ICEBREAKER OIL TANKERS

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Filed: Oct. 30, 1970

Appl. No.: 85,329

U.S. Cl. 114/41, 114/16 R
Int. Cl. B63b 35/12
Field of Search 114/40-42, 74 R, 16 E, 145 R, 67 A, 16 R, 43.5; 115/16

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ABSTRACT
An oil tanker icebreaker of S.S. Manhattan proportions defined as a semi-submersible having an oil car-
rying hull portion riding submerged in the presence of an oil field and a narrow enclosed superstructure upwardly depending therefrom confronting the ice in the amount of 25 per cent of that which confronted the Manhattan and providing the buoyancy reserve the vessel needs. The vessel is further characterized by three large cast steel ice saws disposed forward of the narrow superstructure which undercut the ice, and an ice ramp which transversely fractures and elevates the sawn ice above the ice sheet level where it is divided and sideways displaced atop of the ice sheet by the fine prow of the superstructure leaving a path clear of ice to the rear. Since the vessel is designed to navigate without the assistance of a conventional icebreaker, supplementary water ballast compartments additional to the regular ballast tanks are incorporated on the bottom of the hull containing a multiplicity of perforations, the water ballast being ejected therethrough to provide an upward force of considerable magnitude either by the admission of compressed air or alternatively including the extraction of the latent heat in the exhaust steam normally wasted, enabling the vessel to break out of and maneuver in any polar ice situation it may encounter. Two unconventional forms of propulsion are included which eliminate the phenomena of propeller slip, while the efflux of jet turbines is utilized to truncate hummocks and high ice ridges. A special rudder also functions as a vessel water-brake.

12 Claims, 12 Drawing Figures
ICEBREAKER OIL TANKERS

The experience gained from the two voyages of the S.S. Manhattan in attempting to force a path through the Northwest Passage has suggested that a larger vessel with considerably more power is necessary to that end. The design of the Manhattan adopted the technique employed was to utilize the momentum of 150,000 tons deadweight to crush a swath of ice some 80 to 100 per cent wider than the beam of the vessel in ice some 10 feet or more in thickness. This it failed to do. Crushing this enormous amount of ice was too great a task for the amount of power the Manhattan possessed. The apparent solution, it was said was to double the size of the tanker or the use of submarines which would cost two or three times as much relatively. However doubling the size might mean increasing the beam by as much as 50 or 60 feet and the draft from 55 to 75 feet. Increasing the draft to this extent would demand the extension of the off-shore docking facilities at Prudhoe Bay from 25 to 35 miles to obtain the needed depth of water. Such addition to the pipeline serving the dock would further lower the temperature of the entrained oil to the point where heating and extra pumping facilities would be needed at the dock.

Present invention indicates a tanker the size of the S.S. Manhattan as being adequate for year round operation. The importance of the concept presently outlined is that the oil carrying portion of the tanker i.e. the hull, avoids the ice by being wholly submerged at a below-ice elevation while a superstructure enclosed to point well above the ice level having a width one third of the hull to confront the ice, upwardly depends from the hull to constitute the buoyancy reserve the vessel needs. The submerged hull portion never comes in contact with the ice until the vessel reaches multiyear ice and the hard polar ice cap which in the past has defied penetration and which therefore warrants special consideration. This contraction of confrontation is the basic feature of the invention but other features herein described contribute their share of improvements.

Apart from the design of the superstructure, the disposition of the hull and the standard provisions of water ballasting for dealing with its load of oil or in lieu thereof the vessel of this invention is characterized by supplementary water ballast compartments occupying the central half and forward third of the vessel's bottom which is suitably perforated over the whole of the bottom of the compartment area for the quick ejection and re-admission of sea water ballast. These compartments could be some 4 feet deep. The outside top deck of the submerged hull portion slopes downward from its point of juncture with the superstructure on both major and minor axes to provide extra ice clearance for the oil cocks and other equipment located on the outer part of the hull deck.

Ejecting water ballast from the regular tanks with the object of reducing the draft of the tanker when clear of the ice field incidentally and beneficially exposes the oil cocks well above the sea water level for service at docking time. A service of alleysways transversely breach the superstructure so that both sides of the tanker may be serviced, at the same time incorporating and protecting oil cocks and other equipment located at ice level therein.

The vessel is further characterized by ice sawing and disposal elements comprising three cast steel saws upwardly depending from the foredeck of the superstructure designed to undercut the ice in parallel lines. These saws embrace a width of ice wider than the superstructure enough to provide ice clearance with the object of eliminating ice friction on its sides. Also included is an ice ramp confined within the spacing of the saws inclined at an angle below-ice elevation to an above-ice elevation. Ice being brittle it fractures transversely as it progresses up the ramp at which point it is divided by the fine prow of the superstructure and sideways displaced on top of the ice sheet to provide a path to the rear clear of ice. With all these measures it is confidently expected the tanker will be enabled to cruise through the relatively soft first and second year ice having a maximum thickness of 7 feet at some 12 knots. As the tanker moves westward it encounters multiyear and eventually the permanent polar ice cap which besides being harder increases to a 10 foot underwater thickness excluding hummocks and pressure ridges and where these exist in quantity the ice can thicken. Furthermore these ridges can occupy as much as 30 per cent of the area in some localities, rise 10 feet in height and extend back 20 and 30 feet, and the force necessary to saw and transversely fracture the ice at these points increases greatly. Due to the extra thickness of the ice and the fine angle setting of the saws the bow of the tanker will be depressed and while this adds beneficially to the upward force at this point the vessel is slowed up considerably. It should be noted that the saws edge should not incline from the horizontal more than 25° and should follow the pattern of a rip rather than a tenon saw. At the polar ice cap where the high ice ridges and hummocks exist I utilize the efflux of a turbine jet engine having a temperature of about 1,000°F. to truncate them. These engines situated forward of the superstructure are pivotable horizontally and vertically and the efflux being far ranging contact with the ridge can be made far in advance and by fish tailing the exhaust the cutting action will be narrowed and concentrated. Effective use of the jet efflux to supplement the work of the ice saws can be made by vertically fish tailing the efflux in line ahead of the saw particularly where long ridges are encountered.

If the ice breaking oil tanker is to operate in the polar ice cap without the assistance of a conventional icebreaker and have complete manoeuvrability at all times it is imperative that it possess resources of energy to enable it to break out of any situation it might encounter. Even though the underside of the polar ice is porous, on approaching it, as a first step, extra water should be taken into the regular ballast tanks to increase the draft of the vessel rather than make use of the supplementary ballasting compartments on the bottom of the vessel, and this in an amount sufficient only to compensate for the increased depth of the ice.

The concept makes note of two methods by which the above mentioned energy is made available. The first and most simple but rather slow is the ejection of the ballast water from the supplementary compartments by the sole admission the re into of compressed air. This would provide, if a three foot resident layer of water were ejected a total icebreaking lift force of 7,680 short tons. It should be noted in passing that flooding the ballast compartments with sea water as in this arrangement, in view of the large volume of air involved, calls for the exercise of economy by re-using the ballast air and this is affected by ducting this air
back to the intake of the compressor for increased compression and storage in the high pressure tank where it originated. Since ample time is available for this operation the need for a separate air receiver tank is avoided. The second method providing the same amount of energy but in a much shorter space of time is the utilization of the normally wasted latent heat of steam that is irretrievably lost to the cold water of a terminal condenser. This is a more sophisticated arrangement and can provide this energy in a fraction of the time required by the compressed air injection method. One is reminded that the amount of heat wasted in a condenser is equal to the total power delivered to the propeller shaft.

A brief outline of the latter scheme follows: Instead of directing the turbine exhaust into a terminal condenser, where the condensate is formed by a large pumped-in flowthrough of cold sea water I direct it into a multiple continuity of condenser tubing running the whole length of the upper portion of the supplementary water ballast compartments where the compressed air is situated and returning to the engine room at the lower level of the compartment where it becomes immersed in the water ballast having a temperature of 29° F. There it is quickly converted to condensates thus eliminating the need for the expensive conventional condenser. In a second embodiment performing this same function a water jacket secured to the ceiling of the compartments encases the upper outgoing portion of the condenser tubing and contains a replenishable supply of sea water pumped in and then on being heated is ejected through a multiplicity of fine spray nozzles into the resident compressed air. Functioning as a heat exchanger this jacket contains only enough water as can be maintained in flowthrough at the exhaust temperature of about 210° F. or 300° F. if a back-pressure turbine is installed. The hot water spray when injected into the compressed air transfers its heat by conduction to the air expanding it, thus ejecting the water ballast. Separate control may be exercised over the forward supplementary compartment. The air in these compartments occupying about 25 per cent of the total volume is already at a pressure of 1% atmospheres gauge because of the depth at which it is situated and is at a temperature of 29° F. The compartments occupy an area of approximately 80,000 square feet and if occupied to the extent of 1 foot depth by compressed air at a pressure of 26 lbs gauge would contain about 20 tons of air. The use of a back-pressure turbine having an exhaust temperature of about 300° F. and the continuous injection of a hot water spray at this temperature would increase the volume of the resident air by at least 57 per cent. This would indicate the requirement of an additional 25 to 30 tons of air also heated to this extent to accomplish the total exclusion of the water ballast from the compartments generating the upward pressure of 7,680 tons formerly mentioned some of which would be utilized to break through the polar ice if found necessary. The advantage of this latent heat technique over the singular use of compressed air to accomplish this function lies in the economy of air and its speed of application, it being noted that the total benefit realised by both methods is derived from the increase of buoyancy obtained and this cannot exceed the three feet of water ejected from the compartments. A reversing action is possible an can be repeated as often as necessary by controlling the volume of pumped water passing through the heat exchanger since by considerably increasing the volume of cold water the above noted expansion can be quickly reversed allowing the sea water to re-enter the compartments.

When clear of the ice field the vessel should eject the major portion of the ballast water in the supplementary compartments retaining only enough to condense the steam in the tubing for the benefit of the turbine.

The voyage of the S.S. Manhattan revealed there were a number of occasions when it became locked in the ice and all the energy of its reversing turbine was uselessly spent in the form of propeller slip. In order to take another run at the ice the services of a conventional icebreaker were needed to break the grip. To overcome this shortcoming I provide two unconventional forms of propulsion with the object not only of eliminating propeller slip but increasing the overall propulsive efficiency. One is the rotation of a helix worm confined within a horizontal cylindrical duct with means of flowthrough of the entrained water. The validity of the concept lies with the large volume of sea water contained in the duct which has to be unitarily moved. The other form of propulsion is an endless belt paddle system although the term ‘belt’ is more or less symbolic because in one instance hinged steel treads would be used. Like the helix worm it too is narrowly confined within a longitudinal compartment with inlet and outlet openings. Ordinarily with a submerged endless belt paddle assembly the upper tier of paddles would oppose the lower tier but this obstacle is overcome by admitting compressed air into the paddle compartment forcing the sea water down to the level of the lower tier of belting or steel treads so that the upper tier of paddles is moving in air eliminating the water resistance at that elevation. Thus a vast amount of water is locked within the lower tier of paddles and the sides and bottom of the paddle compartment and water being substantially incompressible the mass of water must move as a whole if it is to move at all, consequently the system operates like a crawler tractor. Since there is no slip, this system likewise the helix worm requires the use of extremely low gearing. Some form of friction clutch might be beneficial. In any event throttle means can be employed until some momentum is attained. Both propulsion systems have the means whereby a relentless pressure can be maintained against the ice and since so much time is spent in the ice field one or other of these propulsion forms would be eminently suitable for use. In addition to the elimination of slip the endless belt paddle system contributes a benefit, inherent in its design, in the form of laminar flow at the rear and in the wake of the vessel. Propeller driven vessels by reason of the rotary motion of the propellers and the influences of the propeller bearings and boss generate turbulent flow creating the a wake loss. This beneficial laminar flow is attained by the paddle's elimination of water churning and by the uniform tapering of the stern of the vessel much as the bow is tapered and in this way generating a forward acting vector force created by the side pressure of the sea water pressing on the stern surface adding to the vessel's speed.

Tankers approaching the terminal or required to quickly reduce their speed having to contend with the considerable momentum of the vessel it requiring a distance of some 3 miles to halt them. This distance can
be greatly reduced as well as increasing the vessel's responsiveness directionally by the use of a balanced oversize rudder. This rudder is streamlined, and hollow to reduce its weight in water. The surface on both sides of the rudder post is equal in area and by pivoting it through 90° presents a flat surface to the water flow. An alternative but structurally less effective arrangement would be a closely aligned twin rudder unitarily pivoting as a rudder, and independently opposite as a water-brake. These improvements are not limited to tankers and can be applied to any deep draft vessel.

The top deck of the superstructure is long and large enough to provide take-off-and-landing facilities for light aircraft which have a much greater range than a helicopter and could fly sick and injured personnel to a distant base. A safety grill of rail stressed polypropylene roping could flank the flight deck.

The flight deck can conveniently overhang the beam of the superstructure and this extra space can be utilized for operating a light mobile crane riding on a pair of buried rails without interfering with the operation of the aircraft. The cranes would be mainly used at the terminal and when not in use would be stored against the aircraft hangers.

It should be observed that the S.S. Manhattan in crushing a swath of ice as wide again as its beam forward and to the side thereby subjected itself to dangerous side pressures. In this connection the vessel of this invention avoids such a situation since the ice saws cut a clean narrow channel where the ice immediately ahead is unbroken and therefore inherently capable of resisting compression to a point some distance to the rear. Incidentally disposal of the sawn ice as herein proposed completely eliminates damage to the propellers of icebreakers which in the past has been caused by ice passing under the vessel.

The design of a larger icebreaking oil tanker along the lines of the S.S. Manhattan while conventional would appear to this applicant, under the circumstances of its use, poor engineering practice since it would still deal with the ice on the worst possible terms and to increase its beam from 100 to 170 or 190 feet by doubling its size as is now proposed only accentuates this view.

It may seem that the provisions made herein to deal with the Artic ice are excessive. In that event I provide for their use in part or in any combination as experience indicates. The inclusion of unconventional features in combinations heretofore untried may mitigate against acceptance but it should be realized that in dealing with such odd and variable conditions some measure of innovation is mandatory as the experience with the Manhattan has demonstrated.

Embodiments of the invention will be described with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a broken side elevation of the vessel showing ice saws, ramp, service alleyways and jet engines. FIG. 2 is a broken plan view of the vessel in FIG. 1 showing saw elements, ramp, jet engine emplacement and aircraft deck. FIG. 3 is a plan view of the underside of the vessel in FIG. 1 showing perforations in hull bottom, water ducts and outgoing condenser tubing overlying a baffle plate. FIG. 4 is a side elevation of the ballast compartment in FIG. 3 showing condenser tubing but excluding water ducts.

FIG. 5 is a plan view of an alternative embodiment of the vessel in FIGS. 3 and 4 showing condenser tubing enclosed within a heat exchanger and spray ejection nozzles. FIG. 6 is a side elevation of the embodiment in FIG. 5 showing condenser tubing within a heat exchanger and returning via the water ballast. FIG. 7 is a front view of the vessel at the beneath-ice operating level, jet engine emplacement and aircraft deck. FIG. 8 is a side elevation of half of driven pulley showing its complement of detachable non-buoyant endless-belt braced paddles.

FIG. 9 is a side elevation of a helix-worm-in-duct form of propulsion. FIG. 10 is a side elevation of the hydraulically adjusted idler pulley and its complement of hollow endless-belt paddles. FIG. 11 is a side elevation of the overhanging hull portion and combination rudder water-brake detail. FIG. 12 is an underside plan view of rudder detail shown in FIG. 11, also the tapered hull configuration and associated paddle system.

The hull 1 of the vessel shown in FIG. 1 is depicted at a beneath-polar-ice-sheet elevation lowered to this level by means of ballast water pumped into the regular ballast tanks, a relatively slow process, this in order to make the most effective use of all the teeth of the ice saws 2 and the ice ramp 3 disposed forward of the superstructure 4 in which are located the alleyways 5 breaching the substantially enclosed superstructure 4 and in which are located and protected the oil cocks 6 and other essential equipment. Once the ice saws 2 are correctly adjusted relative to the ice level means must be found to quickly exert and occasionally relax the pressure of saws 2 on the underside of the ice and this is accomplished through the medium of supplementary water ballast compartments 7 at the bottom of the hull 1 which eject, and alternately take in, ballast water via the perforations 8 in the bottom of the compartments 7. These compartments 7 if 4 feet deep initially contain a resident one foot of compressed air overlaying 3 feet of ballast water. It is the ejection of a portion or the whole of this water that creates the buoyancy pressure on the underside of the ice. Three methods variously affecting the ejection (and re-entry) are first the admission of an additional 3 feet of compressed air from the storage tank (requiring excessive storage space), the second the admission of 1 and ½ ft. of compressed air coupled with the extraction of the latent heat in the exhauster steam to heat and so expand the 2½ feet of air now in the compartments 7 indicated in FIG. 4. Also shown in FIG. 4 is a condenser-tubing expansion joint 11 consisting of a sleeve slidingly embracing the spaced ends of the condenser tubing. The third method is a means of accelerating and enlarging the scope of the heat extraction process by the use of a jacketed water heat exchanger 9 as shown in FIGS. 5 and 6 by which the air is expanded by at least 57 per cent which does not include the amount of water vapour introduced. The first of the two methods of heat extraction, avoiding in the main, the continuous injection of water vapour into the resident air includes the use of baffle plates 10 shown in FIGS. 3 and 4, underlying the lengths of condenser tubing 11 and being a less efficient alternative to the heat exchanger 9 shown in FIGS. 5 and 6. These baffles 10 further shield the upper
condenser tubing 11 running the full length of the compartments 7 from incidental contact with the ballast water below. In this first method the multiple lengths of condenser tubing 11 after giving up their heat to the air in the compartments 7 return to the engine room immersed in the ballast water below to create the condensate. This arrangement because of its simplicity is preferred. The alternate installment of the jacketed heat exchanger 9 shown in FIGS. 5 and 6 requires the passage of the condenser tubing 11 through the jacket 9 into which is pumped a continuous regulated supply of sea water via the centrally disposed constant-delivery pump 12 in an amount sufficient only to maintain this water at the exhaust temperature of 210° F or 300° F. If a back-pressure turbine is installed. On being heated to this temperature this pumped-in water is injected into the resident air via the spray nozzles 13 located on the surface of the jacket 9 transferring its heat to the air by conduction. The reverse action contracting the air and so re-admitting the water ballast is accomplished by over-supplying cold sea water via the variable delivery pumps 14 located on the flanks as shown in FIGS. 3 and 5. This reversing arrangement can also be attained with the first heat extraction method as shown in FIG. 3 by the use of water piping 15 terminating in the spray nozzles 13. This construction is however omitted from FIG. 4 for clarity. The condenser tubing 11 is serviced by the header 16, and the water piping 15 by the header 17. In FIG. 6 the water jacket 9 is shown opened to reveal the condenser tubing 11. The ice saws shown in FIGS. 1, 2, and 7 depend for their undercutting effectiveness on the bouyancy pressure and on the momentum of the 150,000 tons deadweight of the vessel. The saws 2 encompass a width slightly more than the beam of the superstructure 4. An ice ramp 3 transversely confined within the limits of the saws 2 fractures the sown ice into chunks which are then divided and side-ways displaced on top of the ice sheet by the fine prow of the superstructure 4 to leave a path clear of ice to the rear. The ice saws 2 are made of cast steel preferably of box construction for added strength, the teeth of the saws 2 conforming to a rip pattern to provide clearance for the blade portion. The superstructure 4 being much narrower than the beam of the vessel is capable of being more strongly reinforced proportionately and by a lesser amount of steel than used on the S.S. Manhattan, however this reinforcement should extend to the upper deck of the hull 1 instead of its sideplates the need for which is now eliminated.

Turbojet engines 18 symbolically shown in FIGS. 1, 2 and 7 are disposed on the foredeck of the superstructure 4 with provision made for pivoting both horizontally and vertically, the efflux being forwardly directed and fished tail to broaden the cutting action on the ice edges. By aligning the jet engines 18 with the ice saws 2 and vertically fished tail the efflux the work of sawing the ice can be supplemented.

Two embodiments of a propulsion system are shown, an endless-belt paddle assembly in FIGS. 1, 3 and 5 supplemented by detail drawings of two types of paddles in FIGS. 8 and 10 also a helix-worm-in-duct type of propulsion as illustrated in FIG. 9. As shown in FIG. 8 an endless belt 19 of rubber covered by a layer of steel cables longitudinally embedded therein, as made by the Goodyear Tire Company for conveying ore has detachable blades 20 anchored in rubber sockets 21 vul-

canized to the belting 19. The detachable blades 20 are diagonally braced on the drive side by a number of steel cables while on the opposite side the bracing could be of polypropylene or nylon cord since both these materials will be required to stretch slightly in passing over the drive pulley 32 shown in FIG. 8 and the idler pulley 23 shown in FIG. 10. The braced paddles 29 are made of plywood clad in metal or Verithane a lightweight porous plastic of great strength. An alternative hollow paddle design 24 is of steel plate construction welded to cast steel hinged treads 25 having rubber pads 26 bonded thereto for better traction. The hollow paddles 24 have enough bouyancy in water to support not only the paddle 24 but the connecting link treads 27 to avoid sagging. The upper tier of hollow paddles 24 moving in air have their weight supported by rollers 28 horizontally angled to accomodate the curvature of the treads 25 and 27 their passage over the rollers 28 being cushioned by the rubber pads 26. Both paddle assemblies have hydraulic means 29 for adjusting the tension of the belting 19 and facilitating their erection and dismantling.

The alternative propulsion system as shown in FIG. 9 is a helix worm 30 journaled at both ends of its shaft and rotating within a close fitting cylindrical duct 31. An inclined entrance to the duct 31 occurs at its forward end either on the side or bottom of the vessel with the exit directly to the rear. It is important to note that the worm 30 does not necessarily have to extend the full length of the duct 31 but it should engage a mass of water sufficiently large to cause the unitary motion of all the water in the duct 31. In contrast to a propeller the worm 30 will be just as efficient when its motion is reversed.

An oversized balanced hollow, and streamlined rudder 32 is shown in FIG. 11 and 12. This rudder 32 when set at right angles to the direction of motion functions as a brake to retard the vessel as it approaches the terminal. At such times it is exposed to considerable stress and requires two point support and room for pivoting details. This is provided by extending the stern of the upper portion of the hull 1 and a stub 33 horizontally extending from the lower portion of the hull 1. FIG. 12 also shows the streamlined tapering of the stern. By slightly widening the top deck 34 of the superstructure 4 light aircraft will be enabled to take off and land and by longitudinally embedding a pair of rails in the widened deck portions 34 the mobility of a small crane will be facilitated.

I claim:

1. A semi-submersible icebreaking bulk carrier vessel having

   a submerged hull portion

   a superstructure longitudinally disposed and vertically depending from said hull portion

   said superstructure permanently extending above the ice sheet

   said superstructure enclosed to the point of providing a reserve of bouyancy for the entire said vessel

   said superstructure having a width less than one half the beam of said submerged hull portion

   said hull portion having supplementary water ballast compartments at its bottom and having upwardly indented openings therein to the sea

   said vessel having air compression and storage means located in said hull portion extraneous of said water ballast compartments
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valved ducted communications between said air compressor and storage means and said water ballast compartments
valved ducted communication between said water ballast compartments and the intake of said compressor for re-compression of said air into said storage means.

2. A semi-submersible icebreaking vessel as described in claim 1

the weatherdeck of said submerged hull portion sloping downward from its point of juncture with said superstructure to the rail on both major and minor axes.
said submerged hull being ballast adjusted so that the level of said point of juncture coincides with that of the underface of the ice sheet.

3. A semi-submersible icebreaking vessel as described in claim 2

having the unitary combination of a triad of rigid ice saws, a ramp and said superstructure, to cut, break, elevate, divide and sideways displace the sawn ice on top of the ice sheet.
said ice saws upwardly depending from the forward sloping weatherdeck being spaced apart and longitudinally aligned with said superstructure to under-cut a swath of ice wider than said superstructure said ramp occupying the space between said saws.

4. A semi-submersible icebreaking oil tanker defined in claim 3

having a series of air-sealed alleyways transversely breaching said superstructure and having oil cocks and other equipment located within their confines.

5. A semi-submersible icebreaking oil tanker defined in claim 3

having a steam turbine as prime mover and means utilizing the latent heat of the exhaust steam of said turbine to generate an upthrust force on said oil tanker.
said means comprising the distribution of said exhaust steam via a header into multiple lengths of outgoing condenser tubing looped through the upper air containing portion of said supplementary water ballast compartments expanding said compressed air to eject said water ballast.
said steam returning to said turbine as condensate within the return condenser tubing traversing the lower water containing portion of said ballast compartments and

pump means generating on demand a supply of hot fresh water within a heat exchanger jacket sealingly enveloping said outgoing condenser tubing a multiplicity of nozzles outwardly projecting from said jacketed heat exchanger capable of spraying the resulting fine mist into said air containing portion of said ballast compartments maximizing the heat extraction process

alternatively pump and nozzle means spraying cold sea water into said heated compressed air in said ballast compartments to contract said air and readmit ballast water.
said condenser tubing having expansion joints.

7. A semi-submersible icebreaker vessel as described in claim 5

having means to truncate ice hummocks and ice pressure-ridges
	said means comprising forwardly directing thereat the efflux of jet turbine engines mounted on the prow of said superstructure
	said jet engines being horizontally and vertically pivotable and being remotely controlled collectively or independently.

8. An icebreaking vessel as described in claim 7

said jet turbine engines having a tail pipe pivotally independent of said engine on its longitudinal axis through substantially 90° of arc
	said tail pipe being progressively deformed in cross section from the circular to a fishtail configuration means remotely controlling the pivoting of said tail pipe.

9. Improvements in rudders in the oil tanker described in claim 5

said submerged hull having an upper stern portion overhanging a lower stern portion

a stub horizontally projecting rearwardly from said lower stern portion

a rudder having its post centrally disposed of its surface and pivotally journalled in said stub and said upper stern portion combining the functions separately performed of a rudder and water brake when appropriately angled

said improvement comprising said rudder being hollow, streamlined, and capable of being pivoted through 180°.

10. A semi-submersible vessel as described in claim 5

driven by means other than a propeller

having the stern portions of said submerged hull uniformly tapered with respect to their center line in plan form inducing laminar flow over their surfaces generating by lateral sea pressure a vector force forwardly acting on said vessel to increase its speed.

11. A semi-submersible icebreaking vessel as described in claim 5

having mobile crane means

said crane riding parallel sets of rails extending down either side of the top deck of said superstructure said rails being embedded in said deck.
12. A semi-submersible icebreaking oil tanker as described in claim 5 having a light aircraft landing runway atop the length of said superstructure said runway laterally overhanging the beam of said superstructure

rail stressed lattice rope safety means outwardly flanking said overhanging portion of said runway hangar means accommodating said light aircraft at the stern end of said runway.