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(54) Title: COMPRESSOR COOLING SYSTEM USING HEAT EXCHANGER PRE-CONDENSER, AND COMPRESSOR PROVIDED FROM A COOLING SYSTEM

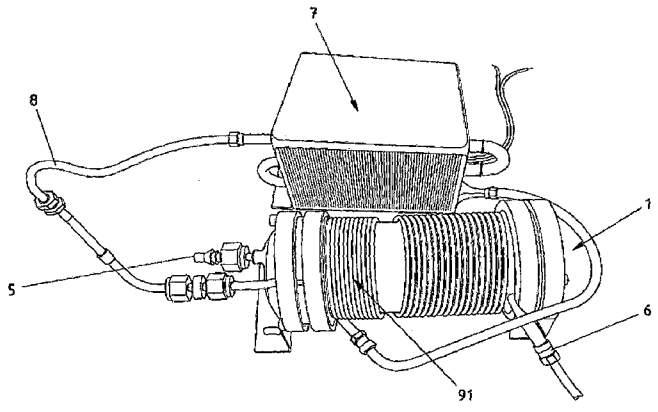


Fig. 1

(57) Abstract: The present invention pertaining to the field of refrigeration equipments was designed to allow an unexpected construction and operation, and which is more efficient than the one achieved by using existing similar equipments. It is consisted of a compressor (1) comprised of a shell (2) within which it is located a compression cylinder (3), whereas from the shell (2) it is projected an inlet tube (5) from an evaporator and a discharge tube (6), which conducts the fluid into a condenser; at least one pre-condenser (7) associated with the compressor (1), the pre-condenser (7) being fed by a tubing (8) from the compression cylinder (3) located within the compressor (1), and equipped with an outlet tube (1 1); and a heat exchanger (91) internal to the outer region of the compressor (1) and cooperative with the pre-condenser (7) through the outlet tube (11) of the pre-condenser (7), the heat exchanger (91) comprising tubes attached around the shell (2) of the compressor (1).

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Description of the Invention Patent for "COMPRESSOR COOLING SYSTEM USING HEAT EXCHANGER PRE-CONDENSER, AND COMPRESSOR PROVIDED FROM A COOLING SYSTEM".

Field of the Invention

The present invention relates to a compressor cooling system – more specifically micro compressors – by using a pre-condenser, which pertains to the field of refrigeration equipments and that was designed to enable a more efficient operation that the one achieved by using the known systems.

Background of the Invention

As it is known in the art, the refrigeration cycle typically consists of a compressor that transforms the low pressure gas into high pressure and high temperature gas that goes into a condenser, where such gas becomes a high pressure subcooled liquid that, then, goes into an expansion device that reduces the fluid pressure in order to conduct it to the evaporator that will transform the subcooled liquid into low pressure – saturated vapor, to further be conducted through the suction line to enter again into the compressor and start a new refrigeration cycle.

Due to their operation characteristics, compressors usually constitute the hottest part of a refrigeration system, the temperature thereof being a function of room temperature where the system is located. However, the inner temperature of compressors have limits that may be extrapolated in case of the room temperature being too high; besides, the operation temperature of the compressor also influences bearing design that will be used therewith - and which should be submitted to harsh approval tests in order to endure the operation under such conditions. Furthermore, a large part of the compressor inefficiency is associated with the consequent coolant gas overheating during its path between the suction valve and the compression cylinder, as well as with the coolant heating during its compression.

The heating of the coolant through the suction path is caused by heat exchanges with the compressor components, which are hotter than the coolant fluid. In turn, the coolant heating in the compression process mainly occurs due to the addition of work imposed by piston and also, due to a heat part from the cylinder walls at the early stages of compression.

Regarding the heating during compression, from the instant that the coolant temperature exceeds the temperature of the cylinder walls, such heating could be avoided if the heat exchange between the wall and the cylinder were intensified. However, as the compression is too fast and the heat exchange area is small, the heat exchange is insufficient in avoiding heating, resulting in high coolant temperature values at the end of the compression. In addition, the temperature of the cylinder walls is high, which prolongers the coolant heating time over the compression cycle.

As a consequence of the coolant heating during compression, the heated coolant

becomes the greatest heat source of the compressor, being the main responsible for heating the compressor components and, therefore, the coolant heating along the suction path. Therefore, effective solutions that allow cooling the coolant during its compression process or that reduce the gas temperature after compression (heat source reduction), will have an impact on the compression efficiency and, consequently, will impact on losses due to the overheating of the coolant during the suction.

Some technological solutions were developed to achieve this goal; among them there is the one disclosed in document EP0173013, which provides the use of an outer heat exchanger located in the system suction line in order to reduce gas temperature before entering the compressor without, however, provide any form of attenuating the gas heating that occurs during the compression step.

On the other hand, document US4936112 describes a compressor equipped with only an inner heat exchanger comprising a plurality of resistive plates welded to each other (or possibly a coil) exclusively directing reducing the temperature of the compressor motor.

Document JP5209596 describes a rotatory-type compressor having an element named "precooler" to cool the compressed gas that exits the compressor and to redirect it back to the inside thereof even through directing reducing the compressor inner temperature through said gas having the temperature attenuated – which presents limitations in efficiency, due to the high temperature reached by the equipment during operation. Similarly, document US5439358 describes the use of gas recirculation ducts associated with a manifold having a plurality of heat exchangers that, however, do not effectively attenuate the temperature of the air compressor from which part the air to such ducts.

It is noted, therefore, that the solutions employed in the present state of the art direct the reduction of gas temperature without, however, providing means for additional and simultaneous cooling of the compressor equipment itself in a more direct and effective manner.

Objectives of the invention

In view of those drawbacks and for the purposes of solving them, is one of the objectives of the present invention to provide a cooling system that directs removing heat from the compressor surface, so as to reduce the gas temperature during the compression process.

Another objective of the invention is to provide a cooling system able to decrease the gas overheating in the suction path simultaneously to the cooling of compressor itself, through the use of an outer heat exchanger that plays the role of rejecting heat from the compressed fluid to the external environment, functioning as a pre-condenser.

The presented system further provides the existence of an outer heat exchanger, wrapped on the compressor, which is very effective due to evaporative process of two-phase

fluid and to the mechanism of heat exchange by conduction in the component to be cooled. Therefrom, it is established the surface temperature of the compressor (and therefore of the internal components thereof) close to the pre-condenser saturation temperature, enabling the compressor operation for high room temperatures.

It is further another object of the present invention to disclose a compressor cooling system that can decrease productivity losses by overheating in the suction, besides improving the compressor energy efficiency.

Summary of the Invention

The present invention achieves the abovementioned objectives through a compressor cooling system by using a pre-condenser which, according to the preferred embodiment of the present invention, comprises: a compressor comprised of a shell within which it is located a compression cylinder, whereas from the shell it is projected an inlet tube from an evaporator and a discharge tube which conducts the fluid into a condenser; at least one pre-condenser associated with the compressor, the pre-condenser being fed by a tubing from the compression cylinder located within the compressor, and equipped with an outlet tube; and a heat exchanger internal to the outer region of the compressor and cooperative with the pre-condenser through the outlet tube of the pre-condenser.

According to a preferred embodiment of the present invention, said outer heat exchanger comprises tubes fastened around the compressor or micro compressor shell.

Optionally, the presented system can operate in series, together with an additional inner heat exchanger located in the compressor and cooperative with the pre-condenser through a spring-tube connected to the end of the outlet tube of the pre-condenser, such an inner heat exchanger being located within the shell and positioned close to hot part of the compressor – preferably close to the compression cylinder or compression cylinder cap, when applicable -, said inner heat exchanger receiving the fluid from the pre-condenser or from the outer heat exchanger through a spring-tube connected to the end of outlet tube of the pre-condenser, and conducts the fluid therein processed into the discharge tube through an output spring-tube.

The present invention further comprises a compressor equipped with a cooling system that contains: a compressor or micro compressor comprised of a shell within which it is located a compression cylinder, whereas from the shell it is projected an inlet tube from an evaporator and a discharge tube which conducts the fluid into a condenser; at least one pre-condenser associated with the compressor, the pre-condenser being fed by a tubing from the compression cylinder located within the compressor, and equipped with an outlet tube; and a heat exchanger internal to the outer region of the compressor and cooperative with the pre-condenser through the outlet tube of the pre-condenser.

In a possible embodiment of the present invention, such compressor equipped with

a cooling system can further include at least one inner heat exchanger located in compressor and cooperative with the pre-condenser through a spring-tube connected to the end of outlet tube of the pre-condenser.

Said objectives are achieved, therefore, by a compressor cooling system comprising means for reducing the temperatures of the heat sources of the compressor equipment, and, thus, reducing the compression initial temperature and improving the efficiency in compression.

Brief Description of the Drawings

Figures show:

Figure 1 – shows a schematic perspective view of a figure by showing a compressor that is cooperative with a pre-condenser and an outer heat exchanger built according a preferred embodiment of the present invention.

Figure 2 – shows a diagram schematically illustrating a refrigeration system built in accordance with the preferred embodiment of the present invention illustrated in Figure 1.

Figure 6 – shows in schematic perspective the embodiment described in the diagram in Figure 5.

Figure 3 – shows an elevated view of the heat exchanger that is associated with a compressor built according to the preferred embodiment of the present invention.

Figure 4 – shows a plan view of the equipment illustrated in Figure 3.

Figure 5 – shows an elevated view having a partial longitudinal cut of an alternative embodiment of the compressor provided from the refrigeration system, which is additionally equipped with an inner heat exchanger coupled to the compressor cylinder cap.

Figure 6 shows a partial transverse cross-sectional and schematic view of Figure 5 showing a second possible embodiment for the invention, in which the inner heat exchanger is coupled to the compressor cylinder.

Detailed Description of the invention

The invention will be described hereinbelow in more details based on the implementation examples represented in the accompanying drawings.

As illustrated in Figure 1, the compressor cooling system using a heat exchanger and a pre-condenser that is the object of this invention is comprised of: a compressor 1 associated with a pre-condenser 7, and a heat exchanger 91 located in the shell 2 of the compressor 1 and cooperative with the pre-condenser 7.

Figure 5 evinces in details that the compressor 1 is comprised of a shell 2 within which is it localized a compression cylinder 3 and the respective cap thereof 4 – except for the case of using micro compressors, which do not present inner cap – from the shell 2 being projected an inlet tube 5 from an evaporator (not shown), and an outlet tube 6 that conducts the already compressed and processed fluid into a condenser (not shown), the compressor 1

being further equipped with a tubing (or tubes) 8 and 1 of interconnection with the pre-condenser 7 wherewith it cooperates, the pre-condenser 7 being fed by a pipe 8 from the compression cylinder 3 located within the compressor 1, - as it may be better noticed from Figures 5 and 6.

According to the preferred embodiment of the present invention illustrated in Figures 1 and 2, the heat exchanger 91 consists of pipes arranged around the compressor or micro compressor 1 shell, coating it totally or partially.

According to such a construction, as the pre-condenser 7 works at the same condenser temperature as the refrigeration system does, it is assured that compressor 1 coated by the heat exchanger 91 will have a low temperature which is close to the condensation temperature, due to the evaporative heat exchange occurring in pipes 91 arranged around the compressor 1.

It is worth to notice that both the compressor cooling system and the compressor itself equipped with a cooling system may comprise an additional heat exchanger 9 positioned within the compressor 1, operating in series with the heat exchanger 91 and with the pre-condenser 7.

Such additional inner heat exchanger 9 preferably should be positioned within the shall 2 close to a hot part of the compressor 1, the inner heat exchanger 1 receiving the fluid from a pre-condenser 7 through a spring-tube 10 connected to the end of the outlet tube 11 of the pre-condenser 7, and conducts the fluid therein processed into the discharge tube 6 through an output spring-tube 12.

Figure 5 illustrates a first constructive possibility for said additional inner heat exchanger 9, whereby the same operates coupled to a compression cylinder 3 of the compressor 1.

Another embodiment of the present invention is presented in Figure 6, in which the additional inner heat exchanger 9 is coupled to the cap 4 of the compression cylinder 3, when available (noticing that micro compressors do not present an inner cap).

The system of the present invention utilizes the gas itself that is compressed and pumped by the compressor 1 in order to transport heat from inside the compressor 1 into the external environment. Generally, the gas used follows its path in the compressor 1 through the cap 4 of the compression cylinder 3, discharge filters, discharge pipe and finally the discharge tube 6 into the condenser (not shown).

When exiting the compressor 1, the compressed gas rejects heat to the external environment through the pre-condenser 7, in which the coolant is brought to the saturation zone. The coolant temperature – which now can be considered diphase – at the end of the pre-condenser 7 is the own condensation temperature of the refrigeration system. The coolant, when exiting the heat exchanger 7 with a lower energy degree (enthalpy), returns to

the compressor 1 and is conducted through the pipes 91 along all outer surface of the shell 2 of the compressor 1. The diphase coolant then exchanges sensitive and latent heat with the heated body of the compressor, reducing the temperature thereof. After accomplishing the heat exchange, this fluid is directed to the discharge tube 6 which then configures the interface of compressor 1 with the other components of the refrigeration system.

It is worth to stress that the heat exchanger 91 has the function of removing heat from hot parts of the compressor 1 and, consequently, reducing losses by overheating the gas in the suction path and compression. The use thereof also directs interconnecting the shell temperature of compressor 1 with the condensation temperature, then preventing the compressor 1 from collapsing when working at high room temperature.

Furthermore, the pre-condenser 7 allows maintaining the surface temperature of the compressor very close to the system condensation temperature, something that is hard to achieve just by means of ventilation.

In cases where the presented system utilizes an additional inner heat exchanger 9, examples of components that can be cooled include the compression cylinder 3 and cap 4 of the compression cylinder 3.

When the component to be cooled is the compression cylinder 3, as illustrated in Figure 6, the compressed fluid exits the compressor 1 through the tubing 8, rejects heat in the pre-condenser or outer heat exchanger 7, and returns to the compressor 1 through the outlet tube 11 of the pre-condenser 7.When reentering the compressor 1, the cooled fluid is conducted through a spring-tube 10 into the inner heat exchanger 9 coupled to the compression cylinder 3. When exiting the inner heat exchanger 9, the fluid is sent through another spring-tube 12 into the discharge tube 6 – which is the interface in which the compressed fluid is delivered to the condenser or the refrigeration system.

The heat exchanged in the compression cylinder 3 reduces the wall temperature of the cylinder 3 and further the fluid temperature in the suction chamber S; therefore, besides the coolant fluid entering colder the cylinder 3, the heating therein is reduced and the heat exchange to the walls during compression is maximized, providing the compression process with a greater thermodynamic efficiency.

Alternatively, as illustrated in Figure 5, the inner heat exchanger 9 can be coupled to the cap 4 (when available) of the compression cylinder 3.In this configuration, the compressed fluid exits the compressor 1 through the feed tubing (pipe) 8 of the pre-condenser 7, rejects heat in the pre-condenser 7, and returns to the compressor 1 through the tube 11. When reentering the compressor 1, the cooled fluid is conducted through a spring-tube 10 into the inner heat exchanger 9 coupled to the cap 4 of the compression cylinder 3. Analogously to what happens in the previously provided embodiment, when exiting the inner heat exchanger 9, the fluid is directed through another spring-tube 12 into

the discharge tube 6 that conducts the compressed fluid into the condenser of the refrigeration system.

The heat exchanged in the cap 4 of the cylinder 3 reduces the temperature of the compressed gas inside and in all parts of the head. Because the compressed gas is the main heat source of compressor 1, reducing the temperature thereof causes overall temperature reduction of the compressor 1 components. Thus, there is a reduction in the initial compression temperature, which results in a greater thermodynamic efficiency in the compression process.

The benefits of using compressor cooling system using the pre-condenser 7 that is the object of this invention are related to reliability and energy efficiency aspects. Regarding the reliability, the cooling of the hot parts of compressor 1 caused by the proposed system avoids critical temperatures in which the existing oil in compressor 1 could suffer from degradation and irreversible changes in the thermal-physical properties thereof.

However, the greatest benefits are associated with the increased energy efficiency of compressor 1. By transporting heat from hot parts of compressor 1 into the external environment, there is a decrease of gas overheating in the suction path, resulting in an increased density of the coolant at the beginning of the compression process and, thus, increasing the amount of mass compressed and pumped by compressor 1. Consequently, there is an increase in the performance coefficient (COP) of compressor 1.

The proposed solution also generates benefits for the operation of the refrigeration system as a whole. By adding a pre-condenser 7, there is a greater heat exchange into the external environment, resulting in lower temperature of the coolant which circulates through the discharge tube 6. Thus, with the coolant being delivered to the cooling system at a lower temperature, the condenser is oversized, resulting in the reduction of condensation system pressure.

Therefore, it is increased the efficiency of the refrigeration cycle, because it reduces the required temperature difference for the heat exchange. In addition, as the condenser becomes oversized, there is also a decrease in the pull down peak pressure, which is a situation that is most critical for compressor 1, in which the possibility of occurring tumbling due charge and temperature excess in the same.

It is worth to say that although a preferable constructive way of the present invention have been shown, it is understood that any omissions, substitutions and constructive changes can be accomplished by a person skilled in the art, without departing from the spirit and scope of the claimed protection. It is also expressly provided that all combinations of the elements that perform the same function in the substantially same way to achieve the same results are within the scope of the invention. Replacing elements of an embodiment described by other ones are also fully intended and contemplated

However, it should be understood that the description provided based on the figures above relates only to some of the embodiments that are possible for the system of the present invention, the real scope of the object of the invention being defined in the appended claims.

CLAIMS

1. A compressor cooling system CHARACTERIZED in that it comprises:

a compressor (1) comprised of a shell (2) within which it is located a compression cylinder (3), whereas from the shell (2) it is projected an inlet tube (5) from an evaporator and a discharge tube (6) which conducts the fluid into a condenser;

at least one pre-condenser (7) associated with the compressor (1), the pre-condenser (7) being fed by a tubing (8) from the compression cylinder (3) located within the compressor (1), and equipped with an outlet tube (11); and

a heat exchanger (91) internal to the outer region of the compressor (1) and cooperative with the pre-condenser (7) through the outlet tube (11) of the pre-condenser (7).

2. A cooling system according to claim 1, CHARACTERIZED in that the heat exchanger (91) comprises tubes attached around the shell (2) of the compressor (1).

3. A cooling system according to claim 1, CHARACTERIZED in that the pre-condenser (7) and the heat exchanger (91) cooperate with at least one additional inner heat exchanger (9) located in the compressor (1), the inner heat exchanger (9) cooperating with the pre-condenser (7) through a spring-tube (10) attached to the end of the outlet tube (11) of the pre-condenser (7).

4. A cooling system according to claim 3, CHARACTERIZED in that the additional inner heat exchanger (9) is located within the shell (2) and it is positioned together with a hot part of the compressor (1), the additional inner heat exchanger (9) receiving the fluid from the pre-condenser (7) through a spring-tube (10) attached to the end of the outlet tube (11) of the pre-condenser (7), and conduces the fluid therein processed into the discharge tube (6) through an outlet spring-tube (12).

5. A cooling system according to claims 3 and 4, CHARACTERIZED in that the additional inner heat exchanger (9) is coupled to the compression cylinder (3).

6. A cooling system according to claims 3, 4 and 5, CHARACTERIZED in that the additional inner heat exchanger (9) is coupled to the cap (4), when available, of the compression cylinder (3).

7. A compressor provided from a cooling system CHARACTERIZED in that it comprises:

a compressor or micro compressor (1) comprised of a shell (2) within which it is located a compression cylinder (3), whereas from the shell (2) it is projected an inlet tube (5) from an evaporator and a discharge tube (6) which conducts the fluid into a condenser;

at least one pre-condenser (7) associated with the compressor (1), the pre-condenser (7) being fed by a tubing (8) from the compression cylinder (3) located within the compressor (1), and equipped with an outlet tube (11); and

a heat exchanger (91) internal to the outer region of the compressor (1) and cooperative with the pre-condenser (7) through the outlet tube (11) of the pre-condenser (7).

8. A compressor according to claim 1, CHARACTERIZED in that it comprises at least one additional inner heat exchanger (9) located in the compressor (1), and which cooperates with the pre-condenser (7) through a spring-tube (10) attached to the end of the outlet tube (11) of the pre-condenser (7).

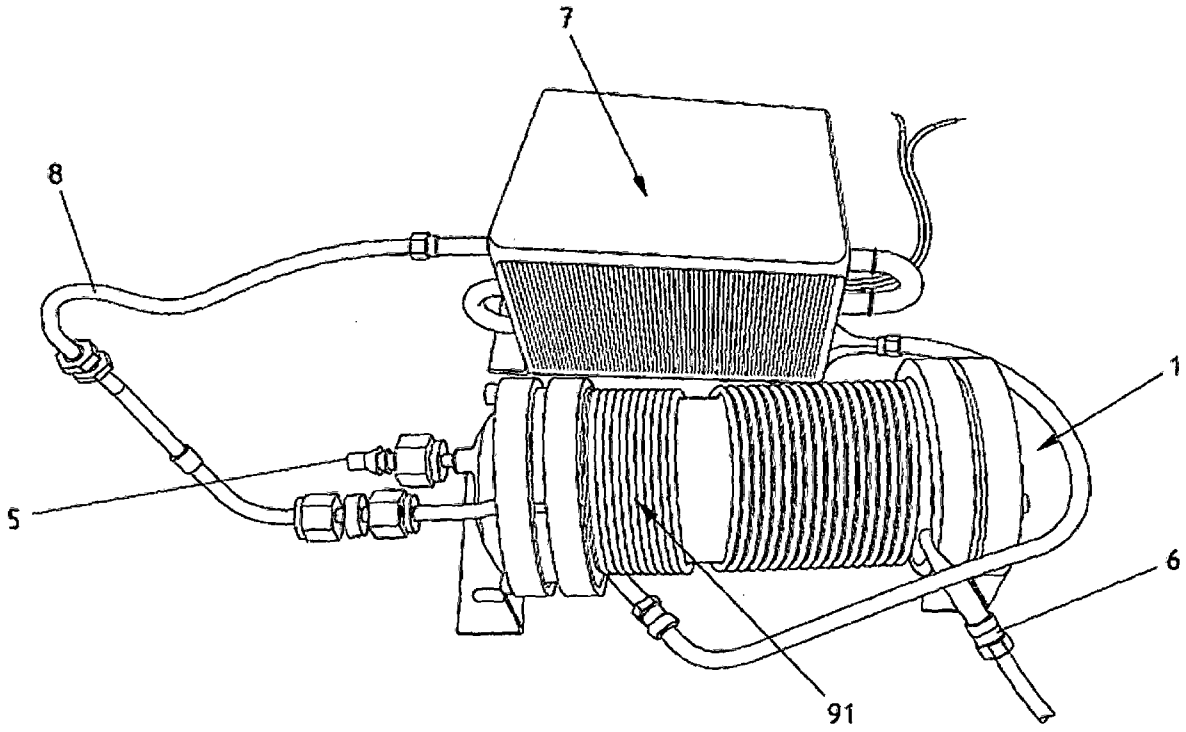

7
8
1
5
6
91

Fig. 1

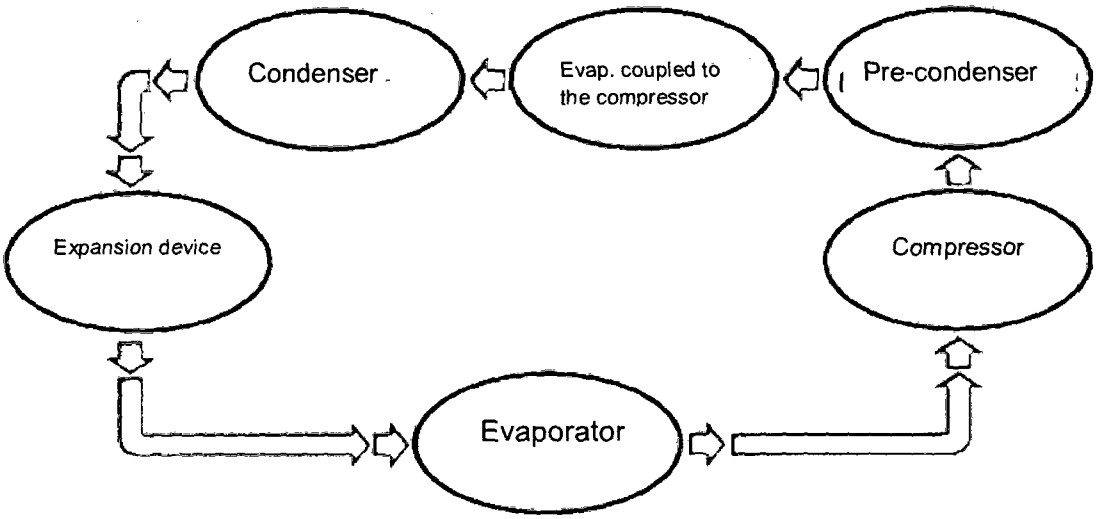

Condenser
Evap. coupled to the compressor
Pre-condenser
Expansion device
Compressor
Evaporator

Fig. 2

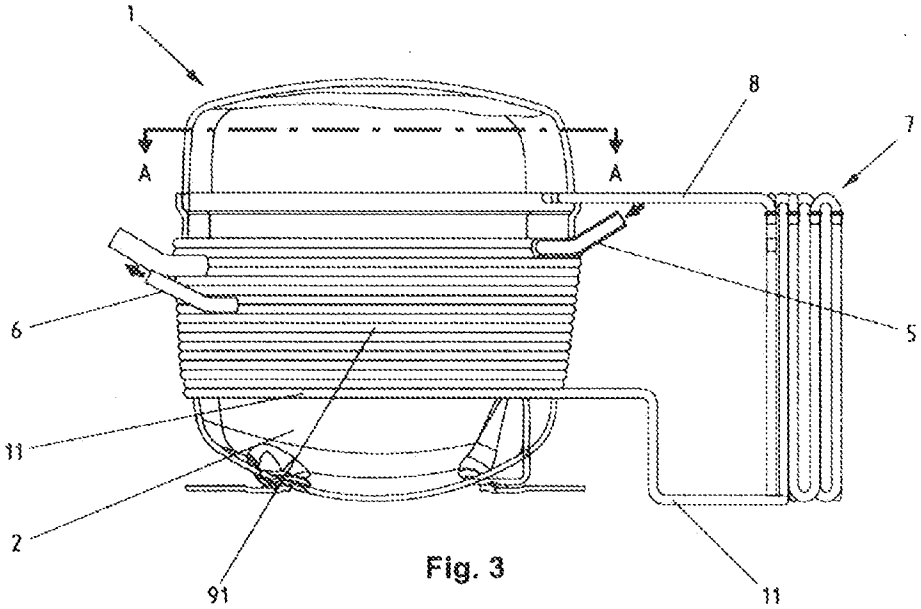


Fig. 3

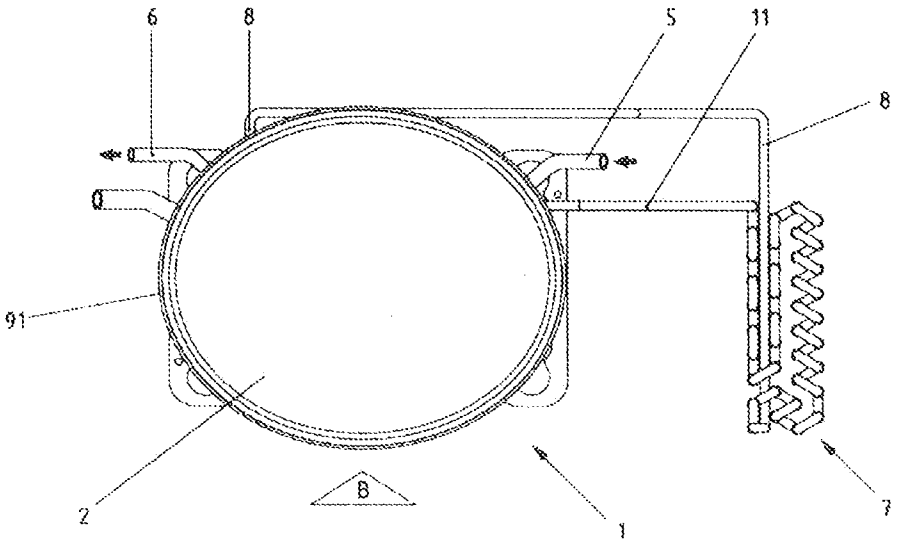
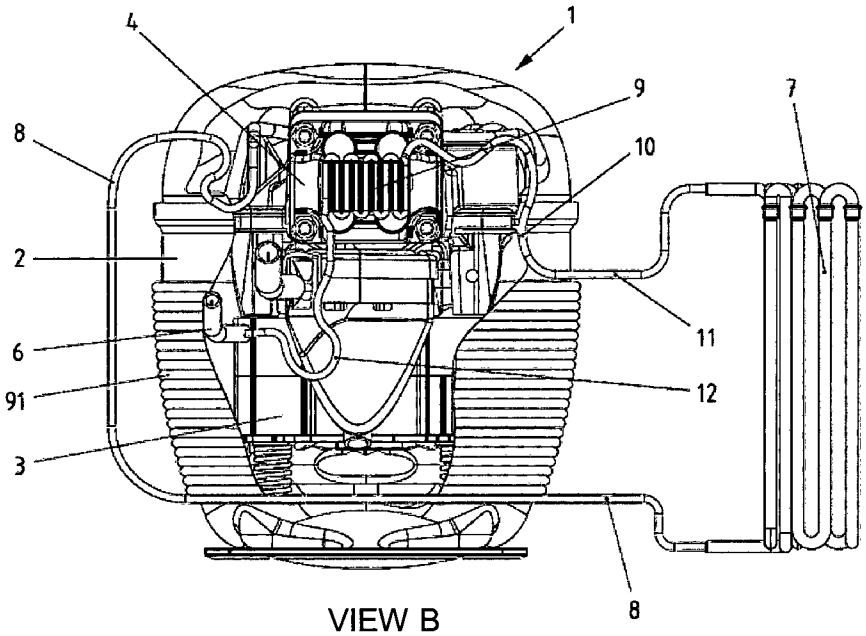
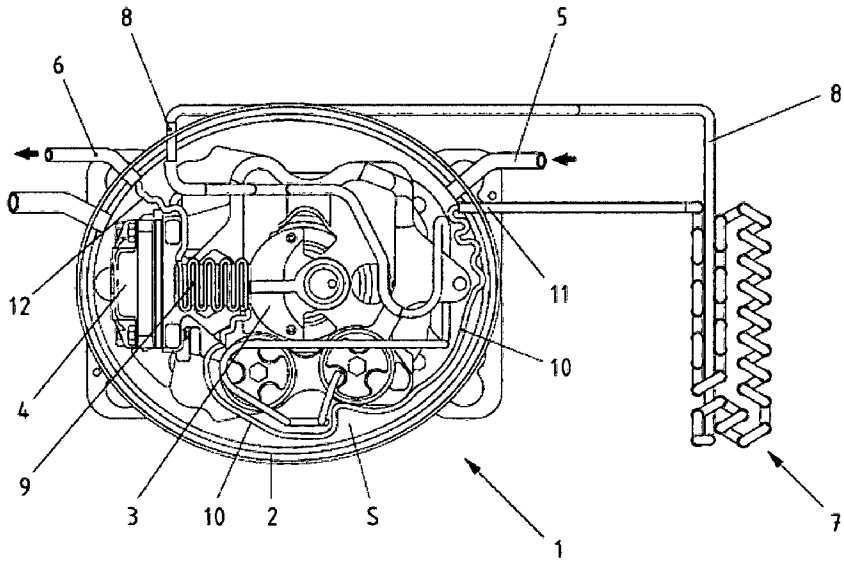


Fig. 4



VIEW B

Fig. 5



CUT AA

Fig. 6

RELATÓRIO DE PESQUISA INTERNACIONAL

Depósito internacional Nº
PCT/BR2012/000043

A. CLASSIFICAÇÃO DO OBJETO

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B. DOMINIOS ABRANGIDOS PELA PESQUISA

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F25B, F04C, F28D

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EPODOC, PAJ

C. DOCUMENTOS CONSIDERADOS RELEVANTES

Categoria*	Documentos citados, com indicação de partes relevantes, se apropriado	Relevante para as reivindicações Nº
A	BR 8207287 A (HEBERT THEODORE M [US]) 29 março 1983 (1983-03-29)	1-8
A	EP 1462739 A2 (SANYO ELECTRIC CO [JP]) 29 setembro 2004 (2004-09-29)	1-8
A	EP 0061349 A2 (HEBERT THEODORE M [US]) 29 setembro 1982 (1982-09-29)	1-8
A	EP 0652123 A1 (VECO SRL [IT]) 10 maio 1995 (1995-05-10)	1-8

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Data da conclusão da pesquisa internacional	Data do envio do relatório de pesquisa internacional:
02/05/2012	140512

Nome e endereço da ISA/**BR**	Funcionário autorizado
INPI INSTITUTO NACIONAL DA PROPRIEDADE INDUSTRIAL Rua Mayrink Veiga nº 9, 18º andar cep: 20090-050, Centro - Rio de Janeiro/RJ Nº de fax: +55 21 3037-3663	**Edimilson Junqueira Braga** Nº de telefone: +55 21 3037-3493/3742

RELATÓRIO DE PESQUISA INTERNACIONAL

Depósito internacional Nº
PCT/BR2012/000043

Categoria*	Citação do documento com indicação de partes relevantes, quando apropriado	Relevante para as reivindicações Nº
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A	US 2003192338 A1 16 outubro 2003 (2003-10-16)	1-8
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INTERNATIONAL SEARCH REPORT

International application N°
PCT/BR2012/000043

A. CLASSIFICATION OF SUBJECT MATTER

F25B6/00 (2006.01), F04C29/04 (2006.01), F28D1/04 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B, F04C, F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Banco de Patentes Brasileiro INPI-BR

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the internationa filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvius to a person skilled in the art

"&" document member ot the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02/05/2012	140512

Name and mailing address of the ISA/BR	Authorized officer
INPI INSTITUTO NACIONAL DA PROPRIEDADE INDUSTRIAL Rua Mayrink Veiga nº 9, 18º andar cep: 20090-050, Centro - Rio de Janeiro/RJ Facsimile N°: +55 21 3037-3663	**Edimilson Junqueira Braga** Telephone N°: +55 21 3037-3493/3742

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