

PATENT SPECIFICATION

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(54) APPARATUS FOR DISPOSING OF MATTER FLOATING ON WATER

(71) We, M.O. (MITSUI-OSAKA) MARITIME CONSTRUCTION COMPANY LIMITED, a Japanese company, of 1-banchi, Saze-cho, Kita-ku, Osaka, Japan, 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 an apparatus for disposing of matter floating on water.

Conventionally, several means have been proposed to dispose of matter such as oil or red tide, which floats on water and which causes ocean pollution and exerts a harmful influence upon the life of mankind. When the floating matter is a oily material such as discharged oils, various methods have been employed for recovering the floating matter. The following methods are among these:

- (1) to treat with a neutralizing agent,
- (2) to absorb into an absorbent, and
- (3) to pump up a thickened layer of the floating matter produced by the use of a spread-preventive barrier, such as an oil fence.

These methods, however, have their own drawbacks when implemented. As for method (1), a large amount of the neutralizing agent has to be ready for use. Also the neutralized oils may well cause a secondary pollution. As for method (2), it is difficult to rid the absorbent of the discharged oil adhering to it. After repeated use of the absorbent, it eventually becomes ineffective. Furthermore, floating matter in the form of rainbow-colored membranes (arising from small amounts of discharged oil) cannot be recovered by this method. In carrying out the method (3),

(with the advantage that it can prevent the discharged oil on the surface from spreading), it has been found that it gave rise to various kinds of troubles in the process of removing the discharge oil encircled.

Since the use of either a neutralizing agent or an absorbent entails the difficulties above-mentioned, the usually adopted method is to gather the discharged oil into a smaller area using the spread-preventive barrier technique, thus making the oil layer thicker, thick enough to be pumped by a special pump such as a vacuum pump or a float-saxon type pump designed especially to be capable of pumping out the layers only near the surface of the water. In this method the difficulty is that the water surface fluctuates with the waves occurring so that it frequently happens that the pump takes in a large amount of water it should not. When the floating matter is other than oily, such as red tide, method (2) or (3) used for oily matter cannot be employed, and only the method (3) can be applied to such a limited degree that the oil fence can only keep the red tide from spreading. It thus remains that virtually no means effective to remove non-oil matter such as red tide.

This invention is concerned with a new technique for removing matter such as oil or red tide which floats on water, such as in the sea, and is especially concerned with a technique for removing small amounts of material which are disposed over a large area of water (e.g. as rainbow coloured oil films).

According to the invention there is provided an apparatus for removing a floating fluid, for example oil on a body of water, the apparatus comprising a floatable vessel; a recovery/

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separation tank in the vessel, inlet means at the front of the recovery/separation tank for drawing in the floating fluid on the surface of the water outside the tank using a difference in level between the surface inside the tank and that of the outside water, the inlet leading to the recovery/separation tank; a water chamber adjacent to the recovery/separation tank for storing the water which settles out in a lower portion of the recovery/separation tank through a water entrance opening into a lower part of the water chamber, a fluid reservoir adjacent to the recovery/separation tank for storing floating fluid overflowing therefrom; first pump means for discharging water from the water chamber and lowering the level of the surface inside of the tank; second pump means for removing floating fluid from the fluid reservoir; and a plurality of vertical plate means for lengthening the flow path of the water running in the lower portion of the tank to the water entrance and shortening the flow path of the floating fluid running in an upper portion of the tank to the fluid reservoir and producing a quiescent area in a middle and/or upper portion of the tank.

Preferred features of the invention are illustrated in the accompanying drawings, wherein:—

Fig. 1 is a sectional side elevation showing a recovery-separation tank which has a floating matter reservoir in one of the preferred embodiments of the invention;

Fig. 2 is a top view partly in section of the embodiment of Figure 1 showing the recovery-separation tank;

Fig. 3 is a sectional view taken on line X—X in Fig. 2;

Fig. 4 is a sectional view taken on line Y—Y in Fig. 2;

Fig. 5 is a forshortened schematic view in side elevation partly in section showing a recovery-separation tank installed between the hulls of a catamaran in one of the preferred embodiments of the invention;

Fig. 6 is a semi-diagrammatical top view of the embodiment of Figure 1 showing the flow of the floating matter and the water;

Fig. 7 is an expanded sectional view of the embodiment of Figure 1 showing the flow of the floating matter and the water in the recovery-separation tank when providing a convex surface on the inflow board according to another embodiment of the invention.

Fig. 8 is a reduced schematic plan view showing the flow near the inlet of the recovery-separation tank;

Fig. 9 is a graphical representation showing recovery-efficiency vs. thickness of oil layer, using the speed of a vessel as a parameter;

Fig. 10 is a graphical representation showing recovery-efficiency vs. wave height, using a vessel speed as a parameter;

Fig. 11 is a reduced plan view according to further embodiment of the invention in which a recovery-separation tank is installed in a barge;

Fig. 12 is a reduced top view according to one of the embodiments of the invention in which the recovery-separation tank is installed in a small power boat;

Fig. 13 is an enlarged top view partly in section showing a recovery-separation tank according to one of the embodiments of the invention in which the recovery-separation tank itself forms a recovery barge;

Fig. 14 is an enlarged sectional view taken on line Z—Z in Fig. 13;

Fig. 15 is a top view showing the one application according to an embodiment of the invention.

Fig. 16 through Fig. 22 are schematic representations showing applications according to preferred embodiments of the invention.

Referring to Figure 1, as recovery-separation tank 2 has at its front an inlet from which an inflow board 4 extends forward, two anti-emulsion plates 5, 5a parallel to each other and slanting downward are located inside of the inlet 1, and a grid for sweeping dust may be provided in the inlet 1 when necessary. The tank 2 in one of the preferred embodiments of the invention is incorporated into a boat with a deck 6 at a top, and a floating matter reservoir 7 is provided at the rear and each side of the tank 2. Referring now to Fig. 5 the tank 2 is located between the hulls 3a, 3b of a catamaran 3 and suspended from the hulls 3a, 3b by an arm 9 with one end of the arm 9 connecting to the side of the tank 2, the other end of that pivoting to a supporting member 8 on the catamaran 3. The tank 2 is capable being raised or lowered by turning support axles 10, 10 of the arm 9 with a crank mechanism 12 which is operated by an oil cylinder 11. Inside the tank 2, there are installed partitions 13a, 13b and baffle plates 14a, 14b with their surfaces facing perpendicularly to the inflow direction of the floating matter A and the top end of the partitions 13a, 13b being positioned at the same height as at the lower surface of the layer of the floating matter A such as oil introduced into the tank 2, and the top part of the baffle plates 14a, 14b being higher than the top end of the partition 13a, 13b. The lower portion inside of the tank 2 is divided with the partitions 13a, 13b which have a flow port 15 at their lower ends, the inflow port 15 of each partition 13 being at the opposite side to that of adjacent partition 13 so that water B e.g. sea water run zig-zag through these flow ports 15. The lower portion of the baffle plate 14a, 14b is open so as to regulate the current of the water B under the floating matter A. The arrows denoted by solid lines in Fig. 6 and 7 indicate the

current of the water B in the lower portion of the tank 2, the arrows denoted by chain lines indicate the current of floating matter A in the upper portion of the tank 2. The anti-emulsion plates 5, 5a are inclined downward from the inlet 1 toward the inside of the tank 2, forming an intermediate layer between the plates 5, 5a. Many tiny holes 16 about 1 cm in diameter are perforated through the anti-emulsion plates 5, 5a so as to introduce the floating matter A and the water B coming in from the inlet 1 in layers maintaining their stratified state, thus draining only the water B through the tiny holes 16 into the lower portion of the tank 2 and carrying the floating matter B along the anti-emulsion plates 5, 5a into the upper portion of the tank, and preventing the floating matter from emulsifying due to impulsive stirring that occurs when the floating matter A rushes in from the surface of water outside the tank 2 in which the surface level L of the water is lower than the surface level L₂ of the water outside the tank 2. In this embodiment of the invention, one example is shown that two anti-emulsion plates 5, 5a are provided, however, only one anti-emulsion plate is enough to prevent emulsification, while many anti-emulsion plates are also effective. The upper anti-emulsion plate 5 of the two has the tiny holes 16 a little larger than those of the lower one 5a so as to well separate the floating matter A from the water B.

A water chamber 17 is installed in the rear part of the tank 2 and a partition 18 spans between the front wall of the chamber 17 and the adjacent partition 13b slanting slightly downward from the lower end of the front wall to the part just above the flow port 15 of the partition 13b. The partition 18 has a plurality of perforations 18a about 1 cm in diameter so as to prevent the floating matter A from invading into the chamber 17 through the water entrance 17. A floating matter collection port 19 controlled by a valve 20 is provided at the upper portion of the tank 2 so that the floating matter A overflows from the tank 2 into the reservoir 7 through the port 19 and is gathered in it.

An opening 21 is provided at the rear of the deck 6 with its top end being above the deck 6 and is divided into a opening 21a for removing the floating matter and a opening 21b for draining out the water, and encircled by a wall 22 so that the top end of the opening 21 is above the surface level L₂ of outside water. A floating-matter suction pipe 23 connected to a suction pump 25 is installed in the opening 21a and a water drainage pipe is connected to a drain pump 26 in the opening 21b. A filter 27 is attached in the flow path of the drainage pipe 24.

Referring now to Fig. 7 which shows one of the preferred embodiments of the invention, a plate 30 of convex section is linked to

or forms the inflow board 4 with the slope of its convex part facing in the direction of the inflow of the water, the numeral 38 indicating a counterplate. When the catamaran is in an area in which floating matter needs recovering, the tank 2 is lowered by driving the oil cylinder H. At the same time, valve 29 is opened by turning a handle 28 to take in contaminated surface water to a prescribed level and on fixing the tank 2 at a depth so that the upper surface of the inflow board 4 comes beneath the surface level L₂ of outside water, the floating matter in layer begins to flow into the tank 2 maintaining its stratified state. In this condition, the catamaran 3 stops or proceeds at a low speed of about 0.5 to 2.0 knots to continue recovery operation. The floating matter together with the water flows into the tank 2 and keep in layers due to a semi-stationary state resulting from the action of the anti-emulsion plates 5, 5a which prevent the floating matter from emulsifying in the water and the incoming liquid from being stirred impulsively as it rushes down into the tank 2 thus the floating matter and the water B are well separated into upper and lower layers. The floating matter A separated into a layer at the upper portion of the tank 2 is forced to flow in the reservoir 7 through the collection ports 19, 19 into the reservoir 7 from whence it is sucked up by the suction pump 25 through the suction pipe 23 so as to be removed and stored in floating-matter storage reservoir 31 provided in the hulls 3a, 3b of the catamaran 3. The water B occupying the lower portion of the tank 2 is meanwhile led to the chamber 17 provided at the rear of the tank 2 through the flow ports 15, 15 and then sucked up by the drain pump 26 through the drainage pipe 24 and the filter 27, and after that is discharged out from the tank 2. The recovery-separation tank 2 is also equipped with an interface detector 32 which monitors the interface between the water and the floating matter, a level detector 33 which reads the level in the tank 2, a level detector 34 which detects the level of the surface of the floating matter inside the reservoir 7, and a densitometer 35 is provided in the flow path of the drain pipe 24 to monitor the amount of oil or other floating matter in the discharge water.

When the output of the detector 33 controls the drain pump 26 so as to keep the surface level liquid in tank 2 within a specified range and at the same time the output of the detectors 32, 32, which are placed at two upper and lower positions in order to read the upper and lower limits of the interface, open the valve 20 so as to flow the floating matter A into the reservoir 7 through the collection port 19 when the thickness of the layer of the floating matter A becomes greater than a certain value e.g. 100mm and closes the valve 20 when that of the layer of the floating

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matter A becomes less than a certain value e.g. 50mm. In this operation the valve 20 is also operative by a handle 36, and the output of the detector 33 controls the opening and closing operation of an outlet valve 37 so as to maintain the surface level (the level of the upper surface of the layer of the floating matter A) within a prescribed range, while the output of the detector 34 controls the rate of the suction pump 25, to keep the level of the floating matter A in the tank 2 within a specified range, for example the suction pump operates when the depth of the liquid is greater than 1,100mm and stops when less than 800mm, thus reducing the fall of the floating matter A below the collection port 19 as much as possible. In conducting the recovery of a floating oil on the surface of water, for example when the oil densitometer 35 reads that the oil concentration is above a prescribed one, the oil cylinder 11 works to move down the tank 2 so as to draw in a great amount of the water through the inlet 1, lowering the oil concentration, and after that the water introduced is discharged through the drainage pipe 24.

The use of a method that processes appropriately the output signals of the detectors 32, 33, and 34 which monitoring the state of recovery and separation may be utilized so as to vary the position of the lower edge of the inlet 1 (or that of the convex of the inflow board 4) against the water surface level L_2 outside the tank 2.

In the embodiment described above, the output signal from each detector is processed to alter the ratio between the amounts of the water and the floating matter which flow in through the inlet 1 so that the floating matter can be recovered in higher efficiency.

Next we refer to the results of experiments we have conducted using models of the recovery-separation tank. It was the aim of the experiment to investigate the (1) floating matter removal capacity; (2) the amounts of oil on the surface of the open water at the entrance to the tank, and the amount of oil that fails to enter the tank; (3) the distribution of the water-flows inside the tank; (4) the distribution of the water-flows under the influence of the oil on the surface immediately before it goes in; and finally (5) recovering efficiency.

Following is the condition under which this indoor experiment were conducted. A towed recovery-separation tank used is 10 meter long, 1.5 meter broad, 0.5 meter deep, and made up with iron-framed canvas; the towing catamaran is 1.9 meter long by 0.8 meter each to a scale of 1 to 10 and made up from wood, the floating matter reservoir included in the tank is 0.45 meter long by 0.3 meter and made of plastics also to a scale of 1 to 10; and the drain pump has the pumping capacity of 12 liters/min. at its maximum efficiency; and the suction pump has the

pumping capacity of 20 liters/min. The one to ten scale is adopted for the height of waves produced by stirring the water with a board near the front edge of the experimental tank. In regard to the oil we used as a model for the floating matter, we did a calculation back deciding from the whole area of the experimental tank (10m $\times$ 1.5b) to determine the amount to be deposited so that the oil membrane to be formed may be 1/10 as thick as it might be in real conditions. Next we set the speed at which the catamaran was to run to one tenth that of a real one, which we did by winding a rope around the turning drum installed in front of the tank and pulling the rope tied to the model catamaran in such a way that the model could be drawn along keeping at a constant speed. The temperature at the time of experiment was between 9 and 10 degrees Centigrade, and the water used was clear water with the temperature kept at 7 degrees Centigrade.

The above-mentioned oil used as the floating matter was A-crude oil at a temperature of 7 degrees Centigrade and a specific weight of 0.8386, immiscible with water, kinematic viscosity of 2.38 Cat, viscosity of 31.7 Rw, pour point of 12.9, flash point of 85°C, less than 0.1% of water, 0.01% of ash content, 0.81% of sulphur content, 0.07% of residual carbon, and 105k cal/kg heat capacity.

First, we will discuss the result gained as to sucking capacity. This experiment, with a small amount of oil and saw dust cast in front of the inlet of the tank, was conducted, while the catamaran, that is to say, the recovery-separation tank was kept stationary. The drain pumps we used were the one with 12 l/min. capacity (the real equivalent of which is 720M/H) and the one with 5 l/min. capacity (the real equipment of which, 300M/H). And finally illustrated as in Figure 7 is the way the experiment was carried out in which an arch-shaped brass board was attached to the inflow board so as to create a convex sloping surface in the direction of inflow. This experiment was conditioned by the above stated specification. The other experiments were carried out only with the inflow board attached. Therefore the result obtained from this experiment were measured time that the floating matter such as oil or a dust took to be down to reach the inlet and the sucking capacity calculated based on that. Table 1 shows the results of the experiment on the sucking ability. And also indicated in the results shown on the Table 1 is that the floating matter was found being sucked into the inlet at the speed of more than 1 cm/sec. and gave a good result of the floating matter being sucked and recovered, especially when arch-shaped introducing plate was installed on the inflow board. The great increase was observed in the sucking rate and also found as to the material used for the inflow board and the

introducing plate was that brass or stainless steel is better suited than plastics. Implicated in this order may be that we need to use the material with good corrosion resistance, erosion resistance, and with a small friction factor.

TABLE 1

Capacity of drain pump	Kinds of floating matter	Time required	Remarks
12 l/min.	A—crude oil	1 min. 46 sec.	flow speed; 0.014 m/sec.
5 l/min.	A—crude oil	2 min. 13 sec.	flow speed; 0.011 m/sec.
12 l/min.	Saw dust	1 min. 43 sec.	
5 l/min.	Saw dust	2 min. 10 sec.	
5 l/min.	Saw dust	1 min. 12 sec.	When attached a introducing plate which is arch-shaped in section

Next we go on to the experiment to observe the oil tending to pass under the tank immediately before its entry into the tank or to be diverted to miss the inlet. This experiment was done in such a way that we could see if the floating matter such as oil flowing along the oblique counter plate set under the front part of the tank and if the floating matter is diverted and drifts off to the both sides of the catamaran, the height of the waves in the experimental tank was set at 3 cm (the real equivalent of which is 30 cm) and with a large dose of saw-dust cast in, the speed of the each of two hulls was set respectively at 0 m/sec., 0.026 m/sec. (the real equivalent of which is 0.5 knots), 0.051 m/sec. (the real equivalent of which is 1 knot), 0.26 m/sec. (the real equivalent of which is 5 knots), and 0.51 m/sec. (the real equivalent of which is 10 knots). And it was carried out with the use of the drain pump for water which had the capacity of 5 lits/min. None of these experiments showed any diversion or passing under of the water. The floating matter however did spray up from the water at the higher speeds resulting in an unsatisfactory data on recovery-efficiency. But these speeds represent from 5 to 10 knots in the real condition where in fact actual recovery operation is conducted at slowed speeds of from 0.5 knot to 1 knot. It seems very unlikely that the above-mentioned scattering of the floating matter would take place if we take into account the fact that the real tank employed is 10 times

bigger than the experimental model one. The Fig. 7 shows the distribution of the flows of the water as well as the floating matter in the experiment (3). It is what was observed with the 10 lits/min. capacity (the real equivalent of which is 600 M/H) of drain pump going and with the help of several strings attached to the various parts of the tank to see the distribution of the flows, the arrows denoted by solid lines show the direction of water flow and the arrows denoted by broken lines the floating matter.

As is obvious from the illustration, two partitions and the baffle plates with the flowing direction upward are capable of giving the residual floating matter in water a buoyant thrust. Moreover, every direction of flow above the perforated plate 15 is upward so that no flowing matter accidentally flows through the plate into the water chamber and therefore that there can be found no floating matter in the drained water. The distribution of the flows in front of the inlet in the experiment (4) is as shown in Fig. 8. This indicates that the flow is most rapid near the bows of the catamaran and it was observed that there was considerable suck-in through the reflecting gunwales of each bows of the catamaran and that it was discovered that a higher speed of flow would be gained if we put the convex on the inflow board to form a introducing bulge. The table 2 shows the results obtained in the experiment (5), the figures in parentheses represent those converted into

actual figures. Also Fig. 9 illustrates recovery-efficiency plotted against the oil layer thickness, Fig. 10 recovery-efficiency against the height of the waves respectively. In Figs. 9 and 10, figures used are all converted into actual ones. Therefore these experiments prove that an increase in the speed of the catamaran or the oil-layer thickness might not only bring the expected result of having an increased recovery efficiency. Also the higher the waves become the better recovery efficiency we get, which might as well be considered to be characteristics. This can be interpreted as the good recovery efficiency due to the increase in speed resulting from the alternative action that the floating matter piled up on the inflow board at the time of wave rise flows into the tank at following wave shrink.

But the exceptional case was observed when the height of the waves read 60 cm that interference among the waves inside the tank took place resulting in a lower recovery efficiency. It is deduced that high efficiency will be obtained when we boost up the capacity of the drain pump as when the vessels are going at higher rate or the waves so high. The experiments as shown in Fig. 9 and 10 were performed with the use of drain pump capable of draining 5 l/min. (the real equivalent of which is 300M/H) which was kept constant, and the amount detailed as recovered was not the one actually recovered, but the one calculated based on the gross amount of the floating matter (crude oil) and the thickness of the layer which the floating matter inside the tank formed.

Test	No.	1	2	3	4
thickness of oil layer	mm (mm)	0.2 (2)	0.2 (2)	0.2 (2)	0.2 (2)
height of wave	cm (cm)	0	0	0	0
time for recovery	min. sec.	5' 13"	2' 42"	1' 46"	1' 20"
speeds of the catamaran	knots	0.05 (0.5)	0.098 (0.98)	0.145 (1.45)	0.198 (1.98)
amounts of recovery	l (M ³)	1.44 (1.44)	1.38 (1.38)	1.38 (1.38)	1.30 (1.30)
recovery efficiency	l/min. (M ³ /H)	0.277 (16.6)	0.51 (30.6)	0.78 (46.8)	0.97 (58.3)

Test	No.	5	6	7	8	9
thickness of oil layer	mm (mm)	0.2 (2)	0.2 (2)	0.2 (2)	0.2 (2)	0.2 (2)
height of wave	cm (cm)	3 (30)	3 (30)	3 (30)	3 (30)	6 (30)
time for recovery	min. sec.	5' 10"	2' 30"	1' 44"	1' 19"	5' 13"
speeds of the catamaran	knots	0.06 (0.6)	0.102 (1.02)	0.15 (1.5)	0.199 (1.99)	0.05 (0.5)
amounts of recovery	l (M ³)	2.39 (2.39)	1.77 (1.77)	1.69 (1.69)	1.58 (1.58)	1.61 (1.61)
recovery efficiency	l/min. (M ³ /H)	0.46 (27.8)	0.71 (42.5)	0.98 (58.5)	1.20 (72.2)	0.31 (18.5)

Test	No.	10	11	12	13	14
thickness of oil layer	mm (mm)	0.2 (2)	0.2 (2)	0.2 (2)	0.2 (2)	0.2 (2)
height of wave	cm (cm)	6 (60)	6 (60)	6 (60)	10 (100)	10 (100)
time for recovery	min. sec.	2' 35"	1' 46"	1' 18"	5' 15"	2' 30"
speeds of the catamaran	knots	0.100 (1.00)	0.145 (1.45)	0.200 (2.00)	0.048 (0.48)	0.102 (1.02)
amounts of recovery	l (M ³)	1.24 (1.24)	1.24 (1.24)	1.38 (1.38)	2.49 (2.49)	1.75 (1.75)
recovery efficiency	l/min. (M ³ /H)	0.48 (28.9)	0.70 (42.1)	1.06 (63.8)	0.475 (28.5)	0.70 (42.1)

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Test	No.	15	16	17	18	19
thickness of oil layer	mm (mm)	0.2 (2)	0.2 (2)	0.5 (5)	0.5 (5)	0.5 (5)
height of wave	cm (cm)	10 (100)	10 (100)	0	0	0
time for recovery	min. sec.	1' 44"	1' 20"	5' 14"	2' 35"	1' 46"
speeds of the catamaran	knots	0.200 (2.00)	0.198 (1.98)	0.049 (0.49)	0.10 (1.0)	0.145 (1.45)
amounts of recovery	l (M ³)	1.57 (1.57)	1.5 (1.5)	3.22 (3.22)	3.11 (3.11)	3.24 (3.24)
recovery efficiency	l/min. (M ³ /H)	0.90 (54.5)	1.14 (68.1)	0.616 (37)	1.21 (72.3)	1.83 (110)

Test	No.	20	21	22	23	24
thickness of oil layer	mm (mm)	0.5 (5)	0.5 (5)	0.5 (5)	0.5 (5)	0.5 (5)
height of wave	cm (cm)	0	3 (30)	3 (30)	3 (30)	3 (30)
time for recovery	min. sec.	1' 19"	5' 13"	2' 24"	1' 40"	1' 18"
speeds of the catamaran	knots	0.199 (1.99)	0.05 (0.5)	0.11 (1.1)	0.152 (1.52)	0.200 (2.00)
amounts of recovery	l (M ³)	3.08 (3.08)	3.85 (3.85)	3.30 (3.30)	3.28 (3.28)	3.25 (3.25)
recovery efficiency	l/min. (M ³ /H)	2.40 (146)	0.74 (44.3)	1.38 (82.5)	1.97 (118)	2.50 (150)

Test	No.	25	26	27	28	29
thickness of oil layer	mm (mm)	0.5 (5)	0.5 (5)	0.5 (5)	0.5 (5)	0.5 (5)
height of wave	cm (cm)	6 (60)	6 (60)	6 (60)	6 (60)	10 (100)
time for recovery	min. sec.	5' 15"	2' 30"	1' 44"	1' 20"	5' 15"
speeds of the catamaran	knots	0.048 (0.48)	0.102 (1.02)	0.15 (1.5)	0.198 (1.98)	0.048 (0.48)
amounts of recovery	l (M ³)	3.63 (3.63)	3.04 (3.04)	3.24 (3.24)	3.28 (3.28)	4.16 (4.16)
recovery efficiency	l/min. (M ³ /H)	0.692 (41.5)	1.22 (73)	1.87 (112.3)	2.46 (147.5)	0.79 (47.5)

Test	No.	30	31	32	33	34
thickness of oil layer	mm (mm)	0.5 (5)	0.5 (5)	0.5 (5)	1 (10)	1 (10)
height of wave	cm (cm)	10 (100)	10 (100)	10 (100)	0	0
time for recovery	min. sec.	2' 35"	1' 45"	1.18"	5' 13"	2' 30"
speeds of the catamaran	knots	0.100 (1.00)	0.146 (1.46)	0.200 (2.00)	0.05 (0.5)	0.102 (1.02)
amounts of recovery	l (M ³)	3.57 (3.57)	3.48 (3.48)	3.41 (3.41)	6.78 (6.78)	6.06 (6.06)
recovery efficiency	l/min. (M ³ /H)	1.38 (83)	1.99 (119.5)	2.63 (157.5)	1.30 (78)	2.43 (145.5)

Fig. 11 shows the examples of another embodiment of the invention wherein the recovery-separation tank 2 is incorporated into a barge 70 that has a floating-matter

storage reservoir 31, with the inlet of the tank 2 being located at the middle front of the barge 70, and the suction pump 25 installed on the barge 70 transfers the floating matter

from the tank 2 to the pool 31, while the drain pump 26 installed on the barge 70 drains out the water occupying the water chamber 17.

This embodiment differs from the above-mentioned embodiment in fixing the tank 2 to the barge 70, however, by controlling the amount of water fed into a ballast tank 71 enables the draught of the barge 70 to vary, thus raising or lowering the inlet 1 relatively to the level of the water outside the tank 2. In Fig. 11 there are also shown a bridge 72 and an engine room 73. Referring now to Fig. 12 there is shown a further embodiment of the invention wherein the recovery-separation tank 2 is provided in the cut-away portion on the forward left side of a relatively small power boat 74 which has the floating-matter storage reservoir 31. The floating matter to be transferred from the reservoir 7 is selectively gathered through a transfer pipe 76 into the reservoir 31 by means of valves 77, 77. This boat 74 is also provided with a bridge 78 and a chimney for discharging the exhaust gas from the engine 75.

In addition to that, the tank 2 shown in Fig. 12 may be so constructed as to rise and fall independently from the boat 74 as in the case described in the embodiment shown in Fig. 5 or the boat 74 may be so constructed as to alter the draught of it as in the embodiment shown in Fig. 11. Fig. 13 and Fig. 14 shows one of the preferred embodiments of the invention in which the tank 2, the reservoir 7, and a buoyancy chamber 39 are incorporated into a recovery barge 50 so that the tank 2 itself can float, a convex section is provided on the upper surface of the inflow board 4 extending forward from the upper end of an elevator 40 which is capable of going up and down with a result that the inflow board 4 united with the elevator 40 can be moved up and down at will by turning a handle 41.

The turn of the handle 41 is reduced by a reduction gear 42 so as to drive the elevator 40 and the inflow board 4 up and down. In addition to this manual operation, the use of a power source such as electric motor which enables the elevator 40 and the inflow board 4 to rise and fall may be utilized. In this case said motor may be controlled by the output signal of the detectors 32, 33, 34, the densitometer 35, or the like. In Fig. 13 and 14, there are also shown a vent duct 44, a dividing wall 45 dividing the buoyancy chamber 39 internally, an entrance board 46 supported by a prop 47, and an anti-rolling member 48 connected by a leg 49 detachably to each side of the recovery barge 50. Unfolding a lid 51 with a handle 52 makes the opening 21a, 21b wide enough to install an extra pipe and pump in addition to the suction pipe 23 and the drainage pipe 24. Lattice plates 83, 84 are provided at the front of

the deck 6 so as to get rid of the dust and drifting wood coming from the deck 6 and manhole 53 are provided in the middle of the tank 2 through the deck 6. Other arrangements are distributed in the same way as described in the former embodiment illustrated in Fig. 1 through Fig. 4. In the above-mentioned embodiment the elevator 40 is also used to shut off the inlet 1 entirely for preventing the inflow of water and floating matter.

Referring now to Fig. 15, two tug boats 54, 54 tow the recovery barge 50 by means of oil fences 55 and tow a container 56 which is linked with the tug boats 54, 54 by wires 57, 57. The suction pump 25 for sucking up the floating matter and the drain pump 26 for draining out the water are installed in the container 56, and also the floating-matter storage reservoir 31 is built inside the container 56. The oil fences 55, 55 fan out from the recovery barge 50 toward the tug boats 54, 54 with their rear ends inserted to connecting holes on the forward sides of the recovery barge 50.

Fig. 16 and 17 show one of the embodiments of the invention in which the recovery barge 50 is driven by a self-propelling container 59 which has the floating-matter storage reservoir 31 along with the suction pump 25 and the drain pump 26.

In Fig. 18 and 19, the recovery barge 50 is stationed by an anchor and the like at the pivot part of the oil fences fanning out forwards, and is supplied with power by means of an electric power line 60 from an electric source equipped in the small self-propelling container 59 so as to gather the floating matter into the pool 31 through the suction pipe 23 (shown in Figure 18). Or the recovery barge 50 is supplied with power from an electric power vessel 61 so as to gather the floating matter through the suction pipe 23 by means of the suction pump 25 and drain pump 26 equipped in the recovery barge 50 itself which conduct transferring the floating matter and discharging the water respectively, and also the recovery barge 50 is connected to a water container 62 for storing the water discharged and a floating matter container 63 for storing the floating matter removed, thus enables the recovery barge 50 to recover a great deal of floating matter due to the increase in ability to drain out the water and the floating matter (shown in Fig. 19). Therefore, the use of this means results in continuous recovery operation because the container 56 is capable of being substituted by another container 56 when the reservoir 31 of the former one 56 becomes full of the floating matter.

Fig. 20 is one of the embodiments in accordance with this invention, and in this embodiment the recovery barge 50 is located near a shore 64 together with the oil fences 55,

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55, so as to prevent a secondary pollution. In Fig. 21 the recovery barge 50 is stationed or moved about along the shore 64 in order to perform recovery operation.

5 In these cases (shown in Fig. 20 and 21), the suction pipe 23 may be connected to the floating-matter storage reservoir 31 which is installed on the ground, thus resulting in high recovery capacity.

10 Referring now to Fig. 22, the tank 2 is located between the shores 82, 82 of a river or canal with its front facing toward upstream. The oil fences 81, 81 span from the inlet 1 of the tank 2 to the each shore 82 so as to catch the floating matter on the water. Alternatively the tank 2 may be installed on the bottom or at a floodgate on the river or the canal.

WHAT WE CLAIM IS:—

20 1. Apparatus for removing a floating fluid, for example oil on a body of water, the apparatus comprising a floatable vessel; a recovery/separation tank in the vessel, inlet means at the front of the recovery/separation tank for drawing in the floating fluid on the surface of the water outside the tank using a difference in level between the surface inside the tank and that of the outside water, the inlet leading to the recovery/separation tank; a water chamber adjacent to the recovery/separation tank for storing the water which settles out in a lower portion of the recovery/separation tank through a water entrance opening into a lower part of the water chamber; a fluid reservoir adjacent to the recovery/separation tank for storing floating fluid overflowing therefrom; first pump means for discharging water from the water chamber and lowering the level of the surface inside of the tank; second pump means for removing floating fluid from the fluid reservoir; and a plurality of vertical plate means for lengthening the flow path of the water running in the lower portion of the tank to the water entrance and shortening the flow

path of the floating fluid running in an upper portion of the tank to the fluid reservoir and producing a quiescent area in a middle and/or upper portion of the tank.

2. Apparatus according to claim 1, wherein the vertical plate means are longitudinally-spaced, vertical partitions which divide the inside of the recovery/separation tank, each upper end of the partitions being, in use, near the lower surface of the layer of the floating fluid, each lower end of the partitions being connected to a bottom wall of the tank, and each partition has a flow port at a lower region thereof, each flow port being at the side of the tank and laterally opposite to the flow port of the adjacent partition.

3. Apparatus according to claim 1, wherein the vertical plate means are longitudinally-spaced vertical partitions and baffle plates, the partitions dividing the inside of the recovery/separation tank, each upper end of the partitions being, in use, near the lower surface of the layer of the floating liquid, each lower end of the partitions being connected to a bottom wall of the tank, and each partition has a flow port at its lower portion thereof, each flow port being at the side of the tank and laterally opposite to the flow port of the adjacent partition, the baffle plates are substantially parallel to each other and divide the inside of the recovery/separation tank, a lower end portion of each of the baffles being spaced from the bottom wall of the tank, an upper end portion of each of the baffles being located, in use, under and/or in the layer of the floating fluid.

4. Apparatus for removing a fluid floating on a body of water, the apparatus being substantially as herein described with reference to the accompanying drawings.

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