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(54) AIR CONDITIONING SYSTEM

(57) An air conditioning system (100) comprises a refrigerant circuit (40) and an electrical circuit (50). The refrigerant circuit (40) includes an indoor heat exchanger (23), an outdoor heat exchanger (13), a compressor (11), a refrigerant pipe (171), a first pressure stat (181), and a second pressure stat (182). The refrigerant pipe (171) is connected to the compressor (11) and forming at least part of the refrigerant circuit (40). The first pressure stat (181) is configured to detect pressure of the refrigerant in the refrigerant pipe (171). The second pressure stat (182) is configured to detect the pressure of the refrigerant in the refrigerant pipe (171). The electrical circuit (50) is configured to drive the refrigerant circuit (40). The first pressure stat (181) includes a first pressure sensor (630) and a first electrical switch (640). The first pressure sensor (630) has a first pressure threshold. The first electrical switch (640) is configured to stop the electrical circuit (50) from driving the refrigerant circuit (40) at least partially in accordance with the pressure detected by the first pressure sensor (630). The second pressure stat (182) includes a second pressure sensor (730) and a second electrical switch (740). The second pressure sensor (730) has a second pressure threshold. The second electrical switch (740) is configured to stop the electrical circuit (50) from driving the refrigerant circuit (40) at least partially in accordance with the pressure detected by the second pressure sensor (730). The first pressure threshold is different from the second pressure threshold.

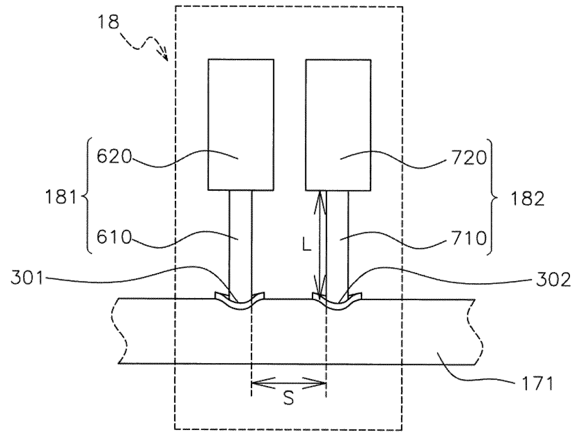

FIG.4

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Description

Technical field

[0001] This invention relates to an air conditioning system with a refrigerant circuit having an indoor heat exchanger, an outdoor heat exchanger, and a compressor.

Background art

[0002] An air conditioner circulates refrigerant in its refrigerant circuit. Such a refrigerant circuit is required to have sufficient stress endurance so that the air conditioner can retain its performance as well as the refrigerant could be prevented from affecting the outside environment in some form due to leakage. The pressure of the refrigerant is preferably observed just after being compressed by the compressor. For this purpose, some air conditioners employ a pressure stat, which is also referred to as an HPS (high pressure switch) unit, in the outdoor unit having the compressor. The pressure stat is a combinational device of a pressure sensor and an electrical switch. When the pressure sensor detects high pressure over a predetermined threshold, the electrical switch shuts down the electrical circuit that is configured to drive the refrigerant circuit.

[0003] Clearly it is more desirable in order to restrain leakage that an air conditioner should employ a plurality of pressure stats in case of malfunction and/or breakdown of one of the pressure stats. In this case, it may be natural that all the pressure stats should have the same pressure threshold level by choosing the same type of the pressure stats available from the market.

Problem to be solved by the invention

[0004] However, as long as the pressure stats have the identical threshold level, it may be difficult to expect the air conditioning system to be more than simple fail-safe.

[0005] It is therefore an object of the present invention to provide an air conditioning system with a plurality of pressure stats to prevent refrigerant from leakage, which can be used in a functional way to realize more than simple fail-safe.

Means for solving the problem

[0006] According to the first aspect of the invention, there is provided an air conditioning system comprising a refrigerant circuit and an electrical circuit. The refrigerant circuit includes an indoor heat exchanger, an outdoor heat exchanger, a compressor, a refrigerant pipe, a first pressure stat, and a second pressure stat. The refrigerant pipe is connected to the compressor and forming at least part of the refrigerant circuit. The first pressure stat is configured to detect pressure of the refrigerant in the refrigerant pipe. The second pressure stat is configured to detect the pressure of the refrigerant in the refrigerant pipe. The electrical circuit is configured to drive the refrigerant circuit. The first pressure stat includes a first pressure sensor and a first electrical switch. The first pressure sensor has a first pressure threshold. The first electrical switch is configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the first pressure sensor. The second pressure stat includes a second pressure sensor and a second electrical switch. The second pressure sensor has a second pressure threshold. The second electrical switch is configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the second pressure sensor. The first pressure threshold is different from the second pressure threshold.

[0007] With this configuration, the two pressure sensors operate in accordance with different thresholds. Accordingly, a variety of functional operations with more complexity compared to the case of employing two identical pressure stats can be realized.

[0008] According to another preferred embodiment of the air conditioning system mentioned above, the second pressure threshold is higher than the first pressure threshold. The first pressure stat is an automatically re-operative type. The second pressure stat is a manually re-operative type.

[0009] With this configuration, the second pressure stat operable with the higher threshold is a manually re-operative type, which means once the second electrical switch turns, the air conditioning system needs a technician to restart its operation. Accordingly, leakage is restrained more securely through observation by the technician.

[0010] According to a further preferred embodiment of the air conditioning system with the second pressure threshold higher than the first pressure threshold, the first pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant pipe. The second pressure stat is located on the downstream side of the first pressure stat with respect to the flow of the refrigerant in the refrigerant pipe.

[0011] With this configuration, the second pressure stat is located downstream on the refrigerant pipe with regard to the first pressure stat. The pressure loss of the refrigerant may cause the second pressure stat to tend to stay out of operation to some extent. On the other hand, the first pressure stat tends to react quickly. Accordingly, the air conditioning system can avoid frequent call for the technician.

[0012] According to another further preferred embodiment of the air conditioning system with the second pressure threshold higher than the first pressure threshold, the second pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant pipe. The first pressure stat is located on the downstream side of the second pressure stat with respect to the flow of the refrigerant in the refrigerant pipe.

[0013] With this configuration, the first pressure stat is located downstream on the refrigerant pipe with regard to the second pressure stat. The pressure loss of the refrigerant may cause the first pressure stat to tend to stay out of operation to some extent. On the other hand, the second pressure stat tends to react quickly. Accordingly, the air conditioning system can restrain refrigerant leakage more securely at any moment.

[0014] According to another preferred embodiment of any one of the air conditioning systems mentioned above, the first electrical switch is electrically connected in series with the second electrical switch.

[0015] With this configuration, the two electrical switches are electrically connected in series. Accordingly, shutdown of the electrical circuit can be achieved by operation of only either one of the two electrical switches.

[0016] According to another preferred embodiment of any one of the air conditioning systems stated above, the difference between the first pressure threshold and the second pressure threshold is bigger than the tolerance of at least one of the pressure sensors.

[0017] With the configuration, no matter how much the threshold varies within the tolerance with regard to any one of the pressure sensors, it remains the same which one of the pressure sensors has a higher pressure threshold. Accordingly, the air conditioning system can operate in a more reliable manner.

[0018] According to another preferred embodiment of any one of the air conditioning systems mentioned above, the refrigerant is flammable.

[0019] With this configuration, the refrigerant used in the refrigerant circuit is flammable. An example of such a flammable refrigerant is R32. Such a flammable refrigerant is preferably used for the above-mentioned air conditioning system which reduces the risk of refrigerant leakage.

Brief description of the drawings

[0020]

Fig. 1 is a schematic diagram of the refrigerant circuit 40 of the air conditioning system 100 according to the first embodiment of the present invention.

Fig. 2 is a schematic diagram of the electrical circuit 50 of the air conditioning system 100.

Fig. 3 is a schematic diagram of the structure of the pressure-related operation unit 18.

Fig. 4 is a schematic diagram of the structure of the pressure-related operation unit 18.

Fig. 5 is a schematic diagram of the structure of the first pressure stat 181.

Fig. 6 is a schematic diagram of the structure of the second pressure stat 182.

Fig. 7 is a top view of the refrigerant circuit 40 in the outdoor unit 10.

Fig. 8 is a side view of the refrigerant circuit 40 in the outdoor unit 10.

Fig. 9A is a cross-sectional view of the pressure-related operation unit 18 of the air conditioning system 100 according to the second embodiment of the present invention.

Figs. 9B-9D are cross-sectional views of the pressure-related operation unit 18 of the air conditioning system 100 according to first, second, and third variations of the second embodiment of the present invention, respectively.

Figs. 10A-10C are the schematic views the pressure-related operation unit 18 of the air conditioning system 100 according to the third embodiment, a first variation thereof, and a second variation thereof of the present invention, respectively.

Detailed description of preferred embodiments of the invention

<First Embodiment>

(1) Overall configuration

[0021] Fig. 1 is a schematic diagram of the air conditioning system 100 according to the first embodiment of the present invention. The air conditioning system 100 serves to cool the room air in the cooling mode whereas heat the room air in the heating mode. The air conditioning system 100 has a refrigerant circuit 40, which circulates refrigerant to perform refrigerant cycles. The refrigerant circuit 40, includes an outdoor unit 10, a first indoor unit 20a to a fifth indoor unit 20e, and a group of refrigerant transportation pipes 30, each of which connects the outdoor unit 10 and the respective one of the plurality of indoor units, i.e. the first indoor unit 20a to the fifth indoor unit 20e. Moreover, the air conditioning system 100 has an electrical circuit 50, which will be discussed with reference to Fig. 2 later.

[0022] The refrigerant is R32 refrigerant, for example, which is flammable to some extent.

(2) Detailed configuration

(2-1) Outdoor unit 10

[0023] The outdoor unit 10 shown in Fig. 1 is configured to be installed outside of the room or building and serves as a heat source, which is specifically a cold heat source in the cooling mode or a hot heat source in the heating mode.

[0024] The outdoor unit 10 includes a compressor 11, a four way valve 12, an outdoor heat exchanger 13, an outdoor fan 14, and a first outdoor expansion valve 15a to a fifth outdoor expansion valve 15e, as major components of the refrigerant circuit 40. The outdoor unit 10 further includes an outdoor heat exchanger temperature sensor 16, a refrigerant discharge pipe 171, a refrigerant suction pipe 172, a pressure-related operation unit 18, and an outdoor air temperature sensor 19.

(2-1-1) Compressor 11

[0025] The compressor 11 has a discharge port 111 and a suction port 112. The compressor 11 suctions gas-state refrigerant from the suction port 112 through the refrigerant suction pipe 172, compresses the gas-state refrigerant, and discharges it from the discharge port 111 through a refrigerant discharge pipe 171, along the arrow shown in Fig. 1.

(2-1-2) Four way valve 12

[0026] The four way valve 12 serves to change the connection of the refrigerant circuit 40 to switch the air conditioning system 100 from the cooling mode to the heating mode, or conversely. The four way valve 12 makes the connection depicted as solid lines in Fig. 1 for the cooling mode whereas it produces the connection depicted as dashed lines for the heating mode.

(2-1-3) Outdoor heat exchanger 13

[0027] The outdoor heat exchanger 13 performs heat exchange between the refrigerant and the surrounding air. The outdoor heat exchanger 13 functions as a condenser in the cooling mode whereas it acts as an evaporator in the heating mode.

(2-1-4) Outdoor fan 14

[0028] The outdoor fan 14 facilitates the heat exchange by causing the surrounding air to contact the outdoor heat exchanger 13.

(2-1-5) First outdoor expansion valve 15a to fifth outdoor expansion valve 15e

[0029] The plurality of outdoor expansion values, i.e. the first outdoor expansion valve 15a to the fifth outdoor expansion valve 15e, correspond to the plurality of indoor units, i.e. the first indoor unit 20a to the fifth indoor unit 20e, respectively. All of the first outdoor expansion valve 15a to the fifth outdoor expansion valve 15e serve to decompress the refrigerant. The degree of the decompression is adjusted by controlling the actuator that is configured to change the opening degree of the outdoor expansion valve.

(2-1-6) Refrigerant discharge pipe 171

[0030] The refrigerant discharge pipe 171 is connected to the discharge port 111 of the compressor 11 and serves to guide the compressed refrigerant that is discharged out of the compressor 11 toward the four way valve 12. The refrigerant discharge pipe 171 may include a muffler 173 to reduce the noise caused by the fluctuation of the refrigerant flow although the muffler 173 is not essential.

(2-1-7) Refrigerant suction pipe 172

[0031] The refrigerant suction pipe 172 is connected to the suction port 112 of the compressor 11 and serves to guide the refrigerant from the four way valve 12 to enter the compressor 11. The refrigerant suction pipe 172 may include an accumulator 174, which can abstract and store some liquid-state refrigerant contained in the flowing gas-state refrigerant in order to restrain the compressor 11 from being damaged.

(2-1-8) Pressure-related operation unit 18

[0032] The pressure-related operation unit 18 serves to restrain the refrigerant from leaking out of the refrigerant circuit 40. As shown in Fig. 1, the pressure-related operation unit 18 is mounted on the refrigerant discharge pipe 171. The detailed configuration of the pressure-related operation unit 18 will be discussed later.

(2-1-9) Temperature sensors

[0033] The outdoor heat exchanger temperature sensor 16 serves to monitor the temperature of the refrigerant flowing through the outdoor heat exchanger 13. The outdoor air temperature sensor 19 serves to detect the temperature of the atmosphere outside the room or building.

(2-2) First indoor unit 20a to fifth indoor unit 20e

[0034] Fig. 1 shows five indoor units, i.e. the first indoor unit 20a to the fifth indoor unit 20e. The first indoor unit 20a to the fifth indoor unit 20e serve to provide temperature-adjusted air for users in corporation with the outdoor unit 10. The five indoor units are typically installed inside of different rooms. Alternatively, at least part of the five indoor units may be installed inside of the same room. It is clear that the number of the indoor units may be other than five, meaning one or two, for example.

[0035] Hereinafter, only the first indoor unit 20a will be discussed, and the explanation will be omitted with regard to the remaining indoor units 20b to 20e, each of which has a substantially similar structure to that of the first indoor unit 20a.

[0036] The first indoor unit 20a includes an indoor heat exchanger 22, an indoor fan 23, an indoor heat exchanger temperature sensor 26, and an indoor air temperature sensor 29.

(2-2-1) Indoor heat exchanger 22

[0037] The indoor heat exchanger 22 performs heat exchange between the refrigerant and the room air. The indoor heat exchanger 22 functions as an evaporator in the cooling mode whereas it acts as a condenser in the heating mode.

(2-2-2) Indoor fan 23

[0038] The indoor fan 23 facilitates the heat exchange by making the room air contact the indoor heat exchanger 22.

(2-2-3) Temperature sensors

[0039] The indoor heat exchanger temperature sensor 26 serves to monitor the temperature of the refrigerant flowing through the indoor heat exchanger 22. The indoor air temperature sensor 29 serves to detect the temperature of the air inside the room.

(2-3) Refrigerant transportation pipes 30

[0040] The group of refrigerant transportation pipes 30 has a plurality of liquid-state refrigerant transportation pipes 31 a to 31e and a plurality of gas-state refrigerant transportation pipes 32a to 32e. Each of the liquid-state refrigerant transportation pipes 31 a to 31e connects the outdoor unit 10 with the respective one of the plurality of indoor units, i.e. the first indoor unit 20a to the fifth indoor unit 20e, to allow passage of the refrigerant in a liquid-state or a gas-liquid two-phase state. Each of the gas-state refrigerant transportation pipes 32a to 32e connects the outdoor unit 10 with the respective one of the indoor units to allow passage of the refrigerant in a gas-state.

(2-4) Electrical circuit 50

[0041] The electrical circuit 50 shown in Fig. 2 drives and controls a variety of actuators that are employed in the refrigerant circuit 40. Specifically, the electrical circuit 50 controls the rotational speed of the motor of the compressor 11, the connection of the four way valve 12, the rotational speed of the motor of the outdoor fan 14, the opening degrees of the first outdoor expansion valve 15a to the fifth outdoor expansion valve 15e, as well as the rotational speed of the motor of the indoor fan 23 for each of the first indoor unit 20a to the fifth indoor unit 20e.

[0042] The electrical circuit 50 also detects the state of the electrical switches 630, 730 of the pressure-related operation unit 18, which are connected in series. If the open-circuit state occurs between the terminal SW+ and the terminal SW-, which means both ends of the serially connected electrical switches, at least part of the electrical circuit 50 shuts down, stopping supply of the power to the actuators.

[0043] In addition, the electrical circuit 50 monitors the outdoor heat exchanger temperature sensor 16 and the outdoor air temperature sensor 19 of the outdoor unit 10, as well as the indoor heat exchanger temperature sensor 26 and the indoor air temperature sensor 29 for each of the first indoor unit 20a to the fifth indoor unit 20e, to properly control the air temperature in each of the rooms.

[0044] The electrical circuit 50 may be located entirely in any one of the outdoor unit 10 and the first indoor unit 20a to the fifth indoor unit 20e. Alternatively, the electrical circuit 50 may be divided into at least part of the outdoor unit 10 and the first indoor unit 20a to the fifth indoor unit 20e.

(3) Detailed configuration of pressure-related operation unit 18

(3-1) General configuration

[0045] As shown in Fig. 3, the pressure-related operation unit 18 includes a first pressure stat 181 and a second pressure stat 182, which are mounted on the refrigerant discharge pipe 171 at the first connection portion 301 and the second connection portion 302, respectively.

[0046] The first connection portion 301 includes a first hole 311 formed on the refrigerant discharge pipe 171 and a first burr portion 312 surrounding the first hole 311. Similarly, the second connection portion 302 includes a second hole 321 formed on the refrigerant discharge pipe 171 and a second burr portion 322 surrounding the second hole 321.

[0047] The first pressure stat 181 and a second pressure stat 182 are mounted onto the refrigerant discharge pipe 171 by inserting the connection pipe 610 of the first pressure stat 181 into the first hole 311 as well as inserting the connection pipe 710 of the second pressure stat 182 into the second hole 321. Additional brazing may be performed to secure the mounting by applying the molten metal to the first connection portion 301 and the second connection portion 302.

[0048] Fig. 4 shows the state after the mounting of the first pressure stat 181 and the second pressure stat 182 onto the refrigerant discharge pipe 171 is completed. In this figure, the metal material used in the brazing process is omitted.

(3-2) First pressure stat 181

[0049] Fig. 5 shows the structure of the first pressure stat 181. The first pressure stat 181 includes a connection pipe 610 and a body 620. The body 620 includes a pressure sensor 630 and an electrical switch 640. The pressure sensor 630 includes a sensing chamber 631, a membrane member 632, and a transmission rod 633. The electrical switch 640 includes a first terminal 641 that is connected to a movable conductor 642 with a first contact 643, and a second terminal 644 with a second contact 645.

[0050] The connection pipe 610 serves to guide the refrigerant from the refrigerant discharge pipe 171 to the body 620 so that the pressure sensor 630 can detect the pressure of the refrigerant. While the pressure of the refrigerant filling the sensing chamber 631 is lower than the threshold specifically designed for the first pressure stat 181, the first contact 643 and the second contact 645 keep in contact with each other, making electrical connection between the first terminal 641 and the second terminal 644, that is, the ON-state, or the close-circuit state, of the electrical switch 640. Here, the threshold is 4.0 MPa with a tolerance ranging from the lower limit -0.15 MPa to the upper limit +0.0 MPa, for example. In other words, the actual value of the threshold of the first pressure stat 181 can be within the range from 3.85 MPa to 4.0 MPa.

[0051] When the pressure of the refrigerant filling the sensing chamber 631 exceeds the threshold, the membrane member 632 deforms and push the transmission rod 633 and hence the movable conductor 642, leading to electrical disconnection of the first terminal 641 from the second terminal 644, that is, the OFF-state, or the open-circuit state, of the electrical switch 640.

[0052] The first pressure stat 181 is of automatically re-operative type. After the electrical switch 640 turns into the OFF-state, the electrical switch 640 can automatically return to the ON-state under a certain condition, such as the pressure of the refrigerant in the sensing chamber 631 falling below the threshold level reduced by a hysteresis, which is 3.0 MPa with a tolerance ranging from the lower limit -0.15 MPa to the upper limit +0.15 MPa, for example.

(3-3) Second pressure stat 182

[0053] Fig. 6 shows the structure of the second pressure stat 182. The second pressure stat 182 includes a connection pipe 710 and a body 720. The body 720 includes a pressure sensor 730, an electrical switch 740, and a re-operation mechanism 750. The pressure sensor 730 includes a sensing chamber 731, a membrane member 732, and a transmission rod 733. The electrical switch 740 includes a first terminal 741 that is connected to a movable conductor 742 with a first contact 743, and a second terminal 744 with a second contact 745. The re-operation mechanism 750 includes a push button 751, a push bulk 752, and a spring 753.

[0054] The connection pipe 710 serves to guide the refrigerant from the refrigerant discharge pipe 171 to the body 720 so that the pressure sensor 730 can detect the pressure of the refrigerant. When the pressure of the refrigerant filling the sensing chamber 731 is lower than the threshold specifically designed for the second pressure stat 182, the first contact 743 and the second contact 745 are in contact with each other, making electrical connection between the first terminal 741 and the second terminal 744, that is, the ON-state, or the close-circuit state, of the electrical switch 740. Here, the threshold is 4.17 MPa with a tolerance ranging from the lower limit -0.15 MPa to the upper limit +0.0 MPa, for example. In other words, the actual value of the threshold of the second pressure stat 182 can be within the range from 4.02 MPa to 4.17 MPa.

[0055] In this way, because the tolerance ranges do not overlap with regard to the first pressure stat 181 and the second pressure stat 182, the relationship of the threshold levels is prevented from reversing with regard to the first pressure stat 181 and the second pressure stat 182.

[0056] When the pressure of the refrigerant filling the sensing chamber 731 exceeds the threshold, the membrane member 732 deforms and push the transmission rod 733 and hence the movable conductor 742, leading to electrical disconnection of the first terminal 741 from the second terminal 744, that is, the OFF-state, or the open-circuit state, of the electrical switch 740. At this time, the second terminal 744 are also pressed by the transmission rod 733 and shift upward, together with the components of the re-operation mechanism 750.

[0057] The second pressure stat 182 is of manually re-operative type. Once the electrical switch 740 turns into the OFF-state, the electrical switch 740 does not return to the ON-state unless the technician executes re-operation treatment. This is because, once an OFF-state is realized, the second terminal 744 is located upward compared to the original position, being spaced apart from the movable conductor 742 that is now restored.

[0058] For re-operation treatment, the technician uses the re-operation mechanism 750. Specifically, the technician pushes the push button 751 together with the push bulk 752, making the second terminal 744 slide back to the original position so that the first contact 743 and the second contact 745 can get in touch again.

(3-4) Mounting structure

(3-4-1) Different connection portions

[0059] As will be understood from Fig. 4, the first pressure stat 181 and the second pressure stat 182 are individually connected to the refrigerant discharge pipe 171 at the different connection portions, i.e. the first connection portion 301 and the second connection portion 302, which are spaced away from each other.

(3-4-2) Long connection pipes

[0060] As shown in Fig. 5 and Fig. 6, the connection pipe 610 and the connection pipe 710 have a certain length, which is desirable in particular when the first pressure stat 181 and the second pressure stat 182 are secured to the refrigerant discharge pipe 171 by brazing using hot molten metal. Due to the molten metal applied to the first connection portion 301 and the second connection portion 302, the temperature of such connection portions becomes extremely high. The certain length of the connection pipe 610 and the connection pipe 710 desirably restrains the functional portions, such as the pressure sensor 630, the electrical switch 640, the pressure sensor 730, and the electrical switch 740, from being damaged due to such extreme heat.

(3-4-3) Close to the compressor

[0061] The pressure-related operation unit 18 is preferably mounted close to the compressor 11.

[0062] Fig. 7 shows the structure of the refrigerant circuit 40 in the outdoor unit 10. The outdoor unit 10 has a casing 101 surrounding the inner space, which is divided into the heat exchanger room 102 and the actuator room 103 by means of a separation wall 104. In the actuator room 103 is accommodated the compressor 11, the four way valve 12, the refrigerant discharge pipe 171 with the muffler 173, the accumulator 174, the pressure-related operation unit 18, and so on.

[0063] It should be noted that the pressure-related operation unit 18 is arranged in the actuator room 103 so as to be located close to the discharge port 111 of the compressor 11 along the refrigerant discharge pipe 171. This close arrangement helps secure detection of abnormal rise of the refrigerant pressure. If the distance between the compressor 11 and the pressure-related operation unit 18 is designed long, such a long flow path may cause some pressure loss, which may reduce the pressure values detected by the first pressure stat 181 and the second pressure stat 182, and therefore inhibit detection of rise of the refrigerant pressure.

(3-4-4) Laterally extending portion

[0064] Fig. 8 shows the structure of the refrigerant circuit 40 in the actuator room 103. The refrigerant discharge pipe 171 includes several portions, such as the outlet portion 171 a, the muffler 173 which can be omitted, the U-shaped portion 171b, the vertically extending portion 171c, the laterally extending portion 171 d, and portions that are invisible in this figure. The outlet portion 171 a is a pipe directly connected to the discharge port 111 of the compressor 11. The U-shaped portion 17b is connected the outlet of the muffler 173. The vertically extending portion 171 c extends right after the U-shaped portion 172. The laterally extending portion 171d extends generally in the horizontal direction and specifically inclines at the angle within the range from -10 degree to +10 degree with regard to the horizontal plane, for example.

[0065] It should be noted that the pressure-related operation unit 18 is mounted at the laterally extending portion 171d. This arrangement, in which the connection pipe 610 and the connection pipe 710 are oriented vertically, restrains the stress due to the gravitation from applying to the first connection portion 301 and the second connection portion 302 on the refrigerant discharge pipe 171, thereby reducing the risk that the refrigerant discharge pipe 171 may rapture.

[0066] In addition, the diameter of the laterally extending portion 171 d may be made larger than the diameter of the outlet portion 171 a, which can be directly/indirectly connected to the laterally extending portion 171 d. It is advantageous to arrange the first connection portion 301 and the second connection portion 302 on the laterally extending portion 171d having a larger diameter and therefore an enhanced strength in terms of stress endurance. Preferably, the laterally extending portion 171 d has a diameter of 3/8 inch or more.

(3-4-5) interval S

[0067] As shown in Fig. 4, the connection pipe 610 of the first pressure stat 181 and the connection pipe 710 of the second pressure stat 182 have a length L. At the same time, the connection pipe 610 and the connection pipe 710 are mounted on the refrigerant discharge pipe 171 with an interval S. Preferably, the interval S is equal to or larger than 0.4 times as the length L of the connection pipe 610, 710.

(4) Operation of the pressure-related operation unit 18

[0068] If the pressure of the refrigerant rises to an abnormal level in the refrigerant discharge pipe 171, such abnormal state can be detected by any one of the first pressure stat 181 and the second pressure stat 182, which can shut down at least part of the electrical circuit 50.

[0069] Accordingly, at least part of the actuators, such as the compressor 11, is quickly deactivated, and then the pressure of the refrigerant is restrained from increasing any longer. In this way, refrigerant leakage is restrained from occurring.

[0070] Since the first pressure stat 181 has a lower threshold than that of the second pressure stat 182, the first pressure stat 181 essentially tends to detect the abnormal pressure faster than the second pressure stat 182.

(5) Characteristics

(5-1)

[0071] The first pressure sensor 630 and the second pressure sensor 730 operate in accordance with different thresholds. Accordingly, a variety of functional operations with more complexity compared to the case of employing two identical pressure stats can be realized.

(5-2)

[0072] The second pressure stat 182 operable with the higher threshold is a manually re-operative type, which means once the second electrical switch 740 turns, the air conditioning system 100 needs a technician to restart its operation. Accordingly, leakage is restrained more securely through observation by the technician.

(5-3)

[0073] The second pressure stat 182 is located downstream on the refrigerant pipe with regard to the first pressure stat 181. The pressure loss of the refrigerant may cause the second pressure stat 182 to tend to stay out of operation to some extent. On the other hand, the first pressure stat 180 tends to react quickly. Accordingly, the air conditioning system 100 can avoid frequent call for the technician.

(5-4)

[0074] The first electrical switch 640 and the second electrical switch 740 are electrically connected in series. Accordingly, shutdown of the electrical circuit 50 can be achieved by operation of only either one of the two electrical switches.

(5-5)

[0075] No matter how much the threshold varies within the tolerance with regard to any one of the first pressure sensor 630 and the second pressure sensor 730, it remains the same which one of the first pressure sensor 630 and the second pressure sensor 730 has a higher pressure threshold. Accordingly, the air conditioning system 100 can operate in a more reliable manner.

(5-6)

[0076] The refrigerant used in the refrigerant circuit 40 is flammable. An example of such a flammable refrigerant is R32. Such a flammable refrigerant is preferably used for the above-mentioned air conditioning system 100 which reduces the risk of refrigerant leakage.

(6) Variations

(6-1) Order of the pressure stats

[0077] In the air conditioning system 100 according to the above-mentioned embodiment, the first pressure stat 181 is mounted closer to the compressor 11 than the second pressure stat 182. On the contrary, however, in the air conditioning system, the second pressure stat 182 may be mounted closer to the compressor 11 than the first pressure stat 181.

[0078] With this configuration, the second pressure stat 182 may be less susceptible to a pressure loss, which reduces the pressure of the refrigerant at a farther location from the discharge port 111 along the refrigerant discharge pipe 171. Thus, the second pressure stat 182 tends to react quickly. Accordingly, the second pressure stat 182 may detect the abnormal pressure faster, and in some cases faster than even the first pressure stat 181. Therefore, refrigerant leakage can be restrained more securely, involving call of the technician more frequently for checking the air conditioning system 100.

(6-2) Number of the pressure stats

[0079] The air conditioning system 100 according to the above-mentioned embodiment employs two pressure stats. However, the air conditioning system may have more than three pressure stats. With this configuration, refrigerant leakage can be restrained more securely.

<Second Embodiment>

(1) Configuration

[0080] The air conditioning system 100 according to the second embodiment differs from the first embodiment only in the structure of the pressure-related operation unit 18, while being common in the other features.

[0081] Fig. 9A shows the pressure-related operation unit 18 according to the second embodiment. In this figure, brazing molten metal to fix the first pressure stat 181 and the second pressure stat 182 onto the refrigerant discharge pipe 171 is omitted.

[0082] The pressure-related operation unit 18 includes a reinforcement joint 33A mounted on the refrigerant discharge pipe 171. The reinforcement joint 33A securely supports the connection pipe 610 and the connection pipe 710 with regard to the refrigerant discharge pipe 171. The reinforcement joint 33A has a first branching portion 332A and a second branching portion 333A both branching from a main portion 331 A. The first branching portion 332A is positioned at the first hole 311 of the refrigerant discharge pipe 171. Similarly, the second branching portion 333A is positioned at the second hole 321 of the refrigerant discharge pipe 171. The first branch portion 332A and the second branch portion 333A are configured to receive the connection pipe 610 and the connection pipe 710, respectively.

[0083] Accordingly, the first connection portion 301 and the second connection portion 302 show higher stress endurance due to the reinforcement joint 33A.

(2) First variation

[0084] Fig. 9B shows the pressure-related operation unit 18 according to a first variation of the second embodiment. The pressure-related operation unit 18 includes two separated reinforcement joints 33B, which are mounted on the refrigerant discharge pipe 171 and correspond to the first connection portion 301 and the second connection portion 302, respectively. Similarly, brazing molten metal is omitted in this figure.

[0085] With this configuration, higher stress endurance can be achieved for the first connection portion 301 and the second connection portion 302 by means of the two separated reinforcement joints 33B. This configuration is preferable for the case that the first connection portion 301 and the second connection portion 302 are spaced away from each other by a relatively long distance.

(3) Second variation

[0086] Fig. 9C shows the pressure-related operation unit 18 according to a second variation of the second embodiment. Brazing molten metal is omitted in this figure.

[0087] Similarly to the original configuration of the second embodiment, the pressure-related operation unit 18 includes a reinforcement joint 33A mounted on the refrigerant discharge pipe 171. The reinforcement joint 33A securely supports the connection pipe 610 and the connection pipe 710 with regard to the refrigerant discharge pipe 171.

[0088] In this variation, the refrigerant discharge pipe 171 is divided into two parts. The gap between these two parts contains the first connection portion 301 and the second connection portion 302, which are specifically embodied by the first branch portion 332A and the second branch portion 333A, respectively.

[0089] With this configuration, the pressure-related operation unit 18 can be assembled in advance of the first pressure stat 181, the second pressure stat 182, and the reinforcement joint 33A. Accordingly, it is easy for the worker to mount the pressure-related operation unit 18 on the refrigerant discharge pipe 171.

(4) Third variation

[0090] Fig. 9D shows the pressure-related operation unit 18 according to a third variation of the second embodiment. Similarly to the first variation of the second embodiment, the pressure-related operation unit 18 includes two separated reinforcement joints 33B, which are mounted on the refrigerant discharge pipe 171 and correspond to the first connection portion 301 and the second connection portion 302, respectively. Brazing molten metal is omitted in this figure.

[0091] In this variation, the refrigerant discharge pipe 171 is divided into a plurality of parts. The gaps between these parts contribute to constitution of the first connection portion 301 and the second connection portion 302.

[0092] With this configuration, the first pressure stat 181, the second pressure stat 182, and the two reinforcement joints 33B can be at least partly assembled in advance. Accordingly, it is easy for the worker to mount the pressure-related operation unit 18 on the refrigerant discharge pipe 171.

<Third Embodiment>

(1) Configuration

[0093] The air conditioning system 100 according to the third embodiment differs from the first and second embodiments only in the structure of the pressure-related operation unit 18, while being common in the other features.

[0094] Fig. 10A shows the pressure-related operation unit 18 according to the third embodiment. In this figure, brazing molten metal to fix the first pressure stat 181 and the second pressure stat 182 onto the refrigerant discharge pipe 171 is omitted.

[0095] The pressure-related operation unit 18 includes a first pressure stat 181 and a second pressure stat 182 arranged relatively close to each other. The body 620 of the first pressure stat 181 is fixed to the body 720 of the second pressure stat 182 by means of the banding band 183A, which functions as a fixing means. The connection pipe 610 of the first pressure stat 181 and the connection pipe 710 of the second pressure stat 182 are individually connected to respective connection portion 301, 302 of the refrigerant discharge pipe 171.

[0096] With this configuration, the first pressure stat 181 and the second pressure stat 182 move together when they receive vibration from the compressor 11. Accordingly, the first pressure stat 181 and the second pressure stat 182 are restrained from colliding with each other into breakdown.

[0097] Further, the first pressure stat 181 and the second pressure stat 182 are fixed to each other at their bodies 620, 720. Accordingly, the bodies are stably fixed.

(2) Variations

(2-1) First variation

[0098] Fig. 10B shows the pressure-related operation unit 18 according to a first variation of the third embodiment. The body 620 of the first pressure stat 181 is fixed to the body 720 of the second pressure stat 182 by means of a deformable and/or sticky material 183B.

[0099] With this configuration, the first pressure stat 181 and the second pressure stat 182 move together when they receive vibration from the compressor 11. Accordingly, the first pressure stat 181 and the second pressure stat 182 are restrained from colliding with each other into breakdown.

(2-2) Second variation

[0100] Fig. 10C shows the pressure-related operation unit 18 according to a second variation of the third embodiment. The body 620 of the first pressure stat 181 and the body 720 of the second pressure stat 182 are integrally formed with a resin material 183C.

[0101] With this configuration, the body 620 of the first pressure stat 181 and the body 720 of the second pressure stat 182 are integrally formed as one piece having a plurality of pressure sensors, i.e. the pressure sensor 630 and the pressure sensor 730. This configuration may be produced by integral molding, for example. The integrally formed bodies have two or more connection pipes which are individually connected to respective connection portions of the refrigerant discharge pipe 171.

[0102] Accordingly, the first pressure stat 181 and the second pressure stat 182 are firmly fixed and are easier to be mounted on the refrigerant discharge pipe 171.

(2-3) Other variations

[0103] Instead of the banding band 183A, the deformable and/or sticky material 183B, or the resin material 183C, the pressure-related operation unit 18 can employ other types of fixing means, such as a metal member, or a combination of the fixing means mentioned so far.

[0104] Accordingly, such a variety of fixing means enable the first pressure stat 181 and the second pressure stat 182 to be stably fixed in a more desirable manner.

11	compressor
13	outdoor heat exchanger
23	indoor heat exchanger
33A, 33B	reinforcement joint
40	refrigerant circuit
50	electrical circuit
100	air conditioning system
171	refrigerant discharge pipe
171a	outlet portion
171d	laterally extending portion
181	first pressure stat
182	second pressure stat
301	first connection portion
302	second connection portion
610, 710	connection pipe
620, 720	body
630, 730	pressure sensor
640, 740	electrical switch

Claims

1. An air conditioning system (100) comprising:

a refrigerant circuit (40) including:

an indoor heat exchanger (23),
an outdoor heat exchanger (13),
a compressor (11);
a refrigerant pipe (171) connected to the compressor and forming at least part of the refrigerant circuit,
a first pressure stat (181) configured to detect pressure of the refrigerant in the refrigerant pipe; and
a second pressure stat (182) configured to detect the pressure of the refrigerant in the refrigerant pipe; and

an electrical circuit (50) configured to drive the refrigerant circuit;

wherein

the first pressure stat includes:

a first pressure sensor (630) having a first pressure threshold; and
a first electrical switch (640) configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the first pressure sensor;

the second pressure stat includes:

a second pressure sensor (730) having a second pressure threshold; and
a second electrical switch (740) configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the second pressure sensor; and

the first pressure threshold is different from the second pressure threshold.

2. The air conditioning system according to Claim 1, wherein the second pressure threshold is higher than the first pressure threshold,
the first pressure stat is an automatically re-operative type, and
the second pressure stat is a manually re-operative type.

3. The air conditioning system according to Claim 2, wherein,
the first pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant pipe, and
the second pressure stat is located on the downstream side of the first pressure stat with respect to the flow of the refrigerant in the refrigerant pipe.

4. The air conditioning system according to Claim 2, wherein
the second pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant pipe, and
the first pressure stat is located on the downstream side of the second pressure stat with respect to the flow of the refrigerant in the refrigerant pipe.

5. The air conditioning system according to any one of Claims 1 to 4, wherein the first electrical switch is electrically connected in series with the second electrical switch.

6. The air conditioning system according to any one of Claims 1 to 5, wherein the difference between the first pressure threshold and the second pressure threshold is bigger than the tolerance of at least one of the pressure sensors.

7. The air conditioning system according to any one of Claims 1 to 6, wherein the refrigerant is flammable.

Amended claims in accordance with Rule 137(2) EPC.

1. An air conditioning system (100) comprising:

a refrigerant circuit (40) including:

an indoor heat exchanger (23),
an outdoor heat exchanger (13),
a compressor (11);
a refrigerant discharge pipe (171) connected to the compressor and forming at least part of the refrigerant circuit, the refrigerant discharge pipe being connected to the discharge port (111) of the compressor (11) and serves to guide the compressed refrigerant that is discharged out of the compressor (11);
an electrical circuit (50) configured to drive the refrigerant circuit;

characterized in that
the refrigerant circuit (40) further includes:

a first pressure stat (181) and a second pressure stat (182), which are mounted on the refrigerant discharge pipe (171) at a first connection portion (301) and a second connection portion (302), respectively;
the first pressure stat (181) configured to detect pressure of the refrigerant in the refrigerant pipe; and
the second pressure stat (182) configured to detect the pressure of the refrigerant in the refrigerant pipe;

wherein
the first pressure stat (181) includes:

a first pressure sensor (630) having a first pressure threshold; and
a first electrical switch (640) configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the first pressure sensor;

the second pressure stat (182) includes:

a second pressure sensor (730) having a second pressure threshold; and
a second electrical switch (740) configured to stop the electrical circuit from driving the refrigerant circuit at least partially in accordance with the pressure detected by the second pressure sensor; and

the first pressure threshold is different from the second pressure threshold.

2. The air conditioning system according to Claim 1, wherein
the second pressure threshold is higher than the first pressure threshold,
the first pressure stat is an automatically re-operative type, and
the second pressure stat is a manually re-operative type.

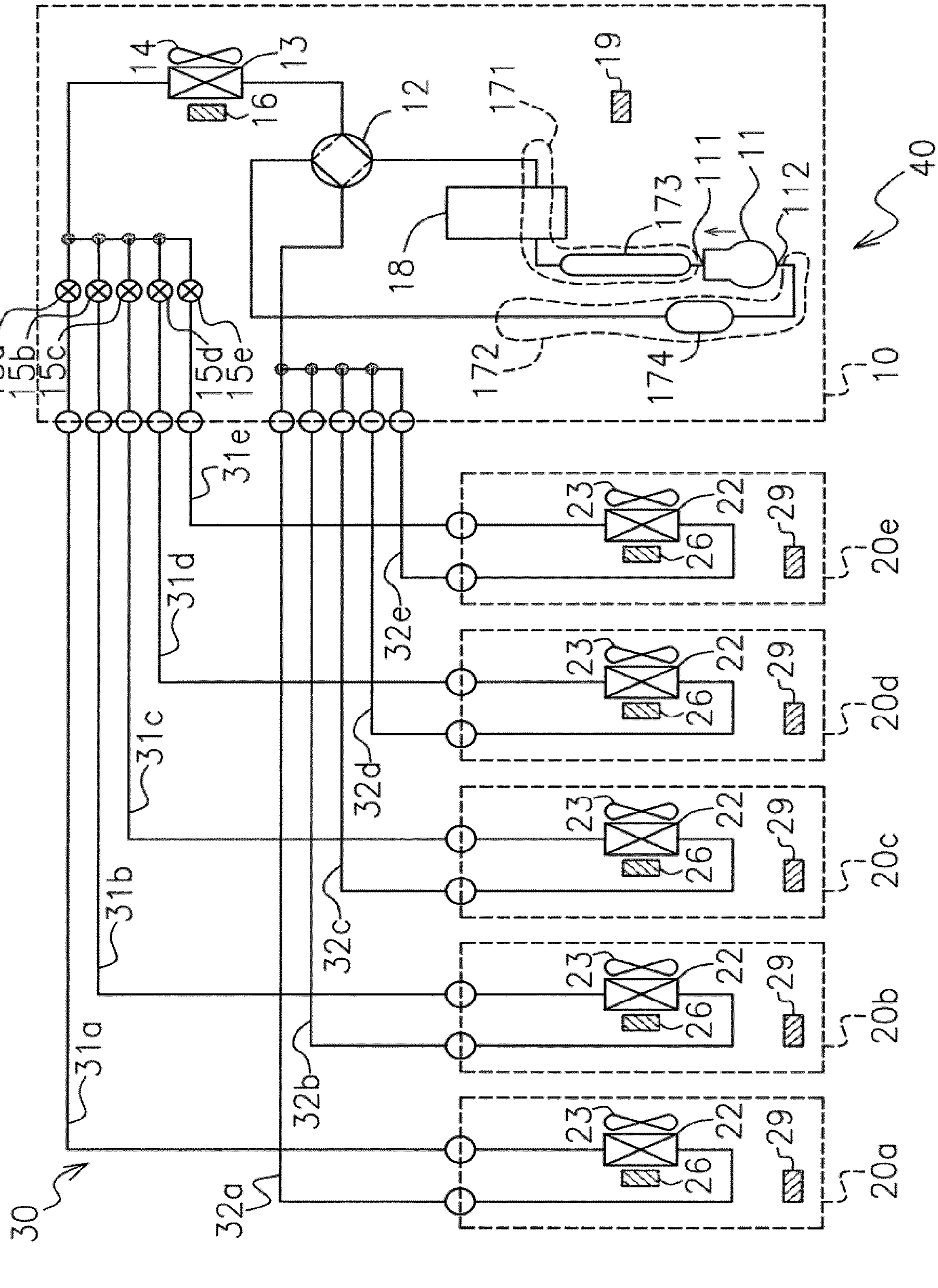
3. The air conditioning system according to Claim 2, wherein,
the first pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant discharge pipe, and
the second pressure stat is located on the downstream side of the first pressure stat with respect to the flow of the refrigerant in the refrigerant discharge pipe.

4. The air conditioning system according to Claim 2, wherein
the second pressure stat is located on the downstream side of the compressor with respect to the flow of the refrigerant in the refrigerant discharge pipe, and
the first pressure stat is located on the downstream side of the second pressure stat with respect to the flow of the refrigerant in the refrigerant discharge pipe.

5. The air conditioning system according to any one of Claims 1 to 4, wherein the first electrical switch is electrically connected in series with the second electrical switch.

6. The air conditioning system according to any one of Claims 1 to 5, wherein the difference between the first pressure threshold and the second pressure threshold is bigger than the tolerance of at least one of the pressure sensors.

7. The air conditioning system according to any one of Claims 1 to 6, wherein the refrigerant is flammable.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31d
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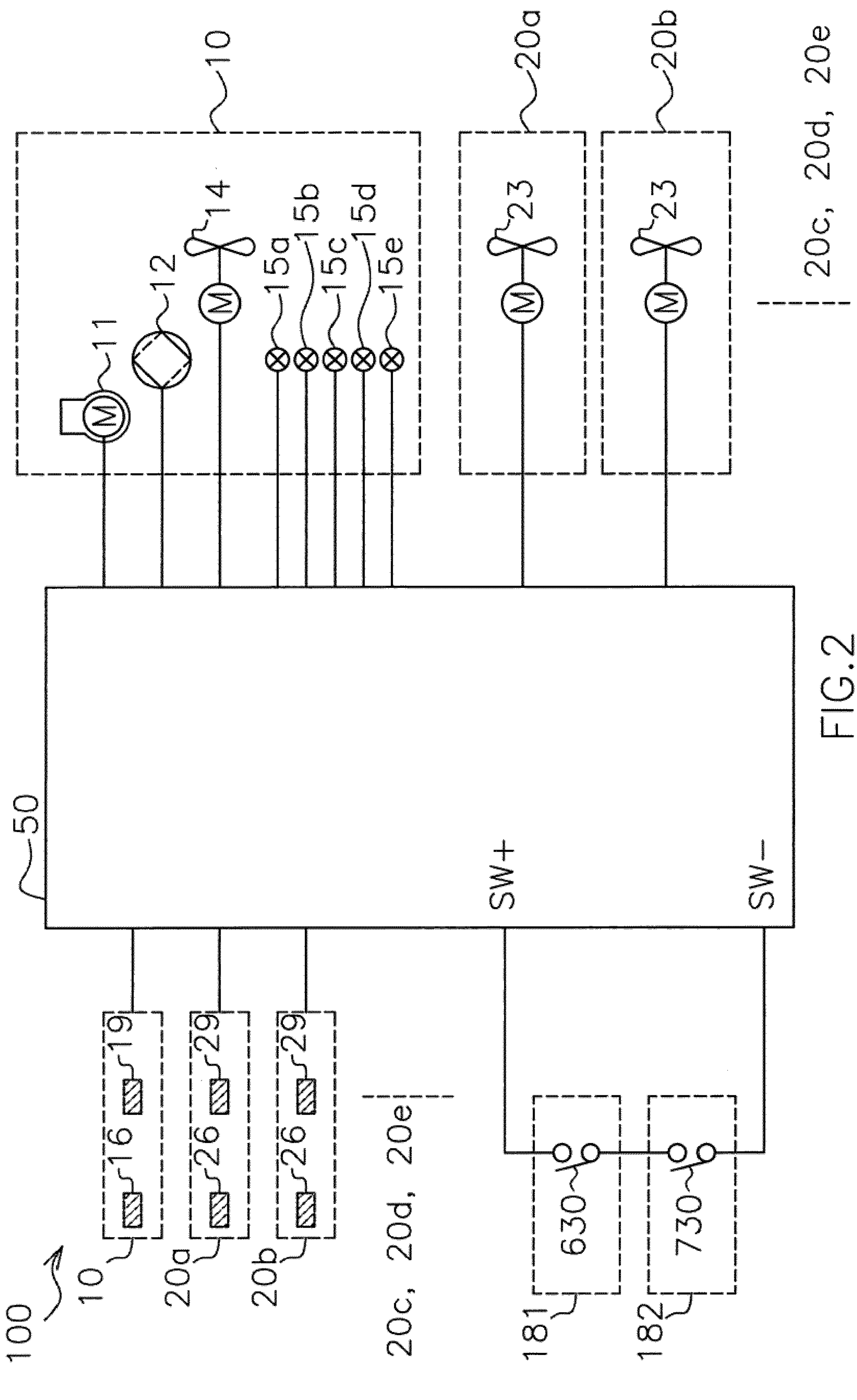
FIG.1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23
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23
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SW+
SW−
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29
20b
26
29
20c, 20d, 20e
630
730
181
182

FIG.2

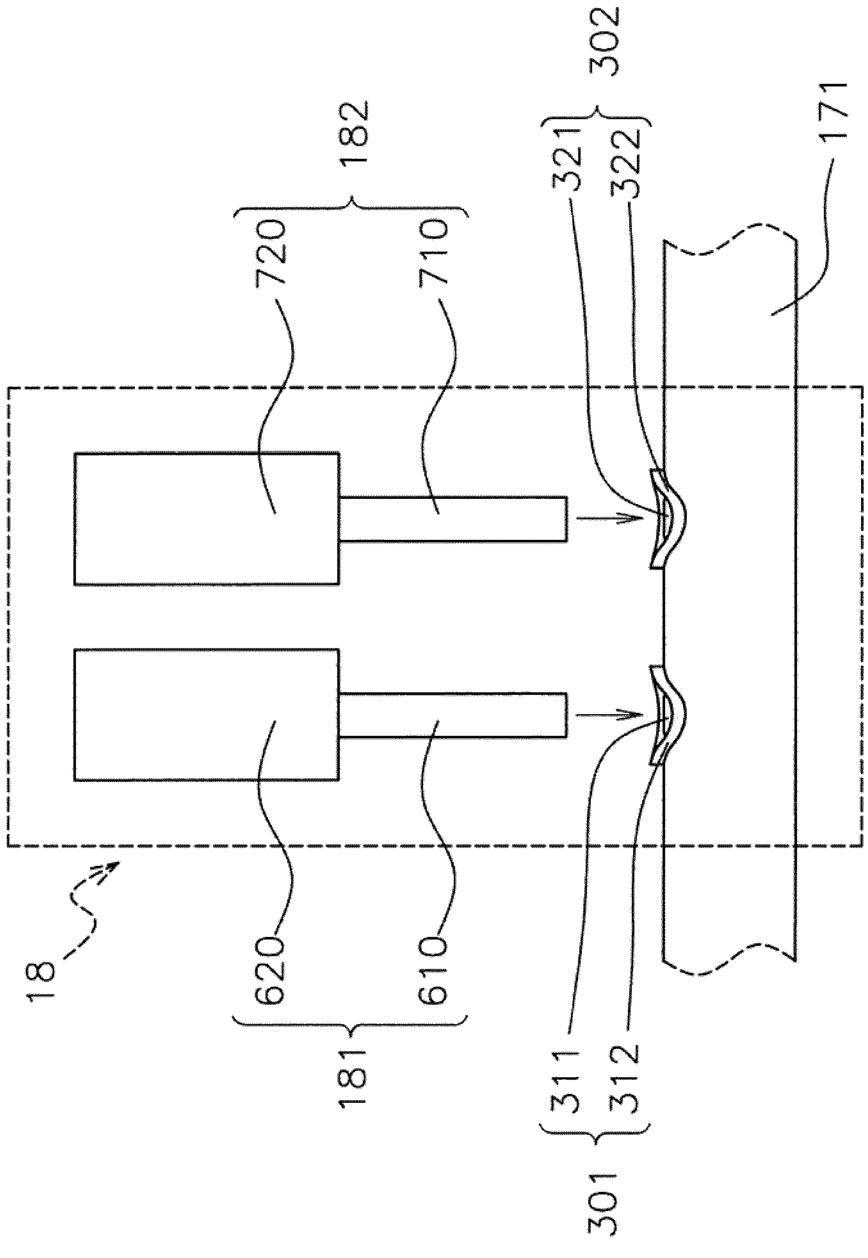


FIG.3

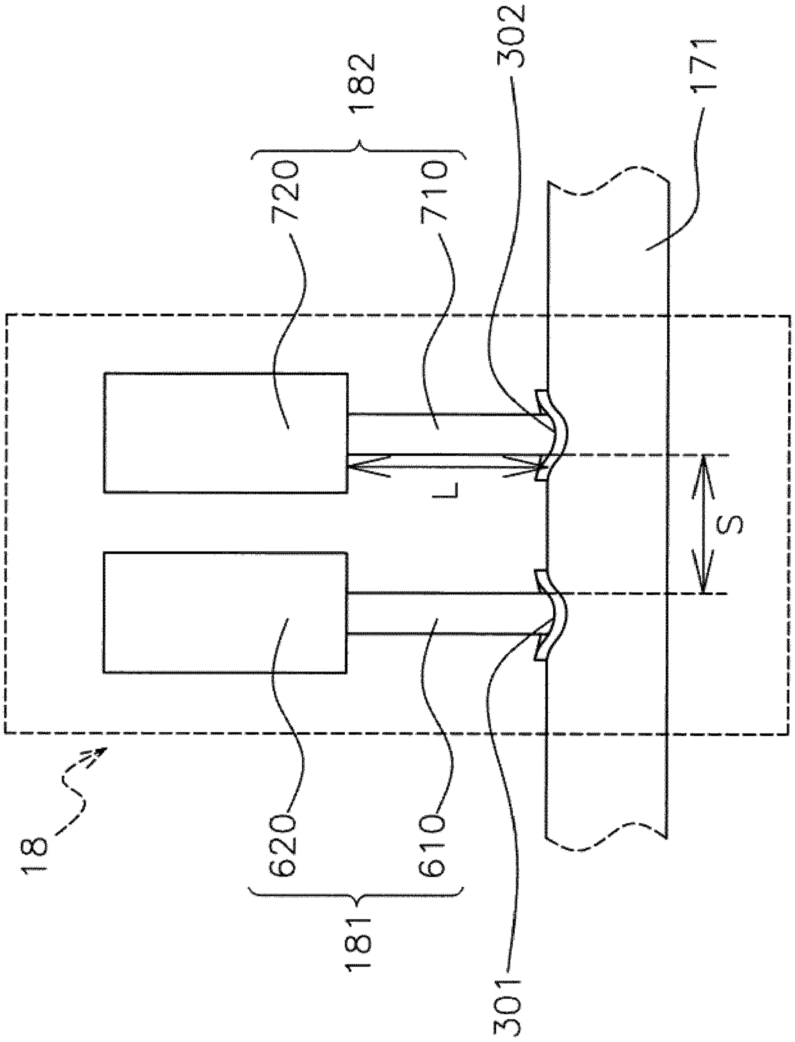


FIG.4

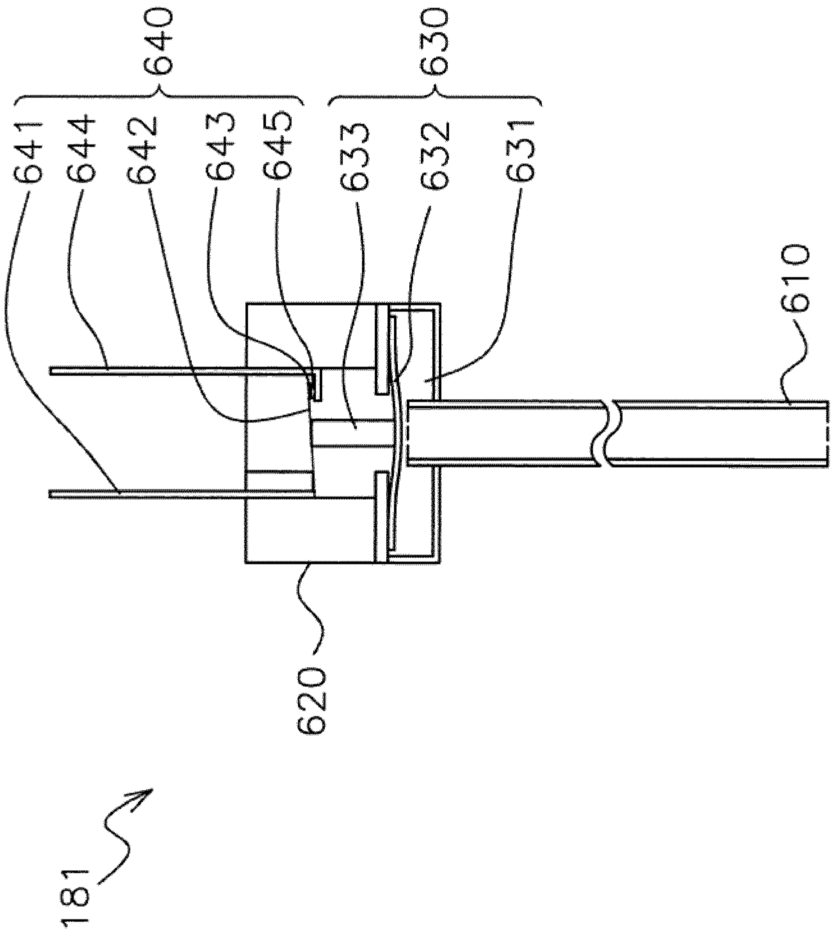


FIG.5

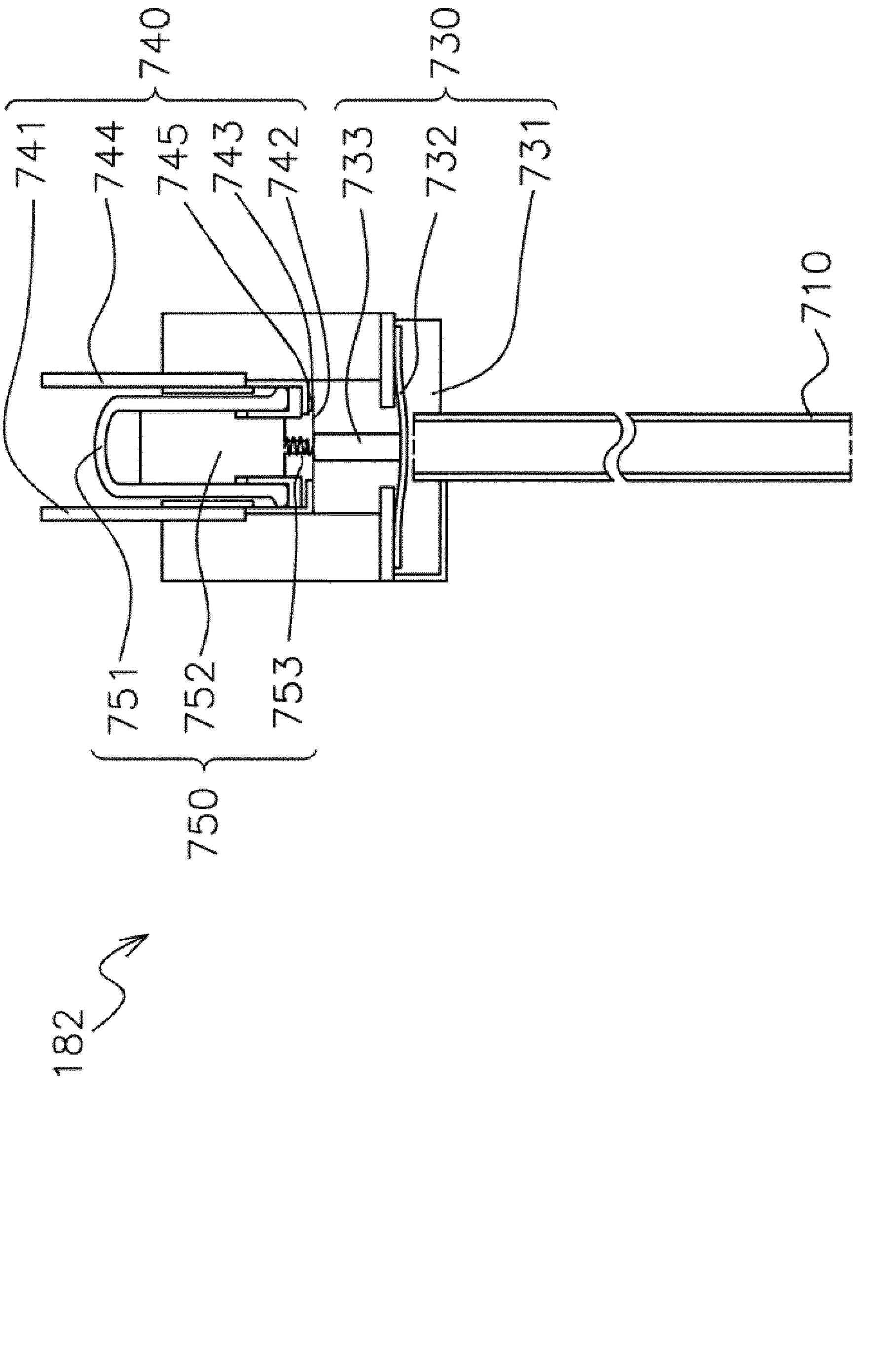


FIG.6

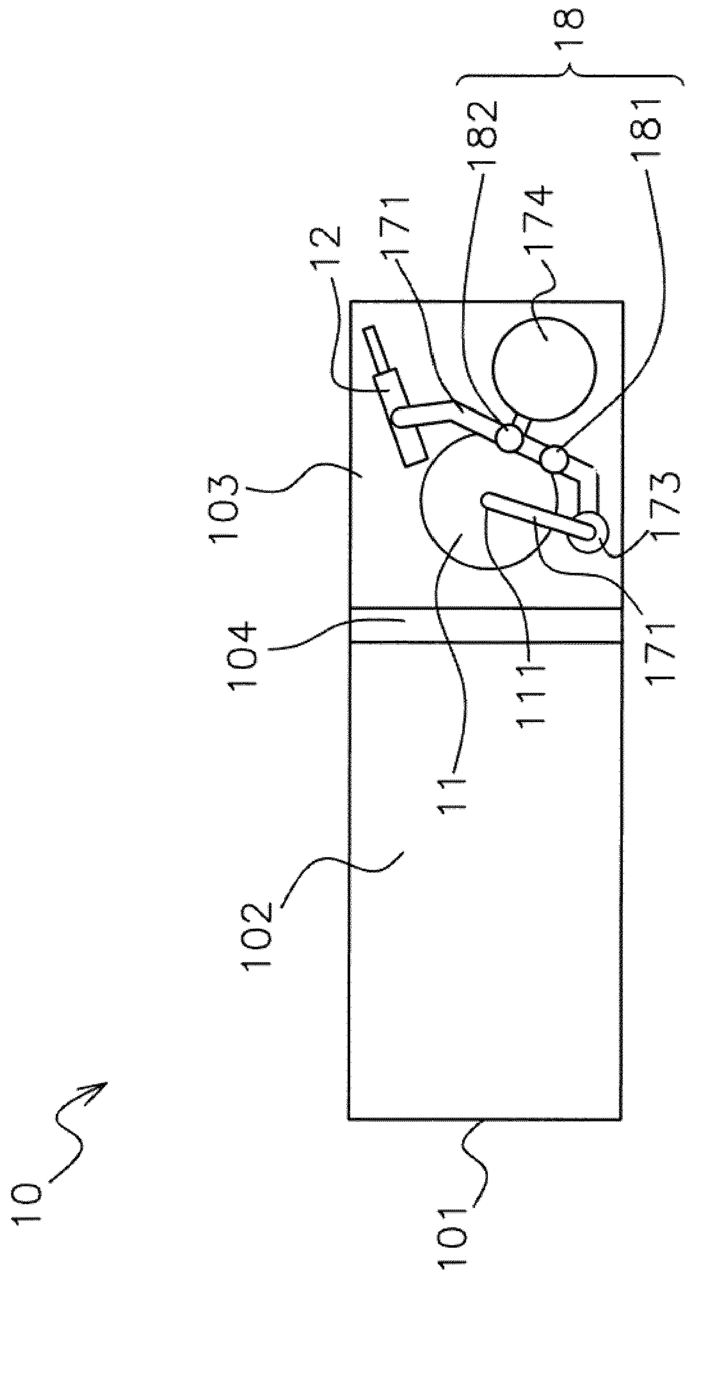


FIG. 7

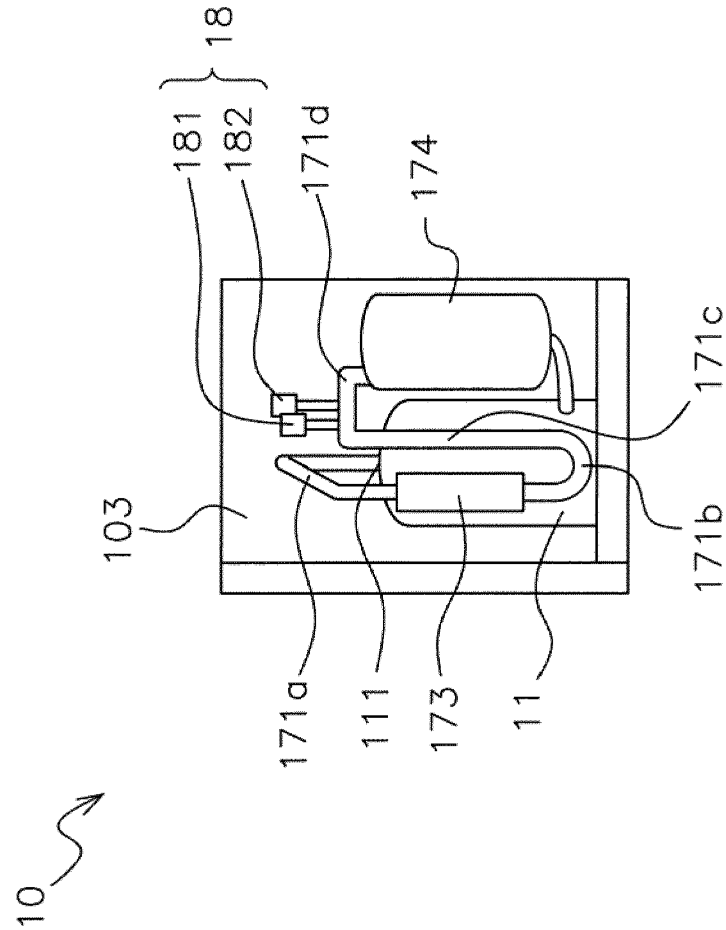


FIG.8

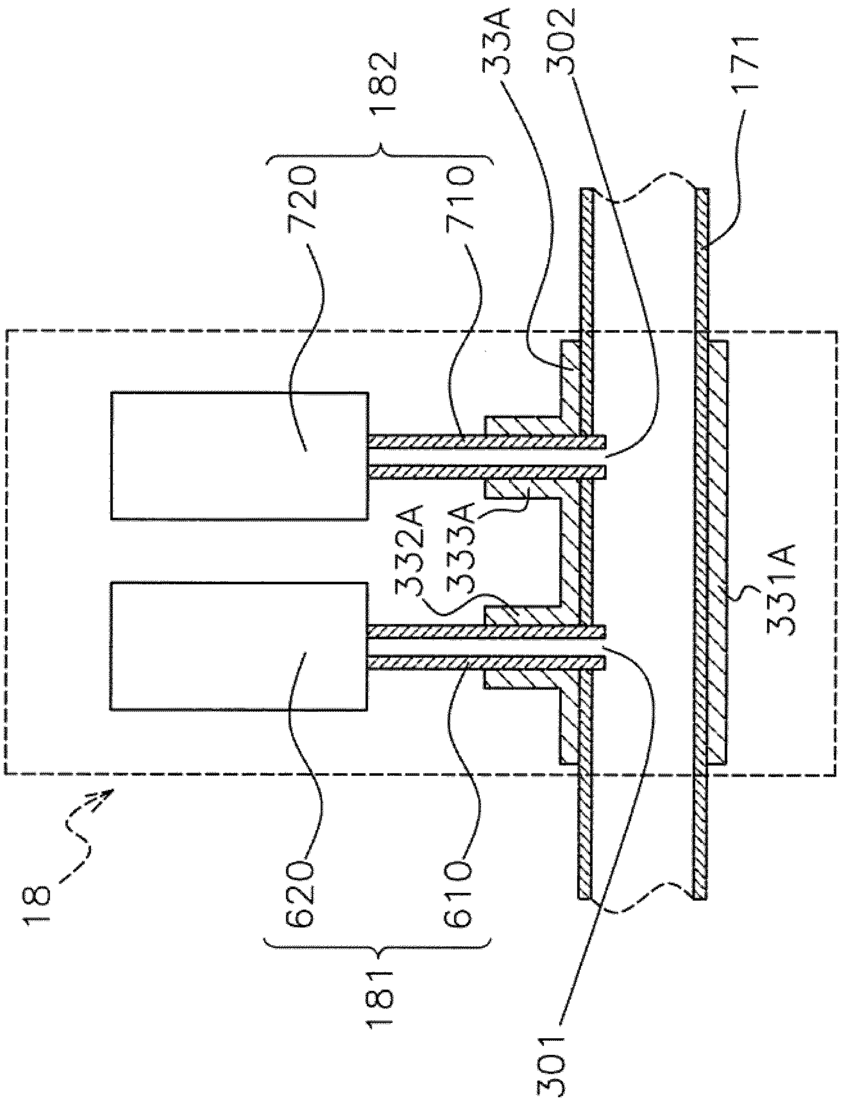


FIG.9A

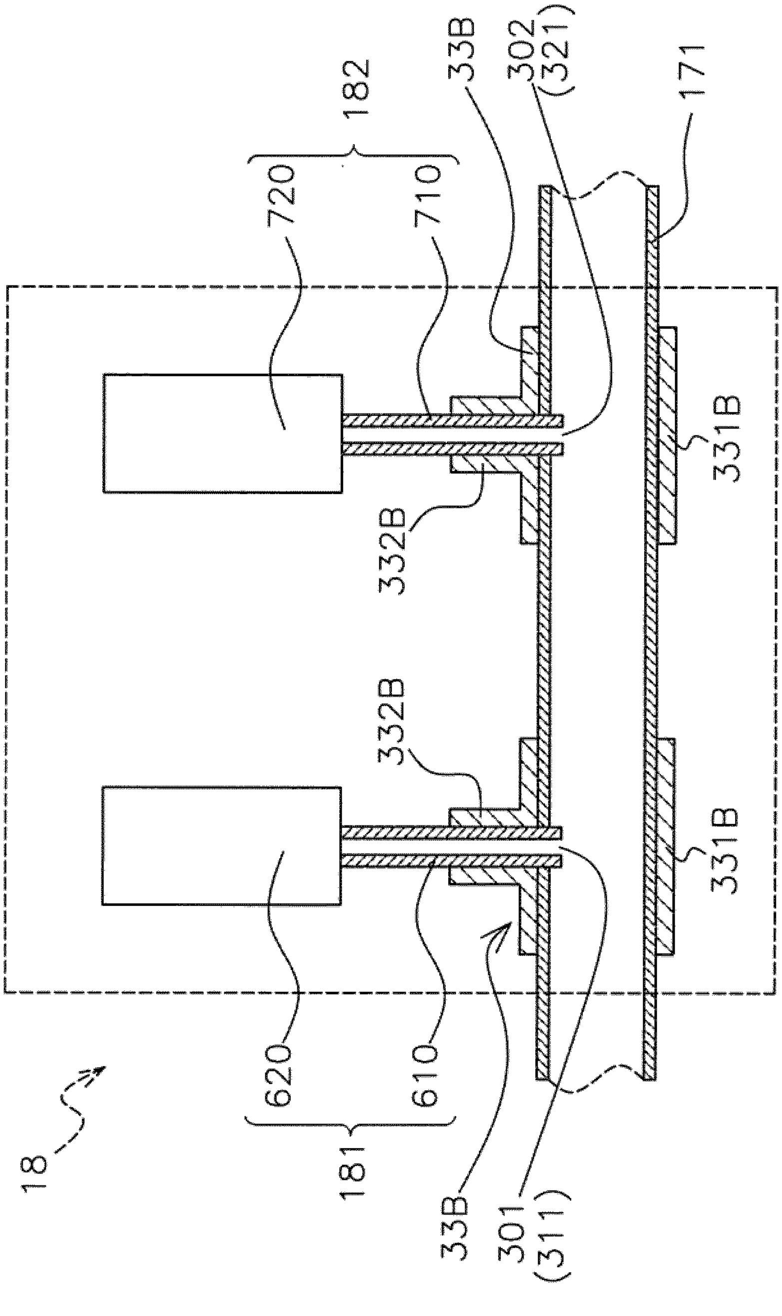

18
181
620
610
182
720
710
33B
302
(321)
171
332B
331B
332B
331B
33B
301
(311)

FIG.9B

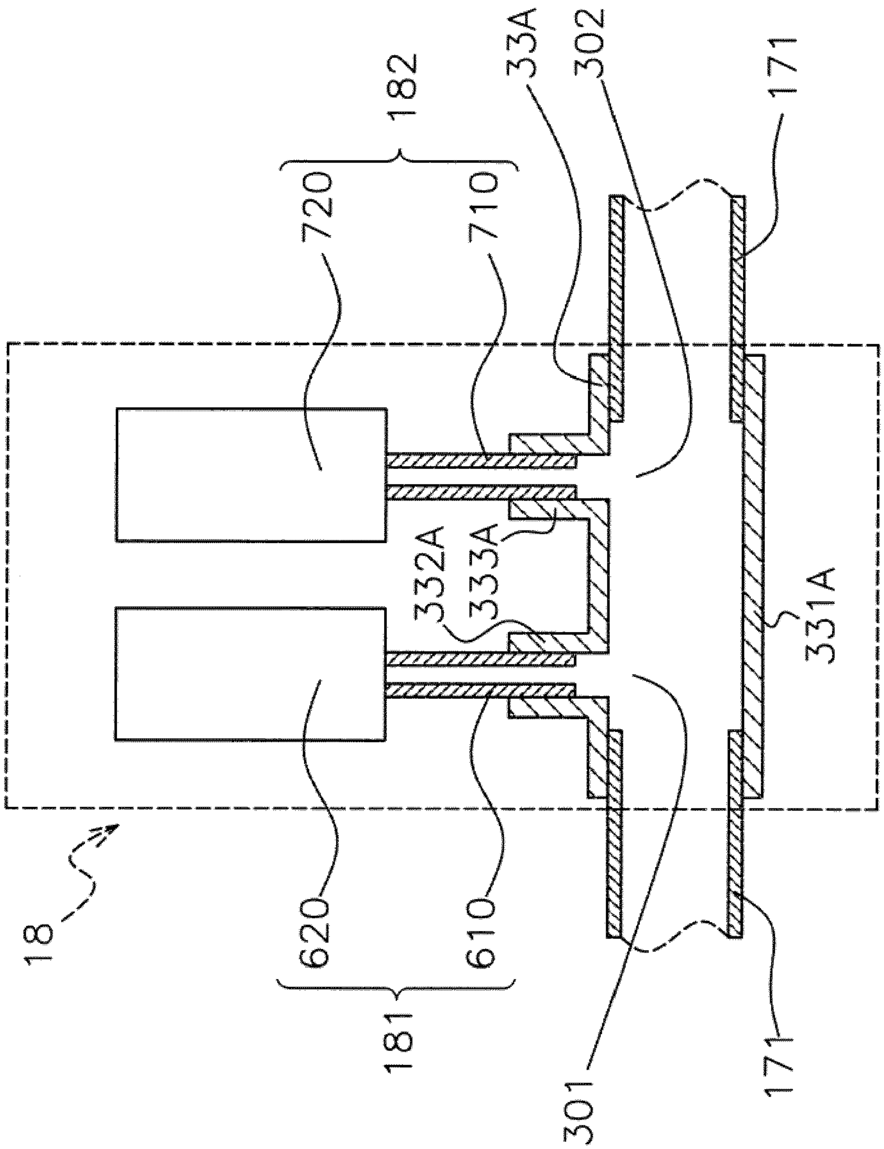
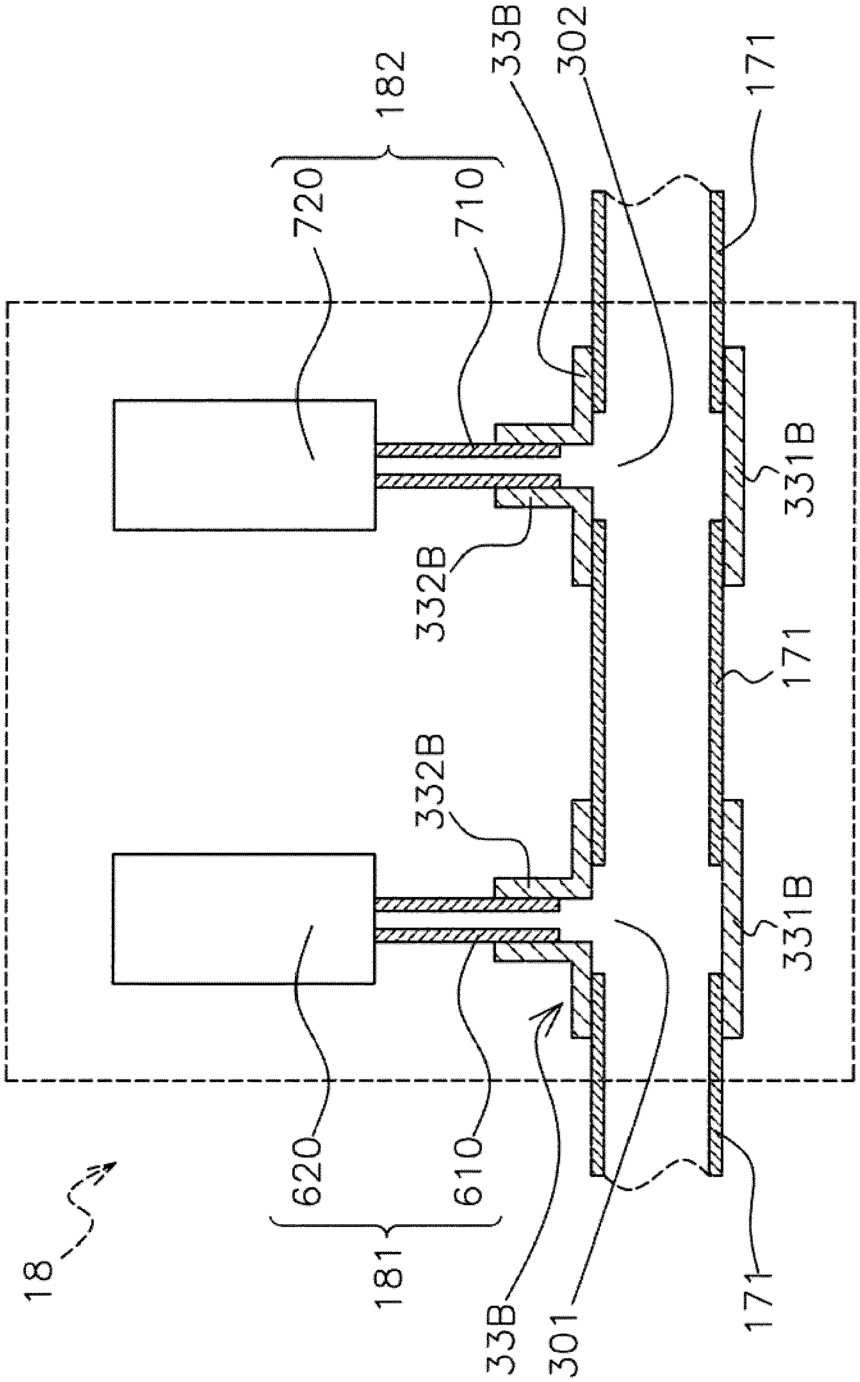


FIG.9C


18
181
182
620
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710
33B
33B
301
302
332B
332B
331B
331B
171
171
171

FIG.9D

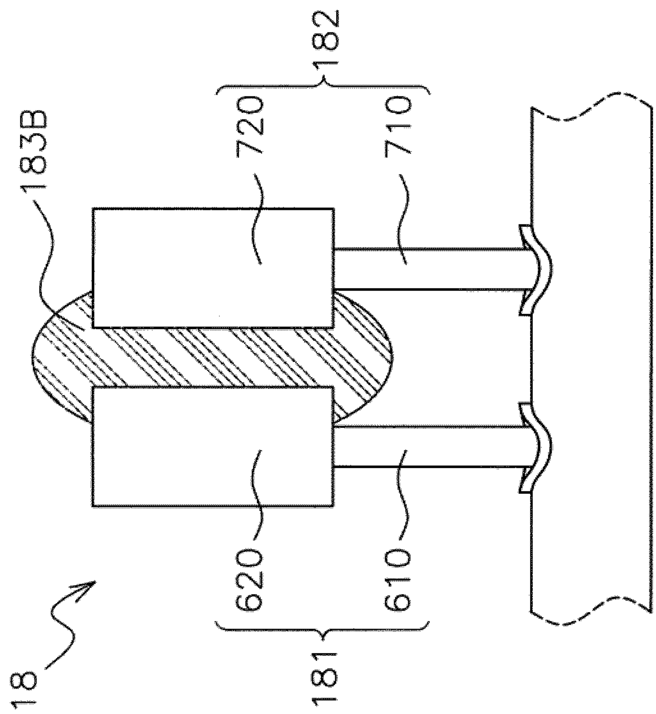

FIG.10B

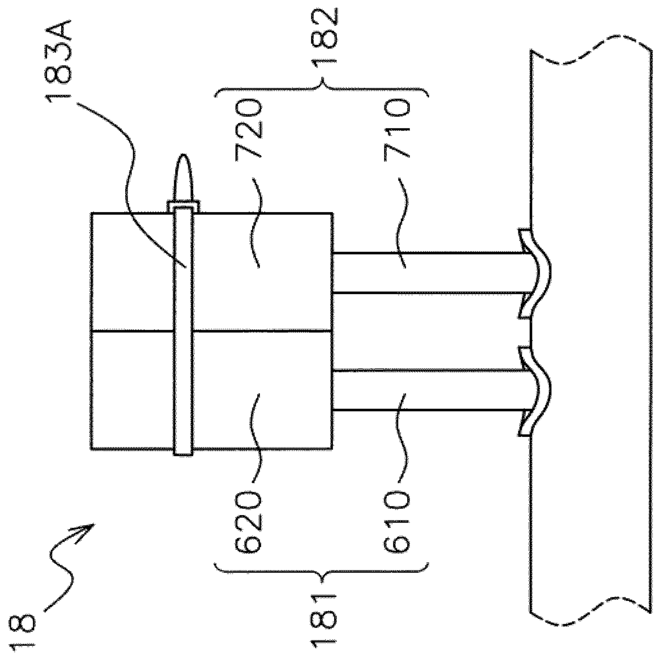

FIG.10A

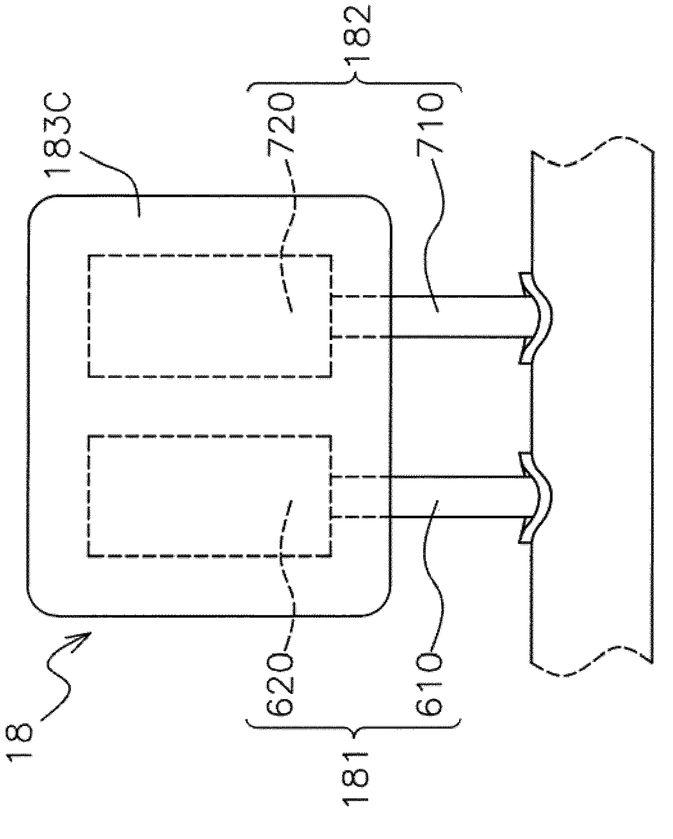

FIG.10C

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 3447

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F25B
H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 July 2016	Lucic, Anita

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