Aug. 6, 1963 H. E. SHEETS ET AL 3,100,006

SUBMERGED FUELING METHODS AND APPARATUS

Filed March 3, 1960 3 Sheets-Sheet 1

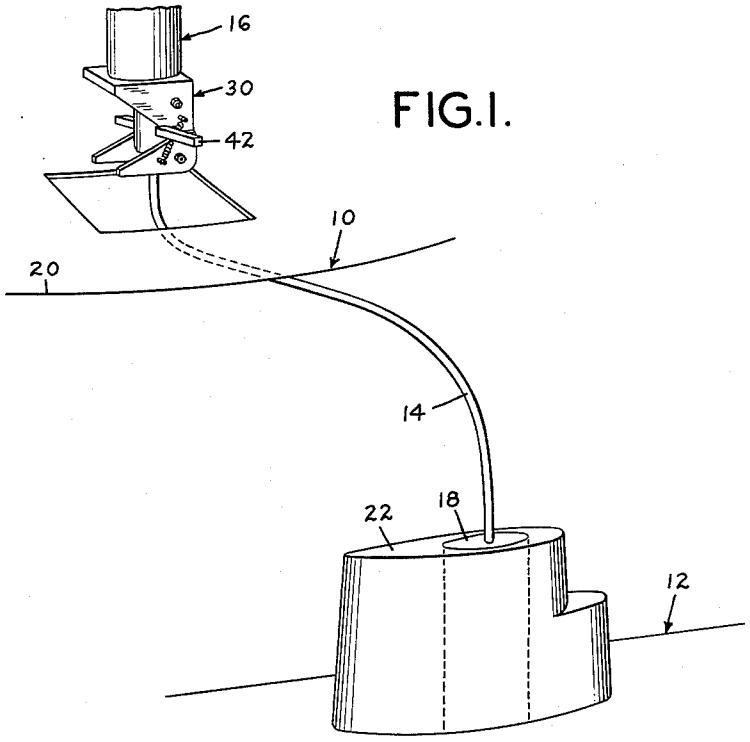


FIG.1.

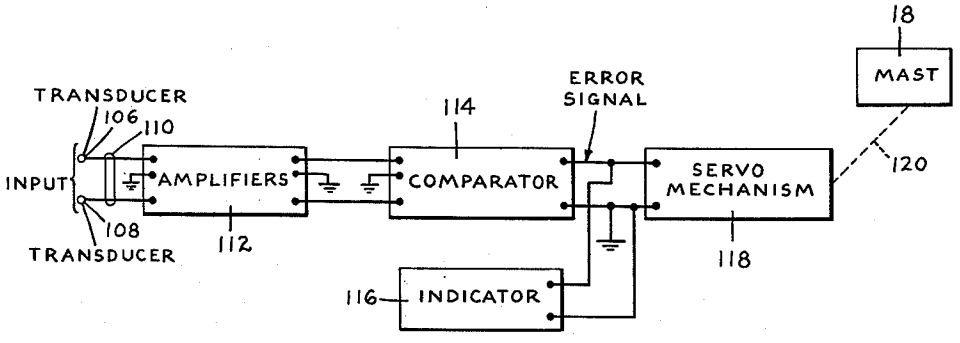


FIG.8.

INVENTORS
HERMAN E. SHEETS
J. VINCENT HARRINGTON
BY
Brumbaugh, Free, Graves & Donohue
THEIR ATTORNEYS

Aug. 6, 1963 H. E. SHEETS ET AL 3,100,006

SUBMERGED FUELING METHODS AND APPARATUS

Filed March 3, 1960 3 Sheets-Sheet 2

FIG. 2.

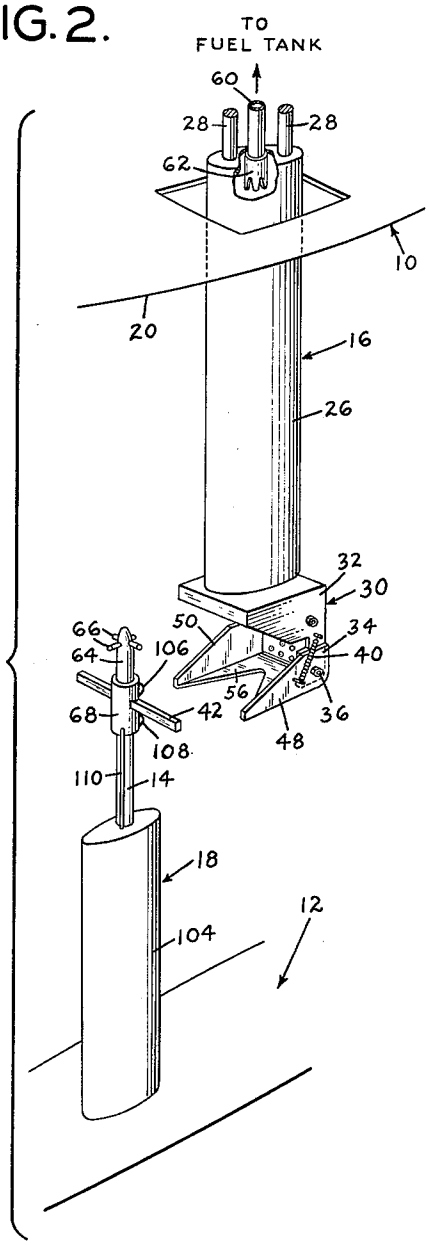
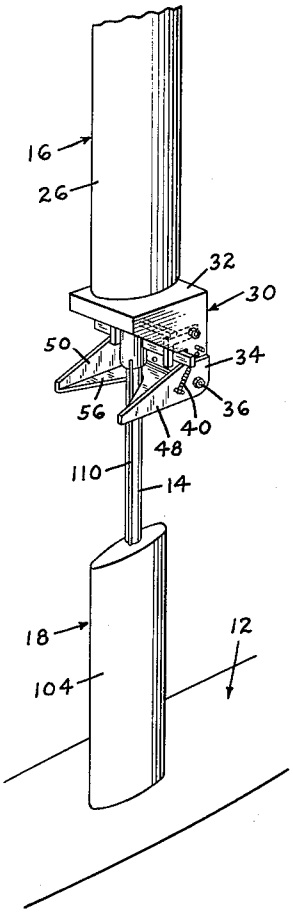


FIG. 3.



INVENTORS
HERMAN E. SHEETS
J. VINCENT HARRINGTON
BY
Brumbaugh, Free, Graves & Donohue
THEIR ATTORNEYS

Aug. 6, 1963 H. E. SHEETS ET AL 3,100,006

SUBMERGED FUELING METHODS AND APPARATUS

Filed March 3, 1960 3 Sheets-Sheet 3

FIG.6.

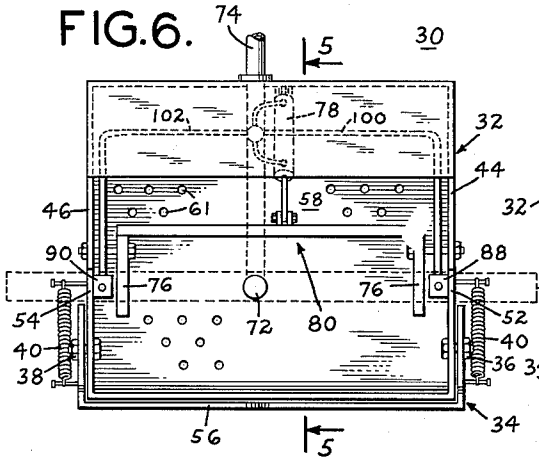


FIG.5.

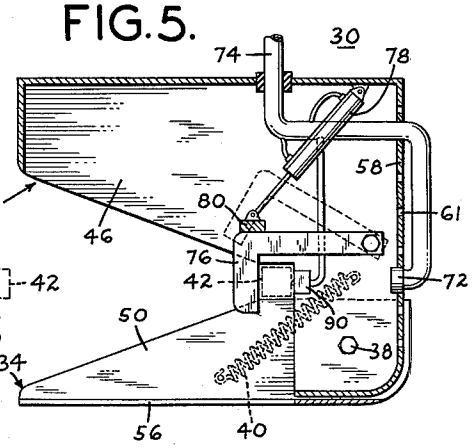


FIG.7.

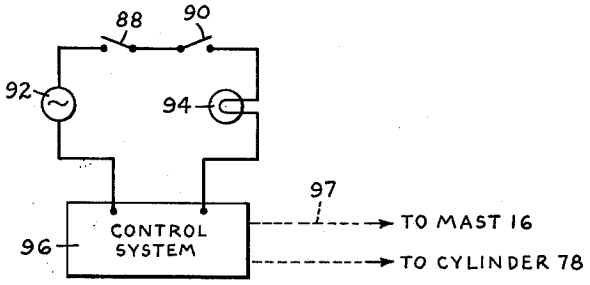
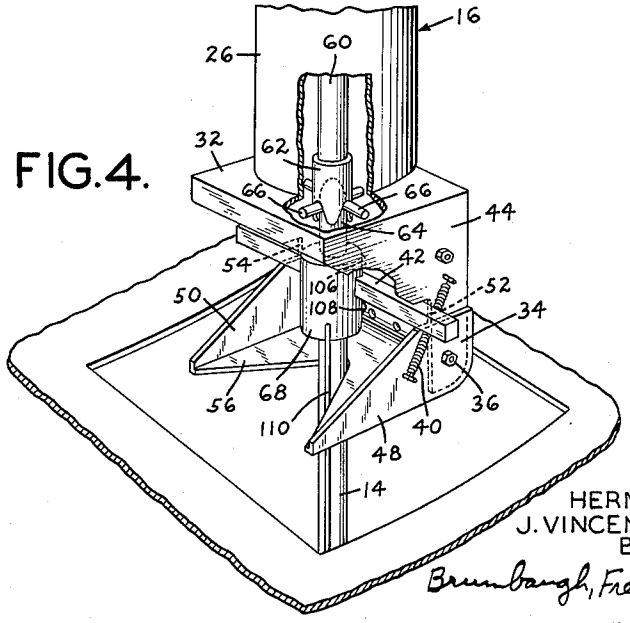


FIG.4.



INVENTORS
HERMAN E. SHEETS
J. VINCENT HARRINGTON
BY
Brumbaugh, Free, Graves & Donohue
THEIR ATTORNEYS

United States Patent Office 3,100,006 Patented Aug. 6, 1963

3,100,006
SUBMERGED FUELING METHODS AND APPARATUS

Herman E. Sheets and James Vincent Harrington, Mystic, Conn., assignors to General Dynamics Corporation, New York, N.Y., a corporation of Delaware

Filed Mar. 3, 1960, Ser. No. 12,601
9 Claims. (Cl. 141—1)

The present invention relates to submerged fueling methods and apparatus and, more particularly, to a system for transferring fuel at sea between a submarine and a surface vessel.

The present practice for transferring a liquid cargo at sea, for example to refuel a surface vessel, requires that the vessel and the tanker steam on preselected parallel courses into the sea at the same speed, and that a hose be passed therebetween for the transfer of fuel. Present hose-handling apparatus and hoses limit the maximum separation between the ships to about 100 feet. Great care must be exercised when fueling is undertaken in this manner to avoid collisions, and in bad weather operations may be entirely curtailed.

Another disadvantage of such surface-to-surface fueling techniques is that often it is necessary for both surface vessels to maintain a heading other than the desired course during refueling. Therefore, during combat conditions not only is the surface tanker more vulnerable to enemy action, but if defensive action is required by the vessel being refueled, there is often a delay in disengaging the hose-handling apparatus between the two vessels. Frequently air and escort support is required, in these circumstances, to safeguard the surface tanker.

The present invention eliminates many of the disadvantages accompanying the surface-to-surface transfer technique by refueling at sea between surface and submerged vessels one of which is designed to operate as a tanker for fueling the other vessel. Couplings on the surface and submerged vessels, after being guided into engagement by sonar and locked, cooperate to provide hose between the vessels through which fueling is accomplished. In one embodiment of the invention, both the surface vessel and the submarine are provided with retractable masts and suitable sonar-indicating apparatus for guiding the two masts into engagement while the submarine is submerged. One mast may then be locked to a hose section on the other mast and retracted into its corresponding vessel.

In a preferred embodiment of the invention, the submarine mast operates in response to sonar signals transmitted by the surface vessel and received by sonar apparatus on the submarine. In this manner, the submarine mast, which carries a hose section, is automatically positioned to engage and lock with the surface vessel mast.

The present invention enables the surface vessel to maintain any desired course during the fueling operation in contrast to the necessity in surface-to-surface refueling of heading into the sea. Moreover, the difficulty in detecting the submarine eliminates the need for escorts, ordinarily necessary for surface tankers, to protect the submarine while it is traveling to and from the refueling point.

One or more surface vessels may be refueled with different types of fuel from a single submarine and several of such fueling vessels can attend to several surface vessels traveling together. Additionally, the principles of the present invention can be combined with other known and established mechanical and electronics systems for employing a submerged storage tank, instead of a submarine, which may be contacted by a surface vessel to take on fuel.

These and further advantages of the present invention will be more readily understood when the following description is read in connection with the accompanying drawings, in which:

FIG. 1 illustrates apparatus to transfer fuel between surface and submerged vessels in accordance with the principles of the present invention;

FIG. 2 shows the refueling apparatus of FIG. 1 in greater detail prior to coupling between the submerged and surface vessels;

FIG. 3 illustrates the refueling apparatus coupled together;

FIG. 4 is an enlarged perspective of the coupled refueling apparatus of FIGURES 2 and 3 following retraction into the surface vessel;

FIG. 5 is a cross section of the coupling shown in FIG. 4 taken along the view of line 5—5 of FIG. 6 looking in the direction of the arrow;

FIG. 6 is a front view of the coupling shown in FIG. 4;

FIG. 7 is a schematic circuit diagram of a position sensing circuit; and

FIG. 8 is a schematic circuit diagram in block form of a sonar receiver and mast drive mechanism.

Referring to an illustrative embodiment of the invention in greater detail with particular reference to FIG. 1, a surface vessel 10, shown in fragmentary form, is being refueled by a submarine 12, also shown in fragmentary form. While the description herein is directed primarily to refueling of surface vessels by submarines, it will be understood that the present invention contemplates the transfer of fuel through hose between surface and submerged vessels in either direction. Moreover, the terms "fuel" and "hose" have been used in the interests of clarity, and are intended to refer to any material that may be pumped through connecting conduit between and into the submerged and surface vessels.

Returning to FIG. 1, a fuel hose 14 extends from a retractable mast 18 in superstructure 22 of the submarine 12 to a retractable mast 16 incorporated into keel 20 of the surface vessel 10. The hose 14 may be extended any desired distance from the submarine 12 to permit refueling of the surface vessel 10 without danger of collision in even the roughest seas.

Referring to the retractable masts 16 and 18 in greater detail with reference to FIGURES 2, 3 and 4, the surface vessel mast 16 comprises an aerodynamically shaped hollow metal body 26. Hydraulically actuated rods 28 (FIG. 2) connected to the upper end of the mast 16 control its vertical position and the depth to which a coupling or yoke 30 on the lower end of the mast is extended from the keel of the surface vessel 10. The retractable masts 16 and 18 may both conveniently be 20 to 25 feet long to provide 50 feet between the vessels during engagement of the coupling 30 with another coupling 42 in the form of a crossbar on the upper end of the hose 14, which is shown somewhat extended from the mast 18.

Referring next to FIGURES 4, 5 and 6, the coupling 30 consists of a top section 32 attached to the mast 16 and having its sides connected by pins 36 and 38 to the sides of a pivoted bottom section 34. Sides 44 and 46 of the top section 32, and sides 48 and 50 of the bottom section 34, are angularly cut to provide a V-shaped opening terminated at slots 52 and 54. A bottom plate 56 is also formed with a V-shaped opening, as shown, to center the upper end of the coupling 42 in the coupling 30. Perforations 61 may be provided in a rear plate 58 of the upper section 32 to decrease the water pressure exerted on the coupling 30 as the surface vessel 10 moves through the water.

Heavy springs 40 on each side of the coupling 30 strongly bias the bottom section 34 into the position shown from which it is movable under extraordinary stress with

respect to the top section 32. With this structure emergency decoupling is possible, as pointed out hereinafter. If desired, the top and bottom sections may be made integral and remotely controlled hydraulic pins positioned at the rear of the slots 52 and 54 to eject the crossbar 42 positively.

To lock the crossbar 42 into the slots 52 and 54 of the coupling 30, pivoted hooks 76 are actuated by a suitable hydraulic cylinder 78 connected to a bar 80 attached at its ends to the hooks 76. In operation, the hooks 76 are swung into position over the bar 42 after it has entered the slots 52 and 54, as discussed in greater detail below.

The coupling 30 engages and locks the crossbar coupling 42 on the end of the hose 14 which extends from the retractable mast 18 of the submarine 12. Thus, the crossbar 42 rides along the angled surfaces of the sides 44 and 46, or the sides 48 and 50, into the slots 52 and 54, and the hose 14 is centered by the bottom plate 56, when the vessel 10 and the submarine 12 are properly maneuvered.

A cylindrical member 63 joins a male quick release coupler 64 to the end of the hose 14 extending from the mast 18 of the submarine 12. The hollow cylindrical member 63 carries the crossbar 42 and provides a rigid extension from the mast 18. The upper section of the hose 14 is also quite rigid, due to wire braid reinforcement therein to resist abrasion, and may also extend somewhat from the mast 18 to facilitate coupling to the yoke 30, as shown in FIGS. 2 and 3.

A pipe or hose 60 (FIG. 4) located in the keel of the vessel 10, is terminated at its lower end by a female quick release coupler 62, its other end being coupled to the fuel system of the surface vessel in any desired manner such as through a conventional valve controlled manifold (not shown). The coupler 62 is coaxially related to the mast 16 and normally remains fixed in position inside the keel 20. Therefore, retraction of the mast 16 with the crossbar 42 locked in the coupling 30 results in the insertion of the male quick release coupler 64, guided by pins 66, into the female coupler 62, as shown in FIG. 4.

Also carried by the retractable mast 16 of the surface vessel in the yoke 30 is a high frequency transducer 72 coupled by a cable 74 to sonar signal generating circuits on the surface vessel 10 to transmit a narrow sonar beam. As shown, the transducer 72 is vertically aligned with the slots 52 and 54.

A pair of pressure responsive switches 88 and 90 in the coupler 30, connected by cables 100 and 102 to the vessel 10, are actuated by seating of the cross bar 42 in the slots 52 and 54. As shown in FIG. 7, the switches 88 and 90 are series connected with a power source 92, an indicator 94, and a control system 96 located in the surface vessel 10. Accordingly, closure of both switches 88 and 90 by seating of the cross bar 42 in the slots 52 and 54 is indicated in the vessel 10. Moreover, the control system 96 actuates the hydraulic cylinder 78 to swing the hooks 76 into position and lock the cross bar 42 into the slots 52 and 54. Finally, the control system 96 actuates a drive mechanism 97 (FIG. 7) such as double acting hydraulic rams joined to the rods 28 to retract the mast 16 into the surface vessel 10, thereby drawing the hose 14 into the surface vessel 10 and joining the complementary nozzles 62 and 64. Of course, such retraction of the mast 16 may be manually controlled in response to energization of the indicator 94.

Subsequent to retraction of the mast 16 with the hose 14, the submarine 12 may be advised by any desired signalling apparatus to retract its mast 18 and dive to greater depths for decreasing the possibility of collision between the two vessels. As the submarine dives, it pays out the hose 14 and at some predetermined depth on the order of 100 to 200 feet, fuel is pumped between the two vessels as they proceed on a preselected course at suitable speed.

The mast 18 of the submarine operates in response to signals received by a pair of vertically spaced transducers

106 and 108, which generate signals in response to sound waves from the transducer 72 in the yoke 30, mounted on the supporting cylinder 68 on the end of the hose 14. A cable 110 integral with the hose 14 connects the two transducers to sonar apparatus (FIG. 8) carried in the submarine 12. Preferably the transducers 72, 106 and 108 generate and respond to sonic-wave frequencies on the order of 100 to 200 kilocycles (kc.) to provide a high resolution indicating system for aligning accurately the relative positions of the yoke or coupling 30, and the crossbar 42.

The transducer 72 carried by the coupling 30 radiates a narrow beam of sonic-wave energy towards the after portion of the surface vessel 10 and into the area in which the mast 18 of the submarine should be located. The separate signals generated by each of the transducers 106 and 108 are coupled by the cable 110 to the sonar apparatus on the submarine. Due to the vertical spacing between the transducers 106 and 108, sonar signals of unequal intensity are received by the transducers whenever the mast 18 of the submarine is above or below the transducer 72 and the horizontal plane of maximum sonar wave energy, which is located at the level of the slots 52 and 54 in the coupling 30.

Referring to FIG. 8, the separate transducer signals in the cable 110 are fed to separate amplifiers 112 having their outputs joined to inputs of a comparator 114. The amplitude difference of the signals results in the generation of an error signal at the comparator output representative of the vertical spacing between the transducer 72 and the mid-point of the transducers 108 and 106. A servomechanism 118 responds to the error signal by actuating the mast 18 through a conventional electrohydraulic or electromechanical drive 120 until the error signal is reduced to a predetermined value, for example zero. Moreover, an indicator 116 displays the error signal to enable adjustment of the submarine's depth in relation to the coupling 30.

In a typical fueling operation in accordance with the invention, both vessels reduce their speed when the submarine 12 approaches the surface vessel 10 at periscope depth from the rear. As it draws near the surface vessel 10, the submarine 12 submerges to a depth dependent in each particular instance on the length of the masts 16 and 18. Sonar apparatus carried by both the surface vessel 10 and the submarine 12 facilitates the use of triangulation and computer procedures to maneuver the two vessels into close proximity.

The submarine mast 18 is then driven up or down by the servomechanism 118 and drive 120, in response to signals received by the transducers 108 and 106 from the transducer 72, to adjust the coupling crossbar 42 into vertical alignment with the coupling 30. Relative horizontal movement between the submarine and the surface vessel then causes the cross bar 42 to enter the coupling 30 and finally the slots 52 and 54, following which the hooks 76 automatically lock the cross bar 42 in place.

The submarine 12 then retracts its mast 18 and dives to greater depths of 100 to 200 feet while paying out hose. At the same time the hose 14 is drawn into the surface vessel 10 by retraction of the mast 16, and the male and female complementary quick release nozzles 64 and 62 engage and seal. In accordance with a predetermined fueling plan, the submarine 10 pumps a supply of diesel fuel, or aviation fuel, or both at separate intervals, through the hose 14 into the pipe 60 in the surface vessel 10. Standard manifolds opened and closed by valves on the vessels suitably direct the fuel to storage tanks in accordance with the amount of fuel to be taken aboard the vessel 10. The weight of the submarine is controlled during the fueling process to prevent unusual changes in its buoyancy.

If the submarine is to be fueled, the same connection is made between the vessels except that the surface vessel pumps the fuel.

After the fuel has been pumped from the submarine 12 to the surface vessel 10, the mast 16 is lowered, the hooks 76 raised, the crossbar 42 slipped out of the slots 52 and 54, and the hose 14 retracted into the submarine 12. In an emergency, a heavy vertical force on the hose 14 causes the lower yoke section 34 to pivot against the strong springs 40, to permit quick decoupling of the surface vessel and submarine. If desired, the hydraulic ejection pins mentioned above may be incorporated in the coupling 30 to force the cross bar 42 positively from the slots 52 and 54.

The present invention provides submerged-to-surface vessel fueling methods and apparatus readily adapted to existing vessels as well as newly built vessels. It will be apparent that the above-described embodiments of the invention are illustrative only and modifications thereof will occur to those skilled in the art. For example, other suitable coupling means between the surface and submerged vessels may be used to transfer fuel or other material that may be pumped between the two vessels through hose. Therefore, the invention is not to be limited to the particular apparatus disclosed herein, but is to be defined by the appended claims.

We claim:

1. In apparatus to transfer fuel between submerged and surface vessels, a coupling mechanism comprising first coupling means extendable from the submerged vessel, second coupling means extendable from the surface vessel to lock with the first coupling means when guided into coupling engagement therewith, a hose extending between one of the coupling means and one of the vessels, sonar signal generating means associated with one of the coupling means to transmit a relatively narrow beam of sonic wave energy, sonar receiving means associated with the other coupling means responsive to the sonic wave energy to generate electrical signals which are a function of the vertical displacement between the first and second coupling means, means responsive to the electrical signals to vary the depth of the one coupling means and align it vertically with the other coupling means to facilitate engagement of said first and second coupling means, means on said first and second coupling means to lock them together following engagement thereof, and means to retract the locked first and second coupling means into the other one of the vessels.

2. Apparatus as defined in claim 1, wherein the electrical signal responsive means includes a servo-mechanism to control the vertical position of said one coupling means with respect to the position of the other coupling means.

3. Apparatus as defined in claim 1, wherein said sonar receiving means includes at least two spaced apart transducers each of which provides signals of different intensity when the first and second coupling means are not vertically aligned.

4. Apparatus as defined in claim 1, wherein the first and second coupling means include means enabling an extraordinary vertical force applied thereto to separate said coupling means when locked.

5. A method of transferring fuel between submerged and surface vessels comprising the steps of maneuvering the vessels to position the submerged vessel below the surfaced vessel, extending couplings from the vessels one of which is attached to a hose extending from one of the vessels, engaging and locking the couplings, retracting the locked couplings and the hose into the other of the vessels to extend the hose between the vessels, connecting the hose with a fuel system in the other vessel, and pumping fuel through the hose between the submerged and surface vessels.

6. In apparatus to transfer fuel between submerged and surface vessels, a coupling mechanism comprising first coupling means on the submerged vessel, second coupling means on the surface vessel to lock with the first coupling means when guided into coupling engagement therewith, a hose extending between one of the coupling means and one of the vessels, means carried by the first and second coupling means to guide them into coupling engagement, means for locking together the engaged first and second coupling means, and means to retract the locked first and second coupling means into the other one of the vessels.

7. Apparatus to transfer fuel between submerged and surface vessels, comprising first coupling means on the submerged vessel, second coupling means on the surface vessel to lock with the first coupling means when guided into coupling engagement therewith, pipe sections on the vessels flexible portions of which are adapted to extend between the vessels, first and second complementary nozzles terminating the flexible pipe portions and carried by the first and second coupling means respectively in aligned relationship when the first and second coupling means are engaged, means carried by the first and second coupling means to guide them into coupling engagement, means for locking together the engaged first and second coupling means to join the first and second complementary nozzles, and means to retract the locked first and second coupling means to one of the vessels to extend the flexible pipe portions between the vessels, whereby fuel may be transferred between the vessels.

8. Apparatus to transfer fuel between submerged and surface vessels, comprising first coupling means extendable from the submerged vessel, second coupling means extendable from the surface vessel to lock with the first coupling means when guided into coupling engagement therewith, a pipe section on each of the vessels a flexible portion of one of which is adapted to extend between the vessels, the flexible pipe portion being carried by one of the coupling means, the other pipe section being coupled to the other one of the coupling means, complementary nozzles terminating the flexible pipe portion and the other pipe section and positioned in aligned relationship when the first and second coupling means are engaged, means carried by the first and second coupling means to guide them into coupling engagement, means for locking together the engaged first and second coupling means to join the first and second complementary nozzles, and means to retract the locked first and second coupling means to one of the vessels to extend the flexible pipe portion between the vessels, whereby fuel may be transferred between the vessels.

9. Apparatus as recited in claim 8, wherein the means carried by the first and second coupling means to guide them into coupling engagement comprises sonar apparatus on the first and second coupling means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,301,738	Potter	Apr. 22, 1919
1,379,928	Lake	May 31, 1921
1,685,927	Miller	Oct. 2, 1928
1,771,205	Burke	July 22, 1930
1,777,184	Stamper	Sept. 30, 1930
1,848,372	Moran	Mar. 8, 1932
2,692,102	Cobham et al.	Oct. 19, 1954
2,802,492	Gosselin	Aug. 13, 1957
2,941,761	Cox et al.	June 21, 1960