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(54) **REFRIGERATION SYSTEM**

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(57) **ABSTRACT**

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A refrigeration system comprising: a Stirling machine (1); a refrigerating chamber (4); a first thermal energy transfer device (2) operatively associated with a refrigerating portion (1b) of the machine and with the refrigerating chamber (4); a second thermal energy transfer device (3) operatively associated with a heat receiving means, external to said machine, and with the heating portion (1a) thereof, the first thermal energy transfer device (2) comprising: at least one capillary pump (10) mounted in the refrigerating chamber (4) to evaporate, by the heat absorbed from the latter, the circulating fluid received in said capillary pump (10); a condenser (20) operatively coupled to the refrigerating portion (1b) of the Stirling machine (1) to condense the circulating fluid received, in the gaseous state, from the capillary pump (10); and pipes (30, 40) to conduct in a closed loop, the circulating fluid between the capillary pump (10) and the condenser (20).

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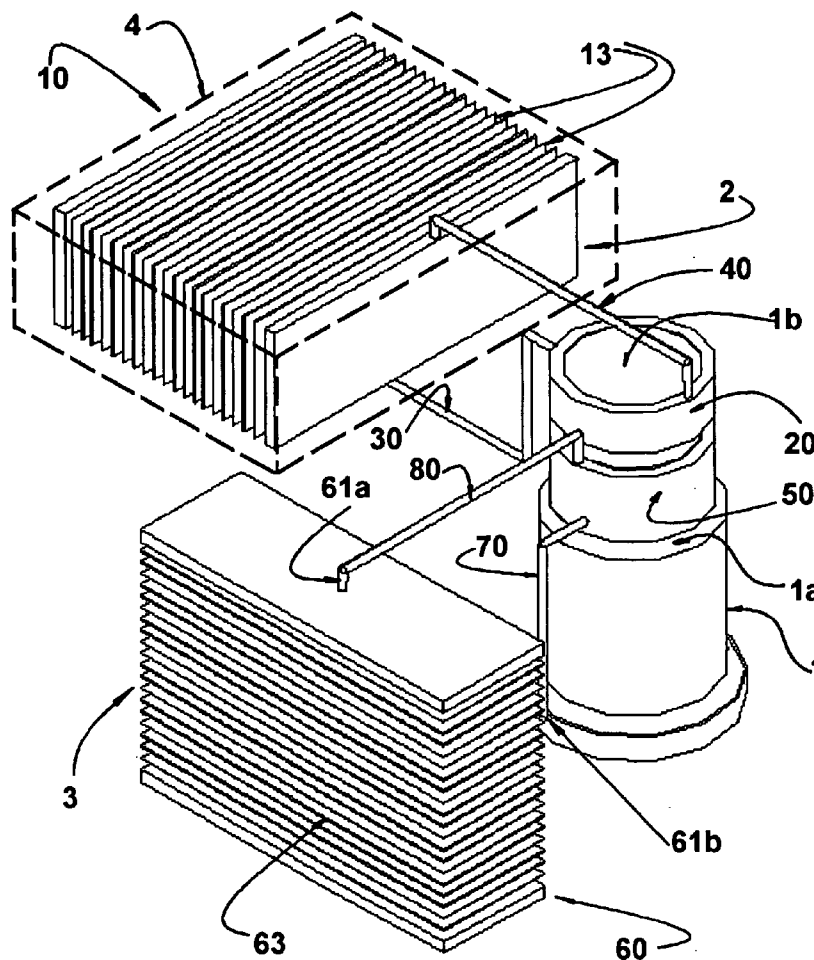
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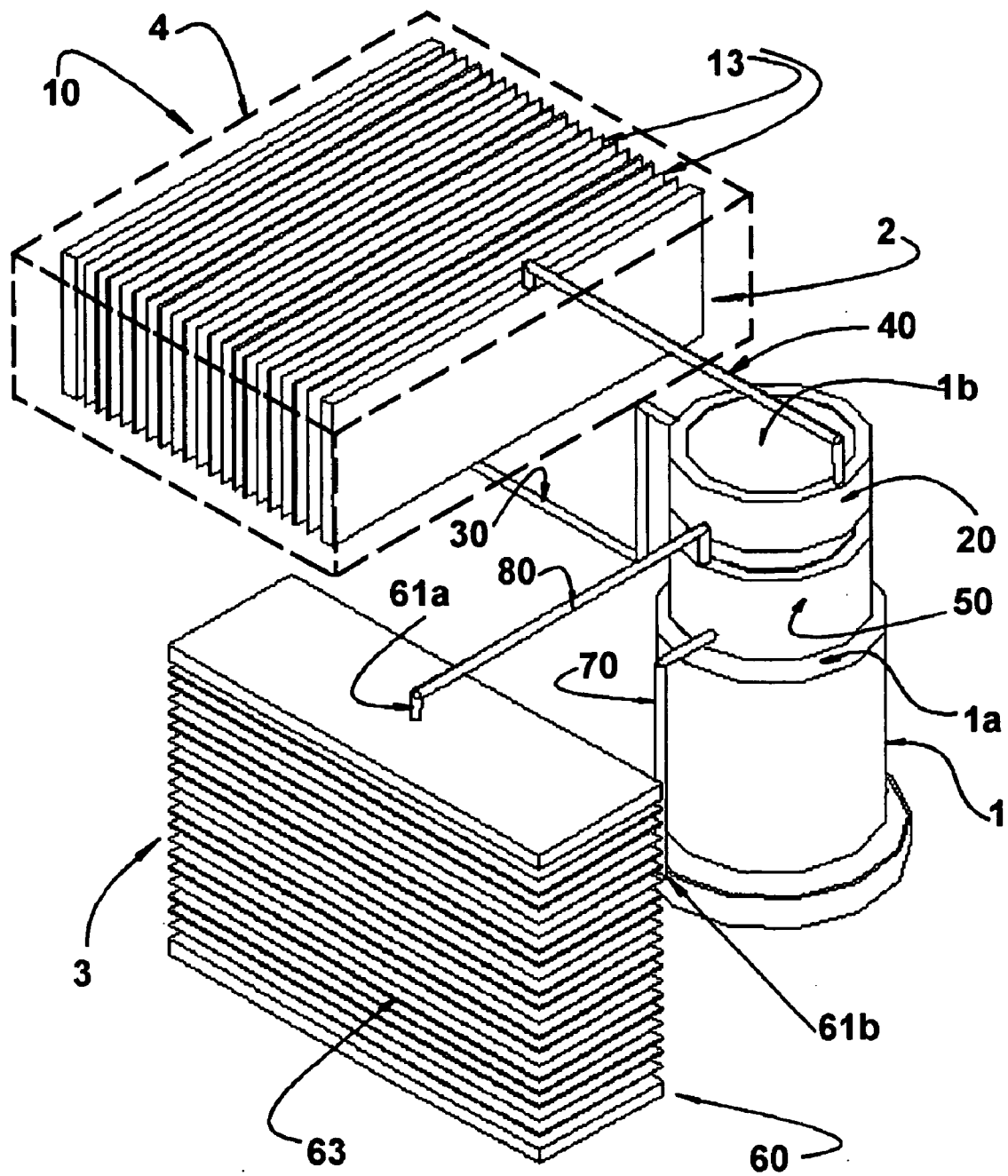


FIG. 1

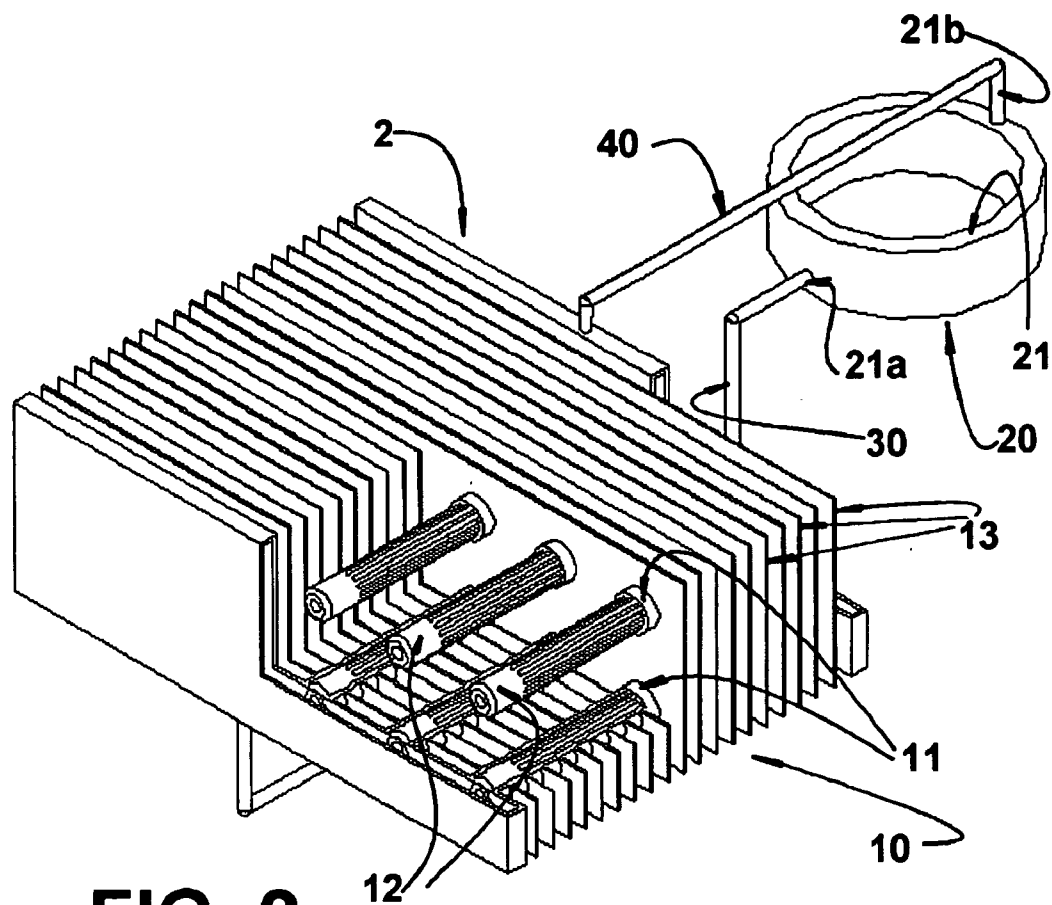


FIG. 2

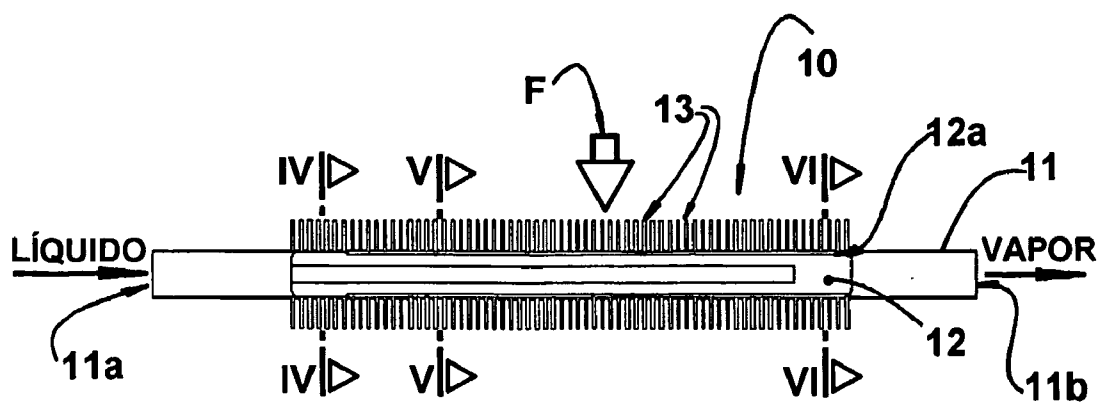


FIG. 3

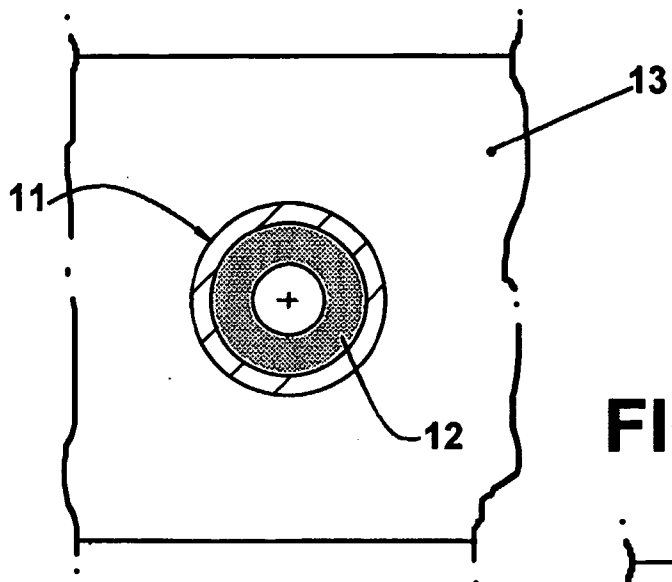


FIG. 4

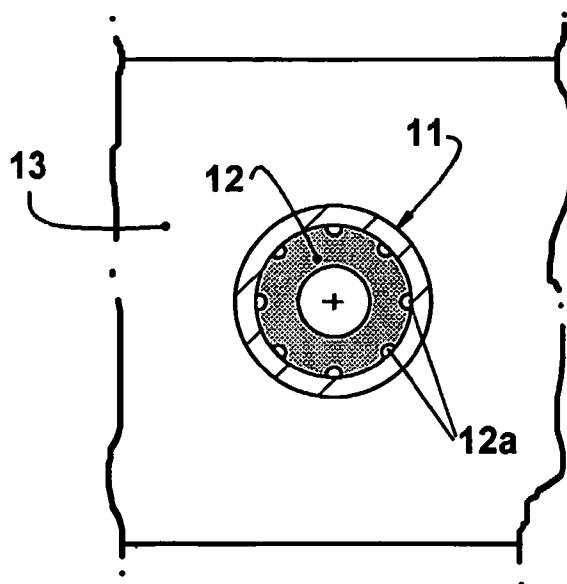


FIG. 5

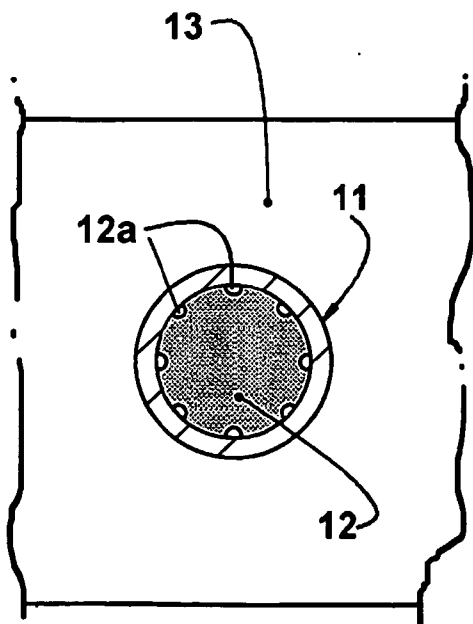
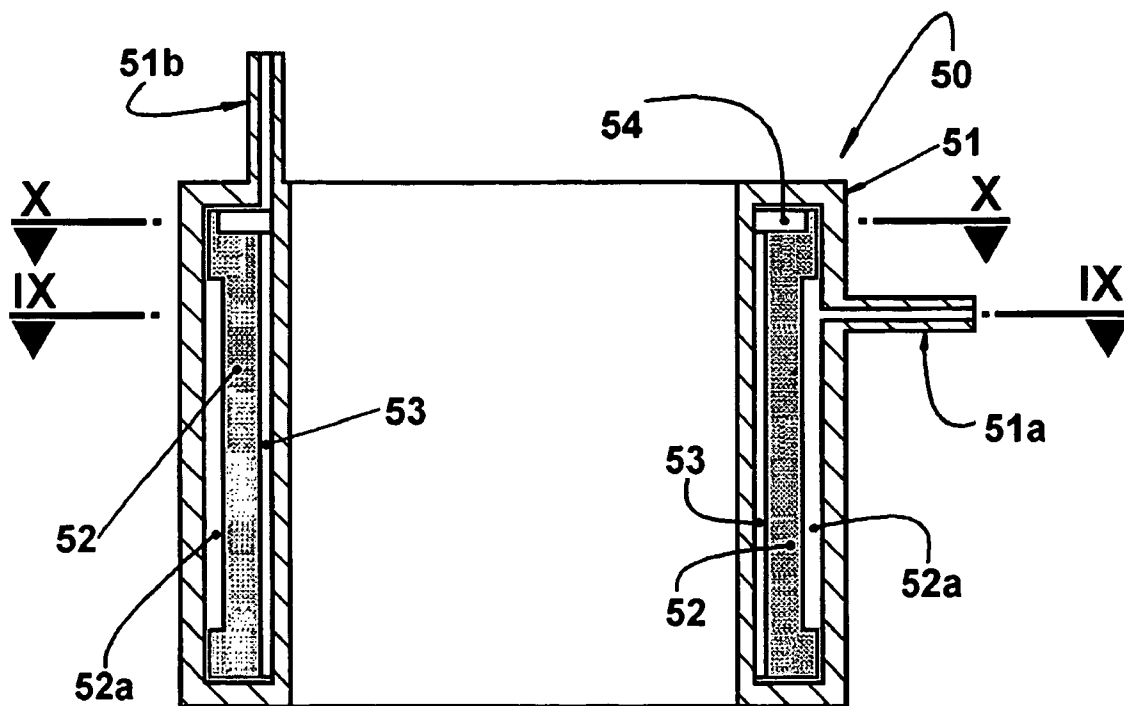
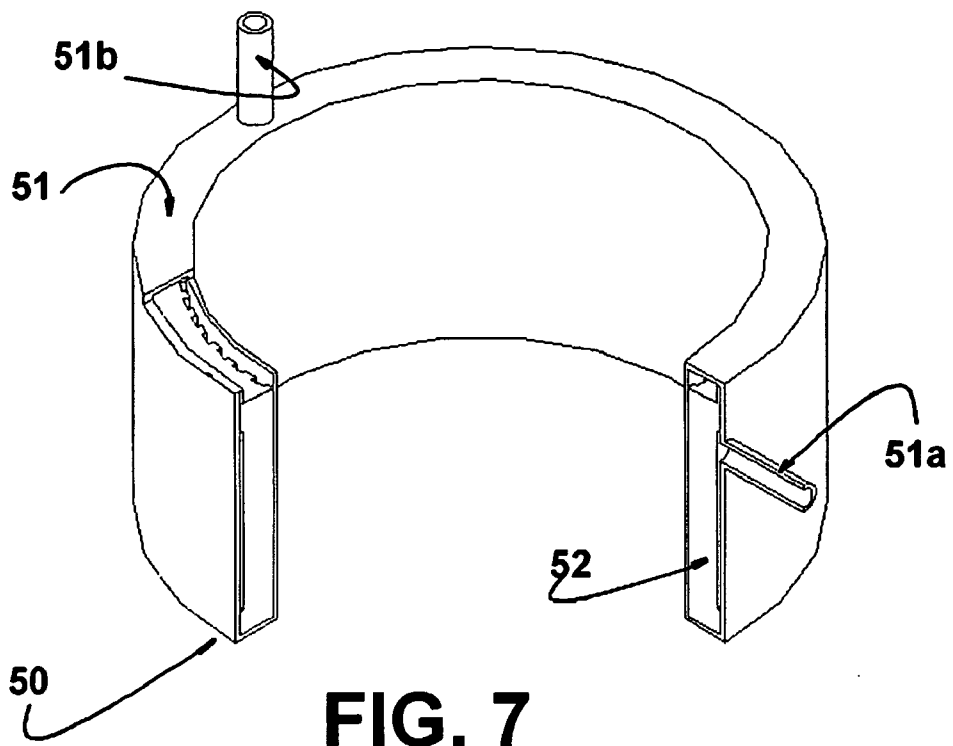
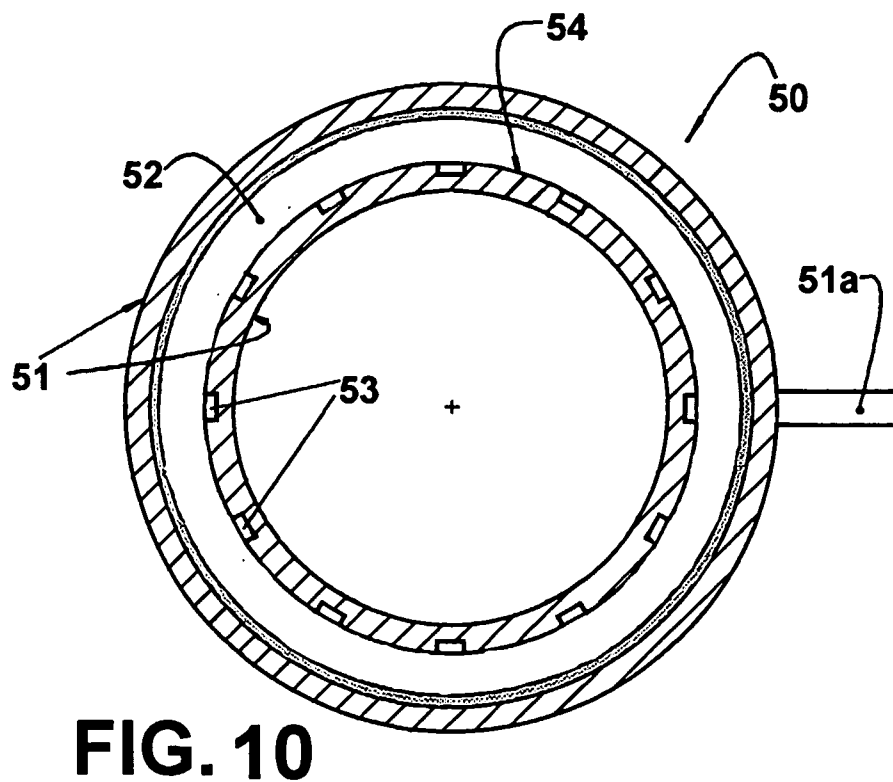
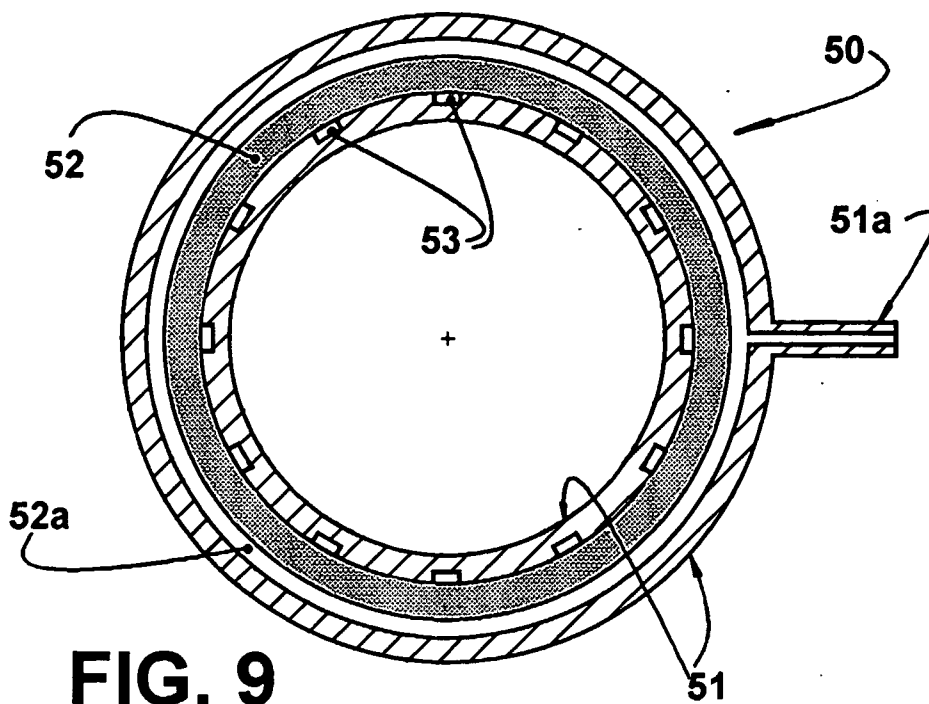


FIG. 6





REFRIGERATION SYSTEM

FIELD OF THE INVENTION

[0001] The present invention refers to a refrigeration system that uses a Stirling machine as a source of thermal energy to be transferred to environments located outside and spaced in relation to the compressor, particularly to the heat exchangers (heads) thereof.

BACKGROUND OF THE INVENTION

[0002] Stirling machines have been known for many years, operating in several applications. They are widely used as systems to produce movement (motors) and in the field of energy generation, by using heat sources. Stirling machines are also used to refrigerate environments, or in refrigeration systems, mainly in systems with low capacity (below 100 W, in ASHRAE check point) and low storage temperatures (lower than -100° C.)

[0003] Such machines comprise a hermetic shell, within which is mounted a motor, which can be of the linear type driving a piston that compresses the gas existing inside the shell. There are further provided, in the interior of the hermetic shell, heat exchangers that are coupled to a hot external heat exchanger, or hot head, and to other heat exchanger coupled to a cold external heat exchanger, or cold head, both heat exchangers being produced in a metallic material with good thermal conductivity, which allows them to be capable to reject heat to the environment external to the machine and to absorb heat from another environment, respectively.

[0004] The Stirling machines generally have the heat of its hot head directed to a heat releasing environment, and its cold head is associated with a refrigeration system to refrigerate a determined environment.

[0005] The Stirling machine works by using, for example, helium as a refrigerant fluid, but other alternatives of refrigerant fluid may be used, such as hydrogen, or nitrogen, as described in Patent U.S. Pat. No. 5,927,079.

[0006] Stirling machines need auxiliary devices to allow transferring heat from its hot heat exchanger to the environment whereto heat is desired to be transferred, as well as devices that allow heat to be absorbed from the environment requiring to be refrigerated through the cold head. There are known in the art some devices that allow effecting such heat transfers.

[0007] The known prior art presents different alternatives to make possible said transfer, such as: employing auxiliary heat exchangers of the thermosiphon type, as taught in Patent U.S. Pat. No. 6,347,523; providing fins on the heads and using an auxiliary air movement system; using heat pipes; using a fluid pumping system employing pumps driven by one of the oscillating, mechanical, or electrical movements, among others.

[0008] In one of the known prior art solutions in which the Stirling machines are used in a refrigeration system, as described in Patent U.S. Pat. No. 5,927,079, the refrigeration of a determined environment is carried out by pumping a refrigerant fluid, under low temperature, which is refrigerated by heat exchange while passing around the cold head of the Stirling machine to an evaporator provided in the envi-

ronment to be refrigerated. In this construction, the fluid under low temperature and refrigerated in the cold head of the Stirling machine is conducted through the pipes of the evaporator by using pumping means disposed between the Stirling machine and the evaporator. In this construction, the removal of heat from the hot head of the Stirling machine is achieved by the circulation of water in a closed loop that passes through said hot head of the Stirling machine, which circulation is also achieved by action of a pump element mounted in the heat removing loop.

[0009] However, these known solutions present some disadvantages, such as in the systems employing the thermosiphon as the working principle, the need to level the component parts, such as pipes and heat exchangers.

[0010] In the case of the known solutions that use fins on the heads and heat exchange by air, the disadvantage resides in the fact that high heat transfer capacities are not possible to be achieved. In said systems, a saturation limit in relation to the heat transfer capacity is easily reached. This is due to the efficiency saturation of the fins with the increase of their length and/or decrease of the distance therebetween, or even due to the impossibility of finding air movement equipments with sufficient capacity to allow reaching the pressure and flowrate levels required for determined heat transfer capacities. In addition, such solutions cause an increase in the level of vibrations of the refrigeration system and a reduction of reliability, as a function of the large quantity of the existing moving parts. The known solutions that use heat pipes further present the following disadvantage: high pressure loss of the system due to the necessary provision of a porous material outside the evaporation region, which reduces the capacity to transfer heat at great distances.

OBJECTS OF THE INVENTION

[0011] Thus, it is an object of the present invention to provide a refrigeration system that uses a Stirling machine, which allows achieving an efficient refrigeration of environments, without the problems existing in the known solutions, such as low heat transfer capacity, pressure loss in the system, and low reliability.

[0012] Another object of the present invention is to provide a refrigeration system such as mentioned above, which reduces the need to level component parts of the system, such as pipes and heat exchangers.

[0013] A further object of the present invention is to provide a system such as proposed above, which presents minimum moving parts, reducing the possibility of occurring vibration in the refrigeration system.

SUMMARY OF THE INVENTION

[0014] These and other objects are achieved through a refrigeration system of the type which comprises: a Stirling machine having a heating portion and a refrigerating portion; a refrigerating chamber; a first thermal energy transfer device operatively associated with the refrigerating portion and with the refrigerating chamber, so as to transfer the heat from the latter to the refrigerating portion by means of a circulating fluid; a second thermal energy transfer device, operatively associated with a heat receiving means, external to said machine, and with the heating portion thereof, so as to transfer heat from the heating portion to the heat receiving means by means of a circulating fluid.

[0015] According to the invention, the first thermal energy transfer device comprises at least one capillary pump mounted in the refrigerating chamber, in order to evaporate, by the heat absorbed from the latter and by action of the capillarity induced by said fluid passing through the capillary pump, the circulating fluid received in said capillary pump; a condenser operatively coupled to the refrigerating portion of the Stirling machine, in order to condense the circulating fluid received, in the gaseous state, from the capillary pump; and pipes to conduct in a closed loop the circulating fluid, in the liquid state, from the condenser to the capillary pump and, in the gaseous state, from the latter to the condenser.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention will be described below, with reference to the enclosed drawings given by way of example for a preferred embodiment, and in which:

[0017] **FIG. 1** is a schematic perspective view of the refrigeration system of the present invention, with the Stirling machine being operatively associated with an environment to be refrigerated;

[0018] **FIG. 2** is a schematic perspective view of a construction for the thermal energy transfer device of the refrigeration system of the present invention;

[0019] **FIG. 3** is a longitudinal sectional view of a first construction for a capillary pump of the present invention driven by the heat removed from the environment to be refrigerated;

[0020] **FIGS. 4, 5 and 6** are cross-sectional views of the first construction for the capillary pump respectively taken according to lines IV-IV, V-V and VI-VI of **FIG. 3**;

[0021] **FIG. 7** is a somewhat schematic partially cut perspective view of a second construction for the capillary pump of the present invention driven by the heat removed from the heating portion of the Stirling machine;

[0022] **FIG. 8** is a diametrical cross-sectional view of the second construction for the capillary pump illustrated in **FIG. 7**;

[0023] **FIG. 9** is a cross-sectional view of the capillary pump of **FIG. 7**, taken according to line IX-IX of **FIG. 8**; and

[0024] **FIG. 10** is a cross-sectional view of the capillary pump of **FIG. 7**, taken according to line X-X of **FIG. 8**.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

[0025] The refrigeration system of the present invention comprises a Stirling machine 1, for example of the type which uses a linear motor operatively associated with a first thermal energy transfer device 2 and a second thermal energy transfer device 3, one of them being operatively coupled to a refrigerating chamber 4. In the example of the illustrated construction, the first thermal energy transfer device 2 is the one associated with the refrigerating chamber 4.

[0026] The Stirling machine 1 comprises, conventionally, a heating portion 1a and a refrigerating portion 1b, each one

operatively connected to one of the first and second thermal energy transfer devices 2, 3, as described below.

[0027] According to the present invention, the first thermal energy transfer device 2 contains a first circulating fluid to transfer thermal energy between the refrigerating portion 1b of the Stirling machine 1 and the refrigerating chamber 4, the second thermal energy transfer device 3 containing a second circulating fluid to transfer thermal energy between the heating portion 1a of the Stirling machine 1 and a heat receiving means, which is usually the atmosphere or ambient air, maintaining a certain space from the machine.

[0028] In a way of carrying out the present invention, the first and the second circulating fluids are the same and defined for example, but not exclusively, by at least one of the elements selected from the group consisting of ether, water, and alcohol. It should be pointed out that other types of circulating fluids are possible, without altering the scope of protection claimed herein.

[0029] According to the present invention, in one or in both the first and the second thermal energy transfer devices 2, 3, there is provided at least one capillary pump, to be described below, through which passes a respective circulating fluid received in the liquid state and which, during its passage through said capillary pump, is submitted to a phase change, passing from the liquid state to the gaseous state. Each one of said first and second thermal energy transfer devices 2, 3, also comprises a respective heat exchanger, in which the respective circulating fluid coming from the capillary pump and in the gaseous state is submitted to a phase change, passing to the liquid state.

[0030] According to the present invention, the first thermal energy transfer device 2 comprises at least one capillary pump 10, associated with the refrigerating chamber 4 and presenting: a hermetic shell 11 provided with an inlet 11a for the circulating fluid in the liquid state, and with an outlet 11b for the circulating fluid in the gaseous state and which is disposed spaced from the inlet 11a and separated from the latter by a porous means 12, lodged inside the shell 11 and through which the circulating fluid passes in its path from an inlet side to an outlet side of the porous means, as it changes from the liquid state to the gaseous state by the evaporation provoked by a heat source to which a region of the shell 11 is exposed, and also by action of the pressure loss generated upon the fluid passing through the porous material, against which is seated the outlet side of the porous means 12 where the outlet 11b is provided.

[0031] In the first thermal energy transfer device 2, the heat source is represented by the air, which passes, preferably in a forced airflow, through the interior of the refrigerating chamber 4, in which is mounted the capillary pump 10, or the assembly of capillary pumps 10, driven by the heat removed from any environment to be refrigerated. In this construction, the circulating fluid in the liquid state supplied to the capillary pump 10 comes from a heat exchanger in the form of a condenser 20 operatively coupled to the refrigerating portion 1b of the Stirling machine 1 to transfer to said refrigerating portion 1b the heat which the circulating fluid absorbed upon changing to the gaseous state in the capillary pump 10, condensing said circulating fluid and allowing it to return, in the liquid state, back to the inlet 11a of the shell 11 of the capillary pump 10.

[0032] As it can be noted in **FIGS. 1 and 2**, the capillary pump 10, or the assembly of capillary pumps 10, are

connected to the condenser **20** by a pair of pipes **30, 40**, one of the latter being coupled to the inlet **11a** for the circulating fluid in the liquid state in each capillary pump **10**, while the other pipe is coupled to the outlet **11b** for the circulating fluid in the gaseous state of each capillary pump **10**.

[0033] In the illustrated embodiment, the first thermal energy transfer device **2** comprises a plurality of capillary pumps **10**, disposed parallel in relation to the respective closed loop of circulating fluid and which are mounted inside the refrigerating chamber **4**, so as to operate, in conjunction, as an evaporator to evaporate the circulating fluid, using the heat of the airflow **F** flowing through said refrigerating chamber **4**.

[0034] In the construction illustrated in **FIGS. 2-6**, each capillary pump **10** has its shell **11** defined by an elongated pipe, constructed in any adequate material and presenting high thermal conductivity, said shell **11** being transversally incorporated to a plurality of heat exchanging fins **13**, which are parallel to and spaced from each other and arranged generally parallel to the direction of the airflow **F** to be refrigerated and which flows through said evaporator defined by the plurality of capillary pumps **10**.

[0035] In said embodiment of **FIGS. 2-6**, the shell **11** in the form of an elongated pipe has an end defining the inlet **11a** and the opposite end defining the outlet **11b** of the circulating fluid, said inlet **11a** and outlet **11b** being separated from each other by a porous means **12**, affixed to the inside of the shell **11** and also presenting a tubular shape, with an open end adjacent to the inlet **11a** to receive, in the interior of the porous means **12**, the circulating fluid in the liquid state, and with a closed opposite end adjacent to the outlet **11b** of the shell **11**. The porous means **12** has its external diameter dimensioned to allow it to be tightly seated in relation to the internal surface of the shell **11**.

[0036] In order to allow the circulating fluid to radially traverse the annular thickness of the porous means **12** while evaporating to the gaseous state, and to allow said fluid to be captured to continue its path through the outlet **11b** and through the pipe **40** toward the condenser **20**, longitudinal passages **12a** are formed, between the porous means **12** and the shell **11**, having an end that is closed by the porous means **12** itself near the inlet **11a**, and an opposite end opened to the outlet **11b**.

[0037] In the illustrated embodiment, the longitudinal passages **12a** are obtained by the provision of respective longitudinal grooves in the external surface of the porous means **12**. However, it should be understood that said grooves could be also provided along the internal surface of the shell **11**.

[0038] Considering that the condenser **20** of the first thermal energy transfer device **2** transfers heat from the circulating fluid in the gaseous state to the refrigerating portion **1b** of the Stirling machine **1**, this condenser **20** preferably presents a cylindrical annular shell **21** with an internal wall seated around the refrigerating portion **1b**, so as to be able to transfer heat, by conduction, to the latter.

[0039] The internal construction of the condenser **20** can be effected in different manners, provided that it allows achieving an efficient thermal exchange between the circulating fluid and the refrigerating portion **1b** of the Stirling machine **1**.

[0040] Anyway, the shell **21** of the condenser **20** is provided with an inlet **21a** and an outlet **21b**, which are respectively connected to the pipes **30, 40** and the inlet **21a** and the outlet **21b** are interconnected inside the shell **21** by any connecting means, such as a coil immersed in a heat conducting means, for example a liquid in a simultaneous direct contact with the internal wall of the shell **21** and with the connecting means that connects the inlet **21a** to the outlet **21b**.

[0041] As already mentioned in relation to the evaporator of the first thermal energy transfer device **2**, the condenser **20** should have its shell **21** and its internal component parts constructed in a material of high thermal conductivity and which resists both the working conditions of the system and the circulating fluid that is used.

[0042] According to the description above, the first thermal energy transfer device **2** is constructed to remove the heat from the refrigerating chamber **4** by means of a circulating fluid that is impelled only by one evaporator, operating jointly with a condenser and in the form of an assembly of parallel capillary pumps **10**. The condenser is mounted to the refrigerating portion of the Stirling machine that works as an absorbing source of the heat removed by the evaporator from the environment to be refrigerated.

[0043] However, the heat generated in the heating portion **1a** of the Stirling machine **1** must be transferred to an external means which is capable of absorbing said heat. This is the function of the second thermal energy transfer device **3**, which also uses a circulating fluid to absorb the heat from the Stirling machine and to release said heat to the atmosphere or ambient air, as already mentioned above.

[0044] According to the construction illustrated in **FIGS. 1, 7, 8, 9** and **10**, the second thermal energy transfer device **3** comprises a capillary pump **50** presenting an annular hermetic shell **51** provided with an external inlet **51a** for the circulating fluid in the liquid state, and with an internal outlet **51b** for the circulating fluid in the gaseous state and which is spaced from the inlet **51a** and separated from the latter by a porous means **52**, which is also annular, lodged inside the shell **51**, and through which the circulating fluid flows along its path and while changing from the liquid state to the gaseous state, by the evaporation caused by a heat source placed in contact with the internal wall of the cylindrical annular shell **51**, as well as by action of the pressure loss generated upon the fluid passing through the porous material.

[0045] In the construction mentioned above, the heat source is defined by the heating portion **1a** of the Stirling machine **1**, around which it is affixed, in direct contact, the internal wall of the shell **51** of the capillary pump **50**. The circulating fluid in the liquid state is supplied to the capillary pump **50** from a condenser **60**, which is positioned at a certain distance from the Stirling machine **1**, so as to transfer to the atmosphere the heat which the circulating fluid absorbed upon changing to the gaseous state in the capillary pump **50**, condensing said fluid and allowing it to return in the liquid state back to the inlet **51a** of the shell **51** of the capillary pump **50**. The circulating fluid flows in pipes **70, 80**, which connect the inlet **51a** and the outlet **51b** of the capillary pump **50** to an outlet **61b** and to an inlet **61a** of the condenser **60**, respectively. In the illustrated embodiment, the capillary pump **50** of the second thermal energy transfer

device **3** presents an inlet **51a**, which is disposed radially and medianly opened to an annular gap **52a** defined between the porous means **52** and the external wall of the annular shell **51**, in order to allow the circulating fluid in the liquid state to be homogeneously supplied around the porous means **52**. The opposite axial ends of the annular gap **52a** are closed by the seating of the porous means **52** against the external wall of the shell **51**.

[0046] In the illustrated constructive example, the annular gap **52a** is obtained by the provision of an external circumferential recess in the porous means **52**. It should however be understood that said recess could be also provided in the internal surface of the external wall of the shell **51**.

[0047] With the construction described above, the circulating fluid in the liquid state penetrates in the annular gap **52a** through the inlet **51a** and starts its inward radial path, through the thickness of the porous means **52** and while evaporating to the gaseous state, said fluid being then captured to continue its path through the outlet **51b** and through the pipe **80** toward the condenser **60**. For this purpose, longitudinal passages **53** are formed between the porous means **52** and the internal wall of the shell **51**. Said longitudinal passages, which can be defined by grooves in the internal wall of the shell **51**, are circumferentially interconnected by a channel **54**, generally positioned close to one of the ends of the porous means **52** and whose interior communicates with the outlet **51b**. In the illustrated embodiment, the channel **54** is defined by an internal circumferential recess provided in the porous means **52**.

[0048] The internal wall of the shell **51** is shaped and dimensioned to seat around the heating portion **1a** of the Stirling machine **1**, in order to use the heat produced thereby to evaporate the circulating fluid arriving at the longitudinal passages **53**. The heat is transferred, by conduction, from the heating portion **1a** of the Stirling machine **1** to the internal wall of the shell **51** of the capillary pump **50**.

[0049] The condenser **60** to be used in the second thermal energy transfer device **3** may present different constructions, provided they are adequate and compatible with the operation of the capillary pump **50**.

[0050] A possible construction for the condenser **60** is the one used for the evaporator of the first thermal energy transfer device **2**. In this case, the condenser **60** comprises a plurality of tubular shells (not illustrated), which are parallel to each other and transversally incorporated to a plurality of heat exchanging fins **63**. The tubular shells have an end defining an inlet **61a** for the circulating fluid in the gaseous state and which is connected to the pipe **80**, and an opposite end defining an outlet **61b** for the condensed circulating fluid, which is already in the liquid state, after transferring the heat to the ambient air, or to any other available heat absorbing means.

[0051] Within each tubular shell flows the circulating fluid, which transfers heat to the exterior, condenses and returns to the capillary pump **50**.

[0052] The refrigeration system of the present invention can further comprise a reservoir (not illustrated), associated with each thermal energy transfer device to control the working temperature by adjusting the amount of circulating fluid in each of the first and second thermal energy transfer devices **2, 3** in relation to a given amount of heat supplied

to each of the capillary pumps **10, 50** of the present invention. Each circulating fluid transports heat from the hot region of the respective thermal energy transfer device to the cold region of the same thermal energy transfer device, as a function of the capillary forces generated by the difference of surface tension in relation to the temperature differential in each thermal energy transfer device.

[0053] The refrigeration system of the present invention can be further provided, although not illustrated, with a system for the dynamic neutralization of vibrations, which minimizes the transmission of the vibrations, generated by the reciprocating movement of the piston of the linear motor of the Stirling machine **1**, to the shell and/or to other components to which said machine is connected. These components are mounted within the hermetic shell, which supports the components and promotes the tightness required in the compression and expansion strokes of the gas contained therein.

[0054] The refrigeration system of the present invention provides a pumping system by capillary forces, which minimizes the difficulties of leveling the system, pipes and heat exchangers in relation to each other. The refrigeration system of the present invention also allows achieving a high heat transfer capacity, since it presents low pressure loss, thus allowing a higher heat transfer capacity to be achieved at great distances.

[0055] Besides the advantages above, the refrigeration system of the present invention allows achieving high levels of reliability, since it does not present moving parts and is protected from vibrations.

1. A refrigeration system comprising:

- a Stirling machine (**1**) having a heating portion (**1a**) and a refrigerating portion (**1b**);
- a refrigerating chamber (**4**);
- a first thermal energy transfer device (**2**) operatively associated with the refrigerating portion (**1b**) and with the refrigerating chamber (**4**), so as to transfer heat from the latter to the refrigerating portion (**1b**) by means of a circulating fluid;
- a second thermal energy transfer device (**3**), operatively associated with a heat receiving means, external to said machine, and with the heating portion (**1a**) thereof, so as to transfer heat from the heating portion (**1a**) to the heat receiving means by means of a circulating fluid, characterized in that the first thermal energy transfer device (**2**) comprises at least one capillary pump (**10**) mounted in the refrigerating chamber (**4**) in order to evaporate, by the heat absorbed from the latter and by action of the pressure loss generated by the fluid passing through the capillary pump, the circulating fluid received in said capillary pump (**10**); a condenser (**20**) operatively coupled to the refrigerating portion (**1b**) of the Stirling machine (**1**), in order to condense the circulating fluid received, in the gaseous state, from the capillary pump (**10**); and pipes (**30,40**) to conduct, in a closed loop, the circulating fluid, in the liquid state, from the condenser (**20**) to the capillary pump (**10**) and, in the gaseous state, from the latter to the condenser (**20**).

2. The refrigeration system according to claim 1, characterized in that the second thermal energy transfer device (3) comprises a capillary pump (50) operatively coupled to the heating portion (1) of the Stirling machine (1) in order to evaporate, by the heat absorbed from said heating portion (1a) and by action of the pressure loss generated by the fluid passing through the capillary pump, the circulating fluid received in said capillary pump (50); a condenser (60) operatively associated with a heat receiving means external to the Stirling machine (1) in order to condense the circulating fluid received, in the gaseous state, from the capillary pump (50); and pipes (70,80) to conduct in a closed loop the circulating fluid, in the liquid state, from the condenser (60) to the capillary pump (50) and, in the gaseous state, from the latter to the condenser (60).

3. The refrigeration system according to claim 1, characterized in that the capillary pump (10,50) comprises a shell (11,51), provided with an inlet (11a, 51a) for the circulating fluid in the liquid state, and with an outlet (11b, 51b) for the circulating fluid in the gaseous state and which is spaced from the inlet (11a, 51a) and separated from the latter by a porous means (12,52) lodged inside the shell (11,51) and through which flows the circulating fluid, by generation of said pressure loss, from an inlet side to an outlet side of the porous means (12,52), due to the pressure difference between both sides, while said circulating fluid is changing from the liquid state to the gaseous state, by evaporation, on the outlet side of the porous means (12,52) that is exposed to the heat received from one of the parts defined by the refrigerating chamber (4) and the heating portion (1a) of the Stirling machine (1).

4. The refrigeration system according to claim 3, characterized in that the capillary pump (10) of the first thermal energy transfer device (2) has a shell (11) in the form of an elongated pipe, which is transversally incorporated to and traverses a plurality of heat exchanging fins (13), which are disposed parallel to the direction of an airflow (F) to be refrigerated and which passes through the capillary pump (10), one of the ends of the shell (11) defining the inlet (11a) and the opposite end defining the outlet (11b) of the capillary pump (10), the porous means (12) presenting a tubular shape and having an end opened to the inlet (11a) and an opposite closed end that is adjacent to the outlet (11b), and longitudinal passages (12a) being further provided, between the porous means (12) and the shell (11), having closed ends that are adjacent to the inlet (11a), and opposite ends opened to the outlet (11b) of the shell (11), said longitudinal passages directing the circulating fluid, already in the gaseous state, to the outlet (11b) of the shell (11).

5. The refrigeration system according to claim 4, characterized in that the longitudinal passages (12a) are defined by longitudinal grooves provided in the porous means (12).

6. The refrigeration system according to claim 4, characterized in that a plurality of shells (11) are provided parallel to each other, incorporated to a plurality of fins (13), and mounted inside the refrigerating chamber (4).

7. The refrigeration system according to claim 3, characterized in that the capillary pump (50) of the second thermal energy transfer device (3) presents a shell (51) of annular shape, with an external wall receiving the inlet (51a) and with an internal wall associated with the outlet (51b), the porous means (52) having an annular shape and being lodged inside the shell (51), in order to be seated against the internal and external walls of said shell (51), there being

further provided: an annular gap (52a) defined between the porous means (52) and the external wall of the shell (51) and into which is opened the inlet (51a); a plurality of longitudinal passages (53) between the porous means (52) and the internal wall of the shell (51); and a channel (54) interconnecting circumferentially the longitudinal passages (53) and being opened to the outlet (51b) of the shell (51).

8. The refrigeration system according to claim 7, characterized in that the annular gap (52a) is defined by an external circumferential recess provided in the porous means (52).

9. The refrigeration system according to claim 7, characterized in that the channel (54) is defined by an internal circumferential recess provided close to one of the ends of the porous means (52).

10. The refrigeration system according to claim 7, characterized in that the longitudinal passages (53) are defined by grooves provided in the internal wall of the shell (51).

11. The refrigeration system according to claim 1, characterized in that the condenser (20) of the first thermal energy transfer device (2) comprises an annular shell (21), with an internal wall seated around the refrigerating portion (1b) of the Stirling machine (1), so as to transfer heat, by conduction, to the latter, said shell (21) being provided with an inlet (21a) and with an outlet (21b), which are respectively connected to pipes (40,30) that conduct the circulating fluid in the gaseous state and in the liquid state, said inlet (21a) and outlet (21b) being interconnected inside the shell (21).

12. The refrigeration system according to claim 2, characterized in that the condenser (60) of the second thermal energy transfer device (3) comprises a plurality of tubular shells which are parallel to each other and transversally incorporated to a plurality of fins (63), said shells having an end defining an inlet (61a) connected to the pipe (80) that conducts the circulating fluid in the gaseous state, and an opposite end defining an outlet (61b) connected to the pipe (70) that conducts the circulating fluid in the liquid state, said tubular shells and said fins (63) transferring heat to the environment in which the condenser (60) is mounted.

13. The refrigeration system according to claim 2, characterized in that the capillary pump (10,50) comprises a shell (11,51), provided with an inlet (11a, 51a) for the circulating fluid in the liquid state, and with an outlet (11b, 51b) for the circulating fluid in the gaseous state and which is spaced from the inlet (11a, 51a) and separated from the latter by a porous means (12,52) lodged inside the shell (11,51) and through which flows the circulating fluid, by generation of said pressure loss, from an inlet side to an outlet side of the porous means (12,52), due to the pressure difference between both sides, while said circulating fluid is changing from the liquid state to the gaseous state, by evaporation, on the outlet side of the porous means (12,52) that is exposed to the heat received from one of the parts defined by the refrigerating chamber (4) and the heating portion (1a) of the Stirling machine (1).

14. The refrigeration system according to claim 13, characterized in that the capillary pump (10) of the first thermal energy transfer device (2) has a shell (11) in the form of an elongated pipe, which is transversally incorporated to and traverses a plurality of heat exchanging fins (13), which are disposed parallel to the direction of an airflow (F) to be refrigerated and which passes through the capillary pump (10), one of the ends of the shell (11) defining the inlet (11a) and the opposite end defining the outlet (11b) of the capillary

pump (10), the porous means (12) presenting a tubular shape and having an end opened to the inlet (11a) and an opposite closed end that is adjacent to the outlet (11b), and longitudinal passages (12a) being further provided, between the porous means (12) and the shell (11), having closed ends that are adjacent to the inlet (11a), and opposite ends opened to the outlet (11b) of the shell (11), said longitudinal passages directing the circulating fluid, already in the gaseous state, to the outlet (11b) of the shell (11).

15. The refrigeration system according to claim 13, characterized in that the capillary pump (50) of the second thermal energy transfer device (3) presents a shell (51) of annular shape, with an external wall receiving the inlet (51a) and with an internal wall associated with the outlet (51b), the porous means (52) having an annular shape and being lodged inside the shell (51), in order to be seated against the internal and external walls of said shell (51), there being further provided: an annular gap (52a) defined between the porous means (52) and the external wall of the shell (51) and

into which is opened the inlet (51a); a plurality of longitudinal passages (53) between the porous means (52) and the internal wall of the shell (51); and a channel (54) interconnecting circumferentially the longitudinal passages (53) and being opened to the outlet (51b) of the shell (51).

16. The refrigeration system according to claim 13, characterized in that the annular gap (52a) is defined by an external circumferential recess provided in the porous means (52).

17. The refrigeration system according to claim 13, characterized in that the channel (54) is defined by an internal circumferential recess provided close to one of the ends of the porous means (52).

18. The refrigeration system according to claim 13, characterized in that the longitudinal passages (53) are defined by grooves provided in the internal wall of the shell (51).

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