

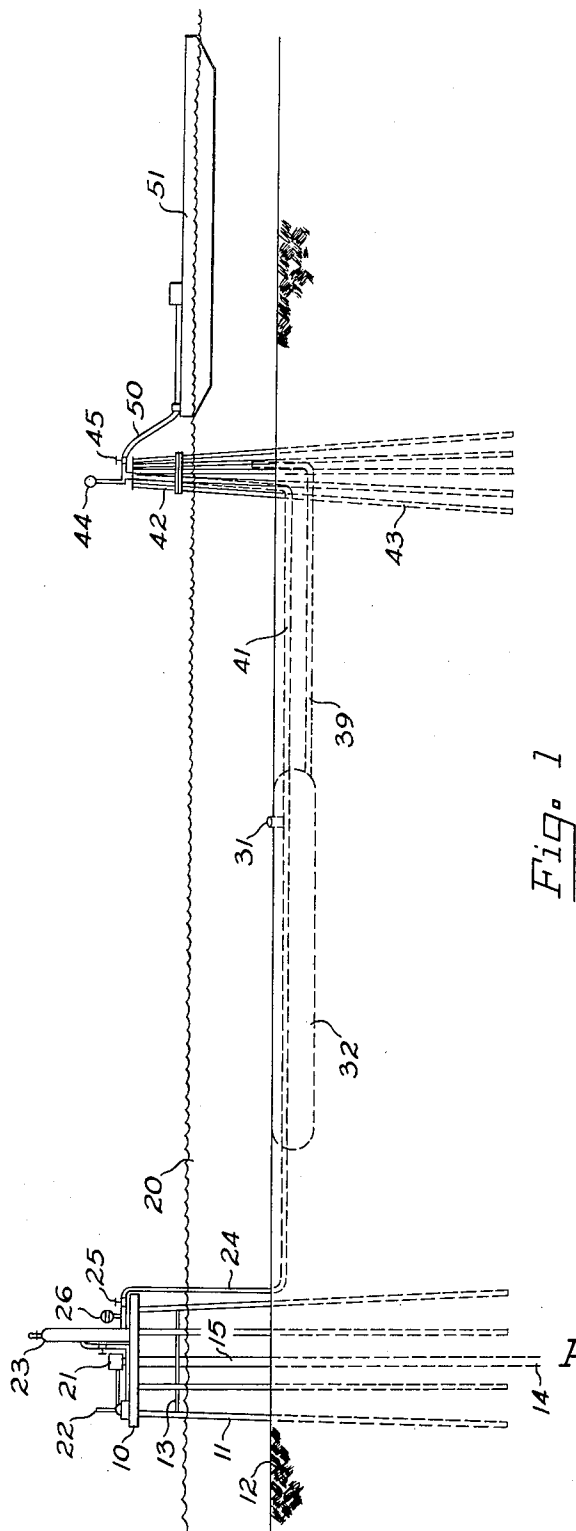
Jan. 17, 1956

R. G. WATTS
SYSTEM FOR GATHERING AND LOADING
OIL FROM UNDERWATER OIL WELLS

2,731,168

Filed Nov. 17, 1952

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

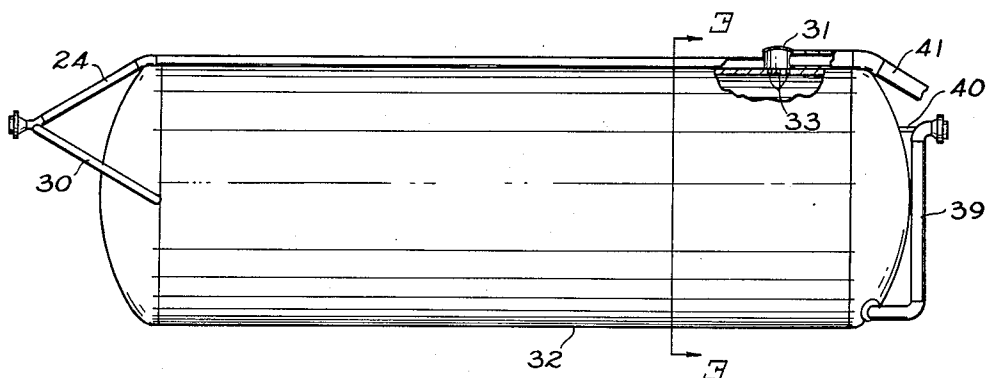


Fig. 2

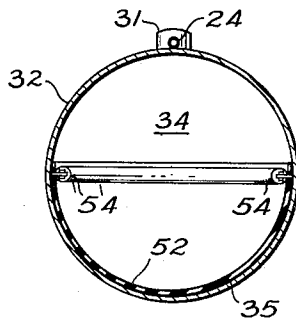


Fig. 3

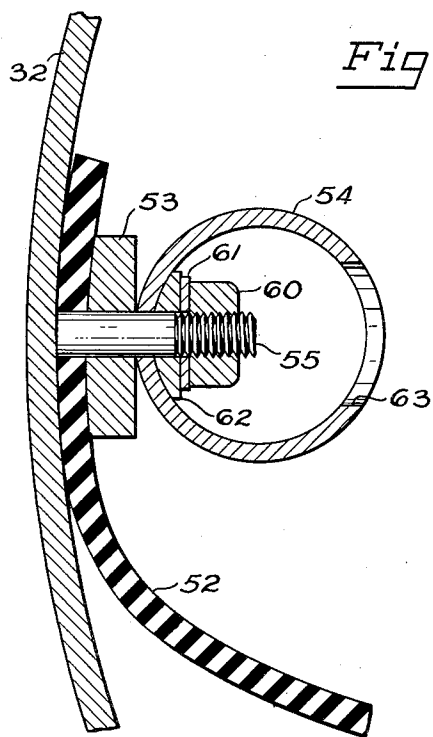


Fig. 5

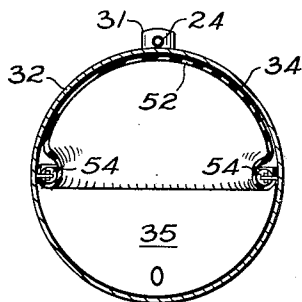


Fig. 4

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1

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SYSTEM FOR GATHERING AND LOADING OIL FROM UNDERWATER OIL WELLS

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2 Claims. (Cl. 220—85)

This invention relates to the production of oil from underwater oil wells and relates more particularly to the gathering and loading for transportation of oil produced from underwater wells.

In the operation of oil wells located on dry land, the oil produced from the well may be passed directly from the well through an appropriate valve and pipe arrangement to storage tanks to await transportation by pipe line or tank car to an oil refinery. Sufficient storage capacity compensates for the fluctuation in the rate at which oil may be transported by pipe line or loaded into tank cars and thus makes possible a continuous rate of production of oil from the well, which is highly desirable from the standpoint of insuring maximum total recovery of oil from the well, maximum utility of the pumps, valves, lines, etc., and stability of operation. The same reasons for desiring uniform rates of production exist in the case of underwater or offshore wells where, as in the case of dry land wells, sufficient storage capacity will compensate for the fluctuation in the rate at which the oil may be transported to the refinery.

The peculiar nature of the location of underwater wells brings up particular problems in maintaining uniform rates of production. Due to the difficulty and expense involved in laying underwater pipe lines from the shore to the well, it is economically desirable to go to other means of transportation, such as oil tankers and barges. However, tankers and barges cannot be loaded during unfavorable weather conditions in the form of high winds and waves, and so production must stop or sufficient storage capacity must be provided to handle continuous production for whatever may be the maximum period of adverse weather conditions.

Tanks submerged in water have been used for the storage of oil, but with their use there has been the problem of the oil escaping into the surrounding water causing destruction of marine life and creating fire hazards due to the oil floating on the surface of the water. Another problem which has been encountered with the use of submerged oil storage tanks has been the mixing of the water with the oil, which is not desirable.

It is an object of this invention to provide an underwater oil storage tank which may at all times be maintained liquid full with oil, water, or oil and water and from which there will be no escaping of oil to the surrounding water. It is another object of this invention to provide an underwater oil storage tank which may be maintained liquid full at all times with oil, water, or oil and water without any mixing of the two liquids within the storage tank. It is another object of this invention to provide a method for gathering and loading oil from underwater oil wells. It is another object of this invention to provide an economical system for maintaining continuous production from underwater oil wells. It is another object of this invention to provide an apparatus for gathering and loading oil from underwater oil wells.

2

These and other objects of the invention will become apparent from the following description thereof.

In accordance with the invention, oil from an underwater oil well is gathered from the well, stored in a storage tank positioned sufficiently below the surface of the water to be unaffected by winds and surface waves, and drawn off from the storage tank to transport barges as desired. The storage tank is maintained liquid full at all times with either oil, water, or oil and water and is provided with sufficient ballast, if necessary, to overcome the buoyancy effect of the surrounding water and to maintain the tank in its underwater position. A particular feature of the invention is that the storage tank may be liquid full at all times without any mixing of the oil and water and thus preventing any possibility of water getting into the transport barge from the storage tank. This is accomplished in accordance with this feature of the invention by providing a flexible membrane or a plurality of flexible membranes within the tank dividing the tank into a plurality of sections variable in volume as needed, due to the flexibility of the dividing membrane or membranes. The storage tank is provided in its oil storage section or sections with an oil inlet line and with an oil outlet line supported at a mooring dolphin, and provision is made to permit water to enter the water containing section or sections of the storage tank as defined by the flexible membrane or membranes.

Fig. 1 is a plan view schematically illustrating one embodiment of the invention. Fig. 2 is a view partially in elevation and partially in section of an underwater storage tank. Fig. 3 is a view taken along line 3—3 of Fig. 2 showing the position of the flexible membrane when the storage tank is substantially filled with oil. Fig. 4 is a view in section taken along the line 3—3 of Fig. 2 showing the position of the flexible membrane when the storage tank is substantially filled with water. Fig. 5 is an enlarged view in section showing the details of securing the flexible membrane to the interior of the storage tank.

The storage tank may be of any suitable type such as a cylindrical tank. The tank may be positioned at the bottom of the body of water where the bottom is hard, or it may be permitted to sink into the bottom where the bottom is soft. If desired, the tank may be positioned intermediate to the bottom and the surface of the water, although, in this case, it will be necessary to provide anchoring means to prevent the tank from rising to the surface where its overall specific gravity is less than the surrounding water, as where it is filled with oil, or hanging means, such as pilings sunk into the bottom, to prevent the tank from sinking to the bottom where its overall specific gravity is greater than the surrounding water, as where it is filled with water. Ballast may be employed to maintain the overall specific gravity of the tank above the specific gravity of the water whereby the tank will maintain its position at the bottom or sink into the bottom, or be prevented from rising if positioned intermediate to the bottom and the surface. Air tanks or the like may be provided to maintain the overall specific gravity of the storage tank below the surrounding water whereby the tank will be prevented from sinking where it is positioned intermediate to the bottom and the surface. In the embodiment of the invention shown in the drawings here, a cylindrical tank is used and it is completely buried in the bottom.

In operation, oil from the well is passed into the storage tank through the oil inlet line at a pressure in excess of the hydrostatic pressure of the surrounding water and the water contained in the tank below the flexible membrane is displaced to the surrounding water, the flexible membrane assuming substantially the shape of the lower half of the storage tank as the storage tank becomes filled

with oil. If the pressure of the well is not in excess of the hydrostatic pressure within the storage tank, a pump may be employed to provide the necessary pressure. The displaced water leaves the storage tank through a water line located at the bottom of the tank and flows back to the surrounding water.

Oil is removed from the tank through an oil outlet line supported by a mooring dolphin to a transport barge. Since water has a higher specific gravity than oil and the oil in the tank is at the hydrostatic pressure of the surrounding water, the oil may flow to the barge without the assistance of pumps, where the tank is at a sufficient depth. However, the use of a pump is desirable, in any case, in order to lessen the time required to load the transport barge. Water enters the tank through the same line through which it leaves, or a separate line may be provided, thereby displacing the oil being loaded on the barge but remaining separated from the oil in the storage tank by the flexible membrane which allows the tank to become substantially filled with water, at which time the membrane will have assumed the approximate form of the upper half of the tank.

Referring to the drawings, producing platform 10 is supported by a plurality of piles 11 which are sunk deep into bottom 12 and are steadied by a plurality of braces 13. Extending from platform 10 downward into well 14 is casing 15. Platform 10 is at a sufficient height above water 20 to protect it and the equipment mounted upon it from the effect of high waves during adverse weather conditions. Mounted on platform 10 are well head 21, heater 22, separator 23 and the usual lines and valves. Oil from well 14 passes through the various equipment just enumerated into separator 23. Line 24 provided with valve 25, diaphragm valve 26, and brace 30 leads from separator 23 to dome 31 mounted on storage tank 32, which is sunk into bottom 12, provided with ports 33 to allow flow of oil to and from dome 31. Oil flows from separator 23 through line 24, dome 31, and ports 33 into upper section 34 of tank 32. Water from that surrounding the storage tank flows to and from lower section 35 of the storage tank through line 39, one end of which is open to the water and situated sufficiently below its surface that it will always be under hydrostatic pressure. Brace 40 is secured between line 39 and tank 32. Oil is removed from the upper section of the tank by line 41 which leads from dome 31 to dolphin 42 which in this embodiment is supported on piles 43 which are sunk into bottom 12. Dolphin 42 may, of course, be a buoy anchored in position. Dolphin 42 is provided with means, not shown, for mooring a transfer barge to it. Line 41 is provided with relief valve 44, valve 45 and means for connecting flexible hose 50 which supplies the oil to loading barge 51. Dolphin 42 is placed at a sufficient distance from platform 10 to reduce fire hazards by preventing the spread of fire from the dolphin to the platform. Also, the dolphin is at a distance from the platform which will permit the mooring of the loading barge to the dolphin at any position within a circle around the dolphin without the loading barge coming in contact with the platform.

Cylindrical tank 32 is divided into upper section 34 and lower section 35 by flexible membrane 52. Membrane 52 is secured around its entire outer edge to the inside of the tank, thus providing a complete separation of tank 32 into two separate compartments variable in volume. The line of contact of the edge of the membrane with the inside of the tank lies in a horizontal plane which divides the tank into approximately equal upper and lower sections. The membrane is held in liquid tight contact with the inside of the tank by bar 53 and pipe 54, which are secured by a plurality of bolts 55, nuts 60, lock washers 61, and contour washers 62. Bolts 55 are welded to the inside of tank 32. At the points where bolts 55 pass through pipe 54, the pipe is provided with ports 63 to

allow access with a socket wrench. In addition to aiding bar 53 in maintaining contact with membrane 52, pipe 54 prevents membrane 52 contacting bolts 55 which might tear or otherwise damage membrane 52. In order to minimize corrosion, the above enumerated securing apparatus is positioned above membrane 52 within the oil-containing upper section 34.

Flexible membrane 52 is composed of a material, such as polyethylene or neoprene rubber, which will withstand contact with oil and sea water for long periods of time without deterioration and will be flexible enough to conform to the inside shape of the upper and lower halves of tank 32. When the tank is substantially filled with oil, the membrane will be in the position shown in Fig. 3 and when the tank is substantially filled with water, the membrane will be in the position shown in Fig. 4. The membrane must be of sufficient size to allow it to assume the above described shapes without stress being put upon the membrane. The use of this flexible membrane provides the means whereby the storage tank may be liquid full at all times with oil, water, or oil and water without any mixing of the two liquids. Therefore, no water will be pumped with the oil into the loading barge and no oil will flow from the tank into the surrounding water. As oil is pumped into the tank, water is displaced from it to the surrounding water. When the oil is removed from the tank, water flows from the surrounding water through line 39 into lower section 35 of the tank, replacing the oil which is being removed to a loading barge.

Having thus described my invention, it will be understood that such description has been given by way of illustration and example only and not by way of limitation, reference for the latter purpose being had to the appended claims.

I claim:

1. In an underwater oil storage tank having a flexible impervious membrane dividing said tank into an upper oil-containing section and a lower water-containing section, means positioned above said membrane within said oil-containing section for securing said membrane in liquid tight contact with the inside surface of said tank, said means comprising in combination a plurality of bolts secured to the inside surface of said tank and projecting inwardly therefrom, said bolts passing through said membrane near its periphery to maintain said membrane in position in said tank, a bar fitted on said bolts adjacent to said membrane holding said membrane in liquid tight contact with the inside surface of said tank, and means secured on said bolts to maintain said bar in position and to prevent said membrane from contacting the inward ends of said bolts.
2. In an underwater oil storage tank having a flexible impervious membrane dividing said tank into an upper oil-containing section and a lower water-containing section, means positioned above said membrane within said oil-containing section for securing said membrane in liquid tight contact with the inside surface of said tank, said means comprising in combination a plurality of bolts secured to the inside surface of said tank and projecting inwardly therefrom, said bolts passing through said membrane near its periphery to maintain said membrane in position in said tank, a bar fitted on said bolts adjacent to said membrane holding said membrane in liquid tight contact with the inside surface of said tank, a pipe fitted on said bolts adjacent to said bar to aid in holding said bar in contact with said membrane and to prevent contact of said membrane with the inward ends of said bolts, a plurality of contour washers on said bolts adjacent to the inside surface of said pipe, a plurality of lock washers on said bolts adjacent to said contour washers, a plurality of nuts screw-threaded on said bolts adjacent to said

lock washers, and a plurality of ports in said pipe so positioned and of such size as to permit access to said nuts.

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