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OIL PUMPING APPARATUS AND METHOD

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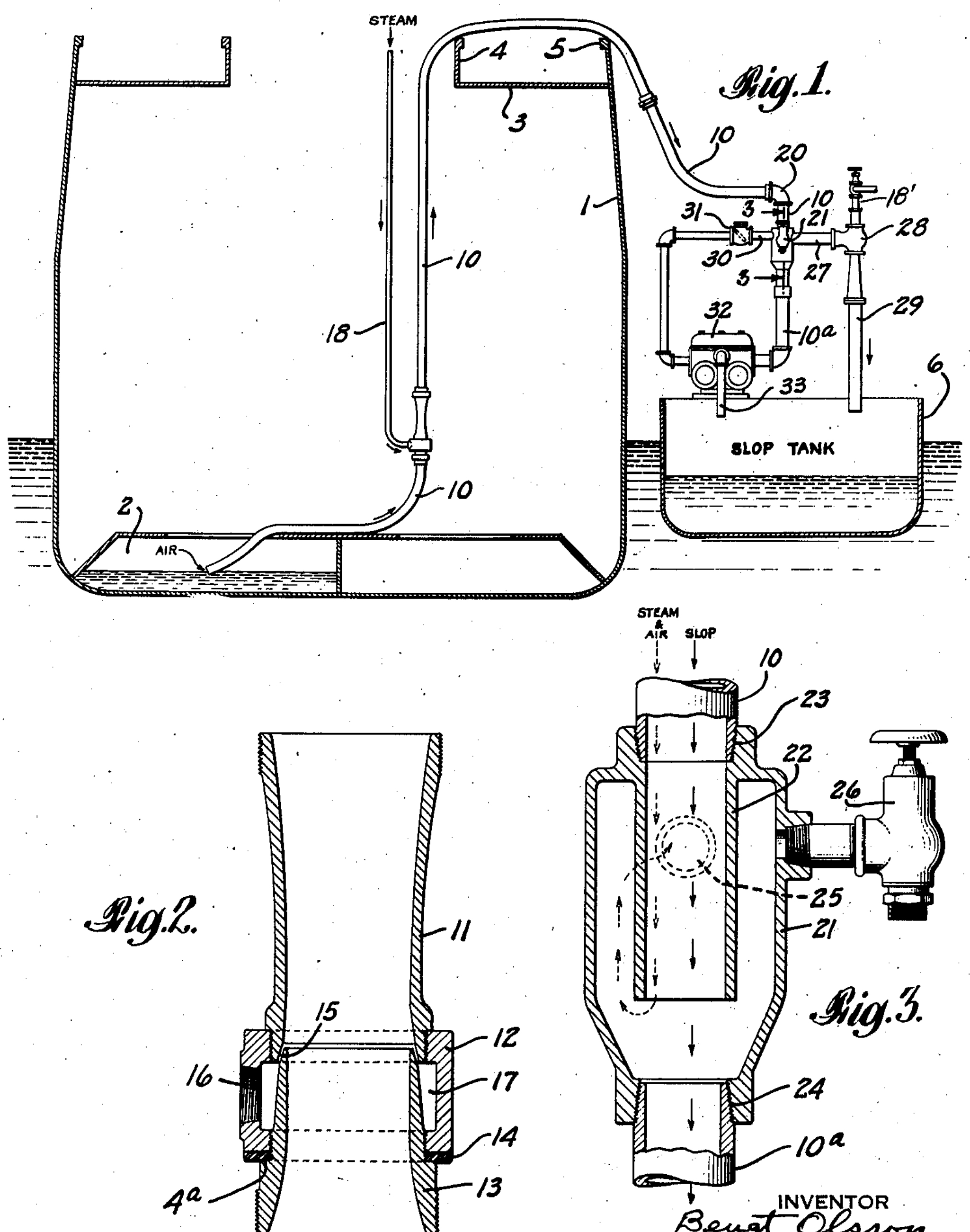

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OIL PUMPING APPARATUS AND METHOD

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9 Claims. (Cl. 103—5)

This invention relates to an air lift system which is peculiarly adapted for the transfer of liquids from one receptacle over a high elevation to another receptacle and has for its principal objects the provision of a novel method, as well as a simple, compact and durable apparatus for accomplishing such purpose.

Heretofore as I am well aware, it has been proposed, as set forth in the Pohle Patents No. 338,295, 347,196 and 487,639 to employ an air lift wherein a compressed fluid, such as air or steam is introduced into the intake end of the delivery pipe or at different points along a vertical leg of the same for the purpose of raising water, petroleum oil, sewage and the like to a relatively great elevation as compared with that obtainable by means of a vacuum pump, unassisted by an air lift, such liquid being conveyed thru the delivery pipe either in the form of a column of intimately commingled air and water, the former being present in the form of small bubbles, or else in the form of a column composed of alternate layers of air and liquid. Accordingly I do not broadly claim herein the employment of the air lift principle for the purpose of the transfer of liquid from one receptacle to another.

My invention is fully disclosed in the following detailed specification and drawing forming a part thereof in which latter

Figure 1 is an elevation of my improved pumping apparatus showing the same in position on a slop tank adjacent a marine vessel, the double bottoms of which are being cleaned with such apparatus.

Figure 2 is a detailed vertical section of the booster employed in said apparatus, and

Fig. 3 is a detailed vertical section, partly in elevation of the reliever element taken on the line 3—3 of Fig. 1.

Referring to the drawing and the construction shown therein, the reference numeral **1** designates the hull of an oil-burning marine vessel, **2** the fuel oil tanks in the double bottom thereof, **3** the deck, **4** the hatch opening and **5** the rail of said hull. Alongside the vessel a slop barge **6** is moored.

One leg of a delivery hose **10** is suspended within the vessel, the same passing up through the hatch and over the rail **5** to the pumping equipment, hereinafter described, mounted on said barge. A steam booster or ejector nozzle is interposed in the delivery hose **10** at a point distant from the intake end thereof, and preferably between the first and second lengths of hose, i. e. at a distance of about 25 ft. from said intake end.

The said steam booster comprises an elongated outlet nozzle or reducer member **11** which is coupled by means of a union **12** to an abbreviated intake nozzle **13**. Said member **11** preferably has an internal diameter of about 3″ adjacent its lower end and the abbreviated intake nozzle has an internal diameter of 4″ at its intake end and an internal diameter of 3″ at its discharge end. A spacer ring **14** serves to form an annular passage **15** between the inner face of the lower end of the outlet nozzle **11** and the outer face of the upper end of the intake nozzle **13**, which passage can be regulated to any predetermined width, the same preferably being about 1/16″ to 3/16″ clearance or width, the latter corresponding in cross-sectional area to about 25% or so of the cross-section of the 3″ bore of said booster or some 15% of the cross-sectional area of the 4″ hose to which it is attached. As shown, said union has a tapped aperture **16** which opens into an annular chamber **17** which surrounds the nozzle **13** and is in communication with said aperture **15**. A coupling of a steam supply line **18** is threaded into said tapped aperture **16**.

An elbow **20** is interposed in the hose **10** at a short distance from its point of discharge into the top of a reliever member **21**, which latter (see Fig. 3) comprises a housing having a central sleeve portion **22** that is in permanent communication with the hose **10** and is adapted to discharge into the main chamber of said reliever, which latter has a converging bottom portion that is tapped, as designated by the numeral **24**, to receive a conduit **10a** which in turn constitutes a continuation, in effect, of the delivery hose **10**.

An aperture **25**, formed in the lateral wall of the reliever, serves as a discharge outlet for air and steam that collects in the top of said main chamber of the reliever member. A relief valve **26** is mounted on the wall of said reliever member and is in permanent communication with the interior thereof. Said relief valve, in practice, is set to relieve the vacuum should the same tend to exceed the optimum vacuum desired in said receptacle. A hose **27**, which is connected to said discharge aperture **25**, serves to conduct either mixed air and steam or else when no air has been admitted, then steam alone from the chamber to an air pump **28** preferably of the steam ejector type from which such gas or gases are discharged into pipe **29** and thence delivered either into the said slop tank or into a separate receptacle. A valve-controlled steam line **18′**

serves to supply steam to the said ejector pump 28.

A conduit 30 communicates with the chamber opposite the inner end of conduit 27, said conduit having a clapper valve 31 interposed therein. Said conduit 30 communicates at its lower end with the suction chamber or so-called "low-side" of a duplex force pump 32 and with which chamber the conduit 10a also communicates. A discharge conduit 33 which is in communication with the compression chamber or so-called "high side" of said pump 32, serves to discharge sludge drawn into the pump from the conduit 10a into the slop tank of the barge 6.

My improved method of operation, unlike the "high vacuum" method disclosed in Patents Nos. 1,405,173 and 1,480,482, does not primarily depend for its operation upon the creation of a high vacuum of 25'' to 28'' of mercury in an overside receptacle for the purpose of creating an inrush of air at high velocity of some 800 ft. per second into the intake nozzle but, on the contrary, my method of operation, being primarily due to the push-and-pull action of the steam booster interposed in the intake line, will operate effectively with even an extremely low vacuum existing in the reliever 21 during the actual pumping operation, for example but about 10'' to 12'' of mercury.

When a vacuum of 10'' to 12'' of mercury is maintained in the reliever 21, which may be appropriately termed a vacuum separator chamber, the maximum temperature of the saturated steam discharging from the line into the reliever will be well below 212° F., the temperature of saturated steam at atmospheric pressure as will be apparent by reference to any accepted steam table, such for example as the table appearing in the book entitled "Porters Steam Engine Indicator," which work is widely accepted as standard by American engineers and from which the figures for the temperatures of saturated steam at various sub-atmospheric pressures were taken for the table entitled "Properties of saturated steam" at page 663 of "Kents Mechanical Engineers Pocket-Book" published by John Wiley & Sons, New York, 1910. As will be apparent by reference to said table "Properties of saturated steam", the temperature of saturated steam at sub-atmospheric pressures ranging from 10'' to 12'' of mercury will be even less than 193.2° F., which latter temperature is that of steam under a vacuum of 9.56'' of mercury.

When the operation is conducted with the intake nozzle completely submerged in the sludge, it has been found that the amount of sludge pumped is at least ⅓ to ½ greater than if the nozzle is but partially submerged in the manner shown in Fig. 1.

Furthermore, in actual operation, with the relief valve 26 set to relieve at a pressure of 12'' of mercury, and when introducing steam at a pressure of about 80 lbs. per square inch at the booster, and with the intake nozzle but partially submerged as indicated in Fig. 1, there will be but about 3'' to 6'' of vacuum immediately below the booster and at a point adjacent, but above, the booster the conditions in the system will fluctuate from a vacuum of between 2½'' and 4'' of mercury to an occasional pressure of 5 lbs. though usually at this latter point in the line, the vacuum is fairly steady around 2½'' of mercury throughout the pumping operation. This is in contrast to a vacuum well in excess of 20'' of mercury in those cases where a vacuum of 28'' is pulled on the overside receptacle and air is being admitted in small quantities at the intake nozzle.

As will be apparent from the foregoing, if the ring aperture 15 is of a size equal to 25% of the cross-section of the 3'' bore of the booster, then if the steam pressure at the point of entrance into this aperture is 80 lbs., the sludge which has been drawn into the booster by the suction induced by the forwardly projected steam current, will be pushed forward at this point with a force of 20 lbs. or double the effective force, measured in pounds, of a vacuum of 20'' and which latter is about the maximum vacuum it is possible to create in the intake nozzle of a transmission line where air is being simultaneously admitted into the intake nozzle of such line in the manner customarily employed in the aforesaid "high vacuum" method of operation.

In those cases where it is impossible to completely submerge the intake nozzle, due to the lack of depth of the liquid sludge in the tanks which are being cleaned, it is, of course, necessary to admit air to the intake nozzle along with the sludge, but owing to the adaptability of my process to either situation, the pumping operation will proceed smoothly upon the admission of the air, though less efficiently than when no air at all is admitted to the intake nozzle.

My improved system of pumping sludge and other liquids is ideally adapted for removing oil sludge from the double bottoms of oil-burning marine vessels which operations frequently require that the pumped sludge be elevated to heights much in excess of 34 feet, the maximum lift by straight suction, these lifts frequently being from 45 ft. to 50 ft. or more. Furthermore, by inerposing in the line additional boosters above the position of the booster shown in Fig. 1, say at intervals of 25 ft., it is possible to elevate the pumped sludge to much greater heights, say 100 or more feet. Likewise, my improved system is especially adapted for removing the oil residuum from refinery tanks located near but not necessarily at the water front, because the force pump 32 employed renders it possible to convey the pumped material a thousand feet or so, as is often required, in order to deliver it to a slop barge in the neighboring harbor, whereas if such pump were not employed, it would be necessary to have the slop tank in close proximity to and considerably below the reliever 21 into which latter the sludge would be primarily delivered from such storage tank.

The function of the conduit 30 and clapper valve 31 is to insure that substantially the same sub-atmospheric pressure will normally exist in the "low side" of the pump 32 at the moment of the commencement of the suction impulse as exists in the receptacle 21 and consequently the maximum suction effect of the pump can be realized and the material entering the receptacle 21 through the sleeve 22 will be delivered primarily by gravity through the conduit 10a and into the "low side" of the pump from which it passes to the "high side" of the pump and is thence discharged through the outlet conduit 33 in the well known manner. Should, however, the pressure in the receptacle 21 for any reason increase beyond that existing in the "low side" of the pump, then the clapper valve 31 will close during the period that such excess pressure continues to exist in the receptacle 21 and consequently the pumped sludge will still continue to flow, due to gravity, into the conduit 10a and thence to the low side of the pump 32 while at the same time no sludge will be permitted to pass through the clapper valve to the low side of the pump.

My method comprises essentially a "piston and bubble" form of transmission, since ordinarily the vacuum existing at the intake end of the transmission line is so low, being but about 3" to 6" of mercury, that the sludge material enters the same in the form of a wave accompanied by a substantial volume of air and, as this mass of sludge and air passes the ring aperture of the booster, the steam will be momentarily blocked from passage into the transmission line until sufficient pressure is developed behind the steam to cause it to cut through the passing column of sludge. Thereupon the pressure of the steam behind the sludge will cause the consolidation of the sludge in advance thereof into a solid piston of liquid sludge and the steam and air in the line will be consolidated into a large bubble alternating with the pistons of sludge. The moving bubble of steam and air behind the lowermost piston of sludge tends to suck or drag more sludge and air into the transmission line through the intake end thereof and the cycle of operations is then repeated. The steam in the bubbles interposed between the various pistons of sludge will gradually be partially condensed to water as it passes upwardly along the transmission line so that the amount of steam required to be removed from the receptacle 21 through the steam-air ejector pump 28, together with the air which is admixed therewith, is materially less than the amount of steam introduced through the booster into the transmission line. The maintenance of the moderate vacuum at the discharge end of the transmission line serves to minimize condensation in the line, thereby conserving the propelling efficiency of the jet, besides relieving the head pressure in the line and thereby facilitating the transmission of the pumped material therethrough.

Furthermore, as previously stated, even when there is no air admitted through the intake end during the operation of the apparatus, the pumping rate is considerably increased as compared with that obtainable by any method wherein the transmission is in the form of an air emulsion. Also when operating without the admission of any air at all into the intake nozzle, as is the case when the same is completely submerged in the liquid being pumped, it is possible, due to the high-pressure and the relatively large volume of the steam jet introduced into the booster, to elevate the pumped viscous liquid to a height of 50 or more feet if desired or greatly in excess of 34 feet, which latter is the m[illegible]mum height to which water can be lifted by straight suction and this accomplishment of itself clearly shows that form of transmission in my improved method of operation constitutes essentially a "bubble and piston" form of transmission, as distinguished from the well known emulsion or spray form of transmission.

My improved method can be carried out in an apparatus which is remarkably simple and cheap to construct and which furthermore can be easily transported on a barge or truck.

The subject matter claimed herein is in general substantially shown and claimed in my abandoned application No. 41,611 filed Sept. 21, 1935.

The term "air-lift" as employed in the claims is used in a generic sense to include a column of liquid levitated or lightened by bubbles of air or other gas, including dry steam, irrespective of the size of such gas bubbles.

The term "moderate" as employed in the claims to qualify the degree of vacuum, is to be understood as being used in its ordinary sense (see Standard Dictionary or any other dictionary) and refers to a vacuum less than an extreme or "high" vacuum such as required in the performance of the Wheeler method claimed in the Wheeler Patent No. 1,405,173 and of which the example thereof given in such patent represents the equivalent of 25" to 28" of mercury and in no event is such term "moderate" vacuum to be understood as referring to a vacuum represented by more than 20" of mercury, which latter would represent two-thirds of a perfect vacuum.

Various changes in the details of the apparatus and of the method of operation set forth herein may be made without departing from the spirit of my invention as embraced within the scope of the appended claims.

Having thus described my invention, what I claim and desire to obtain by United States Letters Patent is:

1. In a pumping apparatus for viscous material, the combination comprising a transmission line, vacuum-creating means connected to the end of said line adjacent the discharge end thereof, a substantially unobstructed steam jet interposed at an intermediate point in the line, separator means for separately discharging the pumped viscous material from the gaseous material transmitted through the line, including a force pump connected to the discharge end of the transmission line at a level below said separator means and means for substantially equalizing the pressure in the low-side of said pump and the pressure in said separator means for minimizing any obstruction to the gravity flow of the viscous material into the low-side of said pump.

2. In a pumping apparatus for viscous material, a transmission line, vacuum creating means connected to said transmission line adjacent the discharge end thereof, a substantially unobstructed steam jet interposed at an intermediate point in the line, a force pump, a separator chamber, having a plurality of outlets connected to the transmission line adjacent its discharge end, one of said outlets being connected to the aforesaid vacuum creating means and another of said outlets being positioned at a lower level than the first outlet and being connected to said force pump and means for substantially equalizing the pressure in the separator and in the low-side of said force pump to thereby facilitate the gravity flow of the pumped viscous material from the separator to the force pump.

3. In a pumping apparatus, the combination comprising a transmission line having an intake leg and a discharge leg, vacuum creating means in communication with the discharge end thereof, means for admitting a high pressure-fluid jet into the intake leg of the line for developing a moderate vacuum in the intake end of the line in order to suck the materials to be pumped through said intake and into said jet, a separator chamber in communication both with said vacuum creating means and with the discharge end of said transmission line, which chamber serves to separate the gaseous and liquid materials from each other, and means in communication with such separator chamber for forcibly discharging the separated liquid material into the atmosphere.

4. In a pumping apparatus, the combination comprising a transmission line having an intake leg and a discharge leg, vacuum creating means in communication with the discharge end thereof,

means for admitting an annular, high pressure-fluid jet into the intake leg of the line for developing a moderate vacuum in the intake end of the line in order to suck the materials to be pumped through said intake and into said jet, a separator chamber in communication both with said vacuum creating means and with the discharge end of said transmission line, which chamber serves to separate the gaseous and liquid materials from each other, means in communication with such separator chamber for forcibly discharging the separated liquid material into the atmosphere, including a suction pump, and means for equalizing the pressures in the suction side of the pump and said separator chamber.

5. The continuous method of pumping viscous material, which comprises maintaining the intake orifice of the intake leg of a transmission line in contact with viscous material to be pumped, while admitting a high pressure steam jet into said intake leg at a point beyond its intake end in the direction of flow to thereby create sufficient vacuum in such intake end to rapidly suck the viscous material thereinto, then continuously effecting the transmission of said viscous material through the line and into a separator chamber immediately associated with the discharge end of said line while continually maintaining a moderate vacuum pressure in such chamber to minimize condensation in the line and conserve the propelling efficiency of such jet, effecting the gravity separation in such chamber of the pumped viscous material from the pumped gaseous material and continually removing the separated gaseous material from the upper portion of said chamber while simultaneously removing the separated viscous material from the lower portion thereof.

6. The continuous method of pumping viscous material to an elevation, which comprises partially submerging the intake end of a transmission line in viscous material to be pumped, while admitting a high pressure steam jet into said line beyond said intake end in the direction of flow, to thereby create sufficient vacuum in such intake end to rapidly suck viscous material and air thereinto, then continuously effecting the transmission of viscous material, air and steam through the transmission line and into a chamber of substantially greater cross-section than that of said transmission line while continually maintaining a moderate vacuum pressure in said chamber to minimize condensation in the line and conserve the propelling efficiency of such jet, effecting the gravity separation in such chamber of the pumped viscous material from the pumped gaseous material and continuously removing the separated gaseous material from the upper portion of said chamber while simultaneously removing the separated viscous material from the lower portion thereof.

7. The continuous method of pumping viscous material, which comprises continuously admitting an annular high pressure steam jet into a transmission line at a point beyond the intake end thereof in the direction of flow and creating an uninterrupted moderate vacuum at the intake end while maintaining the intake orifice thereof completely submerged in viscous material to be pumped while excluding the admission of atmospheric air into the transmission line in advance of the location of said steam jet and also simultaneously creating a moderate vacuum at the discharge end of said transmission line so as to minimize condensation in the line and to conserve the propelling efficiency of such jet and to thereby effect the gaseous-bubble-and-liquid-piston transmission of such viscous material through said line, delivering the viscous material so transmitted through the line into a vacuum separator chamber which is in permanent communication with the suction line and, while maintaining a moderate vacuum therein, continuously effecting the gravity separation of the pumped viscous material from the pumped gaseous material while simultaneously forcibly and separately discharging said pumped viscous and gaseous material from said vacuum chamber.

8. In a pumping apparatus, the combination comprising a transmission line, means for delivering a steam jet into said transmission line at a location adjacent, but not at, the intake orifice thereof, a vacuum separator adjacent the discharge end of the transmission line and into which said line delivers material conveyed therethrough, a force pump associated with said separator for removing the separated liquid therefrom, means for separately withdrawing gaseous material from said separator and equalizing means, including a conduit having a check valve interposed therein, for substantially equalizing the absolute pressure in the upper end of the separator chamber and the suction side of the force pump at the moment of and just prior to the commencement of the suction stroke of the pump.

9. The continuous method of pumping viscous material, which comprises continuously admitting an annular high pressure steam jet into a transmission line at a point beyond the intake end thereof in the direction of flow and creating an uninterrupted moderate vacuum at the intake end while maintaining the intake orifice thereof in contact with viscous material to be pumped, conveying the pumped viscous and gaseous material through said transmission line and into a separator chamber adjacent the discharge end of said transmission line in which a moderate vacuum is being continuously maintained, effecting the gravity separation in said chamber of the transmitted viscous and gaseous material, withdrawing the separated viscous material from the lower portion of the separator chamber into the low pressure side of a suction pump while maintaining independent communication between the upper portion of the separator chamber and the low side of the pump, to equalize the absolute pressures therein up to the very moment of the commencement of the suction stroke of the pump, and forcibly discharging the pumped viscous material from said pump while separately withdrawing the pumped gaseous material from the upper portion of said separator chamber.

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