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GAS ENGINE-REFRIGERATOR

Filed Dec. 23, 1968

FIG. 1

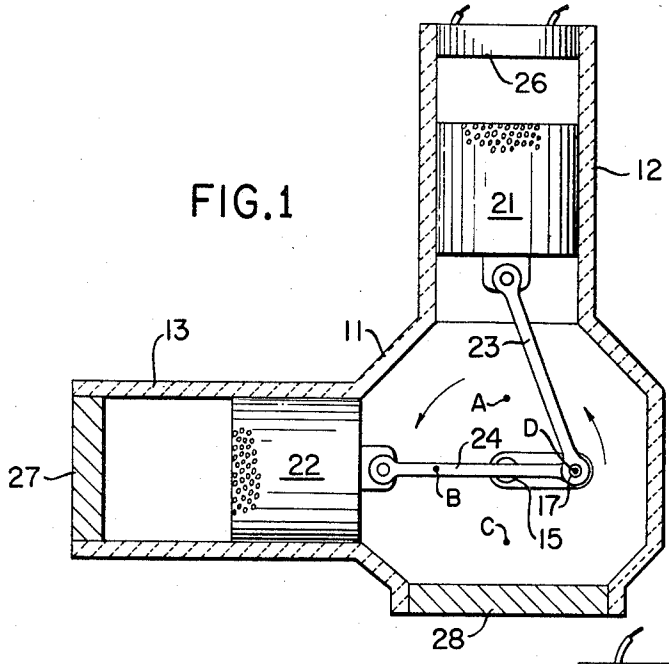


FIG. 2

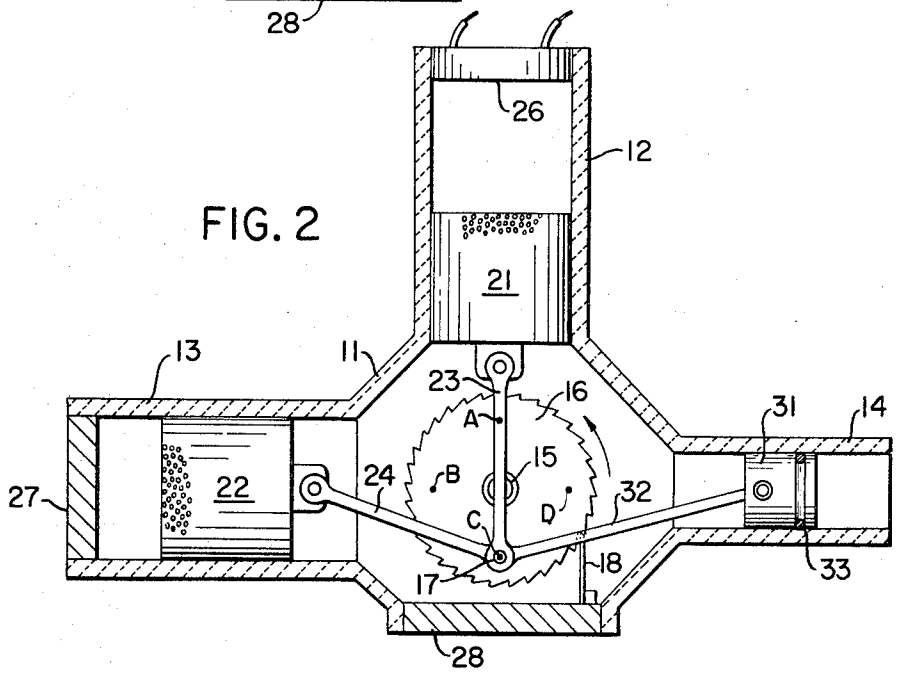
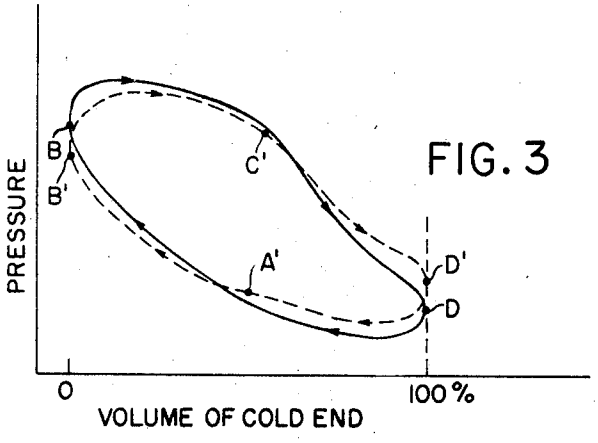


FIG. 3



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GAS ENGINE-REFRIGERATOR

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ABSTRACT OF THE DISCLOSURE

The apparatus has an enclosure with protruding closed-end cylinders arranged in out-of-phase relationship wherein porous blocks functioning as regenerators are connected to a common crank on a crankshaft so that the porous blocks slide in their respective cylinders. The apparatus includes means, in the form of a piston and cylinder assembly disposed substantially opposite one of the closed-end cylinders, for changing the total volume of the enclosure. The piston is subjected to a substantially steady pressure and the piston is also connected to the common crank. A heat source is applied to the other closed-end cylinder so that when the crankshaft is started to rotate in a given direction, a low temperature refrigeration is obtained in the cylinder without the heat source, and, with a predetermined quantity of gas in the enclosure, uninterrupted energy may be coupled from the crankshaft.

This invention relates to machines adapted to use input heat as a power source to induce engine operation, whereby useful work, refrigeration or both may be obtained.

In U.S. Pat. No. 1,275,507, R. Vuilleumier teaches a process for obtaining refrigeration wherein the secondary effect of temperature changes due to changes in pressure is used to obtain refrigeration.

An object of this invention is to provide a novel machine that uses substantially the Vuilleumier Refrigeration Process to provide either refrigeration or useful mechanical work which may be used to overcome friction and thus eliminating any need for an external power supply.

Another object is to provide a rigid, reliable machine for the above-mentioned object.

These and other objects and features of advantages will be further understood by reference to the following specification and the drawing wherein:

FIG. 1 is a schematic of a typical prior art refrigerator using the Vuilleumier Refrigeration Process.

FIG. 2 is a schematic of the novel gas engine-refrigerator; and

FIG. 3 is a plot of pressure versus the position of the regenerator within the cold well for the prior art refrigerator of FIG. 1 and the novel gas engine-refrigerator of FIG. 2.

SUMMARY OF THE VUILLEUMIER PROCESS

Referring to the drawing and to FIG. 1 in particular, the Vuilleumier Refrigeration Process will be explained in conjunction with the machine shown, which includes an enclosure **11** with two appendages communicating therewith. The appendages include a hot cylindrical sleeve **12**, and a cold cylindrical sleeve **13**, protruding radially from an axis at which is located a shaft **15**. Sleeves **12** and **13** have their axes oriented approximately at right angles to each other. Within sleeves **12** and **13** are disposed regenerators **21** and **22**, respectively. The regenerators are made of a porous metal to allow gas to freely pass therethrough and, in addition, to store heat so that any gas passing therethrough will either absorb heat from or give up heat to the regenerators. The regenerators **21** and **22** are disposed in sliding relation within their respective sleeves and are connected to the same crank **17** on shaft **15** by connecting rods **23** and **24**, respectively. On the end of the hot sleeve **12** is disposed a means **26** which seals the end thereof. The means **26** is at an elevated temperature, as it is heated by any suitable heat source, so that the means **26** supplies energy to the system. On the end of the cold sleeve **13** is disposed another means **27** which seals the end thereof and acts as a heat load, as it is capable of becoming cold when the device is operated. Enclosure **11** has a heat conducting wall **28** which functions as a heat sink and could be exposed to the atmosphere to maintain the gas, bounded by enclosure **11** and both regenerators, at ambient temperature. Means such as a radiator (not shown) may be employed to modify the ambient temperature to some value between the temperature of means **26** and means **27**.

The device operates by rotating the shaft **15** in the counterclockwise direction as shown by the arrows in FIG. 1. When hot regenerator **21** is near means **26** or crank **17** is at position A, very little or none of the gas within the sleeve **12** is at the hot temperature of means **26**, while cold regenerator **22** has travelled approximately half the distance towards means **27**. The pressure within enclosure **11** is inherently at a relatively low value as shown in FIG. 3 by point A on the solid line. The solid line shows the relative pressure within the enclosure with respect to the position of the cold regenerator **22** or the volume of gas at the cold end **27** for the machine FIG. 1. As the crank **17** moves from point A to point B (FIG. 1) the volume of the hot gas within sleeve **12** increases while the volume of the cold gas within sleeve **13** decreases. This causes the average pressure of the gas to increase as shown by the solid line from point A to point B (FIG. 3). The increase in average pressure tends to increase the temperature of the gas within enclosure **11**, but wall **28** being at ambient temperature maintains this gas at ambient temperature by removing heat. When the crank **17** moves from point B to C (FIG. 1) the volumes of both the hot and cold gases increase together. The temperature of means **26** and **27** could be such that the pressure varies very little, as shown by the curve from points B to C. When the crank moves from position C to D, the volume of the hot gas decreases while the volume of the cold gas increases. The average pressure, within the enclosure, drops appreciably and tends to drop the temperature of the gas within the enclosure **11** and within the cold sleeve **13**. The gas within the enclosure **11** is maintained at ambient temperature by absorbing heat through wall **28**. However, the gas in sleeve **13** disposed between regenerator **22** and the means **27** may only absorb heat from means **27** dropping the temperature thereof. Heat is absorbed from means **27** during each cycle or revolution of the shaft **15**. The area bounded by the solid line in FIG. 3 indicates the amount of energy that is theoretically absorbed from means **27** for each cycle.

THE NOVEL APPARATUS

Referring to FIG. 2, there is shown an embodiment of a novel device which can perform useful work by using the process discussed above. Parts, in FIG. 2, having the same reference numbers as parts in FIG. 1, perform the same function and are equivalent, except that enclosure **11** has a means for changing the volume thereof. The means is a movable wall, for example, in the form of a piston **31** that moves in a cylinder **14** to change the volume of the enclosure **11**. The cylinder **14** is substantially aligned with cylinder **13** and disposed on the opposite side of the crank **17**. The piston **31** is connected at its crank end to crank **17** by a connecting rod **32**. A suitable seal, for example, a piston ring **33** is provided between the piston **31** and the cylinder **14**. The head end of cylinder **14** may

be open to the atmosphere so that atmospheric pressure acts on the top of the piston. A ratchet disc **16** is fixed to the rotating shaft **15** and has suitable teeth that engage a pawl **18** in a standard manner that allows disc **16** to rotate only in the counterclockwise direction as viewed in FIG. 2 and in the direction of the arrow. Now, as disc **16** rotates in the direction of the arrow the pressure within the enclosure **11** will rise to a value above atmospheric and fall to a value below atmospheric. The piston **31**, being connected to a crank **17**, moves away from the center of the enclosure when the cold regenerator **22** moves towards the center and the piston moves towards the center when the cold regenerator moves away so that both actions aid in either increasing or decreasing the average pressure within the device when crank **17** is at points B and D (FIG. 2) respectively. Thus, when the crank **17** is at position A, the piston **31** is midway between its ends of travel and the pressure within the enclosure would approximately be the same as in the embodiment in FIG. 1 with the crank **17** in the same position A. This is shown in FIG. 3 by the dash lines crossing the solid line near point A. Then, when the crank **17** of FIG. 2 moves to position B the pressure within the enclosure would be at a value, for example B′ (FIG. 3), which is lower than point B. When the crank **17** moves to position C, the pressure within the enclosure would again be approximately the same as in the embodiment of FIG. 1, with the crank **17** in the same position C. When the crank **17** moves to position D, the pressure within the enclosure would be at a value D′ (FIG. 3) which is higher than point D.

Therefore, when the crank **17** is at position D, atmospheric pressure causes the piston to move inward so that, after crank **17** passes position A, inertia carries the crank **17** to position B. The internal pressure now acts to move piston **31** outward. The thermodynamic cycle of this embodiment of FIG. 2 is represented by the dash line in FIG. 3. The area enclosed by the dash line is obviously smaller than the area enclosed by the solid line indicating that some refrigeration has been traded off for work. The engine disclosed may be powered by any available heat supply and operated to concurrently provide a refrigerating effect at any temperature range below ambient and a mechanical work ouput. The engine is particularly useful in installations where simplicity in construction and trouble-free service are required. One skilled in the art can substitute a flexible diaphragm for the piston to further improve its reliability. Also, the need for a tight seal **33** can be reduced by closing off the cylinder **14** to form a reservoir having a substantially steady pressure at other than ambient pressure. Thus, gas escaping past seal **33** does not leave the system, and an equilibrium pressure in the reservoir is achieved. The apparatus may be started to work by varying the pressure in the reservoir or by rotating the apparatus to cause the chankshaft to rotate by the inertia of the components. Other modifications of the invention will appear to those skilled in the art. Accordingly, the invention is not limited to the exact details of the illustrated embodiments but includes all such modifications and variations coming within the scope of the claims.

What is claimed is:

1. An apparatus adapted to deliver mechanical work output and refrigeration, said apparatus comprising:
- an enclosure containing an amount of gas,
- a cold well and a hot well communicating with said enclosure and extending radially from an axis,
- a heat source disposed on the end of said hot well,
- a regenerator disposed within each of said wells and in sliding relation therewith,
- means for moving said regenerators in a predetermined sequence so that the gas pressure within said enclosure varies and in turn refrigeration is obtained within said cold well, and
- means responsive to the position of the regenerator within said cold well to vary the effective volume of said enclosure to cause further pressure variations so that power may be extracted from the apparatus.

2. The apparatus of claim **1** wherein:
- said means includes:
- a piston and a cylinder wherein said piston slides axially of said cylinder,
- said piston having a head end and a crank end;
- rod means connecting said crank end of the piston to said crankshaft so that said piston moves inwardly as said regenerator in said cold well moves outwardly, and
- means for applying a pressure to the head end of said piston.

3. The apparatus of claim **2** wherein:
- said cylinder is disposed substantially on the opposite side of said crankshaft from said cold well, and
- said regenerators and said piston are connected to a common crank on said shaft so that said piston and said regenerator in said cold well move in the same direction.

4. The apparatus of claim **3** wherein:
- said wells and cylinder are disposed at an angle of substantially 90° to each other with said hot well disposed between said cold well and said cylinder, and
- means are provided for causing the crankshaft to rotate in one direction so that the crank rotates through an angle of substantially 90° from its position closest to said hot well to its position closest to said cold well.

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WILLIAM J. WYE, Primary Examiner

U.S. Cl. X.R.

60—24; 62—86