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(71) Applicant: **Whirlpool S.A.**
04578-000 São Paulo - SP (BR)

(72) Inventors:
- **JUNIOR, Fernando Antonio Ribas**
  89219-202 Bairro Costa e Silva
  Joinville, SC (BR)
- **KREMER, Rodrigo**
  Blumenau - SC (BR)

(74) Representative: **Pulieri, Gianluca Antonio**
Jacobacci & Partners S.p.A.
Piazza della Vittoria, 11
25122 Brescia (IT)

(54) **REFRIGERATION COMPRESSOR**

(57) The present invention relates to a thermally efficient refrigeration compressor, comprising a housing which surrounds the component parts of the compressor and a heat accumulating material occupying a volume internal (4, 7, 15, 18, 23, 27) or adjacent (9, 11, 30, 32, 37) to the compressor housing. Accordingly, the present invention takes advantage of the thermodynamics existing between the compressor and the refrigeration system, achieving a reduction of the internal temperatures reliably and efficiently and consequently improving the performance of the compressor.

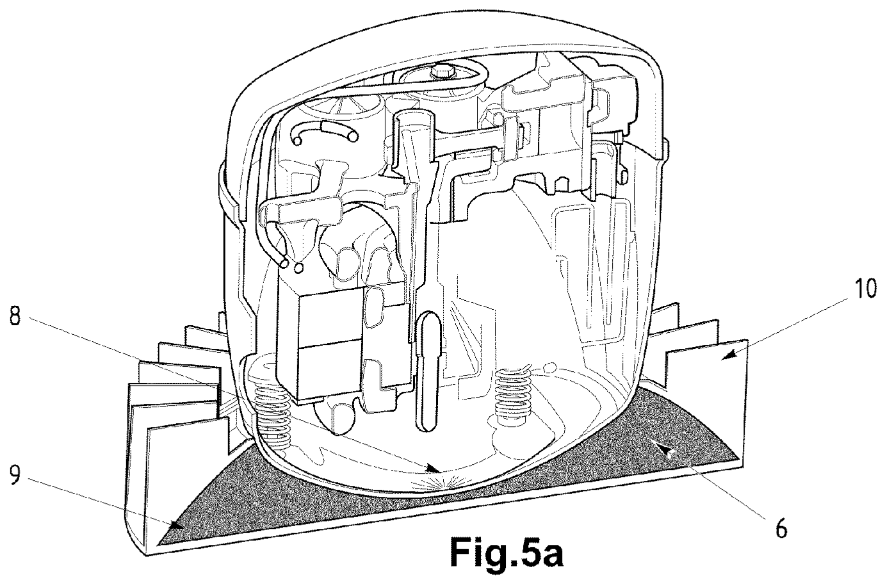

Fig.5a

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Description

Field of the Invention

[0001] The present invention relates to a refrigeration compressor and, more particularly, to a compressor whose cooling is carried out by using characteristics from its thermal transient when said compressor is applied to a refrigeration system.

Background of the Invention

[0002] A compressor has the function of increasing the pressure of a certain fluid volume to a pressure required for carrying out a refrigeration cycle. In the refrigeration industry, it is common to use hermetic compressors generally comprising a sealed housing where the compressor parts are mounted: a motor-compressor assembly comprising a cylinder block having an end closed by a cylinder head which defines a discharge chamber in communication with a compression chamber defined inside the cylinder, the compression chamber being closed by a valve plate provided between the cylinder end and the cylinder head.

[0003] During the operation of the compressor, the heat generated by compression of gases eventually heats the component parts of the compressor.

[0004] One major issue of the refrigeration industry is the performance of refrigeration compressors. Indeed, various works and studies have been made with a view to increase such performance, in particular those aiming to increase the amount of gas sucked during the suction and to reduce the power required to compress the gas.

[0005] These solutions require reducing the gas temperature during the suction (increasing its density) and reducing the temperature of the compression chamber wall in contact with the gas. In this respect, it should be understood that the development of solutions which promote the reduction of the temperature levels of the compressor directly acts upon the increase of the volumetric and electrical efficiency, the latter being a result of the thermodynamic portion (reduction of losses due to overheating and increase of the compression process efficiency).

[0006] Over the years, various thermal concepts have been employed in order to reduce the internal temperature levels of the compressor.

[0007] One of these concepts lies in insulating the discharge system, which is one of the major internal heating sources of the compressor. Solutions concerned to this kind of approach can be found in US Patent 3.926.009 and US Patent 4.371.319, which exploit the discharge insulation by applying double-wall concepts (thermal insulation by means of an enclosed space).

[0008] Patent WO 2007/068072, however, utilizes the concept of insulating the heating sources of the cylinder. According to this document, a spacing conduit is built over the valve plate and open into the inner cavity of the compressor housing, maintaining the compressor cylinder cap spaced apart from the valve plate and forming an annular plenum around the spacing conduit. This allows to reduce the heat transmission from the cylinder cap to the valve plate, which eventually reduces the heating of the cylinder block in the region of the compression chamber, increasing the efficiency of the compressor.

[0009] Another way of controlling the internal thermodynamics of the compressor is through the inclusion of heat-transfer elements, with the purpose of removing heat from the sources which have higher influence on the thermal efficiency of the compressor and transferring this heat into areas distant therefrom. In this concept, it is worth mentioning Patent WO 2007/014443, which proposes a solution for increasing the efficiency of compressors which utilizes heat tubes for removing heat from heated portions in contact with the cylinder. Said document proposes a hermetic compressor having a heat dissipation system, in which a heat energy transfer duct is coupled to the cylinder block. The duct has a heat absorption end on the cylinder and another heat release end spaced apart from the cylinder block, such that the heat generated with the coolant compression inside the cylinder is absorbed and dissipated to an area further away from the cylinder, thereby reducing the cylinder temperature and also increasing the compressor efficiency.

[0010] Another possible solution in order to reduce the temperature of the compression cylinder is to optimize the use of the lubricating oil of the compressor as a cooling means. The oil actually has the main function of lubricating the compressor gearing in order to ensure the reliability and durability of its parts. Based upon the use of oil for cylinder cooling purposes is US Patent 4,569,639, in which the inventors have proposed the use of an elongation on the shaft output and a baffle on the cylinder head, such that the oil flow which comes out from the shaft elongation is directed to the cylinder head, thereby cooling the cylinder. This cylinder elongation has a hole through which the oil is discharged horizontally towards the cylinder head baffle, while this elongation is rotated. The baffle also has a hole at the approximately same height as the height at which oil is discharged, so that the oil flows on the cylinder head and cools it.

[0011] By means of the description of the prior art set out above, it can be seen that different concepts and solutions have been applied in order to reduce the internal temperatures of the compressor, however, it should be noted that such solutions have been developed focusing on the compressor seen as a thermal device separately.

Objects of the Invention

[0012] The present invention aims to promote the cooling of the compressor by using characteristics of the thermal transient from the compressor when the same is applied to a refrigeration system.

[0013] Accordingly, the present invention takes advantage of the thermodynamics existing between the compressor and the compression system, achieving the reduction of internal temperatures reliably and efficiently and hence improving the performance of the compresor.

Summary of the Invention

[0014] The present invention achieves the above objects by means of a hermetic compressor comprising a housing which encloses the component parts of the compressor, with a heat accumulating material occupying an internal volume or adjacent to the compressor housing. The heat accumulating material acts as a thermal capacitor able to absorb high amounts of heat while the compressor is on and to reject heat while the compressor is off, in order to increase the thermal efficiency of the compressor.

[0015] In an embodiment of the invention, the heat accumulating material rejects heat at a first amount of heat while the compressor is on and a second amount of heat while the compressor is off. In this respect, the heat accumulating material can reject a minimum amount of heat while the compressor is on and a high amount of heat while de compressor is off.

[0016] It should still be noted that the heat accumulating material can absorb heat while the compressor is on and reject some from this heat to one of the components of the compressor while the compressor is off.

[0017] The heat accumulating material may be a latent heat accumulator or a sensitive heat accumulator, however, the use of a PCM (phase-change material) is particularly advantageous for the proposed inventive concept.

[0018] In this respect, it is to be noted that, for the present invention, the PCM comprises the entire material which, at a certain design temperature, starts to receive latent heat, that is, a process at a substantially constant temperature and with a high heat absorption capacity. In this respect, although a PCM material is usually defined as a material that goes through a change between the liquid phase and the solid phase, there are a few PCM materials that, instead of changing their phase, change the structure of their matter; these PCMs are called solid-solid PCMs. Thus, although a phase change is mentioned throughout the text, the PCM nomenclature also covers materials which change their structure at a certain design temperature, absorbing high heat rates.

[0019] The heat accumulating material may occupy an idle volume inside the compressor, or may even be a part of the structure from at least one of the compressor parts.

Brief Description of the Drawings

[0020] Figures show:

Figure 1 - Figure 1 shows a first embodiment of the refrigeration compressor of the present invention;

Figures 2 and 3 - Figures 2 and 3 show result graphs of a numerical simulation indicating the heat removal obtained by means of the embodiment shown in Figure 2;

Figure 4 - Figure 4 shows a second embodiment of the refrigeration compressor of the present invention;

Figures 5a to 5c - Figures 5a to 5c show a third embodiment of the refrigeration compressor of the present invention;

Figure 6 - Figure 6 shows a fourth embodiment of the refrigeration compressor of the present invention;

Figure 7 - Figure 7 shows a fifth embodiment of the refrigeration compressor of the present invention;

Figure 8 - Figure 8 shows a sixth embodiment of the refrigeration compressor of the present invention;

Figure 9 - Figure 9 shows a seventh embodiment of the refrigeration compressor of the present invention;

Figure 10 - Figure 10 shows an eighth embodiment of the refrigeration compressor of the present invention;

Figures 11 a to 11b - Figures 11a to 11b show a ninth embodiment of the refrigeration compressor of the present invention; and

Figure 12 - Figure 12 shows a tenth embodiment of the refrigeration compressor of the present invention.

Detailed Description of the Invention

[0021] In the following, the present invention will be described in detail with reference to the examples as shown in the drawings. While the detailed description uses as an example an alternative compressor for the refrigeration, it should be understood that the principles of the present invention may be applied to any type, size or arrangement of refrigeration compressor. Accordingly, the present invention may be applied to hermetic or semi-hermetic reciprocating compressors, to rotating compressors or scrolling compressors, or to any type of refrigeration compressor able to receive a volume of a heat accumulating material acting as a thermal capacitor.

[0022] When a compressor begins its operation, shortly after begins the heat generation at various components, such as the engine, the compression cylinder and the discharge area. When the compressor is seen on a thermally-stabilized regime, all the energy generated by the hot components is dissipated to the others. However, during the heating periods (when temperatures still do not rise), many of the generated energy, rather than being dissipated, is absorbed by the component itself, so as to increase its internal energy and, hence, its temperature. This ability to store energy during the transient period is directly related to the heat capacity of the respective component. Supposing a component having a heat capacity tending towards infinity, its temperature would be virtually constant, as too much energy would be needed in order to increase it. In this optimum scenario, the component would virtually work at the initial temperature, which would lead the dissipated heat to zero, without other components being heated.

[0023] When observing a compressor operating on a stabilized temperature regime (a substantially long uninterrupted working time), the heat capacity does not play any role, as it only serves to change the heating time of the components.

[0024] However, when observing the application of the compressor to the refrigeration system, due to the dynamic characteristics of this system, the compressor does not work uninterruptedly. It goes through a cycling process, wherein in some cases, it remains longer in the off state than in the on state. Hence, the temperatures of the internal components of the compressor during its operation on the refrigeration system are not stabilized.

[0025] The present invention is based on the use of elements which are able to absorb the heat from hot components during the compressor operation time. The use of these elements has a direct impact on the temperature reduction of these components, increasing the thermodynamic efficiency of the compressor. In fact, the present invention discloses a thermal managing mechanism for compressors which makes use of the thermal behavior of its components when on a refrigeration system, thereby reducing the heating of the compressor during its working period.

[0026] Thus, in order that the concept proposed by the present invention may be applied efficiently, it is necessary to put it into the context of application to refrigeration systems.

[0027] Supposing a compressor having high heat content capacity and working uninterruptedly, the temperature of these elements would continually increase and a temperature reduction would not be achieved. However, upon observing the actual working cycle of a compressor in the refrigeration system, there is a long time period during which the compressor is off, and in this time period, enough time may be elapsed so that the energy absorbed by these high heat content elements is lost to the compressor environment and therefrom to the external environment.

[0028] Thus, taking into account the actual working cycle of a compressor in the refrigeration cycle, it can be seen that a closed cycle can be achieved, wherein the thermal energy absorbed by the high heat capacity elements is rejected before a new on-period occurs.

[0029] The term "high heat content elements" as used herein means heat absorbing elements, wherein a wide range of materials could be used for manufacturing such elements.

[0030] Similarly, although the term "elements" is used herein, the present invention is based on the use of heat accumulating materials occupying an internal volume or adjacent to the compressor housing, and is not limited to a "self-contained element" to be inserted into the internal space of the compressor.

[0031] An inherent advantage related to the use of phase-change heat absorbing elements lies in the fact that they work with a substantially constant temperature during the heat absorbing process (which boosts this absorption and also prevents these components from heating the other components). In addition, once the working temperature from these components is set (by selecting a material having a desired phase-change temperature), it is possible to adjust the working temperature from the internal components at an optimum point based on the system dynamics, thereby achieving higher control over the solution.

[0032] Accordingly, it is desirable to use a heat absorbing material which works at a constant temperature that may be previously set.

[0033] In view of the needs and advantages shown above, in a preferred embodiment of the present invention, a material which goes through phase change during the heat absorbing process (latent heat accumulator) is used. These materials, known as PCMs (Phase Change Materials), comprise paraffins, special-purpose greases, among other components, which may be manufactured so as to change their phase at different design temperatures. It is to be understood, however, that while most of the phase changes are solid-solid, structural changes from matter (solid-solid PCM) also able to absorb high amounts of heat at a design temperature are also included within the scope of the present invention.

[0034] In addition to being able to control the phase-change temperature through the composition of the employed material, this process provides a high energy absorption capacity with a substantially constant temperature, as opposed to a sensitive heat accumulation process, which entails significant temperature variations.

[0035] Of course, although the preferred embodiment of the present invention employs PCMs, other high specific heat materials may also be used, since they are also able to absorb heat with a slow increase in their temperature (sensitive heat accumulators). One example of a high specific heat material which may be applied according to the advantages provided by the present invention is water.

[0036] In particular, it should be understood that the present invention is based on the inclusion of a heat accumulating material occupying an internal volume or adjacent to the compressor housing. Thus, this material (whether it is a PCM or any other high heat content material) may be employed in many locations in the compressor, wherein this location should be determined according to its efficacy in reducing the temperatures from the internal components, the available space for allocating these components, the involved costs, and the technological challenges to that end.

[0037] According to the basic principles of the present invention, the heat accumulating material acts as a thermal capacitor, absorbing high amounts of heat while the compressor is on and rejecting this heat while the compressor is off.

[0038] The dynamic behavior of this "thermal capacitor" may take two different forms: it may absorb high amounts of heat, rejecting as little as possible while the compressor is on and then reject heat while in the off state, or it may absorb high amounts of heat during the on state and keep an uniform heat removal rate during on and off times. In this latter form, although there is a heat rejection while the compressor is on, the energy removal generated is much higher during this same period, contributing to the lowering of the thermal profile.

[0039] The presence of one or another dynamic characteristic will depend on heat input and output boundary conditions (convection coefficients and temperature potential), and will vary according to the design.

[0040] Figure 1 shows a first embodiment of the present invention, where the heat accumulating material is located in a volume formed between a casing which surrounds the cylinder cap and the compressor cylinder cap.

[0041] This region of the cylinder cap is critical for the compressor, since various gas communications flow therethrough. The suction gas, in order to get into the cylinder, passes over the region of the suction muffler which is in contact with the cylinder cap. The high temperature gas from the compression is also discharged to the cap, from where it follows to the remainder of the discharge system. Thus, by removing the gas heat on the cylinder cap and hence lowering the temperature thereof, one may observe a lower heating on the suction muffler output and the heat dissipation throughout the discharge system downstream the cap is reduced, since the temperature potential between the gas itself and the internal environment of the compressor is decreased. In addition, the cap, upon cooling, absorbs more heat from the cylinder, promoting the thermodynamic efficiency of the compressor.

[0042] In figure 1, a portion of a compressor is shown, along with the casing 1 which surrounds the cap 2 of the cylinder 3. Inside the space formed between the casing 1 and the cap 2, a volume 4 is created, where the heat accumulating material is stored (as previously mentioned, this material could be a grease, a paraffin, another type of PCM, or even another material having a high heat capacity).

[0043] As may be seen in figure 1, the casing 1 may further comprise outer fins 5. The choice of adding the 5 results from the system thermodynamics itself: The entrance of heat into this system is very intense, as the gas from the cylinder cap strikes against the walls of the respective cap at high speed, giving rise to a high heat transfer rate. In order to reject the heat from the internal environment of the compressor, however, gas speeds are lower, especially while the compressor is off, when the gas in the internal environment only moves by natural convection. In order to be able to reject all the heat absorbed at high rates during the time period in which the compressor is on, the external heat transfer area is increased by adding fins 5. Optionally, a dark painting may also be chosen for the casing 1 and the fins 5, so as to increase the heat transfer by radiation.

[0044] It should be noted, however, that the inclusion of fins 5 is only a preferred embodiment, and is not required in order to achieve the advantages obtained by adding a heat accumulating material into the volume formed between the cylinder cap 2 and the casing 1.

[0045] In the same manner, the fins could be inner fins, adjacent to the heat accumulating material, which would facilitate the flow of heat along its structure. As some materials exhibit low thermal conductivity, the inclusion of fins allows to maximize the heat flow along the material. In addition, other solutions designed for maximizing the heat transfer along the heat accumulating material could also be used within the scope of the present invention, such as, for example, porous metallic matrices injected along with the heat accumulator.

[0046] In order to prove the efficacy of the present invention, a numeric simulation was performed, indicating the heat removal potential of the cylinder cap of a compressor, using the concept of the example embodiment shown in figure 1 (in which the heat accumulating material is located in a volume formed between a casing which encloses the cylinder cap and the compressor cylinder cap.)

[0047] Figures 2 and 3 show graphs illustrating the results from the simulation performed (in figures, line A corresponds to the embodiment with the volume of heat accumulating material and line B corresponds to a conventional compressor).

[0048] Figure 2 shows a graph illustrating the heat rejected from the cylinder cap into the internal environment of the compressor. Although it seems that the cap having the heat accumulating material dissipates more heat than the normal cap, it should be analyzed the heat removed from the refrigerant gas inside the cylinder cap. This analysis, shown in figure 3, shows that while the compressor is on (ON period in the figure) the heat accumulating element dissipates about 3W more than the normal cap, however, during this same period, the system removes extra 8 W from the gas. Thus, on the overall balance, a gas cooling is achieved and, hence, the thermal profile of the compressor is lowered, which contributes to increasing the energetic efficiency.

[0049] The graphs from figures 2 and 3 may be interpreted according to the following analysis of the system behavior: The heat enters the heat accumulating material from a gas at high speed and temperature. In order to discharge the same amount of heat to the internal environment of the compressor, however, more time is required, since it is discharged into a gas at a lower speed (low convection coefficient) and with a lower temperature potential. Accordingly, it is required more than the time period during which the compressor is on in order to close the heat charge and discharge time, and hence, this process ends up by being a continuous discharge process, but having a much more intense heat gas absorption during the period in which the compressor is on (which period should be taken into account for purposes of the present invention).

[0050] Figure 4 shows a second example embodiment of the present invention. In this embodiment, the heat accumulating material is provided into the discharge system of the compressor.

[0051] As can be seen in figure 4, in this embodiment, an enclosure 6 of heat accumulating material is added into a discharge volume V downstream the cylinder cap 2. Thus, a concentric casing 7 is welded to the discharge tube, creating a hermetic volume, in which the heat accumulating material is deposited. It should be noted that the main advantage of this embodiment lies on its simple construction itself.

[0052] One of the benefits from adding the heat accumulating material onto the discharge way, whether on the cylinder cap or any other component downstream, is that, depending on the design optimization, upon achieving a substantially reduced gas temperature on the compressor outlet, the latter will have to reject less heat on the system condenser, which involves lowering the condensation temperature (and pressure), and hence, the cycle efficiency will be increased as a whole, as the difference between the temperatures of the heated source (condenser) and the cold source (evaporator) is reduced.

[0053] Similarly to what was shown above with respect to the first embodiment, this embodiment shown in figure 4 may include fins 5, preferably arranged externally and attached to the concentric casing 7. The presence of these fins increases the external area, and consequently, aids in removing heat while the compressor is off.

[0054] As mentioned with respect to the first embodiment of the invention, internal fins could be provided in order to maximize the heat transfer along the heat accumulator matrix.

[0055] Figures 5a, 5b, and 5c show a third embodiment of the present invention, wherein the heat accumulating material is employed externally to the region of the compressor crankcase 8.

[0056] As shown in figure 5a, in this embodiment a volume of phase-change material 6 is provided on the lower portion of the compressor in a volume separate from the internal environment of the compressor. This volume may assume the form of a reservoir 9 to be closed by means of welding, gluing, or other forms that can assure the airtightness of the subject region, so as to ensure the sealing between the internal compressor volume and the heat accumulator volume.

[0057] As shown in figures 5a to 5b, this reservoir 9 may include metal fins 10 in the region of the heat accumulator volume, in order to facilitate the heat transfer from the heat accumulating material into the external environment, thereby maximizing the efficiency of the heat discharge process.

[0058] The embodiment shown in figures 5a-5c has two significant advantages: Once the oil is cooled, since it is at a lower temperature, the oil removes heat from the other components of the compressor as it passes along them, causing these components to be cooled (including the cylinder region and the suction filter). If the compressor exhibits a construction where the cylinder and the cylinder head are located on the region next to the oil, the effects resulting from the inclusion of this type of accumulator into this region are even greater, since the cooling of the oil and the adjacent areas more effectively reaches the compression cylinder.

[0059] In addition, during the operations of the compressor in the cooling system, the compressor components, in this case, the oil, may go through fairly differentiated temperature regimes. On a pull-down test (critical scenario), the oil is very hot, and on a power consumption test, it is much cooler. Thus, the oil viscosity highly differs between the two regimes, which affects the entire bearing design and does not allow these components to be accurately optimized. The inclusion of phase-change heat accumulators at a certain temperature allows them to be adjusted so as to remove more heat on high temperature regimes and, thus, reduce the oil temperature on critical regimes, such as pull-down, thus bringing the temperatures from both pull-down and power consumption operation modes closer to each other. Consequently, oil viscosity variations in the application are reduced, allowing for a more optimized bearing design, which leads to increased energetic efficiency of the compressor.

[0060] A fourth illustrative embodiment of the present invention involves adding the heat accumulating material into a region on the outer portion of the compressor housing, said region being generated in association with the compressor base plate.

[0061] This embodiment, shown in Figure 6, comprises providing an enclosure 11 formed in association with the base plate 12 of the compressor at the portion adjacent to the outer portion of the compressor crankcase region 8.

[0062] Thus, the body of the enclosure 11 utilizes part of the base plate 12, thereby facilitating the assembly process.

[0063] Similarly to what was discussed with respect to the other embodiments, the outer wall of the enclosure 11 may be provided with fins 13, in order to facilitate the heat transfer and to maximize the efficiency of the process of dissipating heat to the external environment.

[0064] A fifth illustrative embodiment of the present invention comprises adding a heat accumulating material into an enclosure 14 formed in the region of the compressor crankcase 8, wherein the enclosure 14 is internal to the compressor.

[0065] This embodiment, shown in figure 7, comprises an enclosure partially defined by the inner wall of the housing and by a further wall 15, wherein the enclosure 14 thus defined is located in a region immersed into the compressor oil.

[0066] Similarly to what was discussed with respect to the other embodiments, the wall of the enclosure 14 may be provided with fins 16, in order to facilitate the heat transfer and to maximize the efficiency of the process.

[0067] As previously shown with respect to the third illustrative embodiment of the present invention, the use of heat accumulator for oil in the crankcase region may bring two important advantages, according to the aim of this application:

By promoting the cooling of the oil during the current compressor operation, the heat accumulating material enhances the amount of heat which it removes from the components, allowing the temperature levels of the compressor to be reduced and consequently increasing the energetic and volumetric efficiency.

[0068] By promoting the cooling of the oil having a focus on the critical application conditions, it is possible to reduce the temperature differences from the critical condition to the nominal application condition, thereby facilitating the optimizing and design of the apparatus (since viscosity variances are reduced.)

[0069] The provision of the heat accumulator on the crankcase region has the advantage of relying on the whole base region of the housing together with the base plate as heat dissipating elements for the heat stored during the compressor operation time, which makes the discharge process of this thermal capacitor easier to be implemented.

[0070] In this respect, the provision of a latent heat accumulator (particularly a phase change material - PCM) is highly advantageous in this scenario, since it could be employed not only reduce suction chamber and cylinder temperatures, but also to control and modulate the oil temperature. By designing the application with a focus on the crankcase region of the compressor, it becomes possible to store the heat energy from the oil on a preset temperature range in order to prevent overheating at extreme conditions (through the PCM heat absorption), thus bringing the viscosity levels of the application closer to those of extreme scenarios.

[0071] This result has a direct impact on the reduction of design constraints (the requirement of simultaneously meeting the critical and nominal conditions of the application), thus facilitating the development of new mechanisms with higher energy efficiency.

[0072] In this respect, it should be noted that the embodiments of the invention shown in figures 5 and 6, where the heat accumulating material is provided on a region close to the crankcase, exhibit advantages similar to those described above with respect to the embodiment of figure 7.

[0073] Figure 8 shows a sixth illustrative embodiment of the present invention, where the heat accumulating material is added to the suction muffler.

[0074] As can be seen from this figure, in this embodiment, an enclosure having a heat accumulating material 18 is provided on the suction tube 19 of the suction filter 20 of the compressor.

[0075] Thus, the heat accumulating material acts on the cooling of the gas when it passes through the tube 19, reducing its temperature on the cylinder entrance, and consequently increasing the energetic and volumetric efficiency.

[0076] Where the heat accumulating material is a latent heat accumulator (PCM), the phase change temperature should be lower than the gas temperature at the region of the tube, such as to generate a temperature potential which favors heat removal.

[0077] It should be noted that the heat accumulating material could be a sensitive heat accumulator (e.g., water or oil), wherein, in this case, it must be carefully designed, taking into account temperature variations both in the absorption process and in the heat dissipation process by the heat accumulating matrix. Preferably, the heat accumulator is provided on the suction muffler in view of the system characteristics: a major cause of energetic inefficiency in compressors is the gas overheating during suction, and is based on the unnecessary heating of gas along the way from the suction pipe to the compression cylinder. Substantial efficiency gains were observed in the past by changing metal suction filters for plastic suction filters. Nowadays, virtually every compressor for application in domestic refrigeration employs plastic filters, but nevertheless the temperature of gas at the cylinder entrance is around 20 to 30°C, which is higher than the temperature at the compressor entrance.

[0078] Thus, in the sixth embodiment of the present invention, the heat accumulating material acts on the cooling of the gas when it passes through the tube 19, reducing its temperature on the cylinder entrance, and consequently increasing the energetic and volumetric efficiency.

[0079] Where a latent heat accumulator (PCM) is used, the phase change temperature should be lower than the gas temperature at the region of the tube, such as to generate a temperature potential which favors heat removal. One may choose a sensitive heat accumulator (e.g., water or oil), however, this design should be carefully planned in order to ensure the thermal discharge of the heat accumulator while the compressor is off.

[0080] Similarly to what was said with respect to the other embodiments of the present invention, the fins as seen in the drawings are only an illustrative embodiment, and whether they should be provided depends upon the application design for the heat accumulator. The provision of such fins aims at enhancing gas heat removal (by increasing its area) from the tube to the region of the heat accumulator.

[0081] Mixed solutions from materials for the suction filter and heat accumulators could be devised in order to maximize the performance of heat removal. It could be considered, for example, the use of a suction cap (which contains, for said design, the suction tube) from metal material (e.g., steel or aluminum), allowing for a lower thermal resistance of the gas against the PCM.

[0082] Figure 9 shows a seventh illustrative embodiment of the present invention, wherein the heat accumulating material is provided at the region of the compressor cylinder 3.

[0083] In this embodiment, holding channels 23 for the heat accumulating material 24 are formed along the cylinder. As shown in the figure, the channels 23 can be closed by the seal of the cylinder head 22 itself. However, the channels can be alternatively closed by means of welding, gluing, or any other suitable means.

[0084] Where the heat accumulating material is a latent heat accumulator (PCM), it is possible to control the characteristics of the material so that it acts on heat removal during the regular compressor operation time, thereby reducing the temperature of the cylinder, and, hence, of the gas therein. This reduction has a direct impact on the increase of the energetic efficiency of the compressor. For example: if the cylinder works nominally at a temperature of 90°C, this material could be designed such that it would change its phase at 60°C and enhance heat transfer, so that the new cylinder temperature is lower than 90°C, consequently leading to an increase on the thermodynamic efficiency.

[0085] Another possible application for the region of the cylinder would be the addition of a material having a phase change temperature higher than the continuous operation temperature, yet lower than in critical operation periods, such as to adjust the proper operation of the heat accumulator to extreme working regimes, such as high thermal stress regimes. This would advantageously give robustness to the product, since the lubrication and bearing process is improved by allowing the cylinder 3, the piston 21, and the oil at this region to work at a cooler temperature in these regimes. In addition, the efficiency could be increased indirectly, since by having a higher robustness at extreme condition, some of the design criteria may be relaxed (such as, for example, reducing the oil viscosity, since, at high temperatures, the PCM ensures a proper viscosity), allowing to improve the compressor operation at normal operation conditions.

[0086] Similarly to the other embodiments described above, the presence of fins is optional and depends on the design concerned. In said embodiment shown in the figure, fins 25 were provided with a view to facilitate the thermal discharge by increasing the exchange area of the heat accumulating matrix (which may be latent - PCM - or sensitive) as the thermal charging, due to the high convection inside the cylinder, is more intense than at the side of the internal environment of the compressor.

[0087] Figure 10 shows an eighth illustrative embodiment of the present invention, wherein the heat accumulating material is included in an enclosure or cylinder jacket 27 of the electric motor of the compressor (see figure 10, where numeral 26 denotes the rotor and numeral 26 the stator.)

[0088] In the illustrated embodiment, this cylinder jacket 27 is fitted by interference into the outer region of the stator 26, such as to reduce the thermal resistances inherent to this kind of assembly to a minimum.

[0089] Thus, as the motor heats, and upon reaching a certain working temperature specified in the application of the heat accumulator, the latter would absorb the heat dissipated by the motor, causing it to work at lower temperature than it would without the presence of the heat accumulator.

[0090] In addition to the cooling of the motor itself, the presence of the heat accumulator prevents the heat dissipated into this component to from escaping to the internal environment of the compressor, resulting in reduction of the cavity temperature and indirectly of energy losses due to overheating of gas.

[0091] Another advantage from this solution is to be able to ensure the reliability of compressors working at a critical temperature regime, such as, for example, compressors having low energy efficiency, thus reducing the use of steel and particularly copper (low-cost compressors).

[0092] In the embodiment shown in the figure, dissipating fins were not included; however, such fins could be added within the inventive concept of the present invention.

[0093] Figures 11a and 11b show a ninth illustrative embodiment of the present invention, wherein the heat accumulating material is applied to the suction tube 28, the discharge tube 29, or to both suction and discharge tubes 28, 29 (tubes).

[0094] The application of heat accumulators to the suction tube gives rise to at least two advantages. The first is concerned with the overheating of the suction gas still before entering the compressor, due to the heating of this tube by the housing, which is at a higher temperature. This flow of heat, upon going through the tube, finds lower resistance on the suction gas, which exhibits a heat transfer coefficient much higher than the external side, since the latter is generally characterized as natural convection. The addition of the heat accumulating material into an enclosure 30 around the suction tube 28 is intended to create a preferential passageway for the flow of heat coming from the housing, different from the suction gas. Accordingly, the addition of fins 31 can increase the exchange area for the heat accumulator.

[0095] Another advantage from this application lies in creating a barrier for the heat coming from the discharge tube 29, which is much hotter than the suction tube 28 and the housing itself. In some compressors, due to design requirements, the suction tube 28 and the discharge tube are very close to each other 29 (see, for example, the illustrated example embodiment). Accordingly, a thermal short-circuit should be expected, since there is a high temperature gradient between the suction and discharge gases. However, the presence of this heat accumulating element also acts by creating a preferential passageway for the heat coming from this component.

[0096] This same effect is desired when this heat accumulator 32 is applied to the discharge tube 29, forming a passageway for the preferential heat other than the one that carries this heat energy towards the suction area. In the same manner, the presence of fins 33 plays the role of facilitating this heat transference into the heat accumulating matrix.

[0097] Another advantage inherent to the application of the heat accumulator 32 to the discharge tube 29 is the temperature reduction of the discharge gas, since the heat dissipation for this accumulator is enhanced. As the discharge temperature is reduced, there may be indirect efficiency gains due to a reduced need of exchanging this heat on the condenser. As a consequence from this reduction on the heat to be exchanged on the condenser, it could have its size reduced (cost reduction) or, while maintaining the size of the condenser, the pressure and the saturation temperature therein is reduced, increasing the efficiency of the thermodynamic cycle.

[0098] As further possible embodiments, the enclosure for the heat accumulator could be made from metal and/or plastic, wherein when it is made from metal, the latter could be welded to the housing and the tube. In the case of plastic, gluing would be the first feasible choice.

[0099] Figure 12 shows a tenth illustrative embodiment of the present invention, wherein the heat accumulating material is applied to the top 35 of the compressor housing.

[0100] This, in the illustrated embodiment, a preferably metallic plate 36 is laid over the compressor cap, said components being joined by any suitable means (e.g., welding or gluing), ensuring the formation of a hermetic enclosure for housing the heat accumulating material 37.

[0101] As a result from the application onto this area, a temperature level lower than the nominal housing is achieved, absorbing more heat from the internal environment, reducing the internal temperature and accordingly the losses due to overheating of gas during the suction process.

[0102] As mentioned with respect to the other illustrated embodiments, the plate 36 may comprise fins 38 intended to increase the heat transfer area.

[0103] It should be understood that the description shown in connection to the figures above relates to possible embodiments for the refrigeration compressor of the present invention only, and that the actual scope thereof is as defined in the attached claims.

[0104] In this respect, it should be understood that the inventive concept underlying the present invention lies in taking advantage from the thermodynamics existing between the compressor and the refrigeration system in order to achieve a reduction on the internal compressor temperatures reliably and efficiently and, consequently, to increase the performance of the compressor.

[0105] This inventive concept is implemented by means of a refrigeration compressor comprising a heat accumulating material which acts as a thermal capacitor, so as to increase the thermal efficiency of the compressor.

[0106] Although any other kind of heat accumulating material (e.g., a latent heat accumulator or a sensitive heat accumulator) could be used within the scope of the present invention, the above description clearly shows that the present invention is particularly efficient with the use of a latent heat accumulator as a phase-change material (PCM).

[0107] The arrangement of the heat accumulating material and the means of application thereof to the construction of the compressor are dependant on the compressor design, and the embodiments illustrated in the detailed description are merely examples of possible embodiments.

[0108] In this respect, the figures show embodiments in which the heat accumulating material (preferably, a PCM) is applied to an idle volume inside the compressor housing - whether in an enclosure specifically designed to that purpose, or in a space formed between components of the compressor, or even in enclosed spaces formed inside the components of the compressor, or a volume externally adjacent to the compressor housing. It should be noted, however, that the present invention is not limited to the embodiments described herein.

[0109] For example, the present invention, rather than using a volume created between two plates, for example, could use an elastic material having a PCM therein (a rubber sheet), wherein said material could be attached to the compressor housing by means of glue or other adhesion means. This variant would allow the PCM material to be changed over the time.

[0110] In addition, the heat accumulating material (preferably a PCM) could, for example, be used directly in the manufacturing of one of the compressor components or even in the compressor housing.

[0111] In a similar way, the fins provided by the described embodiments could be external, as shown in the figures, or internal, adjacent to the heat accumulating material, in order to facilitate the flow of heat along its structure. As mentioned throughout the text, the addition of fins allows to maximize the flow of heat along the material. In this respect, it should be noted that other solutions for maximizing the heat transfer along the heat accumulating material could also be used within the scope of the present invention, such as, for example, porous metallic matrices injected along with the heat accumulator.

[0112] Although the present invention may use any kind of heat accumulator material, the following examples of PCM materials which could be used within the scope of the present invention are listed for informative purposes: models RT52 and RT65 available from Rubitherm Technologies GmbH, models Plus Ice - S58 and S72 (PCM solutions based on hydrated salt) and models Plus Ice A55, A62 and A70 (organic base PCM solutions) available from Change Material Products Limited, and models Climsel C58 and Climsel C70 available from Climator Sweden AB.

Claims

1. A refrigeration compressor comprising a housing which surrounds the component parts of said compressor, **CHARACTERIZED by** comprising a heat accumulating material acting as a thermal capacitor able to absorb high amounts of heat while the compressor is on and to reject heat while the compressor is off, so as to increase the thermal efficiency of the compressor.

2. Compressor, according to claim 1, **CHARACTERIZED in that** the heat accumulating material rejects a first amount of heat while the compressor is on and a second amount of heat while the compressor is off.

3. Compressor, according to claim 2, **CHARACTERIZED in that** the heat accumulating material rejects a minimum amount of heat while the compressor is on and a high amount of heat while the compressor is off.

4. Compressor, according to any one of claims 1, 2, or 3, **CHARACTERIZED in that** the heat accumulating material absorbs heat while the compressor is on and rejects part from this heat to one of the compressor components while the compressor is off.

5. Compressor, according to any one of claims 1 to 4, **CHARACTERIZED in that** the heat accumulating material is a latent heat accumulator.

6. Compressor, according to any one of claims 1 to 4, **CHARACTERIZED in that** the heat accumulating material is a sensitive heat accumulator.

7. Compressor, according to any one of claims 1 to 6, **CHARACTERIZED in that** the heat accumulating material takes up an volume which is internal (4, 7, 15, 18, 23, 27) or adjacent (9, 11, 30, 32, 37) to the compressor housing.

8. Compressor, according to claim 7, **CHARACTERIZED in that** the heat accumulating material takes up an idle volume in the interior of the compressor.

9. Compressor, according to claim 7, **CHARACTERIZED in that** the heat accumulating material is part of the structure of at least one of the compressor parts.

10. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material is arranged in a volume (4) formed between a casing (1) which surrounds the cap (1) of the compressor cylinder (3) and the cap (2) of the compressor cylinder (3).

11. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material takes up a hermetic volume (6) formed by a casing (7) substantially concentric to the compressor discharge tube.

12. Compressor, according to claim 7, **CHARACTERIZED in that** the heat accumulating material is arranged in a reservoir (9) adjacent to the lower portion of the compressor.

13. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material is arranged in an enclosure (11) formed in association with a base plate (12) of the compressor, said enclosure (11) being external to the compressor and being at least partially formed by a portion of the base plate (12).

14. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material is arranged in an enclosure (14) formed in the internal area of a compressor crankcase (8), wherein said enclosure (14) is defined between by an inner wall of the compressor housing and a further wall (15).

15. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material is arranged in an enclosure (18) provided in a suction tube (10) of a suction filter (20) of the compressor.

16. Compressor, according to claim 8, **CHARACTERIZED in that** the heat accumulating material is arranged in a cylinder jacket (27) formed in the electric motor of the compressor.

17. Compressor, according to claim 7, **CHARACTERIZED in that** the heat accumulating material is arranged in a hermetic enclosure (37) formed by the compressor top wall and a further plate (36).

18. Compressor, according to claim 9, **CHARACTERIZED in that** the heat accumulating material is provided in retention channels (23) formed along a cylinder of the compressor.

19. Compressor, according to claim 9, **CHARACTERIZED in that** the heat accumulating material is applied to a suction tube (28) of the compressor.

20. Compressor, according to any of claims 9 or 10, **CHARACTERIZED in that** the heat accumulating material is applied to a discharge tube (29) of the compressor.

21. Compressor, according to any one of claims 1 to 20, **CHARACTERIZED in that** the heat accumulating material has inner fins in order to maximize the flow

of heat along the material.

22. Compressor, according to any one of claims 1 to 20, **CHARACTERIZED in that** the region which surrounds the heat accumulating material has outer fins in order to maximize the transfer of heat with the external region.

23. Refrigeration compressor comprising a housing which surrounds the component parts of said compressor, **CHARACTERIZED by** comprising a phase-change material (PCM) occupying a volume internal (4, 7, 15, 18, 23, 27) or adjacent (9, 11, 30, 32, 37) to the compressor housing, said phase-change material (PCM) acting as a thermal capacitor able to absorb high amounts of heat while the compressor is on and to reject heat while the compressor is off, so as to increase the thermal efficiency of the compressor.

24. Compressor, according to claim 23, **CHARACTERIZED in that** the phase-change material (PCM) takes up an idle volume in the interior of the compressor.

25. Compressor, according to any of claims 23 or 24, **CHARACTERIZED in that** the phase-change material (PCM) is part of the structure of at least one of the compressor parts.

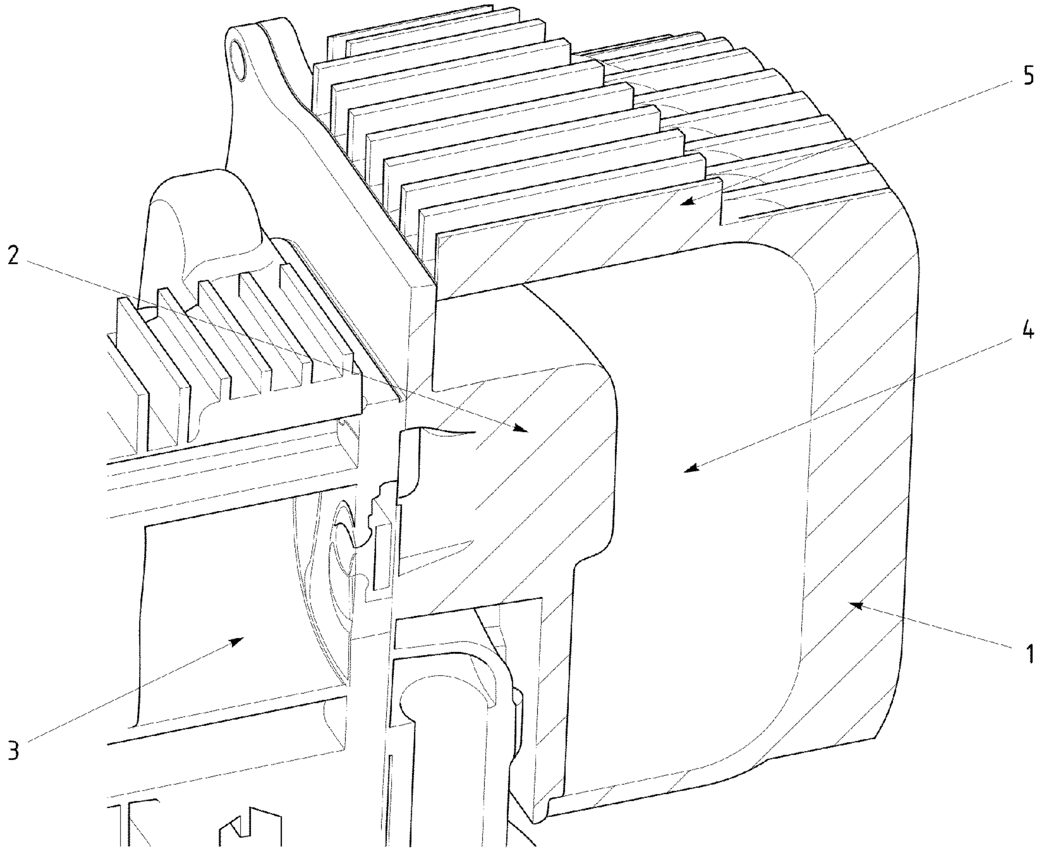
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Fig.1

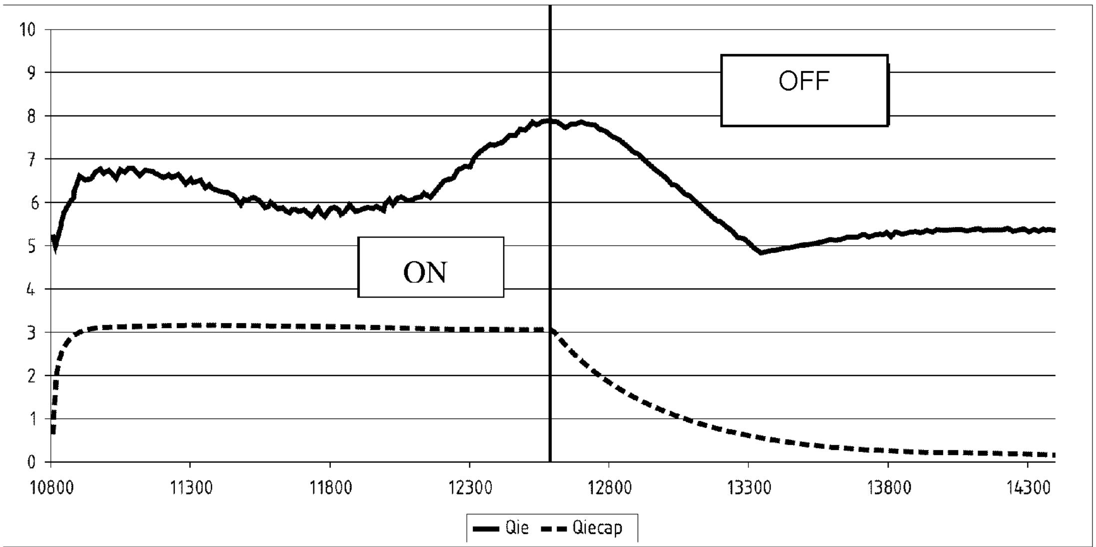
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Fig.2

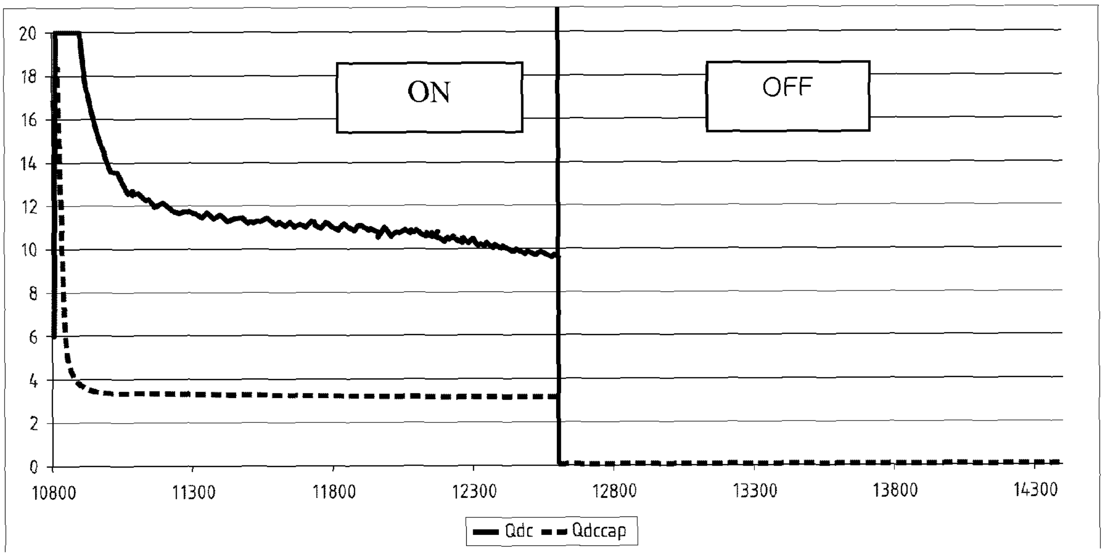
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Fig.3

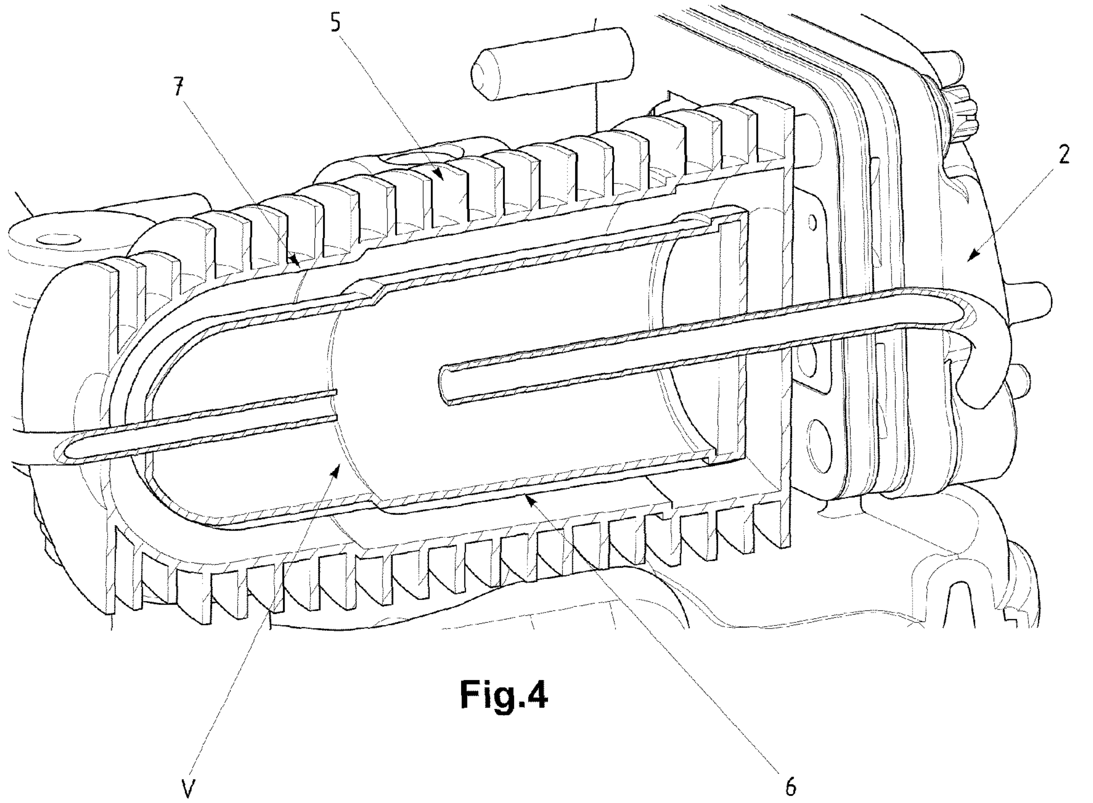
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Fig.4

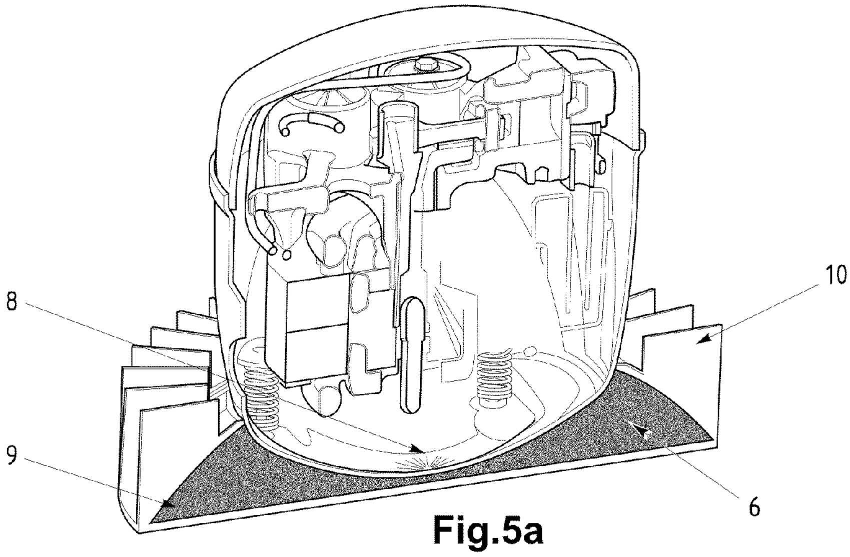

Fig.5a

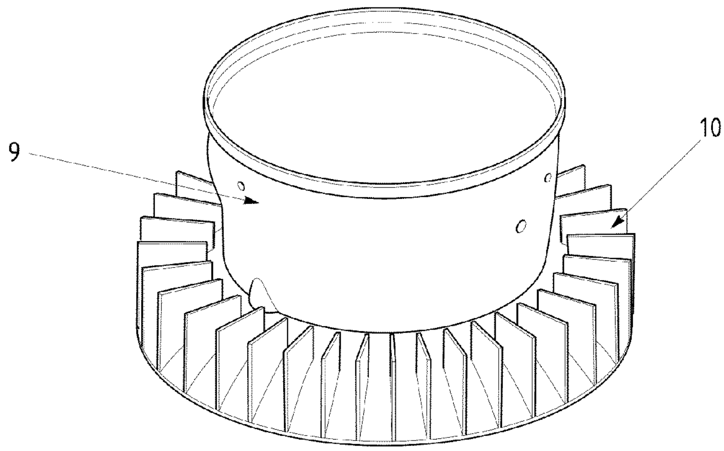

Fig.5b

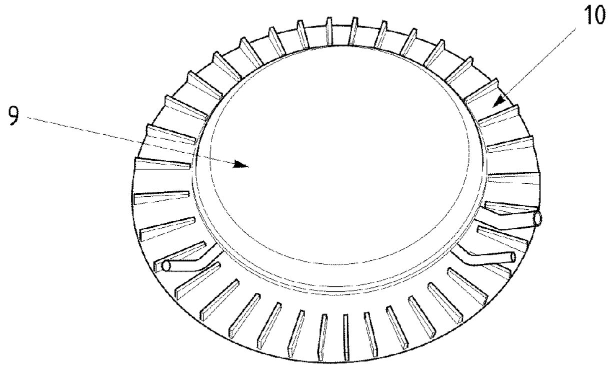

Fig.5c

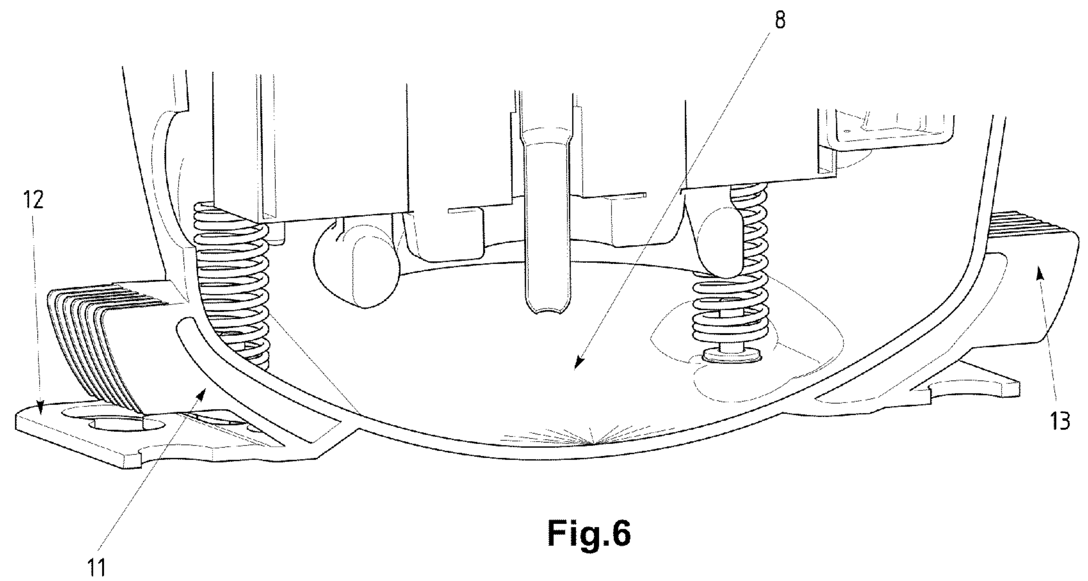

Fig.6

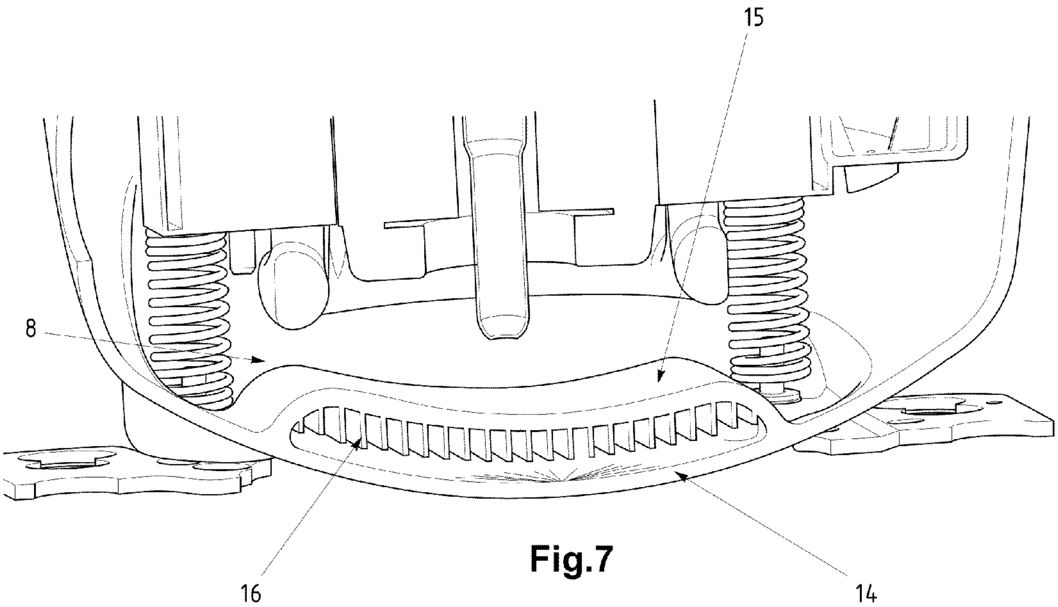

Fig.7

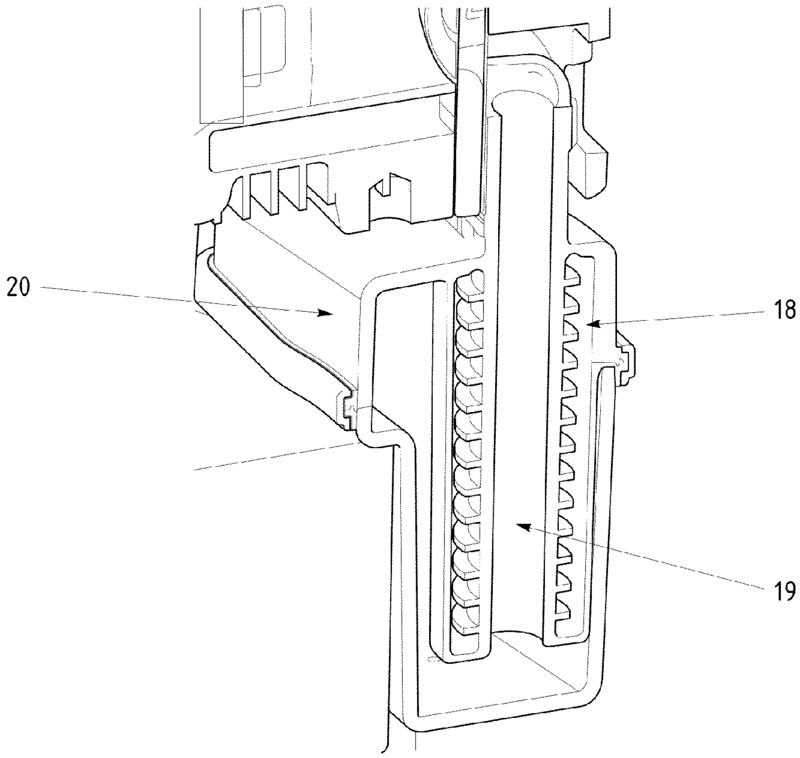

Fig.8

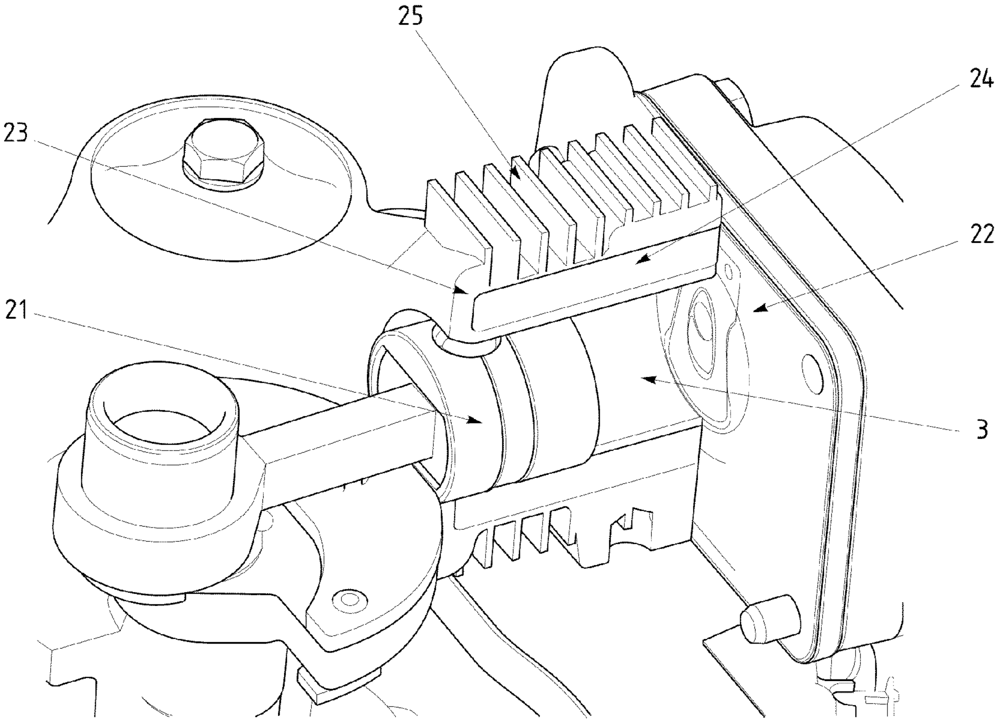

Fig.9

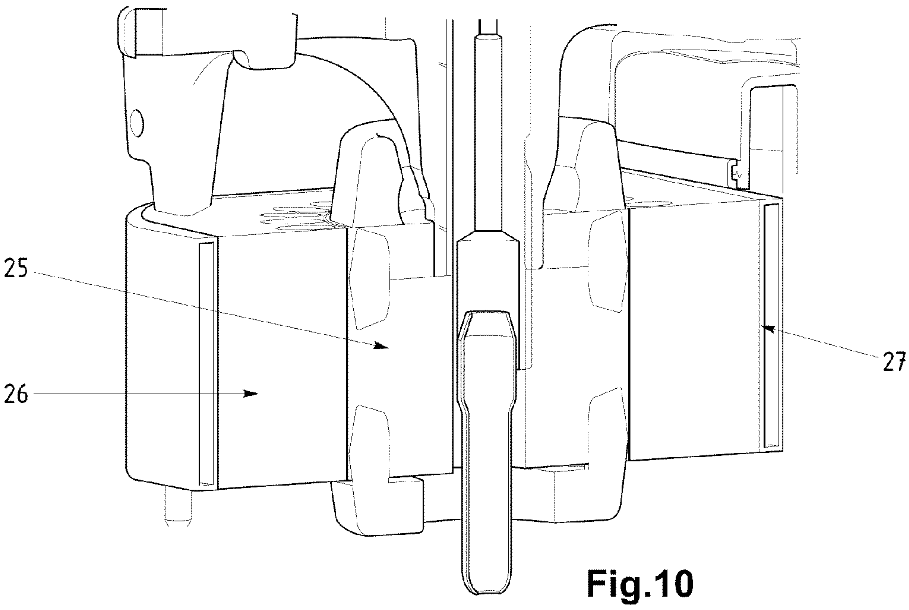

Fig.10

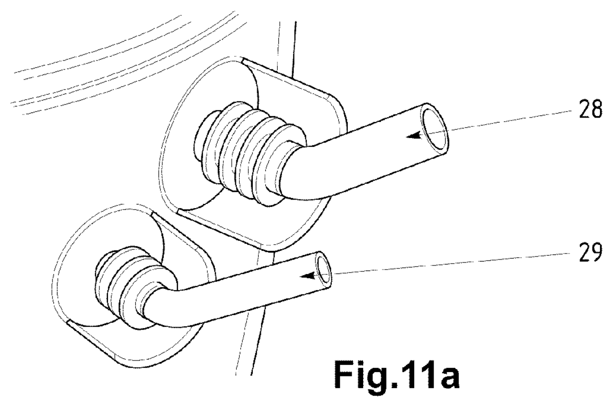

Fig.11a

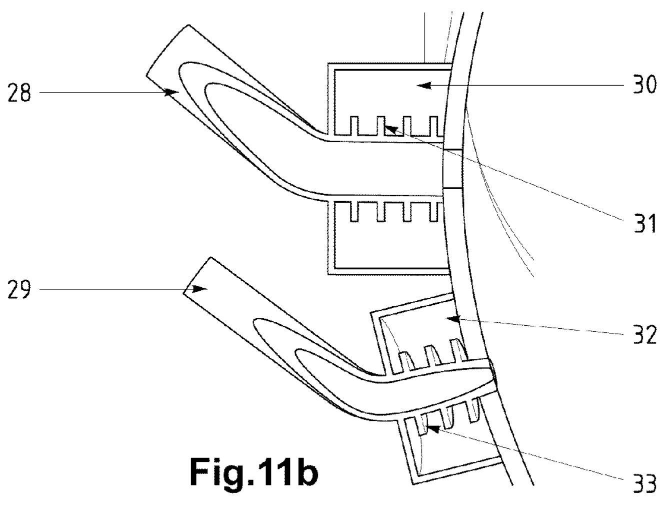

Fig.11b

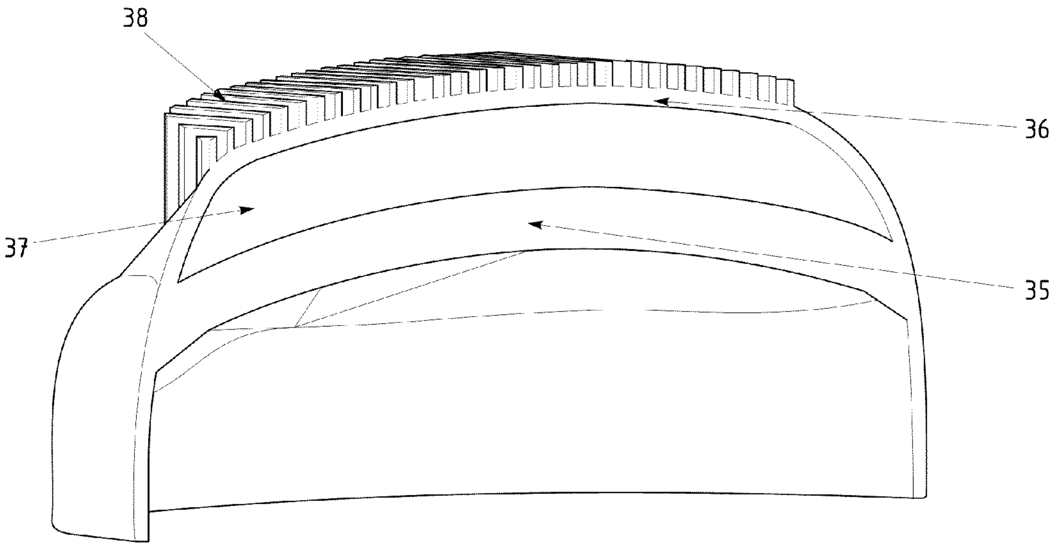

Fig.12

International application No.

PCT/BR2010/000373

INTERNATIONAL SEARCH REPORT

Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

Refrigeration compressor comprises a housing which surrounds the component parts of said compressor. A heat accumulating material (6), which can be arranged within or adjacent to the compressor housing, acts as a thermal capacitor being able to absorb heat while the compressor is on and to release heat while the compressor is off, so as to increase the thermal efficiency of the compressor. The heat accumulating material can be a phase change material (PCM).

INTERNATIONAL SEARCH REPORT

International application No
PCT/BR2010/000373

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B39/06
ADD.

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)
F04B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/132955 A1 (ARCELIK AS [TR]; OGUZ EMRE [TR]; SOYSAL F ALPER [TR]) 5 November 2009 (2009-11-05) paragraphs [0025], [0031], [0032]; claim 1; figures 1-4	1-25
X	US 4 371 319 A (MURAYAMA AKIRA [JP] ET AL) 1 February 1983 (1983-02-01) cited in the application figures 3-5	1-4,6-22
X	WO 2007/014443 A1 (WHIRLPOOL SA [BR]; POSSAMAI FABRICIO CALDEIRA [BR]; VASILIEV LEONARD L) 8 February 2007 (2007-02-08) cited in the application figures 11,12	1-4,6-22

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international 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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 March 2011	31/03/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Olona Laglera, C

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/BR2010/000373

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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			EP	1910676	A1	16-04-2008
			JP	2009503342	T	29-01-2009
			KR	20080025193	A	19-03-2008
			US	2008310974	A1	18-12-2008

Form PCT/ISA/210 (patent family annex) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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- US 4371319 A **[0007]**
- WO 2007068072 A **[0008]**
- WO 2007014443 A **[0009]**
- US 4569639 A **[0010]**