Oct. 17, 1933. H. E. THOMPSON 1,930,731

METHOD AND APPARATUS FOR TRANSFERRING LIQUID MATERIAL

Filed Dec. 14, 1932 2 Sheets-Sheet 1

Fig. 1

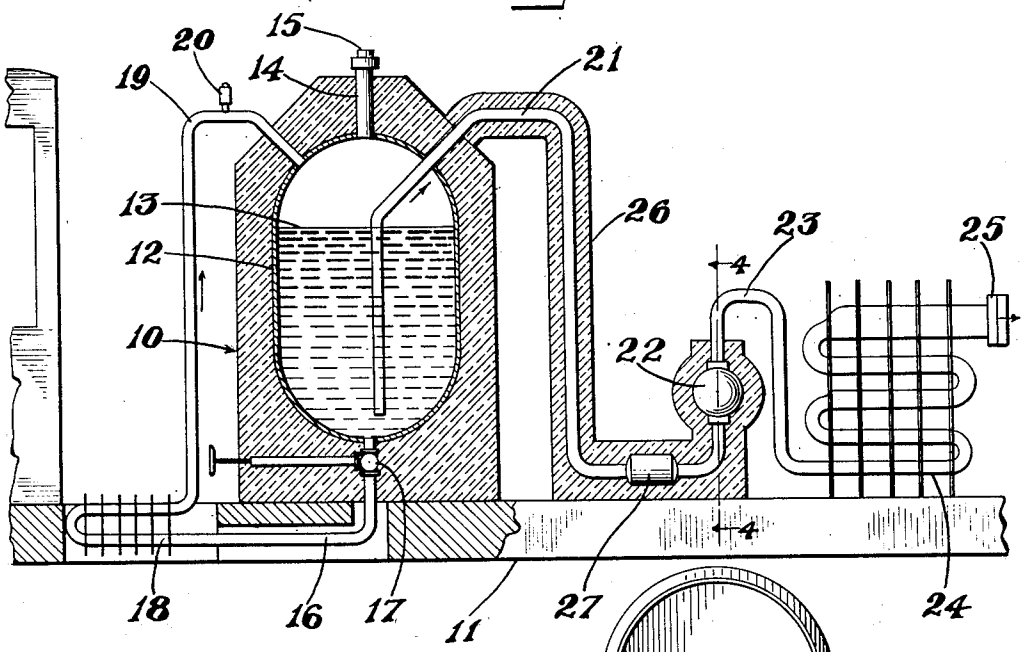
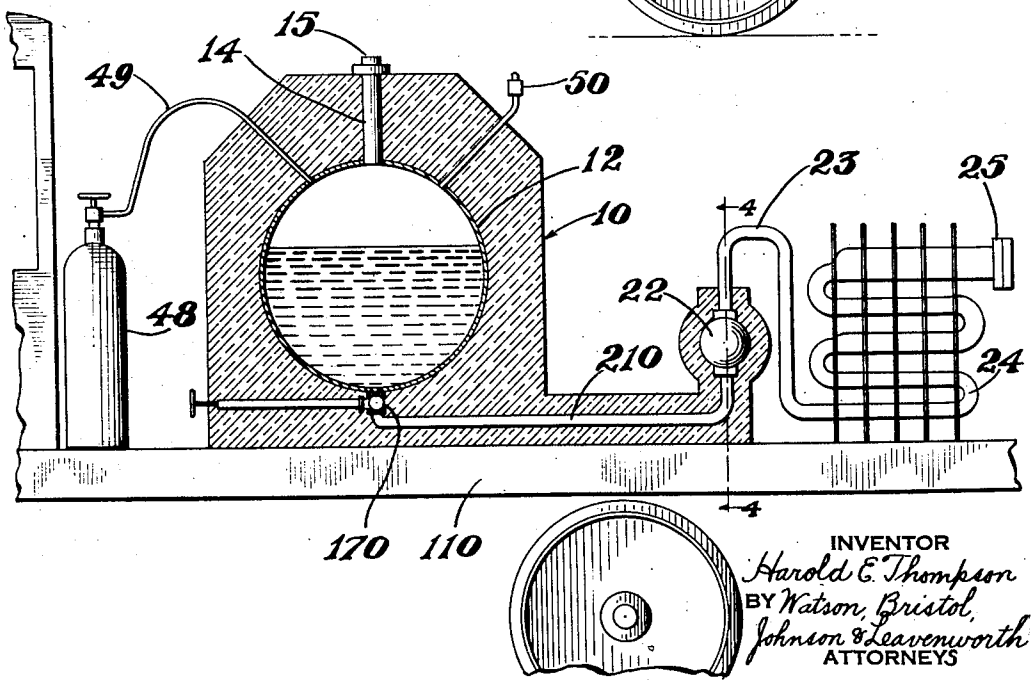


Fig. 2



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Fig. 3

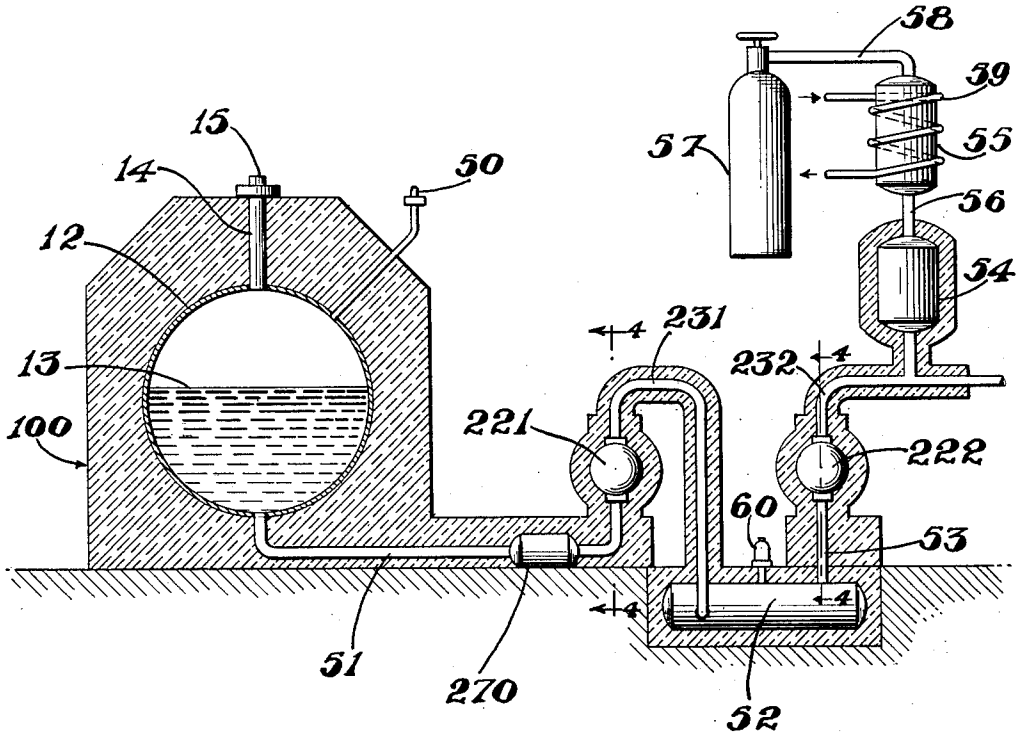
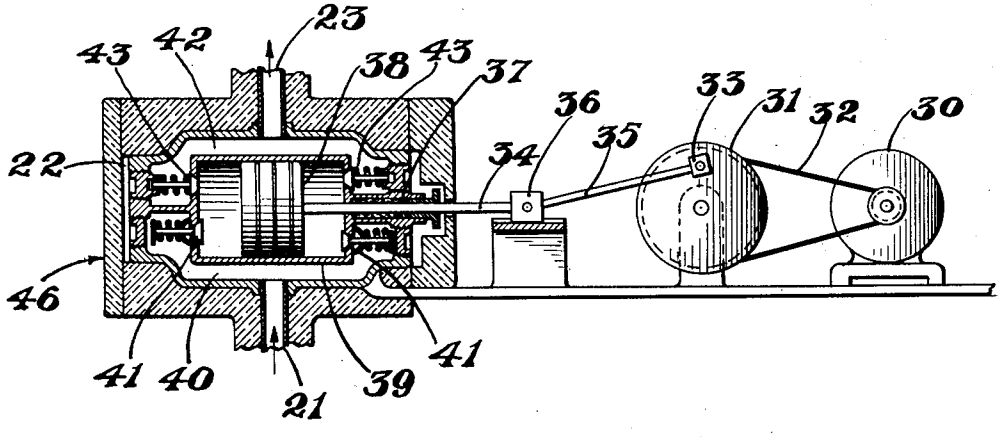


Fig. 4



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UNITED STATES PATENT OFFICE

1,930,731

METHOD AND APPARATUS FOR TRANSFERRING LIQUID MATERIAL

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Application December 14, 1932
Serial No. 647,188

19 Claims. (Cl. 62—1)

This invention relates to a method and apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, and particularly to liquefied gases which when under atmospheric pressure can be stored in the liquid phase only when their temperature is below 273° K.

The invention has for its object generally the provision of an improved method and apparatus for carrying out the same, whereby volatile liquids of the character indicated are transferred from suitable containers to a device or vessel adapted to receive the same, preferably in the gas phase, at a relatively high pressure.

More specifically, it is an object to provide a method and suitable apparatus by which a storage or transport container may hold liquefied oxygen at a relatively low pressure and may transfer the same to a receiver by means of a force-applying device such as a pump for delivery at the desired high pressure, for example, through a conduit which may include a vaporizing device whereby the oxygen is delivered in the gas phase.

It is also an object to provide a method and apparatus for pumping liquids which are volatile at ordinary atmospheric pressures and temperatures, in a manner which avoids having the pumping means become gas-bound, so that the pressure may be elevated substantially to any desired value.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view partly in section and partly in elevation showing apparatus including a transport container adapted to supply a gas material in the liquid phase and convert the same to the gas phase at a desired pressure, in accordance with the invention;

Fig. 2 is a view similar to Fig. 1 showing a modified form of apparatus constructed in accordance with the invention;

Fig. 3 is a view mainly in section showing still another modification adapted to achieve very high pressures; and

Fig. 4 is a fragmentary sectional view showing details of a pump structure suitable for use in the apparatus shown either in Figs. 1, 2 or 3, the plane of the section being indicated by the line 4—4 in the respective figures.

Heretofore, when it was desired to transfer liquids which are volatile at normal atmospheric pressure and temperature to receiving devices or vessels, where the material received is maintained in the gas phase at relatively high pressures, this was achieved by maintaining the volatile material under a sufficient pressure to effect the desired transfer. This had the result of requiring all parts including the supply container to be built to resist great stress.

The alternative to this procedure involves generally the use of a force applying device, for example a pump, whereby the material may be drawn from the supply container by the suction of the pump and delivered at the desired pressure. The use of a suction device, however, is not feasible where the volatile material gasifies at ordinary atmospheric pressures and temperatures, since the suction device will not draw over gas material; for example, the suction stroke of a pump under these conditions merely causes the liquid in the clearance space to vaporize, this vapor being re-condensed during the delivery stroke of the pump. Under these circumstances, a pump is seen to accomplish no useful work and is said to be "gas-bound".

In accordance with the present invention, volatile material which vaporizes at normal atmospheric temperature and pressure, such as a liquefied gas, is delivered by forcing means from a supply source such as a storage or transport container into a receiving device, where the material is maintained at the desired high-pressure without the forcing means becoming gas-bound. This is effected by certain steps which effect the desired elevation of pressure in a plurality of stages. Two steps are preferably employed to raise the pressure, as desired, in a corresponding number of stages. In the first step, a pressure elevation is accomplished in conjunction with the liquid to be transferred such that the pressure that is attendant the temperature environment no longer permits the liquid being moved to flash into vapor under the influence of suction. This initial pressure elevation is, in general, a relatively

small part or fraction of the total pressure elevation to be attained.

By the present invention, the pressure elevation of the first step is accomplished in any one of several different ways. One way in which this is accomplished is to apply temporarily an increase in pressure to the supply body of volatile material, which in amount is sufficient to avoid the tendency to flash into vapor under the application of suction without subjecting the parts, particularly the supply container, to the total stress involved in achieving the total pressure elevation desired. The pressure thus applied to the supply body of gas material may conveniently be had by gasifying a small portion of the volatile material and applying the same to the surface of the supply body while it is desired to transfer liquid from the container, the latter being of a type adapted to be closed.

A second way in which this initial pressure elevation is accomplished is to provide an auxiliary source of pressure which may be temporarily applied to the surface of the supply body of volatile material while in a closed container. This is readily achieved in practice by providing an independent vessel or cylinder containing gaseous material under relatively high pressure and supplying the same during the period of transfer to the surface of the volatile material in the storage or transport container, or during the period that it is desired to withdraw volatile material from the storage or transport container.

Each of the first and second ways of accomplishing this step of initially attaining a partial elevation of the pressure to the desired value, is particularly adapted for transport service, since this step may be attained with a relatively small amount of apparatus, and hence may be provided on trucks for transporting storage containers without unduly weighting down the trucks.

A third way in which this initial pressure fraction is attained is by means of a pump so located that no suction is required to draw over the volatile liquid, the flow being effected merely by means of the natural forces operating in the system, for example by means of the force of gravity. To this end, a pump is employed in the first stage of pressure elevation, preferably protected from the uncontrolled influence of heat from an external source, arranged to receive its supply of liquid under the influence of the hydrostatic head of the system produced by gravity. In the second step of the process, one accomplishes a further elevation of the pressure, which gives finally the desired value and may force the volatile material through a vaporizing means which supplies the volatile material in the gas phase at the desired high pressure. This second step of pressure elevation is readily accomplished by pumping means arranged to receive the material delivered under the fractional pressure elevation accomplished in the first stage, since liability of the gas material to flash into vapor is now avoided. This second stage means accordingly may be a pump designed to deliver the volatile material at substantially any desired pressure.

Referring now to the drawings and particularly to Fig. 1, 10 denotes generally a container of the insulated variety adapted for transport service and is mounted on the body of a truck denoted generally at 11. This container has an inner vessel 12 arranged to hold a liquid supply body 13 of volatile material to be gasified, for example liquid oxygen. This container has a filling conduit 14 leading to the upper end of the vessel 12, the conduit having a gas-tight closure 15. A withdrawal conduit 16 leading preferably from the bottom of the vessel 12 has a control valve 17 and discharges into a small vaporizing means 18 that communicates by way of conduit 19 with the upper end of the vessel 12 above the normal liquid level of the body 13 held therein. Safety means 20, such as a safety valve, is also provided to relieve the excess accumulation of pressure which may arise within the vessel 12.

The small vaporizer 18 is of a capacity sufficient to vaporize a quantity of liquid material that will accomplish the fractional pressure elevation to be achieved in the first step of the method of the present invention. This vaporizer is controlled and receives its portion of liquid from the vessel 12 by manipulating valve 17. The vaporizer shown is supplied with heat from any convenient source, for example, from the atmosphere at normal temperatures. Accordingly, the vaporizer 18 is installed on the truck in a manner such as to be readily exposed to a circulating body of atmospheric air. This is here shown as done by placing the vaporizer 18 on the truck in a floor opening adjacent to the container 10 arranged to have a draught of air passing therecver.

When sufficient pressure has been generated and applied to the surface of the body 13 to prevent the same from flashing into vapor when being delivered to the second stage pressure elevating means, the forcing action to accomplish the second stage pressure elevation may be started. This is here achieved by providing a suction conduit 21 leading from the vessel 12 to the suction side of a pump 22 that is also located on the truck adjacent the transport container 10. A delivery conduit 23 leads from the delivery side of the pump 22 and communicates with a high pressure vaporizer 24 that has sufficient capacity to gasify the volatile material at a rate adapted to supply the demand and may be mounted on the truck 11. This vaporizer has a discharge conduit 25 for delivering the volatile material in the gas phase at the desired pressure. This may be either directly to a gas consuming apparatus or to a receiving vessel which holds the same temporarily in storage until used, (such vessels being well known in the art, and are shown, for example, in U. S. patent to Heylandt 1,786,159, the illustration thereof being omitted from the drawings in the interests of clearness).

The suction conduit 21 and the pump 22 which effects the second stage pressure elevation are preferably heat insulated, as indicated at 26, in order to avoid heat leakage, which would otherwise operate to decrease the efficiency of the system and to offset partially or wholly the advantage of the partial pressure elevation accomplished in the first stage of the method of the present invention. A portion of the conduit 21 may also with advantage be enlarged as indicated at 27 to provide a suction pot which operates to even the flow through the conduit 21 from the container 10 to the pump 22.

The pump 22 may be driven in any convenient manner, for example, by means of an electric motor 30, as shown in Fig. 4, which may be supplied with electric energy from any convenient source, for example from the lighting and ignition system of the truck 11. This motor is shown as mechanically coupled to drive a fly-wheel 31 by means of a belt 32, which fly-wheel drives a crank 33 that is coupled to the piston rod 34 of the pump by a connecting rod 35 and cross-head

36. The piston rod 34 is shown as passing through a packing gland 37 and provided with a piston 38 which is adapted to reciprocate in the cylinder 39, here shown as double acting. The suction chamber of the pump is here shown on the lower side at 40 and has communication with the cylinder 39 through inwardly opening valves 41, here indicated as of the poppet variety. The discharge chamber is similarly shown on the upper side of the pump at 42 and communicating with the ends of the cylinder through outwardly opening valves 43, also indicated as of the poppet variety. The suction conduit 21 leads directly to the suction chamber 40, while the discharge conduit 23 leads from the discharge chamber 42, the whole pump being encased in heat insulation, indicated generally at 46, which may be regarded as an extension of the heat insulation already referred to and shown at 26.

By this means, it is seen that the second stage pressure elevation is accomplished as follows: When the pump piston 38 is displaced, for example to the right, the poppet valve 41 on the left opens to admit liquid to fill the space made vacant by piston displacement. This liquid flows through the suction conduit 21 under the influence of the partial pressure elevation effected in the first stage and applied to the surface of the liquid in the container 10, so that flow is accomplished without liability of the liquid flashing into vapor. The piston displacement toward the right is at the same time accompanied by an opening of the poppet valve 43 on the right to admit liquid to the delivery chamber 42 and force the same under a head of pressure to flow out through the conduit 23 into the vaporizer 24. When the piston displacement toward the right is completed, a stroke toward the left is begun. The displacement effected during such stroke causes the poppet valve 41 on the left to close and the poppet valve 41 on the right to open, this opening and closing of the valves 41 being accompanied substantially at the same time as the closing of the poppet valve 43 on the right and the opening of a poppet valve 43 on the left, whereby the liquid just drawn into the cylinder 39 by the piston displacement from left to right is now forced out through the poppet valve 43 on the left into the discharge chamber 42, thereby continuing the pumped supply of volatile liquid to the vaporizer 24 as long as the partial pressure elevation accomplished in the first stage is maintained.

In Fig. 2 an arrangement of apparatus is shown adapted for effecting the initial partial pressure elevation in the second way described above. Here a transport container denoted generally at 10 is mounted on a truck body 110 and is provided with an inner vessel 12 adapted to hold a body of volatile liquid insulated from the thermal environment of the atmosphere similar to the arrangement shown in Fig. 1. The vessel 12 is also shown as provided with a filling connection 14 and a closure 15. The container is also provided with a withdrawal conduit 210 leading to the suction side of a pump 22 that has a discharge conduit 23 leading to a vaporizer 24. The withdrawal conduit is preferably controlled by a valve 170.

In this arrangement, the initial pressure fraction is supplied by means of compressed gas from an auxiliary vessel 48 through a conduit 49 leading to the vessel 12 and entering the same above the normal liquid level therein. The gas thus supplied should be without chemical affinity for the liquid material within the vessel 12 in order to avoid contaminating or disturbing the equilibrium of the latter. Where the liquid material in the vessel 12 is, for example, liquid oxygen, the compressed gas in the auxiliary reservoir 48 would preferably be oxygen in the gas phase compressed to several atmospheres. A safety valve is also preferably employed, as indicated at 50, in order to avoid the undue accumulation of pressure within the container 10. In other respects, the system of Fig. 2 is like that shown in Fig. 1 and operates similarly.

An arrangement for accomplishing the initial partial pressure elevation here desired, in accordance with the third way described above, is illustrated in Fig. 3. Here, a storage container 100 of the insulated variety has an inner vessel 12 for holding a body 13 of volatile material and has a filling connection 14 provided with a closure 15. A withdrawal conduit 51 is provided leading from the bottom of the vessel 12 to the suction side of a first stage pump 221. This conduit is preferably provided with a suction pot, as indicated at 270, the whole being arranged to permit the flow of fluid into the pump cylinder under the influence of the mechanical forces operating in the system. Here, the flow is caused by the hydrostatic head of the body 13. The first stage pump 221 has a discharge conduit 231 leading to an inter-stage capacity chamber 52, from which the suction conduit 53 leads to a second stage pump 222. A discharge conduit 232 leads from the discharge side of the pump 222 to supply the volatile material now elevated to the desired pressure to a suitable receiving device, such as a high pressure vaporizer (not shown in the interests of clearness).

Where the forcing means of the second stage is a pump of the reciprocating variety delivering volatile material at a relatively high pressure, there is, unless suitable precautions are taken, a surge transmitted in the body of the volatile material being delivered. Such a surge effect is sometimes referred to as a "water hammer". The precautions to be taken to avoid this effect involve, in general, the use of surge suppressing means adapted to react against the surge in substantially a dead beat manner. This is readily accomplished by means of a surge chamber connected to the high pressure delivery conduit and containing compressed gas which when momentarily further compressed by the surge reacts to apply compensating pressure.

Where the volatile material being pumped is a liquefied gas of low boiling point, such as liquid air, liquid oxygen, or the like, the body of gas in the surge chamber is liable to be condensed by the refrigerating effect of the liquefied gas being delivered. According to the practice of the present invention, means are provided in conjunction with the surge chamber for maintaining the compensating pressure substantially constant without liability of diminution through condensation. To this end, an auxiliary chamber is arranged to have communication with the surge chamber and receive a portion of the gas which is heated to compensate for the refrigerating effect. In this manner, a desired gas pressure is maintained in the surge chamber without likelihood of contamination of the gas material being delivered.

Any surges engendered in the conduit 232 as a result of the periodic impulses impressed by the pump 222 are suppressed by means of a surge chamber 54 which communicates with the dis-

charge conduit 232 at any suitable point, for example, one in proximity to the pump 222, as indicated in the drawings. This surge chamber, as well as the discharge pipe lines, are also preferably highly insulated. A second or auxiliary chamber 55 is connected to the first chamber by a connection 56, the second chamber receiving a supply of inert gas from an external source, for example, from a cylinder of compressed gas, as shown at 57, connected by a conduit 58 with the top of the second chamber. Condensation of gas in this chamber is avoided by means of heat, which is applied through a coil 59, disposed about the chamber 55 and has a suitable heating agent coursing therethrough.

In this last arrangement, the first stage pump effects the initial pressure elevation to the desired fractional value of the final pressure and discharges the material at such pressure into the chamber 52, from which it is drawn by the second stage pump 222 and finally elevated by the second pump to the desired high pressure. The liquid material in the chamber 52 is thus under a pressure such that when sucked up into the suction chamber of the second stage pump 222, there is no liability of the liquid material to flash into vapor. While the liquid material thus passed into the chamber 52 is desirably always under pressure, a too high pressure is to be avoided. Accordingly, a relief valve is shown at 60 adapted to afford relief for the chamber 52 in case there is an excess accumulation of pressure within the inter-stage chamber.

In order that the desired pressure fraction may be maintained in chamber 52, both pumps are arranged to deliver liquid at the same rate. This may be accomplished in any convenient manner, for example, by providing that the pumps, with equal volumetric displacements, shall be driven at speeds that remain substantially constant. To compensate for any inequalities in the delivery rates of pumps 221 and 222, it may be desirable, though it is by no means necessary, to have the first stage pump made to pump at a slightly greater rate than the second stage pump and the excess gas material delivered permitted to discharge from the relief valve 60. This may be returned by way of a conduit which conducts the same to the suction side of the first stage pump or to the storage vessel 12. The loss of valuable gas material is thus avoided while the partial pressure is maintained.

Since certain changes in carrying out the above process and in the constructions set forth, which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, from a source of supply at a relatively low pressure to a receiver at a relatively high pressure, which comprises causing a flow of liquid from said source to said receiver, and during said flow elevating the pressure to the desired value in a plurality of stages, in the first of which an intermediate pressure is attained sufficient to avoid flashing into vapor under suction and in the remainder of the stages attaining the desired pressure value compressibly.

2. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, from a source of supply at a relatively low pressure to a receiver at a relatively high pressure, which comprises causing a flow of liquid from said source to said receiver, and during said flow elevating the pressure to the desired value in two stages, in the first of which an intermediate pressure is attained sufficient to avoid flashing into vapor under suction, and in the second attaining the desired value by applying force compressibly to the flowing liquid.

3. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, from a source of supply at a relatively low pressure to a receiver at a relatively high pressure, which comprises causing a flow of liquid from said source to said receiver, and during said flow elevating the pressure to the desired value in two stages, in the first of which an intermediate pressure is attained sufficient to avoid flashing into vapor under suction by utilizing the natural forces operating in the system, and in the second stage attaining the desired pressure value by pumping the flowing liquid against a head of pressure.

4. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, to be supplied at a desired high pressure, which comprises charging a heat insulated container with a supply body of liquid material having a pressure environment not substantially different from that of the atmosphere, withdrawing liquid from said container under natural forces operating in the system to a first stage pressure elevating means whereby an intermediate pressure elevation is achieved sufficient to prevent flashing into vapor when delivered to a subsequent stage, and thereafter in a second stage forcing the liquid up to a desired higher pressure by means of an externally operated pump.

5. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, to be supplied at a desired high pressure, which comprises charging a heat insulated container with a supply body of liquid material having a relatively low pressure environment, withdrawing liquid from said container under natural forces operating in the system to a first stage pump externally operated, effecting a partial pressure elevation by means of a pump to a value sufficient to prevent flashing when delivered to a second stage pump, and thereafter effecting a pressure elevation by said second stage pump sufficient to achieve a desired higher pressure.

6. The method of transferring liquid material, volatile at normal atmospheric pressure and temperature, to be withdrawn from a supply body and transferred to a receiver at a desired high pressure, which comprises causing a flow of liquid material from said supply body having a pressure environment not substantially different from that of one atmosphere, introducing liquid from said body under natural forces operating in the system to a first stage pump externally operated, effecting a pressure elevation by said first stage pump less than said desired high value but sufficient to prevent flashing when delivered to a second stage pump, then effecting a pressure elevation to the desired value by said second stage pump, and suppressing surges in the delivery of the medium from said second stage pump.

7. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held nor-

mally at a relatively low pressure, delivery means connected to said container, means for effecting a partial elevation of the pressure in the material delivered to a desired intermediate value, and forcing means arranged to receive said liquid material delivered at the partial pressure and effect a further pressure elevation to a desired value.

8. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, delivery means connected to said container, means for effecting a partial elevation of the pressure in the material delivered to a desired intermediate value, and a pump arranged to receive said liquid material at said partial pressure and to deliver the same at a pressure of the desired value.

9. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, delivery means connected to said container, means for effecting a partial elevation of the pressure in the material delivered to a desired value, pumping means arranged to receive the liquid material at said partial pressure and to deliver the same with a further elevation of the pressure, and a high pressure vaporizing means arranged to receive the material delivered by said pumping means and to deliver the same in the gas phase at the desired high pressure.

10. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, delivery means connected to said container, means for effecting a partial elevation of the pressure in the material delivered to a desired intermediate value, delivery means leading from said partial pressure elevating means having an enlargement, and a reciprocating pump having a suction conduit leading from said enlargement and a delivery conduit leading to a receiving device; said pump being arranged to effect a further pressure elevation whereby the material is finally delivered at the desired pressure.

11. Apparatus for transporting and delivering a liquefied gas, volatile at normal atmospheric pressure and temperature, comprising a transport vehicle, a container of the insulated type mounted on said vehicle, delivery means connected to said container, additional means on said vehicle for effecting a partial elevation in the pressure of the material in said delivery means to a desired value, pumping means on said vehicle arranged to receive said material at said partial pressure elevation and to effect a further pressure elevation, and vaporizing means arranged to receive said material from said pumping means and to discharge the same in the gas phase at a desired high pressure.

12. Apparatus for transporting and delivering a liquefied gas, volatile at normal atmospheric pressure and temperature, comprising a transport vehicle, a container of the insulated type mounted on said vehicle, delivery means connected to said container, additional means on said vehicle for effecting a partial elevation in the pressure of the material in said delivery means to a desired value, a reciprocating pump on said vehicle having its suction side connected to said delivery means and adapted to receive said material at said partial pressure elevation, a second delivery means leading from the discharge side of said pump, and a high pressure vaporizer on said vehicle connected to receive the material from said second delivery means and to discharge the same in the gas phase at a desired high pressure.

13. Apparatus for transporting and delivering a liquefied gas, volatile at normal atmospheric pressure and temperature, comprising a transport vehicle, a container of the insulated type mounted on said vehicle, delivery means connected to said container, additional means on said vehicle for effecting a partial elevation in the pressure of the material in said delivery means to a desired value, a reciprocating pump on said vehicle having its suction side connected to said delivery means and adapted to receive said material at said partial pressure elevation, a second delivery means leading from the discharge side of said pump, power means associated with the power plant of said vehicle for propelling said pump, and a high pressure vaporizer on said vehicle connected to receive the material from said second delivery means and to discharge the same at a desired high pressure to a receiving device.

14. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, a second stage pump having its suction side connected to said second delivery conduit, and a third delivery conduit adapted to lead the discharge from the second stage pump to a receiving device.

15. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, an inter-stage enlargement in said second delivery conduit, a second stage pump having its suction side communicating with said enlargement, and a third delivery conduit leading the discharge from said second stage pump to a receiving device.

16. Apparatus for transferring liquid material, volatile at normal atmospheric presssure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, said first stage pump applying a partial pressure elevation to the material being delivered sufficient to avoid having the same flash into vapor under the influence of suction, a second stage pump having its suction side connected to receive said liquid material under said partial pressure elevation and arranged to deliver the same at a further pressure elevation to a desired

value, and means for insuring the delivery of material from said pumps at substantially the same rate.

17. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, said first stage pump applying a partial pressure elevation to the material being delivered sufficient to avoid having the same flash into vapor under the influence of suction, a second stage pump having its suction side connected to receive said liquid material under said partial pressure elevation and arranged to deliver the same at a further pressure elevation to a desired value, a third delivery conduit leading the discharge from said second stage pump to a receiving device, and a surge suppressing device connected to said third delivery conduit; said device including means for avoiding diminution of pressure therein through condensation.

18. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid ma erial adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, said first stage pump applying a partial pressure elevation to the material being delivered sufficient to avoid having the same flash into vapor under the influence of suction, a second stage pump having its suction side connected to receive said liquid material under said partial pressure elevation and arranged to deliver the same at a further pressure elevation to a desired value, an interstage enlargement in the conduit leading from said first stage pump to said second stage pump, and means associated therewith for insuring the delivery of material from said pumps at substantially the same rate.

19. Apparatus for transferring liquid material, volatile at normal atmospheric pressure and temperature, comprising a container for a supply body of said liquid material adapted to be held normally at a relatively low pressure, a delivery conduit leading from said container in which flow is effected under the influence of natural forces, a first stage pump having its suction side connected to said conduit, a second delivery conduit leading from the discharge side of said first stage pump, said first stage pump applying a partial pressure elevation to the material being delivered sufficient to avoid having the same flash into vapor under the influence of suction, a second stage pump having its suction side connected to receive said liquid material under said partial pressure elevation and arranged to deliver the same at a further pressure elevation to a desired value, an interstage enlargement in the conduit leading from said first stage pump to said second stage pump, means associated with said enlargement for insuring the delivery of material from said pumps at substantially the same rate, a third delivery conduit leading the discharge from said second stage pump to a receiving device, and a surge suppressing device connected to said third delivery conduit including means for preventing gas condensation therein by the refrigerating effect of the material being delivered.

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