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CRYOGENIC PUMPING SYSTEM

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Fig. 1

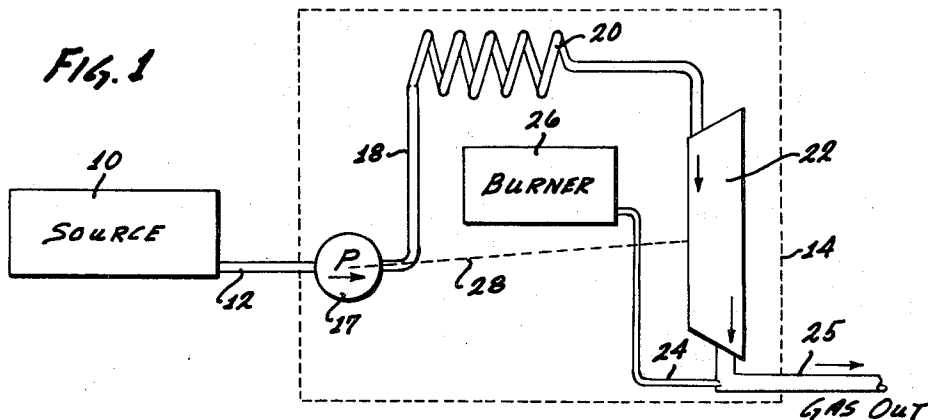


Fig. 2

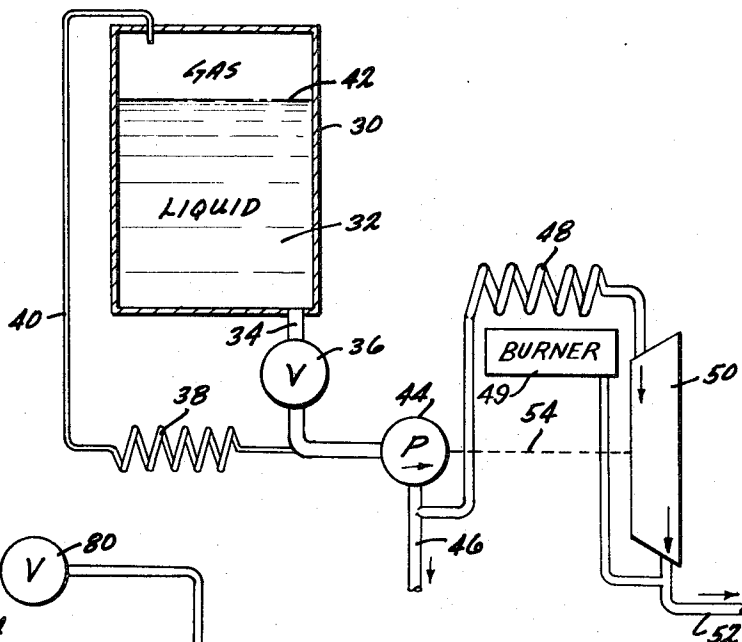
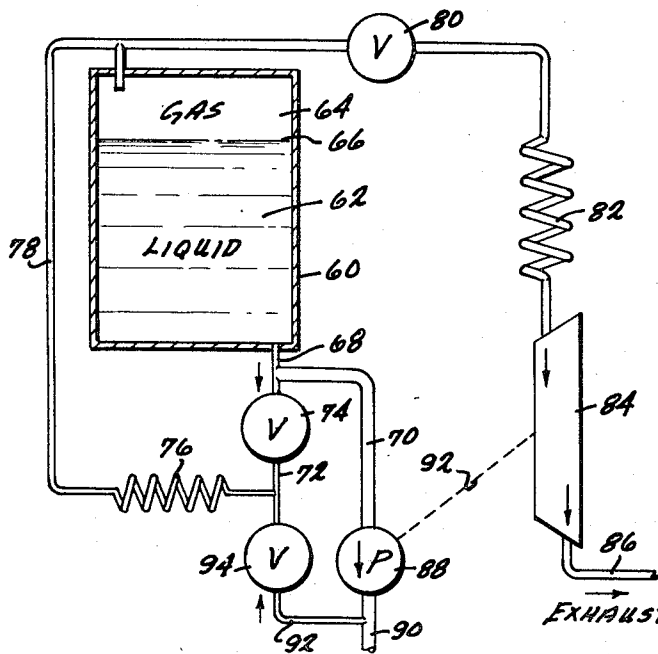


Fig. 3

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CRYOGENIC PUMPING SYSTEM

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5 Claims

ABSTRACT OF THE DISCLOSURE

A pumping system is disclosed for use in association with cryogenic fluid, to accomplish fluid flow by utilization of the negative energy stored by the cryogenic fluid. A heat exchange means receives the cryogenic fluid to gasify a quantity thereof and thereby drive a turbine which is connected to motivate a pump. One embodiment includes a burner to supply additional heat to the heat exchanger upon combination of spent gas from a turbine. In another embodiment a second heat exchanger is provided across the fluid interface of a cryogenic tank so as to pressurize the tank. Various check and other valves are also incorporated in the embodiments disclosed for controlling the flow of the fluid.

This application is a continuation-in-part of Ser. No. 504,349, filed Oct. 24, 1965, now Patent No. 3,451,342, granted June 24, 1969.

BACKGROUND AND SUMMARY OF THE INVENTION

In modern technology, the need sometimes arises to perform mechanical work in an environment which includes a reservoir of cryogenic fluid and a source of heat, as the atmosphere or some other mass or body having a non-cryogenic temperature. Typically, the need might arise for a fluid pump in such an environment as for transferring the cryogenic fluid from its container.

Considering applications of the present invention in somewhat greater detail, the expanded field of cryogenics has resulted in a widespread need for pumping systems to transport cryogenic fluid. For example, the need for a pumping system arises in the operation of transportation vehicles, pipelines, storage tanks and so on. In the past, it has been somewhat conventional to employ conventional pumping systems, e.g. an electric motor and fluid pump combination, in these applications. However, such conventional pumping systems are relatively expensive and require an integral electrical system or other auxiliary power source. Consequently, a considerable need exists for an effective, inexpensive and safe pumping system for transporting fluid in systems utilizing cryogenic fluid.

In general, the present invention comprises a simple pumping system which utilizes the negative energy of cryogenic fluid to power a turbine which is in turn mechanically coupled to a pump. The system incorporates heat exchangers and valves to afford the requisite control.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing, which constitutes a part of this specification, an exemplary embodiment demonstrating various objectives and features hereof is set forth as follows:

FIG. 1 is a schematic diagram illustrating a pumping system constructed in accordance with the present invention;

FIG. 2 is a schematic diagram illustrating an alternative embodiment of a pumping system incorporating the present invention; and

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FIG. 3 is a schematic diagram of still another embodiment of a pumping system incorporating the principles of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

Referring initially to FIG. 1, there is shown a source 10 of cryogenic fluid which may comprise a tank, a pipe, or virtually any source for providing a stream of cryogenic fluid. The source 10 is connected through a duct 12 to a pumping system 14. It is to be noted, that the pumping system 14 is provided energy by utilization of the cryogenic fluid flowing therethrough. In this regard, the pumping system 14 utilizes the negative energy of a cryogenic fluid then burns the spent cryogenic fluid to provide additional energy.

Considering the system 14 in greater detail, the duct 12 is coupled through a pump 17 (impeller or the like) to a duct 18 which is in turn connected through a heat exchanger 20 to a turbine 22. The discharge from the turbine 22 is to a duct 24 which is in turn connected to a burner 26 positioned in the proximity of the heat exchanger 20 and to a supply line 25.

The system of FIG. 1 is well suited to provide gaseous fuel (natural gas) to a distribution system (through line 25) from a cryogenic tank (source 10). In such an application, the system accomplishes the dual purposes of gasifying the fluid and delivering it at an elevated distribution pressure. Generally the system accomplishes these changes without external power because the negative energy of the cryogenic fluid is used. Such an operation involves the pump accomplishing a pressure that is greater than desired, so that the gas emerges in the line 25 at the desired pressure.

The heat exchanger 20 and the turbine 22 as well as the burner 26 may take a variety of well known forms of such elements. Specifically, for example, the turbine 22 may comprise a rotary high speed gas turbine, the drive shaft of which is connected to the pump by a mechanical linkage as indicated by the dashed line 28.

In the operation of the system as shown in FIG. 1, some external forces may be required for starting. For example, it may be necessary to drive the pump 17 externally in some systems until the operation is established. At that time, the pump 17 draws cryogenic fluid from the source 10 supplying a stream to the heat exchanger 20. The heat exchanger gasifies the cryogenic fluid as a result of exposure to ambient temperature as well as heat which may be drawn from the burner 26. Thus, gas at a substantial pressure is developed which is utilized to drive the turbine 22. The rotational drive of the turbine 22 is coupled to drive the pump 17, as indicated above through a mechanical coupling indicated by the line 28. The fluid from the turbine 22 (at elevated pressure) then flows to the burner 26 for combustion and to the distribution pipe or line 25. In this regard, the burner 26 may be controlled or even eliminated from the system in some applications in which ambient temperature is relied upon to gasify the cryogenic fluid. However, in the system as disclosed in FIG. 1, the burner affords an efficient means of utilizing gas from the turbine 22.

In the utilization of the negative energy of the cryogenic fluid, it is to be appreciated that the considerable negative temperature of the fluid results in a rapid heating thereof within the heat exchanger 20. Of course, as energy (heat) is drawn into the cryogenic fluid, it reaches the temperature of vaporization and is consequently gasified to drive the turbine 22. Of course, the utilization of the burner 26 in the system presumes that the cryogenic fluid is combustible, e.g. natural gas.

In the specific application for the system of FIG. 1, a pipeline is also applicable. That is, the duct 12 and the outlet line 25 may be portions of a pipeline through which liquid natural gas is to pass. The insertion of the pumping system 14 then results in the effective gasification of the cryogenic fluid as well as pressurization to flow through the pipeline. The system thus will accomplish an efficient, convenient, and economical delivery structure, which does not require auxiliary power apparatus or supply means.

As suggested above, the system hereof may take a variety of different forms, and may be integrated with various cryogenic structures. For example, FIG. 2 shows a system incorporating the principles of the present invention for use in conjunction with a storage tank 30 containing cryogenic fluid 32. The tank 30 may comprise a relatively low-pressure vessel with the result that auxiliary pumping means is required to expedite the flow of fluid therefrom. However, to supplement the operation of the pumping means, a structure is provided for accomplishing a limited pressure within the tank 30. Specifically, the outlet 34 from the tank is connected through a valve 36 and a heat exchanger 38 to a duct 40 that is returned to the top of the tank 30. Consequently, the heat exchanger 38 is coupled across the liquid-gas interface 42 defined within the tank 30. As a consequence, upon opening the valve 36, fluid is passed to the heat exchanger 38 to be gasified by ambient temperature. Upon gasification of the cryogenic fluid, it develops a pressure which is applied through the duct 40 to the interface 42 thereby forcing the cryogenic fluid 32 from the outlet 34 more effectively.

The main stream of cryogenic fluid flowing through the outlet 34 is supplied through a pump 44 to a discharge duct 46. A small stream of fluid is passed from the discharge duct 46 to a heat exchanger 48 wherein such fluid is gasified to drive a turbine 50. The spent fluid from the turbine 50 is discharged through a duct 52 and the rotary energy developed by the turbine 50 is coupled to drive the pump 44 as indicated by a dashed line 54. Consequently, the pump 44 effectively forces cryogenic fluid through the duct 46 in an efficient and convenient delivery operation.

In the system of FIG. 2, some initial starting forces may be necessary to initiate a delivery operation. However, alternatively, control may be accomplished simply by opening the valve 36. That is, systems may be designed which utilize an open pump 44 so that upon opening the valve 36 sufficient cryogenic fluid is provided to the heat exchanger 48 to initiate a "boot strap" operation which will promptly bring the system to peak operation. As shown, a burner 49 (similar to the burner 26 of FIG. 1) is provided contiguous to the heat exchanger 48 to receive a portion of the discharge from the turbine 50 to supply heat to the heat exchanger 48.

The system of FIG. 2 may be effectively employed in cooperation with tanker trucks, stationary tanks or various other structures utilizing a tank to contain a reservoir of cryogenic fluid from which deliveries are to be made.

Referring now to FIG. 3, there is shown another embodiment of a pumping system incorporating the present invention and including a tank 60, which comprises a vessel capable of containing substantial pressure. The tank 60 contains cryogenic fluid in a liquid phase 62 and a gaseous phase 64, the two being separated by an interface 66. The liquid phase of the cryogenic fluid is coupled to an outlet 68 which is in turn coupled to a main-stream duct 70 and a lesser stream duct 72 including a valve 74. The duct 72 is connected through a heat exchanger 76 and a duct 78 to re-enter the vessel or tank 60 at the gaseous phase 64. The duct 78 is also connected through a valve 80 and a heat exchanger 82 to a turbine 84 having an exhaust duct 86 for spent cryogenic fluid.

The main stream of cryogenic fluid passing from the

tank 60 through the duct 70 is propelled by a pump 88 which is coupled to a system outlet 90. The pump is also connected to provide a small stream through a duct 92 and a valve 94 back to the heat exchanger 76. Consequently, the heat exchanger 76 receives cryogenic fluid through both the valves 74 and 94.

In general, in the operation of the system of FIG. 3, the cryogenic fluid undergoes two stages of gasification. The first stage of gasification is accomplished in the heat exchanger 76 and serves to pressurize the tank 60 as well as to supply fluid to the heat exchanger 82 for further gasification resulting in pressure fluid for driving the turbine 84. As in the embodiments described above, the turbine is connected to drive the pump, specifically, turbine 84 is connected to the pump 88 as indicated by the dashed line 92.

In the operation of the system, the valve 74 may be opened preliminarily to supply a small quantity of fluid to the heat exchanger 76 which is gasified by heat from ambient and thereby pressurizes the tank as a result of re-entry into the gaseous phase 64. Upon opening the valve 80, cryogenic fluid is permitted to flow to the heat exchanger 82 for further gasification by ambient heat to thereby drive the turbine 84. As the turbine 84 is actuated, the pump 88 is driven to provide the main flow stream through the duct 90. Upon opening the valve 94, a portion of that stream is supplied back to the heat exchanger 76 to afford increased cryogenic fluid which establishes the system at a peak of operation.

A consideration of the above in conjunction with the theoretical considerations set forth in the above-referenced co-pending case by applicant indicates that a self-contained system is provided to effectively pump fluid without the requirement of a supply from an auxiliary power source. The system is effective, economical and very practical.

What is claimed is:

1. A pumping system for providing cryogenic fluid fuel at an elevated pressure, comprising:

a source means for providing cryogenic fluid fuel; heat-exchange means connected to receive said cryogenic fluid fuel from said source means and for receiving heat to thereby gasify a quantity of said fluid fuel;

a turbine means connected to said heat-exchange means to receive gasified fluid fuel from said heat-exchange means and be powered thereby to provide drive power;

a pump means coupled to said turbine means whereby to elevate the pressure of fluid fuel from said source and to thereby pump said fuel; and

a burner means connected to receive a portion of said fluid fuel exhausted from said turbine means, said burner means being affixed to supply heat to said heat-exchange means.

2. A pumping system according to claim 1 wherein said source means comprises a fluid container for storing a quantity of said cryogenic fluid fuel.

3. A pumping system according to claim 2, further including a second heat-exchange means, and means for connecting said second heat-exchange means around the phase interface of fluid in said container.

4. A pumping system according to claim 1, further including a valve means coupled to control the flow of cryogenic fluid from said source means.

5. A pumping system according to claim 1, wherein said source means comprises a fluid container for storing a quantity of said cryogenic fluid fuel, further including a second heat-exchange means, and means for connecting said second heat-exchange means around the phase interface of fluid in said container and further including a valve means coupled to control the flow of cryogenic fluid from said source means.

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