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Apparatus for Pumping Low-Temperature Liquids

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WPI Class of 1908

May 31, 1932. R. H. GODDARD 1,860,891

APPARATUS FOR PUMPING LOW TEMPERATURE LIQUIDS

Filed April 23, 1930 2 Sheets-Sheet 1

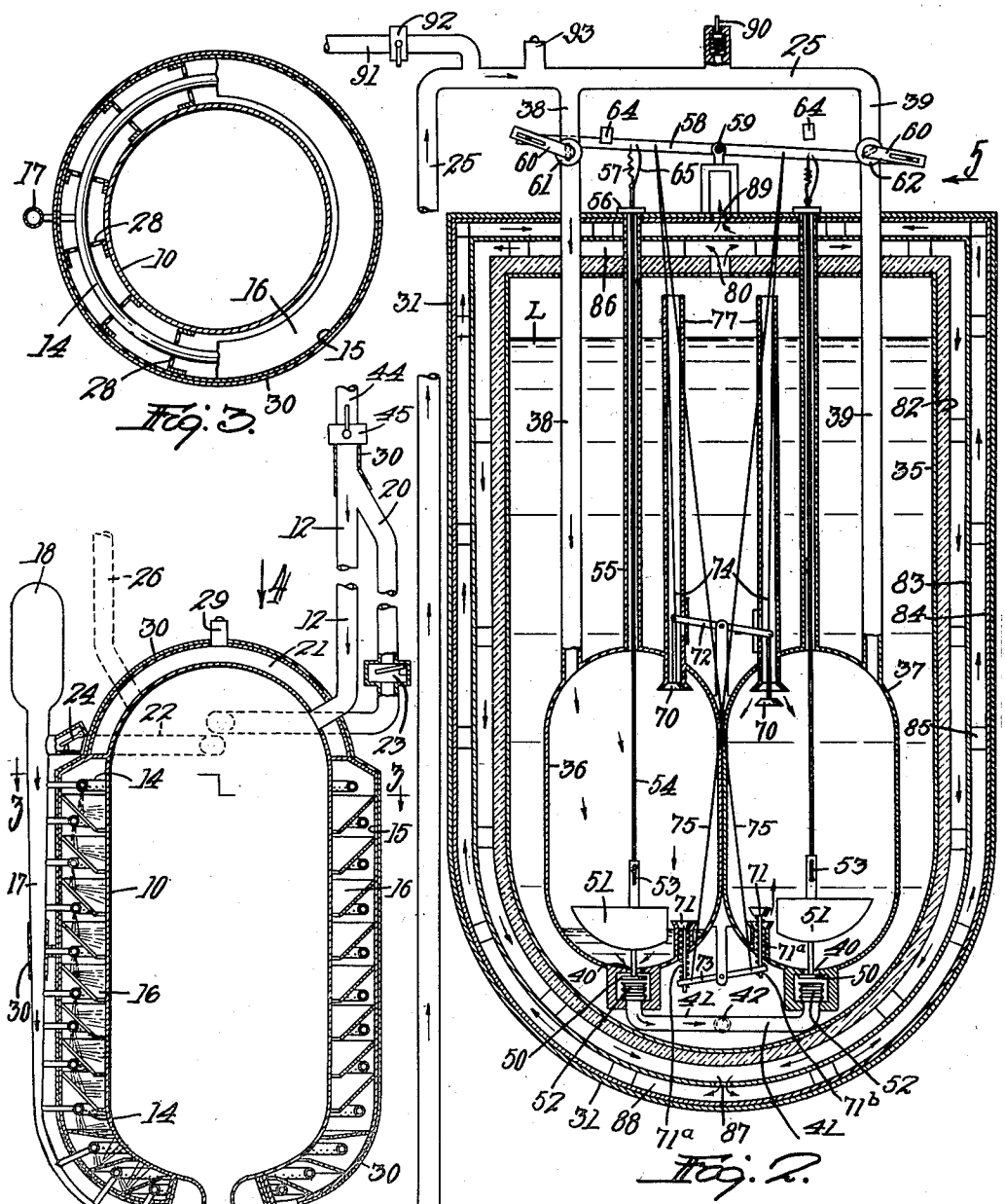

Fig. 3.

Fig. 2.

Fig. 1.

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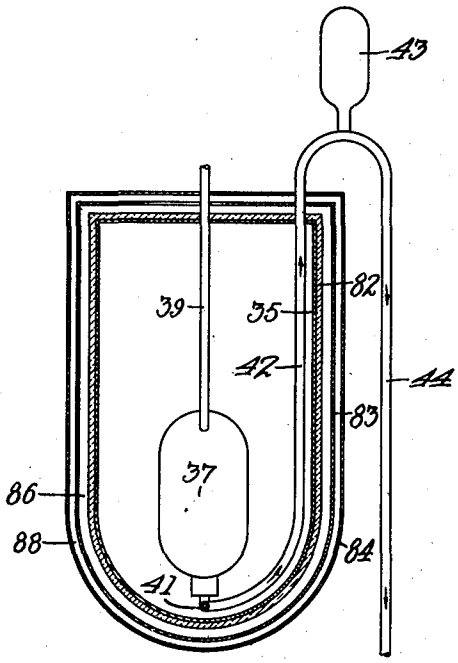


Fig. 5.

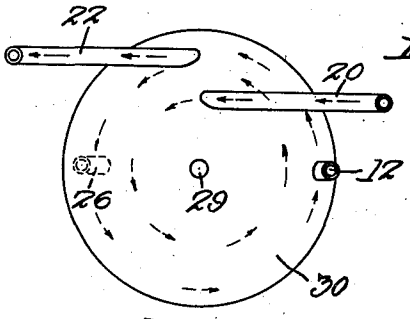
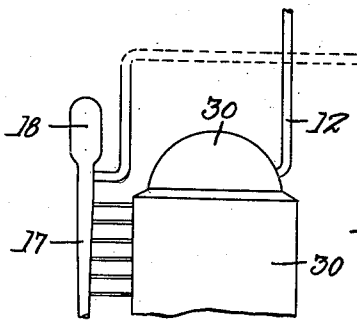


Fig. 4.



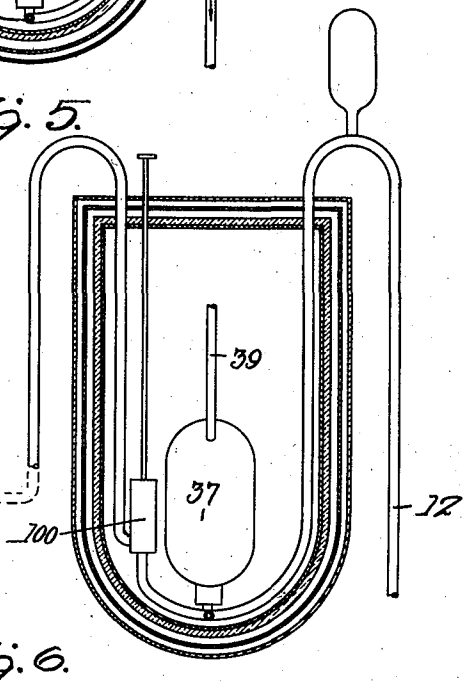


Fig. 6.

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APPARATUS FOR PUMPING LOW TEMPERATURE LIQUIDS

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This invention relates to an apparatus particularly adapted for pumping liquid air or other liquids having relatively low boiling points.

It is desirable in handling such liquids that the moving parts be simplified and reduced in number as much as possible, as effective lubrication is very difficult in such mechanism on account of the extreme low temperature of the liquid.

It is the object of my invention to provide a pumping apparatus in which the pumping action is produced by vapor pressure in a closed pumping chamber.

A further object is to provide an apparatus in which the vapor is produced by evaporation of a portion of the liquid being handled and in which such evaporation is preferably utilized for cooling the walls of a combustion chamber in which high temperatures are developed.

My invention also relates to an improved method of pumping a low temperature liquid by utilizing vapor pressure developed by evaporation of a portion of the same liquid.

My invention further includes arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawings, in which

Fig. 1 is a sectional side elevation of the vaporizing portion of my improved apparatus;

Fig. 2 is a sectional side elevation of the pumping mechanism;

Fig. 3 is a sectional plan view taken along the line 3—3 in Fig. 1;

Fig. 4 is a plan view of certain parts, looking in the direction of the arrow 4 in Fig. 1;

Fig. 5 is a side elevation, partly in section, looking in the direction of the arrow 5 in Fig. 2; and

Fig. 6 is a side elevation, partly in section, showing a modified construction.

My improved pumping apparatus comprises two closely related mechanisms. In the first or vaporizing mechanism a liquid having a low boiling point, such as liquid air or hydrogen, is evaporated under such conditions as to develop vapor under pressure. This vapor under pressure is transferred to the second part of the apparatus in which the vapor thus generated is utilized for pumping more of the same liquid, or of any other corresponding low temperature liquid, and for delivering the same to any desired point.

Vaporizing mechanism

Referring first to the vaporizing mechanism shown in Figs. 1 and 3, I have indicated a combustion chamber 10 having an outlet in the form of a nozzle 11 through which the products of combustion are discharged. Such combustion chamber and nozzle may form part of a rocket mechanism or may be utilized to develop power or for any other desired purpose.

Fuel, preferably in liquid form, is fed to the combustion chamber 10 through an inlet pipe 12, and the combustion is preferably continuous. Very high temperatures are developed in the combustion chamber 10, and special provision is necessary for cooling the walls thereof.

For this purpose I provide a series of annular perforated pipes 14 surrounding the chamber 10 and enclosed by an outer wall or jacket 15. Baffle plates 16 are secured to the jacket 15 and are so positioned that the sprays of liquid delivered from the pipes 14 will strike the baffle plates and will be diverted against the wall of the chamber 10 in a finely intermingled and evenly distributed condition.

The liquid is delivered to the annular pipes 14 from a supply pipe 17, preferably tapering toward its lower end so that an even pressure may be maintained upon the several different spray pipes. A pressure chamber 18 may be connected to the supply pipe 17 to assist in maintaining an even flow of liquid.

Liquid under pressure may be supplied to the pipe 17 by any desired mechanism, but I have shown in Figs. 1 and 5 a construction by which the liquid may be supplied under pressure developed from the high temperature in the combustion chamber 10.

For this purpose, a branch pipe 20 from the supply pipe 12 is connected into a closed space 21 surrounding the upper end or dome of the chamber 10. The branch pipe 20 enters this closed space in a tangential direction, as indicated in Fig. 4, and a similar tangential outlet pipe 22 connects the closed space 21 to the pipe 17 which supplies the spray pipes 14. A check valve 23 is provided in the branch pipe 20 and a second check valve 24 is provided in the connection 22.

The pipe 20 is preferably extended to a substantial height above the check valve 23, so that a considerable weight of liquid may be present in the pipe 20.

The space between the chamber 10 and the jacket 15 forms an air-tight enclosure which is connected at its lower end to an outlet pipe 25. If a mixture of liquid fuels is to be burned in the combustion chamber 10, an additional fuel supply pipe 26 is provided.

As the walls of the combustion chamber 10 are subjected to substantial pressure and are commonly formed of quite thin metal, a series of braces 28 (Fig. 3) are preferably provided between the wall of the chamber 10 and the jacket 15. These braces may preferably be formed of perforated metal so as to interfere as little as possible with the free circulation and delivery of the liquid spray.

The method of operation of this part of my apparatus is as follows:—

Combustion being started in the chamber 10, the walls thereof are quickly heated to a high temperature. A low temperature liquid being allowed to flow through the branch pipe 20, a portion thereof enters the closed space 21 and is immediately vaporized by the high temperature of the end wall of the chamber 10. Vapor under pressure is thus generated which acts to close the check valve 23 and to force the surplus liquid and vapor through the check valve 24 into the feed pipe 17. The tangential positions of the pipes 20 and 22 introduce the liquid into the chamber 21 with a whirling action and the surplus liquid is thrown to the outer portions of the space 21 into which the pipe 22 projects.

As the remaining liquid in the space 21 is vaporized, the pressure falls, allowing the valve 23 to open and admit a further charge of liquid, which is again vaporized, and the same cycle of operations takes place. A safety valve 29 prevents an excessive rise in pressure in the space 21. In this way an intermittent flow of liquid to the feed pipe 17 is produced without the employment of pumping apparatus involving the use of moving pistons or similar mechanism. The action is somewhat similar to that of a hydraulic ram, and the pressure in the pipe 17 will be higher than in the branch pipe 20, as is necessary to overcome the vapor pressure in the jacket 15.

The liquid under pressure, being thus delivered through the feed pipe 17, is forced out through the openings in the spray pipes 14, and is quickly vaporized upon contact with the outer surface of the highly heated combustion chamber 10. Vapor under pressure is thus generated which escapes through the pipe 25 and is utilized for pumping operations in the second part of my apparatus, as will be hereinafter described.

The outer surface of the jacket 15, the feed pipe 17, and other associated parts may preferably be covered with a suitable heat-insulating material as indicated at 30 and 31 in Figs. 1 and 2.

Pumping apparatus

The mechanism for utilizing the vapor pressure generated as previously described, is shown in detail in Fig. 2. The liquid L to be pumped is contained in a tank or storage receptacle 35, which contains two pumping chambers 36 and 37, each of which is strongly constructed to withstand substantial pressures. The chambers 36 and 37 are preferably entirely immersed in the liquid L in the tank 35.

The delivery pipe 25 of the vaporizing apparatus is connected through branch pipes 38 and 39 to the upper ends of the pumping chambers 36 and 37. Each chamber has an outlet 40 at its lower end connected by branch pipes 41 to an outlet pipe 42, which preferably extends upwardly inside the tank 35, as indicated in Fig. 5, and passes through suitable stuffing boxes to the outside of the tank 35, where it may be provided with an air chamber or pressure regulator 43, and then extends downward, as indicated at 44, to deliver liquid at any desired point.

If desired, the lower end of the pipe 44 may be connected, as indicated in Fig. 1, to deliver liquid to the fuel supply pipe 12 and the branch pipe 20 previously described. A suitable valve 45 (Fig. 1) controls the flow through the pipe 44.

A valve 50 is provided for closing the opening 40 in the bottom of each pumping chamber 36 or 37. This valve 50 is provided with a stem extending upward through the opening 40 and connected to a float 51. As the valve 50 descends it engages and closes the open upper end of a resilient collapsible extension of the branch pipe 41 for a purpose to be described.

Each float 51 has a lost motion connection 53 with the lower end of a wire or rod 54, which extends upward through a tube 55 and stuffing box 56, and is connected at its upper end by a spring 57 to a rocking lever 58. The lever 58 is mounted on a fixed pivot 59, and the opposite ends of the lever engage arms 60 by which valves 61 and 62 in the pipes 38 and 39 may be alternately opened and closed. Spring clips 64 engage one end or the other of the lever 58 to hold it yield-

ingly in a given position until forcibly removed therefrom.

Vapor under pressure is forced through one of the branch pipes, as 38, into the pumping chamber 36. The liquid in the chamber is forced out through the opening 40, around the valve 50, and into the collapsible end 52 of the branch pipe 41, from which it is delivered to the pipe 42. When most of the liquid in the chamber 36 has been ejected, the float 51 falls to a point where the valve 50 closes the open end of the collapsible member 52. This prevents further flow through the pipe 41, but the continued admission of vapor under pressure through the pipe 38 exerts downward pressure on the callapsible member 52, depressing the same along with the valve 50 and float 51.

This causes downward movement of the wire 54, stretching the spring 57 until the tension of the clip 64 is overcome, after which the lever 58 reverses its position with a snap action, closing the valve 61 and opening the valve 62. A flexible but non-extensible connection 65 may be made between the lever 58 and the wire 54, so that a direct pull may be exerted if the spring 57 does not overcome the clip 64.

Each pumping chamber is provided with an upper valve 70 and a lower valve 71. The upper valves 70 are connected to a rocking lever 72 and the lower valves 71 are connected to a rocking lever 73. The opposite ends of the lever 72 are connected by wires 74 to the lever 58, and the opposite ends of the lever 73 are similarly connected by crossed wires 75 to the lever 58. When the lever 58 is reversed, the rocking levers 72 and 73 are also reversed, and the valves 70 and 71 in one of the pumping chambers will be opened while the corresponding valves in the other chamber will be closed.

Assuming that the chamber 36 has been emptied and the lever 58 is rocked from the position shown in Fig. 2 to its opposite position, the valves 70 and 71 in the emptied chamber 36 will be opened, while the corresponding valves in the opposite chamber will be closed. The chamber 36, being thus opened at the lower and upper ends, the liquid L in the tank 35 will flow into the chamber through the lower valves 71 and the vapor in the chamber will escape through the upper valve 70. As this vapor is commonly at high temperature and pressure and as it is desirable to evaporate as little as possible of the liquid L, I provide a pipe 77 above each upper valve 70, so that the vapor may pass upward to the space above the liquid L with little or no mingling with the liquid, thus reducing the evaporating effect. The lever 72 extends into each pipe 77 through a slot suitably covered and protected to prevent leakage into the pipe.

The connection from the lever 73 to each valve 71 is preferably through a compression spring 71^a through which yielding opening pressure is exerted. A cross pin 71^b in the valve stem provides for positive closing action. The spring 71^a allows the valve 71 to remain closed until the pressure in the chamber has been materially reduced by the escape of gas or vapor through the valve 70.

As soon as the emptied pumping chamber 36 or 37 begins to fill with liquid, the float 51 therein will rise and close the opening 40, thus preventing reverse flow through the corresponding branch pipe 41. The gas or vapor escaping through the pipe 77 leaves the tank 35 through an upper opening 80.

The tank 35 is preferably surrounded by a covering 82 and is preferably enclosed within an inner casing 83 and an outer casing or jacket 84, the parts 83 and 84 being supported in spaced relation to the tank 35 and covering 82 by spacing members 85, preferably of heat-insulating material.

Instead of discharging the vapor direct to the atmosphere, it is preferable to discharge the vapor through the opening 80 into the jacket space 86 between the covering 82 and the casing member 83. The vapor flows downward in the space 86 to an outlet 87 where it escapes into the space 88 between the casing 83 and the outer covering or jacket 84. The vapor then flows upward through this outer space to an opening 89 where it escapes to the atmosphere. The low temperature liquid L in the tank 35 is thus effectively protected from radiation to the atmosphere.

A manually operated vent valve 90 is provided for venting the pipe 25 when starting the apparatus, and a connection 91 having a valve 92 is provided through which gas or liquid under pressure may be admitted for starting the apparatus. A safety valve 93 may be added.

In Fig. 6, I have indicated the use of a simple manually operated pump 100 for placing the liquid under pressure in the feed pipe 17, this apparatus taking the place of the pulsating feeding mechanism previously described. By using this pump 100, a suitable pressure may be maintained in the pressure tank 18.

My improved pumping apparatus is particularly adapted for feeding liquid fuel to a continuous combustion chamber, such as may be used in rocket mechanism, and for similar purposes. The liquid contained in the feed pipe 17 cools the wall of the combustion chamber 10 when sprayed thereon, and prevents destruction thereof, while at the same time the heat of the chamber generates vapor pressure effective for operating the pumping apparatus. This vapor, being delivered alternately to the pumping chambers 36 and 37, produces a continuous flow of fuel from the tank 35 through the pipe 12 to the combustion chamber 10, and a portion of this

fuel is diverted through the branch pipe 20 to the feed pipe 17. The apparatus when once started is continuous in its operation until the tank 35 is substantially emptied.

In the claims the term "low temperature liquid" is intended to indicate a liquid having a relatively low boiling point.

Having described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims.

What I claim is:—

1. Apparatus for pumping low temperature liquids comprising a tank to contain the liquid, a pair of pumping chambers each having an inlet and an outlet for liquid, means to provide a continuous supply of vapor under pressure for said chambers, and means to render said vapor effective to force liquid from one of said chambers while the other chamber is being filled with liquid from said tank, said vapor supply means being connected to said liquid outlets.

2. Apparatus for pumping a low temperature liquid comprising a tank to contain the liquid, a pair of pumping chambers each having a liquid outlet, means to supply vapor under pressure, means to conduct said vapor to said pumping chambers, admission valves for said conducting means, upper and lower filling valve for said pumping chambers, an outlet valve for each chamber, and automatic valve controlling mechanism effective to actuate all of said admission, filling and outlet valves as said chambers are emptied and filled, whereby alternative and successive filling and emptying of said pumping chambers is affected, said vapor supply means being connected to said liquid outlets.

3. In an apparatus for pumping low temperature liquids, mechanism including a combustion chamber for producing vapor under pressure, pumping apparatus, and means to render said vapor effective in said pumping apparatus to pump a portion of said low temperature liquid, and to feed another portion of said liquid to said vaporizing mechanism.

4. In a pumping apparatus, a vaporizing mechanism comprising a heated combustion chamber, a closed casing surrounding said chamber but spaced therefrom, pumping means to pump a low temperature liquid, and to feed a portion of said liquid under pressure to said closed casing and to spray said liquid on the exterior surface of said combustion chamber within said closed casing, and means to conduct the vaporized liquid from said casing to said pumping means to provide an actuating force therefor.

5. In a pumping apparatus, a tank to contain the liquid to be pumped, a pumping chamber having an outlet port, an outlet connection from said port, an open collapsible member extending within said connection toward said port, and a float-controlled valve effective to close the port when the valve is raised and to close the open end of the collapsible member when the valve is lowered.

6. The combination in a pumping apparatus as set forth in claim 5 in which the valve and collapsible member are depressed by pressure in said chamber after said collapsible member is closed by said valve, said pumping chamber having an inlet for fluid under pressure and an inlet for the liquid to be pumped and valve-controlled mechanism therefor, is operated by such further movement of said valve.

7. In a pumping apparatus for low temperature liquids, a tank containing liquid to be pumped, a closed pumping chamber in said tank, means to generate vapor under pressure, means to admit the vapor under pressure to said chamber to eject the liquid contained therein and to feed a portion of such liquid to the generator as a source of vapor supply, valve means permitting escape of said vapor from said chamber as said chamber is filling, and means to conduct said vapor through the liquid of said tank to a vented portion of said tank above said liquid.

8. The combination in a pumping apparatus as set forth in claim 7 in which the conducting means comprises a tube rising above the surface of the liquid and connected at its lower end to the vapor outlet of said chamber.

9. The combination in a pumping apparatus as set forth in claim 7 in which a lower valve for inlet of liquid is provided in said chamber and actuating means to open said valve after the pressure in said chamber drops to a predetermined point.

10. In a pumping apparatus for low temperature liquids, a pair of pumping chambers each having an inlet and outlet for liquid, means connected to said liquid outlets, to admit vapor under pressure to said chambers alternately to eject liquid therefrom, valves controlling said admission means, and float-controlled means in said pumping chambers connected to simultaneously close one of said valves and open the other valve.

11. In a pumping apparatus for low temperature liquids, a pair of pumping chambers each having an inlet and outlet for liquid, means connected to said liquid outlets, to admit vapor under pressure to said chambers alternately to eject liquid therefrom, valves controlling said admission means, float-controlled means in said pumping chambers connected to simultaneously close one of said valves and open the other valve, and means to cause said valves to be moved with a snap action.

12. In a pumping apparatus, a combustion chamber, means to spray liquid under pres-

sure over a portion of said chamber, a casing forming a closed jacket space about another portion of said chamber, said casing having an inlet and an outlet, means to feed liquid to said jacket space, and means to conduct vapor and excess liquid from said space to said spraying means, thereby providing an actuating force therefor, a pumping chamber connected to said casing outlet, whereby said vapor will be effective as a pumping medium.

13. The combination in a vaporizing apparatus as set forth in claim 12 in which check valves are provided to prevent reverse flow of liquid or vapor with respect to the inlet or outlet of said closed jacket space.

14. The combination in a vaporizing apparatus as set forth in claim 12 in which check valves are provided to prevent reverse flow of liquid or vapor with respect to the inlet or outlet of said closed jacket space, and in which the liquid is introduced and the vapor and excess liquid is removed in substantially tangential directions with respect to said combustion chamber.

15. Apparatus for pumping low temperature liquids comprising a tank to contain the liquid, a pair of pumping chambers, means to provide a continuous supply of vapor under pressure for said chambers, means to render said vapor effective to force liquid from one of said chambers while the other chamber is being filled with liquid from said tank, and a surrounding casing for said tank enclosing a jacket space through which the vapor released from said pumping chambers passes before escape to the atmosphere.

16. Apparatus for pumping low temperature liquids comprising a tank to contain the liquid, a pair of pumping chambers, means to provide a continuous supply of vapor under pressure for said chambers, means to render said vapor effective to force liquid from one of said chambers while the other chamber is being filled with liquid from said tank, and a plurality of casings for said tank enclosing superposed jacket spaces through which the vapor released from said pumping chambers passes successively before escape to the atmosphere.

In testimony whereof I have hereunto affixed my signature.

ROBERT H. GODDARD.