April 29, 1952 A. E. STEELE 2,594,512

LIQUID PUMPING SYSTEM

Filed May 6, 1949

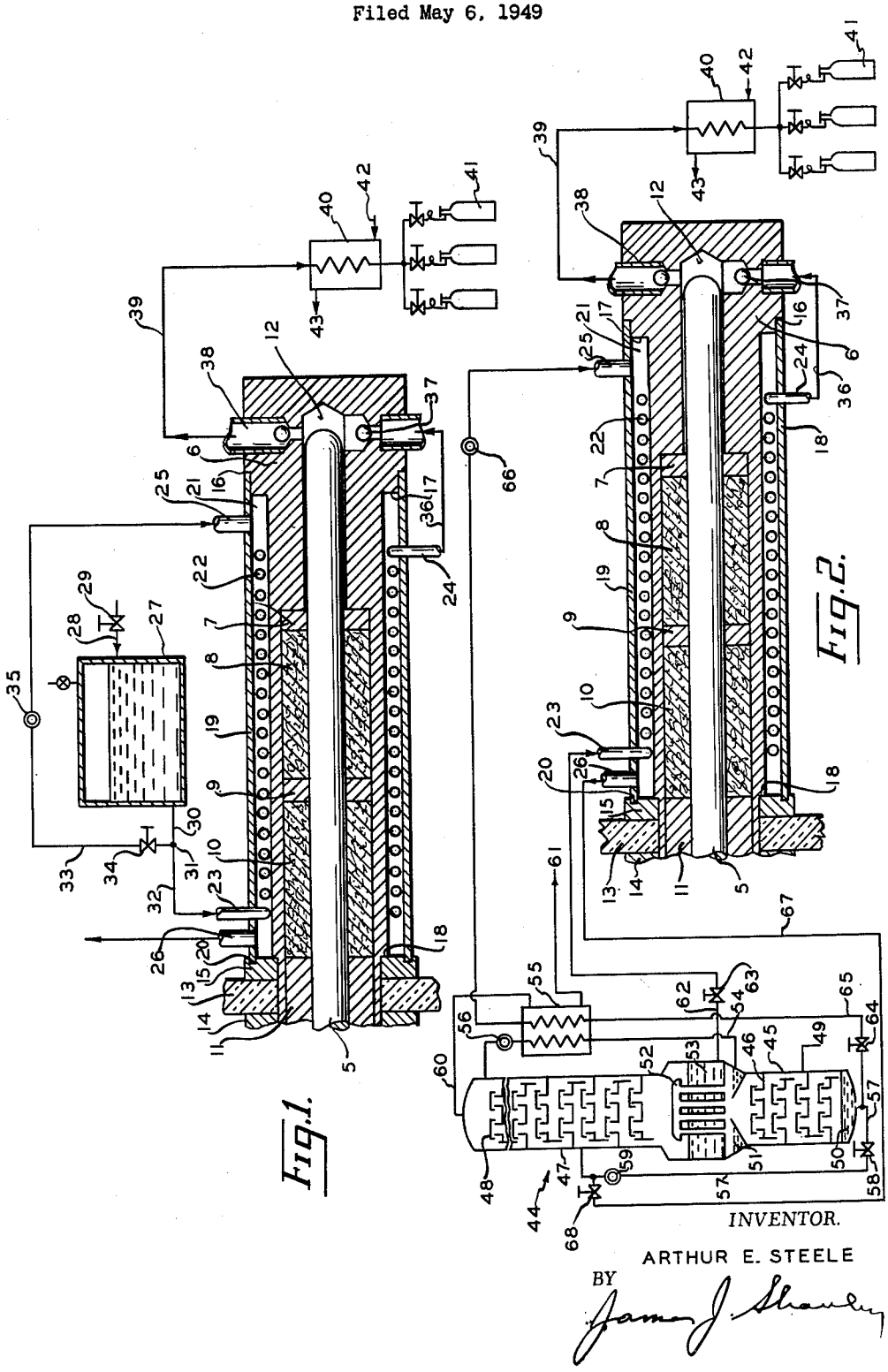


FIG. 1.

FIG. 2.

INVENTOR.

ARTHUR E. STEELE

BY

James J. Shanley

Patented Apr. 29, 1952 2,594,512

UNITED STATES PATENT OFFICE

2,594,512

LIQUID PUMPING SYSTEM

Arthur E. Steele, McKeesport, Pa., assignor to Air Products, Incorporated, a corporation of Michigan

Application May 6, 1949, Serial No. 91,840

3 Claims. (Cl. 62—1)

1

This invention relates to the pumping in liquid phase of liquefied gases or volatile liquids, as for example liquid oxygen, liquid nitrogen, liquid air, liquefied petroleum gases, natural gasoline, or any like normally gaseous product, or any liquid volatile under the pumping conditions.

In the production, storage and use of certain liquids having extremely low boiling points at atmospheric pressure, it is often highly economical and desirable to transfer them from one point to another in the liquid rather than in the gaseous condition.

For example, it is now common practice to store liquefied petroleum gases in large quantities, at or near atmospheric pressure, in heavily insulated tanks. Such liquefied gases have, on occasion, to be transferred at a controlled rate to a vaporizer wherein they are vaporized and superheated, under pressure, to a temperature suitable for delivery into a distribution system. The use of the present invention is a simple and convenient means for effecting such transfer.

It is also common practice to store oxygen and other so-called permanent gases in the liquefied form, to transport the liquid through pipe lines, and to bring it back to the gaseous condition at the point at which it is to be used or placed in pressure cylinders for final distribution. In such cases, the stored liquefied gas is usually at slightly above atmospheric pressure while the conditions of use or distribution may require that the gasefied liquid be at a relatively high pressure, often up to or over 2500 pounds per square inch. In such service, it is extremely desirable to apply the finally required pressure to the liquid rather than to a gaseous stream, as both the cost of power and the weight of apparatus required in the former case are small fractions of the corresponding figures in the latter.

In pumping liquids which, at normal atmospheric pressure, boil at temperatures ranging from zero degrees to 190° below centigrade zero, great difficulty is experienced in keeping a pump in operation. At the lower temperatures, the heat head between the atmosphere and the liquid stream is so great that even the best of insulation becomes relatively ineffective. In consequence, some atmospheric heat leaks into the liquid on the suction side of the pump and, as the liquid is usually just at its boiling point, any input of heat causes the evolution of gas, which has its usual effect of reducing the effective stroke length and finally of locking the pump.

In all cases, when pumping against considerable back pressure, the liquid is heated somewhat

2

by the very act of increasing its pressure and any such liquid leaking back past the discharge valve, into the pump cylinder, may partially vaporize under intake stroke conditions, contributing to vapor lock. Further, the actuating end of the pump, the end to which power is applied, is almost necessarily in contact with the atmosphere and at a temperature much higher than that of the liquefied gas, the metallic structure of the pump thus transmitting atmospheric heat to the stream being pumped. Additionally, because of the impossibility of lubricating the plunger packing adequately, more or less heat is produced by rod friction and added to the atmospheric heat tending to raise the temperature of the stream at the suction end of the pump.

One remedy for these difficulties is found in subcooling the liquid stream going to the pump to a temperature below its boiling point at the pressure existing in the pump cylinder during the suction stroke, as described and claimed in copending applications Serial No. 488,650, filed May 27, 1943, now Patent No. 2,480,093, dated August 23, 1949 and Serial No. 605,407, filed July 16, 1945, now Patent No. 2,480,094, dated August 23, 1949 of Carl R. Anderson.

An important object of the present invention is the provision of apparatus for simultaneously subcooling a stream of volatile liquid to be pumped and refrigerating the stream during pumping.

A further important object of the present invention is the provision of a compact and simplified pump structure for pumping volatile liquids.

Further objects of the present invention will become evident by resort to the attached drawings and the following description, in which:

Fig. 1 is a partly diagrammatic view of a system embodying the present invention and adapted to carry out applicant's method in which a portion of a pump is shown in longitudinal section, and

Fig. 2 is a similar view of a system for pumping a product directly from a fractionating column.

Referring to Fig. 1, the pump illustrated is a single acting plunger pump similar to that described in Patent No. 2,439,957, dated April 20, 1948, to C. R. Anderson and operates in a similar manner. As the prime mover and associated structure by which power is applied to the pump to reciprocate the plunger are not part of the present invention, they are not shown.

The structure comprises a plunger 5 reciprocated within a pump body 6 by a crank, not shown. The pump body 6 has a cylindrical bore which is enlarged through the major portion of its length

to receive the following succession of elements: a metallic packing retainer 7, a soft packing 8, a retainer 9, a graphite spacer bushing 10 and a lantern ring 11. At the discharge end of the pump body, the bore is smaller to form a pump cylinder 12. At about the location of the lantern ring, a rigid disc 13 of hard, heat insulating material such as Bakelite is positioned on the pump body by lock nuts 14 and 15. Near the discharge end of the pump body 6, the pump body is reduced in diameter to form a shoulder 16. A further step 17 is provided to a still smaller diameter which is constant throughout the length of the enlarged bore to the lock nut 15. At this point, the diameter is again reduced slightly to form a second shoulder 18, against which the lock nut 15 is in contact. A jacket tube 19 is provided surrounding the pump body throughout its length of constant diameter which rests against shoulder 16 at the discharge end of the pump body and fits into an annular groove 20 provided in the lock nut 15. In this manner, the jacket tube 19 is radially spaced from the pump body to include an enclosed space 21 between the jacket tube and the pump body closed at one end by the shoulder 16 and at the other end by lock nut 15. A helical coil 22 or any shaped conduit having an extended surface is placed within the space 21, entering the jacket tube at 23 and leaving at 24. The jacket tube 19 is also provided with an inlet 25 and an exit 26 to permit the passage of a fluid through the space 21 around the coil 22. A storage vessel is shown at 27 with an inlet conduit 28 controlled by valve 29 and an outlet conduit 30. The outlet conduit is divided at 31 into a conduit 32, which leads to the inlet 23 to the coil 22, and a second conduit 33 controlled by valve 34, which leads to an expansion valve 35 and to the inlet 25 to the space 21 between the jacket tube and the pump cylinder. Conduit 36 leads from the coil outlet 24 to the intake valve 37 in the pump cylinder. The discharge valve 38 in the pump cylinder is connected to conduit 39 leading to a vaporizer 40 and thence to storage cylinders 41. The valve arrangements illustrated are such as would be suitable in a pump horizontally disposed, and would be somewhat modified if a vertical arrangement is preferred.

The operation of the arrangement described in Fig. 1 is as follows: a liquid to be pumped, stored in container 27 is withdrawn through conduit 30 and is divided at 31 into two streams. The major portion of the withdrawn liquid is passed through conduit 32 into inlet 23 to the helical coil 22. A small portion of the liquid withdrawn from the container 27 is diverted at 31 through conduit 33 and valve 34 to the expansion valve 35 where it is expanded to approximately atmospheric pressure. The resultant refrigeration produced is used to subcool the main stream of the liquid before it is pumped, and at the same time to cool the liquid during the pumping step by heat exchange through the pump cylinder. This expanded stream passes into the space 21 through the inlet 25 and thence passes in heat exchange relation with both the liquid flowing through the coil 22 and the liquid being pumped in the pump cylinder 12. The helical coil 22 acts as a baffle to the flow of the cooling fluid and causes it to follow a helical path through the space 21. The expanded fluid leaves the space 21 through outlet 26, whence it may be recompressed and returned to the storage tank, recycled, or returned to the fractionating column. The main stream of liquid passing through coil 22 passes out through exit 24 and conduit 36 to the intake valve 37. The intake and discharge valves are situated at the same end of the cylinder so that the movements of liquid within the cylinder during the two pumping strokes are in the same directions as the movements of the plunger. While in the pump cylinder, the liquid being pumped is again cooled by heat exchange with the expanded fluid through the pump body 6 from the space 21. Upon movement of the plunger 5 to the right, the liquid is forced under pressure through the discharge valve 38 and conduit 39 to a vaporizer 40. The liquid stream is vaporized in the vaporizer 40 by heat exchange with a warmer fluid entering at 42 and leaving at 43. The vapors so produced may then be stored in the cylinders 41.

As a specific example, consider the liquid stored in the container 27 to be oxygen. It is maintained under a pressure of approximately 1.7 atmospheres and a temperature of about 95.5° K. The portion of the oxygen passed through the conduit 33 is expanded in the expansion valve 35 to atmospheric pressure, thus being cooled to a temperature of 90.2° K. when entering the space 21. The liquid oxygen to be pumped on leaving the coil 22 has been subcooled to a temperature of about 91° K. by heat exchange with the expanded fluid, at which temperature it is pumped in the pump cylinder.

The system shown in Fig. 2 shows a typical double stage fractionating column 44, which may be used for fractionating a mixture of difficultly liqueflable gases. The system will be described for the fractionation of air, although it would be equally effective for other mixtures.

Double fractionating column 44 comprises the usual high pressure section 45 with a plurality of bubble plates 46 arranged therein, and a low pressure section 47 containing a plurality of bubble plates 48. The liquid air to be fractionated enters the high pressure section through pipe 49. The air is separated in this section into crude oxygen which collects in a pool 50 at the bottom of the column, and crude nitrogen which collects in pool 51 at the top of this section after being condensed in a condenser 52 by heat interchange with the boiling pure oxygen product collecting in pool 53 around the condenser 52. The crude nitrogen is removed from the high pressure section through conduit 54, is passed through heat interchanger 55, expanded by expansion valve 56 and returned to the upper portion of low pressure section 47. The crude oxygen, in the normal operation of the fractionator, is removed through pipe 57, valve 58 and is expanded in expansion valve 59 before being returned to a midportion of the low pressure section.

In the low pressure section, the pure oxygen product collects in a pool 53 at the bottom thereof, and the nitrogen product passes out of the column through pipe 60, heat interchanger 55 and conduit 61.

In the operation of this system as proposed by the present invention, the pure oxygen product is removed in liquid form from the low pressure section through conduit 62 and valve 63 whence it enters the pump jacket at 23 and passes through coil 22 arranged in the space 21 as described above. In passing through this coil, it is subcooled by heat interchange with another colder product of the fractionating column. After passing through coil 22, the liquid oxygen passes through conduit 36 into intake valve 37 to the pump cylinder wherein it is pumped to

the desired pressure. It is thereafter vaporized in vaporizer **40** and stored in cylinders **41** as described heretofore.

When the product of the column to be used for the cooling is crude oxygen, for example, a portion of the crude oxygen from the high pressure section of the column is by-passed through valve **64** and conduit **65**, through heat interchanger **55**, expansion valve **66**, and thence through inlet **25** to the space **21** surrounding the coil **22**. This expanded stream of product from the fractionating column in passing through the pump jacket accomplishes two purposes simultaneously; namely, subcooling the product oxygen in coil **22** and cooling the oxygen being pumped in the pump cylinder.

The crude oxygen after passing through space **21** leaves through jacket outlet **26**, through conduit **67** and valve **68**, joins the expanded stream of crude oxygen flowing in conduit **57** and is returned therewith into the low pressure section of the fractionating column.

I claim:

1. Apparatus for pumping a highly volatile liquid and preventing the evolution of vapor during pumping comprising a source of supply for the liquid to be pumped, a source of supply of a cooling fluid, a pump including a pump cylinder and an intake for the cylinder, a spaced jacket surrounding the pump to form a cooling space having an entrance at one end of the cooling space and a discharge at the other end thereof, a conduit leading from the source of supply of the cooling fluid to the entrance to the cooling space, a conduit of thermal conducting material arranged in the cooling space between the entrance and discharge ends of the cooling space, a connecting conduit leading from the source of supply of the liquid to be pumped to the conduit arranged in the cooling space, and a connecting conduit leading from the conduit arranged in the cooling space to the cylinder intake of the pump.

2. Apparatus for pumping a highly volatile liquid and preventing the evolution of vapor during pumping comprising a source of supply for the liquid, a pump including a pump cylinder and an intake for the cylinder, a spaced jacket surrounding the pump to form a cooling space having an entrance at one end of the cooling space and a discharge at the other end thereof, a conduit connecting the source of supply to the entrance to the cooling space, an expansion valve in the last claimed conduit, a conduit of thermal conducting material arranged in the cooling space between the entrance and discharge ends of the cooling space, a conduit connecting the source of supply to the conduit arranged in the cooling space, and a conduit connecting the conduit arranged in the cooling space to the cylinder intake of the pump.

3. Apparatus for making and pumping a liquefied gas comprising an air fractionating column, a withdrawal conduit therefrom for a stream of pure liquid product, a withdrawal conduit therefrom for a stream of second product, a pump including a pump cylinder having an intake, a spaced jacket surrounding the pump cylinder to form a cooling passageway between the jacket and the pump cylinder, a second passageway in and in heat exchange relation with the space between the jacket and the pump cylinder, a connection from the pure liquid withdrawal conduit to the second passageway, a conduit connecting the second passageway to the pump cylinder intake, a conduit connecting the second product withdrawal conduit with the cooling passageway, an expansion valve in the last claimed conduit, an outlet from the cooling passageway, and a conduit connecting the outlet from the cooling passageway with the air fractionating column.

ARTHUR E. STEELE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 21,189	Price	Aug. 29, 1939
1,161,937	Horst	Nov. 30, 1915
2,007,251	Kniskern	July 9, 1935
2,033,094	De Motte	Mar. 3, 1936
2,332,711	Gould	Oct. 26, 1943
2,440,216	Anderson	Apr. 20, 1948
2,480,093	Anderson	Aug. 23, 1949

FOREIGN PATENTS

Number	Country	Date
495,795	Germany	1930
668,512	France	1929