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(54) APPARATUS FOR REMOVING SUBSTANCES OF LOW PUMPABILITY FROM TANKS

(71) We, INSTITUT FRANCAIS DU PETROLE, a body corporate organised and existing under the laws of France, of 4 avenue de Bois-Preau, 92502 Rueil-Malmaison, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to apparatus for removing substances of low pumpability from tanks.

Reference will be made in the following to a particularly attractive but non-limiting application of embodiments of the invention, i.e. the removal from tanks of oil tankers or from oil tanks of ships, which are stranded or sunk, of hydrocarbons which are of high viscosity or even practically in the solid state at the temperature of the surrounding medium.

Removal of such hydrocarbons by pumping is very difficult, if not impossible. Such hydrocarbons subject the surrounding medium to high pollution hazards because of the risk of the ships being destroyed, particularly as a result of storms or currents.

More generally, however, embodiments of the invention may be used for removing products which are difficult to pump from natural or artificial tanks, e.g. subterranean or underwater tanks, tanks located on land, or floating tanks.

According to the present invention there is provided apparatus for removing a substance of low pumpability from a tank, the apparatus comprising at least one drain pipe for the substance, the drain pipe being equipped with means for connecting it to the tank, and means for feeding the tank with hot water, said feeding means comprising at least one primary injection device having at least one nozzle for creating at least one striking and stirring hot water jet, the injection device being capable of connection to the upper part of the tank and being connected to at least one hot water injection pipe, and at least one secondary injection device located in the drain pipe and oriented in the direction of discharge of the substance whereby, in use, the secondary injection device is in communication with the tank above the level of said at least one nozzle.

The apparatus preferably comprises separating means connected to the drain pipe for separating the removed substance from the water and means for reheating and recycling the separated water, the recycling means being connected by the or at least one said hot water injection pippe to the or at least one said primary injection device.

In use of preferred embodiments of the invention described hereinbelow, an aqueous phase is formed and permanently maintained at the upper part of the tank, above the substance to be removed, by the jet or jets of hot water which are introduced into the tank in the aqueous phase, and the substance is discharged while dispersed in the aqueous phase.

In use of the preferred embodiments, the hot water jet or jets provide for a good stirring of the aqueous phase in the tank, facilitating heat transfer through convection or conduction, disaggregate the substance to be removed and scatter the same in the aqueous phase so as to form a mixture of a low viscosity which can be easily drained off. The jet or jets have a vertically downward vertical component directed towards the interface between the aqueous phase and the substance to be removed, being for example inclined by 30° to 40° on the vertical, these values being however non-limiting. Such an arrangement facilitates heat transfer between the hot water and the substance, as well as mechanical stripping action of the jets on the substance, and produces whirls which tend to rise and drive up the product therewith.

The removal of substances of a specific gravity lower than unity which are difficult to pump can be facilitated by draining off the substance scattered in water from a point of the tank located above the striking and stirring jet.

In use of the preferred embodiments of the invention, the pressure in the tank is kept at a value slightly lower than the pressure of the surrounding medium by virtue of the secondary injection, thereby avoiding or at least reducing any risk of pollution of the medium by the substance. Such secondary injection can have the additional advantage of reheating a drain or discharge circuit for the substance during starting periods, merely by hot water circulation through this circuit. It can also provide for washing or rinsing the drain or discharge circuit with hot water before disconnecting the same from the tank, thus obviating or at least reducing any risk of pollution of the surrounding medium, which is of particular advantage when discharging tanks at sea.

More generally, it should be noted that the use in a closed circuit of hot water for displacing the substance to be recovered reduces the risks of pollution during tank discharge operations at sea, since the fluid used has substantially the same composition as that of the surrounding medium, which is an advantage as compared to the use of solvents.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, wherein:

Figure 1 diagrammatically illustrates an apparatus not in accordance with the invention for removing products of low pumpability from a sunken ship;

Figure 2 is a diagrammatic view of a detail of the apparatus of Figure 1;

Figure 3 diagrammatically shows an apparatus embodying the present invention;

Figure 3A is a view of a connection box of the apparatus of Figure 3;

Figure 4 shows a modification of the embodiment of Figures 3 and 3A;

Figure 5 illustrates another embodiment of the invention which makes use of a drilling ship;

Figure 5A is a view of detail of the embodiment of Figure 5; and

Figure 6 diagrammatically illustrates an assembly of injection and drain pipes of the embodiment of Figures 5 and 5A.

Figure 1 diagrammatically shows an apparatus not in accordance with the invention, the apparatus being supported by a specially equipped servicing ship positioned above a sunken ship 2 resting on the bottom of a body of water.

The ship 2 is illustrated partially in cross section, the outline of its bows being shown in dotted lines.

The ship 2 is assumed to be an oil tanker containing hydrocarbons 3 which are difficult to pump due to their high viscosity at the surrounding temperature, and which should be removed from the ship. Sea water may have entered the tank or tanks containing this mass of very viscous hydrocarbons.

To achieve removal of the hydrocarbons, at least one pair of pipes, comprising an injection pipe 5 and a drain pipe 6, are connected to the ship's tanks by means of connecting devices 7 and 8, which may be of a known type, secured to a tank wall 2*a*.

In the illustrated arrangement the pipes 5 and 6 are in spaced relationship, but could instead be coaxial.

The pipes 5, 6 are advantageously flexible, as illustrated, their connection to the tank being effected substantially at the same point thereon, or (as shown) at different locations (for example, at the locations of manholes provided at the top of the tank or tanks).

The drain pipe 6 is preferably connected, whenever possible, at the highest point of the tank or tanks, so as to permit complete emptying thereof.

Connection of the pipes 5 can be achieved by divers.

The connectors 7 and 8 secured to the tank can be provided with automatic closure or sealing means, or with safety valves to provide for sealing of the tank when the pipes must be raised, for example if sea conditions make it necessary to discontinue operations. Alternatively, the connectors 7 and 8 may be provided with closure or sealing means which can be electrically or hydraulically closed by remote control from the surface, using remote control lines which may or not be separate from the pipes 5 and 6.

The pipe 5 is stored on a reel having a hollow shaft for connection thereto and is fed with pressurised hot water by a pump 10, through a rotary coupling 11 fitted to the hollow shaft of the reel. (The expression 'hot water' means water at a higher temperature than the surrounding temperature prevailing near the water bottom).

The temperature of the so-supplied hot water may be, for example, between 20° and 100°C, and its discharge pressure at the outlet of pump 10 may reach, for example, several hundred atmospheres.

At the lower part of pipe 5, the pressurised hot water is delivered through one or more striking and stirring jets 12 in the vicinity of the free surface of the hydrocarbon to be removed. The jets 12 advantageously have a vertical component directed towards the water-hydrocarbon interface, the inclination of the jets relative to the vertical being, for example, between 30° and 40°.

To this end, the pipe 5 is connected to a metal mouthpiece 13 whose length may reach several metres, the mouthpiece traversing the connector 7 and being provided with at least one injection nozzle, as described hereinbelow. The mouthpiece 13 may be equipped with a closure or sealing device 13*a* (Figure 2), either automatically or remotely controlled, for sealing the tank should pipe 5 be disconnected while the mouthpiece 13 is left in position.

Flared elements 5*a* and 6*a* limit, respectively, the curvature of the pipe 5 where it is connected to the mouthpiece 13 and that of the pipe 6 where it is connected to the connector 8.

Due to the combined effect of the heat delivered by the injected water and the mechanical action of the jet or jets 12, the hydrocarbons 3 are progressively softened, disaggregated and driven along with the carrying fluid, and they rise to the water surface through the drain pipe 6 in the form of a water emulsion.

The pipe 6 is stored on a reel 14 which also comprises a hollow shaft to which the pipe is connected.

The effluent reaches a separation tank 17, wherein the water and hydrocarbons are separated from each other, via a rotary coupling 15 and a pipe 16.

An overflow system 18 permits the recovery of the hydrocarbons which are drained off through a pipe 19 to a storage tank (not shown) as a function of the level indicated by a level indicated by a level indicator 17*a*, while the separated water is recycled through a pipe 20 to the pump 10. A pipe 21, provided with a valve 22, provides for topping-up with fresh water or sea water as the tank or tanks of the sunken ship are emptied. The whole recovery circuit is thereby maintained full of liquid.

This water addition may be effected in the separation tank 17, as illustrated in Figure 1, or at any other suitable location of the circuit. The amount of additional water depends on the position of the water-hydrocarbon interface, detected by an interface level indicator 17*b*.

Heating of the water may be performed by a heating device 23 using a heat-conveying fluid such as, for example, steam, the heating device being located in the water circuit, or/and by a heating coil (an electrical heating coil or a heating coil fed with heating fluid), such as those equipping the tanks of an oil tanker, the heating coil being located in the separation tank 17. Alternatively, heating may be achieved by direct steam injection into tank 17.

A valve 25 and a pressure gauge 26 permits regulation of the flow rate and injection pressure of water injected through the pipe 5.

The separation tank 17 may be provided with devices 27 of known type (such as those used in separation tanks of oil refineries), to facilitate coalescence and separation of the hydrocarbons and of the aqueous phase.

Figure 2 diagrammatically shows the device for injecting hot water into the tank. This device comprises the mouthpiece 13 connected to the pipe 5 and the traversing connector 7 which is provided on its interior with annular sealing rings around the mouthpiece.

At the lower part of the mouthpiece 13 is located a stationary or rotary ring 28 provided with one or more nozzles 29 from which pressurised hot water is discharged to form the jets 12. The nozzles 29 may be either stationary or movable with respect to the ring 28. Suitable means (not shown) hold the mouthpiece 13 in position to prevent the mouthpiece from being driven away by reaction, due to the action of the jets.

The optional rotation of the ring 28 may be achieved by the reaction effect caused by the jets, as in some watering devices, or by the action of a driving motor.

In another arrangement, the mouthpiece 13 may be constituted by the stator of a turbine such as that of a turbodrill whose rotor 30, carrying a ring 28 provided with nozzles, will be rotated by pressurised water injected through the pipe 5.

The rotary ring 28 and/or nozzles 29 are optionally displaceable in a vertical or transverse direction, so as to facilitate the disaggregation of the hydrocarbon mass.

For example, according to an advantageous arrangement, the mouthpiece 13 can be slidably mounted in the connector 7, so as to follow the progressive lowering of the free surface of the produce to be removed, whenever required.

Downward displacement of the mouthpiece 13 may for example be effected by a motor 31 driving rollers 32 pressed against the mouthpiece 13, the motor 31 being energised via a line 33 which may also be used for remotely controlling the motor 31.

Suitable means may be provided for detecting the level of the mouthpiece 13.

In the apparatus diagrammatically illustrated in Figure 3, sea water decanted in a separation tank 35 on board a servicing ship 34 is sucked by a pump P_1 at the lower part of a tank 35 and injected through a flexible (as shown) or rigid injection pipe 37 into a tank 38*a* of a ship 38, which is stranded or sunk, in the vicinity of the surface 39*a* of hydrocarbons 39, with flow rate control at 36.

The flexible injection pipe 37 is divided at its lower part into two pipes 37*a* and 37*b* which are connected, respectively, to injection nozzles or injection mouthpieces 40*a* and 40*b*. The injection nozzles 40*a*, 40*b* traverse connection boxes 41*a* and 41*b* which are connected to a wall 38*a* of the ship 38 and are slidably mounted therein for vertical displacement. Sealing is ensured by safety elements 42*a* and 42*b* arranged to be closed either automatically upon withdrawal of the mouthpieces 40*a* and 40*b* from the connection boxes 41*a* and 41*b* (in similar manner to the blow out preventers used in oil wells) or by remote control from the water surface.

The water injected through the mouthpieces 40*a* and 40*b* is discharged in the form of striking and stirring jets 43.

This water is a temperature higher than that of the hydrocarbons in the ship and produces heating and a fluidity increase of the hydrocarbons, which rise up through two branch pipes 44*a* and 44*b* of an outlet pipe 44, in admixture with water, to a pump P_3.

The mixture reaches a separation tank 35. Reheating of the water may be achieved by steam injection into a mixer 45*a* or by a heat exchanger coil 45*b* located in the separation tank 35.

Steam is supplied by a pipe 46, with a temperature control at 47, and through condensation, provides the heat required for heat-balancing the operation. By means of a differential pressure gauge 48 connected to the tank 38*a* via a line 82*a* and actuating a shunt valve 49 of the pump P_3, it is possible to prevent the creation in the tank 38*a* of the ship 38 any excess pressure which might damage it, and even to create, on the contrary, a slight negative pressure (vacuum) in the tank 38*a* which obviates any risk of leakage into the surrounding medium and consequently prevents any pollution thereof. The line 82*a* may consist of two flexible pipes, containing a hydraulic fluid, connected to the gauge 48 which adjusts the valve 49 in accordance with the detected pressure difference.

In the apparatus of Figure 3 the separation tank 35 remains full of liquid during operation so as to avoid disturbances caused by swell. Hydrocarbons are collected at the upper part of tank 35 from which they can be removed, under control of the interface level monitored at 50, and discharged through a pipe 51 so as to be either transferred into another oil tanker or burnt. A shunt line 52 between the separation tank 35 and the suction pipe of the pump P_3 is used to provide, during a determined period after starting the device, circulation of sea water around the tank 35 to heat the circuitry.

Topping-up of sea water in the tank 35 is accomplished by a pump P_4 via a suction pipe 53, with pressure control at 54, so as to compensate for the amount of hydrocarbons withdrawn from the separation tank so as to keep the system filled up with liquid.

At least one secondary injection of fluid, such as heated sea water, is effected into the mixture of water and hydrocarbons which reaches the discharge pipe, by means of one or more devices of which at least one is located as close as possible to the point at which the hydrocarbons are withdrawn from the tank 38*a* of the ship 38.

In the apparatus illustrated in Figure 3, this secondary injection is effected by pumps P_{2A} and P_{2B} and by a pipe 55 divided, at its upper part, into two pipes 55*a* and 55*b* respectively connected to the connection boxes 41*a* and 41*b*, these two pipes each ending in an ejector 59, as shown in Figure 3A.

This secondary injection is effected above the main injection achieved by the jets 43, i.e. at a place where the hydrocarbons have already been dispersed in the aqueous phase.

This secondary injection is effected permanently (hence the necessity for two pumps P_{2A} and $P_{2B'}$ one of which is an auxiliary pump). Its flow rate is controlled at 56.

The secondary injection has the following advantages:

- it permits heating of the discharge pipes 44*a*, 44*b* upon starting the system and keeping these pipes hot enough, even in the case of failure of the main pipe P_1.
- by a jet effect, optionally enhanced by means of a venturi, the secondary injection creates a local negative pressure facilitating suction of the hydrocarbons and their disaggregation when a large amount of hydrocarbon enters the discharge pipes.

This local negative pressure is so adjusted as to permanently maintain in the tank 38*a* a pressure slightly lower than in the surrounding medium, thereby preventing any pollution of this medium.

- The secondary injection produces an acceleration of the flow through the pipes 44*a*, 44*b* facilitating raising of the mixture of sea water and hydrocarbons and maintaining in this pipe a sufficient raising velocity, irrespective of the flow rate through the pump P_1.

These effects are negative pressure and acceleration may also be obtained by one or more complementary injections of liquid or gas (steam or air), through nozzles, in the drain pipe.

In a modification of the apparatus of Figure 3, as illustrated in Figure 4, the drain pipe 44 and the secondary injection pipe 55 are not sub-divided at their lower part, as in the apparatus of Figure 3, but are both connected to a central connection box 57, the secondary injection pipe for injecting hot water being connected to a heating coil 58 which surrounds the lower end of the drain pipe 44, so as to facilitate reheating thereof and restarting of the system.

Similarly, a heating coil may be arranged inside or outside each of connection boxes 41*a* and 41*b* of the above embodiment to perform the same function.

In the apparatus illustrated in Figures 5 and 6 a drilling ship 34 provided with a derrick 60 is used for removing hydrocarbons 39 contained in a tank 38*a* of a ship 38. The drilling ship 34 is positioned above the ship 38 by any known means, advantageously be using a dynamic positioning system.

A riser pipe 61 of a type conventional in offshore drilling operations, comprising a telescopic coupling 62 absorbing vertical movements due to swell, is connected at its lower part through a ball joint 63 with a base plate 64 resting on the sea bottom in the immediate vicinity of the ship 38. The riser 61 is kept under tension in known manner from the ship 34, using cables 65 connected to tensioning means 65*a*.

Hot sea water injected into the tank 38*a* through an injection mouthpiece 40 producing jets 43 is drawn from a separation tank 35 through a pipe 66.

The riser 61 comprises on its periphery, in a conventional manner, three lines 67, 68 and 69 (respectively known in the art as a kill line, a boosting line and a choke line) connected to the riser 61 by flanges 70, as shown in Figure 5A.

The pipe 66 for feeding hot sea water is connected to the pipes 67 and 68 secured to the riser 61 via a group of injection pumps P.

At the lower part of the riser 61, above a block 71 of blow out preventers, the pipes 67 and 68 are connected to a main injection pipe 72, itself connected to the injection mouthpiece 40 which is vertically slidable in a connection box 41, as illustrated in Figure 6.

The connection box 41 is connected to a pipe 73 for discharging the hydrocarbon - water mixture, the pipe 73 being connected to the lower part of the riser 61 (Figure 6).

An injection of hot water (secondary scavenging injection) is effected at the inlet of the pipe 73 through a nozzle 74 located at the end of a heating coil 75 surrounding the mouthpiece 40 or the connection box 41.

Feeding of the heating coil 75 with pressurised water is achieved through the third pipe 69 connected to the riser 61 (Figures 5 and 6), the third pipe 69 being supplied with pressurised water through the group of pumps P and being connected at its lower part to the heating coil 75 via a flexible pipe 76.

It is optionally possible to adjust, by flow rate control means such as the regulators 36 and 56 of Figure 3, the injection rate through the mouthpiece 40 and the secondary scavenging flow rate injected through the nozzle 74 (Figure 6).

According to the preferred, but non-limiting, embodiment illustrated in Figure 6, it is no longer necessary to use a sucking pump, such as the pump P_3 of Figure 3, for raising the mixture of hydrocarbons and water in the riser 61. As illustrated, raising of the mixture is performed by a hydro-ejector 77 located in the riser 61 at its lower part and supplied with pressurised water from the ship, the hydro-ejector producing an upward jet in the riser 61 and simultaneously creating a negative pressure at the lower part of the riser 61 and an overpressure at the upper part of the riser 61, thereby raising the mixture of water and extracted hydrocarbons up to a level above sea level. This embodiment has the advantage of only requiring the connection to the tank 38*a* of short pipes, i.e. pipes 72, 73 and 76, thus facilitating the connection and disconnection operations.

The hydro-ejector 77 is advantageously fed with pressurised water through a pipe 78, such as a drill string, located in the riser 61 and comprising at its upper part an injection head 79*a*, of conventional design, supported by a hook and travelling block of the derrick 60. Water injection into the drill string 78 is carried out in known manner through the injection head 79*a* and a flexible line 79 (Figure 5) connected to the injection head 79*a* and to pumping means (not shown) such as those conventionally provided on drilling ships.

The mixture of hydrocarbons and water rising through the riser 61 can flow by gravity through a pipe 80 into the separation tank 35, which can be equipped with a heating coil or heat exchanger 45*b*, as in the above-described embodiment.

The tank 35 may be open at its top part and the separated hydrocarbons discharged by overflowing, through pipe 81, and, for example, directed to a flare where they can be burnt.

Additional (topping-up) sea water may be introduced into the tank 35, either continuously or intermittently, to compensate for the amount of hydrocarbons discharged from this tank, so that the whole system remains full of liquid. Detection of the interface level 50 (Figure 3) is used to control this sea water introduction.

The tank 35 may in some cases be provided with known means (such as those used in the decantation tanks of oil refineries), to facilitate coalescence and separation of the hydrocarbons and the aqueous phase.

The negative pressure created by the

hydro-ejector 77 depends only on the amount of water injected through the pipe 79, for given flow rates in the main injection pipe 72 and the secondary injection pipe 76.

Regulation of the injection flow rate through the pipe 79 can be achieved by means of a differential pressure sensor on the connection box 41, which measures the difference between the internal pressure of the box (transmitted for example by a membrane) and the hydrostatic pressure. These pressures are respectively transmitted to the water surface through a connecting line 82 (Figure 6), for example similar to the connecting line 82*a* described above.

It is thus possible to maintain in the riser 61 a fixed negative pressure upstream of the hydro-ejector 77 and a fixed overcome pressure downstream of the hydro-ejector, irrespective of the flow rates through the main injection pipe 72 and the secondary injection pipe 76. This negative pressure and overpressure help to overpressure drops in the outflow of the water - hydrocarbon mixture, as well as the hydrostatic pressure up to the discharge point of the riser 61 into the pipe 80.

This negative pressure will be fixed at a level so selected as to maintain in the tank 38*a* a pressure slightly lower than the hydrostatic pressure at the level of the tank.

As in the apparatus of Figure 3, it may be advantageous to provide a by-pass pipe (not shown) around the separation tank 35, whereby a circulation of sea water around the tank 35 can be provided during the starting period of the system, in order to heat the circuitry.

During this starting period, before starting the main water injection through the pipes 67, 68, the pipe 72 and the mouthpiece 40, the interior of the connection box 41 may be heated by pumping hot water through the pipe 69, the pipe 76 and the heating coil 75. The secondary injection through the column 78 and the hydro-ejector 77 will also be started.

The main water injection will then be progressively established by initially placing the injection mouthpiece 40 in its uppermost position, to prevent untimely raising of heavy hydrocarbon masses into the box 41, at the beginning of the operation, the mouthpiece being thereafter progressively lowered.

In operation, the scavenging secondary injection through the nozzle 74 will make it possible, as in the above-described arrangements, to disaggregate the hydrocarbon masses reaching the outlet of connexion box 41, since they might otherwise clog the pipe 73.

Suitably calibrated valves are located at various points of the circuit, in particular near the connection box 41 or on this box, to limit any negative pressure or overpressure in the tank 38*a*, which might damage the tank and result in external pollution.

The nozzle 74 may optionally be arranged to create a slight suction effect at the point of connection of the pipe 73 to the box 41.

The mouthpiece 40 may advantageously be so designed as to completely close or seal the outlet opening of the tank 38*a* when it is raised to its uppermost position. This prevents a massive hydrocarbon rise into the box 41 in the case of stopping the main injection or in the case of a rapid disconnection of the injection systems.

Before any disconnection, after stopping the discharge of hydrocarbons, washing with sea water of the discharge pipes is normally performed by means of the secondary injection pipes such as 55, 55*a* and 55*b* or 76, and the pipe 78 in the embodiment illustrated in Figure 6.

Reference is directed to our copending patent application No. 51810/77 (Serial No. 1582901), from which the present application was divided out, which includes claims directed to methods disclosed hereinabove.

WHAT WE CLAIM IS:

1. Apparatus for removing a substance of low pumpability from a tank, the apparatus comprising at least one drain pipe for the substance, the drain pipe being equipped with means for connecting it to the tank, and means for feeding the tank with hot water, said feeding means comprising at least one primary injection device having at least one nozzle for creating at least one striking and stirring hot water jet, the injection device being capable of connection to the upper part of the tank and being connected to at least one hot water injection pipe, and at least one secondary injection device located in the drain pipe and oriented in the direction of discharge of the substance whereby, in use, the secondary injection device is in communication with the tank above the level of said at least one nozzle.

2. Apparatus according to claim 1, comprising separating means connected to the drain pipe for separating the removed substance from the water and means for reheating and recycling the separated water, the recycling means being connected by the or at least one said hot water injection pipe to the or at least one said primary injection device.

3. Apparatus according to claim 1 or claim 2, wherein the or at least one of the primary injection devices is operative to produce at least one said jet having a vertically downward component.

4. Apparatus according to any one of claims 1 to 3, wherein the or at least one said secondary injection device is associated with a venturi.

5. Apparatus according to any one of

the preceding claims, comprising means for rotating the or at least one said injection nozzle.

6. Apparatus according to any one of the preceding claims, comprising means for displacing the or at least one said injection nozzle in translation.

7. Apparatus according to any one of the preceding claims, wherein a secondary scavenging injection pipe surrounds an end of the or at least one said primary injection device to facilitate reheating thereof during the starting period.

8. Apparatus according to any one of the preceding claims, comprising at least one additional injection pipe for displacing a mixture of water and substance to be removed, the additional injection pipe opening through a hydro-ejector into the drain pipe.

9. Apparatus according to any one of claims 1 to 7, for removing the substance from an underwater tank, wherein the drain pipe comprises at least one column for raising the substance, the column being supported by a surface installation, and a flexible pipe connecting the column to the tank, the column comprising at least one additional pipe for injection of a driving fluid, the additional pipe opening into the column through a hydro-ejector.

10. Apparatus according to claim 9, wherein the column has secured thereto two water injections pipes connected by flexible pipes, respectively to the or at least one said primary injection and to the or at least one said secondary injection device.

11. Apparatus according to any one of the preceding claims, comprising safety devices for sealing the tank in the event of disconnection of the hot water injection and drain pipes.

12. Apparatus according to any one of the preceding claims, which is operative in use to keep the pressure in the tank below that of the surrounding medium.

13. Apparatus for removing a substance of low pumpability from a tank, the apparatus being substantially as herein described with reference to Figures 3 and 3A, Figure 4 or Figure 5, 5A and 6 of the accompanying drawings.

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1582902 COMPLETE SPECIFICATION

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Sheet 1

FIG.1

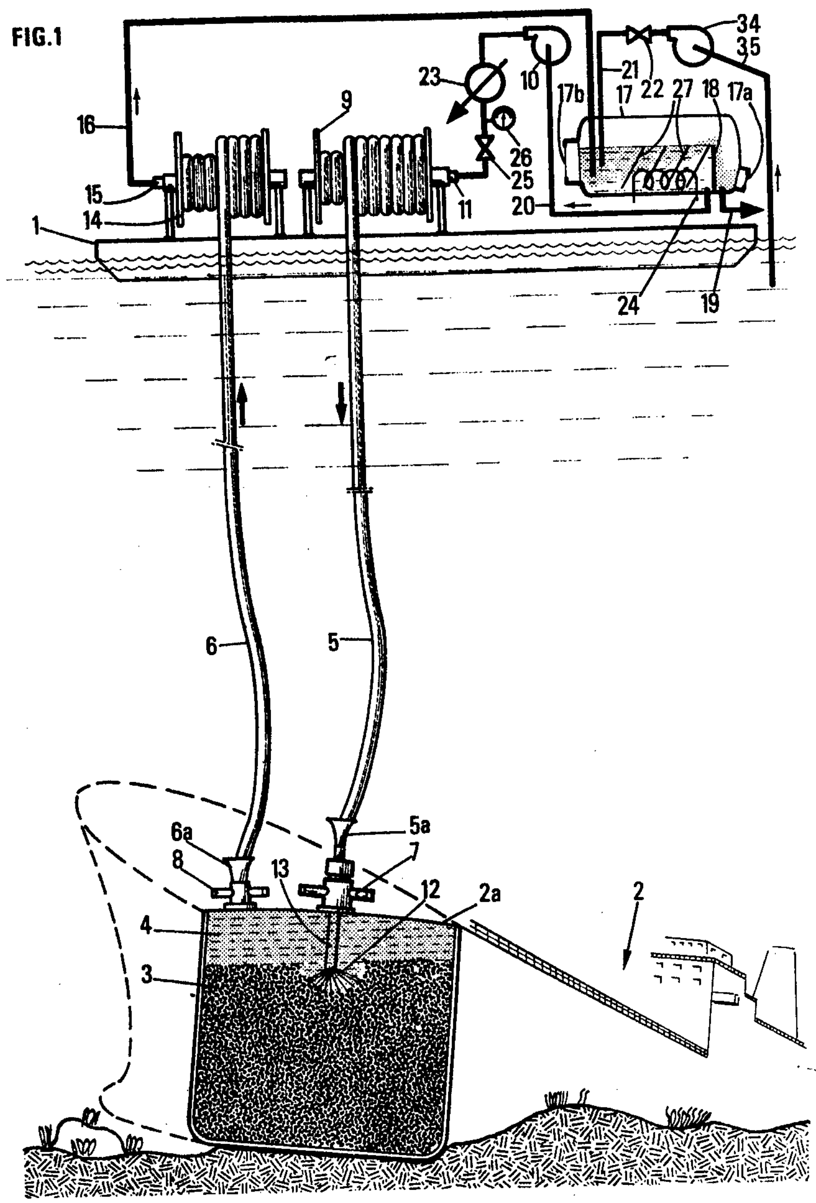
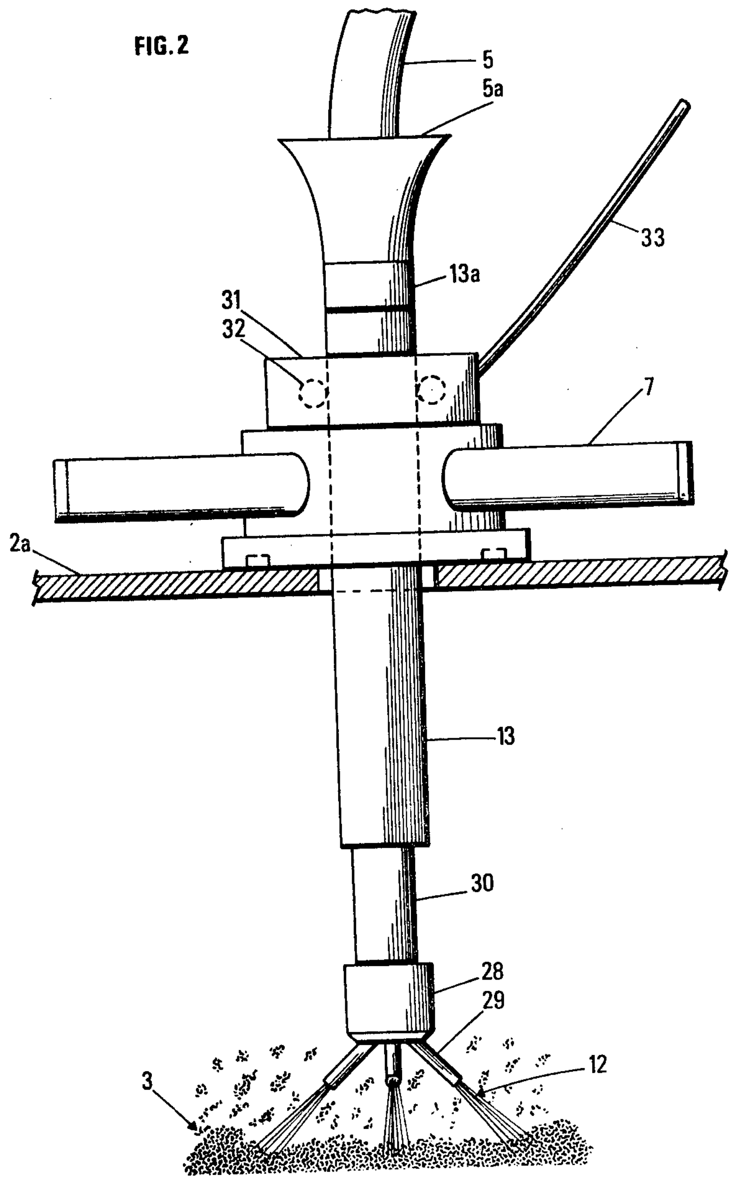


FIG. 2



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Sheet 3

FIG.3

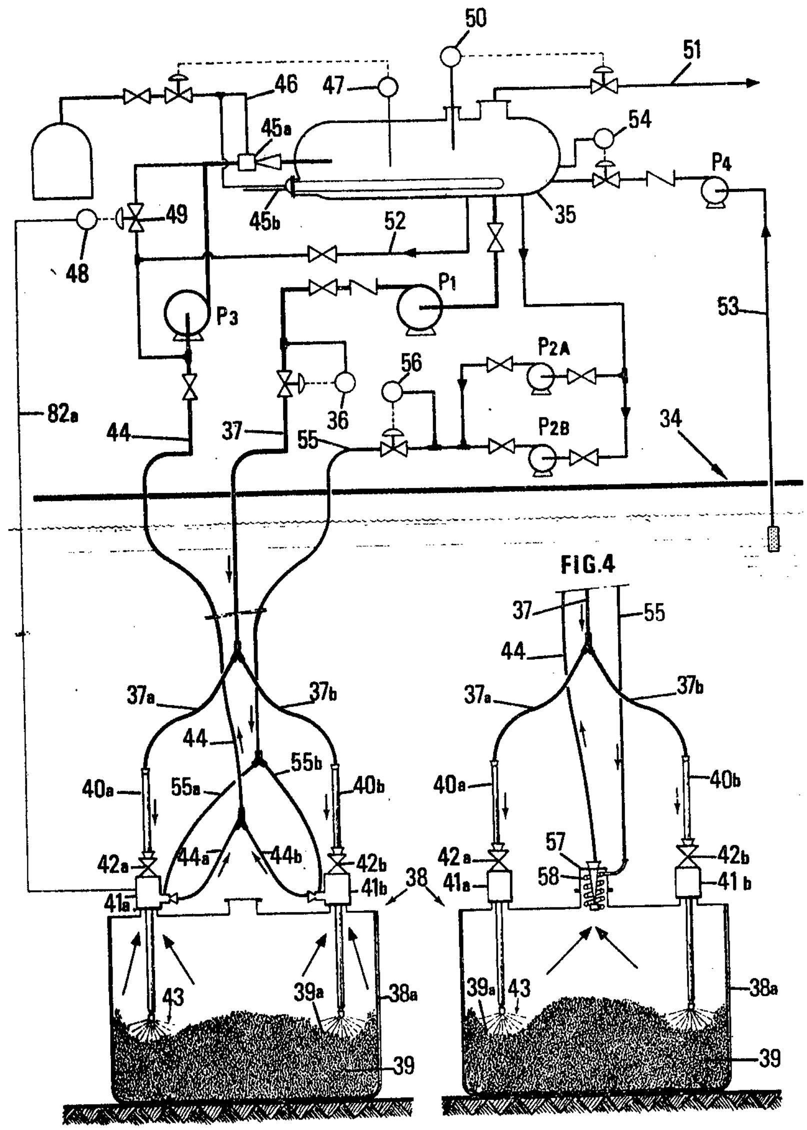
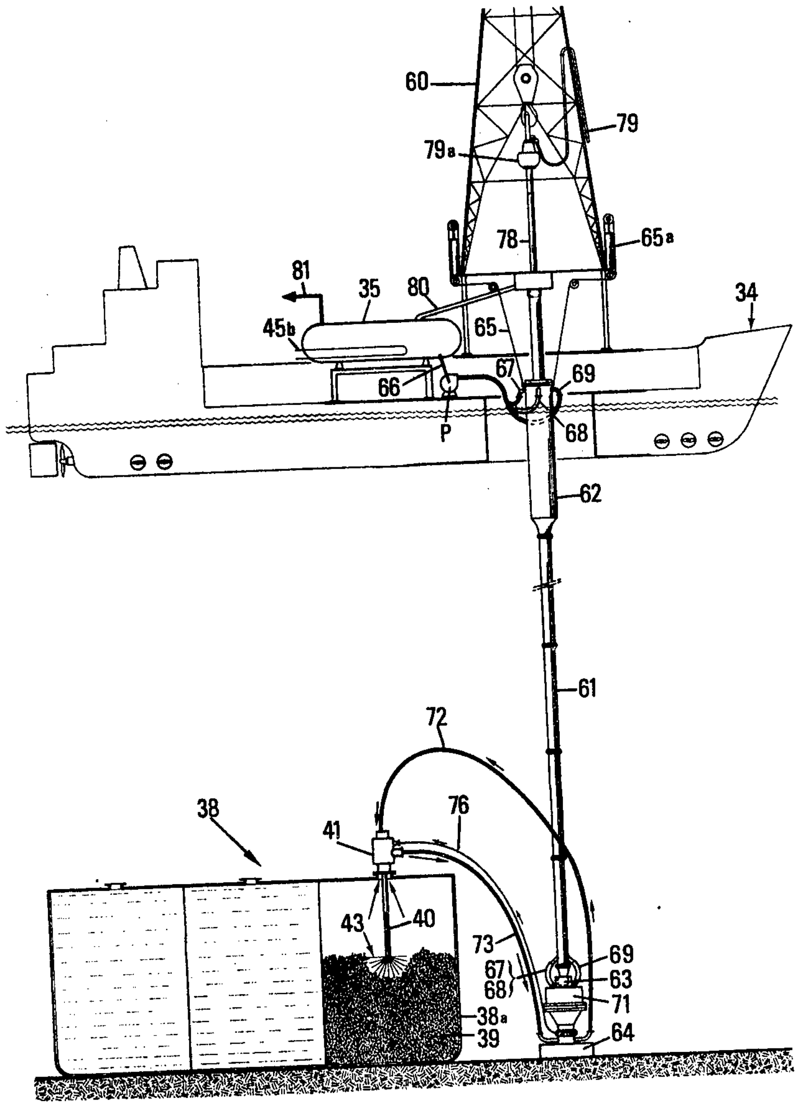


FIG.5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Sheet 5

FIG.3A

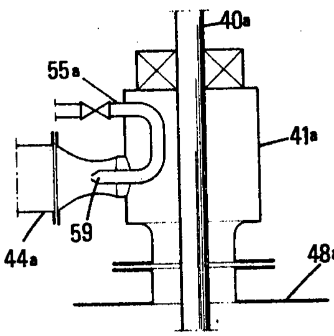

FIG.5A

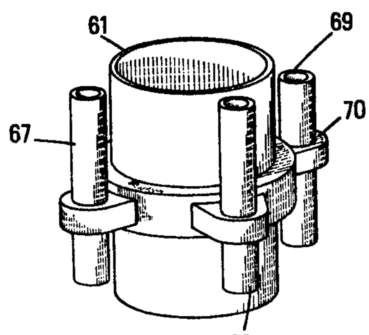

FIG.6