April 20, 1948. C. R. ANDERSON 2,440,216

RECIPROCATING PUMP FOR LIQUEFIED GASES

Filed June 4, 1945 2 Sheets-Sheet 1

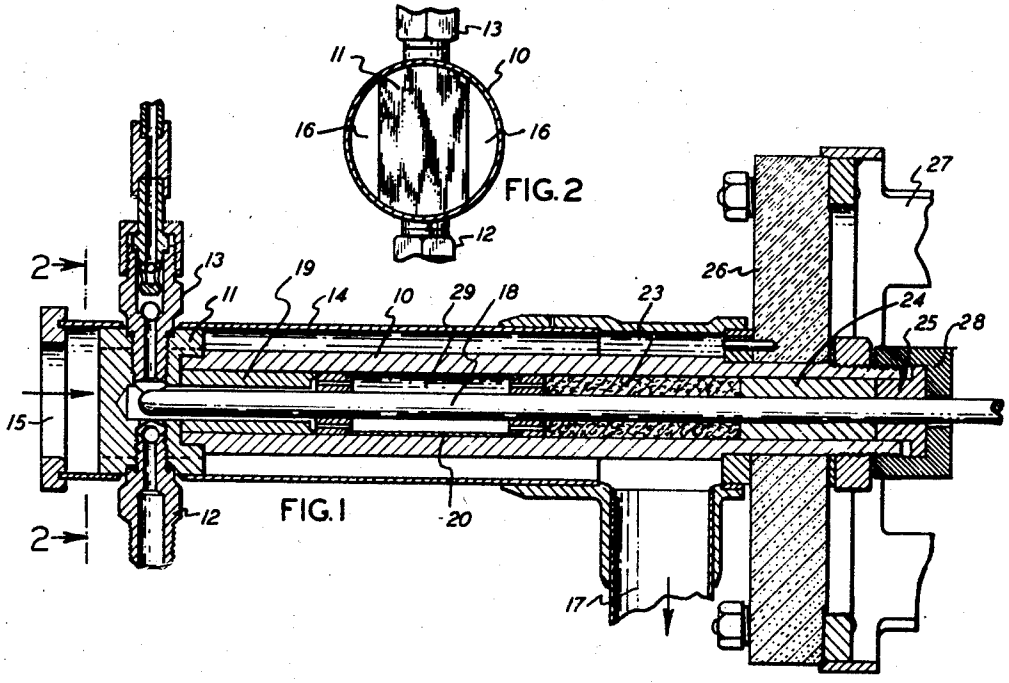


FIG. 2

FIG. 1

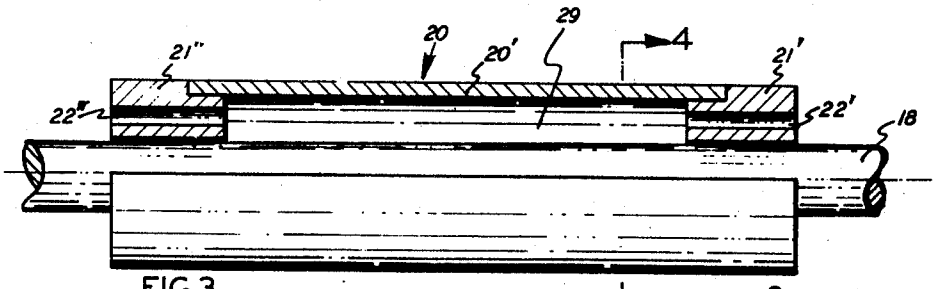


FIG. 3

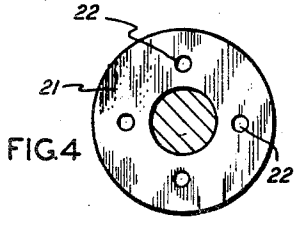


FIG. 4

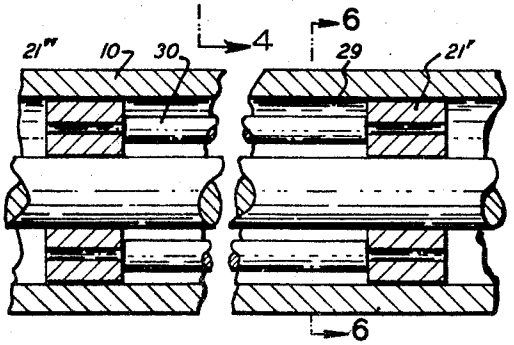


FIG. 5

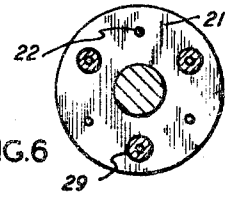


FIG. 6

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RECIPROCATING PUMP FOR LIQUEFIED GASES

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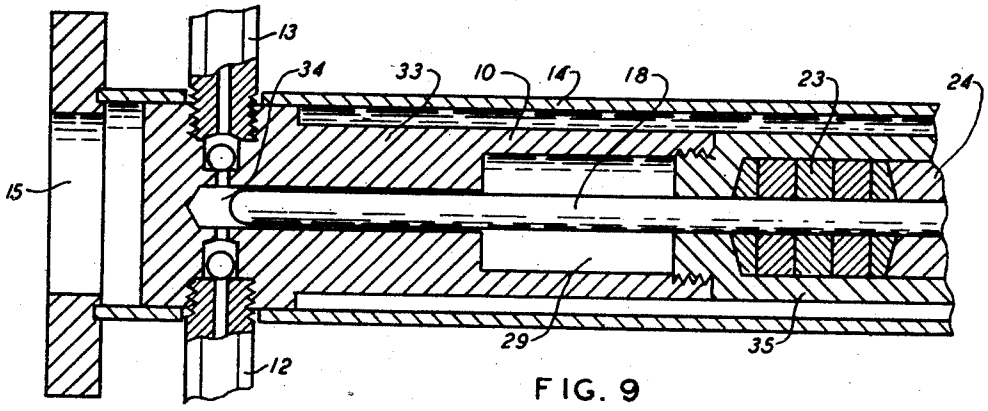


FIG. 9

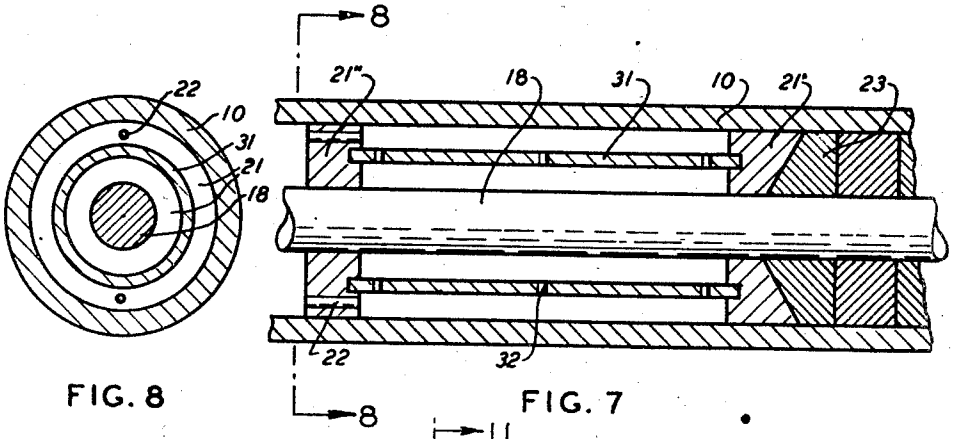


FIG. 8

FIG. 7

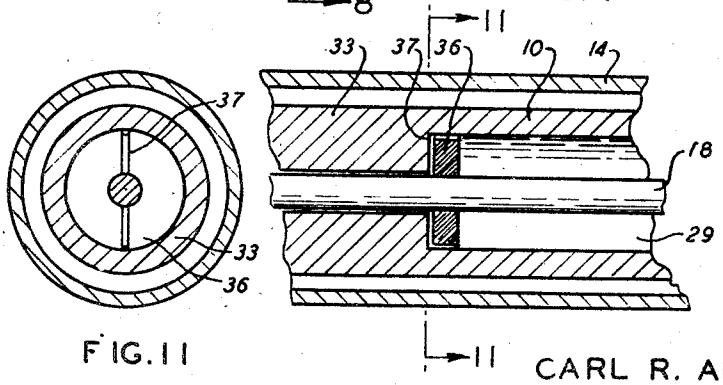


FIG. 10

FIG. 11

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RECIPROCATING PUMP FOR LIQUEFIED GASES

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Application June 4, 1945, Serial No. 597,486

7 Claims. (Cl. 103—1)

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This invention relates to a structural improvement in the cold or pumping end of a reciprocating pump designed to handle liquefied gases at very low temperatures.

The purpose of the invention is to provide means for avoiding gas-lock due to vaporization of the liquefied gas by atmospheric or frictional heat transmitted to the liquid through the cylinder wall and the plunger.

The invention may best be understood with reference to the attached drawings and the following description thereof, in which

Fig. 1 is a longitudinal section through the cold or pumping end of a reciprocating pump adapted to the handling of liquefied gases, as for example liquid oxygen;

Fig. 2 is an end view of the same, as on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged view, partly in section and partly in elevation, of the spacing element generally indicated at 20 in Fig. 1;

Fig. 4 is a section through the spacing element, as on the line 4—4 of Fig. 3;

Fig. 5 is a longitudinal view, partly in section and partly in elevation, of a modified form of the spacing element 20;

Fig. 6 is a cross section through the same, as on the line 6—6 of Fig. 5;

Fig. 7 is a longitudinal section through another modified form of the spacing element 20;

Fig. 8 is an end view of the same, as on the line 8—8 of Fig. 7;

Fig. 9 is a longitudinal section through the cold end of a modified form of pump, in which the spacing element 20 is dispensed with and the pump body is hollowed out to provide space for the liquid which cools the plunger;

Fig. 10 is a sectional view of a fragment of the structure of Fig. 9 modified by the insertion of a guide bushing, and

Fig. 11 is a cross section as on the line 11—11 of Fig. 10.

Referring first to Fig. 1, a metallic cylinder 10 is inserted into a head block 11 into which are connected an intake valve 12 and a discharge valve 13 for the liquid to be pumped. The cylinder is surrounded by a gas jacket 14, a cold gas such as the vapor of boiling liquid nitrogen entering at 15, passing through ports 16—16 (see Fig. 2) and being discharged at 17. This nitrogen vapor, which will be in the saturated condition if protected from heat infiltration up to the point of use, may be drawn from the nitrogen outlet of an air fractionating column if the pump be used in that connection, or may be produced

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by evaporating liquid nitrogen in any closed refrigerating cycle.

Within the cylinder is a plunger 18 which is reciprocated longitudinally by means not shown. Surrounding the plunger and adjacent its working end is a working barrel 19 of metal, bearing at one end against the head block and tightly fitted within the end of the cylinder. This barrel should be bored to give a slight radial clearance over the rod, as of the order of 0.05" to 0.10".

Bearing against the end of the working barrel is a spacing element 20, shown in more detail in Figs. 3 and 4 and in slightly modified forms in Figs. 5 and 7. This element, in the form shown in Fig. 3, consists of a sleeve 20' interposed between two guide bushings 21' and 21". The tube should be closely but slidably fitted within the cylinder and the guide bushings are bored to a neat running fit on the plunger and are provided each with one or more perforations 22.

The material of these guide bushings should be a metal having a low coefficient of friction with the metal of the plunger together with sufficient toughness to avoid excessive wear. Leaded bronze is recommended for this purpose, but other metals having the required properties may be substituted.

Bearing against the spacing element is a packing assembly 23, here illustrated as a soft packing. This type of packing is compressed by means of a follower 24, a gland 25 and a packing nut 26. If rigid packing is preferred, the packing nut serves to hold it in place, or an alternative bolted arrangement may be substituted for the nut.

The crank, cross-head and other actuating members, not shown, are connected with the cylinder through a rigid disc or block 26 and a metallic frame 27 of which only a fragment appears in the drawing.

In the operation of the above described structure in the pumping of liquids which boil at extremely low temperatures, as for example liquid oxygen, the constant leakage of at least small quantities of heat into the liquid-containing end of the pump is unavoidable. Atmospheric heat is excluded from the wall of the cylinder by the flow of cold gas passing through jacket 14 and this gas flow, as will be described, abstracts heat from the liquid within the cylinder. But some atmospheric heat is transmitted through the length of the plunger, the outer end of which must of necessity be warmer than the displacing end, and a variable but usually greater quantity of

heat is generated by friction between the plunger and the packing. However small these increments may be, if this heat is not withdrawn in some manner the pumped liquid will become heated above its boiling point by contact with the heated rod, the pumping space will fill with compressible vapor and the pump will gas-lock.

The spacing element 20, in combination with the gas jacket 14, provides for the continuous abstraction of heat from the rod and is effective in avoiding gas-lock. By reason of the perforations 22'' in the left or outer guide bushing 21'', the liquid oxygen or other liquefied gas being pumped has access to the space 29 surrounding the rod and within tube 20', and in actual operation this pocket is constantly filled with the liquid. The entire length of plunger projecting beyond the inner face of guide bushing 21' (the bushing adjacent packing element 23) is bathed in the pumped liquid, either continuously or, as regards short portion of the plunger, as these portions emerge from the packing or bushings. The heat which would otherwise flow to the tip of the plunger is abstracted by the surrounding liquid and that portion of the plunger located within the working barrel is maintained at a temperature below the boiling point of the liquid being pumped.

The heat withdrawn from the plunger by the liquid in pocket 29 is in turn imparted to tube 20' and, as this tube is in heat conductive contact with the wall of cylinder 10, the heat is finally transmitted to the gas flowing through the jacket and is thereby withdrawn from the system.

The refrigerative effect of the cooling gas is thus exercised through the cylinder and tube walls in maintaining the liquid in pocket 29, and the projecting portion of the plunger, at temperatures below the boiling point of the pumped liquid. In the instance of pumping liquid oxygen, the difference of approximately 12.8° C. between the boiling point of this liquid and the temperature of saturated nitrogen vapor is ample to provide the rate of heat flow necessary to produce this result.

The liquid in pocket 29 is subjected to a periodic elevation and depression of temperature during the pumping cycle. The pocket should therefore be of such size that its liquid contents will have sufficient heat absorbing capacity to prevent flashing under the most adverse conditions of temperature and pressure encountered during the cycle.

In order to limit the extent to which the surface of the plunger is enclosed in metal and thus deprived of liquid contact, it is desirable to make the guide bushings 21'—21'' as short as is consistent with reasonable durability. Their combined length should not exceed and preferably should be less than the maximum stroke of the pump plunger. The bushings should be spaced as far apart as structural conditions will permit, to provide the maximum area of contact between metal and liquid.

It will be noted that the perforations 22' in bushing 21', adjacent the packing assembly, are nonfunctional. These perforations may be omitted, but it is desirable to make the spacer assembly symmetrical in order to avoid the blinding of pocket 29 by the inadvertent insertion of the spacer in reversed position.

The metal to metal contact between tube 20' and cylinder wall 10 interposes some slight resistance to the flow of heat from the liquid in the pocket to the gas in the jacket and, if it is

desired to increase transfer effectiveness to the limit, one of the modified forms of spacer illustrated in Figs. 5 and 7 may be used. In the form of Fig. 5 the guide bushings are as above described but the spacing tube 20 of the first form is replaced by three or more studs 30, forming an open cage. In the form of Fig. 7 a tube 31 is used to space the bushings, this tube being of diameter greater than that of the plunger and less than that of the interior of the cylinder, so as to occupy a medial position. In this form the spacing tube is provided with a number of perforations 32 for the circulation of liquid. In the use of these equivalent forms the liquid in space 29 is in direct contact with the wall of the cylinder and heat transfer from metal to metal is avoided.

In none of the above alternatives is it necessary that the two bushings be identical, nor that they be rigidly interconnected. It is essential, of course, that they be spaced longitudinally to permit the maintenance of a body of the pumped liquid between them.

The maintenance of a cooled body of the pumped liquid surrounding the plunger, which is the essential step of this invention, may be attained without the use of a separable spacing element, in the manner illustrated in Fig. 9. In this construction a body block 33 is bored for part of its length to form the working barrel 34, the remainder of the length being bored to a larger diameter to leave a liberal annular space between the plunger and the wall 10 which corresponds with the cylinder wall of the previous forms. The insertion of a packing box 35 into the open end of the larger bore converts this annular space into a pocket 29 which communicates with the working barrel and functions as previously described. The gas jacket 14 is positioned over the body block and is supplied with cooling gas in the manner illustrated in Fig. 1.

The structure illustrated in Fig. 9 does not provide any guide for the plunger at its point of entry into the working barrel. If the plunger be of such small diameter as to be subject to distortion when pumping at high heads, a guide may be provided in the manner illustrated in Figs. 10 and 11. In this modification of the form of Fig. 9, a bushing 36 closely fitting the plunger is pressed into the bottom of pocket 29, channels 37 being grooved in the face and periphery of the bushing before it is inserted, to provide for the passage of liquid into and out of the pocket.

The instant application is a continuation-in-part of my copending applications Serial No. 507,091, filed October 21, 1943, and Serial No. 548,846, filed August 10, 1944.

I claim as my invention:

1. In a pump for liquefied gases: a plunger of uniform diameter reciprocating in a working barrel; a cylinder surrounding and spaced from said plunger; packing between said plunger and said cylinder, and a spacing element separating said packing from the end of said working barrel, said element comprising a pair of guide bushings arranged to maintain said plunger concentric with said cylinder and means for maintaining said bushings in spaced relation, at least one of said bushings being perforated at a point spaced from said plunger to allow the pumped liquid to flow from said working barrel into the space between said bushings.

2. In combination with a reciprocating plunger pump having a cylinder and a working barrel and plunger packing within said cylinder, a spacing

element adapted to be placed between said packing and said working barrel, said element comprising: a pair of guide bushings arranged to maintain said plunger concentric with said cylinder and means for retaining said bushings in spaced relation, the bushing adjacent said working barrel having a perforation additional to the bore through which said plunger passes.

3. A spacing element substantially as and for the purpose set forth in claim 2, in which said retaining means consists of a metallic tube connecting said bushings.

4. A spacing element substantially as and for the purpose set forth in claim 2, in which said retaining means consists of a plurality of rigid rods connecting said bushings.

5. A pump for volatile liquids comprising a working barrel; a plunger of less diameter than the bore of said barrel and reciprocating therein; a cylinder concentric with and spaced from said plunger; a packing element between said plunger and said cylinder, and means for removing heat from said plunger, said means comprising: a jacket surrounding said cylinder and means for continuously passing a relatively cold fluid through said jacket to cool the wall of said cylinder; a guide bushing arranged to maintain said plunger concentric with the bore of said working barrel, said bushing being perforated at a point spaced from said plunger, and means for widely spacing said bushing from said packing element to provide a chamber for the reception of pumped liquid flowing from said working barrel through said perforated bushing, said liquid cooling said plunger in transmitting heat therefrom to the cooled wall of said cylinder.

6. A pump for liquefied gases comprising a pumping chamber provided with intake and discharge valves; a reciprocating plunger, and a body block having a bore in which said plunger reciprocates, the portion of said bore directed away from said pumping chamber being enlarged to provide an annular space surrounding

said plunger; an element including plunger packing closing the end of said annular space to form a liquid-retaining chamber, said retaining chamber being in communication with said pumping chamber; a jacket surrounding said body block, and means for passing through said jacket a stream of fluid at a temperature sufficiently low to withdraw heat from said body block and from the liquid in said retaining chamber.

7. A pump for liquefied gases comprising a pumping chamber provided with intake and discharge valves; a reciprocating plunger, and a body block having a bore in which said plunger reciprocates, the portion of said bore distant from said pumping space being enlarged to form a wide annular space surrounding said plunger and the portion of said bore adjacent said pumping space being of a diameter slightly greater than that of said plunger to provide a working barrel; a guide bushing closely fitting around said plunger in the end of said annular space adjacent said working barrel; means permitting the flow of pumped liquid around said bushing and between said barrel and said annular space; a closure for the end of said annular space opposite said bushing; a jacket surrounding said body block, and means for passing through said jacket a stream of fluid at a temperature below the atmospheric pressure boiling point of the liquefied gas being pumped.

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