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LIQUID PISTON GAS PUMP

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Fig. 1

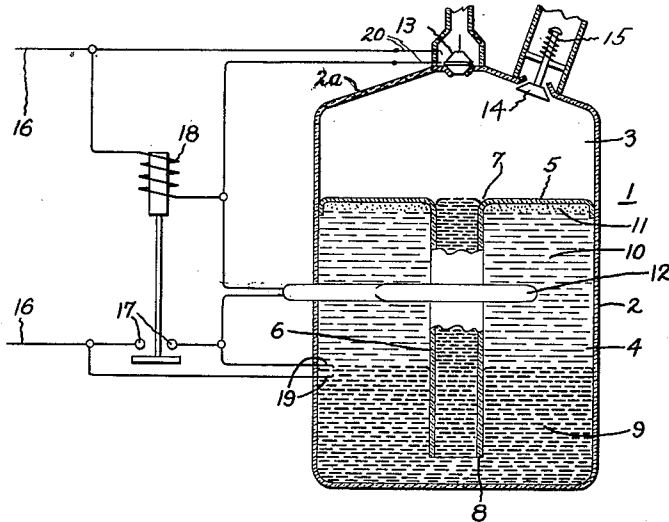
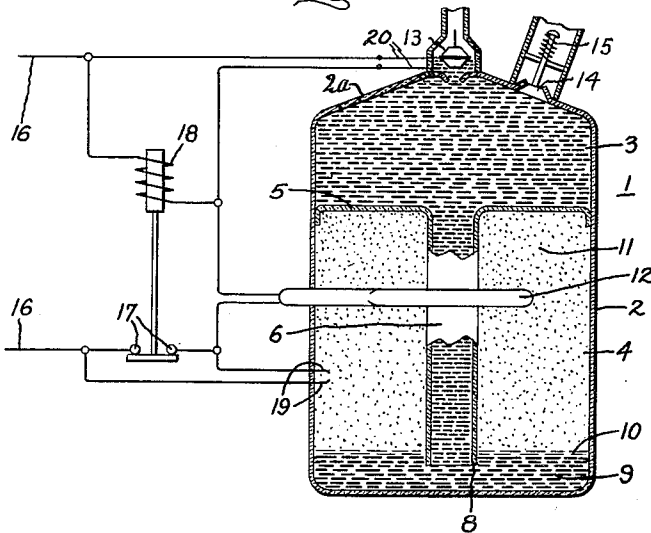


Fig. 2



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LIQUID PISTON GAS PUMP

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9 Claims. (Cl. 230—83)

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This invention relates to pumps for pumping gases and, more particularly, to pumps which require a low energy input and are particularly well adapted for maintaining a vacuum in an evacuated space.

It has been proposed that refrigerators or the like should be insulated by evacuating the space between the inner and outer walls of the cabinets. One way of maintaining this vacuum is by use of a vacuum pump to remove any air which might leak into the evacuated space.

It is, therefore, an object of this invention to provide a pump which is suitable for maintaining a vacuum in the walls of a refrigerator which is compact, inexpensive, and which operates in a simple trouble-free manner employing a minimum number of moving parts and requiring a relatively low amount of input energy.

Further objects and advantages of this invention will become apparent as the following description proceeds, and the features of novelty which characterize this invention will be pointed out with particularly in the claims annexed to and forming part of this specification.

In carrying out the objects of this invention, a pump is provided which includes a housing having an electrical-conducting liquid arranged to act as a pumping element and a vaporizable liquid therein. A heating element is provided for vaporizing the vaporizable liquid to effect pumping movement of the electrical-conducting liquid. A control circuit is arranged for automatically energizing and de-energizing the heating element when the electrical-conducting liquid occupies predetermined positions.

For a better understanding of the invention, reference may be had to the accompanying drawing in which Fig. 1 is a schematic diagram showing the structure of the pump of this invention in section together with the energizing circuit for the heater element; and Fig. 2 is a view corresponding to that of Fig. 1 in which the heater element is energized.

Referring more particularly to the drawing, in Fig. 1 an embodiment of the pump of this invention is shown and generally designated as 1, having a main housing 2 which may preferably be of a mechanically strong electrical insulating material, such as glass. Housing 2 is divided into an upper chamber 3 and a lower chamber 4 by a partition 5. The two chambers are connected by a long tube 6 which extends from a center opening at 7 in partition 5 into the lower chamber 4 to a point 8 which is near the bottom of the housing. The tube 6 extends downwardly

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from the opening 7 for at least three-quarters of the distance from the partition 5 to the bottom of the housing 2. The lower portion of lower chamber 4 is filled with an electrical-conducting liquid 9 of low vapor pressure, such as mercury, and the upper portion of the chamber is filled with an easily vaporizable liquid 10 having the required minimum vapor pressure for the application involved. The liquid 10 is chosen as one whose vapor pressure at the temperature range involved is low enough to secure the required vacuum. In the application to refrigerators, I have found that amyl alcohol, for example, has the desired characteristics. A small amount of the vapor from the vaporization of this liquid is shown at 11.

An electric immersion heater element 12 is immersed in the vaporizable liquid in the lower chamber 4. This heater element is provided for the purpose of vaporizing liquid 10 to force mercury 9 up through the tube 6 into the upper chamber 3.

In the top or dome 2a of housing 2, there is an outlet valve 13 which is closed by gravity and an inlet valve 14 which is biased towards the closed position by a spring 15. When the pump is used to maintain a vacuum, inlet valve 14 is connected to the evacuated space and outlet valve 13 to the atmosphere.

The electrical circuit, by means of which heater element 12 is energized, includes input conductors 16, which are connected to a suitable source of electrical energy, relay contacts 17, the heater element 12, and relay coil 18. A lower pair of control electrodes 19, which extend into the lower chamber, are connected in parallel with relay contacts 17, and an upper pair of control electrodes 20, which extend into the outlet passage at valve 13, are connected in parallel with the relay coil 18. The outlet passage at valve 13 is hereinafter referred to as a portion of upper chamber 3.

The operation of the pump is as follows. The mercury 9 in the lower portion of chamber 4, when at approximately the level shown in Fig. 1, provides an electrical connection between the electrodes 19. This electrical connection completes the power circuit from the power input lines 16 through heater 12 and relay coil 18, causing the relay to pick up and closing the relay contacts 17, as shown in Fig. 2. Since the relay coil 18 and the heater 12 are then energized through relay contacts 17, this circuit will remain energized after the level of mercury 9 recedes as shown in Fig. 2 so that electrodes 19

are no longer interconnected. The heat from heating element 12 vaporizes vaporizable liquid 10, causing an increase in the amount of vapor 11 and a decrease in the amount of liquid 10, creating a pressure in the upper portion of the lower chamber 4 and forcing the level of mercury 9 downward to cause the mercury to rise in tube 6 into the upper chamber 3. This action is shown by Fig. 2 where the liquid 10 has been substantially completely vaporized so that chamber 4 is almost completely filled with vapor 11 in the portion above the level of the lower end of tube 6. As shown in Fig. 2, where the liquid 10 is substantially completely vaporized and the mercury 9 fills the upper chamber 3 and the tube 6, there is still sufficient mercury remaining in the lower chamber to extend above the lower end of the tube 6. In other words, the mercury extends at all times above the lower end of the tube 6. As the mercury rises to fill upper chamber 3 including the outlet chamber at valve 13, as shown in Fig. 2, the mercury electrically interconnects the electrodes 20 to interpose a low electrical impedance path in parallel with the relay coil 18, thus effectively de-energizing coil 18 and causing the relay to drop open, disconnecting contacts 17 and de-energizing the heater element. The heater element will not be re-energized till contacts 19 are again interconnected.

The temperature inside chamber 4 then gradually decreases, the vapor 11 gradually condensing until the mercury 9 has substantially completely returned to the lower chamber 4 to return the pump to the condition shown in Fig. 1. The contacts 19 are then again interconnected by the mercury and the cycle is repeated.

As the mercury rises in the upper chamber, outlet valve 13 opens and inlet valve 14 closes as shown in Fig. 2 to allow gases which have been contained in the upper chamber 3 to be displaced and ejected through the outlet valve 13. Valve 13 is preferably of a material which floats on mercury so that none will be trapped above the valve. The upper wall of the housing is preferably of a generally dome-like shape, as indicated at 2a, which may be conically shaped, as shown, or more nearly the shape of a spherical section with outlet valve 13 near the apex of the dome. Contacts 20 are preferably placed in the small chamber above valve 13 in order to assure that upper chamber 3 is completely filled and the gases are completely displaced before the heater element is de-energized. Contacts 20 may be alternatively placed below valve 13 however. As the mercury returns to the lower chamber on the cooling portion of the cycle, outlet valve 13 closes and inlet valve 14 opens to cause gases to enter upper chamber 3. Thus, the repeated movement of the liquid mercury into and out of upper chamber 3 causes operation of the pump to bring gases into the pump through the inlet valve and then eject the gases from the pump through the outlet valve.

When the pump is used to maintain a vacuum in an evacuated space, the energy input is automatically limited to what is actually required as follows. On the cooling portion of the cycle, when gases are being drawn into upper chamber 3 through the inlet valve 14, the factors causing pump operation are the weight of the mercury and the partial vacuum created by the condensing vapor 11. If the vacuum in the evacuated space, with which the pump is connected, has not been impaired by leakage of gases into

that vacuum, the above operating forces will be inadequate to return the mercury to the lower chamber 4 and contacts 19 will not be interconnected and the heating element 12 will therefore not be re-energized until the vacuum is again impaired and pump operation is required. Thus, the energy input to the pump is automatically limited to that which is actually needed to maintain the desired vacuum.

It will be seen from the above description that the pump of this invention provides an improved, economical, simple, maintenance-free structure having a minimum number of moving parts and providing a superior pump for maintaining a vacuum in an evacuated space with a minimum of energy input and consequent low operating cost.

While a certain specific embodiment has been shown and described, it will, of course, be understood that various modifications may be made in this invention without departing from the invention. The appended claims are, therefore, intended to cover any such modifications within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A pump comprising a housing, a partition dividing said housing into an upper chamber and a lower chamber, said partition including an opening therein, means defining a passage extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, an electrical-conducting liquid of low vapor pressure in the lower portion of said lower chamber and extending at all times above the lower end of said means, a vaporizable fluid in the upper portion of said lower chamber adjacent said first mentioned means, means for heating and vaporizing said fluid, means responsive to a predetermined level of said liquid in said lower chamber for energizing said heating means, means responsive to a predetermined level of said liquid in said upper chamber for de-energizing said heating means, and an inlet valve and an outlet valve at the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

2. A pump comprising a housing, a partition dividing said housing into an upper chamber and a lower chamber, said partition including an opening therein, means defining a passage extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, an electrical-conducting liquid of low vapor pressure in the lower portion of said lower chamber and extending at all times above the lower end of said means, a vaporizable fluid in the upper portion of said lower chamber adjacent said first mentioned means, means for heating and vaporizing said fluid, means for controlling the energization of said heating means, said controlling means including two pairs of electrodes extending into said housing respectively into said upper and said lower chambers, the electrodes in each pair being adapted to be electrically interconnected by said liquid when said liquid rises to a predetermined level in the associated chamber, and an inlet valve and an outlet valve at the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

3. A pump comprising a housing, a partition dividing said housing into an upper chamber and a lower chamber, said partition including an

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opening therein, a hollow tube extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber adjacent said tube, means for heating and vaporizing said fluid, means for controlling the energization of said heating means, two pairs of electrodes extending into said housing respectively into said upper and said lower chambers, the electrodes in each pair being adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in the associated chamber, said electrodes being connected and arranged to control the operation of said controlling means, an inlet valve and an outlet valve at the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

4. A pump comprising a housing, a partition dividing said housing into an upper chamber and a lower chamber, said partition including an opening therein, a hollow tube extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber adjacent said tube, a first means for heating and vaporizing said fluid, a second means for controlling the energization of said first means, two pairs of electrodes extending into said housing respectively into said upper and said lower chambers, the electrodes in each pair being adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in the associated chamber, said electrodes being connected and arranged to control the operation of said second means, the upper portion of said housing having a dome shape, an outlet valve disposed at the apex of said dome in its closed position and an inlet valve adjacent said outlet valve, said valves being arranged for respectively discharging and admitting fluid to be pumped.

5. A pump comprising a housing, a partition dividing said housing into an upper chamber and a lower chamber, said partition including an opening therein, a hollow tube extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber adjacent said tube, means for heating and vaporizing said fluid, a relay for controlling the energization of said means, two pairs of electrodes extending into said housing respectively into said upper and said lower chambers, the electrodes in each pair being adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in the associated chamber, said electrodes being connected and arranged to control the operation of said relay, the upper portion of said housing having a dome shape, an outlet valve disposed at the apex of said dome in its closed position and an inlet valve adjacent said outlet valve, said valves being arranged for respectively discharging and admitting fluid to be pumped.

6. A pump comprising a housing, a partition dividing said housing into an upper chamber and

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a lower chamber, said partition including an opening therein, a hollow vertical tube extending downwardly from said opening into said lower chamber to interconnect said upper chamber with said lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber surrounding said tube, means for heating and vaporizing said fluid, a relay for controlling the energization of said means, two pairs of electrodes extending through the walls of said housing respectively into said upper and said lower chambers, the electrodes in each pair being adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in the associated chamber, said electrodes being connected and arranged to control the operation of said relay, and an inlet valve and an outlet valve at the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

7. A pump comprising a housing, a horizontal partition in said housing dividing the space within said housing into an upper chamber and a lower chamber, said partition including an opening, a hollow tube extending downwardly from said opening into said lower chamber to interconnect said upper chamber and said lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber surrounding said tube, an electrical heater immersed in said vaporizable fluid for heating and vaporizing said fluid, an electrical circuit for energizing said heater including a relay having a coil and a pair of normally open contacts connected in series with said heater, the series combination of said contacts, said heater, and said relay coil being connected to a suitable source of electric power, a first pair of electrodes connected in parallel with said contacts and extending into said lower chamber and adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said lower chamber to energize said coil, a second pair of electrodes connected in parallel with said relay coil and extending into the upper portion of said upper chamber to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said upper chamber to de-energize said coil, and an inlet valve and an outlet valve in the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

8. A pump comprising a housing, a horizontal partition in said housing dividing the space within said housing into an upper chamber and a lower chamber, said partition including an opening near the central portion thereof, a hollow vertical tube extending downwardly from said opening into said lower chamber for at least three quarters of the distance from said partition to the bottom of said housing to interconnect said upper chamber and lower chamber, liquid mercury in the lower portion of said lower chamber and extending at all times above the lower end of said tube, a vaporizable fluid in the upper portion of said lower chamber surrounding said tube, an electrical heater immersed in said vaporizable fluid for heating and vaporizing said fluid, an electrical circuit for energizing said heater including a relay having a coil and a pair of normally open contacts connected in series

with said heater, the series combination of said contacts, said heater, and said relay coil being connected to a suitable source of electric power, a first pair of electrodes connected in parallel with said contacts and extending through the side wall of said housing into said lower chamber and adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said lower chamber to energize said coil, a second pair of electrodes connected in parallel with said relay coil and extending into the upper portion of said upper chamber and adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said upper chamber to de-energize said coil, and an inlet valve and an outlet valve in the upper portion of said upper chamber for respectively admitting and discharging fluid to be pumped.

9. A pump comprising a housing, a horizontal partition in said housing dividing the space within said housing into an upper chamber and a lower chamber, said partition including an opening near the central portion thereof, a hollow vertical tube extending downwardly from said opening into said lower chamber for at least three quarters of the distance from said partition to the bottom of said housing to interconnect said upper chamber and said lower chamber, liquid mercury in the lower portion of said lower chamber, said mercury being sufficient in amount to concurrently fill said upper chamber, said tube, and the portion of said lower chamber from the lower end of said tube to the bottom of said housing, a vaporizable fluid

in the upper portion of said lower chamber surrounding said tube, an electrical heater immersed in said vaporizable fluid for heating and vaporizing said fluid, an electrical circuit for energizing said heater including a relay having a coil and a pair of normally open contacts connected in series with said heater, the series combination of said contacts, said heater, and said relay coil being connected to a suitable source of electric power, a first pair of electrodes connected in parallel with said contacts and extending through the side wall of said housing into said lower chamber and adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said lower chamber to energize said coil, a second pair of electrodes connected in parallel with said relay coil and extending into the upper portion of said upper chamber and adapted to be electrically interconnected by said mercury when said mercury rises to a predetermined level in said upper chamber to de-energize said coil, and an inlet valve and an outlet valve in the top of said upper chamber for respectively admitting and discharging fluid to be pumped.

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