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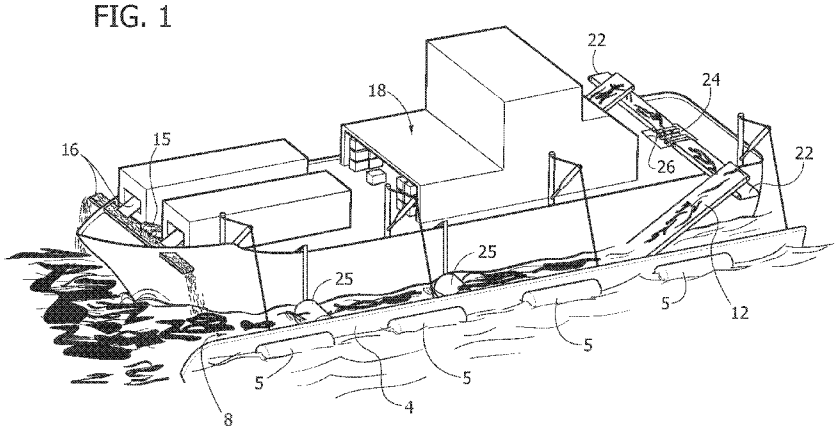
(54) **Title**: METHOD FOR REMOVING A POLLUTING SUBSTANCE FROM A WATER SURFACE

FIG. 1



(57) **Abstract**: A method for removal of a hydrocarbon substance floating on a body of water, in particular petroleum and/or its derivatives, characterized in that it envisages the use of greasy animal wool, with a fibre having a diameter greater than 25 μm, to absorb said substance.

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"Method for removing a polluting substance from a water surface"

* * *

TEXT OF THE DESCRIPTION

The present invention relates to a method for removal of a pollutant floating on a body of water, in particular petroleum and/or its derivatives. In particular, the present invention regards a method of removal that envisages the use of absorbent material.

Methods of this type are already widely known in the art. In general, these methods envisage dipping the absorbent material in the pollutant, and subsequently gathering it after it has been impregnated with said substance.

The object of the present invention is to provide a method of the type referred to above that will be more efficient and economically advantageous than those of the known art.

Said object is achieved by a method having the characteristics specified in Claim 1.

The claims form an integral part of the technical teaching provided herein in relation to the invention.

The invention will now be described, purely by way of non-limiting example, with reference to the annexed representations, in which:

- Figure 1 illustrates a watercraft for implementing the method described herein;
- Figure 2 illustrates a schematic perspective view of the inside of the watercraft of Figure 1;
- Figure 3 illustrates a side view of the watercraft of Figure 1;
- Figure 4 illustrates a top plan view of the watercraft of Figure 1;
- Figure 5 is a diagram of a system for implementing the method described herein; and

- Figure 6 is an axonometric view of a system for providing the method described herein.

Illustrated in the ensuing description are various specific details aimed at providing an in-depth understanding of the embodiments. The embodiments may be obtained without one or more of the specific details, or with other methods, components, or materials, etc. In other cases, known structures, materials, or operations are not illustrated or described in detail so that the various aspects of the embodiment will not be obscured.

The references used herein are provided merely for convenience and hence do not define the sphere of protection or the scope of the embodiments.

The method described herein has the purpose of removing a pollutant, in particular a floating liquid hydrocarbon substance, for example petroleum and/or its derivatives, from a body of water. To remove said pollutant, the method described herein envisages the use of absorbent material.

The method described herein is characterized in that the absorbent material used is greasy animal wool, with large fibres, preferably sheep's wool. In particular, the wool used in the method described herein has fibres of a diameter greater than or equal to 25 μm, preferably between 25 and 40 μm. By "greasy" wool is meant wool straight off the animal that has not yet been subjected to any washing treatment.

The present applicant has found that the type of wool referred to above has specific characteristics that render it particularly suited to the application referred to herein.

In the first place, the present applicant has found, through an intense experimental activity, that the type of wool in question has a capacity of

absorption of hydrocarbon substances, specifically liquid hydrocarbon substances, that is decidedly higher than the majority of absorbent materials used in the known art. Said higher absorption capacity would seem to be attributable at least in part to the diameter of the fibres of the wool used. Moreover, it has been found experimentally that wool of the type indicated can be re-used many more times than is instead allowed with the materials commonly used in this type of applications (which for the most part are plastic-resin or glass synthetic materials), enabling as a whole up to ten times the amounts that can be absorbed by said conventional materials.

In the second place, the present applicant has found that said type of wool is able to absorb selectively only the hydrocarbon substances and not also the water on which these float, as instead occurs with conventional absorbent materials. The present applicant has found that said property is typical of greasy wool, which, since it has not been in fact subjected to any washing treatment, is coated with a layer of grease that renders it water-repellent. It is thus evident that said type of wool guarantees, in the field of the applications in question, results that are decidedly better than conventional absorbent materials, above all in terms of efficiency of absorption, not only because it has a greater capacity for absorbing hydrocarbon substances, but also because it is able, given that it does not absorb water, as instead said conventional materials do, to exploit its capacity fully. In the greasy wool used here, the layer of grease and of equivalent substances is present in a weight percentage of between 15 wt% and 60 wt%.

Furthermore, apart from the properties referred to above, the use of said type of wool for the method in

question brings with it also the following advantages:

- any possible dispersion in the environment of the wool does not create ecological problems in so far as it is a product of natural and biodegradable origin;
- no containers are needed in so far as it has an intrinsic cohesion of its own that prevents dispersion thereof;
- the marked interaction between the wool of said type and petroleum enables removal of patches of petroleum in an effective way, minimizing the hydrocarbon substance residue on the surface of the water;
- it floats on the water also after absorbing the petroleum and it is thus possible to recover it easily;
- its effectiveness of action is not impaired by the wave motion, which rather, thanks to the mechanical action on the petroleum-water interface, is even positive for the purposes of absorption in so far as it improves penetration of the petroleum into the wool;
- it resists organic solvents and is thus not damaged by petroleum;
- the wool impregnated with the hydrocarbon substance absorbed can be used as combustible material, for example within incinerator systems;
- it is easily available practically throughout the world, and is cheaper than fine-fibre wool.

The method described herein can envisage different specific embodiments. In general, said method envisages dipping the wool in the hydrocarbon substance and then taking it out after it has been impregnated with said substance. Preferred embodiments can envisage that the impregnated wool is squeezed in order to separate and collect in a tank the hydrocarbon substance that has been absorbed, and, subsequently, that the squeezed wool is re-used for removing further amounts of said

substance.

In what follows two different types of systems will be described for implementation of the method described herein.

As will be seen hereinafter in detail, the first system, illustrated in Figures 1 to 4, is designed to be installed on a watercraft and has been obtained specifically for interventions on the open sea, for removal of large patches of hydrocarbon pollutant, whilst the second system, illustrated in Figures 5 and 6, has been specifically devised for interventions in confined bodies of water, such as ports, canals, or lakes, or in any case for interventions in which the amounts of pollutant to be removed are decidedly smaller. It is clear that each of the two types of system can in any case be effectively used for both types of intervention referred to above.

WATERCRAFT FOR INTERVENTIONS ON THE OPEN SEA

In general, the watercraft described herein is equipped with a system that enables operation during advance of the watercraft itself. In particular, as will be seen in what follows, said system is pre-arranged for generating, exploiting precisely the motion of advance of the watercraft, a continuous flow of absorbent material in bulk form, which from the watercraft is let down into the sea, directly on the patch of pollutant, and is then brought back again onto the watercraft.

In particular, the system has:

- a frame designed to delimit laterally a strip of body of water that extends along at least one of the sides of the watercraft;

- means for lowering absorbent material in bulk form into said strip of body of water;

- a conveying surface for bringing back onto the

watercraft the absorbent material previously let down, said surface having a portion immersed in said strip of water, which occupies a position that, with respect to where the absorbent material is let down, is set at a distance in the direction opposite to that of advance of said watercraft, said portion being designed to intercept the absorbent material lowered into said strip; as will be seen in what follows, the elements referred to above, which make up the system, are all mounted on the watercraft and are carried by the latter.

Illustrated in Figure 1 is an example of watercraft on which the system in question is to be installed. It is clear that the watercraft can in any case be also of any other type; for example, it can also be a simple floating structure without means of propulsion of its own, which must then be towed by another watercraft.

In various embodiments, as in the ones illustrated in Figures 1 and 2, the aforesaid frame comprises a guard 4, which extends along one side of the watercraft and at a given distance therefrom, is anchored to the watercraft, by means of purposely provided lattices 6 arranged on the deck of the watercraft, and is rendered floating by means of buoys 5 anchored to it. The lattices engage the guard 4 so as to enable this to move vertically with respect to the lattices, in order to remain on the surface of water, in one and the same condition partially immersed, whatever the plane of floating of the watercraft.

The guard constitutes a divisory element of the free surface - or of a slightly deeper portion - of the body of water, which delimits, together with the side of the watercraft facing it, a channel 8 (which is obviously limited laterally but not on the bottom). In

various embodiments, as in the one illustrated, the guard extends substantially from bow to stern. As will be seen in what follows, said channel prevents the absorbent material from dispersing and, at the same time, conveys it, as a result of the headway of the watercraft, towards the conveying surface referred to above, designated by the reference number 12 in the figures.

In various embodiments, as in the ones illustrated in the figures, the aforesaid means (designated by the reference number 16 in the figures) for lowering the absorbent material, i.e., the tufts of wool, in the sea, into the channel 8, are set on the watercraft so as to be able to let down said material at the end of said channel closest at the bow of the watercraft, whilst the conveying surface 12 is set so as to be immersed in said channel substantially at the end of this closest to the stern. In preferred embodiments, the aforesaid means envisage an alternating movement that enables distribution of the tufts of wool substantially throughout the width of the channel 8. In various embodiments, as in the ones illustrated in Figures 1 and 2, said means are formed by a set of chutes and/or conveyor belts 16, the last of which terminates beyond the side of the watercraft for casting said material into the channel 8. In various embodiments, as in the ones illustrated in the figures, pre-arranged on the watercraft is a storage area, designated by the reference number 18, where containers containing the greasy wool to be used in the system are arranged. Set instead in a position corresponding to the lowering means 16 are tufting units 17 designed to break the wool taken from the container up into tufts.

In various embodiments, as in the ones illustrated in Figures 1 and 2, the conveying surface 12 is an

inclined conveying surface, which is anchored to the watercraft, and which from the level of the deck of the watercraft reaches the surface of the sea until it is immersed, at least partially, in the channel 8, in the proximity of the end of the latter closest to the stern. In various embodiments, as in the ones illustrated in Figures 1 and 2, the surface 12 is formed by a mesh conveyor belt, driven by appropriate means (not illustrated), which is made to advance in the direction of ascent of the surface defined thereby. Said belt has the function of intercepting the absorbent material present in the channel and of bringing it back on to the deck of the watercraft. It will be appreciated that the mesh structure of the belt enables interception and collection of the absorbent material, reducing to a minimum the resistance exerted by the water, against the belt as a result of advance of the watercraft.

In various embodiments, as in the ones illustrated in Figures 1 and 2, set downstream of the conveying surface (with reference to the direction of the flow of absorbent material that will be described in what follows) is a further conveyor belt, designated by the reference number 22, which is designed to bring the material gathered as far as an opening 26 where a set of squeezing rolls 24 is located, designed to squeeze the absorbent material for separating from this the pollutant, which ends up in the tank 19 inside the hull of the watercraft. Downstream of said rolls, two conveyor belts 15 and 27 are provided, designed to bring the absorbent material that has been squeezed back again to the lowering means 16. Set instead underneath the lowering means 16, a store 14, where the exhausted absorbent material that is no longer usable, which is conveyed there by the belts 27 and 15

themselves, is gathered; in this case, the belt 15 reverses its direction of advance so as to discharge the material carried by the belt 27 into the store 14.

In various embodiments, as in the ones illustrated in Figures 1 and 2, in order to improve the absorption of the pollutant by the absorbent material, a freely rotating set of rolls 25 is provided within the channel, which are carried by the same frame as the one that carries the guard, and are kept in a position raised with respect to the hull of the watercraft so as to remain immersed in the water and to be set in rotation as a result of the advance of the watercraft. In any case, the rolls 25 can also be motor-driven so as to render their movement of rotation independent of the speed of advance of the watercraft. Said rolls have the function of agitating and mixing the absorbent material contained in the channel 8.

In various embodiments, as in the ones illustrated in the figures, the same configuration described above can be provided in a symmetrical way on both sides of the watercraft.

In view of the above, it is consequently evident that, in order to operate, said system requires the watercraft to advance along the area of sea involved by the patch of pollutant so that said substance is brought into the channel, and the continuous flow of absorbent material referred to above (which will be described in detail hereinafter) is triggered. It should be noted that, during advance of the watercraft, within the channel there converges not only the liquid of the body of water that it delimits but also the liquid that is displaced by the hull of the advancing watercraft itself. Consequently, to all effects the portion of surface of water that is involved in the process of depuration is substantially the same as the

one comprised in the encumbrance defined between the guard and the central part of the bottom of the hull of the watercraft; this means that in the case illustrated, where the system envisages the same configuration on both sides of the watercraft, the width of the total surface of water involved is equal to the one comprised in the encumbrance between the two guards arranged on the opposite sides of the watercraft.

With specific reference now to the operation of the system, this envisages, as first step, lowering of the absorbent material in bulk form into the channel, after tufting thereof has been carried out by the tufting units 17. As a result of the advance of the watercraft, said material traverses the entire channel until it is brought up to the conveying surface, and whilst said material is in the channel, the action of the rotating rolls causes it to be impregnated completely by the pollutant. Once the material has reached the conveying surface, this gathers it and delivers it onto the conveyor belt 22, which carries it up to the rolls 24, where it is squeezed and separated from the pollutant, which is collected in the tank 19 whilst said absorbent material is brought back via the belt 27 to the lowering means 16. From the foregoing it is evident that the system described herein is designed to provide a continuous cycle in which the absorbent material is cast into the channel, gathered, squeezed, and then cast back into the channel again; this process can be repeated a number of times until the material has exhausted its absorbent capacity.

Alternative embodiments can in any case envisage discharge of the absorbent material gathered by the channel 8 directly into the tank 19, and hence not envisage the aforesaid closed cycle so that in said

embodiments the means referred to above, such as the squeezing rolls 24, the conveyor belts 15 and 27, etc., designed for providing said closed cycle, may thus be omitted. The system described herein preferably envisages means for controlling the operation described above in an automatic or semi-automatic way. In particular, said means have the function of controlling the speed of the watercraft and the rate of flow of material that is cast into the channel in a co-ordinated way, according to the required operating conditions. Said means can envisage an interface, via which it is possible to select or set the various combinations. For instance, in the case of thick patches of pollutant it will be necessary to set low cruising speeds and provide large amounts of absorbent material.

Illustrated hereinafter is an example of intervention that can be implemented with the system described above on a patch of petroleum having a thickness of 2 mm. In the case of a watercraft equipped according to what is illustrated in Figures 1 and 2, which has a width of approximately 8 m on the level of the water and presents channels with 50 m long and 2 m wide, at the speed of 7 km/h, a surface of 0.5 km^2 is depolluted every six hours, with a use of 10.5 tonnes of greasy wool (re-used for 10 consecutive cycles), with the production of 31.5 tonnes of exhausted wool containing 21 tonnes of residual petroleum, and with recovery of 950 tonnes of petroleum (equal to approximately 6350 barrels).

It should be noted that the use in said system of the wool referred to above, thanks to the large capacity of absorption that this possesses, enables total removal of the pollutant in very few passages of the watercraft on the surface of polluted water, and in

certain cases even in just one passage.

Finally, it may be noted that in the use of said wool as absorbent material for the system of Figure 2, the wool can be re-used (i.e., squeezed and subsequently lowered again into the sea) as many as about 10 times. In this case, the exhausted wool (i.e., after 10 cycles of use) possesses a calorific power of 27.8 MJ/kg, namely, more than 2000 times the calorific power of normal waste, and almost twice that of dry wood. The exhausted wool can then, for example, be advantageously used in an incineration system.

SYSTEM FOR INTERVENTIONS IN CONFINED BODIES OF WATER

In general, the system described herein constitutes an accessory means, with which, for example, port authorities or other organizations that operate in coastal areas can be equipped, and which can be easily transported by means of lorries, or the like, and operate, where intervention thereof is required, also from the land, and in restricted spaces, for instance on the mooring wharfs of ports.

In general, said system comprises:

- a supporting structure;
- a tank carried by the supporting structure;
- a suction device designed to draw in liquid from the body of water and to pour it into the aforesaid tank;
- a line for conveying absorbent material, mounted on said supporting structure and designed to cause said absorbent material to advance along a closed path of advance, said conveying line having a branch that traverses at least part of said tank so as to immerse said absorbent material at least partially in said liquid poured into said tank; and
- means carried by said supporting structure and

arranged on said conveying line, which are designed to squeeze said layer of absorbent material on said conveying line, after it has passed beyond said tank.

In various embodiments, as in the one illustrated in Figures 5 and 6, the supporting structure referred to above, designated in the figures by the reference number 68, is constituted by a container, for example an ISO container, which is the type of container most widely available on the market in so far as it is used for conveying freight both on land and at sea.

Fixed within said container is the tank referred to above, designated in the figures by the reference number 42. Said tank is preferably divided into a first section 44, sent into which, as will be seen more clearly hereinafter, is the liquid drawn in by the suction device, and a second section 46, where the absorbent material acts. Said tank is thus divided by a divisory wall 48 designed to enable overflow of liquid from the first section to the second section.

With specific reference to Figure 5, the absorbent material is in the form of a web M closed in a loop characterized by a given thickness (which varies according to the type of use for which it is designed). In preferred embodiments, the web M is formed by a containment mesh shaped like a bag, which is filled with the absorbent material and subsequently closed in a loop in the way illustrated in the figures.

Said web is made to turn on itself along a pre-set closed line of advance via purposely provided conveying means. In particular, said means are designed to create a line of advance that traverses the section 46 in such a way that the web M, during its passage into said section, comes to be partially immersed in the liquid contained therein. In various embodiments, as in the one illustrated, said means comprise rolls that can be

driven in rotation, which are suitably arranged with respect to one another to constitute the aforesaid line of advance. Said line of advance can in any case also be obtained by any other means suited for the purposes mentioned.

In various embodiments, as in the one illustrated, the line of advance (and hence the web M) surrounds the tank completely; in particular, with reference to the figures, said line turns around the tank in longitudinal planes of section, in which both of the sections 44 and 46 of the tank are located.

Located downstream of the tank (i.e., downstream with reference to the direction of advance of the web M) is a set of squeezing cylinders 48 designed to squeeze the web after this has emerged from the section 46 in order to separate and collect the pollutant that has been absorbed thereby in said section. The liquid squeezed is collected in a tray 52 underlying the set of rolls 78 and, via a pump 54 connected to said tray, is then sent to a cistern (not illustrated). In various embodiments, as in the one illustrated, the ensemble formed by the set of rolls 78, the tray 52, and the pump 54 is set up against the end of the tank close to the section 44, where, as will be seen hereinafter, also the means that make up the aforesaid suction device are located. Fixed, instead, on the opposite end of the tank is a discharge pipe 62 that communicates with the bottom portion of the tank and has the function of discharging the water contained therein, as will be seen hereinafter.

With reference now to the suction device referred to above, it has a suction hose 56 supported by buoys (not illustrated) and connected, via a flexible pipe 57, to a suction pump 58, which, via a delivery pipe 60, is designed to send the liquid drawn in by the

suction hose to the section 44 of the tank. It should be noted that the suction hose has the function of drawing in the liquid present on the surface of the water. Said liquid will comprise a fraction of water and a fraction of hydrocarbon substance, in variable amounts according to the thickness and the more or less uniform distribution of the patch of pollutant that floats on the surface of the water. The pump is preferably a dual-stage rotary-vane pump in order to limit as much as possible mixing of the water with the hydrocarbon substance drawn in.

With reference now to the operation of the system described above, it envisages intake of the liquid on the surface of polluted water via the suction hose, which is kept on the surface of the water by the buoys associated thereto. The liquid taken in by the suction hose is then sent, via the pump 58, to the section 44 of the tank, from which, by overflowing, it pours into the section 46. Thanks to the laminar flow that is generated, overflowing brings about a separation between water and pollutant that enables a free surface to be obtained, practically consisting only of said pollutant with the water underneath. The pollutant is absorbed by the web of absorbent material and, via squeezing thereof, is separated and gathered in the tray 52, and then sent by the pump 54 to a storage cistern (not illustrated). The water that accumulates underneath the pollutant is, instead, discharged into the sea through the pipe 62.

It may be noted that the system described herein, with the use of a mattress of wool of the length of 20 m, is able to separate approximately 20,000 l of hydrocarbon substance before having to be replaced.

In general, the system described herein, for removal of a pollutant floating on a body of water, in

particular petroleum and/or its derivatives, comprises:

- a supporting structure (68);
- a tank carried by the supporting structure (42);
- a suction device (56, 57, 58, 60), designed to draw in liquid from the body of water and to pour it into the aforesaid tank;
- a line for conveying absorbent material, mounted on said supporting structure and designed to cause said absorbent material to advance along a closed line, said conveying line having a branch that traverses at least part of said tank so as to dip at least partially said absorbent material in said liquid poured into said tank; and
- means (48) carried by said supporting structure and arranged in an area corresponding to said conveying line, which are designed to squeeze the absorbent material on said conveying line after it has passed beyond said tank.

In various embodiments, the aforesaid conveying line comprises a web M of absorbent material, and conveying means designed to get said web to turn along the aforesaid closed line.

In various embodiments, the aforesaid tank is divided into a first section (44), into which the liquid taken in by the suction device is sent, and a second section (46), where said absorbent material passes in the condition where it is at least partially immersed, said tank being divided into said first and second sections by a divisory wall designed to enable overflow of liquid from the first section to the second section.

In various embodiments, the aforesaid supporting structure is constituted by a container (68).

In various embodiments, the aforesaid means for squeezing said absorbent material comprise a unit with

squeezing rolls that is traversed by the aforesaid closed line.

In various embodiments, the aforesaid suction device has a suction hose (1), which is supported by buoys and connected, via a flexible pipe (57), to a suction pump (58) designed to send the liquid taken in by the suction hose to said tank (42). In various preferred embodiments, the aforesaid pump is a rotary-vane pump.

In various embodiments, the aforesaid closed line surrounds said tank (42).

Of course, without prejudice to the principle of the invention, the details of construction of the embodiments may vary, even significantly, with respect to what has been described purely by way of non-limiting example herein, without thereby departing from the scope of the invention as defined by the ensuing claims.

CLAIMS

1. A method for removal of a hydrocarbon pollutant floating on a body of water, in particular petroleum and/or its derivatives, characterized in that it envisages the use of wool in tufts in bulk form, to absorb said substance, said wool being greasy animal wool, with a fibre having a diameter greater than or equal to 25 μm, said method being further characterized in that it envisages:

- spreading said tufts of wool over said hydrocarbon substance in said body of water;
- extracting from said body of water said wool impregnated with said substance;
- squeezing said wool impregnated with said substance; and
- re-using said squeezed wool to absorb further hydrocarbon substance.

2. The method according to Claim 1, wherein said wool has a layer of grease or equivalent substances, that coats it, in an amount of between 15 wt% and 60 wt%.

3. The method according to any one of the preceding claims, wherein said wool has fibres of a diameter comprised between 25 and 40 μm.

4. A watercraft equipped with a system for removal of a pollutant according to the method of Claim 1, characterized in that said system comprises:

- a frame (4) designed to delimit laterally a strip of body of water that extends along at least one of the sides of the watercraft;
- means (16) for lowering tufts of wool in bulk form into said strip of body of water; and
- a conveying surface (12) for bringing back onto the watercraft the wool that has been lowered, said

surface having a portion configured for being immersed in said strip of water, which occupies a position at a distance from said means for lowering said tufts of wool, in the direction opposite to that of advance of said watercraft, said portion being designed to intercept the wool lowered into said strip.

5. The watercraft according to Claim 4, wherein said frame comprises a guard (4) that extends along one side of the watercraft and at a given distance from the latter.

6. The watercraft according to Claim 5, wherein said guard extends, along the side of the watercraft, substantially from bow to stern.

7. The watercraft according to any one of Claims 4 to 6, wherein said means (16) for lowering said tufts of wool are arranged on the watercraft so as to let down said tufts at the end of said strip closest to the bow, whilst said portion of said conveying surface is at the end of said strip closest to the stern.

8. The watercraft according to any one of the preceding claims, wherein said conveying surface (12) is an inclined conveying surface that is configured for reaching, from the level of the deck of the watercraft, the surface of the water, until it is immersed at least partially in said strip of body of water.

9. The watercraft according to any one of the preceding claims, wherein said inclined surface comprises a mesh conveyor belt.

10. The watercraft according to any one of the preceding claims, wherein said system comprises a set of squeezing rolls (24) designed to squeeze the wool gathered in said strip of body of water.

11. The watercraft according to any one of the preceding claims, wherein said system comprises within said strip of body of water a set of rotating rolls

(25) having the function of agitating and mixing the wool lowered into said strip of body of water.

FIG. 1

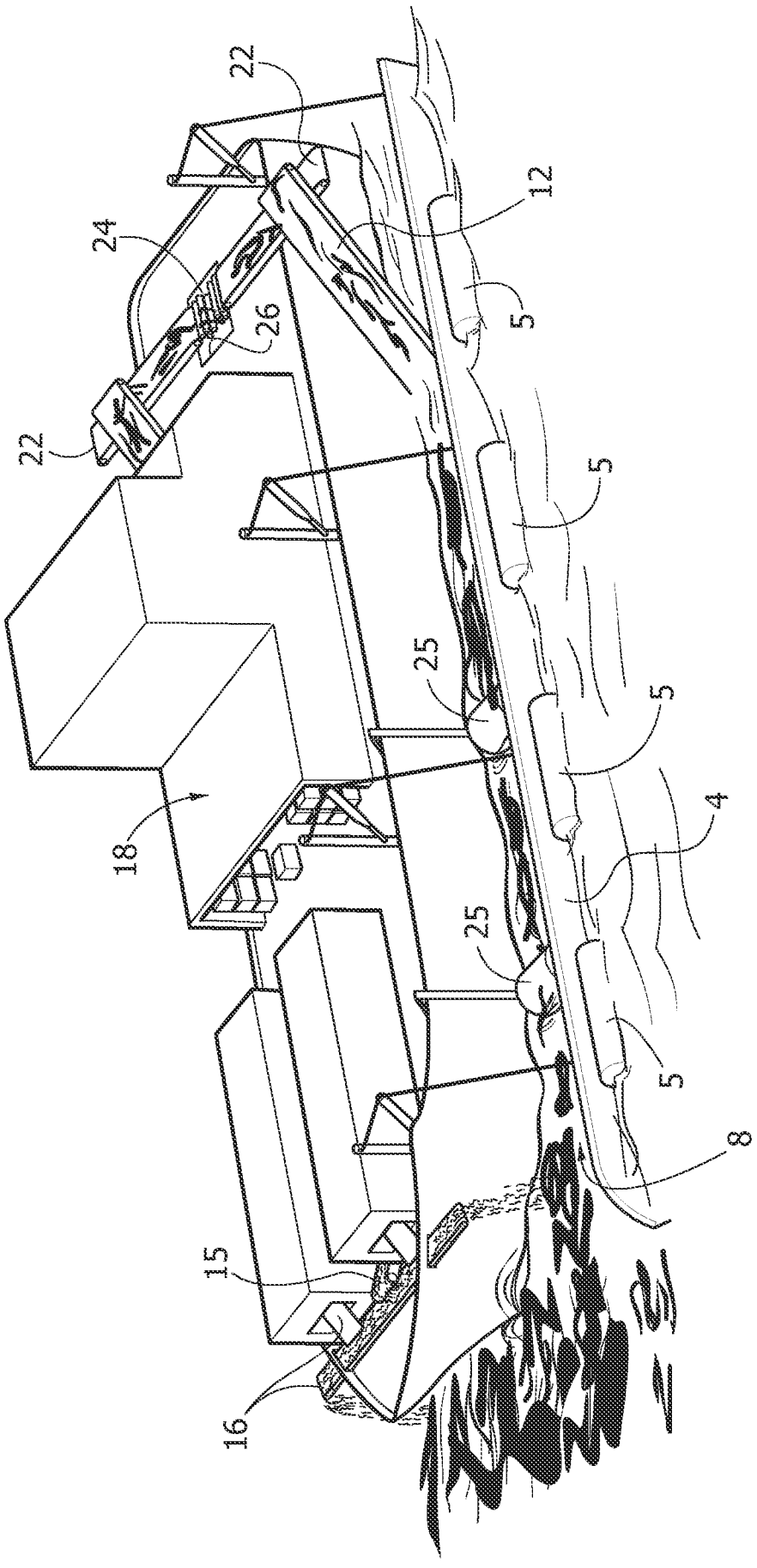


FIG. 2

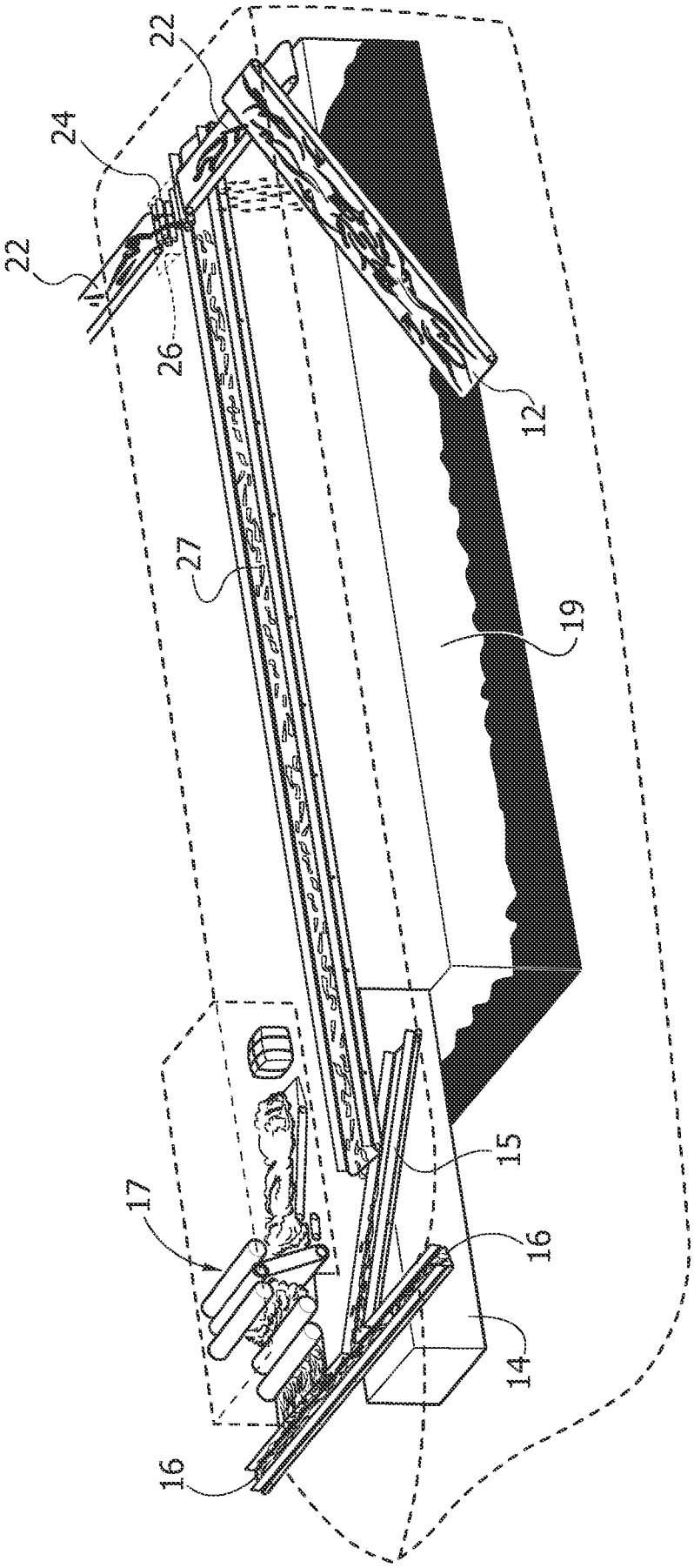


FIG. 3

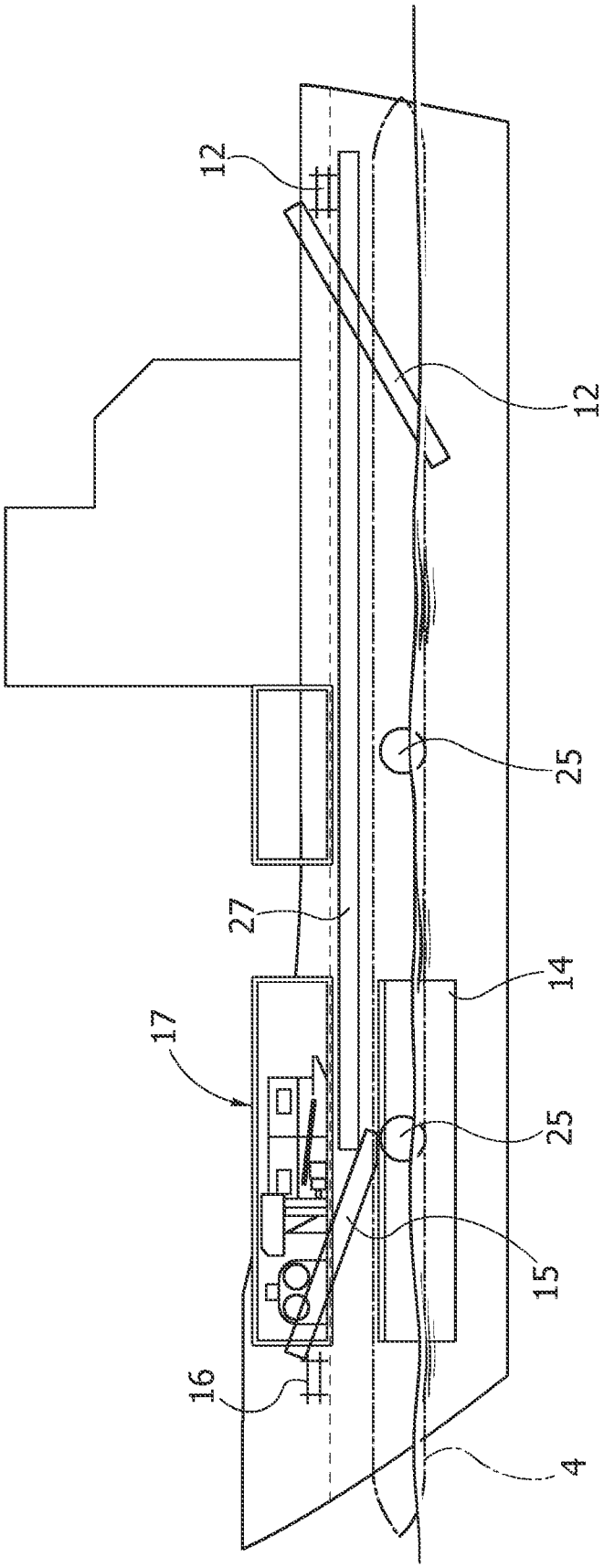


FIG. 4

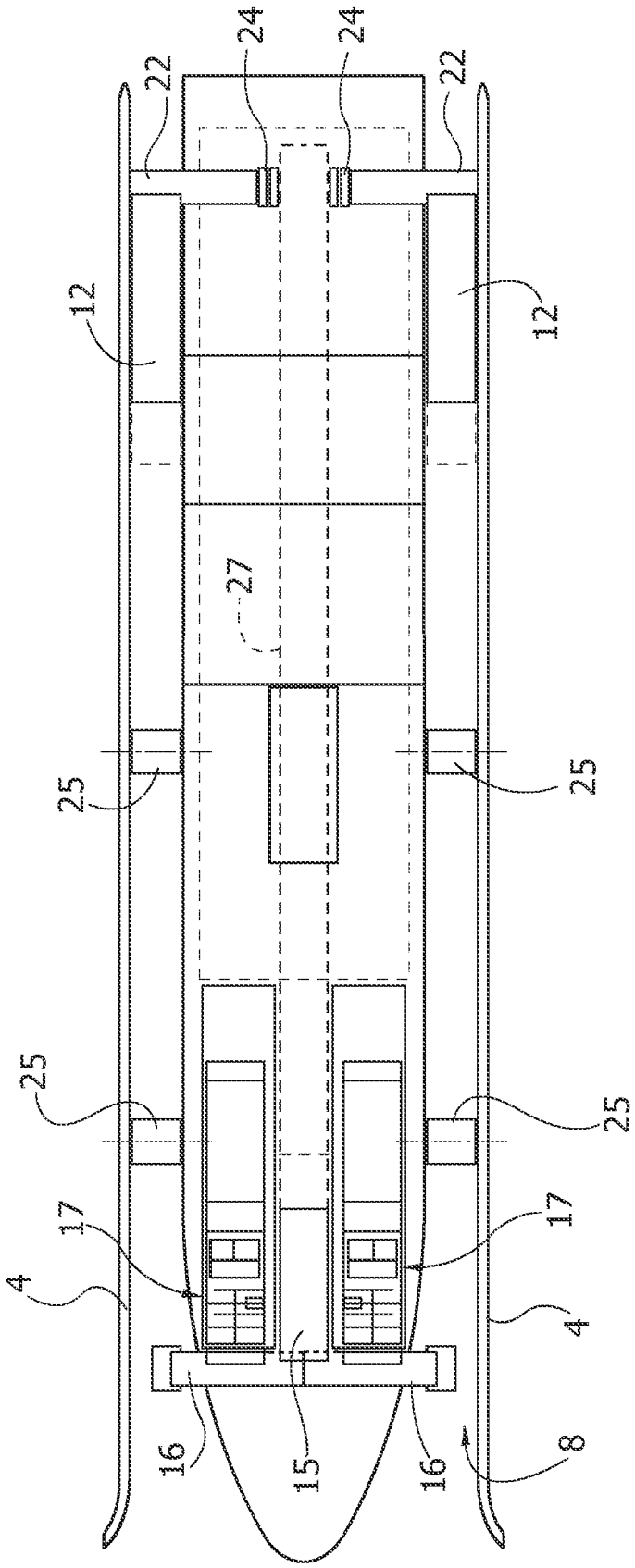
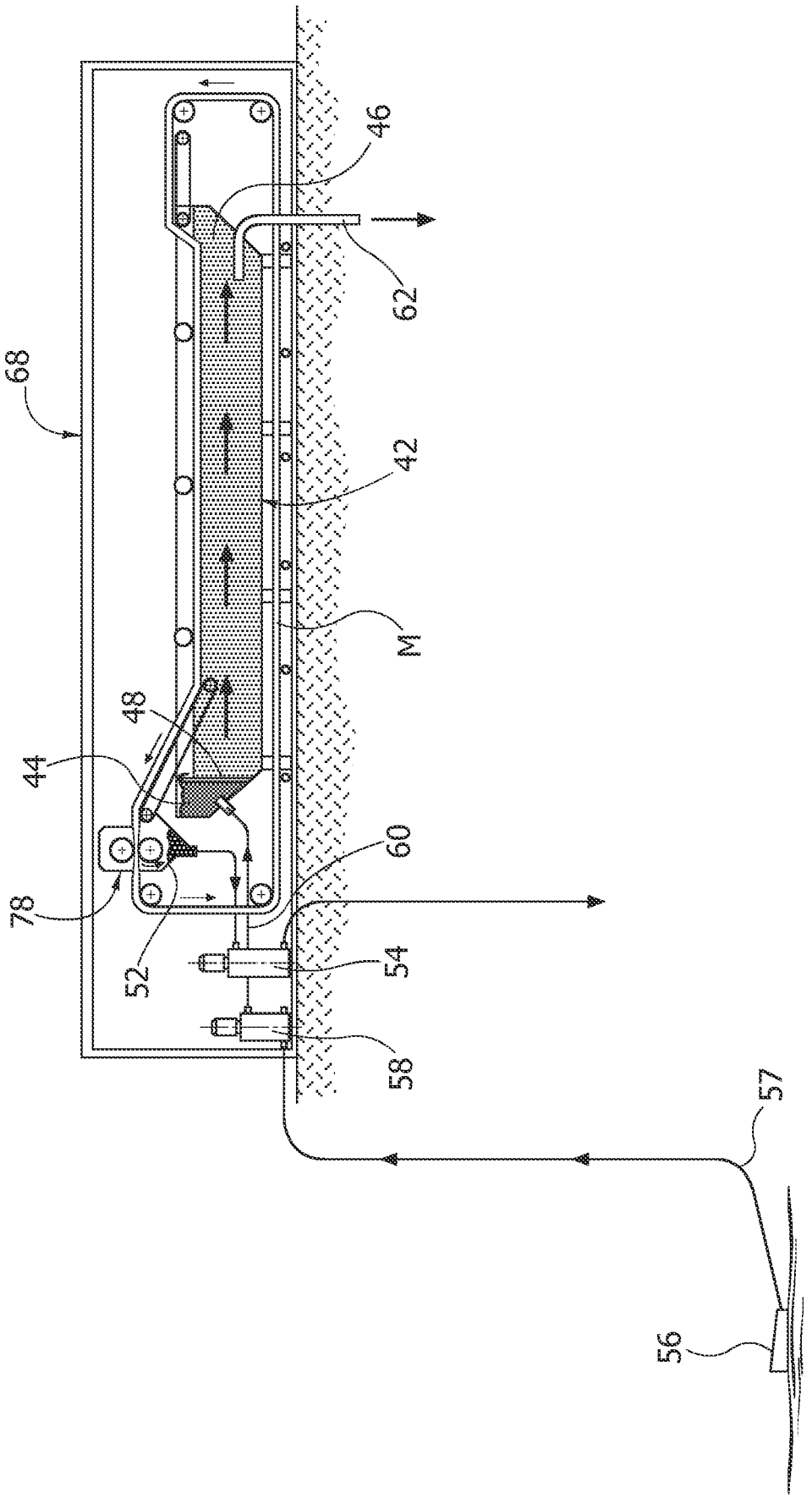


FIG. 5



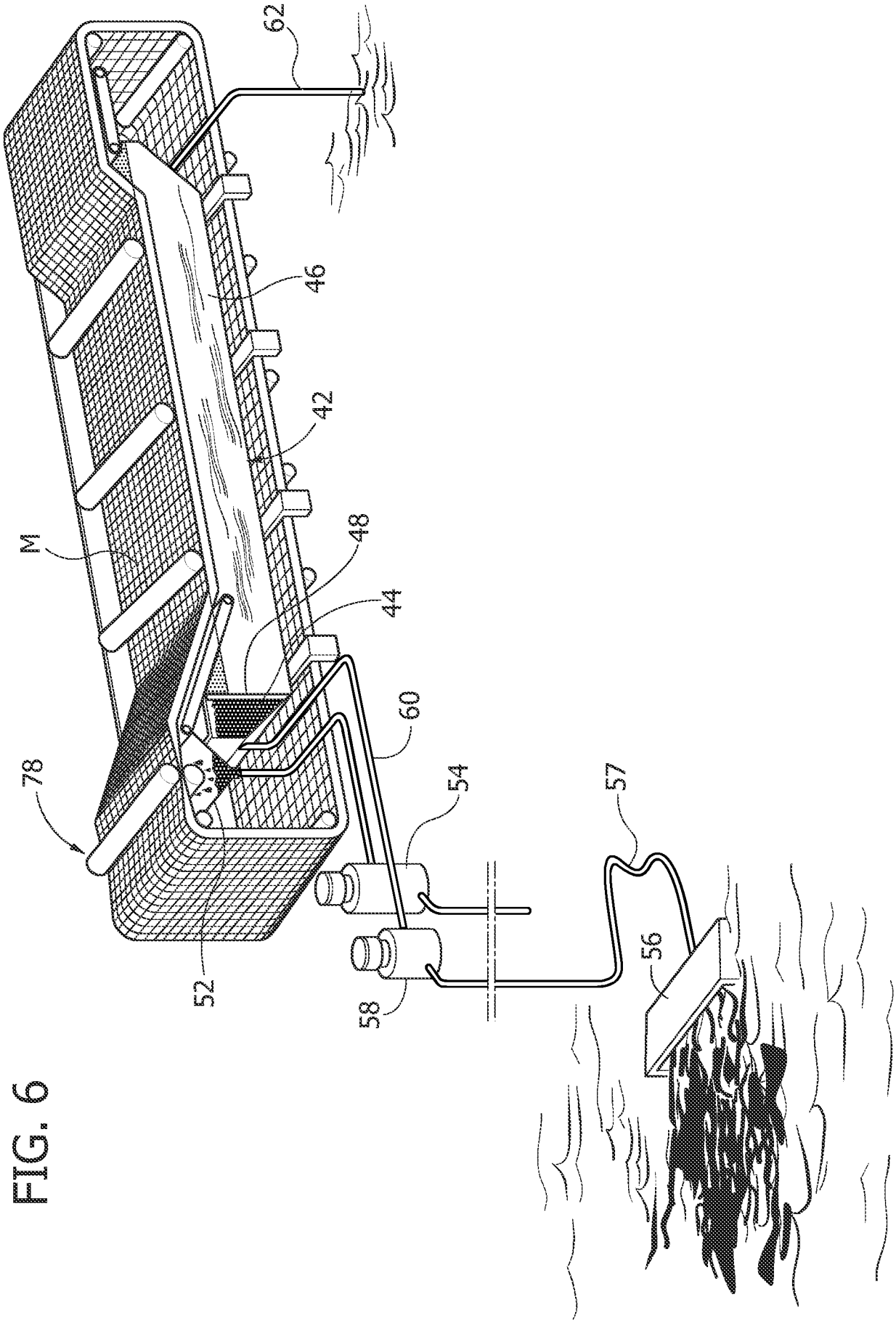


FIG. 6