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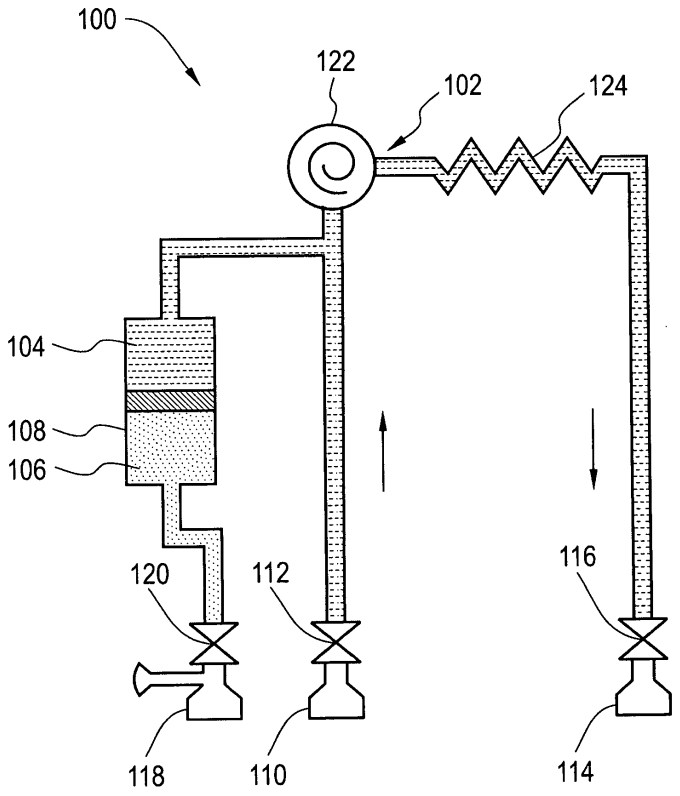
(54) A cooling device and a system thereof

(57) The present invention provides a cooling device (100) for a gas compressor (202), which significantly simplifies the ease of maintenance. The cooling device (100) for cooling the gas compressor (202) comprises a cooling arrangement (102) to cool a cooling medium (104). The cooling device (100) has got interfaces, which makes it attachable or detachable from the gas compressor (202). The cooling device (100) has a first interface (110) for receiving the cooling medium (104) from the gas compressor (202) and a first valve (112) for controlling the flow of cooling medium (104) through the first interface (110). The cooling device (100) also has a second interface (114) for supplying the cooled cooling medium (104) from the cooling arrangement (102) to the gas compressor (202) and a second valve (116) for controlling the flow of cooling medium (104) through the second interface (114).

FIG 1



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Description

[0001] The present invention relates to cooling systems in industry, particularly a cooling device for cooling a gas compressor.

[0002] Gas compression systems are used in a wide variety of applications, including air compression for powering tools, gas compression for storage and transport of gas, etc. In each system, motors or gas turbines are provided for driving the compression mechanism to compress the gas. Providing adequate motor cooling, without sacrificing energy efficiency of the compression system, continues to challenge designers of gas compression systems.

[0003] Gas compressors, like centrifugal gas compressors are usually driven by electric motors that are normally a standalone machine in a casing or within a casing that encases the motor and compressor. While this configuration prevents the risk of leaks from inside to outside of the housing or vice versa, it does not permit direct cooling of the motor or the compressor using ambient air or the environment surrounding the gas compressor. The motor or the gas compressor must therefore be cooled using a separate cooling medium.

[0004] For subsea environment applications, the equipment design shall target the highest level of reliability since maintenance costs are extremely high, especially for heavy equipment at deeper water where heavy duty intervention vessels are very limitedly available. While intervention, even retrieval to the surface of heavy machinery is required; this has got enormous technical and financial impact.

[0005] Considering the risk of failure in the total compressor unit it is likely that the highest chance of failures is related to the cooling system of the compressor, including the individual components of the cooling system.

[0006] It is an object of the present invention to provide a cooling device for a gas compressor system, which significantly simplifies the ease of maintenance.

[0007] The said object is achieved by providing a cooling device according to claim 1 and by a system according to claim 10.

[0008] The underlying idea is to have a separate cooling device for cooling a gas compressor, which is detachable from said gas compressor. The cooling device comprises a cooling arrangement to cool a cooling medium. The cooling device has got a first and second interface to supply and retrieve the cooling medium in and out of the gas. Each one of the interfaces is provided with at least one valve to block the cooling medium or the gas in order to be able to separate the cooling device from the compressor. These interfaces enable the cooling device to be detached from the gas compressor, so that the cooling device alone is moved to a different location, for maintenance, replacement or for a service if required. On an average, the weight of the liquid cooling system will be approximately 10 % of the total compressor unit weight. Given this fact, a separate retrievable cooling system could significantly reduce the cost and complexities, if the service requirement is for the cooling device. In case of a separate retrievable cooling device, there is no need to retrieve the complete gas compressor if there is a need for any servicing of the cooling device away from the site of installation of the gas compressor.

[0009] In a preferred embodiment, the third interface is adapted to receive a flushing medium. In order to avoid Health Safety Environment (HSE) problems, the risk of spillage of hydrocarbons to the surrounding environment shall be minimal. Providing a flushing medium in the third interface, prior to the detaching of the cooling device from the gas compressor will avoid this spillage.

[0010] In a further preferred embodiment, the flushing medium is nitrogen or water. Flushing is required prior to detaching, to prevent the hydrocarbon spillage. Flushing with high pressured nitrogen or sea water will help to remove the excess hydrocarbon residues captured between the valves. Nitrogen or water are used because they are available in plenty and are less costly.

[0011] In an alternative embodiment, the cooling arrangement further comprises a pumping means for pumping the cooling medium. This provides enough pressure for the cooling medium to be circulated in the cooling device and into the gas compressor when the cooling device is in operation.

[0012] In an alternative embodiment, the cooling arrangement further comprises a heat exchanger adapted to cool the cooling medium. The cooling medium, which enters the gas compressor, should be cool enough to cool different hot parts inside the gas compressor. Since the cooling medium is basically reused and the cooling medium that comes out of the gas compressor is hot, there is a need to cool the cooling medium. The heat exchanger ensures a continuous supply of cold cooling medium into the gas compressor.

[0013] In another alternative embodiment, the first, second and third valves are adapted to be operated remotely from a place distant from the cooling device. This allows in having an automatic control for the valves, so that the operations of the valves and the process of detaching the cooling device from the gas compressor becomes much simpler.

[0014] In another alternative embodiment, the cooling medium is oil. To avoid HSE problems, the risk of spillage of oil shall be minimal. The applied oil should be safe environmental friendly oil, for example, transformer oil, where spillage to the seawater is considered acceptable for very small volumes. In another alternative embodiment, the cooling arrangement further comprises a pressure compensating means to balance the pressure of a cooling medium to the pressure of a gas provided from a gas supply to the gas compressor. During the operation of the gas compressor, pressure variation can happen, which may turn hazardous to the gas compressor. Providing a pressure compensating means will ensure the maintenance of reliable pressure in the gas compressor.

[0015] In another alternative embodiment, the cooling

device further comprises a third interface for connecting the cooling arrangement to the gas supply, and a third valve for controlling the gas flow through the third interface. This further enables the pressure compensating means to be connected to the gas compressor system. The third interface also helps in supplying gas for the working of the pressure compensating means.

[0016] In another alternative embodiment, the cooling device is adapted to cool a compressor module, a motor and bearings of the gas compressor. The moving parts of the gas compressor generate a lot of heat. The cooling device is used to cool these regions especially the motor and also the bearing brackets, containing the bearing stators using the cooling medium.

[0017] In another alternative embodiment, said cooling device is adapted to be mounted on the gas compressor having a common rotor axis for the compressor module and the motor. This enables the cooling device to be used in a gas compressor design, where the compressor module and the motor share a common rotor shaft.

[0018] In another alternative embodiment, the cooling device is vertically or horizontally connected to the gas compressor. The cooling device is connected based on the orientation of the gas compressor. For example, the gas compressor having the compressor module and the motor, sharing a common shaft can be mounted vertically or horizontally. Based on this arrangement, the cooling device is connected to the gas compressor accordingly.

[0019] In another alternative embodiment, the compressor module and the motor are accommodated in a common gas-tight casing. This provides a hermetically sealed design for example, with no shaft ends extruding the casing, which in-turn prevents any leakage of oil or hydrocarbons to the external environment making them more advantageous for deep sea applications.

[0020] The present invention is further described hereinafter with reference to illustrated embodiments shown in the accompanying drawings, in which:

FIG 1 illustrates a diagram of a cooling device according to an embodiment of the invention, and

FIG 2 illustrates a diagram of a system for compressing gas according to an embodiment of the invention.

[0021] The compressors, particularly centrifugal compressors, must be provided with means to cool the motor during operation of the unit, in order to prevent degradation of the windings, insulation and the consequent damage to the motor, and with means to cool the cooling oil, so that it does not warm up excessively thereby degrading and loosing its cooling properties.

[0022] FIG 1 illustrates a block diagram of a cooling device 100 according to an embodiment of the invention. The cooling device 100 for cooling a gas compressor 202 as shown in FIG 2 comprises a cooling arrangement 102 to cool a cooling medium 104, for example oil. The invention will be explained with respect to a hermitically sealed gas compressor, even though the idea could be extended to other type of gas compressors. In the illustrated example, the cooling device 100 has got a pressure compensating means 108, to balance the pressure of a cooling medium 104 to the pressure of a gas 106, provided from a gas supply 226 as shown in FIG 2 to the gas compressor 202. Providing a pressure compensating means 108, will ensure the maintenance of reliable pressure in the gas compressor. The cooling device 100 may even be realized without a typical pressure compensating means 108, for example by using a full delta pressure 'can' design for the motor, especially for the motor stator.

[0023] The main idea is to have a cooling device 100, which is detachable from the gas compressor 202, so that this can be transported separately in case of any service or maintenance requirement. For this, the cooling device has got plurality of interfaces. A first interface 110 is used for receiving the cooling medium 104 from the gas compressor. The first interface 110 has got a first valve 112, for controlling the flow of the cooling medium 104, from the gas compressor to the cooling arrangement 102. A second interface 114 is used for supplying the cooling medium 104, which is cooled by the cooling arrangement 102 to the gas compressor 202. The second interface 114 has an associated second valve 116, for controlling the flow of cooling medium from the cooling arrangement 102 to the gas compressor 202. The first and the second interface acts as an inlet and an outlet for the cooling medium respectively. The process of controlling the flow mentioned here with respect to the valves, mainly involves the process of blocking the lines in case of retrieval of the cooling device from the gas compressor.

[0024] The cooling arrangement 102 mainly comprises a pumping means 122, for pumping the cooling medium 104 and a heat exchanger 124, adapted to cool the cooling medium 104. The heat exchanger 124 is exposed to a surrounding medium. The medium could be ambient water. If it is subsea operations, then the medium is sea water. Water at the deep sea, which is in abundance, is used to transfer the heat of the cooling medium 104 via the heat exchanger 124 by way of contact with the heat exchanger 124. Here also, the controlling function of the valves, mainly involves the process of blocking the lines in case of retrieving or while detaching the cooling device 100 from the gas compressor 202.

[0025] The cooling device 100 has a third interface 118 for connecting the cooling arrangement 102 to a gas supply 226, as shown in FIG 2. The third interface 118 has got an associated third valve 120, for controlling the gas connection between the gas supply 226 and the pressure compensating means 108. This third interface 118 is adapted to receive a flushing medium. The flushing medium can be for example, nitrogen or water.

[0026] The first, second and third valves associated with the cooling device 100 are adapted to be operated remotely from a place distant from the cooling device. In case of any retrieval to the surface for any maintenance,

the retrieval would be done by a vessel where subsea intervention activities will be remote operated with a remote operated vehicle (ROV).

[0027] FIG 2 illustrates a block diagram of a system 200 for compressing gas according to an embodiment of the invention. The gas compressor 202 for compressing gas generally has a compressor module 204 having a compressor rotor 206 with one or more compressor impellers 208, and an electric motor 210 having a stator 212 and a motor rotor 214 for driving the compressor rotor 206 of the gas compressor 202. The compressor module 204 and the electric motor 210 are accommodated in a common gas-tight casing 216, which is provided with a gas inlet 218 and a gas outlet 220. The compressor rotor 206 and the motor rotor 214 are arranged on a common rotor shaft 234, which are mounted using the bearings 222 and 224 in the gas compressor 202. Since the electric motor 210 and the compressor module 204 share a common pressurized casing there are no shaft-ends extruding the casing as seen in standard compressor designs. Hence there is absolutely no hazardous emission to the environment.

[0028] This advantage makes this type of gas compressor suitable for submerged application even at great water depths.

[0029] When the cooling device is in operation, the cooling medium 104 completes a closed loop 232. The closed loop comprises of the pumping means 122, the heat exchanger 124, the gas compressor 202 and the pressure compensating means 108. The heat exchanger 124 can be a simple convection type, where cooling piping of the heat exchanger 124 is directly exposed to the cold seawater. The pressure compensating means 108 could be a piston, bladder or membrane type with a pressure reference to compressor suction gas. The loop supplies the cooling medium 104 to various parts in the gas compressor 204, for example the motor 210, the compressor module 204 and the bearings 222 and 224. The compressor illustrated in the present invention could also be a multiphase pump and the suction gas might contain slugs of water, when used in deep sea applications.

[0030] The system further comprises a flushing medium supply line 228, which supplies the required flushing medium 230. The relevant piping between gas supply 226 and the pressure compensating means 108 is filled with the hydrocarbon gas 106. In place of hydrocarbon gas any other alternate medium could be used. Goal is to avoid hydrocarbon spillage to the environment when the cooling device 100 is separated from the gas compressor 202. At both side of the piping interface points, the associated valves need to be closed; i.e. the third valve 120 and a corresponding valve 236 at the gas compressor side. These valves may be physically close to each other, but still there is a small amount of gas 106 in the line between the valves. By flushing with nitrogen or sea water, the hydrocarbons are removed.

[0031] Summarizing, the present invention introduces a cooling device 100 for cooling a gas compressor 202, which is detachable from said gas compressor 202. The cooling device 100 comprises a cooling arrangement 102 to cool a cooling medium 104, which intern cools the hot parts inside the gas compressor 202. The cooling device 100 has got interfaces to supply and retrieve the cooling medium 104 in and out of the gas compressor 202 and another interface to supply gas for the working of the pressure compensating means 108, each one controlled by the respective valves associated with the interfaces. These interfaces enable the cooling device to be detached from the gas compressor 202, so that the cooling device 100 alone is moved to a different location, for maintenance or for a service if required.

[0032] Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternate embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is therefore contemplated that such modifications can be made without departing from the embodiments of the present invention as defined.

Claims

1. A cooling device (100) for cooling a gas compressor (202), said cooling device (100) comprising:

   - cooling arrangement (102) to cool a cooling medium (104),
   - a first interface (110) for receiving the cooling medium (104) from the gas compressor (202),
   - a first valve (112) for controlling the flow of cooling medium (104) through the first interface (110),
   - a second interface (114) for supplying the cooled cooling medium (104) from the cooling arrangement (102) to the gas compressor (202), and
   - a second valve (116) for controlling the flow of cooling medium (104) through the second interface (114).

2. The cooling device (100) according to claim 1, further comprising:

   - a third interface (118) for connecting the cooling arrangement (102) to a gas supply (226), and
   - a third valve (120) for controlling the gas flow through the third interface (118).

3. The cooling device (100) according to claim 2, wherein the third interface (118) is adapted to receive a flushing medium (230).

4. The cooling device (100) according to claim 3, wherein the flushing medium (230) is nitrogen or wa-

ter.

5. The cooling device (100) according to any of the claims 1 to 4, wherein the cooling arrangement (102) further comprises a pumping means (122) for pumping the cooling medium (104).

6. The cooling device (100) according to any of the claims 1 to 5, wherein the cooling arrangement (102) further comprises a heat exchanger (124) adapted to cool the cooling medium (104).

7. The cooling device (100) according to any of the claims 1 to 6, wherein the first valve (112), the second valve (116) and the third valve (120) are adapted to be operated remotely from a place distant from the cooling device (100).

8. The cooling device (100) according to any of the claims 1 to 7, wherein the cooling medium (104) is oil.

9. The cooling device (100) according to any of the claims 2 to 8, wherein the cooling arrangement (102) further comprises a pressure compensating means (108) to balance the pressure of a cooling medium (104) to the pressure of a gas (106) provided from the gas supply (226) to the gas compressor (202).

10. A system (200) for compressing gas, comprising:

- a cooling device (100) according to any of the claims 1 to 9; and
- a gas compressor (202) which is connected to the first interface (110) and the second interface (114) to form a cooling circuit (232) for the cooling medium (104) to cool the gas compressor (202).

11. A system (200) for compressing gas according to claim 10, wherein the cooling device (100) is adapted to cool a compressor module (204) of the gas compressor (202).

12. A system (200) for compressing gas according to claim 10 or 11, wherein the cooling device (100) is adapted to cool a motor (210) of the gas compressor (202).

13. A system (100) for compressing gas according to any of the claims 10 to 12, wherein the cooling device (100) is adapted to cool the bearings (222, 224) of the gas compressor (202).

14. A system (200) for compressing gas according to any of the claims 10 to 13, wherein said cooling device (100) is adapted to be mounted on the gas compressor (202) having a common rotor shaft (234) for the compressor module (204) and the motor (210).

15. A system (200) for compressing gas according to any of the claims 10 to 14, wherein the cooling device (100) is vertically or horizontally connected to the gas compressor (202).

16. A system (200) for compressing gas according to any of the claims 10 to 15, wherein the compressor module (204) and the motor (210) are accommodated in a common gas-tight casing (216).

FIG 1

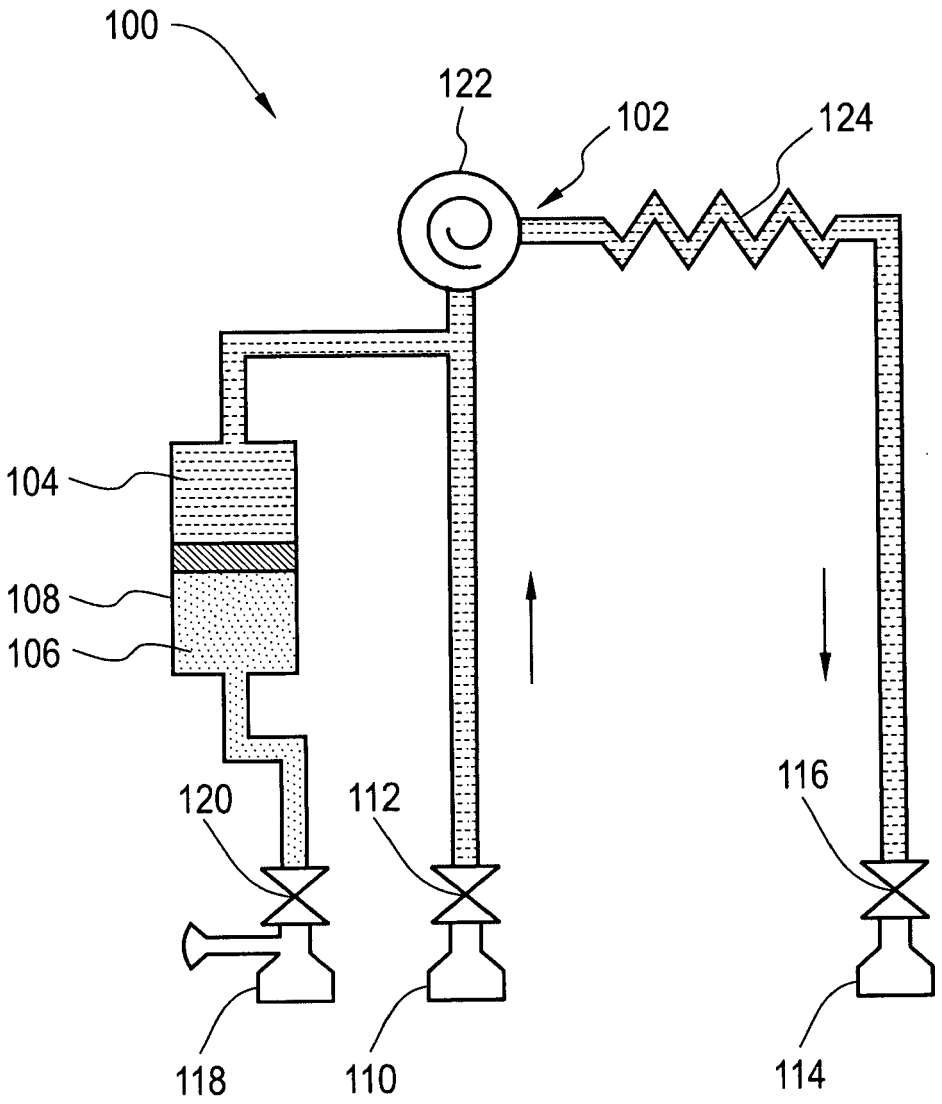
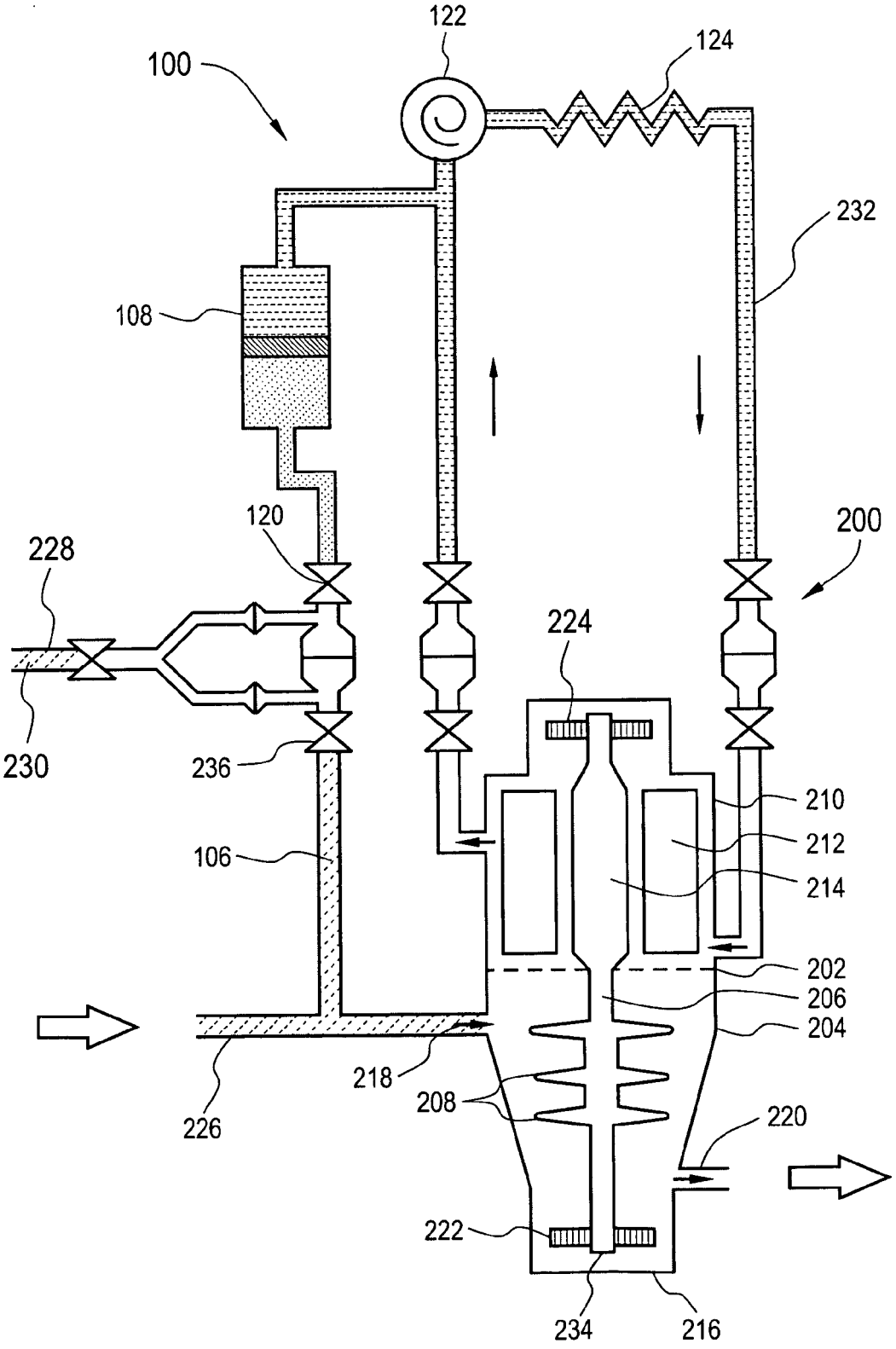


FIG 2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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 8923

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 November 2009	Di Giorgio, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82