Aug. 28, 1962 R. J. MEIJER 3,050,949

HOT-GAS RECIPROCATING MACHINE

Filed June 7, 1956 2 Sheets-Sheet 1

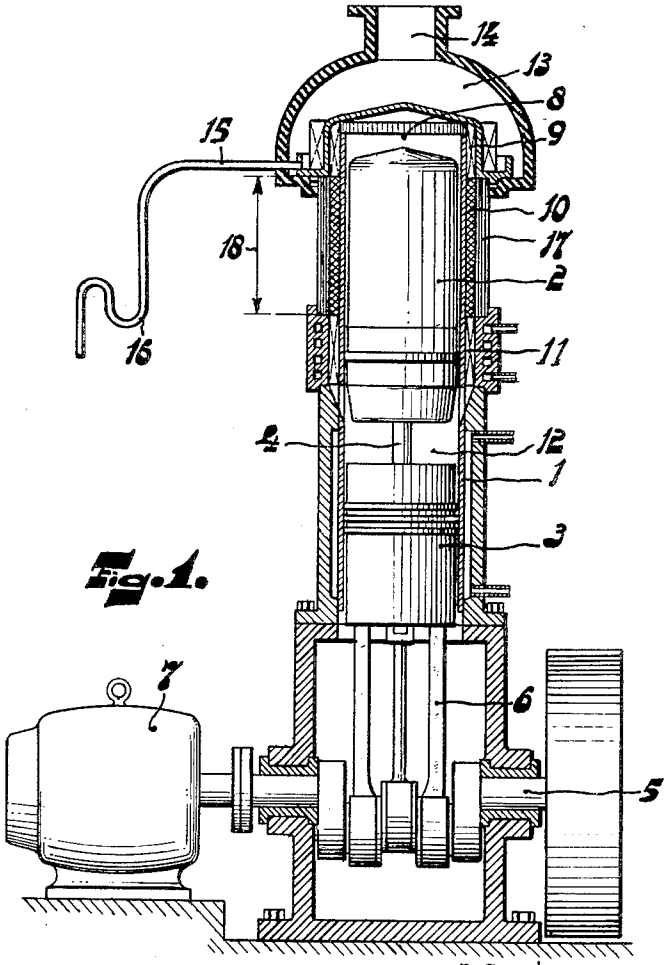



Fig. 1.

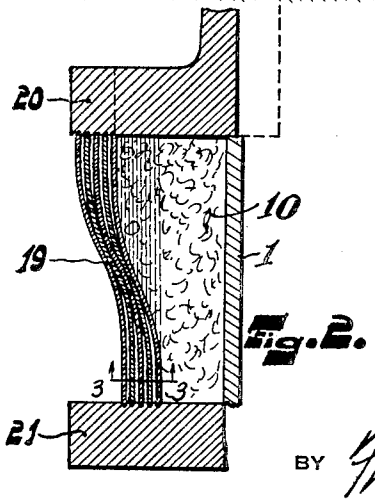



Fig. 2.

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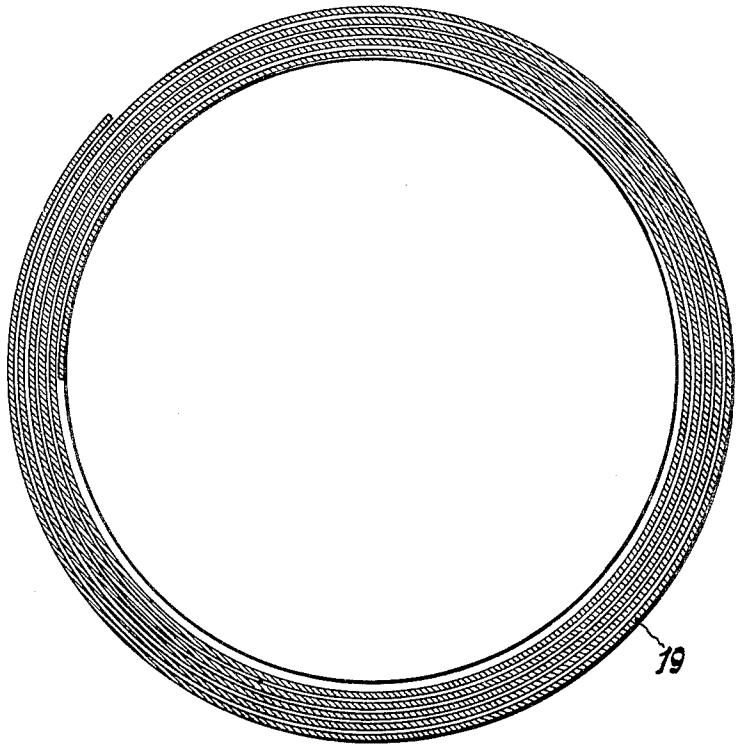



Fig. 3.

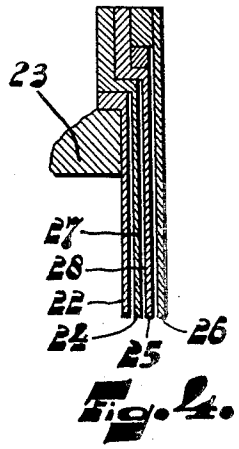



Fig. 4.

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# HOT-GAS RECIPROCATING MACHINE

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2 Claims. (Cl. 62—6)

This invention relates to hot-gas reciprocating machines, each comprising at least two spaces of variable volumes, which communicate with one another via a first heat-exchanger, a regenerator and a second heat-exchanger, whereby a gas in the machine which is always in the same state of aggregation traverses a closed thermodynamic cycle.

Such a hot-gas reciprocating machine may be a hot-gas motor, a cold-gas refrigerator or a heat pump, the latter two operating on the reverse hot-gas motor principle. In one heat-exchanger of the machine, heat is supplied to the gas in the machine. This heat may be extracted either from combustion gases, or in the case of a refrigerator from a medium to be cooled. This heat-exchanger is termed the "heater" in the hot-gas reciprocating machine and the "freezer" in a cold gas refrigerator.

In the other heat-exchanger, heat is extracted from the gas and given off to a cooling medium. This heat-exchanger is termed the "cooler." The regenerator is located between the two heat-exchangers and a comparatively high difference in temperature may usually prevail between the hot and cold end surfaces of the regenerator, for example, a temperature difference of 250° C. in a refrigerator or in certain cases even of 700° C. in a motor. A corresponding difference in temperature exists for the wall bounding, that is surrounding the regenerator space. Since the regenerator may have a comparatively small height, for example from 3 to 4 cms., high tensions may occur in such a wall as a result of the high temperature difference over a small height and the resultant expansion and contraction of the material.

In order to avoid these high tensions in the material of the wall, it has previously been suggested to lengthen the wall of the regenerator, so as to project from one of the end surfaces of the regenerator, from which results an increased height of the wall, through which the difference in temperature exists.

The object of the invention is to construct a hot-gas reciprocating machine in which the wall bounding the regenerator space is also suitable to substantially eliminate the high tensions normally in the past occurring in said wall without lengthening and shortening of the distance along said wall between the operative elements to which said wall is attached

According to the invention, the wall bounding the regenerator space and extending from the hot end of the regenerator to the cold end thereof comprises a plurality of layers located within one another and extending from the hot end to the cold end, which layers can slide along one another when the wall is deformed as a result of the difference in temperature between the hot and the cold portions.

In one embodiment of the invention, the wall comprises a plurality of concentric cylinders. These cylinders may be welded at their upper and lower ends to a common flange, by means of which the wal is secured to the other parts of the machine. However, it is alternatively possible to provide each cylinder with a flange, by means of which the cylinders are secured together and to a common flange.

In another embodiment of the invention, the wall is constituted by a concentric strip. It is desirable to ensure that the stress of the layers does not become excessive. For this purpose, in such an embodiment of the invention, the inner diameter of a layer differs at room temperature by at most 0.2% from the outer diameter of the layer located within it.



In order that the invention may be readily carried into effect, two embodiments will now be described, by way of example, with reference to the accompanying drawings.

FIG. 1 shows a cold-gas refrigerator comprising a regenerator wall according to the invention.

FIGS. 2 and 3 show, on an enlarged scale, wall 17 of FIG. 1 in which the layers are wound concentrically.

FIG. 3 being a horizontal section along the line 3—3 of FIG. 2.

FIG. 4 shows a wall which is constituted by concentric cylinders.

The hot-gas reciprocating machine shown in FIG. 1 is a cold-gas refrigerator of the displacer type. The machine comprises a cylinder 1, in which a displacer 2 and a piston 3 can reciprocate with a substantially constant phase difference. For this purpose, the displacer 2 is coupled by means of a driving-rod mechanism 4 to cranks of a crankshaft 5, whereas the the piston 3 is coupled by means of a driving rod mechanism 6 to a crank on the same crank-shaft 5. The machine is driven by an electric motor 7. The upper surface of the displacer 2 acts upon the volume of gas in a space or chamber 8, the freezing space, and this space communicates by means of a freezer 9, a regenerator 10 and a cooler 11 with a space or chamber 12, the volume of which is influenced by both the displacer and the piston. In the machine a gas, which is always in the same state of aggregation, traverses a thermodynamic cycle, substantial expansion of the gas occurring in the space 8 and substantial compression occurring in the space 12. The machine comprises a condenser space 13, to which a medium, for example, a gas to be cooled, may be supplied through an aperture 14, and a discharge line 15, through which the condensate produced in the space 13 is discharged. The discharge line 15 has a liquid lock 16, resulting in a partial vacuum being maintained in the condenser space such that the gas to be cooled is supplied to the space 13 as a result of the partial vacuum.

The regenerator 10 is surrounded by a wall 17 comprising several separate layers. The upper end of the wall 17 is secured to the freezer 9 and the lower end is secured to the cooler 11. A comparatively great difference in temperature, which may be for example 230° C., occurs through the height 18 of the wall. It should be understood that the freezer 9, regenerator 10 and cooler 11 form a passage which interconnects the spaces 8 and 12 between the cylinder wall 1 and the multiple layer outer wall 17.

FIGURES 2 and 3 show, on an enlarged scale, cross-sections of part of the wall bounding the regenerator.

The wall 17 is constituted by a plurality of layers 19 formed by concentric winding of a strip, as shown in FIGS. 2 and 3.

The edges of the strip are secured to rings 20 and 21. If a great difference in temperature occurs in the wall 17, so that the temperature at the upper side is lower than that at the lower side, the wall is liable to be deformed as shown in dashed lines in FIG. 2. The layers can then slide along one another. The normal slack, which is the condition of the layers of the wall 17 when the wall is relatively hot as shown in full lines in FIG. 2, is changed to the substantially linear condition shown in dashed lines when the wall is cooled.

FIG. 4 shows another embodiment in the present invention, in which the wall comprises a plurality of concentric cylinders. One cylinder 22 is secured, at its upper end, to a housing 23, the other cylinders 24, 25

and **26**, which each have a flange, being fitted therearound in concentric circles. The cylinders are soldered together both at the upper ends and lower ends. The difference in diameter between the outer diameter **27** of cylinder **24** and the inner diameter **28** of cylinder **25** is at most 0.2% of the diameter **27**, in order to avoid excessive tension between the cylinders after deformation.

What is claimed is:

1. A hot-gas reciprocating apparatus comprising a freezer, regenerator and cooler connected in series, a tubular wall surrounding said regenerator and connected to said freezer at one end thereof and to said cooler at the other end thereof and subject to extremes of heat and cold, said wall constituting a plurality of concentric, separated layers of material being normally slack when relatively hot, said layers being deformable upon cooling to a substantially linear condition, the distance between the freezer and cooler being constant when subject to said extremes of heat and cold while a portion of said freezer moves laterally.

2. A hot-gas reciprocating apparatus comprising a freezer, regenerator and cooler connected in series, a tubular wall surrounding said regenerator and connected to said freezer at one end thereof and to said cooler at the other end thereof and subject to extremes of heat and cold, said wall constituting a plurality of concentric, separated layers of flexible material, the inner diameter of each layer differing at room temperature at most 0.2% from the outer diameter of the layer located within it, and said layers being normally slack when relatively hot but deformable upon cooling to a substantially linear condition, the distance between the freezer and cooler being constant when subject to said extremes of heat and cold while a portion of said freezer moves laterally.




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