

April 16, 1963

W. M. GORYL ET AL

3,085,533

SYSTEM FOR TRANSPORTING OIL UNDER WATER

Filed Sept. 15, 1961

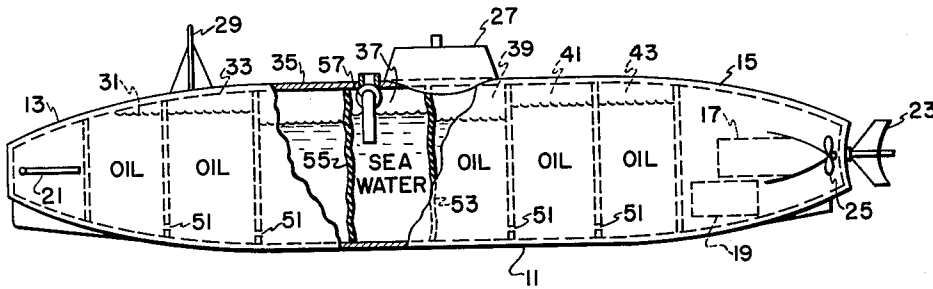


Fig. 1

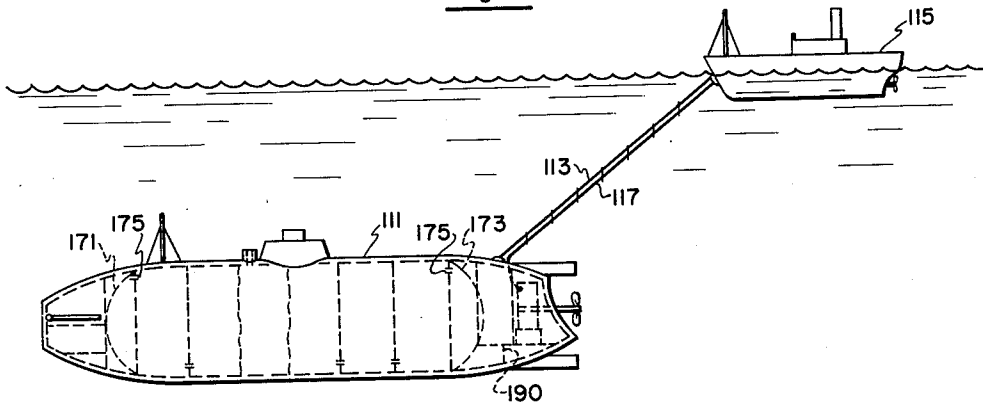


Fig. 2

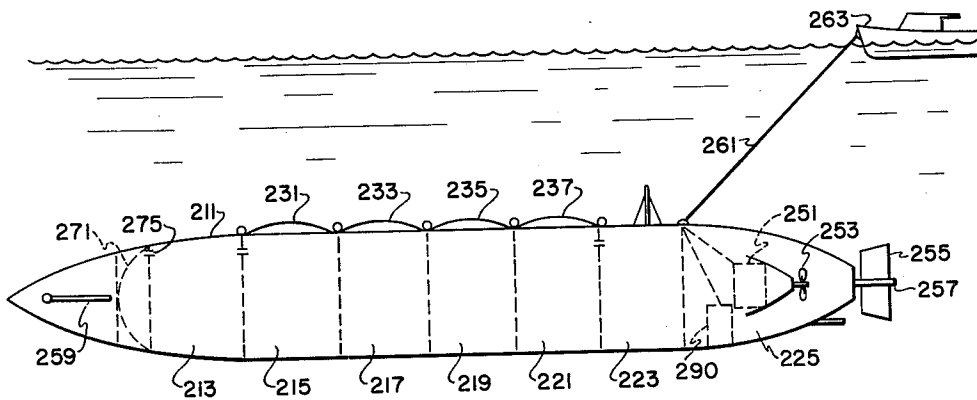


Fig. 3

William M. Goryl
Frank A. Howard

Inventors

By

E. M. Thomas

Patent Attorney

1

3,085,533 SYSTEM FOR TRANSPORTING OIL UNDER WATER

William M. Goryl, New Vernon, N.J., and Frank A. Howard, New York, N.Y., assignors to Esso Research and Engineering Company, a corporation of Delaware
Filed Sept. 15, 1961, Ser. No. 138,392
5 Claims. (Cl. 114-16)

The present invention relates to a system for transporting oil and similar products under water. It has particular application to the transportation of relatively light and volatile petroleum products such as liquid petroleum gas (butane and/or propane), other liquefiable products which may be normally gaseous but can be liquefied under reasonable pressure such as ethylene, propylene, butadiene and the like, and also volatile liquids such as pentane, benzene, and mixtures like gasoline and similar products. In its broader aspects the invention is applicable to means for transporting other high vapor pressure products, including anhydrous ammonia compressed to a liquid, and to numerous other materials. It may also be used for transporting materials of moderate or low vapor pressures, e.g., hydrocarbons such as kerosene and diesel fuel, etc. These, of course, do not require liquefaction under ordinary pressure and temperature conditions.

The transportation of petroleum products for substantial distances over water is a large industry, and the cost of such transportation represents a significant portion of the total costs of most such products. Each month many millions of barrels of petroleum products must be transported for great distances to supply the world markets. The ordinary liquid products of low or moderate vapor pressure are commonly transported in surface vessels, large tankers being especially suitable for this purpose. Even with these products there are advantages in subsurface transportation since the wave action on surface vessels may often constitute a major hazard and always requires large propulsive power. Underwater transportation is relatively free from the effect of surface waves and storms, and the undersea vessels, assuming proper design and proper travel depth, are subjected to much less stress and strain during travel.

The transportation of volatile petroleum products, such as liquid petroleum gas, ethylene, etc., is particularly expensive and difficult. Under ordinary circumstances, these liquid or liquefied products must be kept under substantial pressure to prevent volatilization. It has previously been suggested to transport liquid materials under water in flexible carriers but the control of such vessels is very difficult. It is one object of the present invention to design relatively rigid shipping equipment which takes advantage of the hydrostatic pressure of water at reasonable depths to assist in maintaining volatile materials in liquid form. By the use of flexible barriers between the oil products and the water which supports the vessel, this invention takes advantage of the hydrostatic pressure of the water.

During times of war, the transportation of petroleum products is a major task. In recent wars, substantially over half of all total transportation has involved these products. Surface vessels which are large and which must move relatively slowly are prime targets for enemy action. The loss, or the cost of protection against loss, in wartime amounts to tremendous sums of money. It diverts men and capital from other urgent needs.

For all these reasons the present invention has been designed to make possible underwater transportation with a reduction of hazards and a reduction of complications and expense.

2

A further object is to provide for underwater transportation of the major cargo while providing auxiliary equipment to take care of power requirements, and at least in one form of the invention, to furnish surface accommodations for the necessary personnel. Submarine crews are hard to obtain, especially in wartime and, moreover, even the best trained personnel need to be brought to the surface frequently in most types of marine operations. With such a system, a small control craft may ride the surface while the major cargo and the vessel or vessels containing it stay well below the surface. This takes advantage of the protection afforded by the water as well as of the hydrostatic head and the other advantages mentioned above.

The invention will be more fully understood by referring to the attached drawings wherein:

FIG. 1 is an elevational view with parts broken away and with parts in section showing one form of the invention for accomplishing the present objective;

FIG. 2 is another form of the invention showing an underwater main cargo vessel with an auxiliary surface craft which supplies power and control thereto; and

FIG. 3 represents still another modification in vertical elevational view.

Referring now to FIG. 1, there is shown a submarine vessel having a rigid or substantially rigid hull 11 with a forward compartment 13 which may be adapted to contain controls and other miscellaneous equipment, and an aft compartment 15 which may contain propulsion motors 17, cargo pumping equipment 19, and other essential operating machinery. Space for personnel also may be provided. The vessel is equipped with suitable elevators 21 for controlling its level and with rudder means 23 of conventional type.

Propellers 25 are provided, preferably one or more on each side of the vessel. Other components such as the control room 27 which can be manned if desired, and communications antenna 29 are of more or less conventional type.

The vessel is divided into a plurality of compartments 31, 33, 35, 37, 39, 41 and 43. These are separated by partition walls which act as structural reinforcing members of the vessel and also prevent large surges of the liquid cargo. Openings 51 will be left open so as to provide free communication and flow between adjacent compartments.

One of the compartments indicated at 37 is separated from the adjoining compartments on each side by flexible type barriers 53 and 55 respectively. The arrangement is such that the water in which the vessel is supported may flow into compartment 37 through a valve 57, or may flow out of the vessel through valve 57 so that at all times the pressure within the vessel is equal to the sea water pressure outside the vessel. Thus the vessel shell need not be designed to withstand substantial pressure, either internal or external.

The total cargo volume, which will vary somewhat with changes in temperature and/or pressure, must not differ from the total cargo compartment volume by more than the volume change which can be accommodated by the movement of the flexible barriers 53 and 55, respectively. If this is not the case, the flexible barrier or some other section of the vessel might be damaged by differential pressure.

The invention described in FIG. 1 may, if desired, be an independent submarine vessel with its own crew and its own motive power and source of fuel. A modification is shown in FIG. 2 using essentially the same vessel construction, but provided with operating controls and a prime power source which float on top of the water. The principal vessel 111 in FIG. 2 is controlled through a

power and control cable 113 from a small surface craft 115. The latter, for example, may include prime mover motors, a fuel supply and electric generators to supply electric power to the motors of the submarine vessel 111. A tow cable 117 attached to the submarine is also attached to the surface vessel, and the control and power cable 113 is preferably fastened to the tow cable at intervals to keep them together and prevent separation or entanglement. With this arrangement, the submarine may tow the surface vessel which, in turn, supplies power requirements to the submarine. Control from the surface vessel which is relatively small and makes a relatively insignificant target in the case of hostilities, permits the crew or most of it to be on the surface of the water while permitting continuous navigation of the principal vessel well below the surface. A part of the crew may ride in the submarine if desired.

Obviously, with suitable power which does not consume large quantities of air, such as atomic energy, the submarine vessel can have its own power plant and fuel, in which case the small auxiliary craft 115 is simply a control vessel. The latter is preferably capable of independent locomotion in case it should be separated from the submarine. In other respects the main vessel of FIG. 2 is essentially the same as in FIG. 1 and need not be described in greater detail.

In FIG. 3 another modification is shown wherein a submarine vessel 211 has a plurality of compartments 213, 215, 217, 219, 221 and 223 in addition to the motor room 225. Here the compartments may all be filled with the cargo, which may be highly volatile petroleum products, liquefied anhydride ammonia, or other products of high vapor pressure, and those compartments which are open to the atmosphere are covered by an impervious flexible membrane 231, 233, 235 and 237. This membrane, which may be made in sections, one section for each compartment, is so arranged that it may expand above the normal deck level to a limited extent. Different products can be placed in separate compartments. When volatile products are shipped, the vessel preferably travels at a depth which will keep the product substantially liquefied by reason of the hydrostatic pressure. Under such conditions the membranes 231, 233, etc. should be under no particular tension but as the vessel comes to the surface allowing some volatilization, a reasonable expansion may be permitted preparatory to discharging the cargo.

This vessel preferably has its own motive power 251 with propellers 253, of which only one is shown, and with conventional rudder 255, elevators 257 and 259, etc. A control cable 261 is attached to a small surface craft 263 which may operate in the same manner as craft 115 of FIG. 2. It is preferably capable of independent operation. Cable 261 may include a tow cable of sufficient strength to pull the vessel 263 and this is the preferable arrangement.

In the event it is desirable to keep the submarine vessel submerged over a long voyage without coming up for air, the motive power, if it is of the oxygen consuming type, will be mounted in the surface craft. Atomic powered craft, of course, may carry the power plant and fuel in the submarine vessel itself.

It will be understood that in any case all or part of the crew may have space provided in the submarine vessel, and in the case of a self-powered vessel as in FIG. 1, the surface craft may be dispensed with.

In FIGS. 2 and 3 there are also provided compartments for storing compressed gas which may be used for controlling the buoyancy of the vessel if desired. Thus in FIG. 2, compartments 171 and 173 may be filled with a compressed gas, preferably one that does not form an explosive mixture when combined with the vapors of the cargo. A similar arrangement may be made in the vessel of FIG. 1. With many types of cargo, the gas may be air but with some types, especially the light hydrocarbons,

it is necessary to use an inert gas such as nitrogen or carbon dioxide. In any case compartments 171 and 173 of FIG. 2, or the corresponding compartment 271 of FIG. 3, provide an expansible propellant through a valve such as 175, FIG. 2, or 275, FIG. 3, to move some of the cargo from the adjacent compartments towards the expansible chambers. There expansion can take place against the pressure of the surrounding water. By this means the buoyancy of the vessel may be controlled and adjustments may be made to permit diving or surfacing of the vessel.

If desired, the equipment just described may be replaced or supplemented with conventional submarine diving equipment including special compartments for compressed air and water with suitable pumps, etc.

With appropriate deep harbor unloading equipment, the vessel may be kept below the surface of the water for loading or discharging cargo. For some products such as liquid petroleum gas, this may require rather deep water, deeper than is usually available in harbor facilities. By proper control of the compressed gases and/or the ballast water, and by allowing moderate expansion capacity while the necessary loading or unloading connections are made, the vessel may be operated satisfactorily under the required conditions for loading and unloading.

It will be understood that pumping equipment 19 of FIG. 1, 190 of FIG. 2, or 290 of FIG. 3 will include suitable compressors for compressing the gases stored in vessels such as 171, 173, FIG. 2, or 271, FIG. 3, and equivalent arrangements not shown in FIG. 1. Equipment may be provided also for periodically or continuously withdrawing vapors which accumulate above the oil in the various compartments and recompressing them, with suitable refrigeration where needed, so as to prevent accumulation of undesirable volumes of vapor where the hydrostatic forces on the vessel are insufficient to keep the vapors in equilibrium.

Other modifications will suggest themselves to those skilled in the art, and it is intended to cover such by the appended claims so far as the claims and the prior art permit.

What is claimed is:

1. A submersible vessel for volatile liquid products such as petroleum fractions and the like, which comprises a relatively rigid hull structure, a plurality of compartments contained in said structure for containing said products, rigid partition means between at least some of adjoining compartments, at least some of said compartments separated by rigid partitions being in open communication with each other, and a flexible liquid-tight barrier interposed between one of said last-mentioned compartments containing said products and the body of water surrounding said submersible vessel, whereby the hydrostatic head of said water assists in keeping said products in the communicating compartments in liquid state.

2. A system for transporting low boiling liquids under water, comprising a substantially rigid submarine vessel having a series of consecutive compartments of which at least a pair of adjacent compartments are separated by a rigid partition providing open communication therebetween, one of said pair being enclosed over a substantial area separate from the rigid partition by a wall element composed of a flexible barrier means for subjecting said liquids to static pressure of said water, motor means for propelling said vessel through said water, a surface craft attached to said vessel and control means extending from said craft to said vessel.

3. System according to claim 2 wherein the surface craft comprises means for supplying power for said motor means.

4. System according to claim 2 wherein the vessel tows said craft.

5. A vessel according to claim 1, which comprises a

compressor, a compressed gas compartment, control means for adjusting the buoyancy of said vessel by regulating the volume of said gas, including means for displacing the liquid products in their compartments so as to vary the position of said flexible barrier.

5

1,579,109
2,091,857
2,359,366
2,896,416
2,989,937

References Cited in the file of this patent

UNITED STATES PATENTS

1,301,738 Potter Apr. 22, 1919

443,199
1,162,472

Haseley Mar. 30, 1926
Jaedicke Aug. 31, 1937
Katcher Oct. 3, 1944
Henry July 28, 1959
Rondot June 27, 1961

FOREIGN PATENTS

Great Britain 1936
France Apr. 8, 1958