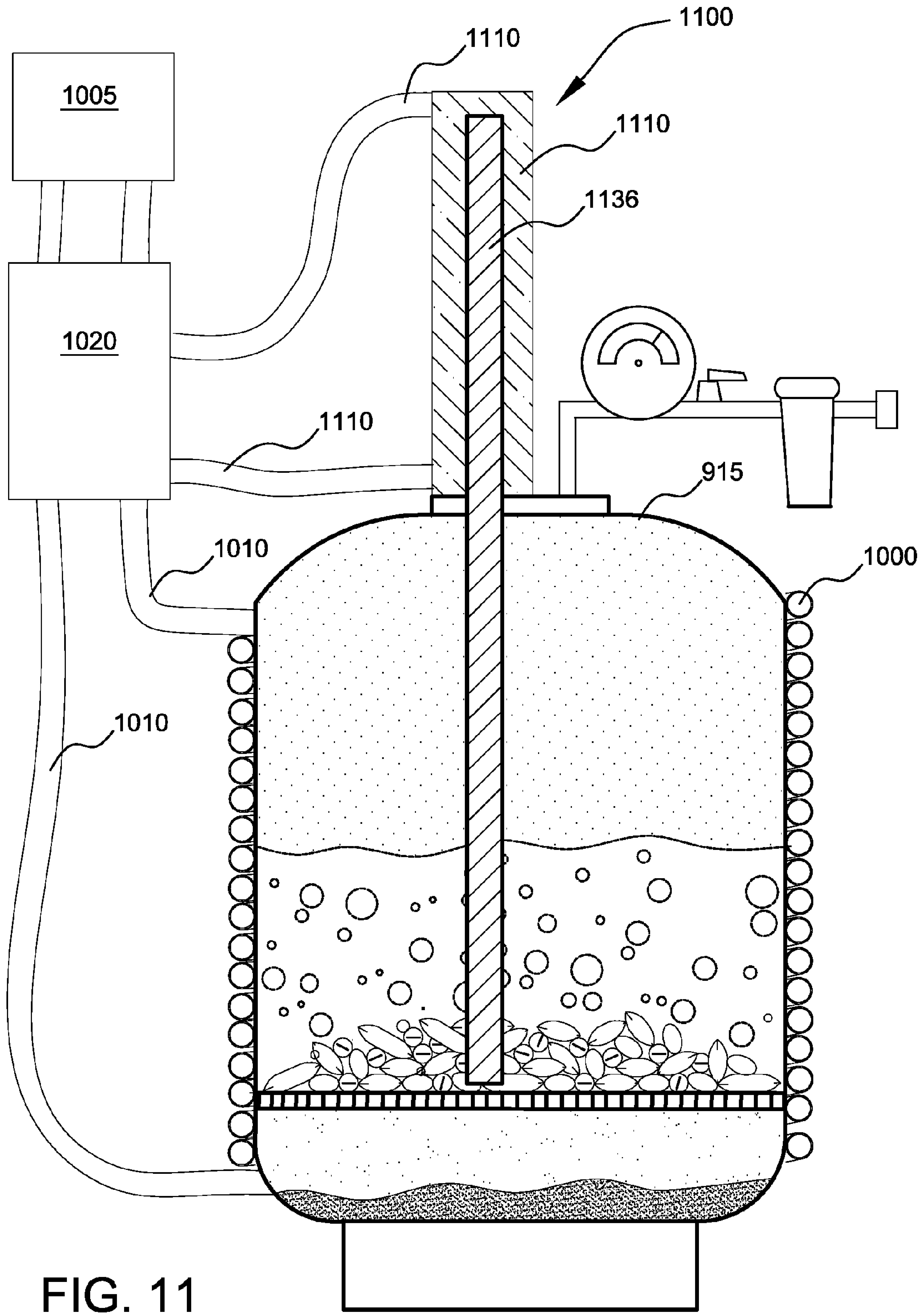


FIG. 11

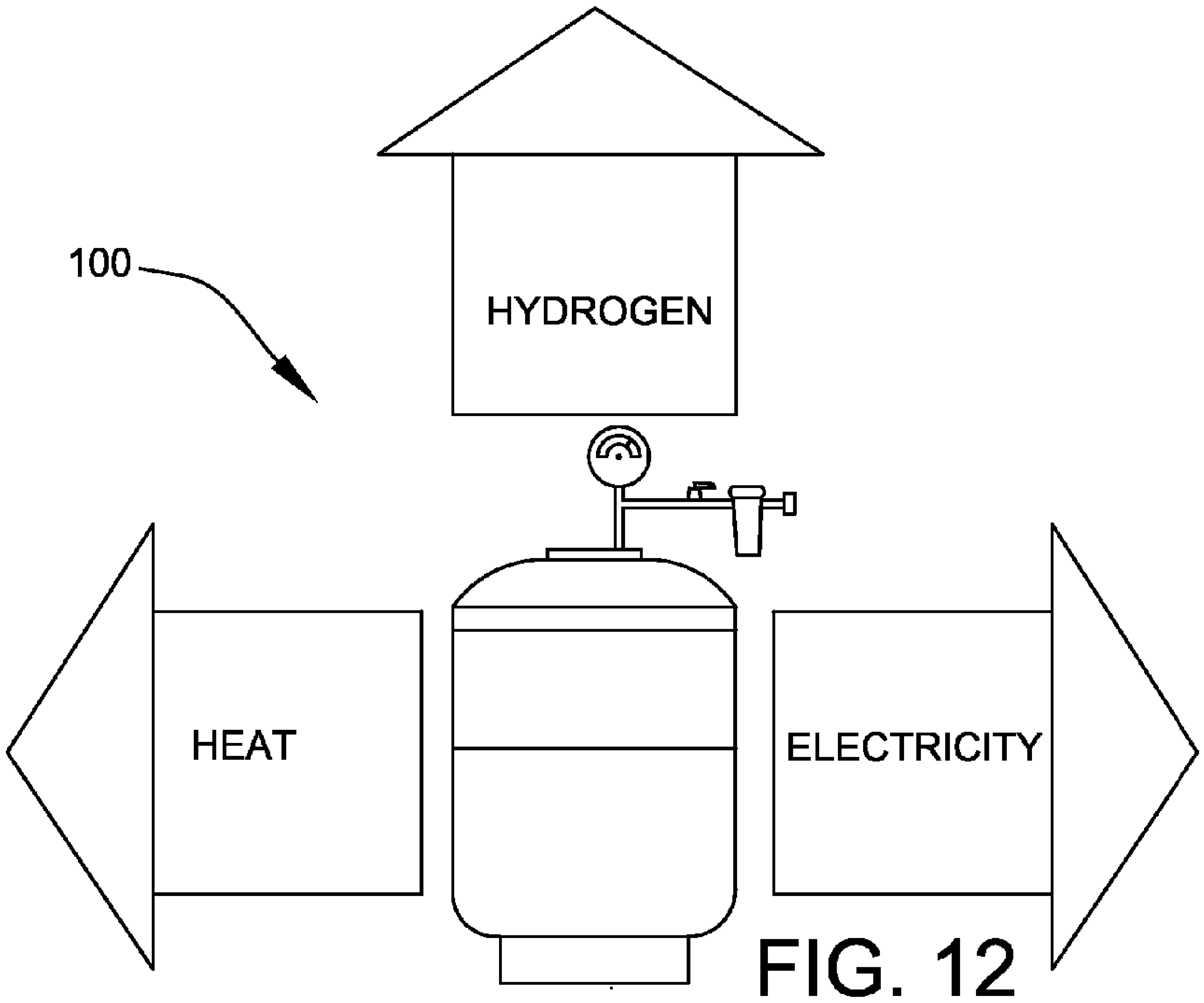


FIG. 12

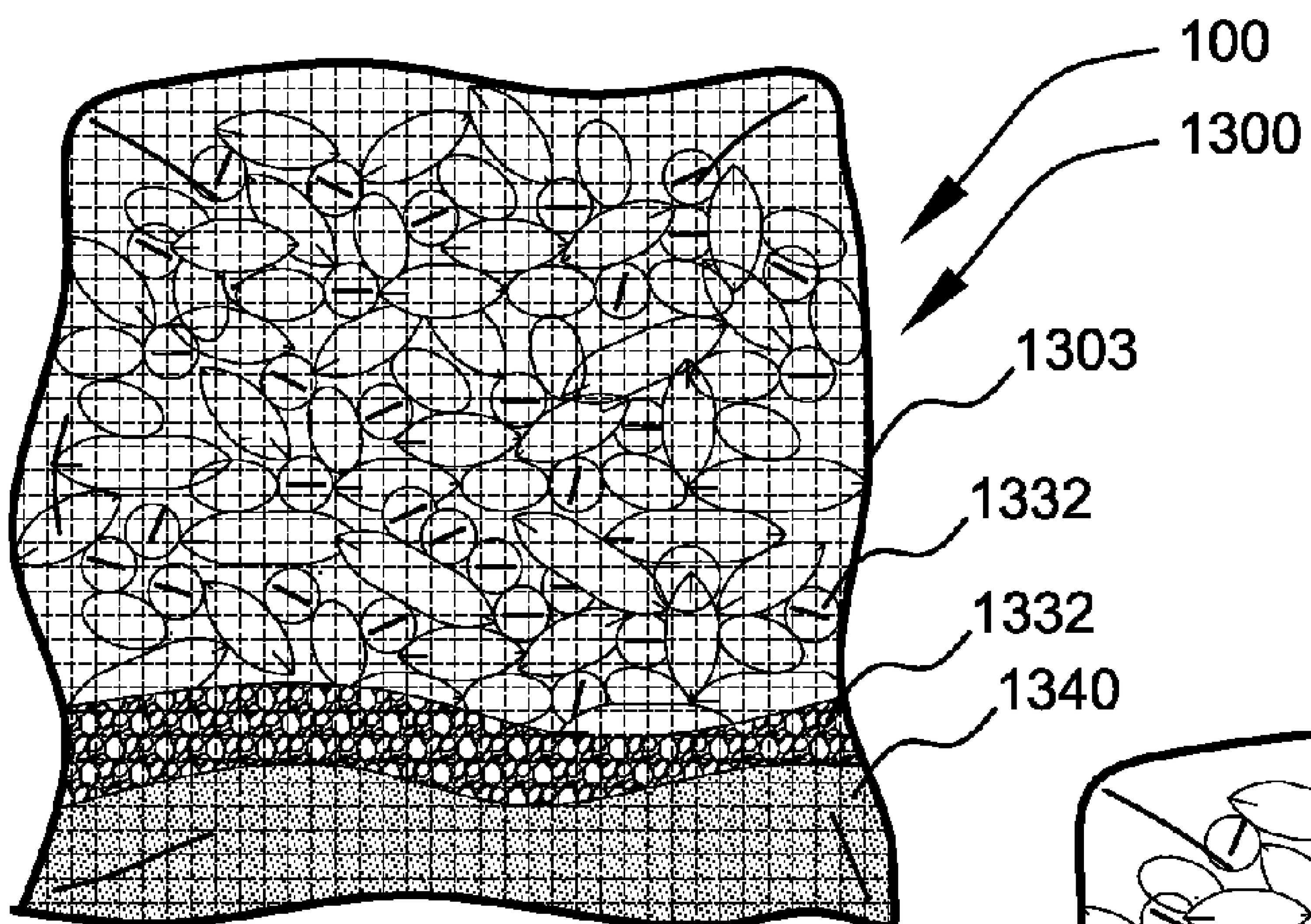


FIG. 13

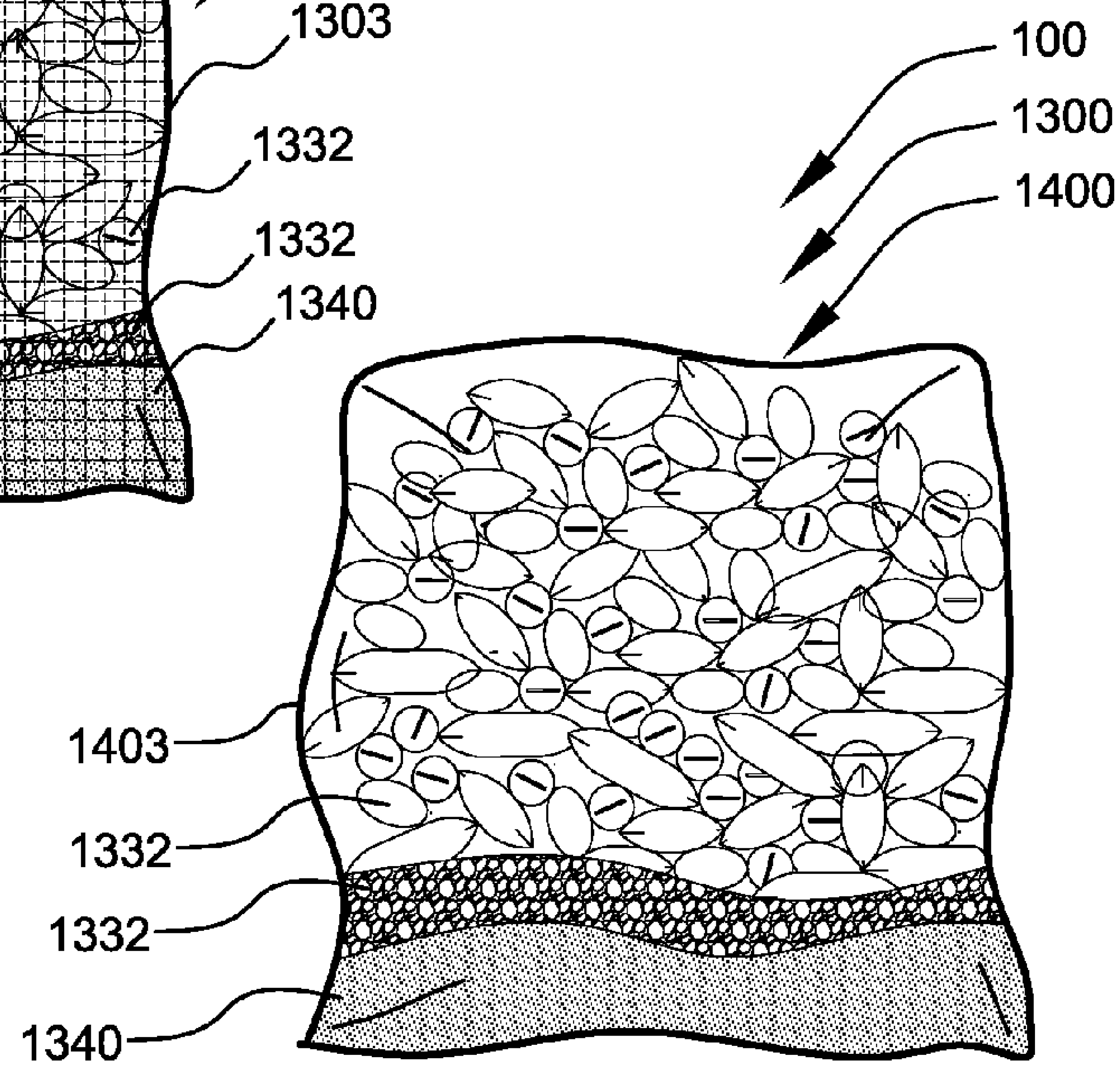


FIG. 14

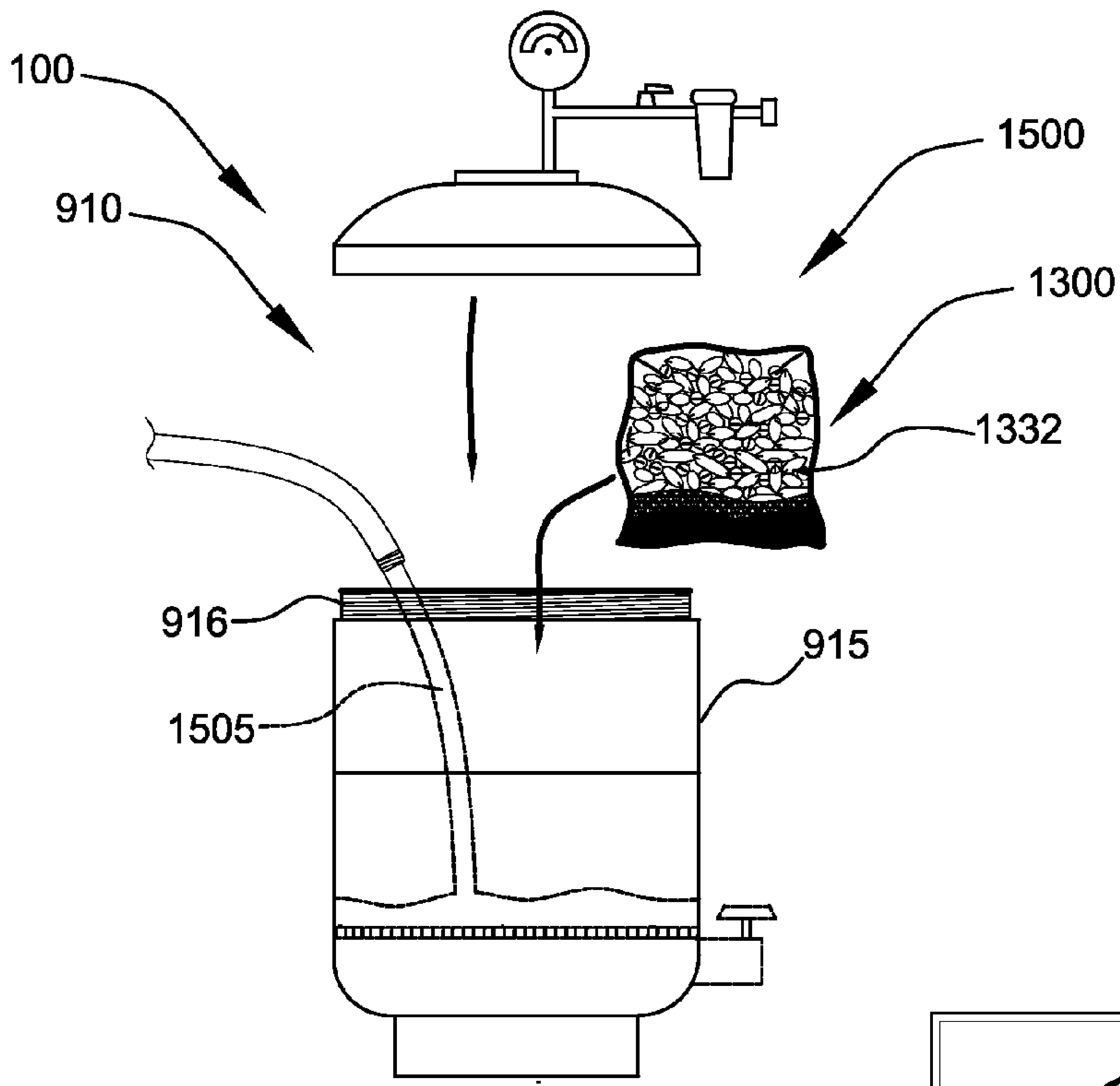


FIG. 15

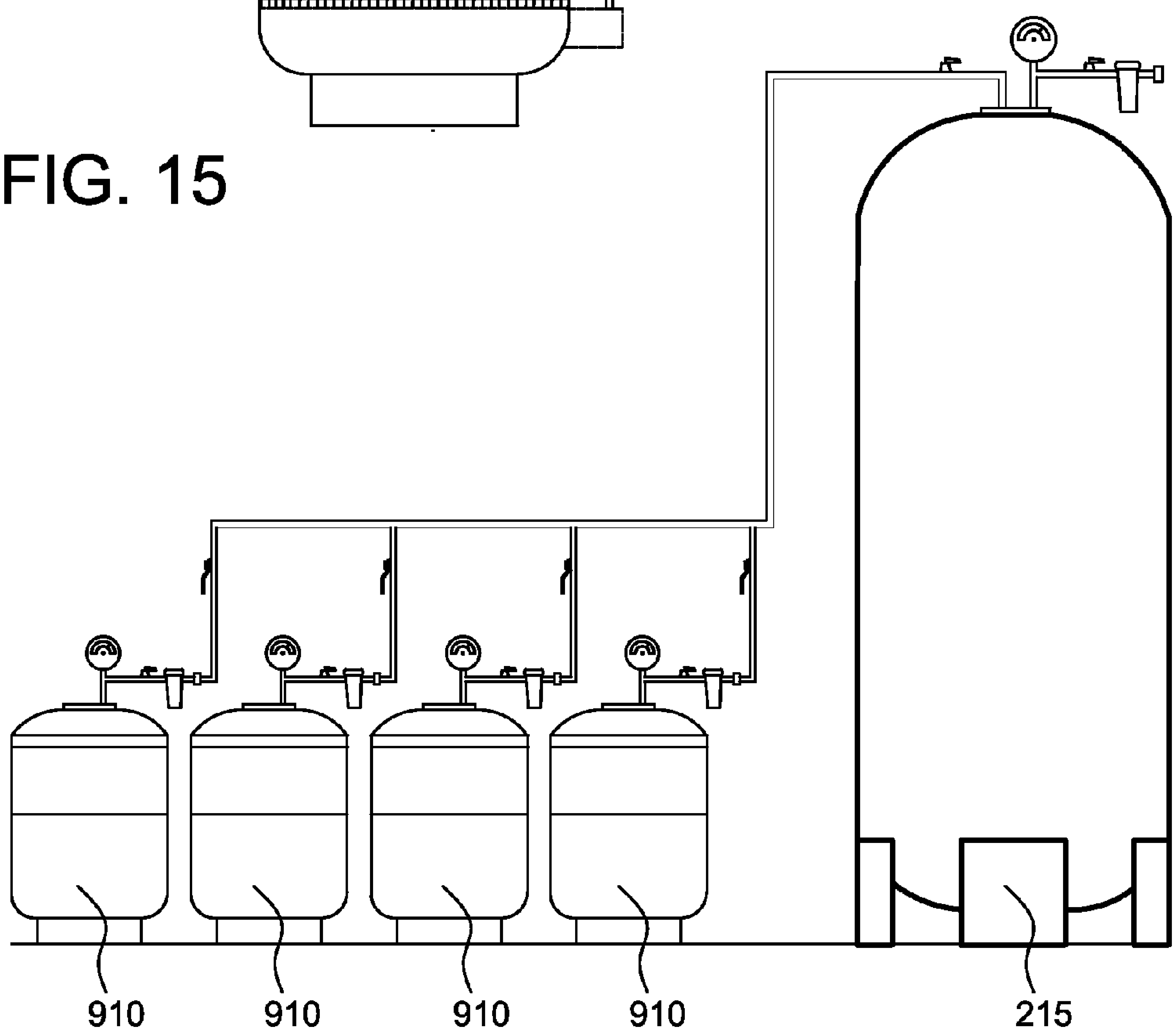


FIG. 16

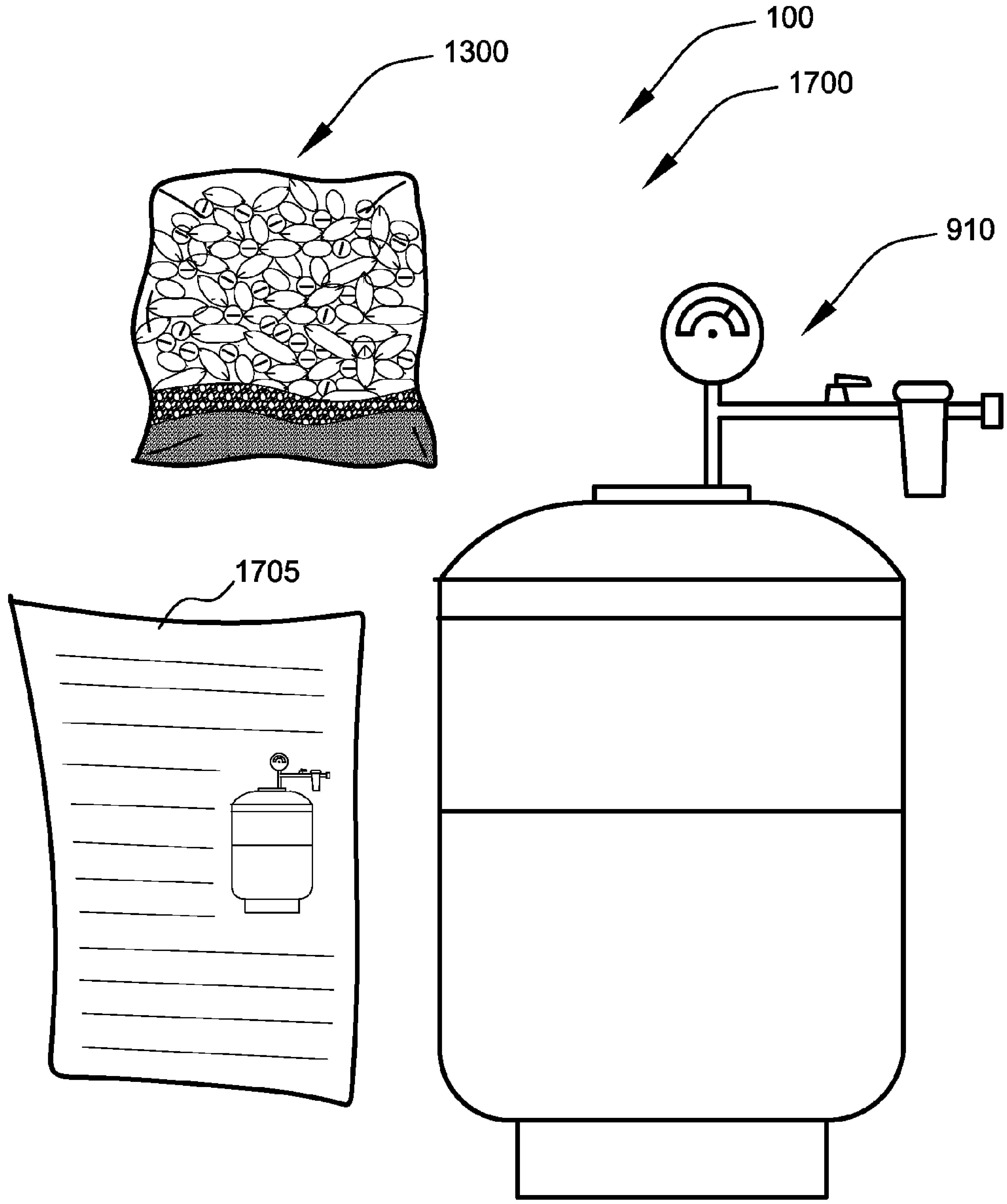
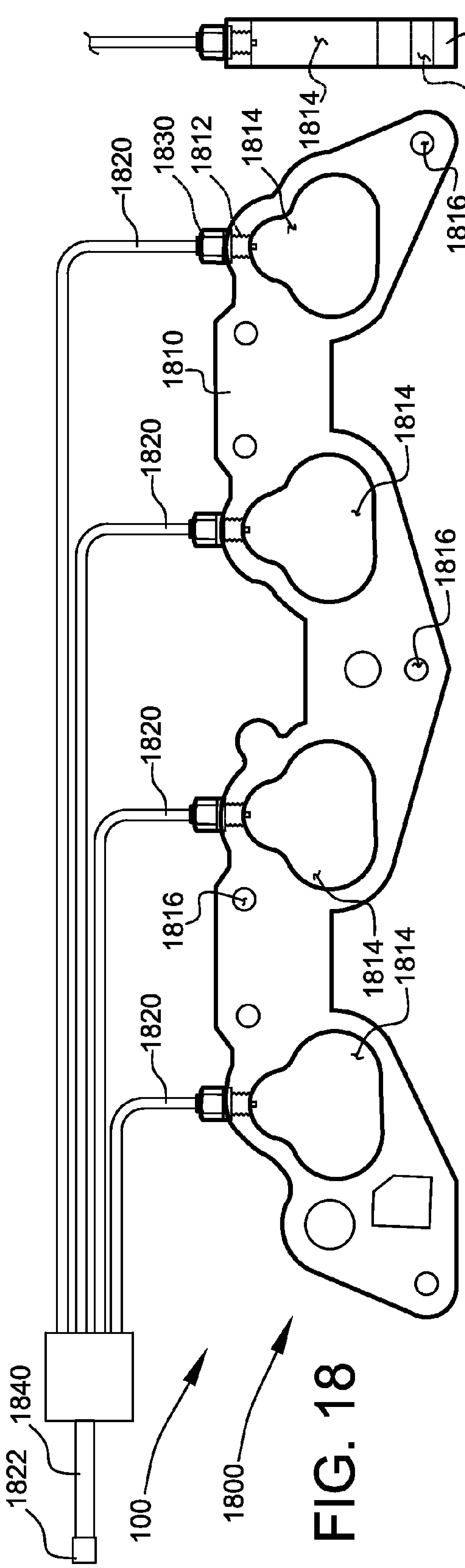


FIG. 17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1814
1816
1820
1830
1812
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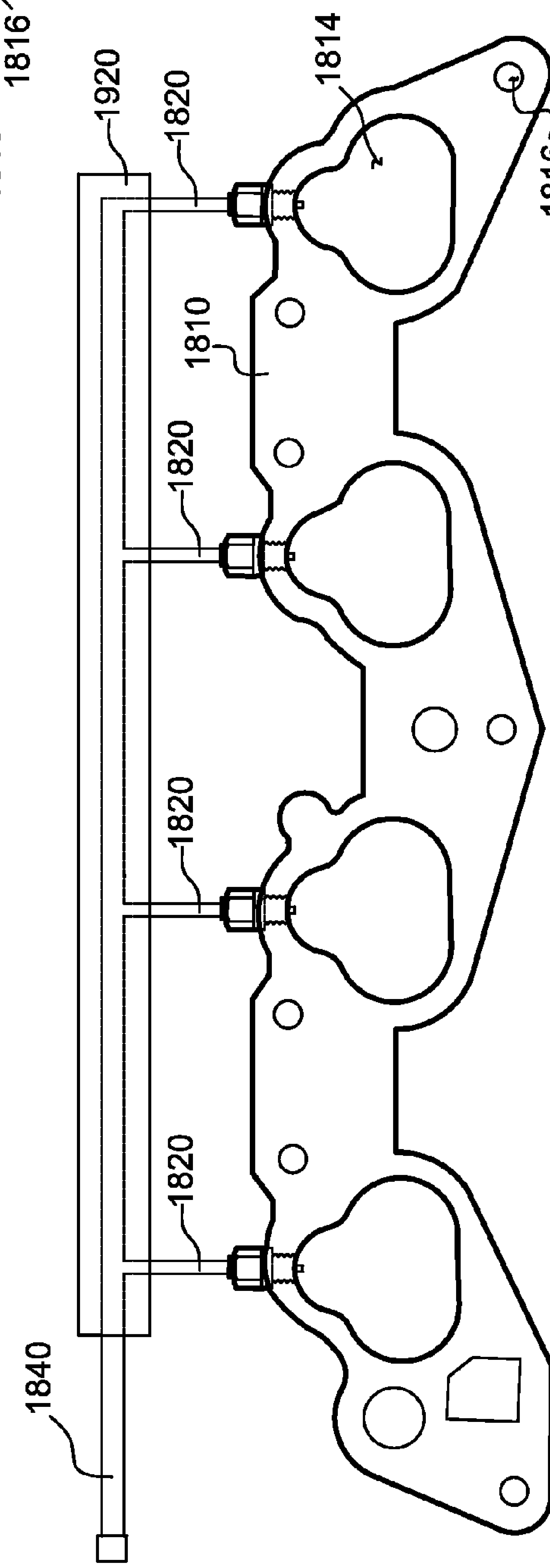
1814
1820
1822
1840
100
1800

FIG. 18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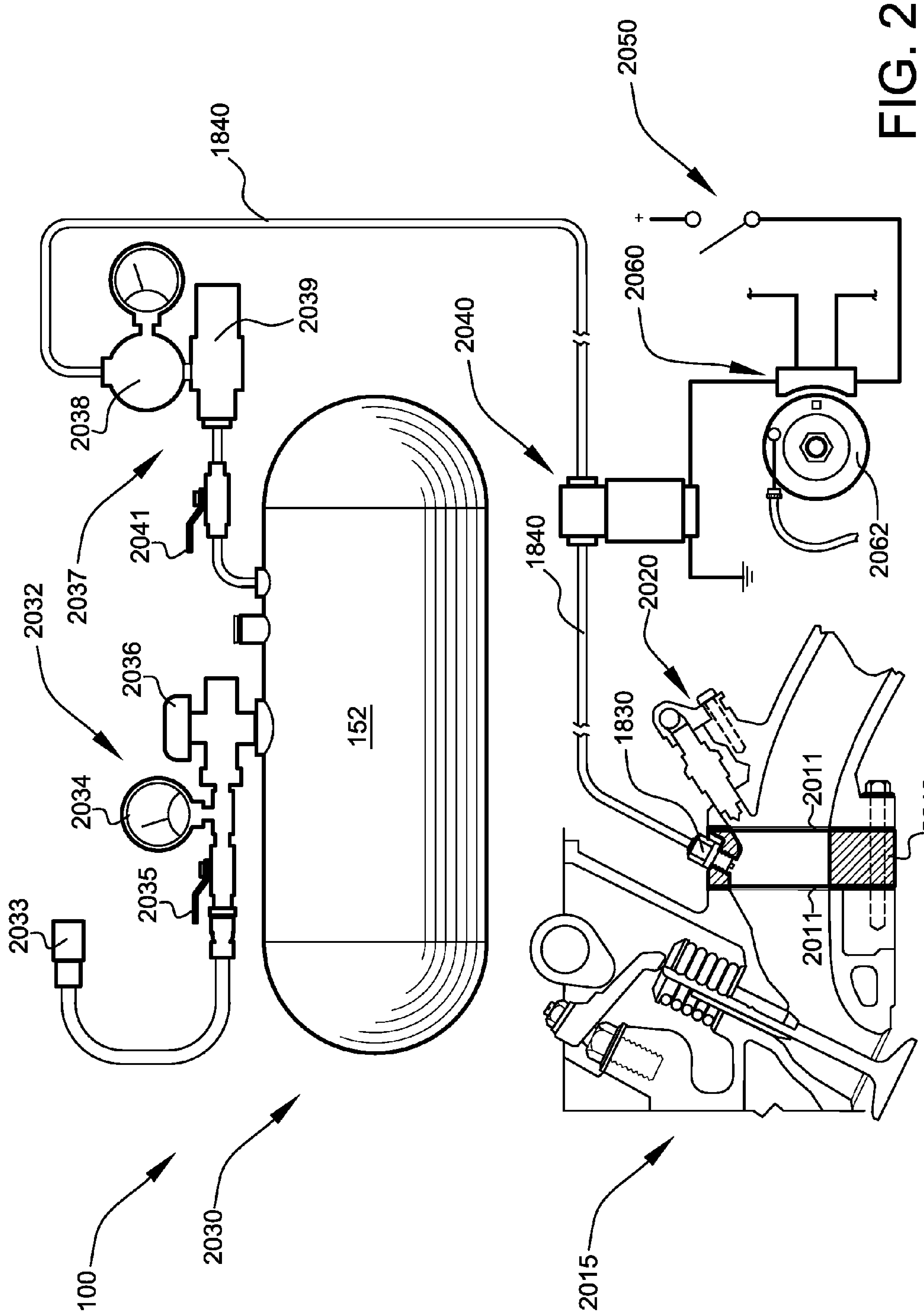
1820
1840

FIG. 19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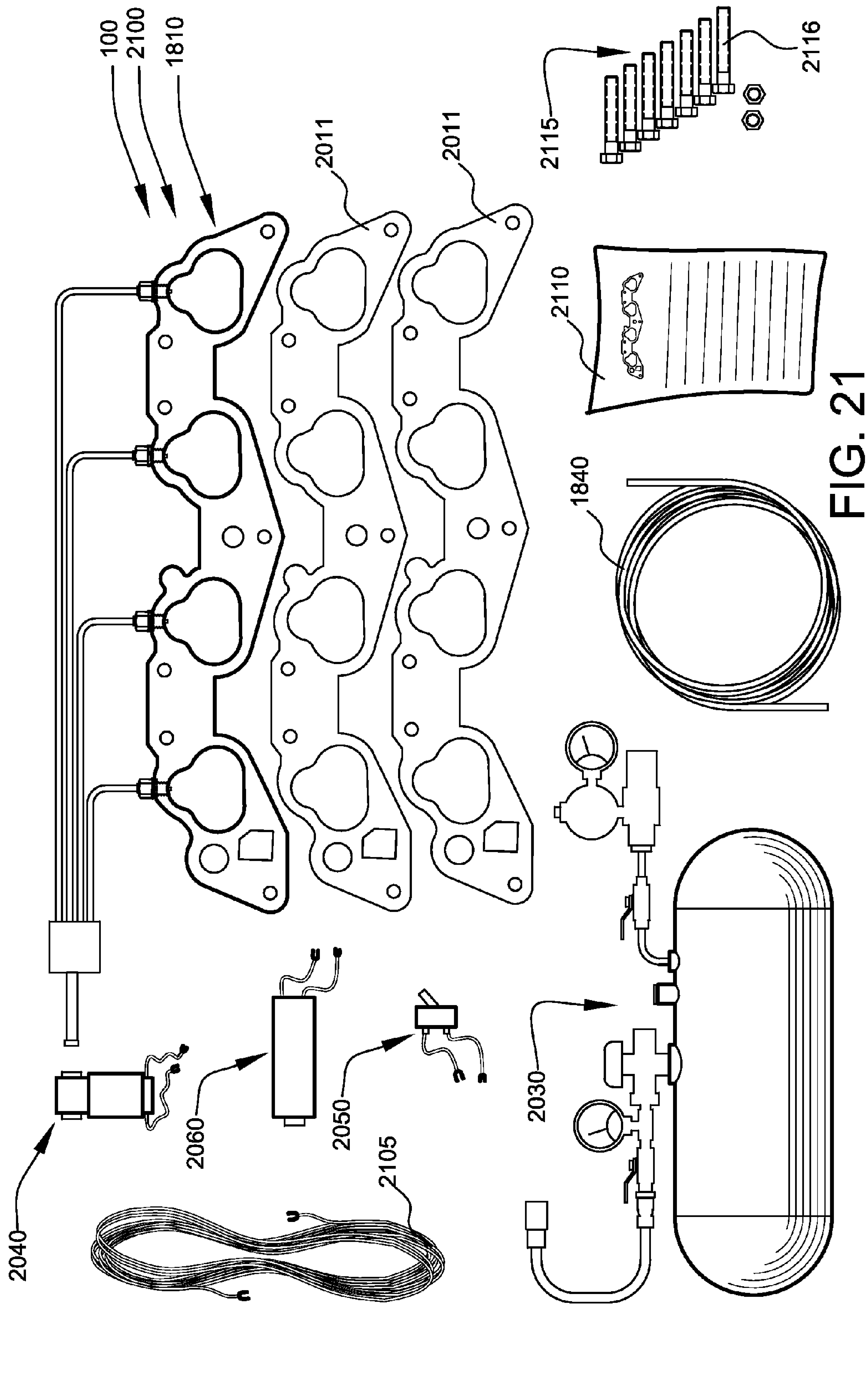
2030
2015
2033
2035
2034
2032
2036
2037
2041
2038
2039
1840
152
2040
1840
2050
2060
2062
2020
1830
2011
2011
2010
+

FIG. 20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2011
2011
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2116
2110
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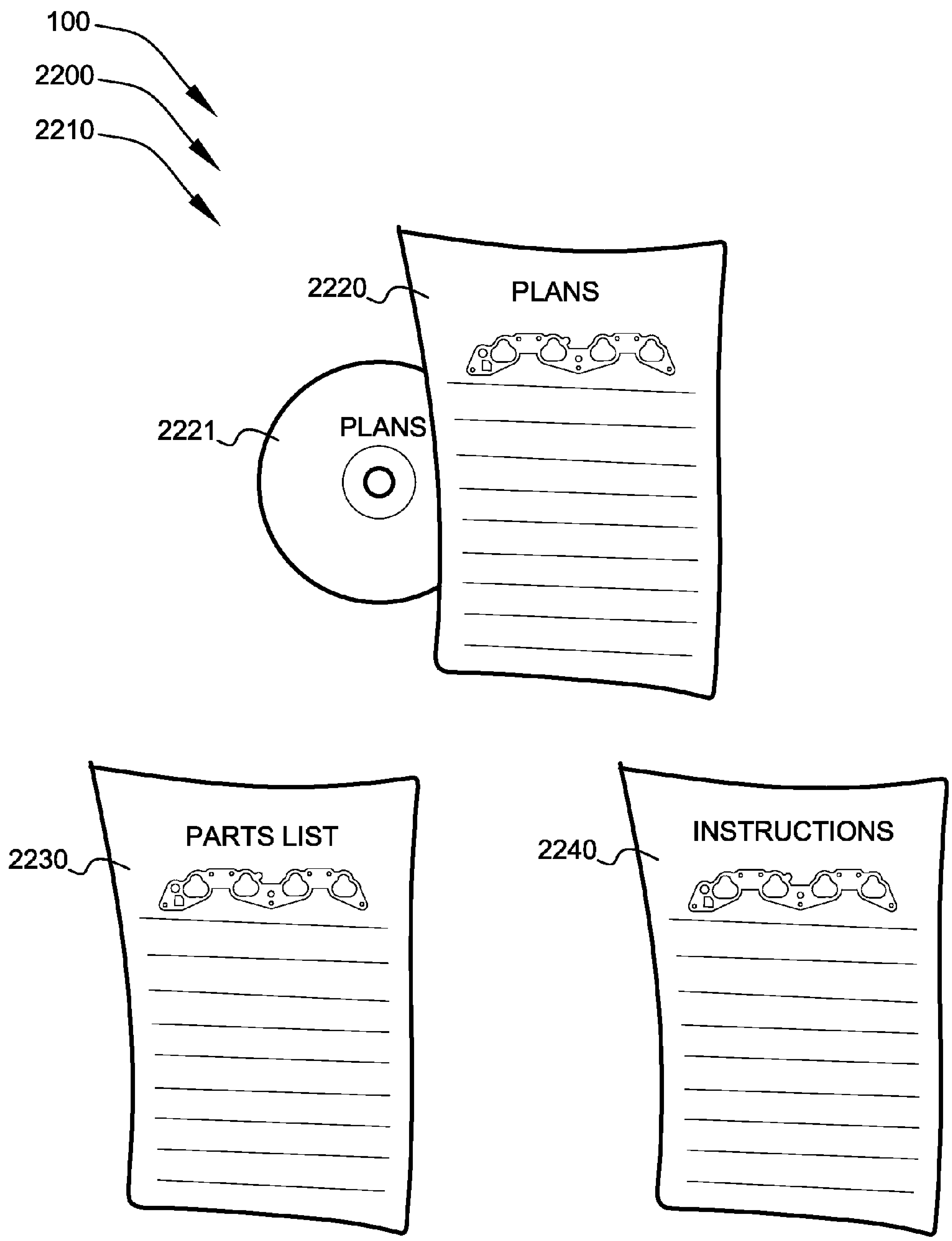
2040
2060
2050
2030
2105

FIG. 21


100
2200
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2220
PLANS
2221
PLANS
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PARTS LIST
2240
INSTRUCTIONS

FIG. 22

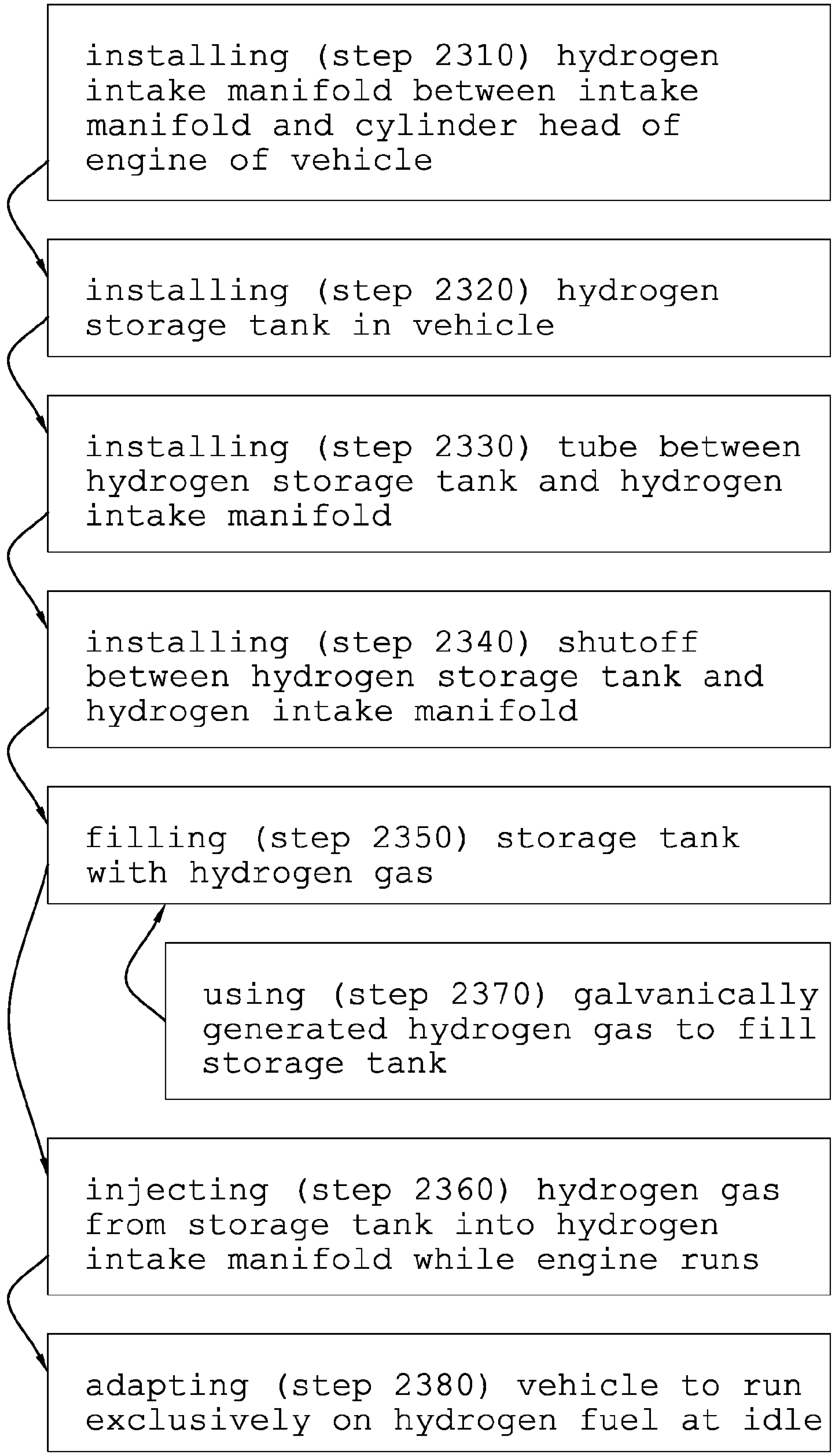
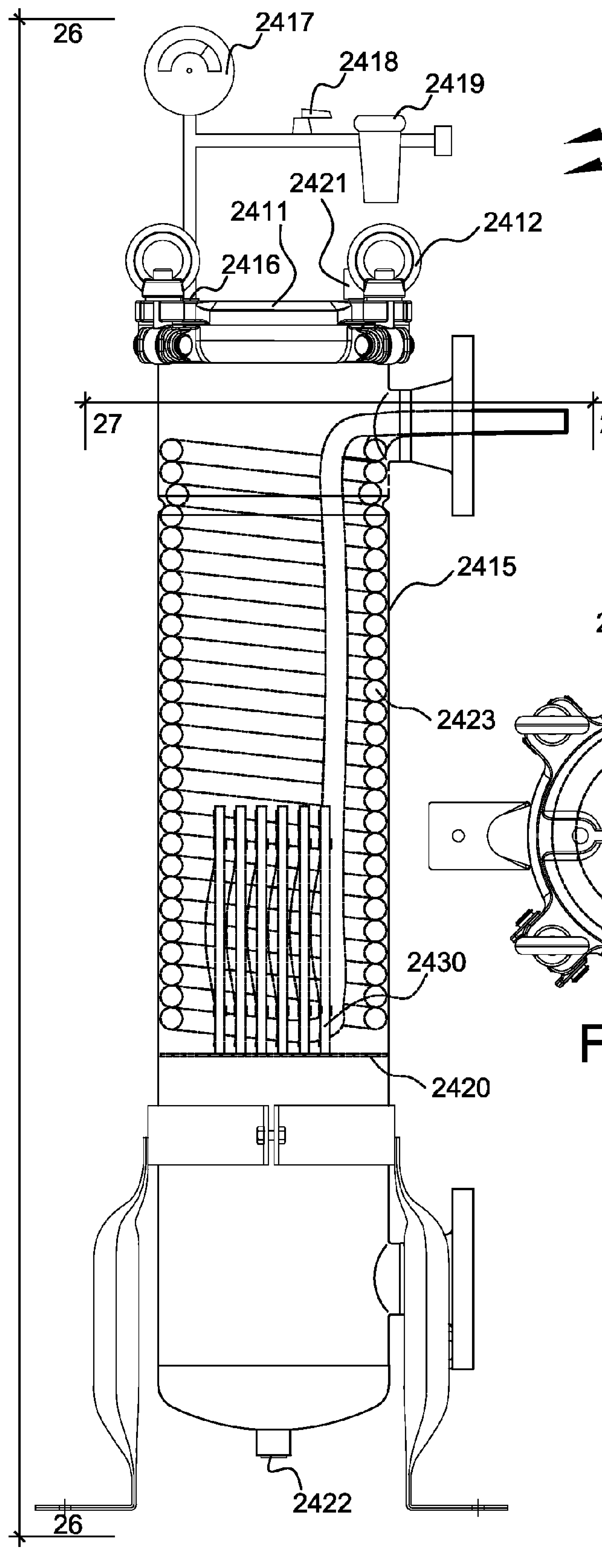

installing (step 2310) hydrogen intake manifold between intake manifold and cylinder head of engine of vehicle
installing (step 2320) hydrogen storage tank in vehicle
installing (step 2330) tube between hydrogen storage tank and hydrogen intake manifold
installing (step 2340) shutoff between hydrogen storage tank and hydrogen intake manifold
filling (step 2350) storage tank with hydrogen gas
using (step 2370) galvanically generated hydrogen gas to fill storage tank
injecting (step 2360) hydrogen gas from storage tank into hydrogen intake manifold while engine runs
adapting (step 2380) vehicle to run exclusively on hydrogen fuel at idle

FIG. 23


26
2417
2418
2419
100
2410
2421
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27
27
2415
2423
2430
2420
2422
26

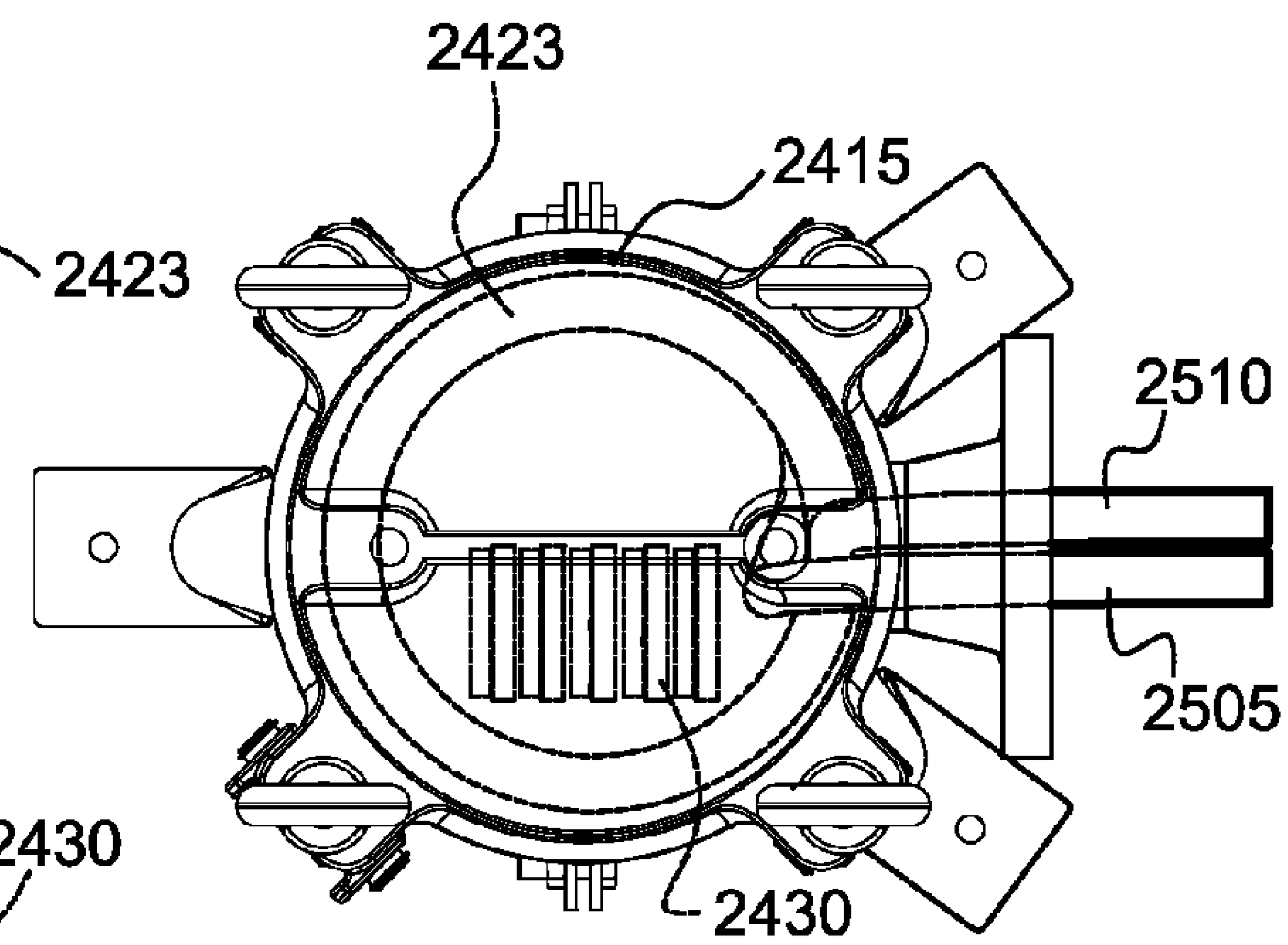

2423
2415
2510
2505
2430

FIG. 25

FIG. 24

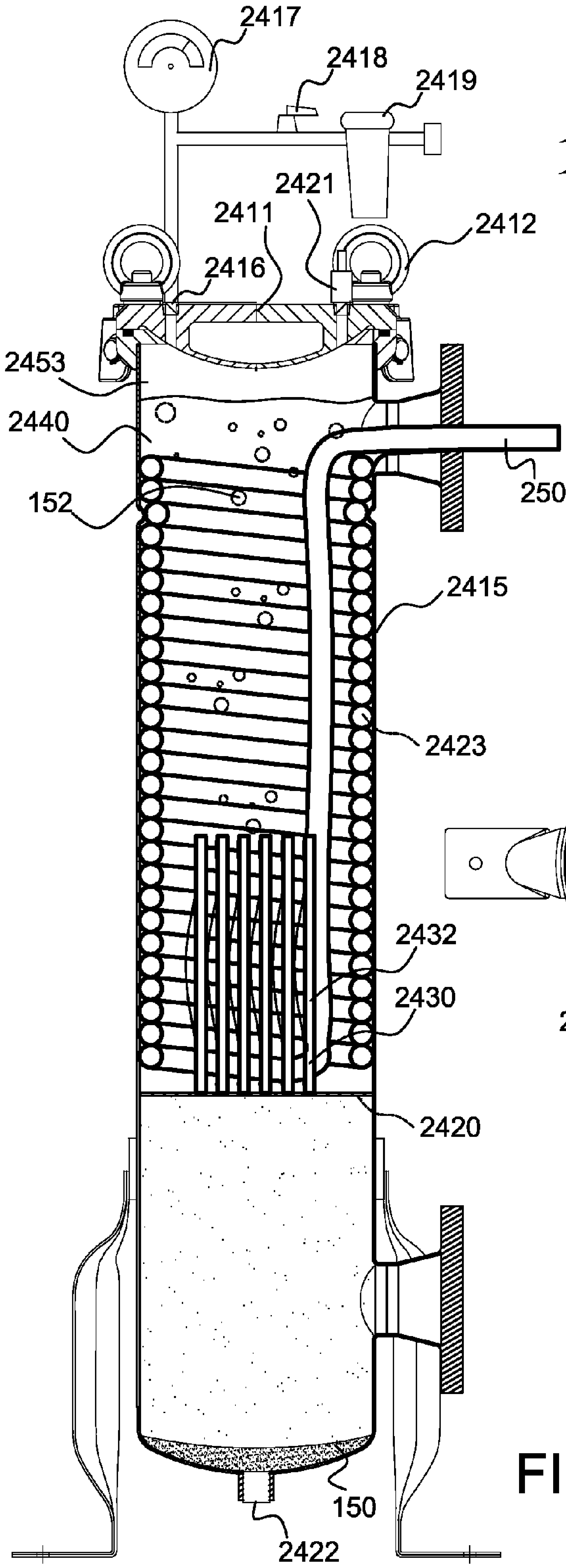

2417
2418
2419
100
2410
2421
2411
2412
2416
2453
2440
2505
152
2415
2423
2432
2430
2420
150
2422

FIG. 26

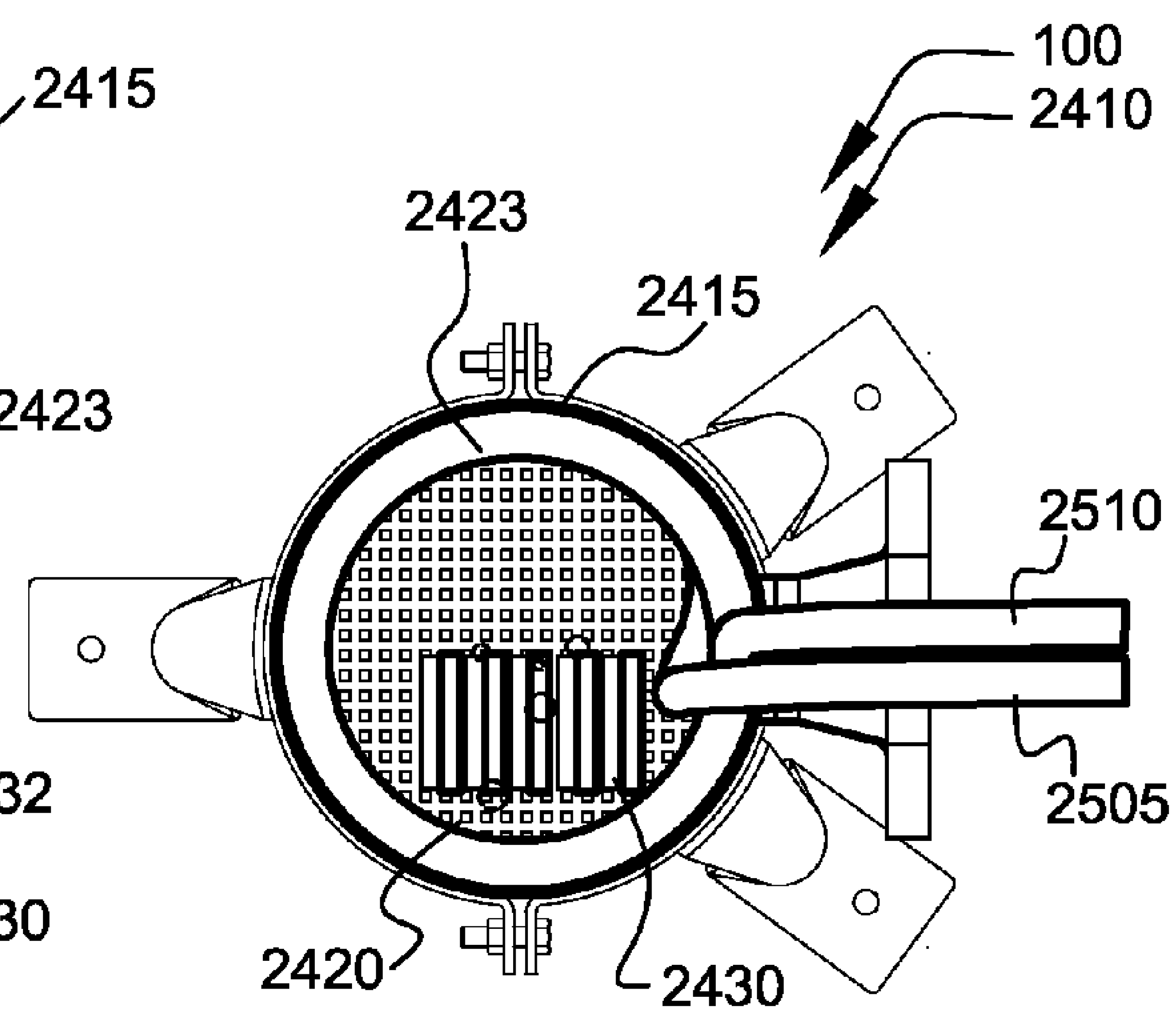

100
2410
2423
2415
2510
2505
2420
2430

FIG. 27

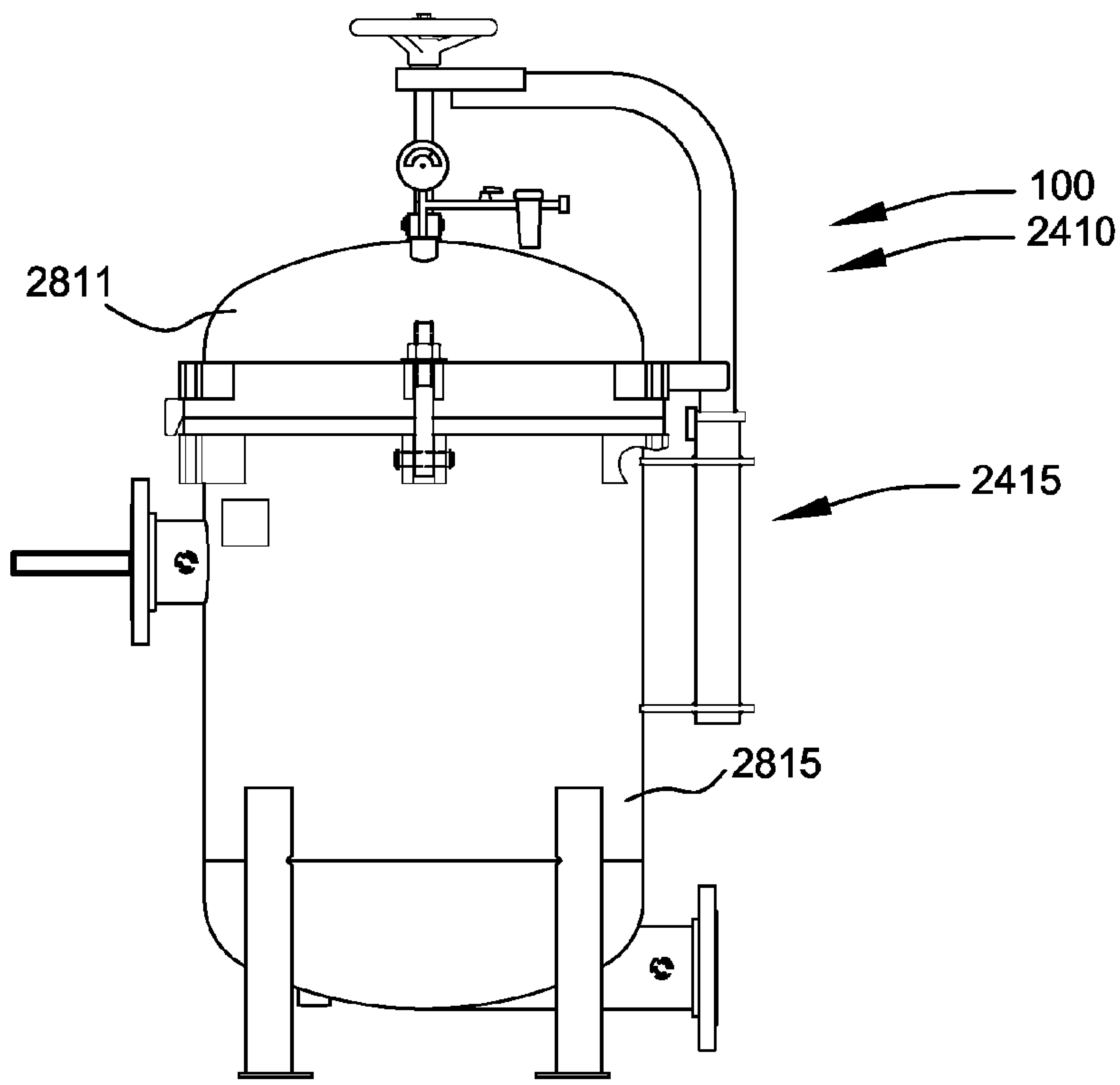

100
2410
2811
2415
2815

FIG. 28

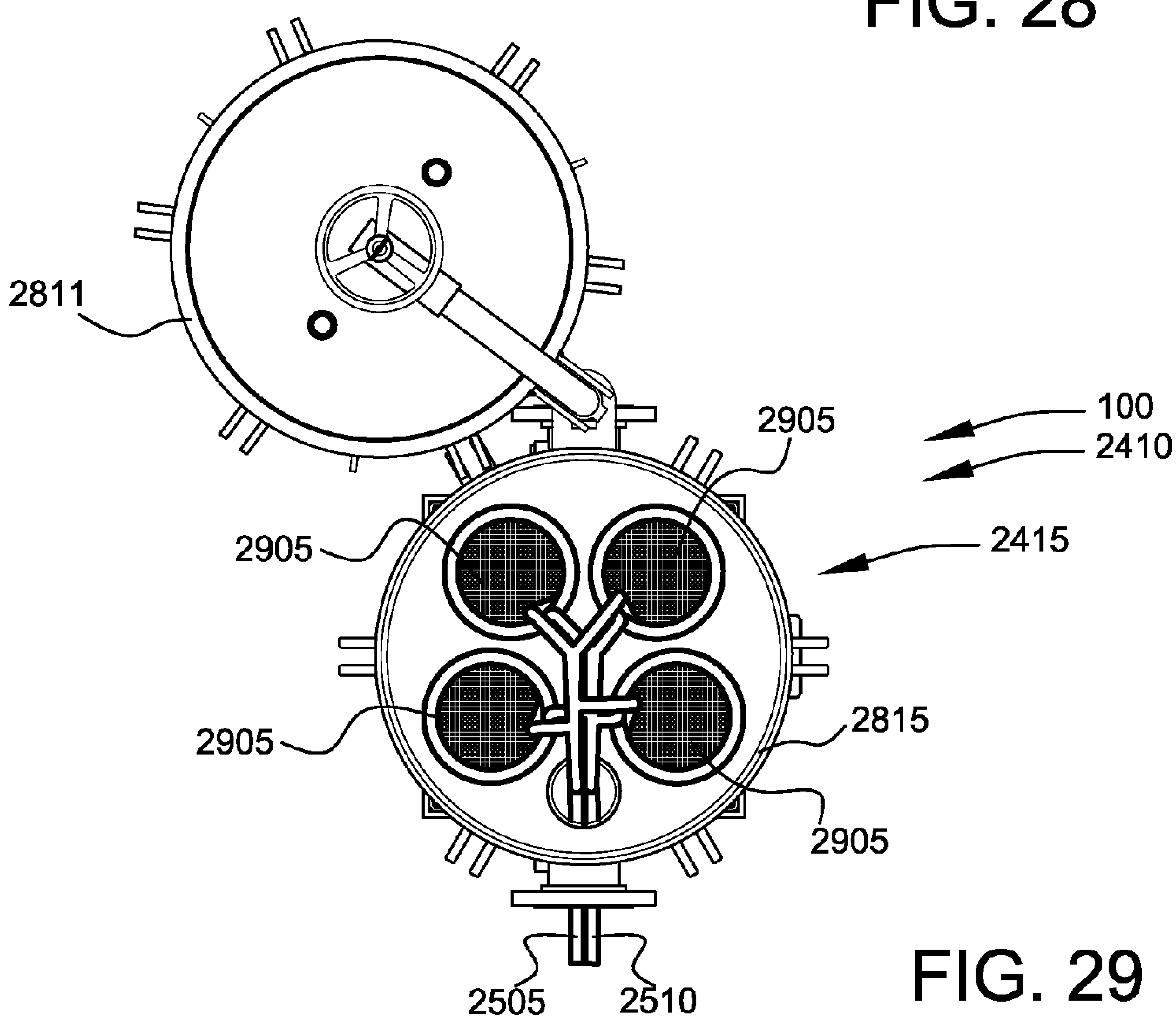

2811
100
2410
2905
2905
2415
2905
2815
2905
2505
2510

FIG. 29

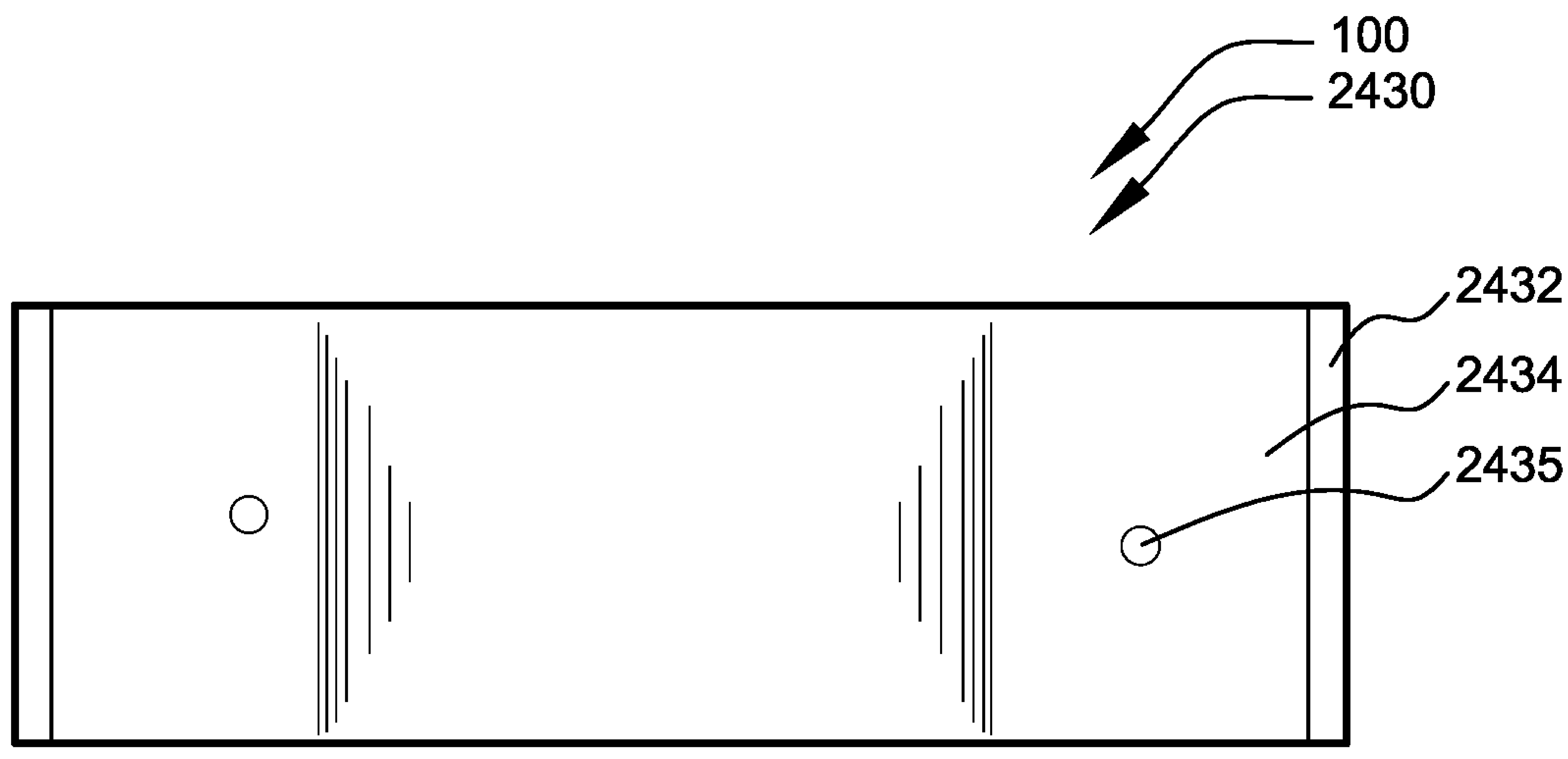


FIG. 30

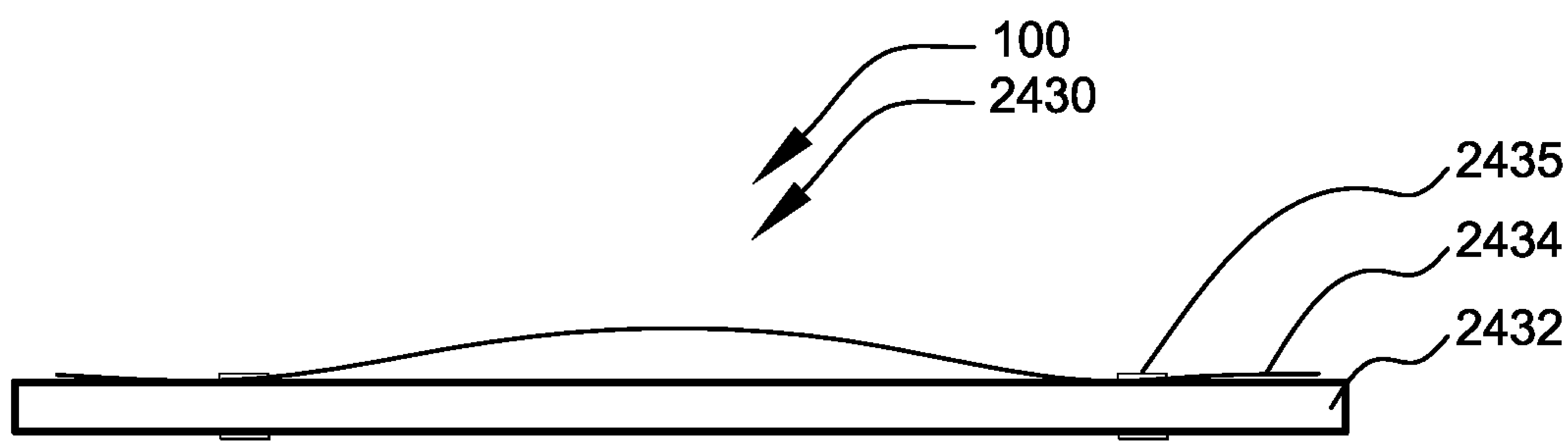
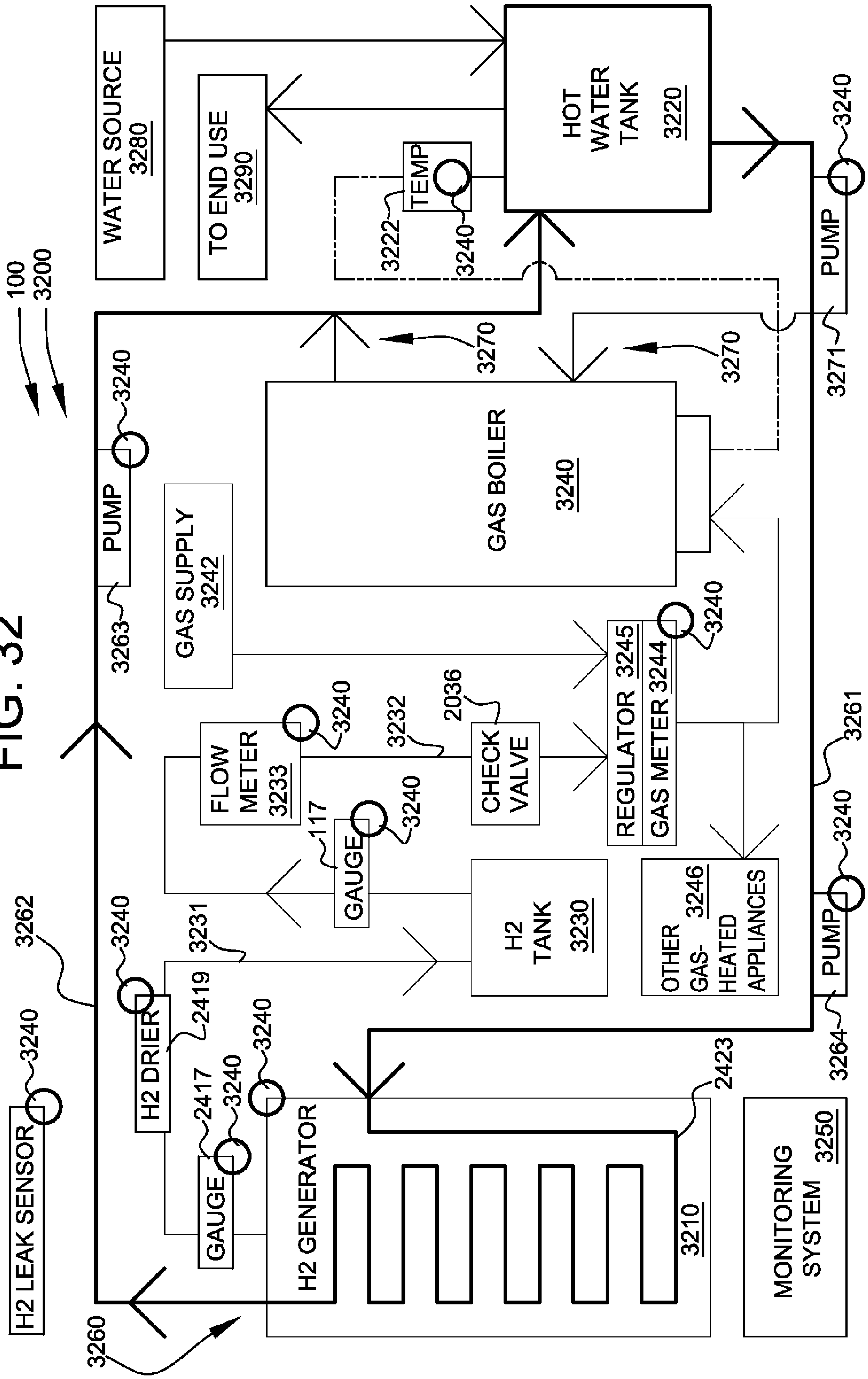


FIG. 31

FIG. 32


100
3200
WATER SOURCE 3280
TO END USE 3290
HOT WATER TANK 3220
TEMP
3222
3240
PUMP
3263
3271
3270
GAS BOILER 3240
GAS SUPPLY 3242
REGULATOR 3245
GAS METER 3244
FLOW METER 3233
3232
2036
CHECK VALVE
GAUGE
117
H2 TANK 3230
3231
OTHER GAS-HEATED APPLIANCES 3246
3261
3262
H2 DRIER
2419
2417
H2 LEAK SENSOR
H2 GENERATOR
3210
2423
3264
MONITORING SYSTEM 3250
3260

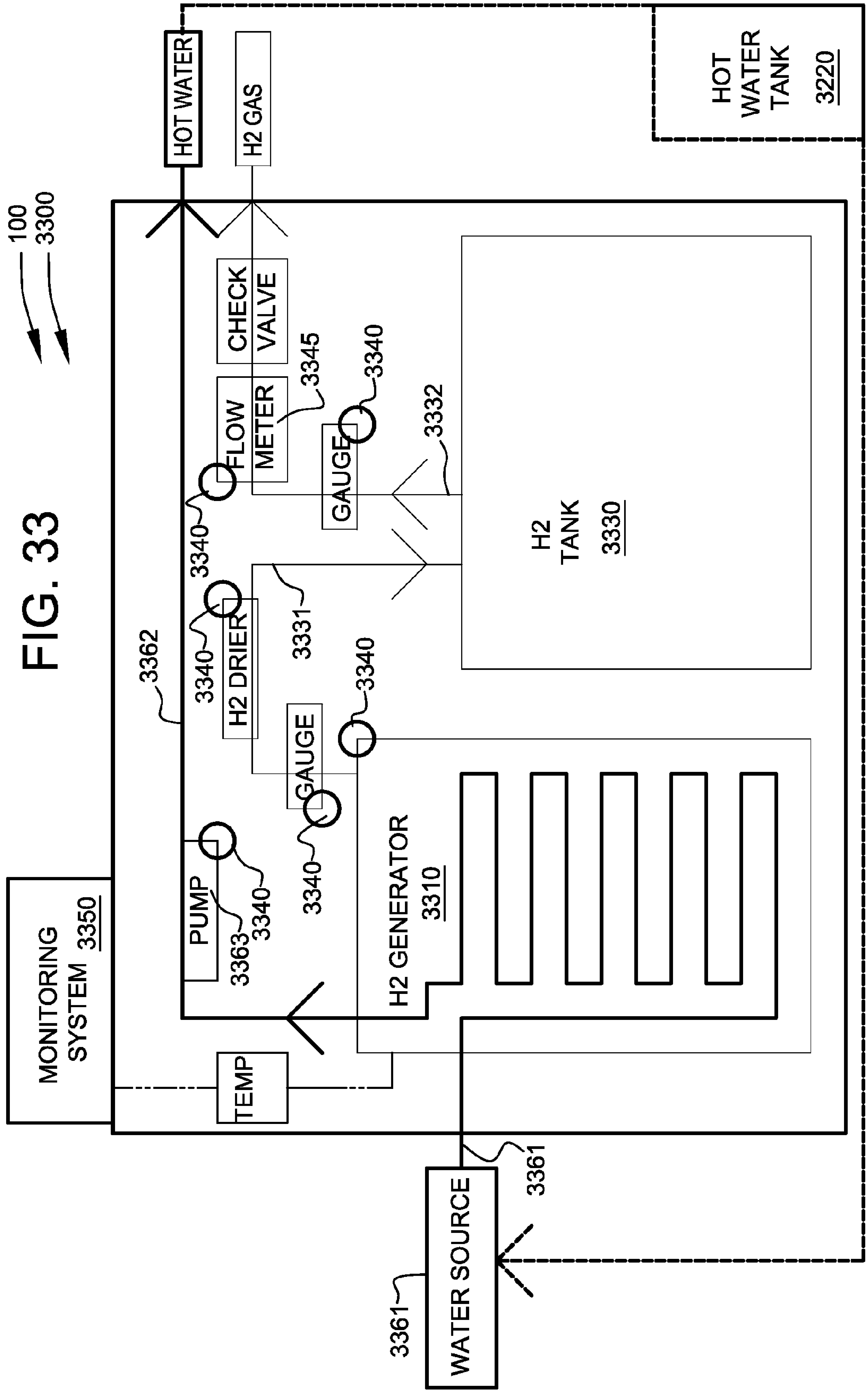

100
3300
HOT WATER
H2 GAS
HOT WATER TANK
3220
CHECK VALVE
FLOW METER
3345
3340
GAUGE
3332
3331
H2 TANK
3330
3362
H2 DRIER
GAUGE
PUMP
3363
H2 GENERATOR
3310
MONITORING SYSTEM
3350
TEMP
3361
WATER SOURCE

FIG. 33

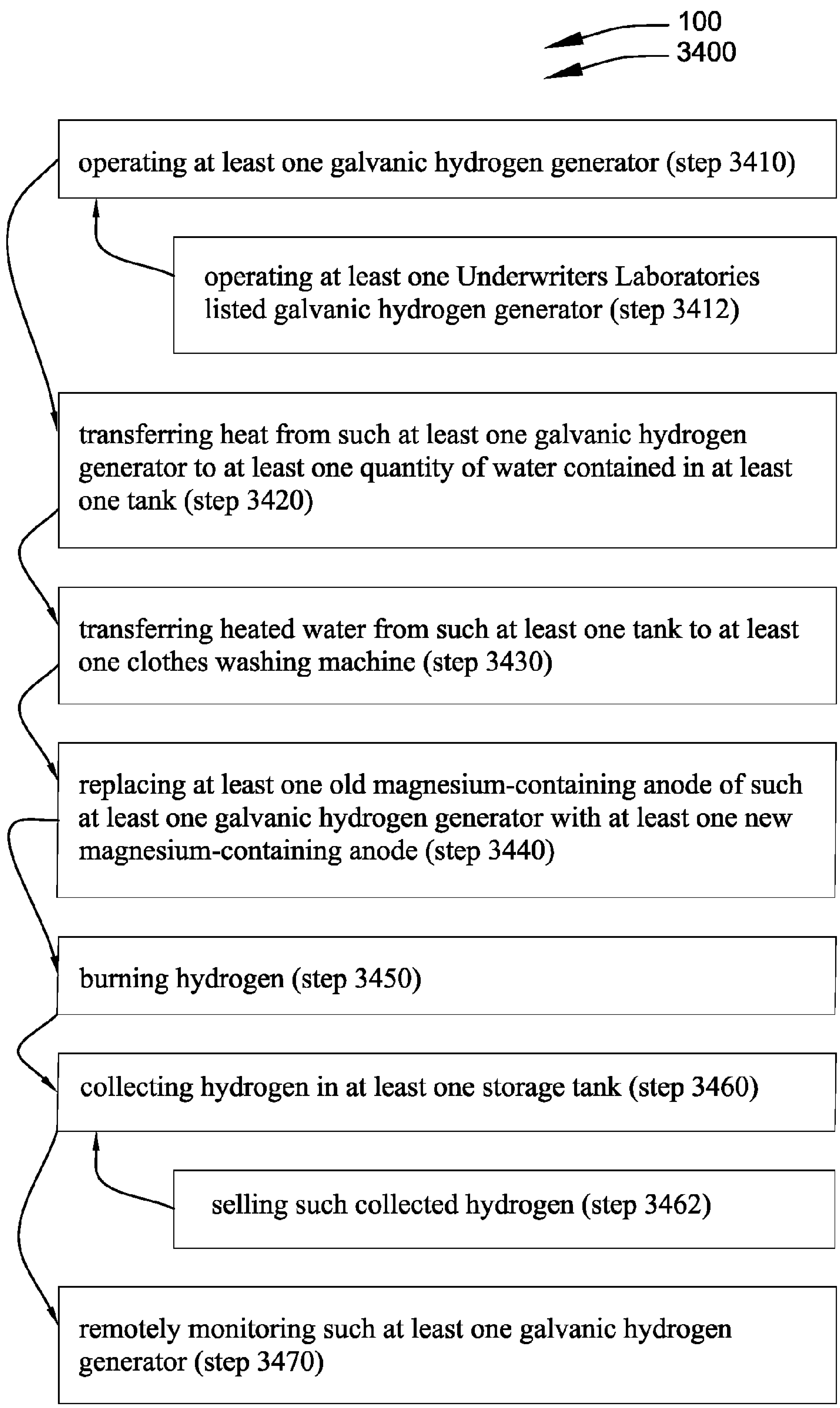

100
3400
operating at least one galvanic hydrogen generator (step 3410)
operating at least one Underwriters Laboratories listed galvanic hydrogen generator (step 3412)
transferring heat from such at least one galvanic hydrogen generator to at least one quantity of water contained in at least one tank (step 3420)
transferring heated water from such at least one tank to at least one clothes washing machine (step 3430)
replacing at least one old magnesium-containing anode of such at least one galvanic hydrogen generator with at least one new magnesium-containing anode (step 3440)
burning hydrogen (step 3450)
collecting hydrogen in at least one storage tank (step 3460)
selling such collected hydrogen (step 3462)
remotely monitoring such at least one galvanic hydrogen generator (step 3470)

FIG. 34

HYDROGEN ENERGY SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to and claims priority from prior provisional application Ser. No. 60/710,538, filed Aug. 22, 2005, entitled "Hydrogen Energy Systems", and is related to and claims priority from prior provisional application Ser. No. 60/745,056, filed Apr. 18, 2006, entitled "Hydrogen Energy Systems", the contents of both of which are incorporated herein by this reference and are not admitted to be prior art with respect to the present invention by the mention in this cross-reference section.

BACKGROUND

[0002] The present invention relates to hydrogen energy systems. More particularly, the present invention relates to efficient galvanic hydrogen generation. Even more particularly, the present invention relates to hydrogen-fueled internal combustion engines.

[0003] No system exists that efficiently, safely, and easily generates hydrogen gas from water for use as fuel without the need to supply electrical power from outside the hydrogen generator. Further, no system exists that provides safe and simple modification of gasoline or diesel-powered internal combustion engines to run partially on hydrogen fuel.

[0004] No system exists that efficiently, safely, and easily provides heated water and hydrogen for hot-water using appliances. Further, so system exists that provides UL listed appliances adapted to generate heat and hydrogen via galvanic reaction.

[0005] Therefore, a need exists for a system that provides for efficient, safe, and easy hydrogen generation from water without the need to supply electrical power from outside the hydrogen generator. Further, a need exists for a system that provides safe and simple modification of gasoline or diesel-powered internal combustion engines to run at least partially on hydrogen fuel.

[0006] Therefore, a need exists for a system that efficiently, safely, and easily provides heated water and hydrogen for hot-water using appliances. Further, a need exists for a system that provides UL listed appliances adapted to generate heat and hydrogen via galvanic reaction.

OBJECTS AND FEATURES OF THE INVENTION

[0007] A primary object and feature of the present invention is to provide hydrogen energy systems.

[0008] It is a further primary object and feature of the present invention to provide such systems comprising galvanic hydrogen generators. It is a further primary object and feature of the present invention to provide such systems comprising hydrogen intake manifolds for internal combustion engines.

[0009] It is a further object and feature of the present invention to provide such systems comprising galvanic hydrogen generator kits. It is a further object and feature of the present invention to provide such systems comprising hydrogen intake manifold kits.

[0010] It is a further object and feature of the present invention to provide such systems comprising pre-made packets of galvanically corrodible materials usable for galvanic hydrogen generation.

[0011] It is a further object and feature of the present invention to provide such systems that efficiently, safely, and easily provide heated water and hydrogen for hot-water using appliances. A further object and feature of the present invention is to provide such a system that provides UL listed appliances adapted to generate heat and hydrogen via galvanic reaction.

[0012] A further primary object and feature of the present invention is to provide such systems that are efficient, inexpensive, and handy. Other objects and features of this invention will become apparent with reference to the following descriptions.

SUMMARY OF THE INVENTION

[0013] In accordance with a preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one galvanic cell, comprising at least one anode; at least one cathode; and at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode; at least one container, adapted to contain such at least one galvanic cell, comprising volume in excess of five gallons, at least one construction seam, at least one hydrogen gas storage headspace, and at least one hydrogen gas release valve; wherein such at least one construction seam is substantially permanently sealed; wherein such at least one anode initially weighs at least about seven pounds; and wherein such at least one container is adapted to hold at least one quantity of water sufficient (relative to the quantity of such at least one anode) to prevent overheating resulting in passivation of such at least one anode.

[0014] Moreover, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte comprising such at least one quantity of water. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight. Also, it provides such a galvanic hydrogen generator system, wherein such at least one anode, such at least one buffer, and such at least one cathode are electrically connected together by such at least one electrolyte. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises such at least one cathode. And, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one electrolyte drain. Further, it provides such a galvanic hydrogen generator system, wherein such at least one anode is located above such at least one electrolyte drain. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one construction seam is substantially permanently sealed by welding.

[0015] Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one container further comprises at least one filter port. Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte filter. Also, it provides such a galvanic hydrogen generator system, wherein such at least one anode initially weighs at least about forty pounds. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one anode initially weighs at least about eighty pounds. And, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises magnesium. Further, it provides such a galvanic hydrogen generator system, wherein such at least one buffer comprises aluminum. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises iron. Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises titanium.

[0016] Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one heat exchanger. Also, it provides such a galvanic hydrogen generator system, further comprising at least one heat-energy converter. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one heat-energy converter comprises at least one Stirling engine. And, it provides such a galvanic hydrogen generator system, wherein such at least one anode is less than about twenty millimeters away from such at least one buffer. Further, it provides such a galvanic hydrogen generator system, wherein such at least one buffer is less than about twenty millimeters away from such at least one cathode.

[0017] Even further, it provides such a galvanic hydrogen generator system, further comprising at least one pH adjuster adapted to adjust pH of such at least one quantity of water to above about pH 10. Moreover, it provides such a galvanic hydrogen generator system, further comprising at least one pH adjuster adapted to adjust pH of such at least one quantity of water to below about pH 10. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one anode is substantially consumed within about one year. Also, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen storage tank adapted to store hydrogen gas at pressures of about 400 pounds per square inch.

[0018] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator kit, relating to generating hydrogen gas from water, comprising: at least one galvanic cell, comprising at least one anode; wherein such at least one anode initially weighs at least about seven pounds; at least one cathode; and at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode; at least one container adapted to contain such at least one galvanic cell, comprising at least one hydrogen gas storage headspace; at least one hydrogen gas release valve; at least one water input port; and at least one water output port; wherein such at least one container is substantially permanently sealed (with the exception of such at least one hydrogen release valve, such at least one water input port, and such at least one water output port); and at least one instruction for using such at least one galvanic cell to generate hydrogen gas.

[0019] In addition, it provides such a galvanic hydrogen generator kit, further comprising at least one electrolyte filter. And, it provides such a galvanic hydrogen generator kit, further comprising at least one heat exchanger. Further, it provides such a galvanic hydrogen generator kit, further comprising at least one heat-energy converter. Even further, it provides such a galvanic hydrogen generator kit, wherein such at least one heat-energy converter comprises at least one Stirling engine.

[0020] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one galvanic charge, comprising at least one anode, and at least one electrolyte material; and at least one container comprising at least one hydrogen gas storage headspace, at least one hydrogen gas release valve, and at least one cathode; wherein such at least one container is adapted to hold at least one quantity of water sufficient (relative to the quantity of such at least one anode) to prevent overheating resulting in passivation of such at least one anode; and wherein hydrogen gas is generated when such at least one quantity of water and such at least one galvanic charge are placed into such at least one container.

[0021] Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises at least one fines. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises at least one pellet. Also, it provides such a galvanic hydrogen generator system, wherein the mass of such at least one quantity of water comprises at least about five times the mass of such at least one anode. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one electrolyte material comprises at least one salt. And, it provides such a galvanic hydrogen generator system, wherein such at least one salt comprises sea-salt. Further, it provides such a galvanic hydrogen generator system, wherein such at least one galvanic charge further comprises at least one water-permeable container.

[0022] Even further, it provides such a galvanic hydrogen generator system, wherein such at least one galvanic charge further comprises at least one water-soluble container. Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one hydrogen gas storage headspace is adapted to contain substantially all hydrogen gas generated by such at least one galvanic charge. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises such at least one cathode. Also, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one sealable opening. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises magnesium. And, it provides such a galvanic hydrogen generator system, wherein such at least one buffer comprises aluminum. Further, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises iron. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises titanium.

[0023] Moreover, it provides such a galvanic hydrogen generator system, further comprising at least one heat exchanger. Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one heat-energy converter. Also, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen storage tank. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one filter port. And, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte filter. Further, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one electrolyte drain. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one anode is located above such at least one electrolyte drain. Moreover, it provides such a galvanic hydrogen generator system, further comprising at least one pH adjuster adapted to adjust pH of such at least one quantity of water to above about pH 10. Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one pH adjuster adapted to adjust pH of such at least one quantity of water to below about pH 10.

[0024] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator kit, relating to generating hydrogen gas from water, comprising: at least one galvanic charge, comprising at least one anode; and at least one electrolyte material; at least one container comprising at least one hydrogen gas storage headspace; at least one hydrogen gas release valve; and at least one cathode; at least one instruction for using such at least one galvanic charge and such at least one container to generate hydrogen gas.

[0025] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one magnesium fines; at least one magnesium pellet; at least one electrolyte material; at least one water-soluble container adapted to contain such at least one magnesium fines, such at least one magnesium pellet, and such at least one electrolyte material. Also, it provides such a galvanic hydrogen generator system, further comprising at least one cathode. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one electrolyte material comprises sea salt.

[0026] In accordance with another preferred embodiment hereof, this invention provides a hydrogen fuel system, relating to injecting hydrogen fuel into at least one internal combustion engine in at least one vehicle, comprising: at least one hydrogen input manifold adapted to input hydrogen between at least one input manifold and at least one cylinder head of such at least one internal combustion engine; wherein such at least one hydrogen input manifold comprises at least one plenum adapted to pass gas between such at least one input manifold and such at least one cylinder head; at least one hydrogen provider adapted to provide hydrogen gas; at least one hydrogen conduit adapted to conduct such hydrogen gas from such at least one hydrogen provider to such at least one hydrogen input manifold; wherein such at least one hydrogen input manifold comprises at least one hydrogen port adapted to port such hydrogen gas from such at least one hydrogen conduit into such at least one plenum; at least one pressure regulator adapted to regulate pressure of such hydrogen gas through such at least one hydrogen port; and at least one flow regulator adapted to regulate flow of such hydrogen gas through such at least one hydrogen port.

[0027] And, it provides such a hydrogen fuel system, wherein each of such at least one plenums passes gas between exactly one output port of such at least one input manifold and exactly one input port of such at least one cylinder head. Further, it provides such a hydrogen fuel system, wherein such at least one hydrogen provider comprises at least one hydrogen storage tank. Even further, it provides such a hydrogen fuel system, wherein such at least one hydrogen provider comprises at least one hydrogen storage tank adapted to hold hydrogen gas compressed to about 400 pounds per square inch. Moreover, it provides such a hydrogen fuel system, wherein such at least one hydrogen provider comprises at least one hydrogen storage tank adapted to hold hydrogen gas compressed to about 300 pounds per square inch.

[0028] Additionally, it provides such a hydrogen fuel system, wherein such at least one flow regulator comprises at least one switch adapted to switch hydrogen gas flow through such at least one hydrogen conduit on and off. Also, it provides such a hydrogen fuel system, wherein such at least one flow regulator comprises at least one switch accessible to at least one driver of such at least one vehicle while driving. In addition, it provides such a hydrogen fuel system, wherein such at least one hydrogen conduit comprises at least one gas manifold. And, it provides such a hydrogen fuel system, wherein such at least one hydrogen conduit comprises at least one tuner adapted to assist tuning such flow of such hydrogen gas through such at least one hydrogen port. Further, it provides such a hydrogen fuel system, further comprising at least one idle sensor adapted to sense idling of such at least one vehicle.

[0029] Even further, it provides such a hydrogen fuel system, further comprising at least one seal adapted to seal between such at least one hydrogen input manifold and such at least one input manifold. Moreover, it provides such a hydrogen fuel system, further comprising at least one seal adapted to seal between such at least one hydrogen input manifold and such at least one cylinder head. Additionally, it provides such a hydrogen fuel system, further comprising at least one fastener adapted to fasten such at least one hydrogen input manifold between such at least one input manifold and such at least one cylinder head. Also, it provides such a hydrogen fuel system, wherein such at least one fastener comprises at least one bolt. In addition, it provides such a hydrogen fuel system, further comprising at least one pressure gauge adapted to gauge hydrogen gas pressure provided by such at least one hydrogen provider.

[0030] In accordance with another preferred embodiment hereof, this invention provides a hydrogen fuel kit, relating to injecting hydrogen fuel into at least one internal combustion engine in at least one vehicle, comprising: at least one hydrogen input manifold adapted to input hydrogen between at least one input manifold and at least one cylinder head of at least one internal combustion engine; wherein such at least one hydrogen input manifold comprises at least one plenum adapted to pass gas between such at least one input manifold and such at least one cylinder head; at least one hydrogen provider adapted to provide hydrogen gas; at least one hydrogen conduit adapted to conduct such hydrogen gas from such at least one hydrogen provider to such at least one hydrogen input manifold; wherein such at least one hydrogen input manifold comprises at least one hydrogen port adapted to port such hydrogen gas from such at least one hydrogen conduit into such at least one plenum; at least one pressure regulator adapted to regulate pressure of such hydrogen gas through such at least one hydrogen port; at least one flow regulator adapted to regulate flow of such hydrogen gas through such at least one hydrogen port; at least one instruction adapted to instruct at least one user to install and use such at least one hydrogen input manifold in at least one vehicle.

[0031] In accordance with another preferred embodiment hereof, this invention provides a hydrogen fuel kit, relating to injecting hydrogen fuel into at least one internal combustion engine in at least one vehicle, comprising: at least one hydrogen input manifold instruction adapted to instruct at least one user to construct at least one hydrogen input manifold adapted to fit between at least one input manifold and at least one cylinder head of at least one internal combustion engine; at least one parts list adapted to list parts required to install such at least one hydrogen input manifold in such at least one internal combustion engine; at least one parts list adapted to list parts required to supply hydrogen gas to such at least one hydrogen input manifold; and at least one instruction adapted to instruct at least one user to install and use such at least one constructed hydrogen input manifold in such at least one vehicle.

[0032] In accordance with another preferred embodiment hereof, this invention provides a method, relating to adapting petroleum-fueled vehicles to use hydrogen fuel, comprising the steps of: installing at least one hydrogen input manifold between at least one intake manifold and at least one cylinder head of at least one engine of at least one vehicle; installing at least one hydrogen storage tank in such at least one vehicle; installing at least one conduit between such at least one hydrogen storage tank and such at least one hydrogen input manifold; and installing at least one shutoff between such at least one hydrogen storage tank and such at least one hydrogen input manifold. And, it provides such a method, further comprising the step of filling such at least one vehicle hydrogen storage tank with hydrogen gas.

[0033] Further, it provides such a method, further comprising the step of injecting hydrogen gas from such at least one vehicle hydrogen storage tank into such at least one hydrogen input manifold while such at least one engine is running. Even further, it provides such a method, further comprising the step of using galvanically generated hydrogen to fill such at least one vehicle hydrogen storage tank. Moreover, it provides such a method, further comprising the step of adapting such at least one vehicle to run exclusively on hydrogen when such at least one engine is operating at idle speed.

[0034] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one anode; at least one container, adapted to contain such at least one anode, comprising volume in excess of three gallons, at least one cathode; at least one lid, at least one hydrogen gas storage headspace, and at least one hydrogen gas release valve; at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode; at least one heat exchanger adapted to move heat from inside such at least one container to outside of such at least one container; wherein such at least one anode initially weighs at least about one-half pound.

[0035] Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte comprising such at least one quantity of water. Also, it provides such a galvanic hydrogen generator system, wherein such at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one anode, such at least one buffer, and such at least one cathode are electrically connected together by such at least one electrolyte. And, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one electrolyte drain. Further, it provides such a galvanic hydrogen generator system, wherein such at least one anode is located above such at least one electrolyte drain.

[0036] Even further, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises magnesium. Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one buffer comprises aluminum. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises iron. Also, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises titanium. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one anode is substantially consumed within about one week. And, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen storage tank adapted to store hydrogen gas at pressures under about 400 pounds per square inch. Further, it provides such a galvanic hydrogen generator system, wherein such at least one galvanic hydrogen generator system comprises at least one Underwriters Laboratories listed appliance.

[0037] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one galvanic hydrogen generator, comprising: at least one anode; at least one container, adapted to contain such at least one anode, comprising volume in excess of three gallons, at least one cathode; at least one lid, at least one hydrogen gas storage headspace, and at least one hydrogen gas release valve; at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode; at least one heat exchanger adapted to move heat from inside such at least one container to outside of such at least one container; wherein such at least one anode initially weighs at least about one half pound; at least one water tank adapted to receive heat from such at least one heat exchanger.

[0038] Even further, it provides such a galvanic hydrogen generator system, further comprising at least one gas-burning water heater. Moreover, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen supply tube adapted to supply hydrogen from such at least one container to such at least one gas-burning water heater. Additionally, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen gas regulator adapted to regulate flow of hydrogen gas through such at least one hydrogen supply tube. Also, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte comprising such at least one quantity of water. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight. And, it provides such a galvanic hydrogen generator system, wherein such at least one anode, such at least one buffer, and such at least one cathode are electrically connected together by such at least one electrolyte.

[0039] Further, it provides such a galvanic hydrogen generator system, wherein such at least one container comprises at least one electrolyte drain. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one anode is located above such at least one electrolyte drain. Moreover, it provides such a galvanic hydrogen generator system, wherein such at least one anode comprises magnesium. Additionally, it provides such a galvanic hydrogen generator system, wherein such at least one buffer comprises aluminum. Also, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises iron. In addition, it provides such a galvanic hydrogen generator system, wherein such at least one cathode comprises titanium. And, it provides such a galvanic hydrogen generator system, wherein such at least one anode is substantially consumed within about one week. Further, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen storage tank adapted to store hydrogen gas at pressures under about 400 pounds per square inch.

[0040] Even further, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen leak sensor. Even further, it provides such a galvanic hydrogen generator system, further comprising at least one hydrogen pressure sensor. Even further, it provides such a galvanic hydrogen generator system, further comprising at least one remote monitoring system. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one galvanic hydrogen generator comprises at least one Underwriters Laboratories listed appliance.

[0041] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising the steps of: operating at least one galvanic hydrogen generator; transferring heat from such at least one galvanic hydrogen generator to at least one quantity of water contained in at least one tank; transferring heated water from such at least one tank to at least one clothes washing machine; and replacing at least one old magnesium-containing anode of such at least one galvanic hydrogen generator with at least one new magnesium-containing anode. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of burning hydrogen.

[0042] Even further, it provides such a galvanic hydrogen generator system, further comprising the step of burning hydrogen in at least one water heater. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of co-burning hydrogen in at least one natural gas water heater. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of burning hydrogen in at least one fuel cell. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of collecting hydrogen in at least one storage tank. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of selling such collected hydrogen.

[0043] Even further, it provides such a galvanic hydrogen generator system, further comprising the step of remotely monitoring such at least one galvanic hydrogen generator. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of remotely monitoring at least one hydrogen leak sensor. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of remotely monitoring at least one hydrogen pressure sensor. Even further, it provides such a galvanic hydrogen generator system, further comprising the step of remotely monitoring at least one water temperature sensor. Even further, it provides such a galvanic hydrogen generator system, wherein such step of transferring heated water from such at least one tank to at least one clothes washing machine comprises the step of transferring heated water from such at least one tank to at least one commercial clothes washing machine. Even further, it provides such a galvanic hydrogen generator system, wherein such at least one tank comprises at least one water storage tank. Even further, it provides such a galvanic hydrogen generator system, wherein such step of operating at least one galvanic hydrogen generator comprises the step of operating at least one Underwriters Laboratories listed galvanic hydrogen generator.

[0044] In accordance with another preferred embodiment hereof, this invention provides a galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising: at least one galvanic hydrogen generator, comprising: at least one anode comprising magnesium; at least one container, adapted to contain such at least one anode, comprising volume in excess of about three gallons; at least one cathode; at least one lid, at least one hydrogen gas storage headspace, and at least one hydrogen gas release valve; at least one heat exchanger adapted to assist heat exchange between such at least one galvanic hydrogen generator and at least one heat sink; wherein such at least one galvanic hydrogen generator is Underwriters Laboratories listed.

[0045] Even further, it provides such a galvanic hydrogen generator system, further comprising at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode. Even further, it provides such a galvanic hydrogen generator system, further comprising at least one electrolyte comprising at least one quantity of water.

[0046] Even further, it provides such a galvanic hydrogen generator system, further comprising each and every novel feature, element, combination, step and/or method disclosed or suggested by this patent application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] FIG. **1** shows a side view illustrating a large galvanic hydrogen generator according to a preferred embodiment of the present invention.

[0048] FIG. **2** shows a side view illustrating the large galvanic hydrogen generator, according to FIG. **1**, with an electrolyte filter and a hydrogen storage tank.

[0049] FIG. **3**A shows a top view illustrating a stack according to the preferred embodiment of FIG. **1**.

[0050] FIG. **3**B shows a side view illustrating a stack according to the preferred embodiment of FIG. **1**.

[0051] FIG. **3**C shows a front view illustrating a stack according to the preferred embodiment of FIG. **1**.

[0052] FIG. **4** shows section **4-4** of FIG. **1** illustrating the galvanic corrosion of the stack, with an expanded detail.

[0053] FIG. **5** shows a Pourbaix diagram illustrating the electrochemical behavior of magnesium under different conditions of electrical potential and electrolyte pH.

[0054] FIG. **6**A shows a diagram illustrating the electrochemical cell of magnesium and aluminum.

[0055] FIG. **6**B shows a diagram illustrating the electrochemical cell of aluminum and iron.

[0056] FIG. **6**C shows a diagram illustrating the electrochemical cell of magnesium and iron.

[0057] FIG. **7** shows a diagram illustrating the combined electrochemical cell of magnesium, aluminum, and iron.

[0058] FIG. **8** shows a front view illustrating a kit comprising the large galvanic hydrogen generator according to FIG. **1**, an electrolyte filter, electrolyte, and a hydrogen storage tank.

[0059] FIG. **9** shows a side view illustrating a small galvanic hydrogen generator according to a preferred embodiment of the present invention, with an optional water outlet.

[0060] FIG. **10** shows a side view illustrating the small galvanic hydrogen generator according to FIG. **9**, with a heat exchanger.

[0061] FIG. **1** shows a side view illustrating the small galvanic hydrogen generator according to FIG. **9**, with a heat exchanger coupled to a titanium cathode.

[0062] FIG. **12** shows a block diagram illustrating the types of energy available from the hydrogen energy system.

[0063] FIG. **13** shows a perspective view illustrating a galvanic charge in a water-permeable pouch according to a preferred embodiment of the present invention.

[0064] FIG. **14** shows a perspective view illustrating a galvanic charge in a water-soluble pouch according to a preferred embodiment of the present invention.

[0065] FIG. **15** shows a diagram illustrating a method of generating hydrogen gas with a galvanic charge according to a preferred embodiment of the present invention.

[0066] FIG. **16** shows a side view illustrating a plurality of small galvanic hydrogen generators serially feeding hydrogen to a large hydrogen storage tank.

[0067] FIG. **17** shows a front view illustrating a kit comprising the small galvanic hydrogen generator according to FIG. **9**, a galvanic charge, and instructions.

[0068] FIG. **18** shows a front view illustrating a hydrogen intake manifold system according to another preferred embodiment of the present invention.

[0069] FIG. **19** shows a front view illustrating a modification of the hydrogen intake manifold system according to FIG. **18** comprising tunable hydrogen supply tubes.

[0070] FIG. **20** shows a cross-sectional view illustrating the hydrogen intake manifold according to FIG. **18** installed between the engine block and the air intake manifold of a typical Honda four-cylinder engine.

[0071] FIG. **21** shows a front view illustrating a hydrogen intake manifold kit according to a preferred embodiment of the present invention.

[0072] FIG. **22** shows a front view illustrating a hydrogen intake manifold instructions kit according to a preferred embodiment of the present invention.

[0073] FIG. **23** shows a diagram illustrating a method of installing a hydrogen intake manifold.

[0074] FIG. **24** shows a front view illustrating a galvanic hydrogen generator according to another preferred embodiment of the present invention.

[0075] FIG. **25** shows a top view illustrating the galvanic hydrogen generator according to FIG. **24**.

[0076] FIG. **26** shows section **26-26** of FIG. **24** illustrating the galvanic hydrogen generator according to FIG. **24**.

[0077] FIG. **27** shows section **27-27** of FIG. **24** illustrating the galvanic hydrogen generator according to FIG. **24**.

[0078] FIG. **28** shows a front view illustrating another galvanic hydrogen generator according to another preferred embodiment of the present invention.

[0079] FIG. **29** shows a top view illustrating the galvanic hydrogen generator according to FIG. **27**.

[0080] FIG. **30** shows a front view of a galvanic hydrogen cell according to another preferred embodiment of the present invention.

[0081] FIG. **31** shows a side view of the galvanic hydrogen cell according to FIG. **30**.

[0082] FIG. **32** shows a block diagram illustrating a galvanic hydrogen generator adapted to provide heated water and hydrogen gas to users.

[0083] FIG. **33** shows a block diagram illustrating a galvanic hydrogen generator appliance adapted to provide heated water and hydrogen gas to users.

[0084] FIG. **34** shows a block diagram illustrating a method of using a galvanic hydrogen generator to provide heated water and hydrogen gas to commercial laundry equipment.

DETAILED DESCRIPTION OF THE BEST MODES AND PREFERRED EMBODIMENTS OF THE INVENTION

[0085] FIG. **1** shows a side view illustrating large galvanic hydrogen generator **110** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises large galvanic hydrogen generator **110**, as shown. Preferably, large galvanic hydrogen generator **110** comprises a container, preferably tank **115**, and galvanic cell **130**, as shown.

[0086] Preferably, tank **115** comprises a gas-tight tank, preferably a stainless steel tank, preferably a 99-gallon gas tank (preferably a propane tank that has been temporarily opened to receive galvanic cell **130** and then has been sealed shut again along construction seam **114**), as shown. Preferably, tank **115** comprises gas outlet **116**, pressure gauge **117**, valve **118**, filter **119**, and support **120**, as shown. Preferably, tank **115** further comprises water outlet **122**, as shown. Preferably, filter **119** removes water vapor from hydrogen gas **152**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other tanks, such as plastic tanks, no tank (open ocean), other tank accessories such as pressure alarms, temperature alarms, pressure relief valves, etc., may suffice.

[0087] Preferably, galvanic cell **130** comprises stack **131** comprising anode **132**, buffer **134**, and cathode **136**, as shown. Preferably, cathode **136** is more electropositive than anode **132**. Preferably, buffer **134** is between anode **132** and cathode **136** in electronegative potential. Preferably, anode **132** comprises magnesium, buffer **134** comprises aluminum, and cathode **136** (at least embodying herein wherein such at least one cathode comprises iron) comprises iron (preferably stainless steel). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other galvanic cell arrangements, such as other metals, no buffer, membrane buffers, etc., may suffice.

[0088] Preferably, galvanic cell **130** comprises electrolyte **140**, as shown. Preferably, electrolyte **140** (at least embodying herein wherein such at least one electrolyte material comprises at least one salt) comprises at least one ionic compound, preferably at least one salt, preferably sea-salt. Most preferably, electrolyte **140** comprises an ionic compound, preferably sea-salt, preferably dissolved in water to form a twenty-percent solution by weight (at least embodying herein wherein such at least one electrolyte material comprises sea salt; and at least embodying herein wherein such at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight). Preferably, tank **115** is at least about half filled with electrolyte **140**, as shown, most preferably filled to at least cover anode **132**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other electrolyte solutions, such as sodium chloride from other sources, other ionic compounds, other salts, other salt percentages, semi-solid electrolytes, solid electrolytes, gaseous electrolytes, etc., may suffice.

[0089] Preferably, when stack **131** and electrolyte **140** are placed in tank **115**, anode **132** rapidly galvanically corrodes, preferably producing magnesium hydroxide **150**, while hydrogen gas **152** is evolved on cathode **136** and to a lesser extent on buffer **134** (which also slowly galvanically corrodes to form aluminum hydroxide). Preferably, hydrogen gas **152** bubbles up into headspace **153** for storage, as shown. Preferably, this galvanic corrosion reaction continues until all of anode **132** has been consumed.

[0090] Preferably, water outlet **122** (at least embodying herein wherein such at least one container comprises at least one electrolyte drain) is opened to release electrolyte **140** in order to stop hydrogen gas **152** generation by stopping the galvanic corrosion of anode **132**. Preferably, support **120** supports stack **131** while permitting electrolyte **140** to flow freely through support **120**, as shown. Preferably, support **120** is a cathodic metal screen, or a strong perforated plastic plate, etc. Preferably, stack **131** rests on support **120** which is preferably above water outlet **122** (at least embodying herein at least one water output port; and at least embodying herein wherein such at least one anode is located above such at least one electrolyte drain), as shown, so that electrolyte **140** can drain entirely off stack **131**, stopping the galvanic corrosion of anode **132**. This arrangement also permits magnesium hydroxide **150** to settle to the bottom of tank **115** without covering up portions of stack **131**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other arrangements, such as suspending the stack above the bottom of the tank, resting the stack on the bottom of the tank, other supports, other methods of stopping the galvanic reaction such as polarizing the electrodes, modifying the electrolyte pH, etc., may suffice.

[0091] FIG. **2** shows a side view illustrating large galvanic hydrogen generator **110** according to FIG. **1**, with electrolyte filter **164** and hydrogen storage tank **215**. Preferably, tank **115** further comprises filter inlet port **160** (at least embodying herein at least one water input port), filter outlet port **162** (at least embodying herein wherein such at least one container comprises at least one filter port), and filter **164**, as shown. Preferably, filter **164** comprises pump **165**, as shown. Preferably, pump **165** pumps electrolyte **140** through filter **164**, removing precipitated magnesium hydroxide **150** from electrolyte **140**.

[0092] Preferably, large galvanic hydrogen generator **110** comprises storage tank **215**, as shown. Preferably, storage tank **215** comprises a gas-tight tank, preferably a stainless steel tank, preferably a 99-gallon propane tank, as shown. Preferably, excess hydrogen gas **152** from tank **115** is moved into storage tank **215** for storage, as shown. Preferably, the galvanic corrosion reaction of anode **132** and cathode **136** produces hydrogen gas **152** in sufficient quantities to generate pressures of at least 100 psi, preferably 300 psi, more preferably 400 psi (at least embodying herein at least one hydrogen storage tank adapted to store hydrogen gas at pressures of about 400 pounds per square inch). Preferably, hydrogen gas **152** pressure is monitored and is maintained at a level that is convenient for storage and transfer of hydrogen gas **152** while being safely within the pressure capabilities of tank **115** and/or tank **215**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other hydrogen storage methods, such as generating metal hydrides, pressurizing the hydrogen, liquefying the hydrogen, using multiple storage tanks, etc., may suffice.

[0093] FIG. **3**A shows a top view illustrating stack **131** according to the preferred embodiment of FIG. **1**. Preferably, stack **131** comprises about seven layers of cathodes **136**, about six layers of anodes **132**, and about ten layers of buffers **134**, as shown. Preferably, buffers **134** are placed between cathodes **136** and anodes **132**, as shown, in order to slow the galvanic corrosion reaction between anodes **132** and cathodes **136**. Preferably, the layers of stack **131** are spaced closely together enough to minimize the electrical resistance of electrolyte **140** while still permitting free flow of electrolyte **140** between the layers of stack **131**, as shown. Preferably, the centers of anodes **132** and buffers **134** are no more than about twenty millimeters apart (at least embodying herein wherein such at least one anode is adapted to be no more than about twenty millimeters away from such at least one buffer). Preferably, the sides of anodes **132** and buffers **134** are no less than about five millimeters apart to start. Preferably, the centers of buffers **134** and cathodes **136** are no more than about twenty millimeters apart (at least embodying herein wherein such at least one buffer is adapted to be no more than about twenty millimeters away from such at least one cathode). Preferably, the sides of buffers **134** and cathodes **136** are no less than about five millimeters apart to start. The Inventor has experimentally found that this spacing provides a consistent and rapid galvanic reaction that avoids overheating and the resulting electrode polarization. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other arrangements, such as other geometric arrangements, other spacings; other electrical connections; other methods of fastening the anodes, cathodes, and buffers to the straps; not using straps; not electrically connecting the anodes to each other; using other numbers of layers of anodes, cathodes, and buffers; not using buffers; etc., may suffice.

[0094] Preferably, anodes **132** are about three inches wide by about twelve inches tall by about one inch thick and weigh about seven pounds each (at least embodying herein wherein such at least one anode initially weighs at least about seven pounds). Preferably, stack **131** comprises about twelve anodes **132**, as shown. Preferably, anodes **132** are electrically connected to each other with strap **133**, as shown. Preferably, strap **133** is connected to anodes **132** with bolts **135**, as shown, which are preferably self-tapped into holes drilled into anodes **132** in order to provide a good electrical connection and to prevent electrolyte access which causes galvanic corrosion between anodes **132** and bolts **135**. The thickness of anodes **132** is the only important dimension, because the thickness determines the distance between the surfaces of anodes **132** and the surfaces of buffers **134** as anodes **132** corrode. Preferably, stack **131** comprises at least about forty pounds of anode **132** (at least embodying herein wherein such at least one anode initially weighs at least about forty pounds). More preferably, stack **131** comprises at least about eighty pounds of anode **132**, most preferably about eighty-four pounds of anode **132** (at least embodying herein wherein such at least one anode initially weighs at least about eighty pounds). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, electrolyte concentration, etc., other anode configurations, such as other electronegative metals, magnesium-based alloys, other numbers of anodes, other shapes of anodes, other weights of anodes, other thicknesses of anodes, anodes that are pre-saturated with hydrogen gas (metal hydride anodes) prior to galvanic reaction, etc., may suffice.

[0095] Preferably, cathodes **136** are about as tall and wide as the adjacent anodes **132**, as shown, and are about one-quarter inch thick. Preferably, cathodes **136** are electrically connected to each other with strap **137**, as shown. Preferably, strap **137** is connected to cathodes **136** with bolts **138**, as shown. Preferably, where tank **115** comprises stainless steel, tank **115** comprises another cathode **136** (at least embodying herein wherein such at least one container comprises such at least one cathode), as shown (or, optionally, the only cathode **136**). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, electrolyte concentration, etc., other anode configurations, such as other electropositive metals, other iron-based alloys, other numbers of cathodes, other shapes of cathodes, other weights of cathodes, other thicknesses of cathodes, etc., may suffice.

[0096] Preferably, buffers **134** are about as tall and wide as the adjacent anodes **132**, as shown, and are about one-quarter inch thick. Preferably, buffers **134** are electrically connected to each other with strap **138**, as shown. Preferably, strap **138** is connected to buffers **134** with bolts **139**, as shown. Preferably, buffers **134** are optional. Preferably, where buffers **134** are not used, the centers of anodes **132** and cathodes **136** are no more than about twenty millimeters apart. Preferably, where buffers **134** are not used, the sides of anodes **132** and cathodes **136** are no less than about five millimeters apart to start. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, electrolyte concentration, etc., other anode configurations, such as other metals, aluminum alloys, other numbers of buffers, no buffers, other shapes of buffers, other weights of buffers, other thicknesses of buffers, other buffer spacing, etc., may suffice.

[0097] FIG. **3**B shows a side view illustrating stack **131** according to the preferred embodiment of FIG. **1**.

[0098] FIG. **3**C shows a front view illustrating stack **131** according to the preferred embodiment of FIG. **1**.

[0099] FIG. **4** shows section **4-4** of FIG. **1** illustrating the galvanic corrosion of stack **131**, with an expanded detail. Preferably, in the presence of electrolyte **140**, anodes **132** are galvanically corroded by cathodes **136**, generating magnesium hydroxide **150** and hydrogen gas **152**, as shown, while also evolving heat and causing an electrical current to flow between anode **132** and cathode **136**. Preferably, magnesium hydroxide **150** settles to the bottom of tank **115** (assuming anodes **132** are magnesium), as shown. Preferably, hydrogen gas **152** bubbles up into headspace **153** (at least embodying herein at least one hydrogen gas storage headspace), as shown. Preferably, the electrical current flows through electrolyte **140** (at least embodying herein wherein such at least one anode, such at least one buffer, and such at least one cathode are electrically connected together by such at least one electrolyte); however, anodes **132** and cathodes **136** can also be preferably wired together to permit the electrical current to flow more efficiently, and/or to permit the electrical current to be harnessed for electrical power. Preferably, galvanic cell **130** (at least embodying herein at least one galvanic cell) as described will generate hydrogen gas **152** and heat at a consistent and convenient rate (preferably at least sufficient hydrogen to supplement the daily fuel of a typical commuter car) for at least about six months, preferably for at least about one year (at least embodying herein wherein such at least one anode is substantially consumed within about one year). Preferably, when anodes **132** have been consumed, large galvanic hydrogen generator **110** is replaced with a new large galvanic hydrogen generator **110**, while the used large galvanic hydrogen generator **110** is taken away for recycling. Due to the possibility of hydrogen embrittlement of tank **115**, tank **115** should be thoroughly inspected before re-use. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other methods of use, such as remote generator monitoring, generator leasing, adapting the system to provide other hydrogen generation rates, etc., may suffice.

[**0100**] FIG. **5** shows a Pourbaix diagram illustrating the electrochemical behavior of magnesium under different conditions of electrical potential and electrolyte pH. Preferably, where anode **132** substantially comprises magnesium, cathode **136** is selected to provide an electrical potential that will result in corrosion conditions below line (a), as shown, wherein magnesium anode **132** corrodes while hydrogen gas **152** is produced at cathode **136**. Preferably, electrolyte **140** is filtered and adjusted as needed to maintain pH below the pH boundary for passivation, as shown, which is where magnesium anode **132** corrodes to form magnesium oxide which is insoluble and which tends to seal anode **132** against further corrosion. The pH of the system may be purposefully raised into the passivation zone in order to shut-down the galvanic corrosion reaction, if desired (at least embodying herein at least one pH adjuster adapted to adjust pH of such at least one quantity of water to above about pH 10). The Pourbaix diagram shown is for pure magnesium in water at 25 degrees Celsius. This diagram was cited from a book by Marcel Pourbaix: "Atlas of Electrochemical Equilibria in Aqueous Solutions", Pergamon, N.Y., 1966.

[**0101**] Preferably, large galvanic hydrogen generator **110** operates at a steady electrolyte **140** temperature between about one hundred to about one hundred fifty degrees Fahrenheit, preferably about one hundred thirty five degrees Fahrenheit. Also, electrolyte **140** is preferably salt water, not pure water. These temperature and electrolyte **140** changes will affect the Pourbaix diagram of the immunity (unreactive bare metal), corrosion, and passivation (unreactive metal oxide surface) conditions for magnesium anodes **132**. Excessive temperature and excessively high pH will result in passivation. Preferably, a sufficiently large volume of electrolyte **140** is used to prevent overheating, preferably by providing a sufficient surface area to radiate away excess heat through tank **115**. Preferably, electrolyte **140** is filtered and/or replaced as needed to remove suspended magnesium hydroxide **150** and thereby lower electrolyte **140** pH (at least embodying herein at least one pH adjuster adapted to adjust pH of such at least one quantity of water to below about pH 10). Preferably, the conditions for corrosion below line (a) are maintained for efficient hydrogen gas **152** generation.

[**0102**] Preferably, electrolyte **140** comprises sea-salt water (at least embodying herein wherein such at least one salt comprises sea-salt), as shown. The chloride ions present in electrolyte **140** freely exchange with the hydroxide ions in the magnesium hydroxide **150** on the surfaces of anodes **132** to form magnesium chloride, which is highly soluble. The magnesium chloride dissolves in electrolyte **140** and then freely exchanges with hydroxide ions in solution to form magnesium hydroxide again, some of which precipitates and settles to the bottom of tank **115**, as shown. In this way, the surfaces of anodes **132** are kept clean and available for corrosion reactions. Other sea-salt ions, such as fluoride, bromide, and iodide, also participate.

[**0103**] FIG. **6**A shows a diagram illustrating the electrochemical cell of magnesium and aluminum. Preferably, magnesium anode **132** reacts with water to form magnesium hydroxide **150** while hydrogen gas **152** forms on the aluminum cathode **136**, as shown. This reaction is driven by the galvanic electrical potential of the magnesium-aluminum cell, which is about 0.67 Volts in seawater, as shown.

[**0104**] FIG. **6**B shows a diagram illustrating the electrochemical cell of aluminum and iron. Preferably, aluminum anode **132** reacts with water to form aluminum hydroxide while hydrogen gas **152** forms on the iron cathode **136**, as shown. This reaction is driven by the galvanic electrical potential of the aluminum-iron cell, which is about 1.23 Volts in seawater, as shown.

[**0105**] FIG. **6**C shows a diagram illustrating the electrochemical cell of magnesium and iron. Preferably, magnesium anode **132** reacts with water to form magnesium hydroxide **150** while hydrogen gas **152** forms on the iron cathode **136**, as shown. This reaction is driven by the galvanic electrical potential of the magnesium-iron cell, which is about 1.93 Volts in seawater, as shown.

[**0106**] FIG. **7** shows a diagram illustrating the combined electrochemical cell of magnesium, aluminum, and iron. Preferably, magnesium anode **132** reacts with water to form magnesium hydroxide **150** while hydrogen gas **152** forms on the iron cathode **136**, as shown. This reaction is driven by the galvanic electrical potential of the magnesium-iron cell, which is about 1.93 Volts in seawater, as shown. Preferably, aluminum buffer **134** behaves as a cathode **136** to the magnesium and as an anode **132** to the iron, as shown. Preferably, aluminum buffer **134** (at least embodying herein wherein such at least one buffer comprises aluminum) corrodes only slightly because it receives anodic protection from the magnesium.

[**0107**] Preferably, buffer **134** (at least embodying herein at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode) slows the galvanic reaction between anode **132** and cathode **136** by physically and electrically separating anode **132** and cathode **136**, which slows the galvanic reaction enough to permit a large mass of anode **132** to be packed into the small space of tank **115** (at least embodying herein at least one container adapted to contain such at least one galvanic cell) without overheating, as shown in FIG. **4**. By slowing the galvanic reaction between anode **132** and cathode **136**, anode **132** is protected from passivation caused by overheating and/or excessive pH. This permits large galvanic hydrogen generator **110** to generate hydrogen gas **152** at a consistent rate for long periods of time. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended hydrogen generation rate, etc., other buffers, such as no buffers, membrane buffers, other metal buffers, salt bridges, etc., may suffice.

[**0108**] FIG. **8** shows a front view illustrating kit **800** comprising large galvanic hydrogen generator **110** according to FIG. **1**, electrolyte filter **164**, electrolyte **140**, and hydrogen storage tank **215**. Preferably, kit **800** is deliverable to a user at any location. Preferably, stack **131** comes pre-installed in tank **115**, as shown. In an alternative preferred embodiment, stack **131** is placed into tank **115** by the user. Preferably, kit **800** is assembled by attaching electrolyte filter **164** (at least embodying herein at least one electrolyte filter), adding water and electrolyte **140** to large galvanic hydrogen generator **110**, and then sealing large galvanic hydrogen generator **110** (at least embodying herein wherein such at least one container is substantially permanently sealed), preferably by welding tank **115** along construction seam **114** (at least embodying herein wherein such at least one container is substantially permanently sealed by welding). Preferably, in order to prevent hydrogen gas **152** generation during welding, electrolyte **140** (preferably dry salt, concentrated brine, etc.) is contained in a time-delayed-opening container, preferably a water-soluble pouch. In an alternative preferred embodiment, water is added through electrolyte filter **164** ports after tank **115** is welded. After tank **115** is sealed, it preferably remains sealed at least until anode **132** is consumed, in order to prevent hydrogen gas **152** leakage.

[**0109**] Preferably, excess hydrogen gas **152** pressure from tank **115** is transferred into storage tank **215**, as shown. Preferably, hydrogen gas **152** is taken from storage tank **215** as needed for use as fuel. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, etc., other kit components, such as usage meters, payment receivers, other hydrogen transfer hose or tube connections, insulation, radiators, additional stacks, monitoring equipment, voltage converters, anode depletion indicators, etc., may suffice.

[**0110**] FIG. **9** shows a side view illustrating small galvanic hydrogen generator **910** according to a preferred embodiment of the present invention, with optional water outlet **922**. Preferably, hydrogen energy system **100** comprises small galvanic hydrogen generator **910**, as shown. Preferably, small galvanic hydrogen generator **910** comprises tank **915** and galvanic cell **930**, as shown.

[**0111**] Preferably, tank **915** comprises a gas tank, preferably a stainless steel gas tank, preferably a 20-pound capacity propane tank, as shown. Preferably, tank **915** comprises gas outlet **116**, pressure gauge **117**, valve **118** (at least embodying herein at least one hydrogen gas release valve), filter **119**, and support **920**, as shown. Preferably, tank **915** further comprises water outlet **922** (which is optional), as shown. Preferably, filter **119** removes water vapor and/or other impurities from hydrogen gas **152**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, economics, etc., other tanks, such as conventional gas cylinders, other sizes of liquefied gas tanks, other types of high-pressure tanks, non-metal containers, etc., may suffice.

[**0112**] Preferably, galvanic cell **930** comprises anode **932** and cathode **936**, as shown. Preferably, cathode **936** is more electropositive than anode **932**. Preferably, anode **932** comprises magnesium and cathode **936** comprises iron (preferably stainless steel). Most preferably, cathode **936** comprises tank **915**, as shown.

[**0113**] Preferably, galvanic cell **930** comprises electrolyte **140**, as shown. Preferably, a sufficient volume of water with electrolyte **140** is present to prevent passivation of anode **932** by radiating away excess heat and by having sufficient volume to prevent the pH of electrolyte **140** from getting too high (at least embodying herein wherein such at least one container is adapted to hold at least one quantity of water sufficient (relative to the quantity of such at least one anode) to prevent overheating resulting in passivation of such at least one anode). Preferably, the pH of electrolyte **140** reaches a steady state during the galvanic reaction that is dependent primarily on the electrolyte **140** volume, the electrolyte **140** temperature, the anode **132** surface area, the cathode **936** surface area, and the concentration of electrolyte **140**. Preferably, tank **915** is at least about half filled with electrolyte **140**, as shown (preferably about two to three gallons of electrolyte **140** in the case of a 20-lb capacity propane tank using about five pounds of anode **132**). Most preferably, a mass of water comprising at least about five times the mass of anode **932** is used (at least embodying herein wherein the mass of such at least one quantity of water comprises at least about five times the mass of such at least one anode). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, type of electrolyte, presence of a heat exchanger, etc., other quantities of electrolyte, such as the ocean, just enough electrolyte to cover the anodes, a larger quantity of electrolyte recirculating from a separate tank or heat exchanger, etc., may suffice.

[**0114**] Preferably, when anode **132** and electrolyte **140** are placed in tank **915**, anode **932** rapidly galvanically corrodes, preferably producing magnesium hydroxide **150**, while hydrogen gas **152** is evolved on cathode **936** (at least embodying herein wherein hydrogen gas is generated when such at least one quantity of water and such at least one galvanic charge are placed into such at least one container), as shown. Preferably, hydrogen gas **152** bubbles up into headspace **953** for storage, as shown. Preferably, a quantity of anode **132** is used that will produce a quantity of hydrogen gas **152** that is safely containable by headspace **953** (at least embodying herein wherein such at least one hydrogen gas storage headspace is adapted to contain substantially all hydrogen gas generated by such at least one galvanic charge) in tank **915**, even if anode **932** is completely consumed without releasing any hydrogen gas **152** from tank **915**. Preferably, about five pounds of magnesium shot are used as anode **932** in the case of a 20-lb capacity propane tank, as shown. Preferably, anode **932** comprises small pellets of anode material (at least embodying herein wherein such at least one anode comprises at least one pellet), most preferably magnesium shot, as shown. Preferably, anode **932** comprises at least one portion of anode material fines having very large surface area (at least embodying herein wherein such at least one anode comprises at least one fines), as shown, preferably shavings, powder, fine wires, etc. Preferably, the anode material fines corrode very rapidly to quickly generate a useful pressure of hydrogen gas **152** in tank **915**. Preferably, about one-fifth of anode **932** initially comprises anode material fines. Preferably, anode **932** is consumed within hours or days in this preferred arrangement.

[0115] Preferably, optional water outlet **922** is opened to release electrolyte **140** in order to stop hydrogen gas **152** generation by stopping the galvanic corrosion of anode **132**. Preferably, support **920** supports anode **932** while permitting electrolyte **140** to flow freely through support **920**, as shown. Preferably, support **920** comprises a cathodic metal screen, as shown, or a perforated plastic plate, etc. Preferably, anode **932** rests on support **920** which is preferably above water outlet **922**, as shown, so that electrolyte **140** can drain entirely off of anode **932** and substantially stop the galvanic corrosion of anode **932**. This arrangement also permits magnesium hydroxide **150** to settle to the bottom of tank **915** without covering up portions of anode **932**, as shown. Any magnesium hydroxide that is released into the environment by draining electrolyte **140** is substantially environmentally harmless (magnesium hydroxide is milk of magnesia, a common antacid). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, safety regulations, etc., other reaction shutdown procedures, such as poisoning the electrolyte, passivating the electrodes, freezing the electrolyte, removing the cathodes, etc., may suffice.

[0116] FIG. **10** shows a side view illustrating small galvanic hydrogen generator **910** according to FIG. **9**, with heat exchanger **1000**. Preferably, small galvanic hydrogen generator **910** comprises heat exchanger **1000**, as shown. Preferably, heat exchanger **1000** absorbs heat from tank **915** and transports that heat to heat sink **1005** (at least embodying herein wherein such at least one heat-energy converter comprises at least one Stirling engine), as shown, which preferably comprises a Stirling engine, a thermocouple, a water heater, and/or a home heating system, etc. Preferably, heat exchanger **1000** at least comprises tubing **1010** and pump **1020**, as shown. Preferably, pump **1020** pumps fluid (preferably water, oil, helium, etc.) through tubing **1010** as a heat carrier. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, rate of heat removal required to avoid passivation, etc., other heat exchanger arrangements, such as submerging the hydrogen generator in fluid, radiator fins on the tank, heat exchange tubes internal to the tank, exchanging heat directly from the electrodes, etc., may suffice.

[0117] FIG. **11** shows a side view illustrating small galvanic hydrogen generator **910** according to FIG. **9**, with heat exchanger **1100** coupled to titanium cathode **1136**. Preferably, small galvanic hydrogen generator **910** comprises heat exchanger **1100**, as shown. Preferably, heat exchanger **1100** comprises at least one titanium cathode **1136**, tubing **1110**, and pump **1020**, as shown. Preferably, pump **1020** pumps fluid (preferably water, oil, glycol, air, etc.) through tubing **1110** as a heat carrier. Preferably, heat is transferred directly off of titanium cathode **1136** which is preferably a rod partially inserted into tank **915**, as shown. In an alternative preferred embodiment, titanium cathode **1136** is placed entirely into tank **915** and heat exchanger **1000** is used to remove the excess heat, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, desired reaction rate, etc., other cathode materials, such as graphite, platinum, silver, nickel, etc., may suffice.

[0118] Because titanium is substantially more electropositive than iron, using titanium cathode **1136** accelerates the rate of galvanic corrosion in small galvanic hydrogen generator **910**. This causes more heat and hydrogen gas **152** to be produced per unit of time; small galvanic hydrogen generator **910** preferably operates at a steady state of about one hundred seventy five degrees Fahrenheit in this preferred arrangement. In order to prevent passivation of anode **932**, this heat is preferably removed from small galvanic hydrogen generator **910** by using heat exchanger **1100** and/or by using heat exchanger **1000**. This arrangement is useful where heat energy is preferred, and where extra-fast hydrogen gas **152** generation is needed. However, extra care must be taken to prevent passivation of anode **932**.

[0119] Because iron is an anode to titanium, it is important to shut down the galvanic corrosion reaction before magnesium anode **932** is completely consumed so that steel tank **915** does not corrode and rupture when titanium cathode **1136** (at least embodying herein wherein such at least one cathode comprises titanium) is being used.

[0120] Preferably, heat exchanger **1000**, heat exchanger **1100**, and heat sink **1005** are also used on large galvanic hydrogen generator **110**. Preferably, kit **800** further comprises heat exchanger **1000**, heat exchanger **1100**, and/or heat sink **1005**.

[0121] FIG. **12** shows a block diagram illustrating the types of energy available from hydrogen energy system **100**. Preferably, excess heat generated by hydrogen energy system **100** can be converted into mechanical energy and/or electricity by Stirling engine, steam engine, etc. Preferably, excess heat can be converted into electricity by use of a thermoelectric materials, thermocouples, Peltier junctions, etc. Preferably, hydrogen gas **152** generated by hydrogen energy system **100** is used as fuel in fuel cells, internal combustion engines, external combustion engines, etc. Preferably, electrical current generated by hydrogen energy system **100** can be harvested by placing a resistor between anode **132** and cathode **136**, especially in the case of large galvanic hydrogen generator **110** which has a conveniently wired-together stack **131**.

[0122] Heat, hydrogen, and electrical voltage are constantly produced by hydrogen energy system **100** as long as galvanic corrosion occurs. Essentially, the flow of electrons from the anode to the cathode, caused by the difference in electronegativity between the anode and the cathode, powers the chemical reaction of magnesium burning in water, which generates heat, hydrogen, and magnesium hydroxide, as shown.

[0123] Heat is a byproduct of the galvanic reaction, and may be removed from the system as long as enough heat remains to permit the galvanic reaction to occur at the desired rate (room temperature, etc.). Removing excess hydrogen gas **152** from the system has only a small increasing affect on the galvanic reaction rate, and the reaction is also substantially unimpeded by high hydrogen pressure in the system. Magnesium hydroxide may need to be removed from the system for the purposes of keeping the pH of the system in the corrosion range, but is otherwise not a significant factor in the reaction rate. The reaction rate is slowed by the coating of magnesium hydroxide **150** that forms on anodes **132**, but this coating is continuously dissolved by chloride ions in electrolyte **140** as previously mentioned.

[**0124**] The current between anode **132** and cathode **136** has a large affect on the performance of the system. If a resistor is applied across the current between anode **132** and cathode **136**, the production of hydrogen gas **152** by the system is slowed because electrons only slowly become available for the galvanic reaction. Further, if electrons flowing between anode **132** (at least embodying herein at least one anode) and cathode **136** (at least embodying herein at least one cathode) are diverted, for example into a separate hydrolysis cell, the hydrolysis performed by those electrons is at the expense of hydrogen gas **152** generation by the galvanic cell. By this same mechanism, the small amount of incidental hydrolysis that occurs in the galvanic cell is at the expense of hydrogen gas **152** production by the galvanic cell. Each electron flowing from anode to cathode can perform electrolysis or corrosion, but not both.

[**0125**] FIG. **13** shows a perspective view illustrating galvanic charge **1300** in water-permeable pouch **1303** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises galvanic charge **1300**, as shown. Preferably, galvanic charge **1300** comprises anode **1332** and electrolyte compound **1340**, as shown. Preferably, electrolyte compound **1340** dissolves in water to form electrolyte **140** (at least embodying herein at least one electrolyte comprising such at least one quantity of water), as shown. Preferably, galvanic charge **1300** comprises water-permeable pouch **1303**, a pre-measured quantity of anode **1332** (preferably magnesium), and a pre-measured quantity of electrolyte compound **1340** (preferably sea-salt), as shown. Preferably, galvanic charge **1300** is added to a pre-measured quantity of water in a container with cathode **136** to generate a galvanic cell, as shown in FIG. **15**. Preferably, galvanic charge **1300** is added to water in tank **915** (where tank **915** comprises cathode **136**), as shown in FIG. **15**.

[**0126**] Preferably, water-permeable pouch **1303** comprises water-permeable material capable of securely holding anode **1332** and electrolyte compound **1340**, as shown. Preferably, water-permeable pouch **1303** (at least embodying herein wherein such at least one galvanic charge further comprises at least one water-permeable container) comprises fabric, non-woven mesh, plastic screening, etc. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, etc., other water-permeable pouch materials, such as paper, pouring the anode and electrolyte into the tank with no pouch, etc., may suffice.

[**0127**] Preferably, anode **1332** (at least embodying herein wherein such at least one anode comprises magnesium; and at least embodying herein at least one magnesium fines; and at least embodying herein at least one magnesium pellet) comprises anode material shot and anode material fines, preferably magnesium shot and magnesium fines, as shown. Preferably, the magnesium fines are consumed over the course of a few minutes or hours to generate a quick supply of hydrogen gas **152**, while the magnesium shot is consumed over the course of a few days or weeks to provide a continuing supply of hydrogen gas **152**.

[**0128**] FIG. **14** shows a perspective view illustrating galvanic charge **1400** comprising water-soluble pouch **1403** according to a preferred embodiment of the present invention. Preferably, galvanic charge **1300** comprises galvanic charge **1400**, as shown. Preferably, water-permeable pouch **1303** comprises water-soluble pouch **1403**, as shown. Preferably, water-soluble pouch **1403** comprises water-soluble material capable of securely holding anode **1332** and electrolyte compound **1340** (at least embodying herein at least one electrolyte material), as shown. Preferably, water-soluble pouch **1403** (at least embodying herein at least one water-soluble container adapted to contain such at least one magnesium fines, such at least one magnesium pellet, and such at least one electrolyte material; and at least embodying herein wherein such at least one galvanic charge further comprises at least one water-soluble container) comprises water-soluble plastic (preferably polyvinyl alcohol film, as shown), paper, etc. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, etc., other water-soluble materials, such as anode foil, etc., may suffice.

[**0129**] FIG. **15** shows a diagram illustrating method **1500** of generating hydrogen gas **152** with galvanic charge **1300** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises method **1500**, as shown.

[**0130**] Preferably, small galvanic hydrogen generators **910** are stored dry (with galvanic charges **1300** either stored inside tank **915** or stored separately) until hydrogen gas **152** is needed. Preferably, when hydrogen gas **152** is needed, water and galvanic charge **1300** are added to one or more small galvanic hydrogen generators **910**, as shown.

[**0131**] Preferably, when anode **1332** has been consumed and the resulting hydrogen gas **152** has been emptied from tank **915**, tank **915** is opened and emptied, is refilled with water **1505**, a new galvanic charge **1300** (at least embodying herein at least one galvanic charge) is placed into tank **915**, as shown, and tank **915** (at least embodying herein at least one container) is re-sealed. Preferably, tank **915** opens and closes with screw-type seal **916**, as shown. Preferably, magnesium hydroxide **150** from the previous use is dried and recycled. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, etc., other steps, such as scheduled galvanic hydrogen generator replacement for users, scheduled galvanic hydrogen generator maintenance for users, galvanic hydrogen generator remote monitoring, providing galvanic hydrogen fuel stations, etc., may suffice.

[**0132**] FIG. **16** shows a side view illustrating a plurality of small galvanic hydrogen generators **910** serially feeding hydrogen gas **152** into storage tank **215**. Preferably, small galvanic hydrogen generators **910** are used to fill storage tank **215**, as shown. Preferably, small galvanic hydrogen generators **910** are serially connected to manifold **1610** which preferably directs hydrogen gas **152** into storage tank **215**, as shown. Preferably, small galvanic hydrogen generators **910** are replaced or recharged when they are spent.

[0133] Preferably, storage tanks **215** (at least embodying herein at least one hydrogen storage tank) and small galvanic hydrogen generators **910** are utilized as home hydrogen fueling stations, portable hydrogen fueling stations, fleet hydrogen fueling stations, etc. Galvanic hydrogen fueling stations are safely portable and provide fast hydrogen generation on demand without a local source of electricity.

[0134] FIG. **17** shows a front view illustrating kit **1700** comprising small galvanic hydrogen generator **910** according to FIG. **9**, galvanic charge **1300**, and instructions **1705**. Preferably, hydrogen energy system **100** comprises kit **1700**, as shown. Preferably, instructions **1705** (at least embodying herein at least one instruction for using such at least one galvanic cell to generate hydrogen gas; and at least embodying herein at least one instruction for using such at least one galvanic charge and such at least one container to generate hydrogen gas) instruct a user to (safely) generate hydrogen gas **152** by adding galvanic charge **1300** and water to small galvanic hydrogen generator **910**, as shown in FIG. **15**. Preferably, kit **1700** comprises multiple galvanic charges **1300**. Preferably, kit **1700** comprises heat exchanger **1000** (at least embodying herein at least one heat exchanger), heat exchanger **1100**, and/or heat sink **1105** (at least embodying herein at least one heat-energy converter). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, other kit components, such as safety monitors, voltage converters, pressure relief valves, replacement filters, etc., may suffice.

[0135] FIG. **18** shows a front view illustrating hydrogen intake manifold system **1800** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises hydrogen intake manifold system **1800**, as shown. Preferably, hydrogen intake manifold system **1800** comprises hydrogen intake manifold **1810**, hydrogen delivery tubes **1820**, hydrogen delivery nozzles **1830**, and hydrogen supply line **1840** (at least embodying herein at least one hydrogen conduit adapted to conduct such hydrogen gas from such at least one hydrogen provider to such at least one hydrogen input manifold), as shown.

[0136] Preferably, hydrogen intake manifold **1810** has about the same shape as the intake manifold gasket for the engine that hydrogen intake manifold **1810** is being installed on (a Honda four-cylinder engine hydrogen intake manifold was used to illustrate this particular embodiment), as shown. Preferably, hydrogen intake manifold **1810** comprises material durable enough to provide good service in an engine environment, preferably metal (preferably steel), gasket material, high-temperature plastics and/or composites, ceramics, etc. Most preferably, hydrogen intake manifold **1810** comprises aluminum, as shown. Preferably, hydrogen intake manifold **1810** is at least thick enough to accommodate the placement of hydrogen delivery nozzles **1830**, as shown in the side view. Preferably, hydrogen intake manifold **1810** comprises bolt-holes **1816** for bolting hydrogen intake manifold **1810** between engine block **2015** and air intake manifold **2020** (as shown in FIG. **20**). Preferably, hydrogen intake manifold **1810** comprises plenums **1814** for passing gas between engine block **2015** and air intake manifold **2020** (as shown in FIG. **20**). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other hydrogen intake manifold shapes, such as other numbers of plenums, other numbers of nozzles per plenum, separate hydrogen intake manifolds for each plenum, other plenum shapes, etc., may suffice.

[0137] Preferably, hydrogen delivery nozzles **1830** connect hydrogen delivery tubes **1820** to hydrogen intake manifold **1810** through hydrogen injection ports **1812** (at least embodying herein wherein such at least one hydrogen input manifold comprises at least one hydrogen port adapted to port such hydrogen gas from such at least one hydrogen conduit into such at least one plenum), as shown. Preferably, hydrogen delivery nozzles **1830** each provide free flow of hydrogen gas **152** into plenums **1814** (at least embodying herein wherein each of such at least one plenums passes gas between exactly one output port of such at least one input manifold and exactly one input port of such at least one cylinder head) of hydrogen intake manifold **1810** (at least embodying herein at least one hydrogen input manifold adapted to input hydrogen between at least one input manifold and at least one cylinder head of such at least one internal combustion engine), as shown. In an alternate preferred embodiment, hydrogen delivery nozzles **1830** shape, regulate, and/or distribute the flow of hydrogen gas **152** into plenums **1814** (at least embodying herein wherein such at least one hydrogen input manifold comprises at least one plenum adapted to pass gas between such at least one input manifold and such at least one cylinder head). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other arrangements, such as no nozzles where the delivery tubes go directly into the plenums, etc., may suffice.

[0138] Preferably, hydrogen delivery tubes **1820** are metal gas delivery tubes, preferably one-quarter inch steel tubing, as shown. Preferably, flammable-gas compatible fittings **1822** are used to connect hydrogen delivery tubes **1820** to hydrogen supply line **1840**.

[0139] FIG. **19** shows a front view illustrating a modification of the hydrogen intake manifold **1800** according to FIG. **18** comprising tunable hydrogen supply tubes **1820**. Preferably, hydrogen delivery tubes **1820** comprise approximately equal lengths of tubing each connected to hydrogen delivery manifold **1920** (at least embodying herein wherein such at least one hydrogen conduit comprises at least one gas manifold), as shown. Preferably, by having hydrogen delivery tubes **1820** (at least embodying herein wherein such at least one hydrogen conduit comprises at least one tuner adapted to assist tuning such flow of such hydrogen gas through such at least one hydrogen port) comprise approximately equal lengths, approximately equal hydrogen gas **152** flow and pressure is delivered to each plenum **1814** (at least embodying herein at least one pressure regulator adapted to regulate pressure of such hydrogen gas through such at least one hydrogen port), as shown. Also, this arrangement is more easily tunable to provide maximum engine performance. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other tunable arrangements, such as equal-length tubes without a manifold, adjustable flow controllers on each tube, etc., may suffice.

[**0140**] FIG. **20** shows a cross-sectional view illustrating hydrogen intake manifold **1810** according to FIG. **18** installed between engine block **2015** and air intake manifold **2020** of a typical Honda four-cylinder engine. Preferably, hydrogen intake manifold **1810** comprises hydrogen intake manifold **2010**, as shown, wherein hydrogen delivery nozzles **1830** are installed at an angle in order to accommodate the shape of engine block **2015**, as shown.

[**0141**] Preferably, hydrogen gas **152** is stored in vehicle hydrogen tank **2030** (at least embodying herein wherein such at least one hydrogen provider comprises at least one hydrogen storage tank), as shown, preferably at about 300 psi when full (at least embodying herein wherein such at least one hydrogen provider comprises at least one hydrogen storage tank adapted to hold hydrogen gas compressed to about 300 pounds per square inch), more preferably at about 400 psi when full (at least embodying herein wherein such at least one hydrogen provider comprises at least one hydrogen storage tank adapted to hold hydrogen gas compressed to about 400 pounds per square inch). Preferably, tank **2030** comprises a 20-gallon liquefied gas tank, preferably a propane tank, as shown.

[**0142**] Preferably, vehicle hydrogen tank **2030** comprises filling assembly **2032**, as shown. Preferably, filing assembly **2032** comprises connector **2033**, pressure gauge **2034**, valve **2035**, and safety valve **2036**, as shown. Preferably, hydrogen gas **152** is added to vehicle hydrogen tank **2030** via filing assembly **2032**. Preferably, vehicle hydrogen tank **2030** comprises distribution assembly **2037**, as shown. Preferably, distribution assembly **2037** comprises pressure gauge **2038** (at least embodying herein at least one pressure gauge adapted to gauge hydrogen gas pressure provided by such at least one hydrogen provider), optional filter **2039**, and valve **2041**, as shown. Preferably, vehicle hydrogen tank **2030** is mounted in the trunk of the user's vehicle. Preferably, galvanically generated hydrogen gas **152** is used to fill vehicle hydrogen tank **2030**. More preferably, hydrogen gas **152** that was generated by large galvanic hydrogen generator **110** and/or small galvanic hydrogen generator **910** is used to fill vehicle hydrogen tank **2030**. Preferably, vehicle hydrogen tank **2030** holds between one and seven day's supply of hydrogen gas **152** for use as supplementary fuel in a gasoline or diesel engine. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other vehicle hydrogen tanks, such as compressed gas cylinders, other types of liquefied gas containers, metal hydride storage banks, electrolysis cells, etc., may suffice.

[**0143**] Preferably, hydrogen supply line **1840** connects vehicle hydrogen tank **2030** to hydrogen delivery tubes **1820**, as shown. Preferably, the flow of hydrogen gas **152** through hydrogen supply line **1840** is controlled by solenoid valve **2040**, as shown. Preferably, solenoid valve **2040** (at least embodying herein at least one flow regulator adapted to regulate flow of such hydrogen gas through such at least one hydrogen port) is switched on and off by dashboard switch **2050** (at least embodying herein wherein such at least one flow regulator comprises at least one switch adapted to switch hydrogen gas flow through such at least one hydrogen conduit on and off), as shown, which is preferably mounted in the vehicle easily accessible to the vehicle driver (at least embodying herein wherein such at least one flow regulator comprises at least one switch accessible to at least one driver of such at least one vehicle while driving). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other hydrogen flow control methods, such a manual control, no control except for the tank valve, computerized flow control, other types of valves, etc., may suffice.

[**0144**] Preferably, optional idle sensor **2060** is switched on and off by dashboard switch **2050**, as shown. Preferably, idle sensor **2060** senses when the engine is operating at idle speed and shuts off the vehicle (gasoline or diesel) fuel pump, allowing the engine to run exclusively on hydrogen fuel. Preferably, the flow of hydrogen gas **152** is tuned to provide the optimal amount of hydrogen gas **152** to run the engine at idle speed. Preferably, the flow of hydrogen gas **152** is driven by the gas pressure in vehicle hydrogen tank **2030** (at least embodying herein at least one hydrogen provider adapted to provide hydrogen gas). Preferably, gasoline is automatically added to the hydrogen fuel by the vehicle fuel injection system to achieve engine speeds above idle. Preferably, when hydrogen intake manifold **2010** is used, the engine is tuned to "top-dead-center" in order to accommodate the high speed of hydrogen gas **152** ignition. Preferably, idle sensor **2060** operates by physically sensing the position of throttle **2062**, by optically sensing the position of throttle **2062**, as shown, and/or by monitoring the existing vehicle throttle position sensor (especially in newer, computerized cars). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, type of vehicle, etc., other hydrogen and gasoline/diesel fuel control methods, such as hydrogen pumps, other types of throttle sensors, computerized hydrogen flow control, computerized hydrogen injectors, etc., may suffice.

[**0145**] Preferably, hydrogen intake manifold **2010** is bolted between engine block **2015** and air intake manifold **2020**, as shown. Preferably, one intake manifold gasket **2011** is installed between hydrogen intake manifold **2010** and engine block **2015**, as shown, and one intake manifold gasket **2011** is installed between hydrogen intake manifold **2010** and air intake manifold **2020**, as shown.

[**0146**] FIG. **21** shows a front view illustrating hydrogen intake manifold kit **2100** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises hydrogen intake manifold kit **2100**, as shown. Preferably, hydrogen intake manifold kit **2100** comprises hydrogen intake manifold **1810**, hydrogen supply line **1840**, vehicle hydrogen tank **2030**, solenoid valve **2040**, dashboard switch **2050**, idle sensor **2060**, electrical wires **2105**, instructions **2110**, two intake manifold gaskets **2011** (at least embodying herein at least one seal adapted to seal between such at least one hydrogen input manifold and such at least one input manifold; and at least embodying herein at least one seal adapted to seal between such at least one hydrogen input manifold and such at least one cylinder head), and fasteners **2115**, as shown. Preferably, fasteners

2115 (at least embodying herein at least one fastener adapted to fasten such at least one hydrogen input manifold between such at least one input manifold and such at least one cylinder head) comprise bolts **2116** (at least embodying herein wherein such at least one fastener comprises at least one bolt), as shown. Preferably, hydrogen intake manifold kits **2100** are customized for the type of engine in which they are to be installed. Preferably, instructions **2110** (at least embodying herein at least one instruction adapted to instruct at least one user to install and use such at least one hydrogen input manifold in at least one vehicle) comprise complete instructions for installing hydrogen intake manifold **1810** in a user's vehicle. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, vehicle type, safety regulations, etc., other kit components, such as tunable nozzles, flow controllers, computer interfaces, tools, hydrogen tank covers, pressure relief valves, tubing connectors, filters, etc., may suffice.

[**0147**] FIG. **22** shows a front view illustrating hydrogen intake manifold instructions kit **2200** according to a preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises hydrogen intake manifold instructions kit **2200**, as shown. Preferably, hydrogen intake manifold instructions kit **2200** comprises instructions **2210**, as shown. Preferably, instructions **2210** comprise hydrogen manifold plans **2220**, parts list **2230**, and installation instructions **2240**, as shown.

[**0148**] Preferably, hydrogen manifold plans **2220** provide detailed specifications for making at least one hydrogen intake manifold (preferably hydrogen intake manifold **1810**) adapted to fit a user's particular vehicle engine. Preferably, hydrogen manifold plans **2220** comprise drawings that can be used to fabricate a hydrogen intake manifold at a machine shop local to the user. Most preferably, hydrogen manifold plans **2220** comprise CAD drawings that can be used to automatically machine a hydrogen manifold on a CAD/CAM system at a machine shop local to the user. Preferably, instructions **2210**, and particularly hydrogen manifold plans **2220** (at least embodying herein at least one hydrogen input manifold instruction adapted to instruct at least one user to construct at least one hydrogen input manifold adapted to fit between at least one input manifold and at least one cylinder head of at least one internal combustion engine), are also provided on electronic media, preferably on compact disc **2221**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, intended use, etc., other instructions media, such as internet downloads, memory sticks, other optical discs, paper-only, etc., may suffice.

[**0149**] Preferably, parts list **2230** provides at least one list of specific parts (tubing, bolts, hydrogen storage tank, pressure gauges, etc.) required by the user to install the hydrogen intake manifold made according to hydrogen manifold plans **2220**.

[**0150**] Preferably, installation instructions **2240** (at least embodying herein at least one instruction adapted to instruct at least one user to install and use such at least one constructed hydrogen input manifold in such at least one vehicle) comprise complete instructions for installing the hydrogen intake manifold made according to hydrogen manifold plans **2220** using the parts listed in parts list **2230** (at least embodying herein at least one parts list adapted to list parts required to install such at least one hydrogen input manifold in such at least one internal combustion engine; and at least embodying herein at least one parts list adapted to list parts required to supply hydrogen gas to such at least one hydrogen input manifold).

[**0151**] FIG. **23** shows a diagram illustrating method **2300** of installing hydrogen intake manifold **1810**. Preferably, hydrogen energy system **100** comprises method **2300**, as shown. Preferably, method **2300** comprises the steps of: installing (step **2310** (at least embodies herein the step of installing at least one hydrogen input manifold between at least one intake manifold and at least one cylinder head of at least one engine of at least one vehicle)) hydrogen input manifold **1810** between intake manifold **2020** and a cylinder head (engine block **2015**) of an engine of a vehicle (or electrical generator); installing (step **2320** (at least embodies herein the step of installing at least one hydrogen storage tank in such at least one vehicle)) hydrogen storage tank **2030** in the vehicle (or electrical generator); installing (step **2330** (at least embodies herein the step of installing at least one conduit between such at least one hydrogen storage tank and such at least one hydrogen input manifold)) a tube (preferably hydrogen supply line **1840**) between hydrogen storage tank **2030** and hydrogen intake manifold **1810**; and installing (step **2340** (at least embodies herein the step of installing at least one shutoff between such at least one hydrogen storage tank and such at least one hydrogen input manifold)) a shutoff (preferably solenoid **2040**) between hydrogen storage tank **2030** and hydrogen intake manifold **1810**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, type of vehicle, etc., other steps, such as performing safety tests, installing pressure relief valves, etc., may suffice.

[**0152**] Preferably, method **2300** comprises the step of filling (step **2350** (at least embodies herein the step of filling such at least one vehicle hydrogen storage tank with hydrogen gas)) storage tank **2030** with hydrogen gas **152**.

[**0153**] Preferably, method **2300** comprises the step of injecting (step **2360** (at least embodies herein the step of injecting hydrogen gas from such at least one vehicle hydrogen storage tank into such at least one hydrogen input manifold while such at least one engine is running)) hydrogen gas **152** from storage tank **2030** into hydrogen intake manifold **1810** while the engine is running.

[**0154**] Preferably, method **2300** comprises the step of using (step **2370** (at least embodies herein the step of using galvanically generated hydrogen to fill such at least one vehicle hydrogen storage tank)) galvanically generated hydrogen gas **152** to fill storage tank **2030**.

[**0155**] Preferably, method **2300** comprises the step of adapting (step **2380** (at least embodies herein the step of adapting such at least one vehicle to run exclusively on hydrogen when such at least one engine is operating at idle speed)) the vehicle to run exclusively on hydrogen gas **152** at idle speed. Preferably, idle sensor **2060** (at least embodying herein at least one idle sensor adapted to sense idling of such at least one vehicle) senses when the engine is operating at idle speed and shuts off the vehicle fuel pump, allowing the engine to run exclusively on hydrogen gas **152** for fuel.

[**0156**] FIG. **24** shows a front view illustrating galvanic hydrogen generator **2410** according to another preferred embodiment of the present invention. Preferably, hydrogen energy system **100** comprises galvanic hydrogen generator **2410**, as shown. Preferably, galvanic hydrogen generator **2410** comprises at least one container, preferably tank **2415**, as shown. Preferably, galvanic hydrogen generator **2410** is adapted to hold a plurality of galvanic cells **2430**, as shown.

[**0157**] Preferably, tank **2415** comprises a substantially gas-tight tank, preferably a stainless steel tank having a lid, preferably about a 5-gallon filter housing (for example, a modified Hayward Filtration Duoline filter housing, manufactured by Hayward Filtration, a Hayward Industries, Inc. company, of Elizabeth, N.J., U.S.), as shown. Preferably, tank **2415** comprises lid **2411**, gas outlet **2416**, pressure gauge **2417**, valve **2418**, and filter **2419**, as shown. Preferably, tank **2415** further comprises water outlet **2422**, as shown. Preferably, tank **2415** further comprises heat exchanger **2423**, as shown. Preferably, tank **2415** comprises pressure relief valve **2421** (at least embodying herein at least one hydrogen gas release valve), as shown. Preferably, filter **2419** removes water vapor from hydrogen gas **152**. Preferably, tank **2415** further comprises support **2420**, as shown. Preferably, lid **2411** (at least embodying herein at least one lid) is held onto tank **2415** under pressure by connectors **2412**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other tanks, such as plastic tanks, no tank (open ocean), other tank accessories such as water filters, emergency shutdowns, etc., may suffice.

[**0158**] FIG. **25** shows a top view illustrating galvanic hydrogen generator **2410** according to FIG. **24**. Preferably, heat exchanger **2423** comprises cold water inlet **2505** and hot water outlet **2510**, as shown. Preferably, heat exchanger **2423** comprises three-quarters inch diameter copper pipe. Preferably, heat exchanger **2423** (at least embodying herein at least one heat exchanger adapted to move heat from inside such at least one container to outside of such at least one container) is attached, preferably brazed, to the interior of tank **2415**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, tank shape, etc., other heat exchangers, such as other pipe configurations, double-walled tank heat exchangers, etc., may suffice.

[**0159**] FIG. **26** shows section **26**-**26** of FIG. **24** illustrating the galvanic hydrogen generator **2410** according to FIG. **24**. Preferably, galvanic hydrogen generator **2410** comprises electrolyte **2440**, as shown. Preferably, electrolyte **2440** comprises at least one ionic compound, preferably at least one salt, preferably sea-salt. Most preferably, electrolyte **2440** (at least embodying herein at least one electrolyte comprising such at least one quantity of water) comprises an ionic compound, preferably sea-salt, preferably dissolved in water to form a twenty-percent solution by weight (at least embodying herein wherein such at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight). Preferably, tank **2415** is filled to substantially cover the coils of heat exchanger **2423**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other electrolyte solutions, such as sodium chloride from other sources, other ionic compounds, other salts, other salt percentages, semi-solid electrolytes, solid electrolytes, gaseous electrolytes, etc., may suffice.

[**0160**] Preferably, support **2420** supports galvanic cells **2430** while permitting magnesium hydroxide **150** to pass through and settle to the bottom of tank **2415**, as shown. Preferably, support **2420** is a cathodic metal screen, as shown, or alternatively a strong perforated plastic plate. Preferably, galvanic cells **2430** rest on support **2420** which is preferably above water outlet **2422** (at least embodying herein wherein such at least one anode is located above such at least one electrolyte drain; and at least embodying herein wherein such at least one container comprises at least one electrolyte drain), as shown, so that electrolyte **2440** can drain entirely off galvanic cells **2430**, stopping the galvanic corrosion of anode **2432** in an emergency (at least embodying herein wherein such at least one anode, such at least one buffer, and such at least one cathode are electrically connected together by such at least one electrolyte). This arrangement also permits magnesium hydroxide **150** to settle to the bottom of tank **2415** without covering up portions of galvanic cells **2430** or heat exchanger **2423**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other arrangements, such as suspending the stack above the bottom of the tank, resting the stack on the bottom of the tank, other supports, other methods of stopping the galvanic reaction such as polarizing the electrodes, modifying the electrolyte pH, etc., may suffice.

[**0161**] FIG. **27** shows section **27**-**27** of FIG. **24** illustrating galvanic hydrogen generator **2410** according to FIG. **24**.

[**0162**] FIG. **28** shows a front view illustrating another galvanic hydrogen generator **2410** according to another preferred embodiment of the present invention. Preferably, tank **2415** comprises tank **2815**, as shown. Preferably, tank **2815** holds about fifty-five gallons of electrolyte **2440** and about sixty pounds of galvanic cells **2430**.

[**0163**] FIG. **29** shows a top view illustrating galvanic hydrogen generator **2410** according to FIG. **28**, with cover **2811** shown swung open. Preferably, tank **2815** comprises multiple chambers **2905**, as shown. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, heat output required, hydrogen output required, etc., other lidded tanks, such as lidded reaction vessels, steel barrels, other lidded industrial tanks, plastic tanks with iron-containing cathodes added, etc., may suffice.

[**0164**] FIG. **30** shows a front view of galvanic hydrogen cell **2430** according to another preferred embodiment of the present invention. Preferably, galvanic cells **2430** are used in galvanic hydrogen generator **2410**, as shown in FIGS.

24-27. Preferably, galvanic cell **2430** comprises anode **2432**, buffer **2434**, and connectors **2435**, as shown. Preferably, connectors **2435** comprise steel. Preferably, tank **2415** comprises cathode **2436** (at least embodying herein at least one cathode), as shown in FIG. **26**. Preferably, cathode **2436** is more electropositive than anode **2432**. Preferably, buffer **2434** is between anode **2432** and cathode **2436** in electronegative potential. Preferably, anode **2432** comprises magnesium. Preferably, buffer **2434** (at least embodying herein at least one buffer having an electrochemical potential between such at least one anode and such at least one cathode) comprises aluminum. Preferably, cathode **2436** comprises iron, preferably stainless steel. Preferably, buffer **2434** is riveted to anode **2432** with connectors **2435**, as shown. Preferably, connectors **2435** comprise cathodes **2436**. Preferably, buffer **2434** is curved, as shown in FIG. **31**, to permit electrolyte **2440** to pass between anode **2432** and buffer **2434**. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other galvanic cell arrangements, such as other metals, no buffer, a straight but offset buffer, membrane buffers, other anode shapes, other buffer shapes, integral cathodes, other surface area ratios, etc., may suffice.

[**0165**] Preferably, when galvanic cell **2430** and electrolyte **2440** are placed in tank **2415**, anode **2432** rapidly galvanically corrodes, preferably producing magnesium hydroxide **150**, while hydrogen gas **152** is evolved on cathode **2436** and to a lesser extent on buffer **2434** (which also slowly galvanically corrodes to form aluminum hydroxide), as shown in FIG. **26**. Preferably, hydrogen gas **152** bubbles up into headspace **2453** (at least embodying herein at least one hydrogen gas storage headspace) for storage, as shown in FIG. **26**. Preferably, this galvanic corrosion reaction continues until substantially all of anode **2432** has been consumed.

[**0166**] Preferably, tank **2415** (at least embodying herein at least one container, adapted to contain such at least one anode, comprising volume in excess of three gallons) holds about fifteen new galvanic cells **2430** (five are shown in FIG. **26**). Preferably, tank **2815** holds about sixty new galvanic cells **2430**. Preferably, galvanic cells **2430** are replaced when the galvanic reaction slows inconveniently or stops. Preferably, galvanic cells **2430** are replaced about weekly (at least embodying herein wherein such at least one anode is substantially consumed within about one week). Preferably, used buffers **2434** and connectors **2435** are removed from tank **2415** from the top while magnesium hydroxide **150** and electrolyte **2440** are drained through water outlet **2422**.

[**0167**] FIG. **31** shows a side view of galvanic hydrogen cell **2430** according to FIG. **30**. Preferably, anode **2432** (at least embodying herein at least one anode) is about three inches wide by about twelve inches long by about one-quarter inches thick. Preferably, anode **2432** weighs more than about one half pound (at least embodying herein wherein such at least one anode initially weighs at least about one-half pound). Preferably, buffer **2434** is about three inches wide by about twelve inches long by about one-sixteenth inches thick. Preferably, anode **2432** weighs about one pound. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other galvanic cell shapes, sizes, and surface area to volume ratios may suffice.

[**0168**] FIG. **32** shows a block diagram illustrating galvanic energy system **3200** adapted to provide heated water and hydrogen gas **152** to users. Preferably, hydrogen energy system **100** comprises galvanic energy system **3200**, as shown. Preferably, galvanic energy system **3200** comprises galvanic reactor **3210** and water tank **3220**, as shown. Preferably, galvanic energy system **3200** further comprises hydrogen tank **3230**, as shown. Preferably, galvanic energy system **3200** further comprises boiler **3240**, as shown. Preferably, galvanic energy system **3200** further comprises sensors **3245** and monitoring system **3250**, as shown.

[**0169**] Preferably, galvanic reactor **3210** comprises large galvanic hydrogen generator **110**. Preferably, galvanic reactor **3210** comprises small galvanic hydrogen generator **910**. Most preferably, galvanic reactor **3210** comprises galvanic hydrogen generator **2410**.

[**0170**] Preferably, galvanic energy system **3200** further comprises galvanic recirculator **3260**, as shown. Preferably, galvanic recirculator **3260** circulates heat between galvanic reactor **3210** and water tank **3220**. Preferably, galvanic recirculator **3260** circulates heat by pumping water between galvanic reactor **3210** and water tank **3220** through cold pipe **3261** and hot pipe **3262** with pump **3263** and/or pump **3264**, as shown. Preferably, water is pumped from water tank **3220**, through galvanic reactor **3210** (where heat is picked up through heat exchanger **2423**), and back to water tank **3220**, as shown. Preferably, water is recirculated through galvanic recirculator **3260** substantially constantly. Preferably, the water in galvanic recirculator **3260** is at atmospheric pressure. Preferably, constant circulation of water through heat exchanger **2423** assists in keeping the temperature of galvanic reactor **3210** low enough to prevent significant passivation of anodes **2432**.

[**0171**] Preferably, hydrogen tank **3230** comprises at least one tank adapted to hold pressurized hydrogen gas **152**, as shown. More preferably, hydrogen tank **3230** comprises at least one twenty-gallon propane tank. Preferably, hydrogen gas **152** generated in galvanic reactor **3210** is transferred to hydrogen tank **3230** through gas tube **3231**, as shown. Preferably, hydrogen gas **152** is stored in hydrogen tank **3230** until needed. Preferably, hydrogen gas **152** is stored in hydrogen tank **3230** at under two hundred pounds per square inch.

[**0172**] Preferably, boiler **3240** burns gaseous fuel to heat water. Preferably, boiler **3240** comprises at least one natural-gas burning boiler. Preferably, boiler **3240** comprises at least one natural-gas burning water heater. Preferably, boiler **3240** is supplied with natural gas from gas supply **3242** through gas meter **3244**, as shown. Preferably, flow of natural gas to boiler **3240** is regulated by regulator **3245**, as shown. In practice, regulator **3245** and gas meter **3244** are commonly a single piece of equipment. Preferably, boiler **3240** is lit in response to the temperature reading of temperature sensor **3222** attached to water tank **3220**. Preferably, if water usage causes the water in water tank **3220** to go below a threshold temperature (preferably 115 degrees Fahrenheit) despite the heat input from galvanic reactor **3210**, then boiler **3240** is lit to provide additional heat. Preferably, galvanic energy system **3200** further comprises boiler recirculator **3270**, as shown. Preferably, boiler recirculator **3270** circulates water from water tank **3220** through the heat exchanger in boiler **3240**, as shown. Typically, galvanic recirculator **3260** and boiler recirculator **3270** share pump **3271** and piping adjacent water tank **3220**, as shown.

[**0173**] Preferably, regulator **3245** receives hydrogen gas from hydrogen tank **3230** through gas tube **3232** (at least embodying herein at least one hydrogen supply tube adapted to supply hydrogen from such at least one container to such at least one gas-burning water heater), as shown. Preferably, hydrogen gas **152** is mixed with natural gas in regulator **3245** (at least embodying herein at least one hydrogen gas regulator adapted to regulate flow of hydrogen gas through such at least one hydrogen supply tube), as shown. Preferably, the mixture of hydrogen **152** and natural gas is burned by boiler **3240** (at least embodying herein at least one gas-burning water heater) to heat water, as shown. Preferably, the mixture of hydrogen **152** and natural gas is piped to other gas-heated appliances **3246**, as shown. Most natural gas burning appliances can use hydrogen **152** and natural gas mixtures, at a lower flow rate, without modification of the appliance. Most natural gas burning appliances can use pure hydrogen **152**, at a lower flow rate, with modification to the gas burner.

[**0174**] Preferably, water is added to water tank **3220** from water source **3280**, as shown. Preferably, water source **3280** comprises at least one municipal water system. Preferably, water is withdrawn from water tank **3220** (at least embodying herein at least one water tank adapted to receive heat from such at least one heat exchanger) and sent to end use **3290**, as shown. Preferably, end use **3290** comprises industrial process heating (for example, heating air for clothes dryers). Preferably, end use **3290** comprises hot water use (for example, hot water for clothes washing machines).

[**0175**] Preferably, sensors **3240** and monitoring system **3250** allow a user to collect status data relating to galvanic energy system **3200**. Preferably, sensors **3240** sense the hydrogen pressure in galvanic reactor **3210**. Preferably, sensors **3240** sense the hydrogen pressure in hydrogen tank **3230** (at least embodying herein at least one hydrogen pressure sensor). Preferably, sensors **3240** sense the temperature in water tank **3220**. Preferably, sensors **3240** sense the operational status of pump **3263** and/or pump **3264**. Preferably, sensors **3240** sense the rate of gas flow through regulator **3245**. Preferably, sensors **3240** sense the rate of gas flow through hydrogen flow meter **3233**. Preferably, sensors **3240** sense hydrogen gas **152** leaking into the atmosphere (at least embodying herein at least one hydrogen leak sensor). Preferably, monitoring system **3250** (at least embodying herein at least one remote monitoring system) allows a user to inspect the output of sensors **3240** via a readout local to the system. Preferably, monitoring system **3250** allows a user to inspect the output of sensors **3240** via a data readout remote to the system. Preferably, sensors **3240** transmit data to monitoring system **3250** wirelessly. In another preferred embodiment, sensors **3240** transmit data to monitoring system **3250** through wire connections. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, regulatory requirements, etc., other sensors, such as sensors attached to alarms, sensors attached to emergency shutoffs, anode life sensors, pH sensors, etc., may suffice.

[**0176**] FIG. **33** shows a block diagram illustrating galvanic energy appliance **3300** adapted to provide heated water and hydrogen gas **152** to users. Preferably, hydrogen energy system **100** comprises galvanic energy appliance **3300**, as shown. Preferably, galvanic energy appliance **3300** comprises galvanic reactor **3310** and hydrogen tank **3330**, as shown. Preferably, galvanic energy appliance **3300** further comprises sensors **3340** and monitoring system **3350**, as shown.

[**0177**] Preferably, galvanic reactor **3310** comprises large galvanic hydrogen generator **110**. Preferably, galvanic reactor **3310** comprises small galvanic hydrogen generator **910**. Most preferably, galvanic reactor **3310** comprises galvanic hydrogen generator **2410**. Preferably, galvanic reactor **3310** is sized to provide for a particular requirement for heat and/or hydrogen gas **152** production. Preferably, titanium cathode **1136** may also be used with galvanic reactor **3310**.

[**0178**] Preferably, galvanic energy appliance **3300** further comprises galvanic recirculator **3360**, as shown. Preferably, galvanic recirculator **3360** circulates heat between galvanic reactor **3310** and an external heat sink (such as, for example, water tank **3220**, an industrial process, a Stirling engine, etc.), as shown. Preferably, galvanic recirculator **3360** circulates heat by pumping water between galvanic reactor **3310** and the external heat sink through cold pipe **3361** and hot pipe **3362** with pump **3363**, as shown. Preferably, water is pumped from the external heat sink (or water source), through galvanic reactor **3310** (where heat is picked up through heat exchanger **2423**), and back out to the external heat sink (or end use), as shown. Preferably, water is recirculated through galvanic recirculator **3360** as heat is needed by the external heat sink. Preferably, water is recirculated through galvanic recirculator **3360** substantially constantly. Preferably, the water in galvanic recirculator **3360** is at atmospheric pressure. Preferably, especially where galvanic energy appliance **3300** is used as an on-demand water heater, the water in galvanic recirculator **3360** is at municipal water pressure.

[**0179**] Preferably, hydrogen tank **3330** comprises at least one tank adapted to hold pressurized hydrogen gas **152**, as shown. Preferably, hydrogen gas **152** generated in galvanic reactor **3310** is transferred to hydrogen tank **3330** through gas tube **3331**, as shown. Preferably, hydrogen gas **152** is stored in hydrogen tank **3330** until needed. Preferably, hydrogen gas **152** is stored in hydrogen tank **3330** at under two hundred psi.

[**0180**] Preferably, flow meter **3345** receives hydrogen gas **152** from hydrogen tank **3330** through gas tube **3332**, as shown. Preferably, hydrogen gas **152** piped to hydrogen-using appliances (such as, for example, fuel cells, hydrogen stoves, automobiles, etc.), hydrogen-using chemical processes, or to larger storage tanks.

[**0181**] Preferably, sensors **3340** and monitoring system **3350** allow a user to collect status data relating to galvanic energy appliance **3300**. Preferably, sensors **3340** sense the hydrogen gas **152** pressure in galvanic reactor **3310**. Preferably, sensors **3340** sense the hydrogen gas **152** pressure in hydrogen tank **3330**. Preferably, sensors **3340** sense the temperature in galvanic reactor **3310**. Preferably, sensors **3340** sense the temperature of water in hot pipe **3362**. Preferably, sensors **3340** sense the status of pump **3363**. Preferably, sensors **3340** sense the rate of gas flow through hydrogen flow meter **3333**. Preferably, sensors **3340** sense hydrogen gas **152** leaking into the atmosphere. Preferably, monitoring system **3350** allows a user to inspect the output of sensors **3340**. Preferably, monitoring system **3350** is battery powered. Preferably, monitoring system **3350** is powered by an electrical outlet. Preferably, monitoring system **3350** is adapted to provide remotely accessible data, such as, for example, Internet accessible data. Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other monitoring system power sources, such as an on-board fuel cell, solar power, etc., may suffice.

[0182] Preferably, galvanic energy appliance **3300** is a freestanding appliance, as shown, with standard gas and/or water connections. Preferably, galvanic energy appliance **3300** is adapted to assist safe and easy replacement of anodes **132**. Preferably, galvanic energy appliance **3300** (at least embodying herein wherein such at least one galvanic hydrogen generator system comprises at least one Underwriters Laboratories listed appliance) is inspected and listed (approved) by Underwriters Laboratories.

[0183] FIG. **34** shows a block diagram illustrating method **3400** of using galvanic reactor **3310** to provide heated water and hydrogen gas **152** to commercial laundry equipment. Preferably, hydrogen energy system **100** comprises method **3400**, as shown.

[0184] Preferably, method **3400** comprises the steps of: operating (step **3410**) at least one galvanic hydrogen generator (preferably galvanic reactor **3310**); transferring heat (step **3420**) from such at least one galvanic hydrogen generator (preferably galvanic reactor **3310**) to at least one quantity of water contained in at least one tank (preferably water tank **3220**); transferring heated water (step **3430**) from such at least one tank (preferably water tank **3220**) to at least one clothes washing machine; and replacing (step **3440**) at least one old magnesium-containing anode **132** of such at least one galvanic hydrogen generator with at least one new magnesium-containing anode **132**, as shown (at least embodying herein the step of operating at least one galvanic hydrogen generator; and at least embodying herein the step of transferring heat from such at least one galvanic hydrogen generator to at least one quantity of water contained in at least one tank; and at least embodying herein the step of transferring heated water from such at least one tank to at least one clothes washing machine; and at least embodying herein the step of replacing at least one old magnesium-containing anode of such at least one galvanic hydrogen generator with at least one new magnesium-containing anode).

[0185] Preferably, method **3400** further comprises the step of burning hydrogen (step **3450**), as shown (at least embodying herein the step of burning hydrogen). Preferably, method **3400** further comprises the step of burning hydrogen in at least one water heater (preferably boiler **3240**) (at least embodying herein the step of burning hydrogen in at least one water heater). Preferably, method **3400** further comprises the step of co-burning hydrogen in at least one natural gas water heater (preferably boiler **3240**) (at least embodying herein the step of co-burning hydrogen in at least one natural gas water heater). Preferably, method **3400** further comprises the step of burning hydrogen in at least one fuel cell (at least embodying herein the step of burning hydrogen in at least one fuel cell). Upon reading the teachings of this specification, those with ordinary skill in the art will now understand that, under appropriate circumstances, considering such issues as advances in technology, user preference, etc., other hydrogen burning steps, such as burning hydrogen in a barbecue grill, in a vehicle engine, in an air heater, and/or in a gas-heated dryer, etc., may suffice.

[0186] Preferably, method **3400** further comprises the step of collecting hydrogen (step **3460**) in at least one storage tank (preferably hydrogen tank **3230**), as shown (at least embodying herein the step of collecting hydrogen in at least one storage tank). Preferably, method **3400** further comprises the step of selling (step **3462**) such collected hydrogen (at least embodying herein the step of selling such collected hydrogen).

[0187] Preferably, method **3400** further comprises the step of remotely monitoring (step **3470**) such at least one galvanic hydrogen generator (preferably galvanic reactor **3310**), as shown (at least embodying herein the step of remotely monitoring such at least one galvanic hydrogen generator). Preferably, method **3400** further comprises the step of remotely monitoring at least one hydrogen leak sensor **3340** (at least embodying herein the step of remotely monitoring at least one hydrogen leak sensor). Preferably, method **3400** further comprises the step of remotely monitoring at least one hydrogen pressure sensor **3340** (at least embodying herein the step of remotely monitoring at least one hydrogen pressure sensor). Preferably, method **3400** further comprises the step of remotely monitoring at least one water temperature sensor **3340** (at least embodying herein the step of remotely monitoring at least one water temperature sensor).

[0188] Preferably, such step of transferring heated water (step **3430**) from such at least one tank (preferably water tank **3220**) to at least one clothes washing machine comprises the step of transferring heated water from such at least one tank (preferably water tank **3220**) to at least one commercial clothes washing machine (at least embodying herein wherein the step of transferring heated water from such at least one tank to at least one clothes washing machine comprises the step of transferring heated water from such at least one tank to at least one commercial clothes washing machine). Preferably, such at least one tank comprises at least one water heater tank (preferably integral to boiler **3240**). Preferably, such at least one tank comprises at least one water storage tank (preferably water tank **3220**).

[0189] Preferably, such step of operating (step **3410**) at least one galvanic hydrogen generator (preferably galvanic reactor **3310**) comprises the step of operating (step **3412**) at least one Underwriters Laboratories listed galvanic hydrogen generator (preferably galvanic energy appliance **3300**) (at least embodying herein wherein such step of operating at least one galvanic hydrogen generator comprises the step of operating at least one Underwriters Laboratories listed galvanic hydrogen generator). Preferably, users will benefit from using a UL listed galvanic energy appliance **3300** because users will not be required to obtain additional regulatory approval to install and use galvanic energy appliance **3300** at their home or business.

[**0190**] Although applicant has described applicant's preferred embodiments of this invention, it will be understood that the broadest scope of this invention includes modifications such as diverse shapes, sizes, and materials. Such scope is limited only by the below claims as read in connection with the above specification. Further, many other advantages of applicant's invention will be apparent to those skilled in the art from the above descriptions and the below claims.

What is claimed is:

1) A galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising:

a) at least one galvanic cell, comprising

i) at least one anode;

ii) at least one cathode; and

iii) at least one buffer having an electrochemical potential between said at least one anode and said at least one cathode;

b) at least one container, adapted to contain said at least one galvanic cell, comprising

i) volume in excess of five gallons,

ii) at least one construction seam,

iii) at least one hydrogen gas storage headspace, and

iv) at least one hydrogen gas release valve;

c) wherein said at least one construction seam is substantially permanently sealed;

d) wherein said at least one anode initially weighs at least about seven pounds; and

e) wherein said at least one container is adapted to hold at least one quantity of water sufficient relative to the quantity of said at least one anode to prevent overheating resulting in passivation of said at least one anode.

2) The galvanic hydrogen generator system, according to claim 1, further comprising at least one electrolyte comprising such at least one quantity of water.

3) The galvanic hydrogen generator system, according to claim 2, wherein said at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight.

4) The galvanic hydrogen generator system, according to claim 2, wherein said at least one anode, said at least one buffer, and said at least one cathode are electrically connected together by said at least one electrolyte.

5) The galvanic hydrogen generator system, according to claim 1, wherein said at least one container comprises said at least one cathode.

6) A galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising:

a) at least one galvanic hydrogen generator, comprising:

i) at least one anode;

ii) at least one container, adapted to contain said at least one anode, comprising

(1) volume in excess of three gallons,

(2) at least one cathode;

(3) at least one lid,

(4) at least one hydrogen gas storage headspace, and

(5) at least one hydrogen gas release valve;

iii) at least one buffer having an electrochemical potential between said at least one anode and said at least one cathode;

iv) at least one heat exchanger adapted to move heat from inside said at least one container to outside of said at least one container;

v) wherein said at least one anode initially weighs at least about one half pound;

b) at least one water tank adapted to receive heat from said at least one heat exchanger.

7) The galvanic hydrogen generator system, according to claim 6, further comprising at least one gas-burning water heater.

8) The galvanic hydrogen generator system, according to claim 7, further comprising at least one hydrogen supply tube adapted to supply hydrogen from said at least one container to said at least one gas-burning water heater.

9) The galvanic hydrogen generator system, according to claim 8, further comprising at least one hydrogen gas regulator adapted to regulate flow of hydrogen gas through said at least one hydrogen supply tube.

10) The galvanic hydrogen generator system, according to claim 6, further comprising at least one electrolyte comprising such at least one quantity of water.

11) The galvanic hydrogen generator system, according to claim 10, wherein said at least one electrolyte comprises at least one solution of about twenty percent sea salt in water, by weight.

12) The galvanic hydrogen generator system, according to claim 10, wherein said at least one anode, said at least one buffer, and said at least one cathode are electrically connected together by said at least one electrolyte.

13) The galvanic hydrogen generator system, according to claim 6, wherein said at least one container comprises at least one electrolyte drain.

14) The galvanic hydrogen generator system, according to claim 13, wherein said at least one anode is located above said at least one electrolyte drain.

15) The galvanic hydrogen generator system, according to claim 6, wherein said at least one anode comprises magnesium.

16) The galvanic hydrogen generator system, according to claim 6, wherein said at least one buffer comprises aluminum.

17) The galvanic hydrogen generator system, according to claim 6, wherein said at least one cathode comprises iron.

18) The galvanic hydrogen generator system, according to claim 6, wherein said at least one anode is substantially consumed within about one week.

19) The galvanic hydrogen generator system, according to claim 6, further comprising at least one hydrogen storage tank adapted to store hydrogen gas at pressures under about 400 pounds per square inch.

20) The galvanic hydrogen generator system, according to claim 6, further comprising at least one hydrogen leak sensor.

21) A galvanic hydrogen generator system, relating to generating hydrogen gas from water, comprising the steps of:

a) operating at least one galvanic hydrogen generator;

b) transferring heat from such at least one galvanic hydrogen generator to at least one quantity of water contained in at least one tank;

c) transferring heated water from such at least one tank to at least one clothes washing machine; and

d) replacing at least one old magnesium-containing anode of such at least one galvanic hydrogen generator with at least one new magnesium-containing anode.

22) The galvanic hydrogen generator system, according to claim 21, further comprising the step of burning hydrogen.

23) The galvanic hydrogen generator system, according to claim 22, further comprising the step of burning hydrogen in at least one water heater.

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