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(54) **AIR TURBO-REFRIGERATION UNIT, METHOD FOR OPERATING SAME, AND TURBO-EXPANDER**

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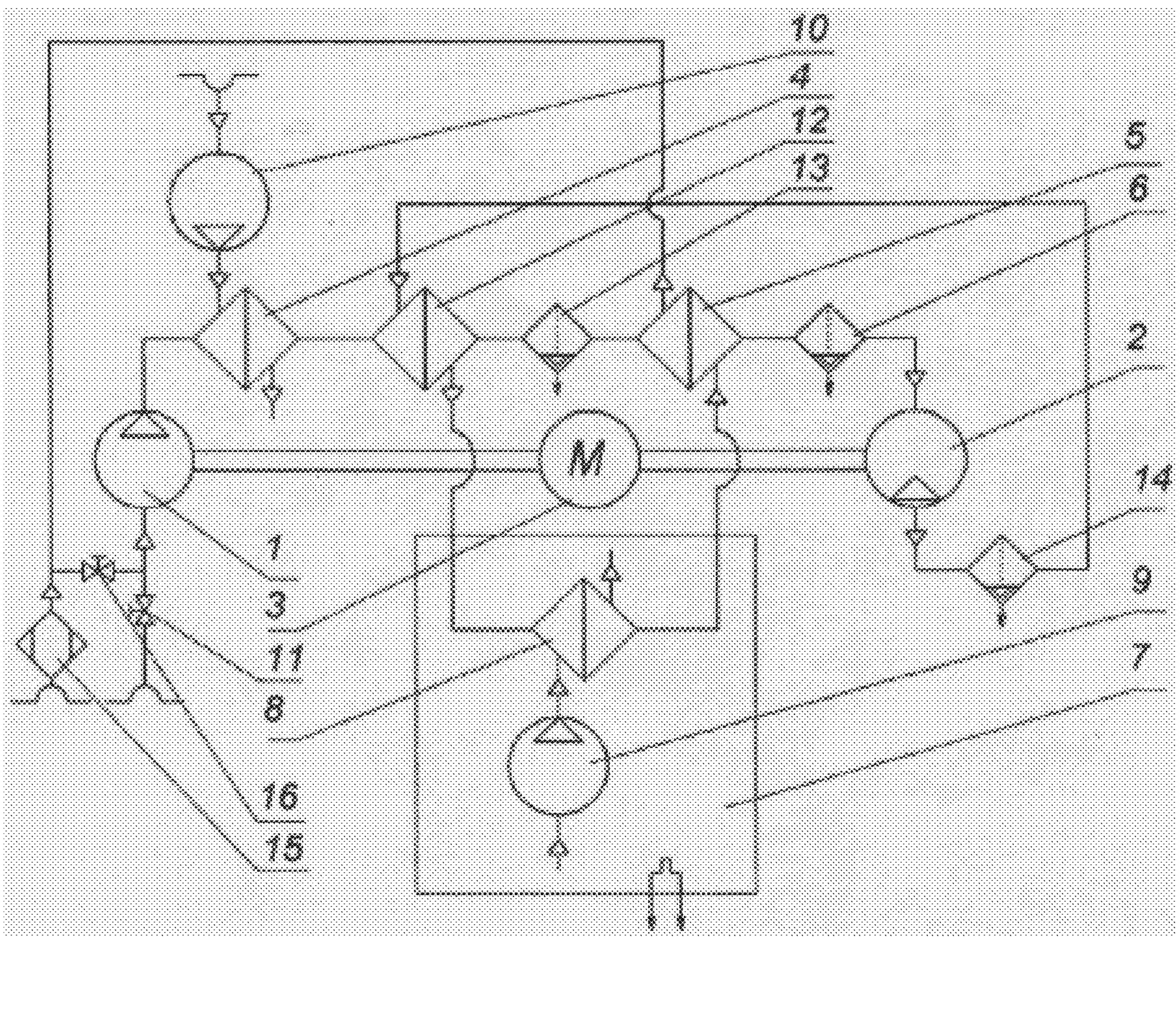
(57) **ABSTRACT**

The invention relates to refrigeration technology and can be used in air conditioning systems, refrigerators, etc. An air turbo-refrigeration unit comprises a compressor disposed on the same shaft as a turbo-expander, an electric motor, a two-cavity heat exchanger, a recuperator, a water trap, and a refrigeration chamber with a cooler and a fan. The unit Is equipped with a two-cavity heat exchanger/cooler, and with a second water trap and a third water trap; the compressor is connected by its outlet to the first cavity of the heat exchanger, which is connected to the first cavity of the heat exchanger/cooler, and the first cavity of the heat exchanger/cooler is connected via the second water trap to the first cavity of the recuperator, which communicates with the inlet of the turbo-expander via the first water trap; the turbo-expander is connected by its outlet via the third water trap to the second cavity of the heat exchange r/cooler, which is communicated with the cooler and is communicated via the cooler with the second cavity of the recuperator, which is communicated with the compressor inlet. The invention makes it possible to prevent the formation of ice and frost on the inner cavities of the turbo-expander and of ducts, which, in turn, prevents shut-off of the air turbo-refrigeration unit and increases the refrigeration capacity of the unit.



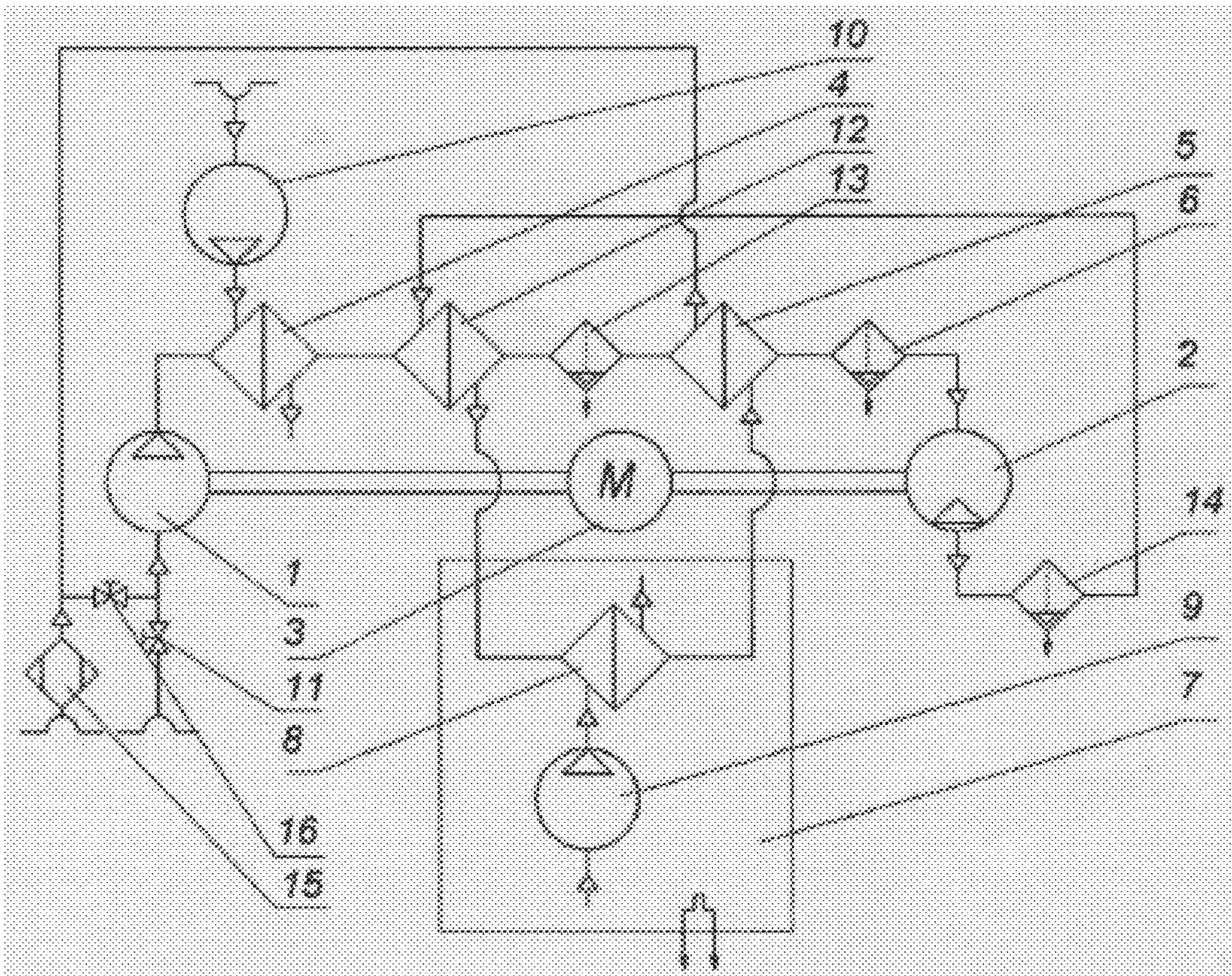


Fig. 1

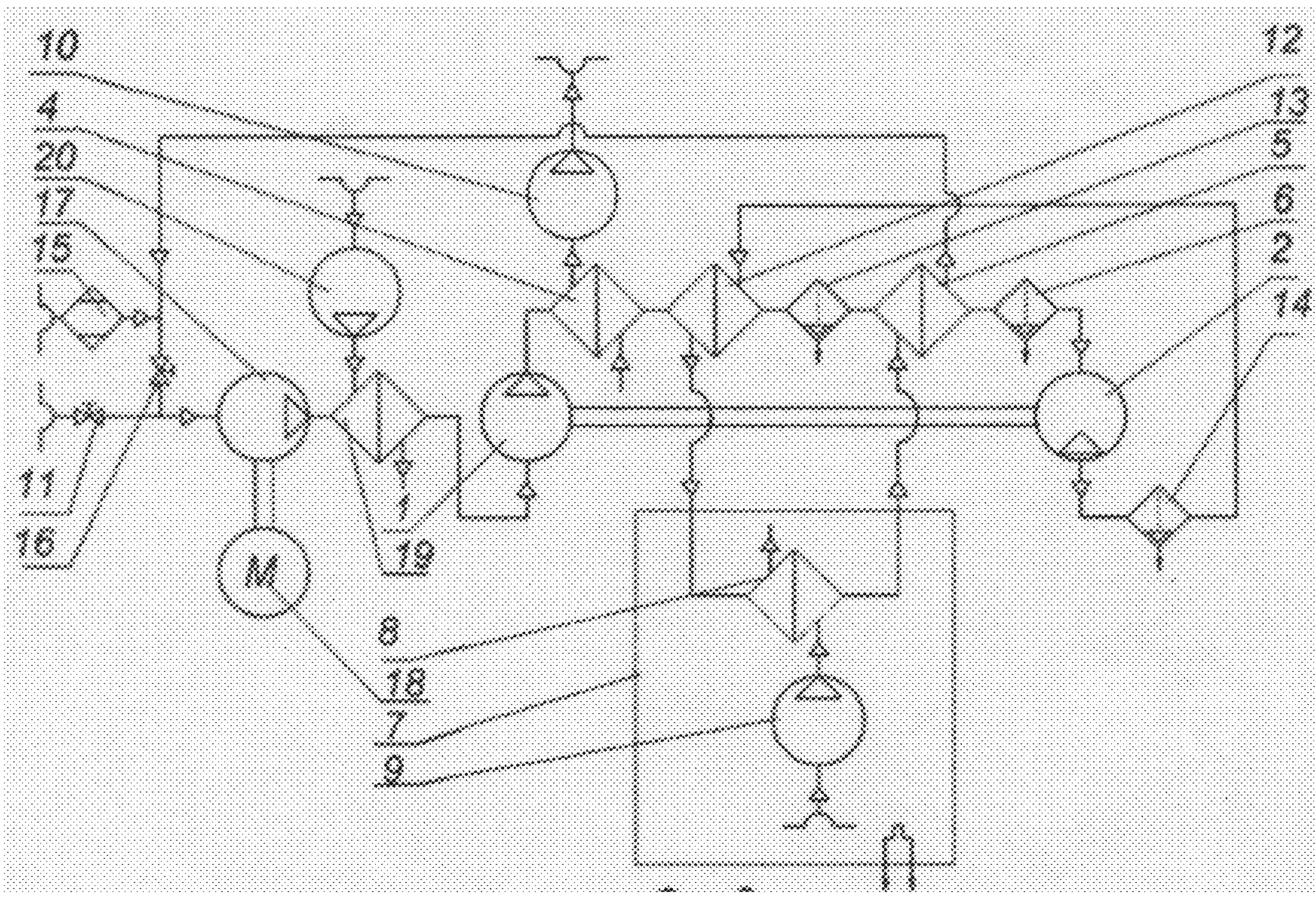


Fig. 2

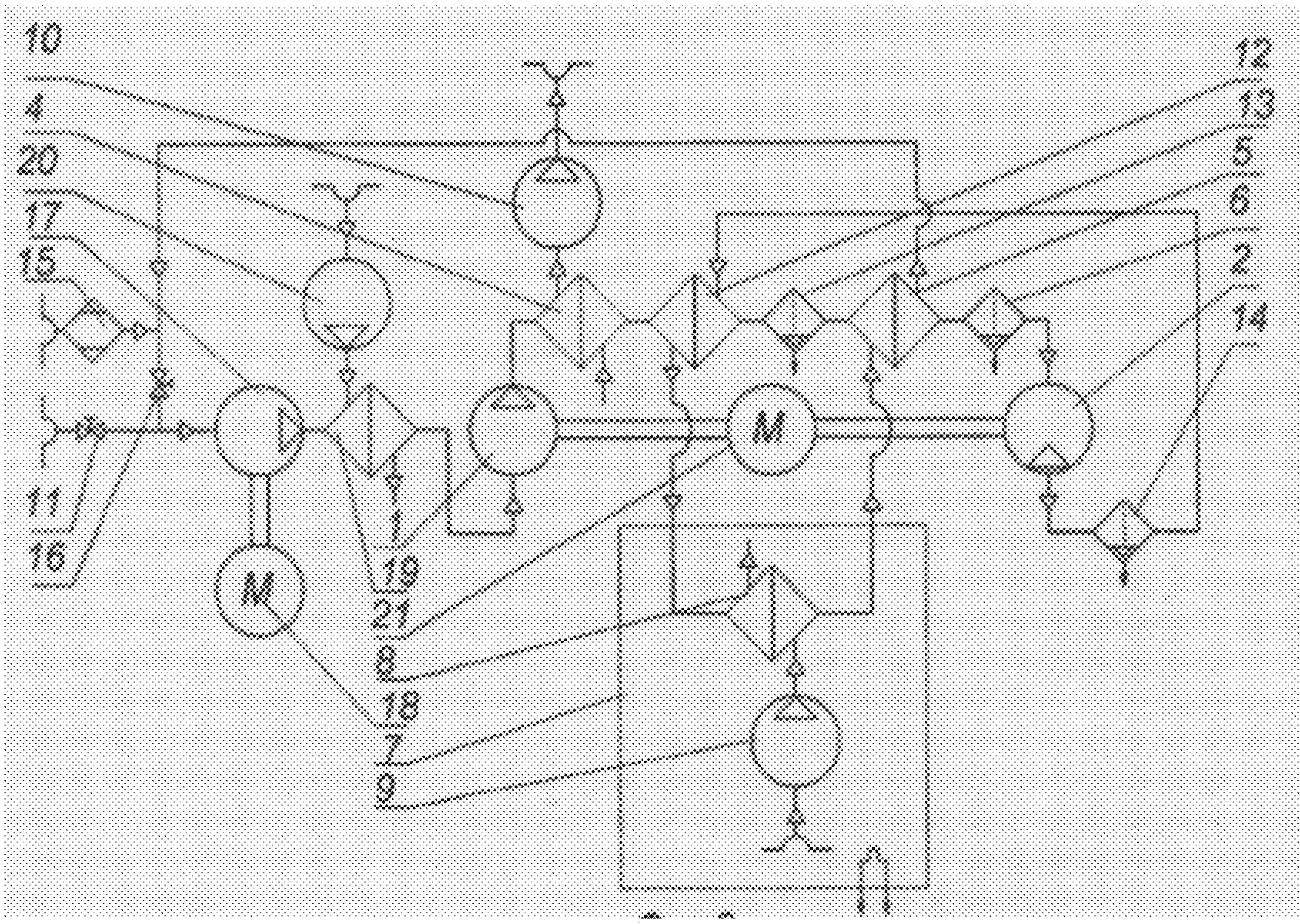


Fig. 3

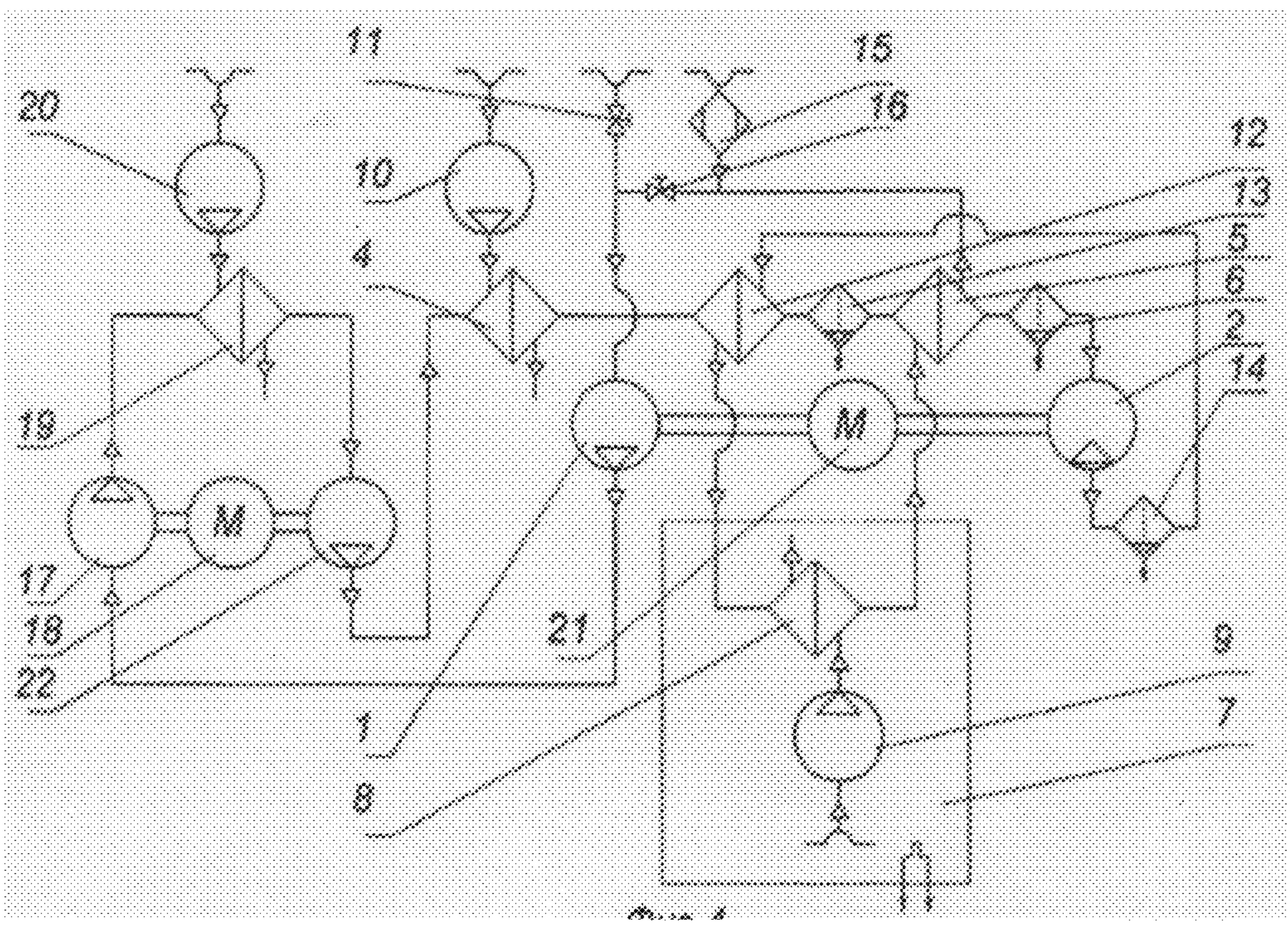


Fig. 4

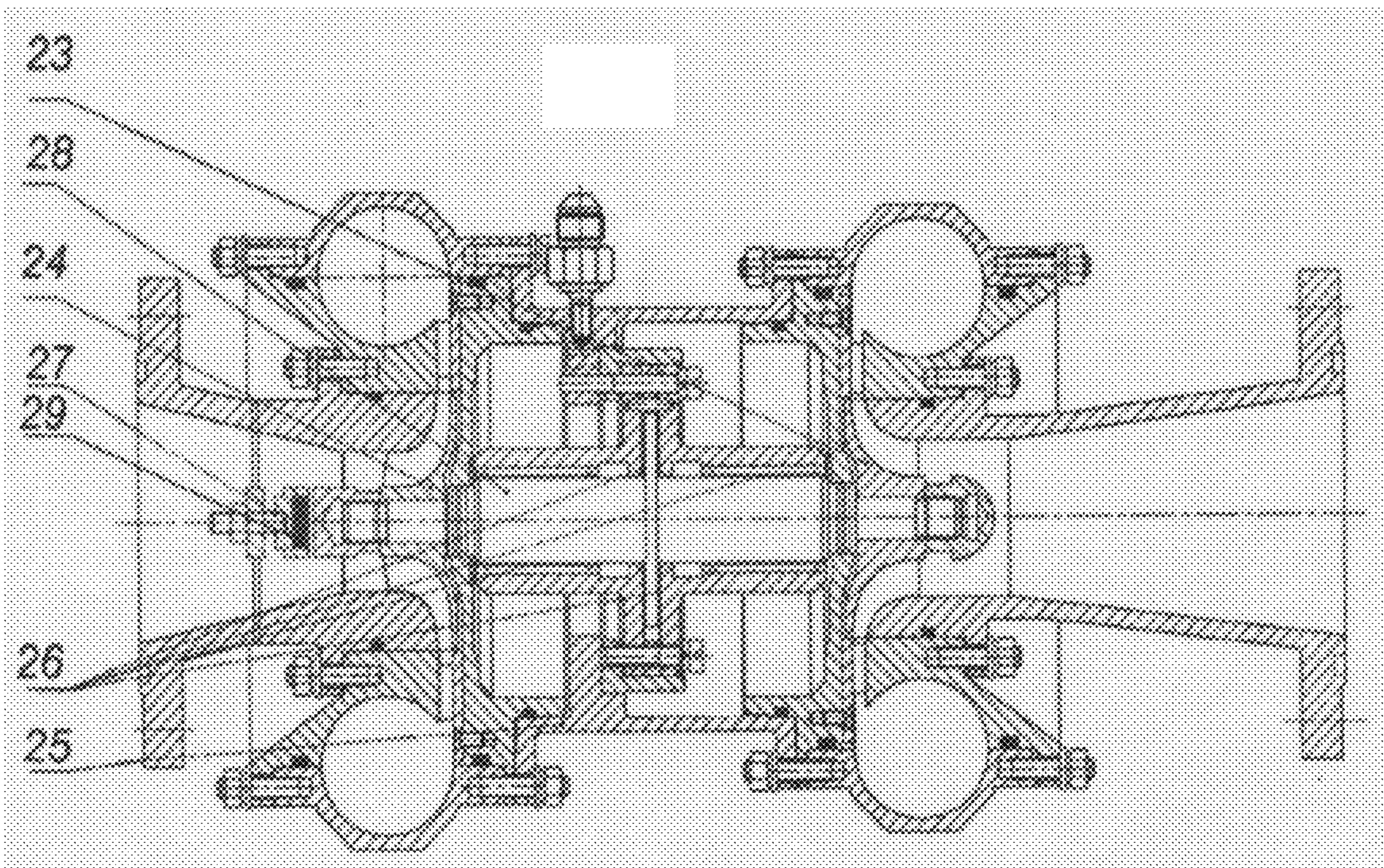


Fig. 5

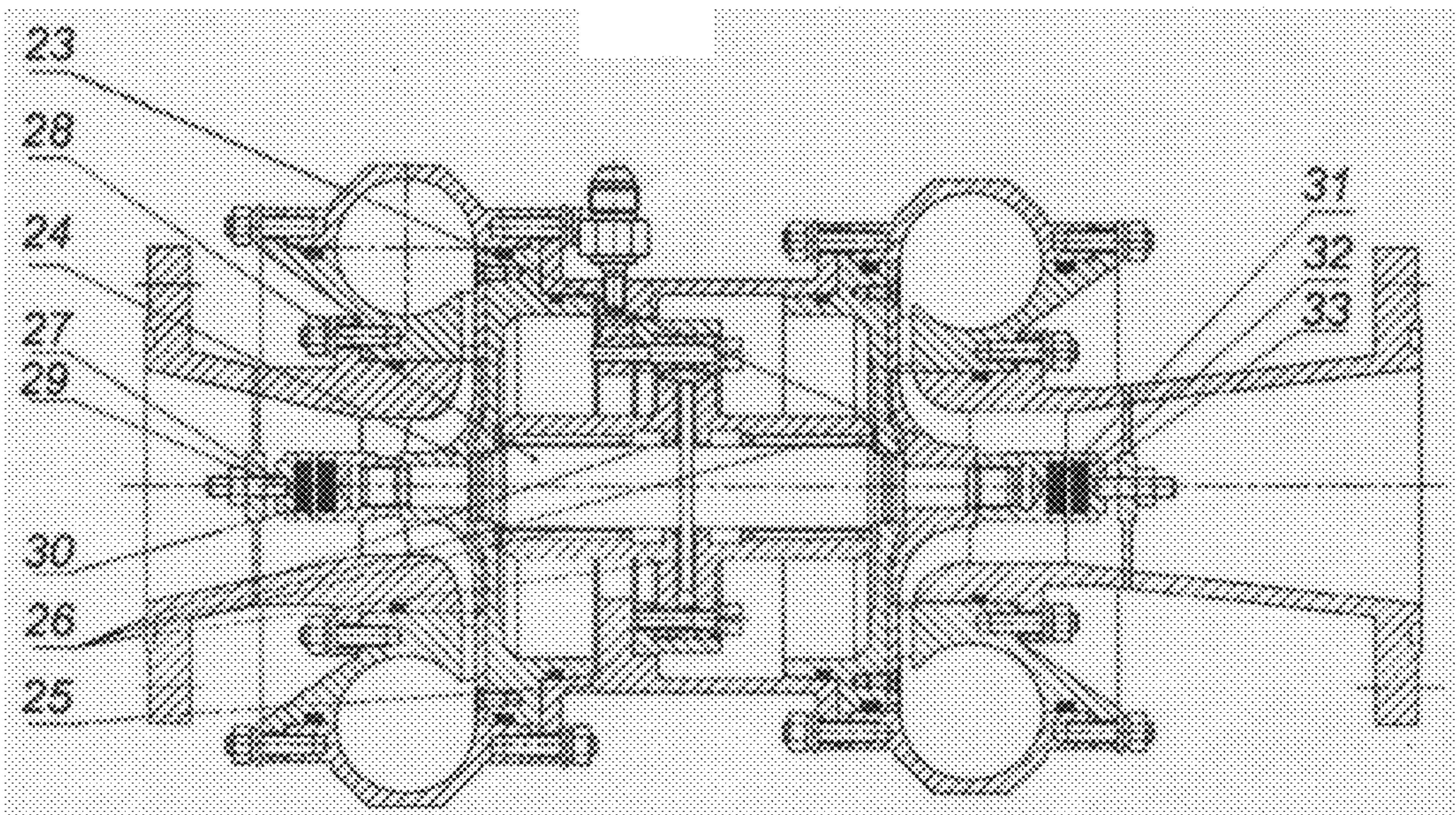


Fig. 6

AIR TURBO-REFRIGERATION UNIT, METHOD FOR OPERATING SAME, AND TURBO-EXPANDER

RANGE OF APPLICATION

[0001] The invention falls into the category of refrigerating equipment and may be used in air conditioning systems, refrigerators, etc.

BACKGROUND OF THE INVENTION

[0002] A refrigerating plant is known which contains a compressor connected via a heat exchanger with a centrifugal expander, and a supplementary pressure blower directly coupled to the centrifugal expander and installed between the heat exchanger and the refrigerating chamber (see Inventor's certificate SU No. 802740, Class F25B 11/00, published on 7 Feb. 1981).

[0003] This plant requires a heat exchanger cooling system, since temperature of the compressor outlet air is sufficiently high (about 120-140° C.) which increases total power consumption of the refrigerating plant. Besides, water vapor in air may result in freezing of passages of the nozzle and working arrays in the turbo-refrigerator.

[0004] The most close to this invention in technical essence and achieved results as to a device as a subject of the invention is an air turbo-refrigerating plant which contains a compressor installed directly coupled to a centrifugal expander, electric motor with the shaft coupled to the shaft of the compressor and centrifugal expander, double-cavity heat exchanger, recuperator, moisture separator, centrifugal expander, refrigerating chamber with a cooler and a blower, where inlet and outlet of the second cavity of the double-cavity heat exchanger open to the atmosphere, besides inlet is via a blower, and the compressor inlet opens via a valve member to the atmosphere (see patent RU No. 2156929, Class F25B 11/00, published on 27 Sep. 2000).

[0005] The same patent discloses a centrifugal expander containing a centrifugal expander wheel and a compressor wheel that are installed on the same shaft installed in the shell within gas-dynamic bearings, and a principle of operation of an air turbo-refrigerating plant, the said principle involving supply of compressed air into the first cavity of the double-cavity heat exchanger where compressed air is cooled with ambient air fed by the blower via the second cavity of the double-cavity heat exchanger, following which compressed air is cooled in the recuperator with cold air supplied from the cooler of the refrigerating chamber, then compressed air is separated from moisture in the moisture separator and dried compressed air is sent to the centrifugal expander where it is cooled by way of expansion and conversion of its pressure energy into mechanical energy of rotation of the wheels of the centrifugal expander and air compressor and then is fed under reduced pressure into the cooler of the refrigerating chamber in order to remove heat from, and cool the latter; from the chiller the air heated there is fed to the second cavity of the recuperator where compressed air is cooled and additionally heated air is fed from the recuperator to the compressor inlet.

[0006] However, this plant and its principle of operation do not ensure required performance reliability due to the fact that because of leakages in connections between tubes and heat exchangers, or during loss of sealing of the closed coolant circulation system of the heat exchanger humid air may penetrate from the atmosphere into the closed coolant circulation system of the heat exchanger, resulting in formation of ice and rime frost in inner cavities of centrifugal expander elements and pipework. As a result it leads to decrease in cooling capacity or shutdown of the air turbo-refrigerating plant (ATRP).

INVENTION SUMMARY

[0007] The object of the invention is remedial of defects and deficiencies found.

[0008] The technical result is that it becomes possible to prevent formation of ice and rime frost in inner cavities of the components of the centrifugal expander and pipework which, in turn, helps to prevent shutdown of air turbo-refrigerating plant and increase its cooling capacity.

[0009] For air turbo-refrigerating plant, the technical result according to the first invention embodiment is achieved since the air turbo-refrigerating plant contains a compressor directly coupled to the centrifugal expander; electric motor with its shaft connected to the air compressor/centrifugal expander shaft; double-cavity heat exchanger; recuperator; moisture separator; refrigerating chamber with a chiller and blower where inlet and outlet of the second cavity of the double-cavity heat exchanger open to the atmosphere where the latter's outlet is via the blower, and the air compressor inlet opens via valve member to the atmosphere, and the plant is equipped with the double-cavity heat-exchanging chiller, and the second and third moisture separators, where the air compressor is connected with its outlet to the first cavity of the double-cavity heat exchanger, the said first cavity being connected to the first cavity of the double-cavity heat-exchanging chiller, the said first cavity connected via the second moisture separator to the first cavity of the recuperator, the latter cavity connected via the first moisture separator to the centrifugal expander inlet, while the centrifugal expander is connected with its outlet via the third moisture separator to the second cavity of the double-cavity heat-exchanging chiller, where this second cavity is connected to the chiller in the refrigerating chamber—and via the latter chiller—to the second cavity of the recuperator which is connect to the compressor inlet.

[0010] The plant may be equipped with an air drying package which opens via with its inlet to the atmosphere, and with its outlet via the second valve member to the compressor inlet.

[0011] The double-cavity heat exchanger may be equipped with Peltier thermoelectric modules.

[0012] According to the second embodiment, the technical result is achieved owing to the fact that an air turbo-refrigerating plant contains a compressor directly coupled to a centrifugal expander, double-cavity heat exchanger, recuperator, moisture separator, refrigerating chamber with a chiller and a blower, with the inlet and outlet of the second cavity of the double-cavity heat-exchanger opening to the atmosphere, with the outlet being via the blower, and the plant is equipped with a double-cavity heat-exchanging chiller, and the second and third moisture separators, the second motor-driven air compressor, and the second double-cavity heat exchanger, with the compressor connected via outlet to the first cavity of the double-cavity heat-exchanger, the said first cavity connected to the first cavity of the heat-exchanging chiller, connected in turn via the second moisture separator to the first cavity of the recuperator connected via the first moisture separator to the inlet of the centrifugal expander, while the latter is connected via the third moisture separator to the second cavity of the heat-exchanging chiller, while this second cavity is connected to the cooler of the refrigerating chamber and—via the latter—to the second cavity of the recuperator, with this second cavity connected to the inlet of the second compressor, where this compressor opens with its inlet via the valve member to the atmosphere and with its outlet, via the first cavity of the double-cavity heat exchanger connected to the compressor inlet, while the inlet and outlet of the second cavity of the second double-cavity heat exchanger opens to the atmosphere, while the outlet is via the second blower.

[0013] The plant may be equipped with an air drying package which opens with its inlet to the atmosphere, and with its outlet via the second valve member is connected to the inlet of the second compressor.

[0014] The plant may be equipped with the second electric motor, the shaft of which is connected to the shaft of the compressor and centrifugal expander.

[0015] The double-cavity heat exchanger may be equipped with Peltier thermoelectric modules.

[0016] According to the third embodiment variant, the technical result is achieved because of the fact that the air turbo-refrigerating plant contains a compressor directly coupled to a centrifugal expander, and a double-cavity heat exchanger, recuperator, moisture separator and a refrigerating chamber with a chiller and blower, with inlet and outlet of the second cavity of the double-cavity heat exchanger opening to the atmosphere, with the inlet via a blower, while the plant is equipped with a double-cavity heat-exchanging chiller, the second and third moisture separators, and the second and third compressors mounted on one and the same shaft, electric motor, the shaft of which is connected to the shaft of the second and third compressors, and the second double-cavity heat-exchanger, with the compressor's outlet connected to the inlet of the second compressor which is connected with its outlet via the first cavity of the second double-cavity heat exchanger to the inlet of the third compressor, whose outlet is connected via the first cavity of the double-cavity heat exchanger to the first cavity of the heat exchanger connected via the second moisture separator to the first cavity of the recuperator connected via the second moisture separator to the inlet of the centrifugal expander, while the latter is connected via the third moisture separator to the second cavity of the heat-exchanging chiller connected to the cooler in the refrigerating chamber and via the latter to the second chamber of the recuperator, which is connected to the outlet of the compressor, with the compressor outlet also opening via the valve member to the atmosphere, while the second cavity of the second double-cavity heat exchanger opens at the inlet and the outlet of the atmosphere, however, at the inlet via the second blower.

[0017] The plant may be furnished with an air dryer package which via inlet opens to the atmosphere and with its outlet via the second valve member connects to the compressor inlet, while the first and second double-cavity heat exchangers are furnished with Peltier thermoelectric modules.

[0018] The Plant may be equipped with the second electric motor the shaft of which is connected to the shaft of the compressor and centrifugal expander.

[0019] Another subject of the invention is a centrifugal expander as a part of the installations described above. The centrifugal expander is composed of wheels of the centrifugal expander and compressor mounted on the common shaft within a shell between gas-dynamic bearings, besides the shell contains an axial shaft stabilizer in the form of a compressor wheel installed in the shell opposite to the shaft end clear of the last stationary magnet.

[0020] An electric magnet may be installed as a fixed magnet in the axial shaft stabilizer.

[0021] In the axial shaft stabilizer a permanent magnet may be installed as a stationary magnet.

[0022] The centrifugal expander may additionally contain a permanent magnet installed on the shaft end opposite to the stationary magnet.

[0023] The centrifugal expander may be equipped with the second axial shaft stabilizer made in the form of the second stationary magnet installed in the shell opposite to the shaft end from the side of the centrifugal expander wheel, with the second permanent magnet installed on the shaft end opposite to the second magnet.

[0024] In the second axial shaft stabilizer, an electric magnet may be installed as a stationary magnet.

[0025] The electric magnet may contain an electromagnetic field strength regulator.

[0026] In the second axial shaft stabilizer, a permanent magnet may be installed as a stationary magnet.

[0027] As to the method as a subject of the invention, the claimed technical result is achieved owing to the fact that the principle of operation of the air turbo-refrigerating plant in any of Claims **1-3** involves supply of compressed air with the compressor into the first cavity of the double-cavity heat exchanger in which compressed air is cooled with ambient air fed by the blower via the second cavity of the double-cavity heat exchanger, then compressed air is cooled in the recuperator with cold air supplied from the cooler of the refrigerating chamber, after which compressed air is separated from moisture in the moisture separator and dried compressed air is fed to the centrifugal expander, where it is cooled by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheels of the centrifugal expander and compressor and fed under reduced pressure to the cooler of the refrigerating chamber in order to remove heat from and cool the chamber; from the chiller the air heated there is sent to the second cavity of the recuperator where compressed air is cooled, and air heated repeatedly is fed from the recuperator to the compressor inlet, with compressed air, before being fed into the first recuperator cavity, is cooled in the double-cavity heat-exchanging chiller with air supplied via the double-cavity heat-exchanging chiller from the centrifugal expander, and separated from moisture in the second moisture separator, with the air cooled in the centrifugal expander, before being fed via the double-cavity heat-exchanging chiller into the refrigerating chamber chiller, separated from moisture in the third moisture separator, while temperature in the refrigerating chamber and cooling capacity of the air turbo-refrigerating plant is regulated by changing rotation speed of the blower in the double-cavity heat exchanger.

[0028] Temperature in the refrigerating chamber may additionally regulated by controlling rotation speed of the air cooling blower.

[0029] Temperature in the refrigerating chamber may additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger by installing Peltier thermoelectric modules in the double-cavity heat exchanger.

[0030] Temperature in the refrigerating chamber may additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger by feeding water through the double-cavity heat exchanger.

[0031] Temperature in the refrigerating chamber may additionally regulated by changing rotation speed of the electric motor, the shaft of which is connected to the compressor/centrifugal expander shaft.

[0032] According to the second embodiment, the technical result may be achieved in the principle of operation of an air turbo-refrigerating plant performed according to any of Claims **4**-**7**, and this principle of operation of the air turbo-refrigerating plant includes supply of compressed air by the compressor into the first cavity of the double-cavity heat exchanger in which compressed air is cooled with ambient air supplied by the blower via the second cavity of the double-cavity heat exchanger, then compressed air is cooled in the recuperator with cold air from the cooler of the refrigerating chamber, following which compressed air is separated from moisture in the moisture separator and dried compressed air is fed into the centrifugal expander where it is cooled by way of expansion and transformation of its pressure energy into mechanical energy of rotating wheels of the centrifugal expander and compressor and fed at reduced pressure into the cooler of the refrigerating chamber for heat removal from the latter and cooling, from the chiller air is fed into the second cavity of the recuperator where compressed air is cooled, where compressed air, before being fed into the first cavity of the recuperator, is cooled in the double-cavity heat-exchanging chiller with air fed into it from the centrifugal expander and is separated from moisture in the second moisture separator, from air cooled in the centrifugal expander before being fed via the double-cavity heat-exchanging chiller into the cooler of the refrigerating chamber, moisture is separated in the third moisture separator, and then from the second recuperator cavity air is fed into the inlet of the second compressor which compresses air and feeds it into the first cavity of the second double-cavity heat-exchanging chiller; in the latter, compressed air is cooled by feeding ambient air through the second cavity of the double-cavity heat exchanger with the second blower, and from the first cavity of the second double-cavity heat exchanger air is fed into the compressor, while temperature in the refrigerating chamber and cooling performance of the air turbo-refrigerating plant is regulated by changing rotation speed of the blower of the double-cavity heat exchanger.

[0033] Temperature in the refrigerating chamber may be additionally regulated by controlling rotation speed of the blower in the second double-cavity heat exchanger.

[0034] Temperature in the refrigerating chamber may be additionally regulated by regulating of rotation speed of the electric motor of the second compressor.

[0035] Temperature in the refrigerating chamber and cooling performance of the refrigerating plant may be additionally regulated by simultaneously adjusting the rotation speed of the electric motor of the second compressor and adjusting the rotation sped of the blower of the second double-cavity heat exchanger and the chiller blower. Temperature in the refrigerating chamber may be additionally regulated by additional cooling of the second double-cavity heat exchanger using Peltier thermoelectric modules.

[0036] Temperature in the refrigerating chamber may be additionally regulated by additional simultaneous cooling of the first and second double-cavity heat exchangers with Peltier thermoelectric modules.

[0037] Temperature in the refrigerating chamber may be additionally regulated by additional cooling of the second double-cavity heat exchanger with water.

[0038] Temperature in the refrigerating chamber may be additionally regulated by additional simultaneous cooling of the first and second double-cavity heat exchangers with water.

[0039] Temperature in the refrigerating chamber may be additionally regulated by regulating the rotation speed of the chiller blower.

[0040] Temperature in the refrigerating chamber may be additionally regulated by regulating rotation speed of the second electric motor, the shaft of which is connected to the shaft on which the compressor and the centrifugal expander are mounted.

[0041] According to the third embodiment variant, the technical result may be achieved in the principle of operation of an air turbo-refrigerating plant performed according to Claims **8**-**11**, while this principle of operation of the air turbo-refrigerating plant involves supply of compressed air into the first cavity of the double-cavity heat exchanger, in which compressed air is cooled with ambient air fed by the blower via the second cavity of the double-cavity heat exchanger, then compressed air is cooled in the recuperator with cooled air from the refrigerating chamber cooler, following which compressed air is separated from moisture in the moisture separator and dried compressed air is fed into the centrifugal expander, where it is cooled by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheels of centrifugal expander and compressor, and fed under reduced pressure into the cooler of the refrigerating chamber for heat removal from, and cooling of the said chamber, then from the cooler air is fed into the second cavity of the recuperator where compressed air is cooled, with this compressed air, prior to being supplied into the first cavity of the recuperator, is cooled in the double-cavity heat exchanging chiller with air fed via this chiller from the centrifugal expander, and is separated from moisture in the second moisture separator; the air cooled in the centrifugal expander, prior to be fed via the double-cavity heat exchanging chiller into the cooler of the refrigerating chamber, is separated from moisture in the third moisture separator; air from the second cavity of the recuperator is fed to the inlet of the compressor which compresses air and delivers it into the second compressor, from where additionally compressed air is fed in the first cavity of the second double-cavity heat exchanger where compressed air is cooled by ambient air fed with the second blower via the second cavity of the double-cavity heat exchanger, while from the first cavity of the second double-cavity heat exchanger air is fed into the third compressor, from which compressed air is fed into the first cavity of the double-cavity heat exchanger, while temperature in the refrigerating chamber and cooling performance of the air turbo-refrigerating plant is regulated by adjusting rotation speed of the blower of the double-cavity heat exchanger.

[0042] Additional regulation of the temperature in the refrigerating chamber may be performed by regulation of rotation speed of the blower which feeds air in the refrigerating chamber via the blower.

[0043] Temperature in the refrigerating chamber may be additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger by installing Peltier thermoelectric modules in the double-cavity heat exchanger.

[0044] Temperature in the refrigerating chamber may be additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger with water. Temperature in the refrigerating chamber and its cooling capacity may be additionally regulated by regulation of rotation speed of the electric motor, the shaft of which is coupled to the shaft of the second and third compressors.

[0045] Temperature and cooling performance in the refrigerating chamber may be additionally regulated by changing regulation of rotation speed of the second electric motor, the shaft of which is coupled to the shaft of the compressor and centrifugal expander.

[0046] As was found in the course of the experiment, pressure of working air in the system downstream of the first compressor and, particularly, downstream of the second compressor increases considerably, since the electric motor creates additional moment on the compressor shaft and increases its power capacity. The heat-exchanging chiller installed downstream of the compressors in the system ensures the deeper drying of air. It can be seen from the formula:

$$d=0.622^{Ps/(P-Ps)};$$

kg/kg where d, kg/kg—the absolute moisture content (kg of water per kg of dry air); Ps—saturated vapor pressure; P—air pressure.

[0047] Thus, as air pressure P increases, absolute moisture content d decreases, which enhances air drying level. Moreover, the second and third moisture separators allow to enhance drying efficiency, and the axial stabilizer of the centrifugal expander shaft made in the form of stationary permanent magnets and/or electric magnets on shaft ends of the centrifugal expander ensure stable operation of the refrigerating plant and maintains nominal refrigerating capacity.

SHORT DESCRIPTION OF DRAWINGS

[0048] FIG. **1** presents the basic diagram of the air turbo-refrigerating plant in its first embodiment variant.

[0049] FIG. **2** presents the basic diagram of the air turbo-refrigerating plant in its second embodiment variant.

[0050] FIG. **3** presents the basic diagram of the air turbo-refrigerating plant in its second embodiment variant with the second electric motor installed.

[0051] FIG. **4** presents the basic diagram of the air turbo-refrigerating plant in its third embodiment variant.

[0052] FIG. **5** presents the longitudinal section of the centrifugal expander of the air turbo-refrigerating plant.

[0053] FIG. **6** presents the longitudinal section of the centrifugal expander of the air turbo-refrigerating plant with the second axial shaft stabilizer.

PREFERRED EMBODIMENT OF THE INVENTION

[0054] The air turbo-refrigerating plant designed according to patent claim **1** (see FIG. **1**) contains the compressor **1** mounted on the same shaft together with the centrifugal expander **2**, electric motor **3**, the shaft of which is connected to the shaft of the compressor **1** and centrifugal expander **2**, double-cavity heat exchanger **4**, recuperator **5**, moisture separator **6**, refrigerating chamber **7** with the chiller **8** and the blower **9**.

[0055] The inlet and outlet of the second cavity of the double-cavity heat exchanger **4** open to the atmosphere, while the inlet of the double-cavity heat exchanger via the blower **19**, and the compressor **1** with its inlet via the valve member **11**, open to the atmosphere.

[0056] The plant is equipped with the double-cavity heat-exchanging chiller **12**, and the second **13** and third **14** moisture separators.

[0057] The compressor **1** is connected with its outlet to the first cavity of the double-cavity heat exchanger **4** with the latter connected to the first double-cavity heat-exchanging chiller **12** connected via the second moisture separator **13** to the first cavity of the recuperator **5** connected via the first moisture separator **6** to the inlet of the centrifugal expander **2**, while the latter with its outlet via the third moisture separator **14** is connected to the second cavity of the double-cavity heat-exchanging chiller **12**, with the above second cavity connected to the chiller **8** and via the latter—to the second cavity of the recuperator **5**, with the above second cavity connected to the inlet of the compressor **1**. The plant may be furnished with the air dryer package **15** which opens via its inlet to the atmosphere, and with its outlet via the second valve member **16**—to the inlet of the compressor **1**.

[0058] The double-cavity heat exchanger **4** may be furnished with Peltier thermoelectric modules (not shown in the drawing).

[0059] According to the second design version (see FIGS. **2** and **3**), the air turbo-refrigerating plant contains the compressor **1** directly coupled with the centrifugal expander **2**, double-cavity heat exchanger **4**, recuperator **5**, moisture separator **6**, refrigerating chamber **7** with the chiller **8** and the blower **9**.

[0060] The inlet and outlet of the second cavity of the double-cavity heat exchanger **4** open to the atmosphere, while its outlet is via the blower **10**.

[0061] The plant is furnished with the double-cavity heat-exchanging chiller **12**, and the second **13** and third **14** moisture separators, second compressor **17** driven by the electric motor **18** and second double-cavity heat exchanger **19**, where the compressor **1** is connected with its outlet to the first cavity of the double-cavity heat exchanger **4**, the above first cavity connected to the first cavity of the heat-exchanging chiller **12** connected via the second moisture separator **13** to the first cavity of the recuperator **5**, with the above first cavity connected via the first moisture separator **6** to the inlet of the centrifugal expander **2**, while the latter is connected with its outlet via the third moisture separator **14** to the second cavity of the heat-exchanging chiller **12**, with the above second cavity connected to the chiller **8** and via the latter—to the second cavity of the recuperator **5**, the above second cavity connected to the outlet of the second compressor **17**, while the latter opens with its inlet via the valve member **11** to the atmosphere, and with its outlet via the first cavity of the second double-cavity heat exchanger **19** is connected to the inlet of the compressor **1**, while the inlet and outlet of the second cavity of the second double-cavity heat exchanger **19** open to the atmosphere, while its inlet is via the second blower **20**.

[0062] The plant may be furnished with the air dryer package **15** which opens via its inlet to the atmosphere, and via its outlet and the second valve member **16** to the outlet of the second compressor **17**.

[0063] The plant may be equipped with the second electric motor **2**, the shaft of which is coupled with the shaft of the compressor **1** and the centrifugal expander **2**. The double-cavity heat exchanger **4** is equipped with Peltier thermoelectric modules (not shown in the drawings).

[0064] According to the Third Embodiment (see FIG. **4**)

[0065] The air turbo-refrigerating plant contains directly coupled compressor **1** and centrifugal expander **2**, double-cavity heat exchanger **4**, recuperator **5**, moisture separator **6** and refrigerating chamber **7** with cooler **8** and blower **8**.

[0066] The inlet and outlet of the second cavity of the double-cavity heat exchanger **4** open to the atmosphere, while its inlet is via the blower **10**.

[0067] The plant is equipped with the double-cavity heat-exchanging chiller **12**, the second **13** and third **14** moisture separators, and the directly coupled second **17** and third **22** compressors, electric motor **28**, with its shaft coupled with the shaft of the second **17** and third **22** compressors, and the second double-cavity heat exchanger **19**.

[0068] The compressor **1** is connected to the inlet of the second compressor **17** which is connected with its outlet via the first cavity of the second double-cavity heat exchanger **19** to the inlet of the third compressor **22**, whose outlet is connected via the first cavity of the double-cavity heat exchanger **4** to the first cavity of the heat-exchanging chiller **12**, the said first cavity connected via the second moisture separator **12** to the first cavity of the recuperator **5**, the said first cavity connected via the first moisture separator **6** with the inlet of the centrifugal expander **2**, while the latter is connected with its outlet via the third moisture separator **14** to the second cavity of the heat-exchanging chiller **12**, the above second cavity being connected to the chiller **8** and via the latter to the second cavity of the recuperator **5**, the above second cavity being connected to the inlet of the compressor **1**, with the said compressor's inlet also opening via the valve member **11** to the atmosphere, while the second cavity of the second double-cavity heat exchanger **19** opening with the inlet and outlet to the atmosphere, and at the inlet via the second blower **20**.

[0069] The plant may be equipped with the air dryer package **15** which opens via its inlet to the atmosphere, and through its outlet via the second valve member **16** to the inlet of the compressor **1**, while the first **4** and the second **19** double-cavity heat exchangers are equipped with Peltier thermoelectric modules (not shown in the drawing). The plant may be equipped with the second electric motor **21** the shaft of which coupled to the shaft of the compressor **1** and centrifugal expander **2**.

[0070] The centrifugal expander **2** which forms a part of the above described plants (see FIG. **5**), contains wheels **23** and **24** of the centrifugal expander **2** and the compressor **1** directly coupled on the shaft installed in the shell **25** within gas-dynamic bearings **26**, where in the shell **25** the axial stabilizer **27** of the shaft **28** is installed in the form installed in the shell **25** opposite to the end of the shaft **28** on the side of the wheel **24** of the compressor **1** with a clearance relative to the last stationary magnet **29**.

[0071] In the axial stabilizer **27** of the shaft **28**, an electric magnet may be installed as a stationary magnet **29**.

[0072] The electric magnet may contain a magnetic field strength regulator (not shown).

[0073] In the axial stabilizer **27** of the shaft **28**, a permanent magnet may be installed as a stationary magnet.

[0074] The centrifugal expander **2** may additionally contain a permanent magnet **20** (see FIG. **6**) mounted on the end of the shaft **28** opposite to the stationary magnet **29**.

[0075] The centrifugal expander **2** may be equipped with the second axial stabilizer **31** of the shaft **28** in the form of the centrifugal **2** installed in the shell **25** opposite to the end of the shaft **28** on the side of the wheel **23** with a clearance relative to the latter with the second stationary magnet **32**, while the second permanent magnet **33** is installed on the end of the shaft **28** opposite to the second stationary magnet **32**.

[0076] In the second axial stabilizer **31** of the shaft **28**, an electric magnet may be installed as a stationary magnet **32**.

[0077] The electric magnet may contain its magnetic field strength regulator (not shown).

[0078] In the second axial stabilizer **31** of the shaft **28** a permanent magnet may be installed as the stationary magnet **32**.

[0079] The principle of operation of the air turbo-refrigerating plant according to FIGS. **1** and **5** is implemented as follows. Compressed air is fed with the compressor **1** into the first cavity of the double-cavity heat exchanger **4**, in which compressed air is cooled with ambient air supplied by the blower **10** via the second cavity of the double-cavity heat exchanger **4**.

[0080] Then compressed air is cooled in the first cavity of the double-cavity heat-exchanging chiller **12** with the air fed through the said first cavity from the centrifugal expander **2** and then is separated from moisture in the second moisture separator **13**.

[0081] Next compressed air is cooled in the recuperator **5** with cold air from the chiller **8** of the refrigerating chamber **7**, following which compressed air is separated from moisture in the moisture separator **6**, and dried compressed air is fed into the centrifugal expander **2** where dried compressed air is cooled and simultaneously depressurized, by way of expansion and transformation of its pressure energy into mechanical energy of rotation of the wheels **24** and **23** of the centrifugal expander **2** and the compressor **1**, respectively, following which the air cooled in the centrifugal expander **2** is separated from moisture in the third moisture separator **14** and fed at low pressure via the second cavity of the double-cavity heat-exchanging chiller **12** into the chiller **8** of the refrigerating chamber **7** in order to withdraw heat from, and cool, this refrigerating chamber.

[0082] From the chiller **8**, air is fed into the second cavity of the recuperator **5** where compressed air is cooled and then fed into the centrifugal expander **2**, and then air is fed from the recuperator **5** to the inlet of the compressor **1**.

[0083] Regulation of temperature in the refrigerating chamber **7** and cooling capacity of the air turbo-refrigerating plant is performed by changing rotation speed of the blower **10** of the double-cavity heat exchanger **4**.

[0084] Temperature in the refrigerating chamber **7** is additionally regulated by regulation of the rotation speed of the blower **9** in the air chiller **8**.

[0085] Besides, additional regulation of temperature in the refrigerating chamber **7** is performed by additional cooling of compressed air in the double-cavity heat exchanger **4** by installing Peltier thermoelectric modules in that double-cavity heat exchanger, by cooling of compressed air in the double-cavity heat exchanger **4** by feeding water through the latter, by regulation of the rotation speed of the electric motor **3**, the shaft of which is coupled with the shaft **28** of the compressor **1** and centrifugal expander **2**.

[0086] The principle of operation of the air turbo-refrigerating plant according to FIGS. **2**, **3** and **5** is implemented as follows.

[0087] The compressor **1** feeds compressed air into the first cavity of the double-cavity heat exchanger **4**, in which compressed air is cooled with ambient air supplied by the blower **10** via the second cavity of the double-cavity heat exchanger **4**.

[0088] Then compressed air is cooled in the first cavity of the double-cavity heat-exchanging chiller **12** with air supplied through the said chiller from the centrifugal expander **2**, and then compressed air is separated from moisture in the second moisture separator **12**.

[0089] Following which compressed air is cooled in the first cavity of the recuperator **5** with cold air supplied from the chiller **8** of the refrigerating chamber **7**, after which compressed air is separated from moisture in the moisture separator **6**; then dried compressed air is fed into the centrifugal expander **2** where air is cooled by way of expansion and transformation of its pressure energy into mechanical energy of rotation of the wheels **23** and **24** of the centrifugal expander **2** and the compressor **1**, respectively.

[0090] Air cooled in the centrifugal expander **2** is separated from moisture in the third moisture separator **14** and fed at low pressure achieved in the centrifugal expander **2** via the second cavity of the heat-exchanging chiller **12** into the chiller **8** of the refrigerating chamber **7** in order to remove heat from the said chamber and cool it, while air heated in the chiller **8** is fed into the second cavity of the recuperator **5** for cooling of compressed air.

[0091] From the second cavity of the recuperator **5** air is fed to the inlet of the second compressor **17** which compresses air and feeds it into the first cavity of the second double-cavity heat exchanger **19**, in which compressed air is cooled by feeding ambient air with the second blower **20** via the second cavity of the second double-cavity heat exchanger **19**, while from the first cavity of the second double-cavity heat exchanger **19** air is fed into the compressor **1**, with temperature in the refrigerating chamber **7** and cooling capacity of the air turbo-refrigerating plant being controlled by regulation of the rotation speed of the blower **10** in the double-cavity heat exchanger **4**.

[0092] Additional regulation of temperature in the refrigerating chamber **7** shall be provided by regulation of the rotation speed of the blower **20** in the second double-cavity heat exchanger **19**, regulation of rotation speed of the electric motor **18** in the second compressor **17**, simultaneous regulation of the electric motor **18** in the second compressor **17**, and regulation of the rotation speed of the blower **20** in the second double-cavity heat exchanger **19** and the blower **9** in the chiller **8**, additional cooling of the second double-cavity heat exchanger **19** using Peltier thermoelectric modules, additional cooling in parallel of the first **4** and the second **19** double-cavity heat exchangers using Peltier thermoelectric modules, additional cooling of the second double-cavity heat exchanger **19** with water, additional cooling in parallel of the first **4** and second **19** of the double-cavity heat exchangers with water, regulation of the rotation speed of the blower **9** of the chiller **8**, regulation of the rotation speed of the second electric motor **21**, the shaft of which is coupled with the shaft of the compressor **1** and the centrifugal expander **2**.

[0093] The principle of operation of the air turbo-refrigerating plant according to FIGS. **4** and **5** is implemented as follows.

[0094] Compressed air is fed into the first cavity of the double-cavity heat exchanger **4** where compressed air is cooled with ambient air fed with the blower **10** via the second cavity of the double-cavity heat exchanger **4**.

[0095] Then compressed air is cooled in the first cavity of the double-cavity heat-exchanging chiller **12** with air fed through the said chiller from the centrifugal expander **2**, following which this compressed air is separated from moisture in the second moisture separator **13**.

[0096] Then compressed air is cooled in the recuperator **5** with cold air, from the chiller **8** of the refrigerating chamber **7**, following which compressed air is separated from moisture is separated moisture in the moisture separator **6**, and then dried compressed air is fed into the centrifugal expander **2** where it, by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheels **23** and **24** of the centrifugal expander and compressor **1**, is cooled and then air cooled in the centrifugal expander **2** is separated from moisture in the third moisture separator **14**, following which dried air is fed at reduced via the second cavity of the double-cavity heat-exchanging chiller **12** into the chiller **8** of the refrigerating chamber **7** for removal of heat from, and cooling, of the said chamber, following which air from the chiller **8** is fed into the second cavity of the recuperator **5** where compressed air is cooled, while from the second cavity of the recuperator **5** air is fed into the inlet of the compressor **1** which compresses air and feeds it into the second compressor **17**, from which additionally compressed air is fed into the first cavity of the second double-cavity heat exchanger **19**, while in the latter heat exchanger compressed air is cooled by feeding ambient air through the second cavity of the second double-cavity heat exchanger **19** with the second blower **20**, and from the first cavity of the second double-cavity heat exchanger **19** air if fed into the third compressor **22**, from which compressed air is fed into the first cavity of the double-cavity heat exchanger **4**.

[0097] Regulation of temperature in the refrigerating chamber **7** and cooling capacity of the air turbo-refrigerating plant is performed by regulation of the rotation speed of the blower **10** of the double-cavity heat exchanger **4**.

[0098] Additional regulation of temperature in the refrigerating chamber **7** is performed by regulating the rotation speed of the blower **9** which feeds air in the refrigerating chamber **7** through the chiller **8**, by additional cooling of compressed air in the double-cavity heat exchanger **4**, by installing in the latter Peltier thermoelectric modules, by additional cooling of compressed air in the double-cavity heat exchanger **4** with water run through this heat exchanger, by regulation of the rotation speed of the electric motor **18**, the shaft of which is coupled to the shaft of the second **18** and third **22** compressors, by regulation of the rotation speed of the second electric engine **21**, the shaft of which is coupled to the shaft of the compressor **1** and the centrifugal expander **2**.

INDUSTRIAL APPLICABILITY

[0099] This invention may be applied in air conditioning systems, refrigerators and other devices and installations where low temperature is to be maintained.

1. An air turbo-refrigerating plant which contains a compressor directly coupled to a centrifugal expander, electric motor with the shaft coupled to the shaft of a compressor and a centrifugal expander, a double-cavity heat exchanger, recuperator, moisture separator, refrigerating chamber with a chiller and a blower, with inlet and outlet of the second double-cavity heat exchanger opening to the atmosphere, where the inlet of the latter is via a blower, and the compressor's inlet opens via its valve member to the atmosphere, characterized in that the plant is equipped with a double-cavity heat-exchanging chiller, and the second and third moisture separators, with the compressor's outlet connected to the first cavity of the double-cavity heat exchanger, the said first cavity being connected to the first cavity of the double-cavity heat-exchanging chiller connected via the second moisture separator to the first cavity of the recuperator, with the said cavity connected via the first moisture separator to the inlet of the centrifugal expander, and the latter's outlet is connected via the third moisture separator to the second cavity of the double-cavity heat-exchanging chiller, the said second cavity connected to the chiller, and—through the latter chiller—to the second cavity of the recuperator, the said second cavity being connected to the compressor inlet.

2. The plant which, according to claim **1**, is characterized in that it is equipped with an air dryer package, the inlet of which opens to the atmosphere, and the outlet of which—via the second valve member—to the compressor inlet.

3. The plant which, according to claim **1** or **2**, is characterized in that the double-cavity heat exchanger is equipped with Peltier thermoelectric modules.

4. The air turbo-refrigerating plant containing a compressor directly coupled to a centrifugal expander, a double-cavity heat exchanger, recuperator, moisture separator, refrigerating chamber with a chiller and a blower, where inlet and outlet of the second cavity of the double-cavity heat exchanger open to the atmosphere, and the outlet is via the blower, the above plant characterized in that the plant is equipped with a double-cavity heat-exchanging chiller, the second and third moisture separators, the second motor-driven compressor and the second double-cavity heat exchanger, with the compressor outlet connected to the first cavity of the double-cavity heat exchanger, the said first cavity being connected to the first cavity of the double-cavity heat-exchanging chiller, the said first cavity connected via the second moisture separator to the first recuperator cavity connected via the first moisture separator to the centrifugal expander's inlet, while the centrifugal expander's outlet is connected via the third moisture separator to the second cavity of the heat-exchanging chiller, the said second cavity being connected to the chiller and, via the chiller, to the second cavity of the recuperator, the latter second cavity connected to the inlet of the second compressor, while the latter opens with its inlet via the valve member to the atmosphere and with the outlet—via the first cavity of the second double-cavity heat exchanger connected to the compressor inlet, and the inlet and outlet of the second double-cavity heat exchanger open to the atmosphere, with the inlet being connected via the second blower.

5. The plant, according to claim **4**, being characterized in that it is equipped with the air dryer package, the latter opening via its inlet to the atmosphere, and connected via it outlet to the inlet of the second compressor.

6. The plant, according to claim **4**, being characterized in that it is equipped with the second electric motor, the shaft of which coupled to the shaft of the compressor and centrifugal expander.

7. The plant, according to any of claims **4-6**, being characterized in that the double-cavity heat exchanger is equipped with Peltier thermoelectric modules.

8. The air turbo-refrigerating plant containing the directly coupled compressor and centrifugal expander, double-cavity heat exchanger, recuperator, moisture separator and refrigerating chamber with a chiller and a blower, with inlet and outlet of the second cavity of the double-cavity heat exchanger open to the atmosphere, while inlet is via the blower, being characterized that the plant is equipped with a double-cavity heat-exchanging chiller, second and third moisture separators, and the second and third compressors being directly coupled, electric motor, the shaft of which is coupled to the shaft of the second and third compressors, and with the second double-cavity heat exchanger, with the compressor inlet connected to the inlet of the second compressor which is connected with its outlet via the first cavity of the second double-cavity heat exchanger to inlet of the third compressor, the outlet of which is connected via the first cavity of the double-cavity heat exchanger to the first cavity of the heat-exchanging chiller, the said chiller's cavity connected via the second moisture separator to the first cavity of the recuperator connected via the first moisture separator to the outlet of the centrifugal expander, while the latter with its outlet is connected to the second cavity of the heat-exchanging chiller, the latter cavity connected to the chiller and, via the latter, to the second cavity of the recuperator, the latter cavity being connected to the compressor inlet, with the latter's inlet opening to the atmosphere via the valve member while the second cavity of the second double-cavity heat exchanger opens to the atmosphere on the side of both the inlet and outlet, and on the side of the inlet—via the second blower.

9. A plant, according to claim **8**, being characterized in that it is equipped with an air dryer package which opens via inlet to the atmosphere and is connected with its outlet via the second valve member to the compressor inlet.

10. A plant, according to any of claims **8** and **9**, being characterized in that the first and second double-cavity heat exchangers are equipped with Peltier thermoelectric modules.

11. A plant, according to any of claims **8** to **10**, being characterized in that it is equipped with the second electric motor, the shaft of which is coupled to the shaft of the compressor and centrifugal expander.

12. The centrifugal expander containing directly coupled wheels of the centrifugal expander and the compressor mounted on same shaft installed in the shell between gas-dynamic bearings, being characterized in that an axial shaft stabilizer is installed in the shell opposite to the shaft end on the side of the compressor wheel clear of the last stationary magnet.

13. The centrifugal expander, according to claim **12**, being characterized in that in the axial shaft stabilizer a stationary electric magnet is installed.

14. The centrifugal expander, according to claim **13**, being characterized in that the electric magnet includes own magnetic field strength regulator.

15. The centrifugal expander, according to claim **12**, characterized in that in the axial shaft stabilizer a stationary permanent magnet is installed.

16. The centrifugal expander, according to claim **12**, characterized in that it additionally contains a permanent magnet installed on the shaft end opposite to the stationary magnet.

17. The centrifugal expander, according to claim **12**, characterized in that it is equipped with the second axial shaft stabilizer installed in the shell opposite to the shaft end on the side of the wheel of the centrifugal expander wheel clear of the second stationary magnet, with the second permanent magnet installed on the shaft end opposite to the second stationary magnet.

18. The centrifugal expander, according to claim **17**, characterized in that in the second axial shaft stabilizer a stationary n electric magnet is installed.

19. The centrifugal expander, according to claim **18**, characterized in that the electric magnet contains a magnetic field strength regulator.

20. The centrifugal expander, according to claim **17**, characterized in that in the second axial shaft stabilizer a stationary permanent magnet is installed.

21. The principle of operation of the air turbo-refrigerating plant, according to any of claims **1-3**, involving supply of compressed air with the compressor into the first cavity of the double-cavity heat exchanger in which compressed air is cooled with ambient air fed with the blower via the second cavity of the double-cavity heat exchanger, following which compressed air is cooled in the recuperator with cold air fed supplied from the cooler of the refrigerating chamber, after which compressed air is separated from moisture in the moisture separator and dried compressed air is fed into the centrifugal expander, where air, by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheels of the centrifugal expander and compressor is cooled and fed under reduced pressure into the cooler of the refrigerating chamber for removal of heat from, and cooling of, the chamber; from the cooler air is fed into the second cavity of the recuperator where compressed air is cooled, after which air is fed from the recuperator to the compressor inlet, characterized in that compressed air, before being fed in the first cavity of the recuperator, is cooled in the double-cavity heat exchanging chiller with air fed through it from the centrifugal expander and is separated from moisture in the second moisture separator, and air cooled in the centrifugal expander, before it is fed via the double-cavity heat-exchanging chiller into the cooler of the refrigerating chamber, is separated from moisture in the third moisture separator, with temperature in the refrigerating chamber and cooling capacity of the air turbo-refrigerating plant being regulated by changing rotation speed of the blower in the double-cavity heat exchanger.

22. Principle of operation, according to claim **21**, characterized in that temperature in the refrigerating chamber is additionally regulated by changing the rotation speed of the blower in the air cooler.

23. The principle of operation, according to any of claims **21** and **22**, characterized in that temperature in the refrigerating chamber is additionally regulated by cooling of compressed air in the double-cavity heat exchanger by installing of Peltier thermoelectric modules.

24. The principle of operation, according to any of claims **21** to **23**, characterized in that temperature in the refrigerating chamber is additionally regulated by cooling of compressed air in the double-cavity heat exchanger, by feeding water through the double-cavity heat exchanger.

25. The principle of operation, according to any of claims **21** to **24**, being characterized in that temperature in the refrigerating chamber is additionally regulated by changing rotation speed of the electric motor directly coupled to the compressor and centrifugal expander.

26. The principle of operation, according to any of claims **4** to **7**, involving supply of compressed air into the first chamber of the double-chamber heat exchanger in which compressed air is cooled with ambient air fed by the blower via the second chamber, after which compressed air is cooled in the recuperator with cold air from the cooler of the refrigerating chamber, following which compressed air is separated from moisture in the moisture separator and dried compressed air is fed into the centrifugal expander where air, by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheels of the centrifugal expander and compressor, and feed at reduced pressure into the cooler of the refrigerating chamber in order to remove heat from the said chamber and cool it; from the chiller air is fed into the second chamber of the recuperator where compressed air is cooled, characterized in that compressed air, before being fed into the first cavity of the recuperator, is cooled in the double-cavity heat-exchanging chiller with air fed through it from the centrifugal expander and is separated from moisture in the second moisture separator, air cooled in the centrifugal expander, before being fed via the double-cavity heat-exchanging chiller into the cooler of the refrigerating chamber, is separated from moisture in the third moisture separator, air from the second chamber of the recuperator air is fed into the inlet of the second compressor which compresses air and delivers it into the first chamber of the double-cavity heat exchanger, in the latter compressed air is cooled feeding ambient air via the second chamber of the second double-cavity heat exchanger with the second blower, while from the first chamber of the second double-cavity heat exchanger air is fed into the compressor, where temperature in the refrigerating chamber and cooling capacity of the air turbo-refrigerating plant is performed by regulation of rotation speed of the blower of the double-cavity heat exchanger. 7. The principle of operation according to claim **26**, characterized in that additional regulation of temperature in the refrigerating chamber is performed by regulation of rotation speed of the blower of the second double-cavity heat exchanger.

28. The principle of operation according to any of claims **26** and **27** characterized in that additional regulation of temperature in the refrigerating chamber is performed by regulation of rotation speed of the electric motor of the second compressor.

29. The principle of operation according to claim **26** characterized in that additional regulation of temperature in the refrigerating chamber and cooling capacity of the refrigerating plant is performed simultaneously by changing the rotation speed of the electric motor of the second compressor and changing rotation speed of the blower in the second double-cavity heat exchanger and chiller blower.

30. The principle of operation according to claim **26**, characterized in that temperature in the refrigerating chamber is additionally regulated by cooling of the second double-cavity heat exchanger with Peltier thermoelectric modules.

31. The principle of operation according to claim **26**, characterized in that temperature in the refrigerating chamber is additionally regulated by additional simultaneous cooling of the first and the second double-cavity heat exchangers using Peltier thermoelectric modules.

32. The principle of operation according to claim **26**, characterized in that temperature in the refrigerating chamber is additionally regulated by additional cooling of the second double-cavity heat exchanger with water.

33. The principle of operation according to claim **26**, characterized in that temperature in the refrigerating chamber is additionally regulated by additional simultaneous cooling of the first and the second double-cavity heat exchangers with water.

34. The principle of operation according to claim **26**, characterized in that temperature in the refrigerating chamber is additionally regulated by changing rotation speed of the chiller blower.

35. The principle of operation according to claims **26**, **32** to **34**, characterized in that temperature in the refrigerating chamber is additionally regulated by changing rotation speed of the second electric motor, the shaft of which is coupled to the shaft of the compressor and centrifugal expander.

36. The principle of operation of the air turbo-refrigerating plant, according to claim **8**, involving supply of compressed air into the first cavity of the double-cavity heat exchanger, in which compressed air is cooled with ambient air supplied with the blower via the second cavity of the double-cavity heat exchanger, following which compressed air is cooled in the recuperator with cold air fed from the cooler of the refrigerating chamber, following which compressed air is separated from moisture in the moisture separator and dried compressed air is fed in the centrifugal expander where it is cooled by way of expansion and transformation of its pressure energy into mechanical energy of rotation of wheel of the centrifugal expander and compressor and fed under reduced pressure into the cooler of the refrigerating chamber for heat removal from the latter and cooling, after which from the cooler air is fed into the second cavity of the recuperator where compressed air is cooled, characterized in that compressed air, before being fed into the first cavity of the recuperator, is cooled in the double-cavity heat-exchanging chiller with air fed via this chiller from the centrifugal expander and is separated from moisture in the second moisture separator, after which air cooled in the centrifugal expander, before being fed via the double-cavity heat-exchanging chiller into the cooler of the refrigerating chamber, is separated from moisture in the third moisture separator, from the second cavity of the recuperator air is fed into the inlet of the compressor which compresses air and feeds it into the second compressor, from which additionally compressed air is fed into the first cavity of the second double-cavity heat exchanger, while in the latter compressed air is cooled by feeding ambient air with the second blower via the second cavity of the second double-cavity heat exchanger, and from the first cavity of the second double-cavity heat exchanger air is fed into the third compressor, from which compressed air is fed into the first cavity of the double-cavity heat exchanger, while regulation of temperature in the refrigerating chamber and cooling capacity of the air turbo-refrigerating plant is performed by regulation of rotation speed of the blower of the double-cavity heat exchanger.

37. The principle of operation according to claim **36**, characterized in that temperature in the refrigerating chamber is additionally regulated by regulating rotation speed of the blower which feeds air into the refrigerating chamber through the cooler.

38. The principle of operation according to any of claims **36** and **37**, characterized in that temperature in the refrigerating chamber is additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger by installing Peltier thermoelectric modules in that heat exchanger.

39. The principle of operation according to any of claims **36** and **37**, characterized in that temperature in the refrigerating chamber is additionally regulated by additional cooling of compressed air in the double-cavity heat exchanger with water fed through that heat exchanger.

40. The principle of operation according to any of claims **36** and **37**, characterized in that temperature in the refrigerating chamber and cooling capacity of the air turbo-refrigerating plant are regulated by changing rotation speed of the blower in the second double-cavity heat exchanger.

41. The principle of operation according to any of claims **36** and **37**, characterized in that additional regulation of temperature in the refrigerating chamber is performed by additional cooling of compressed air in the second double-cavity heat exchanger by installing Peltier thermoelectric modules in that heat exchanger.

42. The principle of operation according to any of claims **36** and **37**, characterized in that additional regulation of temperature in the refrigerating chamber is performed by additional cooling of compressed air in the second double-cavity heat exchanger with water fed through that heat exchanger.

43. The principle of operation according to any of claims **36** and **37**, characterized in that additional regulation of cooling capacity and temperature in the refrigerating chamber is performed by regulation of rotation speed of the electric motor, the shaft of which is coupled to the shaft of the second and third compressors.

44. The principle of operation according to any of claims **36** and **37**, characterized in that additional regulation of cooling capacity and temperature in the refrigerating chamber is performed by regulation of rotation speed of the second electric motor, the shaft of which is coupled to the shaft of the compressor and centrifugal expander.

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