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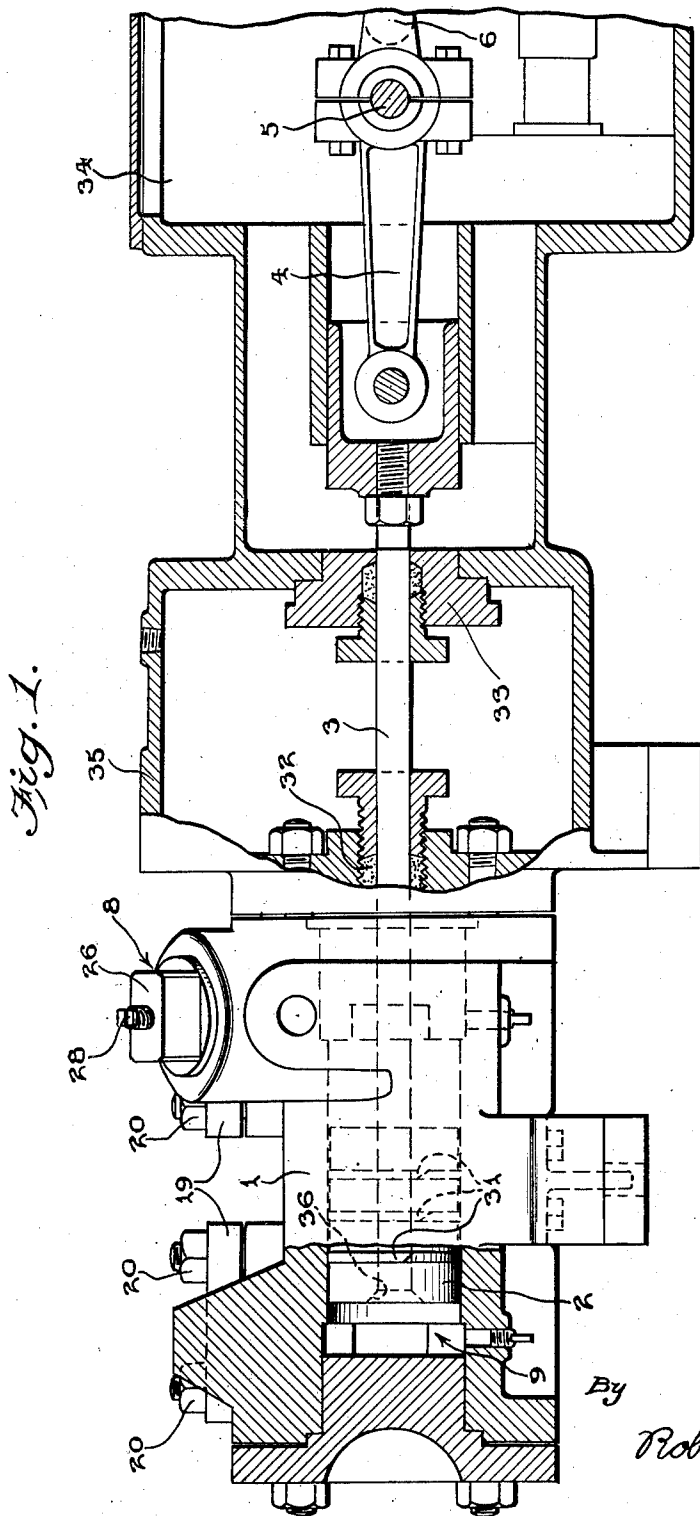
R. W. THOMAS

1,937,859

LIQUEFIED GAS PUMP

Filed Aug. 8, 1929

2 Sheets-Sheet 1



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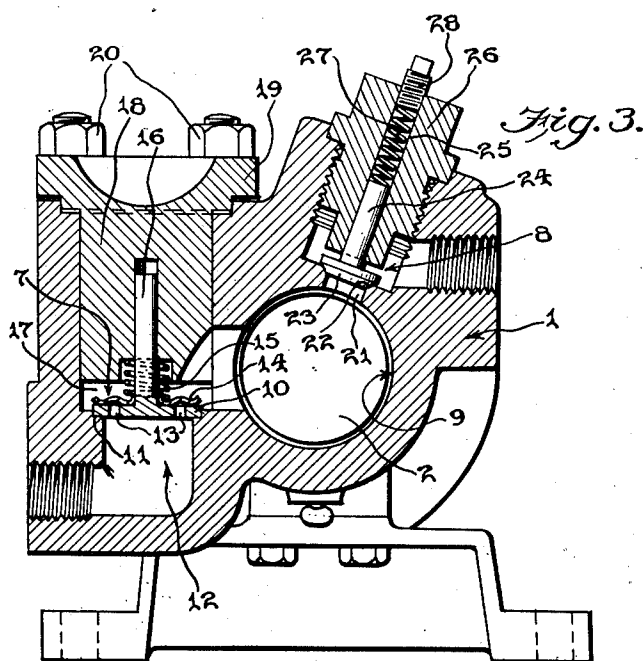
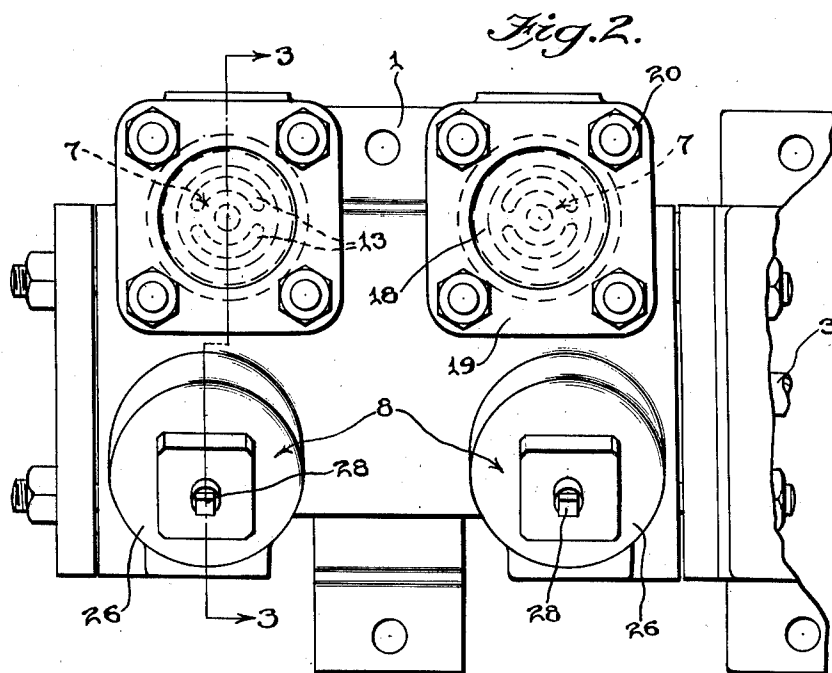
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LIQUEFIED GAS PUMP

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2 Claims. (Cl. 103—175)

This invention relates to improvements in pumps and more especially to a novel pump designed for pumping either a liquid, a gas, or mixtures of liquids and gases or vapors.

5 The primary object of the invention is to provide a pump that is capable of pumping liquefied petroleum gases in general and commercial propane or the like in particular.

The problems involved in pumping liquefied petroleum gases such as commercial propane, are briefly as follows:

10 These commodities are very volatile, having superatmospheric vapor pressures at normal temperatures. They are held under pressure in a liquid condition in steel tanks or cylinders, the exact vapor pressure depending both on the nature of the hydrocarbon involved, and on the temperature of the liquid. For example, commercial propane has a vapor pressure of 120 pounds gauge at 70° F., 165 pounds at 90° F., 195 pounds at 100° F., 210 pounds at 105° F., and 300 pounds at 130° F.

15 It is apparent then, that under any given conditions, a reduction in the pressure on the liquid or an increase in the temperature of the liquid, will result in vaporization of at least a part of the liquid, and in the former case sufficient vaporization will occur to bring the vapor pressure up to the level corresponding with the temperature of the liquid. During this procedure, the liquid is chilled due to the fact that the latent heat of vaporization must be supplied to continue vaporization, and this heat is not only obtained from the sensible heat of the liquid itself, but from heat inflow from the cylinder wall and the surrounding atmosphere or other sources of heat. In the second case, an increase in the temperature of the liquid will produce enough vaporization to absorb the heat input as latent heat of vaporization, which increased vaporization will, in turn, raise the vapor pressure on the container to a level corresponding to the final temperature of the liquid.

20 In pumping these fuels with a mechanical pump it is apparent then that in order to prevent partial or complete vaporization of the liquid hydrocarbon or hydrocarbons either in the pump suction line or in the pump, it is necessary to prevent reduction in pressure on the liquid being pumped and also to prevent an increase in temperature of the liquid. This applies all the way from the originating container to the discharge valve or valves of the pump. After the liquid passes the discharge valves it is usually under sufficient pressure so that normal heat input

even on exposed pipe lines will not produce further vaporization.

Manifestly, these ideal conditions where no pressure reduction occurs and where no heat input takes place, cannot be always maintained. I usually locate my pump wherever possible, below the level of the liquid in the container from which it is being pumped in order to give a static liquid head on the suction to provide energy to push the liquid through the suction line and the suction valves into the cylinder or cylinders on the suction stroke. This again is not always possible as, for instance, where one is unloading a tank car which has no bottom outlet connection and in which the liquid must be pumped through the eduction pipe up to the dome of the car and then back down into the suction line. This unavoidably results in some vaporization in the suction line, even though this vaporization be temporary. It is also difficult, at least during certain portions of the year and certain parts of the day, to prevent some heat input into the suction line and the pump cylinders themselves, even though these elements be buried or well insulated. All of these factors cause departures in commercial practice from the ideal conditions where the liquid gases are delivered to the pumps as liquids and not as mixtures of liquids and vapors.

25 The industries working with such fluids, accordingly, have been faced with two alternatives; (a) maintain the ideal conditions, i. e., keep the product in a liquid form at all times. This is practically impossible from a commercial standpoint; (b) design a pump that will work not only under the ideal conditions, but also under any adverse conditions which may arise from time to time. This procedure appears to be the logical one and is that which I have pursued.

30 In commercial practice, pumps in accordance with my invention will work under three conditions; (a) handle 100 percent liquid, (b) handle mixtures of liquid and vapor, (c) handle vapor alone without any liquid. In order to care for all of these contingencies, it is necessary then that the pump be an efficient gas compressor to accommodate condition (c), it must also be a good liquid pump to handle condition (a), and it must be similar in some respects to a wet vacuum pump to accommodate condition (b).

35 A further and important object of the invention is to furnish a novel pump to care for all of these contingencies.

With the foregoing objects outlined, and with other objects in view which will appear as the

description proceeds, the invention consists in the novel features hereinafter described in detail, illustrated in the accompanying drawings, and more particularly pointed out in the appended 5 claims.

Referring to the drawings:

Fig. 1 is a side elevation of my improved pump with certain parts in longitudinal section to facilitate illustration.

Fig. 2 is a top plan view of the main portion of the pump with a part removed.

Fig. 3 is a transverse vertical sectional view of the line 3—3 of Fig. 2.

In the drawings 1 designates the cast metal cylinder of a double acting pump constructed in accordance with my invention. The bore of the cylinder accommodates the piston 2, which is rigidly connected to a piston rod 3 that is joined to a pitman 4 which is pivotally connected at one end to the piston rod and at its opposite end to the crank 5 of a drive-shaft 6 which may be driven by any suitable means. The intake or suction valves are indicated in their entirety by the reference number 7, and 8 designates the discharge valves.

In designing my improved pump I have adopted air compressor practice and vacuum pump practice insofar as it is possible to use such practices in designing a special liquefied petroleum gas pump. An efficient air compressor must have the clearance cut to a minimum. This has been done in my pump. Ordinary water and oil pumps have clearances from 100 to as high as 200 or 300% of their displacement. I have succeeded in actual practice in cutting the clearance in my pump to less than 25% of the pump displacement and I know that it is possible to have the clearance down as low as 10 or 15%, which will result in even a more efficient and satisfactory liquefied petroleum gas pump.

In order to prevent reduction in pressure in the pump cylinder 9 on the suction stroke, it is essential that no appreciable pressure drop be apparent through the suction valves 7. I have, therefore, constructed each of these valves as follows: A disk 10 of relatively large diameter is seated in an annular recess 11 at the discharge end of the relatively large intake port 12, and this disk is provided with arc-shaped slots 13 of relatively large size, which are normally closed by an annular disk 14 seated by a coil-spring 15 which surrounds a post 16 that is integral with the disk 10. In order to cut the clearance space above the disk 11 to a minimum, the portion of the passageway 17 into which the port 12 leads is restricted by means of an inwardly extending plug 18 which has a flanged outer end 19 that is secured to the cylinder by any suitable means such as bolts 20. It will therefore be seen that I have provided extremely large suction valve areas with low suction valve velocities and I have used extremely light suction valves 14. I may entirely eliminate the valve springs 15 or reduce the tension of these springs so that they offer practically no resistance to the upward movement of the valves 14 on the suction stroke. The suction valves in my pump then, are compromised, for the large size and a low velocity is essential when pumping liquid. When vapors alone or mixed vapors and liquid are being pumped, smaller valves and higher valve velocities can be used, consequently my suction valves are designed to accommodate the worst conditions. On the other hand, my discharge valves 8 have been made exceedingly small, thereby re-

sulting in high discharge velocities. To this end, the port 21 of each discharge valve is relatively small in comparison with the area of the ports 13 of the corresponding suction valves, and each discharge valve seat 22 is positioned relatively close to the bore of the cylinder to accommodate the minimum clearance heretofore mentioned. This seat co-operates with a poppet valve 23 which has a stem 24 that reciprocates in the bore 25 of a threaded plug 26. The valve is forced against the seat by a coiled spring 27, the compression of which may be varied by a screw 28 which engages the plug 26. The high discharge velocities of such valves as this are advantageous, because the small discharge valves allow me to keep the clearance at each end of the stroke down to a minimum figure, and after the liquefied gas is in the cylinder 9 and the suction valve 14 is closed, I can afford to use the energy supplied through the mechanical parts of the pump to the piston 2 to force the liquid through the discharge valve 23 at a high velocity. Even when this pump is running under condition (c) with vapor on the suction, this vapor is condensed to a large extent on the compression stroke and is discharged from the pump practically as a liquid rather than as a compressed gas. The same occurs in condition (b) wherein the vapor mixed with liquid in the pump cylinder is compressed and condensed on the discharge stroke so that the discharge is almost invariably in a liquid condition, particularly when any back pressure or resistance is held on the discharge line. Inasmuch as the function of the pump is to raise the pressure of the liquid, or of the vapor, or of both, it is apparent that this high pressure exists on the discharge under normal conditions.

In order to allow my pump to work with these extremely close clearances when handling liquid and still prevent damage to the mechanical parts due to the high stresses, I run with a low piston speed and a low R. P. M. My limit at the present time has been set at approximately thirty feet piston speed per minute.

It is advantageous to use as long a stroke as is consistent with small clearance, as the longer strokes result in a minimum number of reversals of the piston and a minimum number of openings and closings of the suction and discharge valves. I prefer, in order to accomplish the desired result, to make the bore 9 just slightly smaller than the stroke, for example, if I use a four-inch bore, I will use a five-inch stroke, and if I use a three-inch bore, the piston will have a four-inch stroke. In this connection, it will be noted that the piston runs to within less than 1/64 inch of each cylinder head 29, 30 in order to keep the clearance at a minimum.

For the purpose of disclosing the invention I have shown the pump as of the single cylinder, double acting, packed piston type, although it can, of course, be made with any number of cylinders and single acting cylinders if desired. However, it is my opinion that the double acting cylinder is preferable to the single acting or plunger type pumps.

In order to prevent leakage of the fluid past the piston, I may, for example, use a cast iron piston running in a cast iron cylinder without a liner, and may use a minimum of three graphite impregnated cast iron rings 31. The graphite in this cast iron furnishes a lubricant which is insoluble in the commodities being handled and which prevents early disintegration of the rings and cylinder wall which would occur were ordi-

nary ring materials used. It is understood, of course, that the liquefied gases have practically no lubricating value and when they are being pumped it is equivalent to running the pump absolutely dry, as far as lubrication is concerned.

The rod packing in another improved factor. I prefer to use a good metallic packing 32. Some lubrication is carried through the packing 32 from the power end of the pump, although a wiper ring 33 on the rod is interposed between the crank case 34 and the stuffing box 35.

It will be noted from Fig. 3 that the inlet valve cover caps or plugs 18 have a boss or projection on the inside to cut the clearance space in the pocket 17 above the suction valve to the absolute minimum, and as before stated, the discharge valve seat 22 in the cylinder casing is as near as possible to the inner surface of the cylinder bore 9 in order to cut down clearance at this point. I have already mentioned that no liner is used and this is for the purpose of keeping the clearance down and also so that the piston runs almost against the head at each end of the stroke.

It will be observed further that I have eliminated the nut usually used on the end of the piston rod and have riveted the piston on the rod as shown at 36 to reduce the clearance space which would be necessary if a nut was used.

Another important feature resides in the fact that the pump is so designed that the suction valves 7 are at the bottom portion of the bore of the cylinder and at one side, and that the discharge valves 8 are at the top and on the other side. This gives accessibility to both sets of valves, but keeps the flow of the liquid upward at all times. This results in purging the cylinder of vapor on each discharge stroke and also gives a streamline instead of a reversing flow of the fluid being pumped.

I also wish to emphasize that these special liquefied petroleum gas pumps must have a positive stroke and should be preferably driven by a crank, as illustrated, or by some equivalent means. A direct connected steam driven pump without a crank and fly wheel will not always result in the piston running up precisely to the cylinder heads at each end of the stroke and, therefore, the positive mechanically driven pumps are preferable.

In order to illustrate the advantages of low clearance for handling vapors or mixtures of vapors and liquids, let us assume in the first place an open ended barrel with a piston reciprocating in it. In this case the clearance is infinite and regardless of how much the piston moves back and forth, no fluid will be pumped: the piston merely displacing air from one end of the bore out into the infinite clearance space and vice versa. Now let us take the other extreme where a pump has absolutely no clearance and the piston completely fills all the space at each end of its stroke. In this event, it is apparent that everything in the cylinder must be forced out at the conclusion of each stroke and the cylinder is, therefore, entirely empty on the beginning of the return or suction stroke so that a complete cylinder full of gas will in this event be taken in through the inlet port or valve. This condition of zero clearance, therefore, represents 100% pumping efficiency (disregarding mechanical efficiency), whereas the first example cited shows zero pumping efficiency or no delivery.

My pump has a small clearance and, therefore, must lie between these two fictitious extremes, but it approaches as closely as is practicable from

a designing and manufacturing standpoint, the zero clearance, 100% efficient pump.

The question might be raised as to why all pumps are not designed with low clearance. For the handling of non-volatile liquids such as heavy oils, water, etc. the clearance space has very little effect on the delivery, as the commodity being handled is not compressible and is not sufficiently volatile to vaporize to any marked degree even under reduced pressure or high vacuum conditions. The result is that the cylinders almost completely fill and empty on each stroke regardless of the clearance space. We are all, however, familiar with the inability of the ordinary water pump to start pumping or to "pick up suction" where the source of the water is below the elevation of the pump suction, unless the pump is primed with water. This means that this type of pump with a large clearance will work on non-compressible, non-expansible fluid, but will not operate on a compressible and expansible gas such as air, and well illustrates the distinction which I desire to picture. On the other hand, machines for pumping compressible gases, such as air, are designed with the very minimum possible clearance, but are not adaptable to pumping liquefied petroleum gases for several reasons: (a) The speed is usually entirely too high and the machines are not designed for the heavy loading that would ensue were liquid or mixtures of liquid and gas being pumped, (b) the suction valves do not have a large enough area to provide the low suction velocity and low inlet differential through the suction valves, as is required in the pumping of liquefied petroleum gases. Air compressor suction and discharge valve velocities normally run up into several thousand feet per minute, which is obviously out of the question when handling liquefied gases. Furthermore, it is apparent that the viscosity of a liquid, even one as light as propane, is much greater than the viscosity of air or gas, and friction losses will run much higher at equivalent velocities on the liquid than will be the case with the gases.

In conclusion, those skilled in the art will understand from the foregoing that I have modified known practices in the design of these special liquefied gas pumps and have a new combination and arrangement of elements for an entirely new purpose. Some of the salient features may be summarized as follows: I have provided a liquefied petroleum gas pump having a clearance less than 25% by volume of the piston displacement. This pump is designed to run at a maximum speed of 50 R. P. M. or at 40 feet per minute piston speed. Each suction valve in my pump has velocities below 300 feet per minute (on liquid pumping) and the discharge valve velocities is not less than three times and preferably four or five times the suction valve velocities used. This means that at 30 feet per minute piston speed, the clear area through each suction valve must not be less than $\frac{1}{16}$ of the cross sectional area of the piston, and means further that under the same conditions the cross sectional area of each discharge valve will be not more than $\frac{1}{16}$ of the cross sectional area of the piston. Of course these limits may be varied somewhat so long as the pump will handle liquid, vapor, gas or mixtures thereof.

I do not wish to limit myself to any particular arrangement of the pump parts or to any method of drive. Furthermore, I may use one or more cylinders, each cylinder single or double acting, and the cylinders may be positioned horizontally, vertically or inclined. Packed pistons or plungers

can be used. The valves can be disk, poppet, strip, finger, or otherwise.

From the foregoing it is believed that the invention may be readily understood by those skilled in the art, and I am aware that changes may be made in the details disclosed without departing from the spirit of the invention as expressed in the claims.

What I claim and desire to secure by Letters Patent is:

1. A liquefied petroleum gas pump comprising a cylinder having a bore closed at both ends, the end surfaces of the bore being plane, a plane ended reciprocating piston in the bore, means for reciprocating the piston and causing its ends to come into close proximity to the plane end surfaces of the bore, the spaces between the ends of the piston and the ends of the bore being unobstructed, a relatively large suction valve passageway for each end portion of the cylinder communicating with one side of the bore, disks obstructing said passageways and provided with apertures, disk-shaped valves arranged in said passageways and cooperating with the apertures, a removable plug extending into each passageway and arranged at one side of the cylinder, a discharge passageway for each end portion of the cylinder, arranged at a higher elevation at the opposite side of the latter, each discharge passageway being of relatively small size in comparison with its complementary suction passageway, a removable plug extending into each discharge passageway, a valve for each discharge passageway arranged above the axis of the bore, guide rods

for the last mentioned valves slidable in the last mentioned plugs, and springs in the last mentioned plugs bearing against said guide rods.

2. A liquefied petroleum gas pump comprising a cylinder having a bore closed at both ends, a reciprocating piston in the bore, the end surfaces of the piston and the end surfaces of the bore being formed complementary to each other to permit the entire end surfaces of the piston to come into close proximity to the entire end surfaces of the bore, means for reciprocating the piston and causing its ends to come into close proximity to the end surfaces of the bore, the spaces between the ends of the piston and the ends of the bore being unobstructed, a relatively large suction valve passageway for each end portion of the cylinder communicating with one side of the bore, discs obstructing said passageways and provided with apertures, disc-shaped valves arranged in said passageways and cooperating with the apertures, a removable plug extending into each passageway and arranged at one side of the cylinder, a discharge passageway for each end portion of the cylinder, arranged at a higher elevation at the opposite side of the latter, each discharge passageway being of relatively small size in comparison with its complementary suction passageway, a removable plug extending into each discharge passageway, a valve for each discharge passageway arranged above the axis of the bore, guide rods for the last mentioned valves, and springs for yieldingly holding the last mentioned valves seated.

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