Dec. 23, 1952 T. K. JAMISON 2,622,552

SHIP SALVAGE DEVICE

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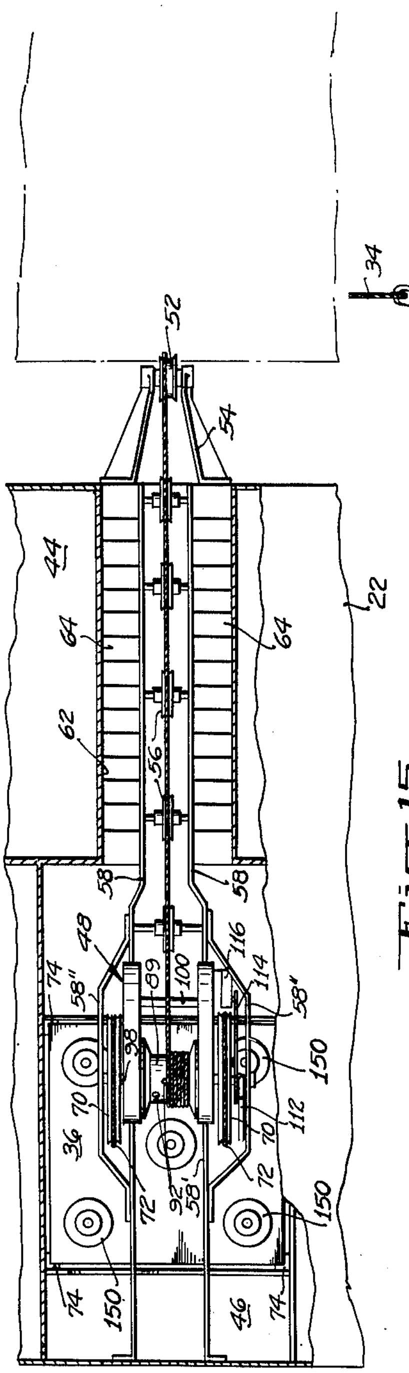

Fig 15

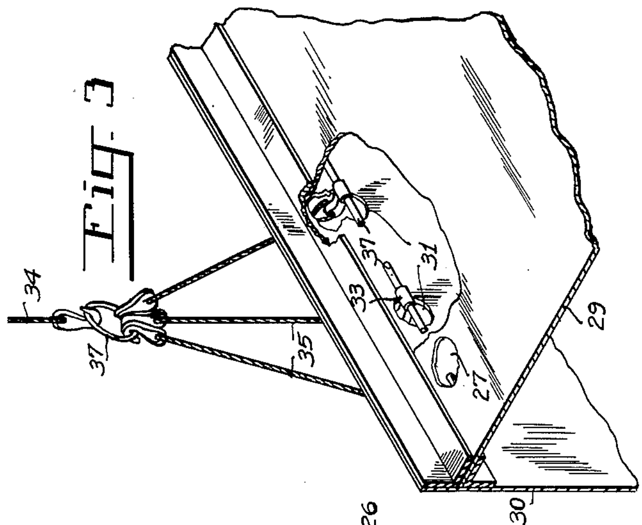

Fig 3

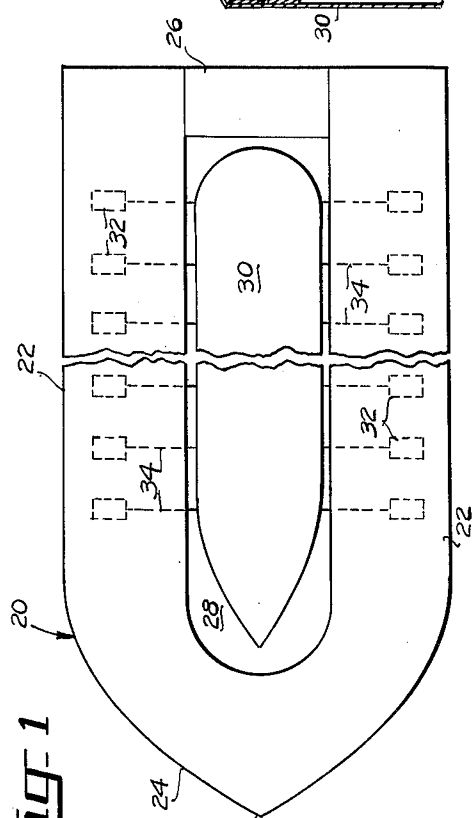

Fig 1

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SHIP SALVAGE DEVICE

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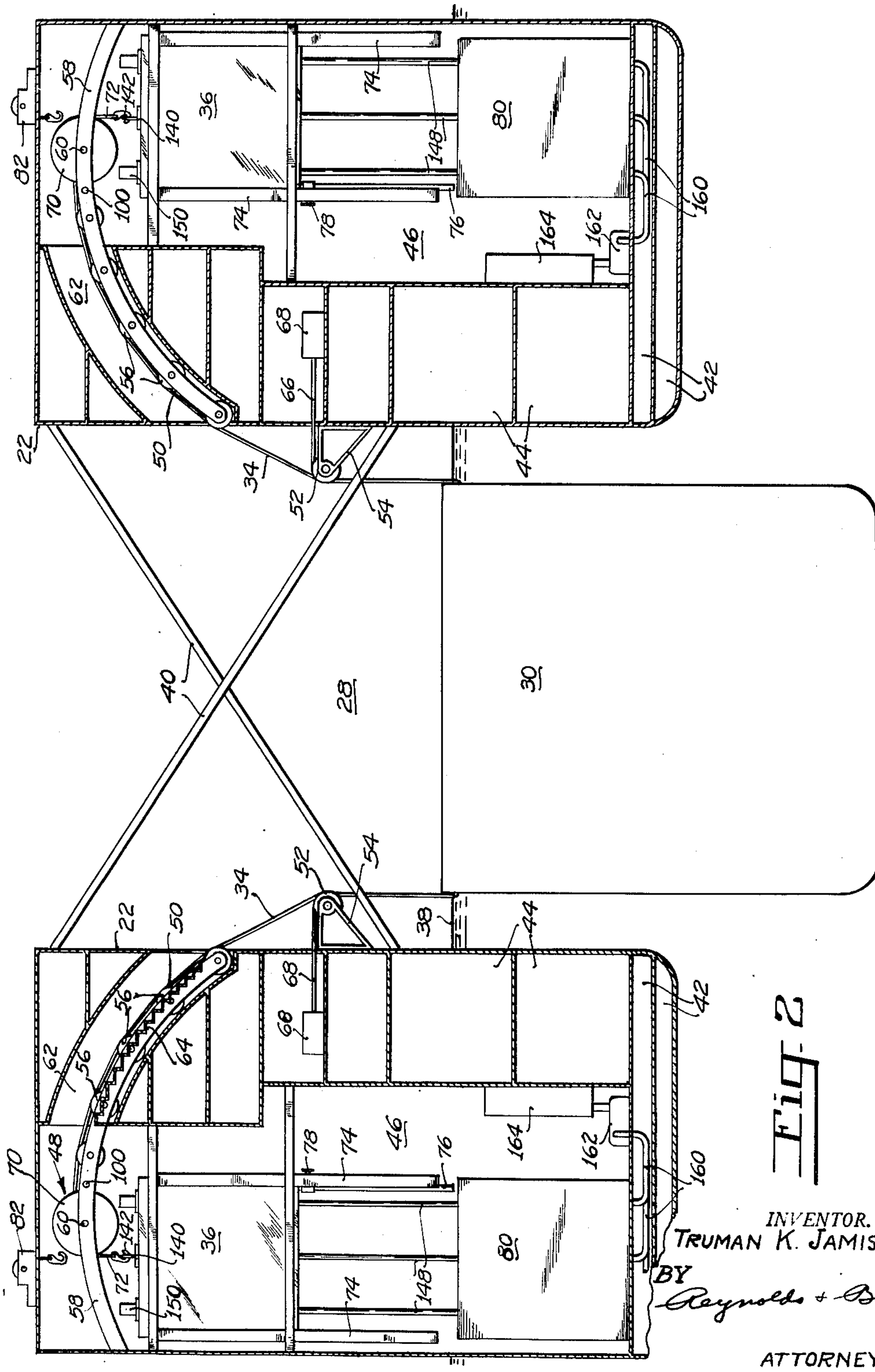

Fig. 2

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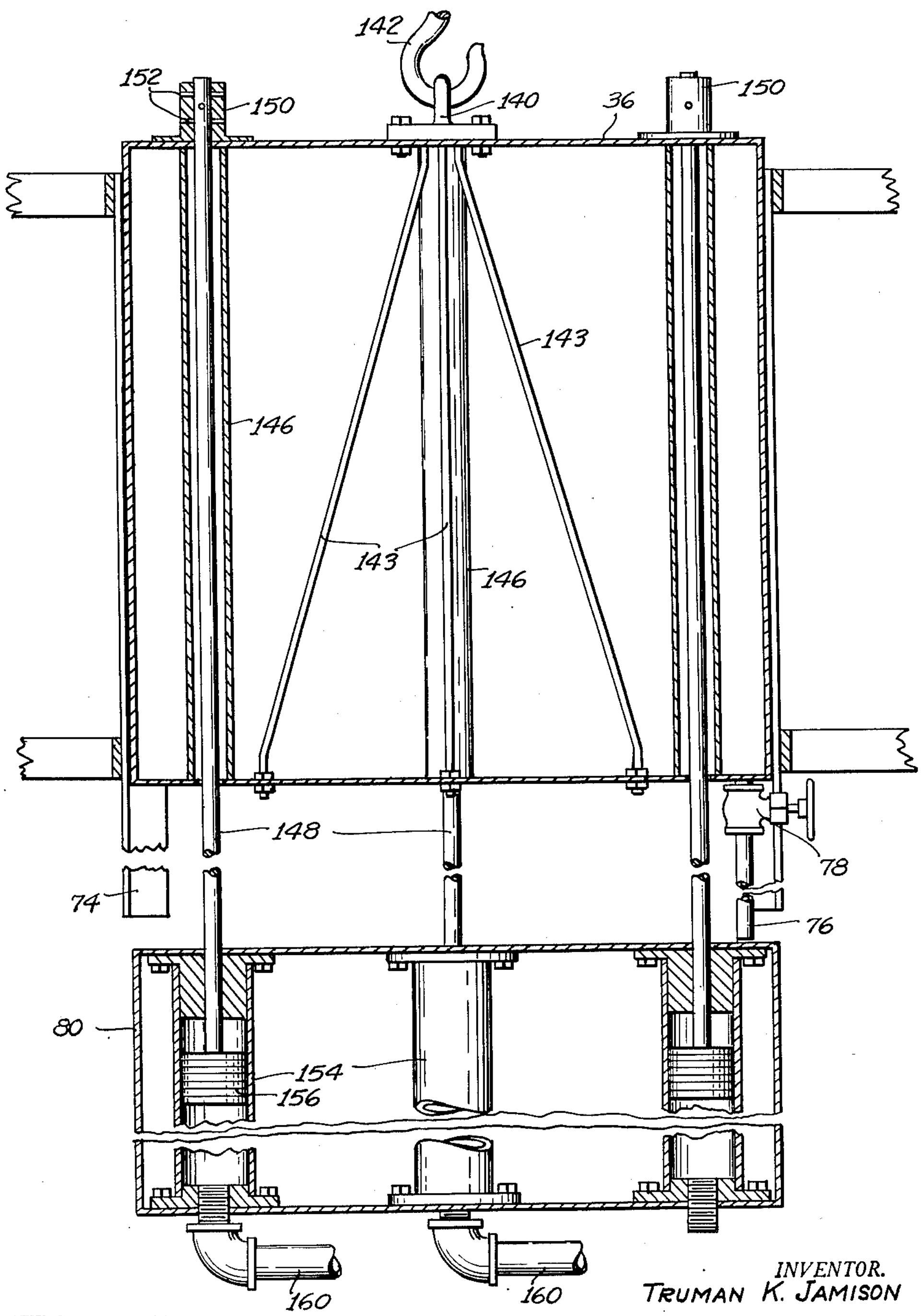

Fig. 4

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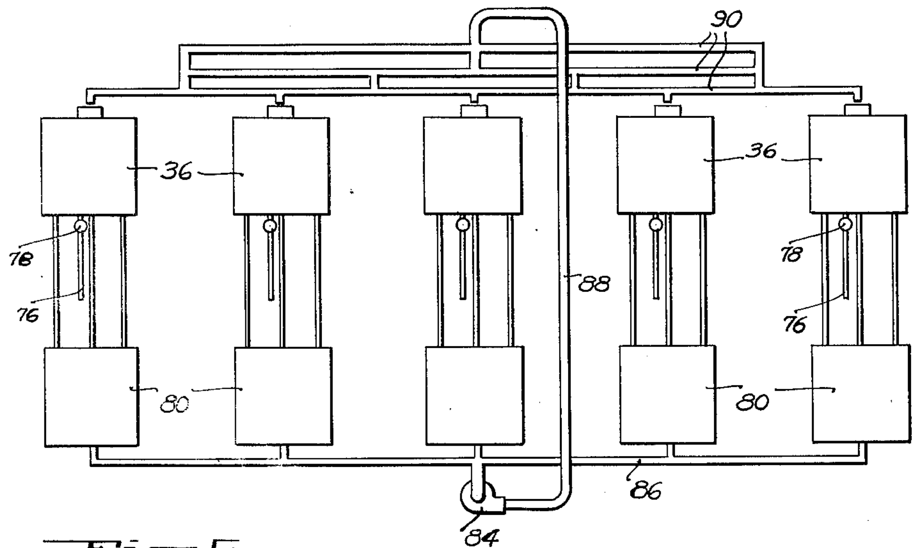
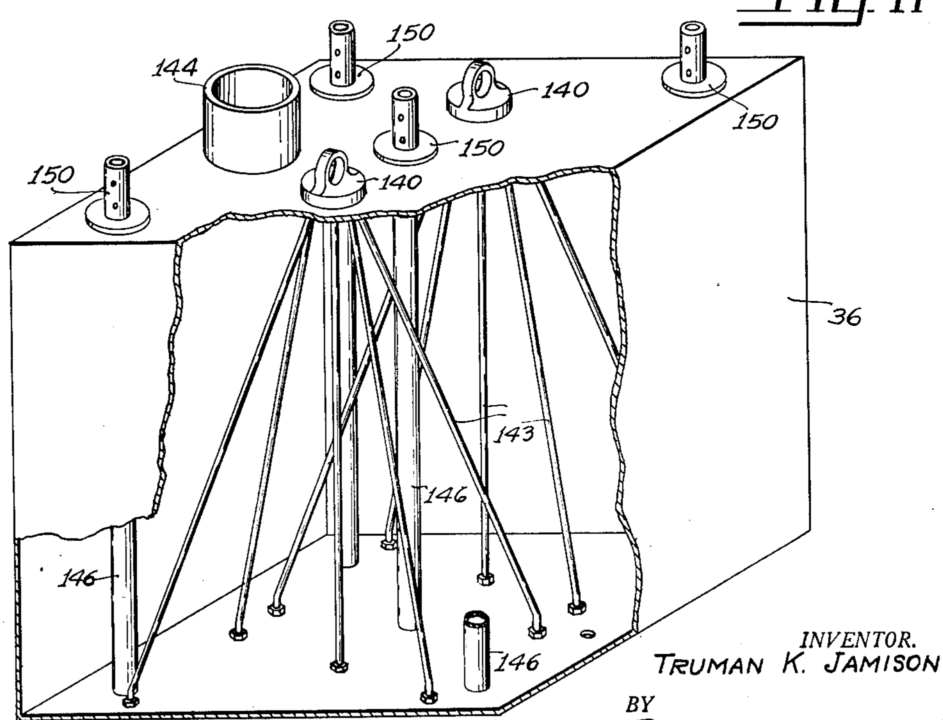


Fig. 5

Fig. 11



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SHIP SALVAGE DEVICE

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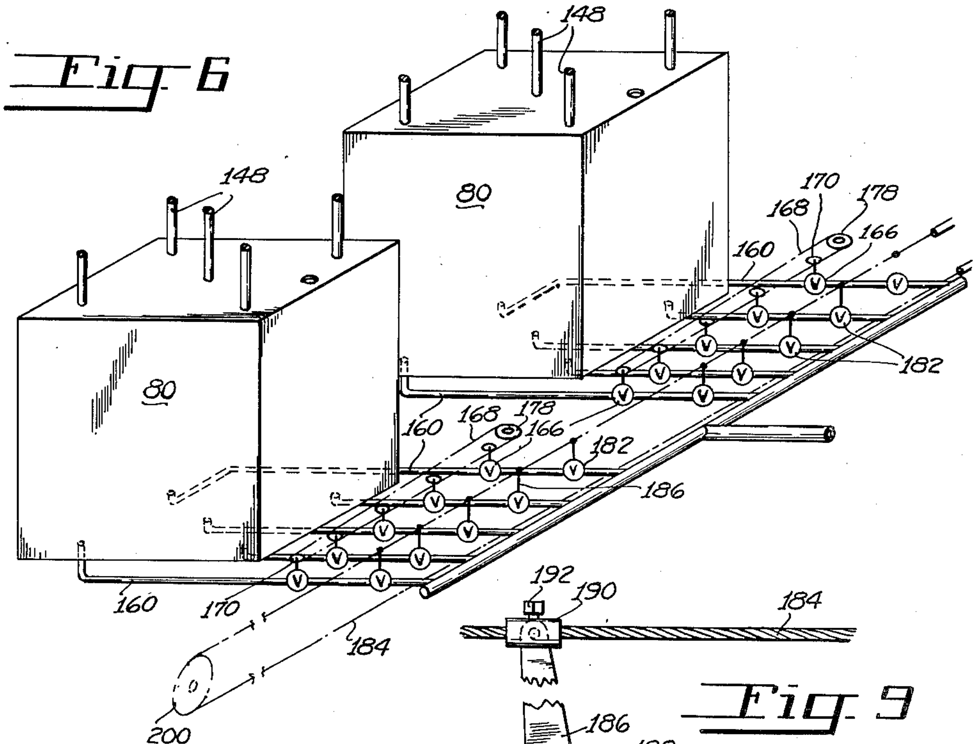
Fig. 6



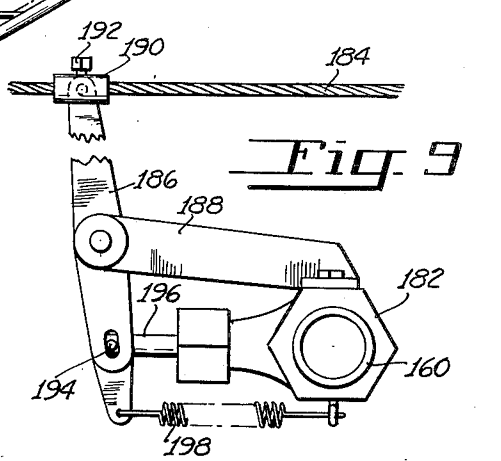


Fig. 9

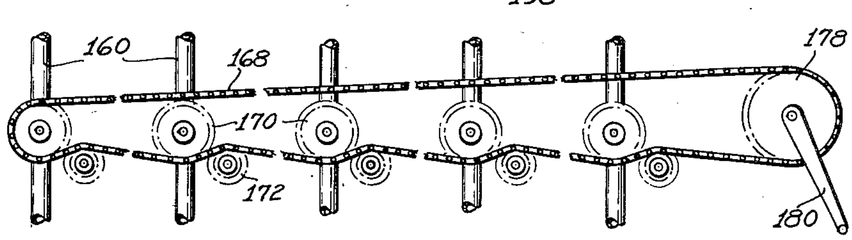


Fig. 7

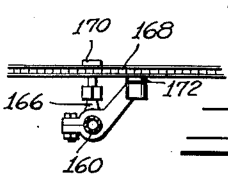


Fig. 8

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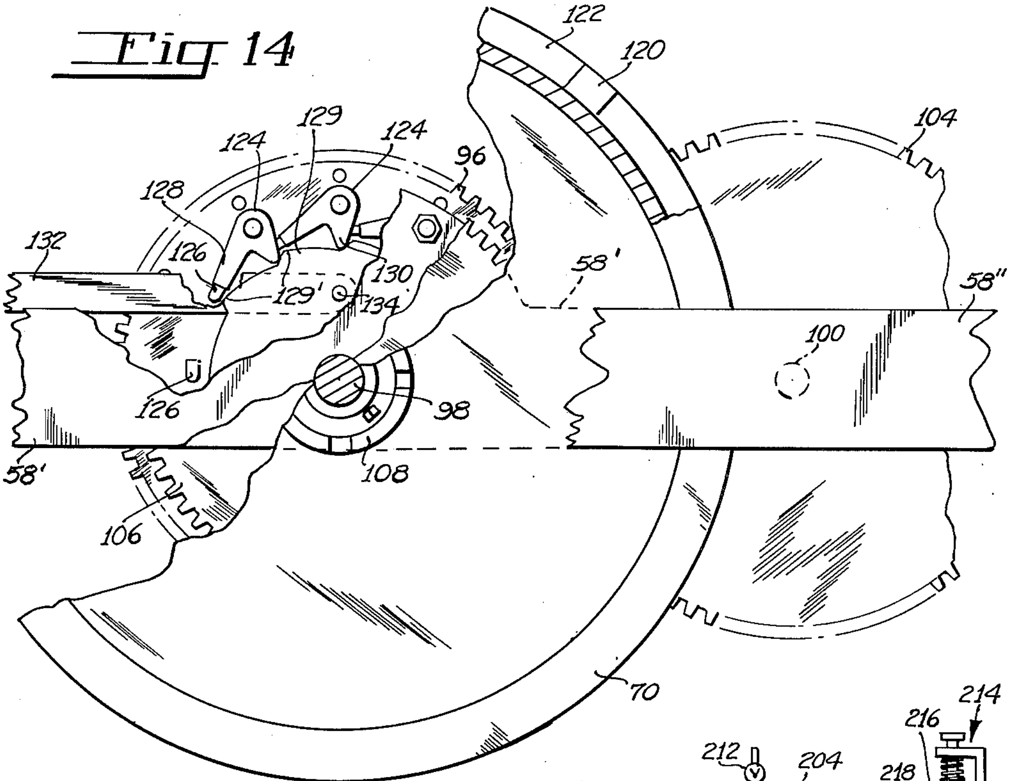
Fig. 14



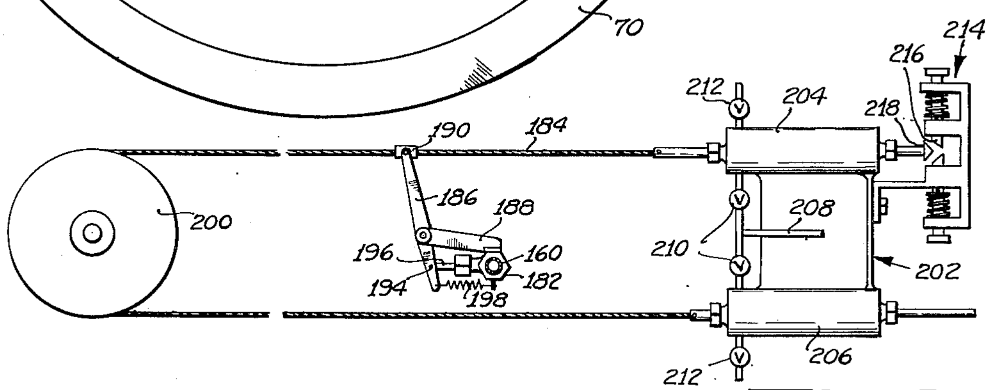


Fig. 10

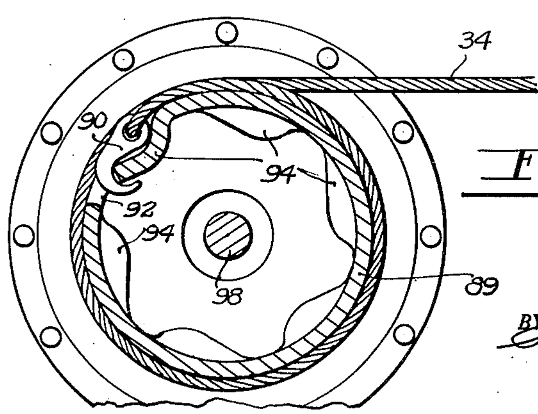


Fig. 13

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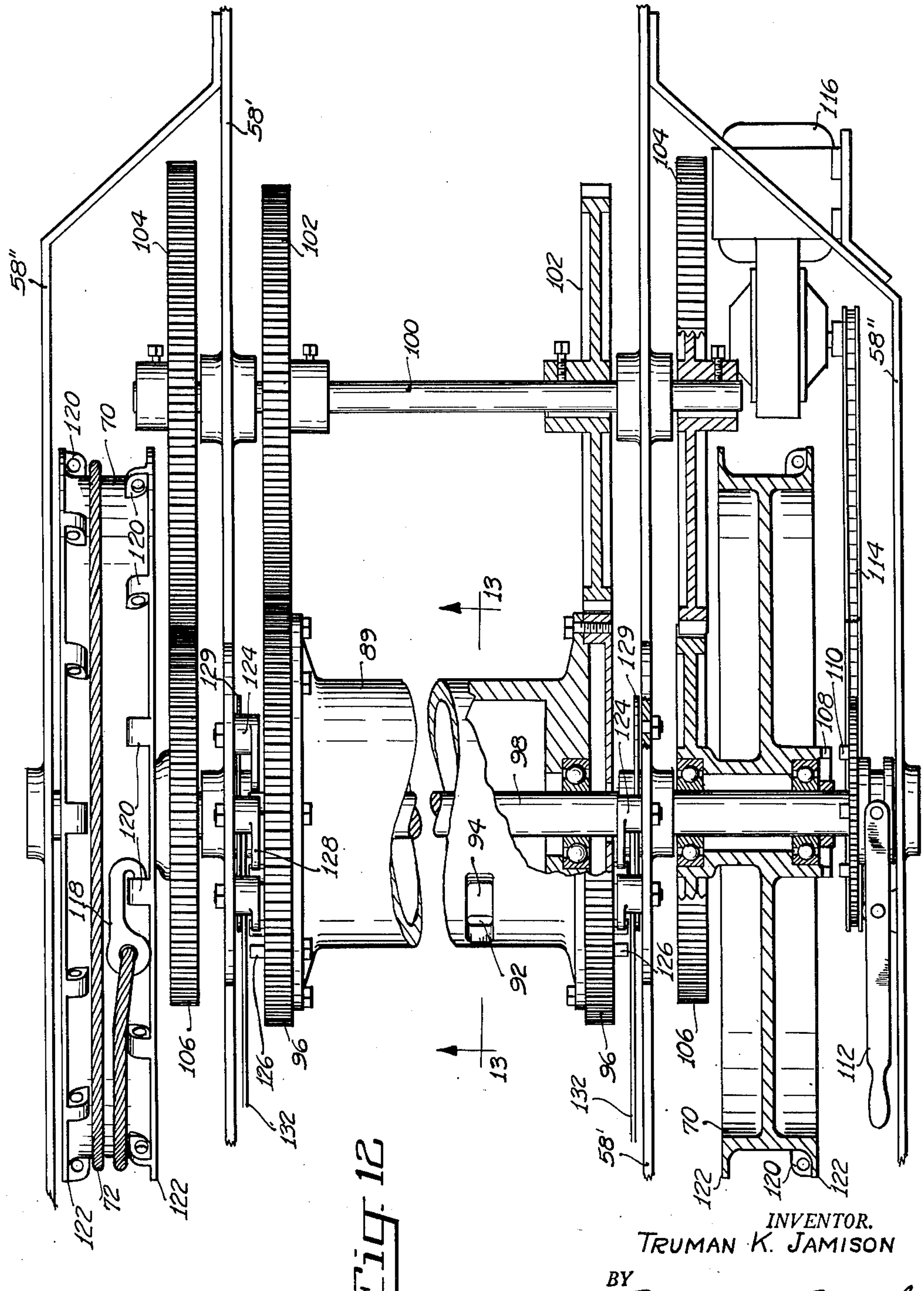

Fig. 12

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Patented Dec. 23, 1952 2,622,552

UNITED STATES PATENT OFFICE

2,622,552

SHIP SALVAGE DEVICE

Truman K. Jamison, Seattle, Wash.

Application June 21, 1948, Serial No. 34,272

9 Claims. (Cl. 114—51)

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This invention relates to ship salvage vessels, and particularly to the hoisting mechanism used in connection therewith to raise sunken ships for salvage or repair purposes.

The hoisting mechanism of my present invention is used preferably in connection with the general type of salvage vessel which may be termed a "pontoon dock," and is so described illustratively herein.

One of the primary purposes of my present invention is to provide hoisting means more readily and rapidly operated, and housed more nearly in its entirety within the confines of the pontoon dock. Accordingly, only the necessary lift cables, cable guides and the like, which project into the sheltered encirclement of the dock, extend laterally beyond the pontoon floats of my device. For certain types of salvaging operations the excellent mobility of the vessel when devoid of exterior lateral projections, and the convenience of all its operating equipment being located inboard, is decidedly advantageous. Also, all the actuating mechanism for driving the lift cables is contained in the pontoon structure.

Raising sunken ships under any conditions presents a complex engineering problem with many aspects. Ships are likely to be found lying at almost any attitude upon the ocean bottoms. Consequently, as a first step it is necessary to right them before or during raising operations and to maintain them level as they are raised into the harbor of the pontoon dock for salvage and repair operations. Multiple independently controllable cable hoisting units, connected to the sunken vessel at different locations along opposite sides of its hull line, are therefore a practical necessity in carrying out the initial phases of the raising operations. Moreover, after the sunken vessel has been righted by controlled operation of the individual hoisting units and is ready for lifting bodily to the surface, it is desirable to coordinate operation of the individual hoisting units, as an integrated system to continue holding the vessel on an even keel as it rises. If allowed to tilt longitudinally or to heel over appreciably cargoes may shift, and strains on the hoisting units will become unbalanced.

Perhaps the most difficult aspect of the problem is the provision of powerful hoisting equipment which requires only comparatively simple and low powered operating equipment, and which is sufficiently compact to be housed in the hull of the salvage vessel. A particular object of my present invention is to devise hoisting mechanism based generally upon the counterweight principle, in which the several member-hoisting units may be conditioned for hoisting action by expenditure of even smaller amounts of power than before, yet such concerted hoisting action produces the desired tremendous lifting force required to raise the vessel.

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Such an object is attained generally by means of counterweight fluid tanks providing the lifting power of the individual hoisting units. The tanks are raised into elevated position while lightened by relieving them of their water load; are refilled with water, or perhaps other fluids; when all tanks are elevated and filled, are released together for descending in unison to hoist the vessel a prescribed incremental distance. In descended position the tanks are again drained to lighten them for subsequent elevating. During the periods between intermittent hoisting operations, occupied by draining, elevating and refilling the tanks, the sunken vessel is held in its successive incrementally raised positions by lift holding mechanism cooperating with the hoist. Although all of the counterweight hoisting tanks operate in concert for hoisting, they may be elevated and refilled in smaller groups independently, one or more at a time, thereby further minimizing the power and power equipment utilized for these purposes.

A further and related object of my present invention is to devise hoisting mechanism of the counterweight type, the cooperating units of which have coordinated check points at equal lifting intervals of each hoisting unit, and in the operation of raising a vessel, all of the units will reach a particular check point before any of the units lifts to its next succeeding check point. By this means the raised vessel is brought to a level position at the end of each incremental hoisting interval and cannot get far out of level at any time even if other controls over lifting do not coordinate properly through some contingency or failure. The intermittently acting hoisting tanks achieve this object, as will be described.

Further objects of the invention are attained in control mechanism, primarily hydraulic, operable to initiate descent of the tanks together, to retard their downward movement to prevent excessive accelerations, and generally to coordinate the downward movement of such tanks.

Such coordinating means comprises a plurality of hydraulic cylinder and piston units which check the descent of individual hoisting tanks by controlled evacuation of hydraulic fluid from the cylinders.

Since it is this source of restraint on downward movement of the tanks which primarily determines rate of descent of the tanks, any circumstantial differences in loading of the individual hoisting units by the sunken vessel, tending to cause one tank to descend more rapidly than another, will be largely overcome. Further coordination results from evacuating the tanks against a common pressure head, as described.

Further features of the invention, in the coordinating and control mechanism, reside in the means for implementing the method of refilling the hydraulic cylinders in connection with elevating the hoisting tanks, in closing off the refilled cylinders of individual groups of tanks until the tanks of combined groups have all been filled and readied for hoisting operation, and thereupon transferring cylinder closing control to means operable to effect opening of the cylinders of the combined groups simultaneously.

These and other features, objects, and advantages of the invention will be further apparent from the following description based upon the accompanying drawing.

Figure 1 is a diagrammatic plan view of a preferred type of pontoon dock to incorporate the present hoisting mechanism.

Figure 2 is a simplified transverse sectional view of the dock, showing a sunken vessel raised by the hoisting mechanism into working position within its harbor.

Figure 3 is a fragmentary isometric view of the upper hull side and adjoining deck plate of the sunken vessel showing preferred means forming a connection to the lift cable of a hoisting unit.

Figure 4 is a sectional elevation view illustrating major elements of a hoisting unit, showing a hoisting tank, hydraulic cylinder and piston means coacting with the tank structure, and a drainage tank arranged beneath the hoisting tank to receive water emptied from the hoisting tank in its descended position.

Figure 5 is a diagrammatic elevation view of a group of hoisting tanks and cooperable drainage tanks, showing a pumping system for refilling the hoisting tanks.

Figure 6 is a diagrammatic isometric view of a representative section or fractional part of the composite system of control valves and piping for the hydraulic mechanism coordinating and controlling descent of the hoisting tanks, the view showing the separately controlled groups of primary or holding valves and the coordinately controlled groups of secondary or final release valves associated with two hoisting units.

Figure 7 is a plan view of typical control mechanism for the group of primary valves closing the hydraulic control cylinders of a single hoisting unit; and Figure 8 is an elevation view of one of these valves so controlled.

Figure 9 is an end elevation view of one of the final release valves for the respective hydraulic cylinders.

Figure 10 is a simplified side view of the preferred type of master actuating control for the conjointly operated final release valves, shown in simplified form connected operatively to one of such valves.

Figure 11 is an isometric view, with parts broken away, of one of the counterweight or hoisting tanks.

Figure 12 is a plan view of a hoisting or lift-holding mechanism for one of the lift cables, showing drum drive pulleys rotated by cable connections to a hoisting tank, and gear reduction means producing mechanical advantage.

Figure 13 is a transverse sectional view of the lift cable drum, taken at right angles to its rotational axis, showing a preferred method of hooking the lift cable to the drum to remove the initial slack in such cable.

Figure 14 is a side view of the lift-holding mechanism shown in Figure 12, particularly illustrating the ratchet mechanism operable to hold the cable drum in successive incrementally rotated positions following each incremental hoisting operation.

Figure 15 is a fragmentary plan view of one side or section of the illustrative parallel-section pontoon dock, supporting and housing one of the hoisting units, illustrating the preferred arrangement for guiding the lift cable and winding it upon the drum.

As diagrammed in Figure 1 the illustrated pontoon dock **20** has two spaced generally parallel sides or pontoon sections **22**, corresponding ends of which are permanently bridged across by a prow section **24**, and the opposite ends of which are interconnected by a removable stern section **26**, defining an enclosed haroor **28**. The sunken vessel **30** will then be raised by hoisting means mounted on the pontoon dock into the harbor **28** for salvage or repair operations. In order to accomplish the raising operation, each of the pontoon sections **22** incorporates a plurality of hoisting units **32** arranged at intervals along its length. Parallel dotted lines **34** in the figure, leading from the units **32** to the respective sides of the vessel **30**, represent the lift cables.

In accordance with this invention as herein described, the individual hoisting units, capable of coordinated vessel hoisting action, are housed within the pontoon sections, can be operated by power mechanism of comparatively small capacity and are rugged in construction and dependable and positive in operation. Moreover, by virtue of their intermittent incremental, or check-point, action these hoisting units keep the sunken vessel under control at all times and lessen danger of mishaps.

In the cross-section shown in Figure 2, a counterweight hoisting tank **36** appears in its relation to the surrounding structure in each of the opposite pontoon sections **22**, wherein such tanks are guided for elevation and descent in effecting the described hoisting action drawing in lift cables **34**. In this figure the sunken vessel **30** is shown in fully raised position, its deck slightly above the water's surface **38**, and ready to be worked upon within the shelter of the dock's harbor **28**.

In the illustrated construction of the pontoon dock, the two opposite pontoon sections **22** are braced and rigidly held apart laterally by the crossed diagonal braces **40**, anchored at their respective ends to the opposite sections, as shown, leaving ample working space beneath the braces **40** to work on the raised vessel. The pontoon sections are of the typical watertight compartmented construction. Bilge compartments **42** are formed at the bottom and successive tiers of watertight compartments **44** up the inboard sides of the dock's pontoon sections adjacent to the harbon **28**, as shown. The remaining general space **46** within the pontoon sections, between the inner vertical walls of the compartment tiers **44** and the outboard walls of the pontoon sections, is reserved generally for the hoisting tanks and associated apparatus to be described. For all practical purposes the two pontoon sections may be substantially identical in their general construction.

In Figure 3 I have illustrated a convenient and reliable method of connecting the lift cables **34** to the sunken vessel. This is accomplished by burning spaced holes **27** through the deck plate **29**, spaced fore and aft, near the side of the vessel **30**, and corresponding holes **31** in the sides of the vessel. Through the holes **31** will be inserted the apertured couplers **33** attached to the ends of short connector cables **35**, and through each of the coupler apertures is passed a crossbar **37** which bears against the inside of the vessel's hull to prevent withdrawal of the couplers **33** by tension on the connector cables **35**. All of the cables **35** are then connected to a ring **37** carried at the lower end of a lift cable **34**. Such a connection distributes the lifting force exerted on the vessel **30** more safely and reliably, over a wider area than if a single point of connection were used.

Lift cables **34** of each hoisting unit carrying the raised vessel **30** enwrap the drum of the respective hoisting or lift-holding mechanisms **48** mounted near the top of the general pontoon compartments **46**. These cables extend from the lift-holding mechanism **48** to the ship **30** through the inwardly and downwardly curved cable races **50** opening into the harbor **28**, to the stand-off guide sheaves **52**. The sheaves **52** are carried by brackets **54** projected a distance into the harbor space **28** to support the raised vessel **30** with its hull sides spaced a working distance away from the inboard sides of the pontoon sections. In this same connection the sheaves **52** should not be excessively high above the water line of the dock or the point of connection of the lift cables **34** to the vessel **30**, because an excessive unguided length of lift cable may give rise to a tendency for the vessel **30** to swing too far laterally for safety or convenience when the dock rolls in heavy swells.

As illustrated, the curved cable races comprise a series of guide sheaves **56** journaled at interval locations between curved support members **58** extending between the outside and inside walls of a pontoon section. The hoisting or lift-holding mechanism **48** is likewise carried by the support members **58**, at a location **60** appropriate to the position of the respective hoisting tanks **36** in the hold space **46**. As seen best in Figures 2 and 15, each cable race is located in a passageway **62**, with a flight of steps **64** at either or both sides of the race to allow access for installation, inspection and repairs of the mechanism, and for convenient access to the harbor through the pontoon sections.

In cases where it is desired to relieve the lift cables **34** of their load after having raised the vessel to an appropriate position within the harbor **28**, the load may be transferred to auxiliary hold cables **66** operating out of appropriate auxiliary winch mechanism **68** (Figure 2) within the pontoon sections. The hold cables **66** may be guided over grooves in the guide sheaves **52** parallel to the lift cables **34**, or by other sets of similar guide sheaves at locations intermediate to the sheaves **52**.

The lift-holding mechanisms **48** operate as mechanical advantage elements in the hoisting system, in a manner to be described subsequently. These mechanisms are preferably of the ratchet type, operable to haul in the lift cables **34** by rotation of the drum drive sheaves **70** and to hold the drums against paying out the lift cables unless deliberately released for that purpose, at times between raising ships. The drive sheaves **70** are enwrapped by drive cables **72** suspending the respective counterweight hoisting tanks **36**. Descent of the tanks **36** guided between the sets of vertical guides **74**, from their raised position shown in Figure 2 to a predetermined lower descended position, causes a corresponding hauling in of lift cables **34** to raise the sunken vessel by an incremental amount, as determined by the dropping distance of the hoisting tanks and the drive ratio of the lift-holding mechanism. At the end of the down stroke of the hoisting tanks **36** the ratchet mechanisms in the lift-holding mechanisms **48** cooperate to hold the incrementally raised vessel **30** until such time as the hoisting tanks can again be raised to elevated position for a succeeding incremental hoisting operation.

Before raising a hoisting tank into elevated position it is preferably first lightened by draining its water load from it, as by means of a pipe **76** and control valve **78**, into a lower receiving compartment or tank **80**. Elevating of the individual tanks is effected conveniently by winches **82** mounted above the hoisting or lift-holding mechanisms **48**, as indicated (Figure 2). Alternatively, the drive sheaves **70** themselves could be rotated reversely, if decoupled from the lift cable drums **89**, to elevate the respective tanks **36**.

Within the range of working loads on a salvage dock constructed according to the invention, moderate variations in height of the dock water line for different weights raised should not alter the functioning of the hoisting mechanism nor the convenience or economy of operating the auxiliary equipment. Reference is made, in particular, to the possibility in some instances that the water line may actually come above the level of the bottoms of the hoisting tanks **36** in descended position, and since the tanks are drained more conveniently by gravity flow than by pumping, this difference in levels might be objectionable were it not for the use of separate drainage tanks **80** within the pontoon structure proper. Drainage of the hoisting tanks **36** into the storage tanks **80** instead of into the sea removes all dependency of the gravity-flow draining operation upon water level outside the pontoon hull, as desired. Then, too, by draining into the tanks **80**, and reusing from these tanks, the total weight of the salvage vessel is kept more or less constant during hoisting operations so that its draft is correspondingly constant.

It will be understood that the valves **78** draining the tanks **36** may be operated either manually or by automatic control means, either separately or conjointly, since no special problem of coordination of this particular operation between the various tanks is necessary. Similarly, the elevating winches **82** may be operated individually or in groups.

Figure 5 illustrates diagrammatically in side elevation a system for draining and refilling a group of five hoisting units, this number being selected arbitrarily for illustration. The diagram shows the drain pipes **76** carried by the counterweight tanks **36**, the drainage tanks **80** beneath the latter, and a pump **84** for returning water from the drainage tanks **80**, through the collecting pipe **86**, the return pipe **88**, and the distribution pipes **90** finally back into the individual hoisting tanks **36** of the group. Other small groups of hoisting tanks in the pontoon dock may be connected in a similar water circulation system, each of which requires comparatively low power pumps. Any suitable type of controls for the draining and refilling operations may be employed.

The preferred type of hoisting or lift-holding mechanism and related mechanism is illustrated in detail in Figures 12, 13 and 14. A plan view of the lift-holding mechanism 48 to a smaller scale appears in Figure 15, wherein the general plan of a single hoisting unit is illustrated. As shown in Figure 13, the lift cable 34 carries a hook 90 at its free end by which the cable, wrapped around the drum 89, is secured to the drum by engaging the hook in one of several drum apertures 92. As seen in Figure 15, the apertures 92 are formed in the drum at circumferential intervals staggered-offset from one another to provide a selection of spaced connecting points, one of which will correspond very closely to the desired position of hook 90 as the lift cable is initially secured to the drum. This multiple aperture arrangement will usually be more convenient for securing the cable to the drum at a selected point around its periphery than by attempting to hoist with a drum having but a single aperture, to align such aperture with the hook 90. The drum 89 is indented or recessed next to each aperture at 94 to receive in depressed position the cable-connecting eye of the hook 90 so that the cable will wind on the drum more uniformly.

The end flanges of the drum 89 are bolted to the sides of concentric gears 96 constituting power transmission elements in a double-ended drive for the drum. The drum and gear assembly rotate freely upon a main shaft 98, journaled at points intermediate their ends in side supporting plates 58′, constituting inner branches of the curved supports 58 which carry the mechanism 48 and the cable race sheaves 56, as shown in Figures 2 and 15. The ends of the mounting shaft 98 are journaled in the outer branches 58″ of the same supporting members 58, leaving intervening spaces for the drive sheaves 70 and other mechanism to be described.

A countershaft 100 journaled in the plates 58′ parallel to the main shaft 98, drives the idler gears 102 which it carries, meshing with the drum gears 96, as shown. On the outer sides of the plates 58′ the projecting countershaft ends carry the respective idler gears 104, likewise connected to the countershaft 100. Registering with the gears 104, a further set of gears 106 is carried by the main shaft 98, driven by the two coacting drive sheaves 70. Through this pair of corresponding gear trains rotation of the drive sheaves 70 caused by unwrapping drive action of drive cables 72 is converted into driven rotation of the drum 89 and hauling in of the lift cable 34. The mechanical advantage derived from use of the hoisting or lift-holding mechanism 48 depends upon the respective diameters of the drive sheaves, the gears and the drum.

It will frequently be necessary to wind up rapidly the lift cables on the drum without load. For this purpose, one end of the main shaft 98 carries a clutch plate 108 engageable by a cooperable clutch plate 110 driven by an auxiliary power transmission system. The clutch plate 110, mounted for free rotation on the shaft 98 and for endwise movement thereon effected by swinging of the clutch actuating lever 112, is driven through an appropriate chain and sprocket drive 114 from a geared electric motor 116 mounted on the adjacent support 58″, as shown. Hence, slack in the lift cables 34 may be taken up rapidly by clutch-engaging movement of the clutch lever 112.

The coacting drive cables 72, suspending a tank 36, wrap around the respective winch drive sheaves 70 through the required angle to permit full descent of the tank without complete paying out of these cables. Each cable 72 has a connecting hook 118 engageable with an apertured lug 120 of a plurality projecting inwardly from the opposite sheave rims 122 at short intervals around the peripheries of the sheaves. The series of lugs 120 at the opposite rims of a sheave are offset to provide an even closer circumferential spacing of the cable-connecting points. By such means, taking up the slack in the drive cable 72, which is hauled in by a winch and line or by way of various well known devices, and connecting it to its drive sheave each time a tank 36 is elevated from lowered position may be done simply, without special mechanism to disconnect the drive sheaves and drum of lift-holding mechanisms 48. While there may be slight discrepancies in the degree of tautness of the drive cables of different hoisting units at the time when all units are poised for an incremental hoisting operation, these can never be appreciable because of the close spacing of the lugs 120 around the periphery of the drive sheaves. Obviously, other arrangements could be made to tauten the drive cables under these conditions, either manually or by mechanical means.

Suitable ratchet mechanism operable to hold the drum 89 against rotation under load in one direction and to permit its free rotation in the opposite direction is illustrated particularly in Figure 14, complemented by the showing in Figure 12. Any mechanism employed for this purpose must be of the releasable type, which can be readily actuated to free the drum for paying out the lift cable as necessary. As shown best in Figure 14, the mechanism includes the arcuately arranged series of pawls 124 pivotally carried by the supporting plates 58′ at the opposite ends of the drum 89 generally above the shaft 98. These ratchet pawls engage a circularly arranged series of ratchet lugs 126 projecting endwise of the drum's end gears 96. The tendency of the pawls 124 is to rock resiliently or by force of gravity into ratchet lug-engaging position of their arms 128, thereby preventing rotation of the drum in cable-releasing direction. The pivoted pawls are swung freely upward by the lugs when the drum is rotated in reverse direction, three on each side being provided.

Pawl release cams 129, free to rock on shaft 98, have spaced lobes 129′ which engage the angled arms 130 of the respective sets of pawls 124. These arms are offset from the lug-engaging arms 128 axially of the pawl to clear the lugs when rotated. Rocking the release cams 129 in one direction forces the pawls out of holding engagement with the ratchet lugs 126 to permit free rotation of the drum lift-holding mechanism 89 as desired. The cams are thus rocked by pulling on the draw links 132 connected respectively by pins 134 to the cams, as shown in Figure 14. Returning the cam to initial position locates the cam lobes offset from the pawl arms 130 in lowered position to permit reestablishing holding engagement of the ratchet lugs. Normally the release cams are not to be used, the lift-holding mechanism 48 locking automatically after succesive hoisting intervals in progressive rotated positions of the drum, until the job of raising the sunken vessel is completed.

Turning now in the discussion from the hoisting or lift-holding mechanism 48 to the counterweight hoisting tank apparatus driving the winches, reference is made to Figures 4 and 11 in particular, which illustrate a preferred type of tank construction. The tanks are cubical in form and may be bolted, riveted or welded in construction. A pair of spaced lifting eyes 140 mounted at the top wall of the tank, shown best in Figure 11, provide anchor holds for the hooks 142 of the cooperable pair of drive cables 72, or corresponding cable hooks for the auxiliary, tank-elevating winches 82, as shown in Figure 2. The flanges of lifting eyes 140 are welded or otherwise secured to the upper ends of tie rods 143 bolted at their lower ends to the bottom of the tank, both to support the tank bottom and to hold the lifting eyes fast to the tank top. The tie rods diverge downward from the lifting eyes 140 to distribute the reinforcing support over the tank bottom in the desired manner.

A manhole opening 144 permits access to the tank for initial construction and repair work within it, and affords a convenient opening through which to refill the tank with water at the times described. As shown in Figure 4, the four corners of the tank slidably engage in the right-angle corners of the angle iron guides 74 to guide the tanks for vertical reciprocation. Suitable lubricant or bearing antifriction means may be employed between these guides and the tank outer walls to lessen friction.

In addition to the tie rods 143, further reinforcing of the tank bottoms and tops is derived from the end-opening vertical tube 146 interconnecting them, as shown in Figures 4 and 11. Five of these tubes are shown in the illustrated case, four near the respective corners of the tank and one at the center. Through these tubes are passed the piston rods 148 of hydraulic cylinder and piston units which cooperate to retard the descent of the tanks in the manner described.

As shown in Figure 4, each of the piston rods 148 projects upwardly through a tube 146 for connection at the top of the tank to the flanges 150, locking pins 152 being passed through flanges and rods to prevent displacement of the tank axially of the piston rods 148. These rods project vertically downward out of the encircling tubes 146 and through the bottom of the tank 36 into hydraulic cylinders 154 for connection to the coacting hydraulic pistons 156. The five cylinders 154 have flanges at top and bottom which are bolted to the top and bottom plates of the drainage tank 80 of a hoisting unit. This reinforces the drainage tank and at the same time maintains the hydraulic cylinders in vertical, piston-guiding position. The hydraulic cylinders are filled and evacuated from their lower ends through pipes 160. As shown in Figure 2, the pipes 160 lead to a hydraulic pumping unit 162 and associated fluid supply reservoir 164.

By filling the hydraulic cylinders of one hoisting unit at a time, instead of filling the cylinders of all such units simultaneously, a single low-power pump unit 162 may be used instead of one large pump or a number of smaller ones, thereby effecting further power savings. To minimize the possibility of airlocks in the hydraulic cylinders during the process of elevating the hoisting tank of that unit by a winch 82, the pump will normally be turned on to keep the expanding cylinder spaces constantly filled with fluid. In addition to serving as retarding devices, the cylinder and piston units could operate as hydraulic jacks to elevate the hoisting tanks as desired. In that event, the hydraulic fluid pump 162 selected would be of sufficient capacity to provide the requisite force hydraulically through the piston and cylinder units to elevate the hoisting tanks without the aid of auxiliary winches 82.

According to the preferred system of controlling the harnessed descents of the tanks, I provide two sets of control valves, one of each type, in the individual fluid cylinder supply pipes 160. These valves are used to close off such cylinders at selected times and to regulate evacuation of the cylinders at other times. As shown in Figure 6, the primary or holding valves 166 in the respective cylinder supply and evacuation pipes 160 of a hoisting unit are interconnected by valve actuating mechanism in the form of a chain 168 and valve-operating sprockets 170 (Figure 7). These valves, 166, may be of the globe type, in which the valve stem is rotated to open and close the valve ports.

As shown in Figure 6, the valve actuating chain is deflected serpentine fashion by the idler sprockets 172 which maintain engagement of the chain with the valve actuating sprockets 170. The chain is rotated or moved by a drive sprocket 178 turned by a control handle 180, which may be either mechanically or manually operated. After the hoisting tank of a particular unit has been elevated and the hydraulic cylinders refilled with hydraulic fluid, the handle 180 will be turned until the globe valves 166 are closed, thereby preventing hydraulic fluid from draining from the cylinders.

As previously explained, time may be saved by conditioning the hoisting units in time-overlapping sequence, thereby making most efficient use of the hydraulic pump and other power equipment used in filling the tanks 36 and the hydraulic cylinders. In some cases it may be preferred to handle the elevating of two or more hoisting tanks together, and simultaneously refilling their hydraulic cylinders, in which event it will be evident that the valve control mechanism, including the chain 168 and drive sprocket 178, may be extended to control the associated primary valves 166 of such tanks.

After all of the hoisting units of one pontoon section have been prepared for hoisting operations, their respective hydraulic control valves 166 may be opened to transfer the control to the secondary or quick-release valve 182 likewise located in pipes 160. At this time the entire weight of the hoisting tanks, freed of the auxiliary winch connections, is preferably carried by the hydraulic cylinder and piston units, and thereby the quick-release valves 182. All of these valves of a pontoon section are interconnected for conjoint operation by single control means, such as a control cable 184 extending along the series of valves 182 in the different pipes 160 for connection to the valve-actuating levers 186. As illustrated the valve levers are pivoted between their ends on fixed supporting arms 188 (Figure 9). A cable-connector sleeve 190 has a set screw 192 which provides the necessary adjustable drive connection between the cable and the lever 186 to cause a valve to operate with the others. The end portion of the lever or the side of its pivot away from the cable is slotted to receive a pin 194 projecting laterally from the valve stem 196, the valve being actuated rapidly by endwise reciprocation of the valve stem in well-known manner. A holding spring 198 holds the valve 182 normally closed.

The control cable 184 is guided for travel on a guide sheave 200. In the illustrated case of Figure 6, the valve levers are connected to the upper stretch of the cable, which extends between the guide sheave 200 and cable actuating mechanism 202 (Figure 10). The end of the upper stretch of cable is connected to a steam-operated cylinder and piston unit 204, operable to draw the upper stretch of cable 184 to open the valves 182. A similar steam-operated unit 206 operable to draw the lower stretch of cable 184 applies a valve closing force to levers 186 to aid the springs 198 in maintaining closure of the quick-acting valves 182 against the tremendous hydraulic force acting upon them with the hoisting tanks poised for descent. A steam supply pipe 208, input valves 210 and exhaust valves 212 control selective operation of the units 204 and 206 respectively. Each pontoon section has a similar valve control arrangement.

Actuation of the corresponding units 204 opens the valves 182 of all of the hydraulic units in one pontoon section conjointly, initiating descent of the hoisting tanks simultaneously. Coordination of the hoisting units in the two pontoon sections may be obtained readily either manually, with the use of clocks for timing operations in the opposite pontoon sections, or by simple electric controls or other synchronizing means operating the corresponding actuating units 204. In this way, both sides of the sunken vessel 30 may be raised together during each hoisting increment.

A catch mechanism 214, shown in Figure 10, with inwardly directed spring-actuated latch fingers 216 engaged by the enlarged head 218 of the cable-connected piston rod of unit 204, holds such rod, and thereby holds open the quick-acting valves 182, until the fingers 216 are withdrawn manually or otherwise from holding engagement with the rod's end. At the same time that the units 204 are actuated to open the valves 182, steam pressure operating the units 206 will be turned off to release the valves for such operation. The normal position of the valves 182 is open, since these are used primarily in carrying the load of the hoisting tanks hydraulically during the last interval before final release of the tanks in each hoisting operation.

As the hoisting tanks descend, hydraulic fluid is forced back into the respective reservoirs 164 common to the different groups of tanks, thereby providing a common pressure head against which the hydraulic pistons work in unison in expelling fluid from the hydraulic cylinders through the then open valves 166 and 182. The opening of the valves 166 may be adjusted to regulate the rate of discharge of hydraulic fluid from the individual hoisting unit cylinders through the pipes 160, and thereby the rate of descent of any or all of the hoisting tanks. This adjustment may be made in accordance with the weight of the particular sunken vessel being raised at any time, or, if desired, to effectively equalize tank descent rates if unbalanced as a result of excessive unbalance in loads.

After all of the tanks in the pontoon sections have descended fully, all hydraulic control valves will again be reopened to condition the hoisting units for a succeeding lifting cycle of operation.

The sequence of operations involved in carrying out a complete lifting cycle of the mechanism is as follows. Initially the hoisting tanks 36, filled with water, are held poised in elevated position (Figure 2) by the hydraulic piston rods 148 (Figure 4), valves 166 and 182 being closed to prevent evacuation of cylinders 156. The individual hoisting cables 34 wound on the ratchet-locked drums of the respective lift-holding mechanisms 48 (Figure 12) are under tension created by the weight of the sunken vessel 30 assumed to be partly raised from the ocean bottom. The primary valves 166 (Figure 6) are now opened, followed at the desired instant by opening of all of the quick-release valves 182, which is effected by the control mechanism (Figures 8 and 9) including the control cable 184. This permits evacuation of hydraulic cylinders 154 through pipes 160 under pressure created by pistons 156, and allows the hoisting tanks 36 to descend in their guides. The drive cables 72 are thereby drawn from the drive sheaves 70 to rotate the lift-holding mechanism drums 89 and wind in a predetermined incremental length of hoist cables 34, which raises the sunken vessel 30 by a corresponding increment. When the hoisting tanks 36 reach the bottom of their descent they are emptied of water through pipes 76 and, thus lightened, are re-elevated by winches 82 (Figure 2) either independently or as aided by pumps 162 simultaneously operated to fill hydraulic cylinders 154. In the meantime the vessel 30 is held in its incrementally raised position by drum ratchets 124 (Figure 14). When the hoisting tanks are re-elevated, the valves 166 and 182 are again closed and the tanks refilled with water by pumps 84 preparatory to a succeeding incremental hoisting operation, which is repeated as many times as necessary to raise the vessel 30 the full distance to the water's surface.

I claim as my invention:

1. Lift-holding means for drawing in by increments a lift cable, and raising a load carried thereby, said means comprising a lift cable drum, a drive sheave, reduction gearing interconnecting said lift cable drum and said drive sheave to effect driving rotation of said drum by rotation of said sheave, at a mechanical advantage, a drive cable, said drive sheave having a peripheral groove therein to receive said drive cable wrapped therearound, and further having at least one cable-end securement means at a selected point on its periphery, and ratchet means normally operable to stop rotation of said lift cable drum in an unwinding direction, but releasable at will to pay out lift cable from such drum, weight means comprising a liquid container, which can be drained and refilled, for securement to the free end of said drive cable wrapped around said drive sheave, whereby unwinding of such drive cable by descent of said weight means rotates said sheave and thereby effects incremental enwrapment of the lift cable upon said drum to raise said load thereby, and hoisting means operable to elevate said weight means independent of rotation of said lift cable drum for a succeeding incremental lifting operation by repeated unwinding of the drive cable from said drive sheave.

2. A ship salvage device comprising a pontoon dock, and hoisting means operable to raise sunken vessels to said dock, said hoisting means comprising a plurality of lift cables for securement to a sunken vessel, individual lift cable haul-in mechanisms cooperating individually with the respective lift cables and located at spaced intervals along a side of said dock, said mechanisms having releasable holding devices normally operable to hold the lift cables against

paying out but permitting operation of said mechanisms to haul in such cables, and means for driving said haul-in mechanisms to raise the sunken vessel connected to the lift cables, said drive means comprising a plurality of counterweight liquid tanks each associated with a different haul-in mechanism, means guiding said tanks individually for direct elevation and descent movement between lowered and elevated positions in said pontoon dock, said tanks being adapted for filling with liquid to increase their weight when in elevated position, and for draining when in lowered position, and means forming a drive connection between individual hoisting tanks and the respective haul-in mechanisms for driving operation of the latter during descent of said liquid tanks, thereby to raise the sunken vessel by an increment, means operable to hold said tanks in elevated position, means actuating said means holding the liquid tanks in elevated position, to release the same and permit simultaneous descent of said tanks by gravity to effect said incremental hoisting operation, and means operable to elevate said tanks for a succeeding incremental hoisting operation.

3. The ship salvage device defined in claim 2, wherein the pontoon dock has laterally spaced pontoon side sections defining a harbor therebetween for receiving raised sunken vessels, a bow pontoon section interconnecting the forward ends of said side pontoon sections and closing the forward end of said harbor, and a removable stern pontoon section interconnecting the aft ends of said side pontoon sections and closing the aft end of said harbor, the cooperating respective lift cables, haul-in mechanisms and associated drive means being arranged at intervals along opposite sides of the pontoon dock for paying out lift cable into and downward through said harbor along opposite inner sides thereof.

4. The ship salvage device defined in claim 3, and liquid storage means within the pontoon dock for supplying weight liquid to the counterweight liquid tanks and for receiving such liquid drained from said tanks, thereby to maintain substantially constant floating level of said dock during filling and draining of the counterweight liquid tanks preparatory to descent and elevational movements, respectively, thereof, and means operable to fill and drain said counterweight tanks from and into said storage means, in elevated and descended position of the tanks, respectively.

5. A ship salvage device comprising a pontoon dock having opposite side sections spaced apart to define a harbor therebetween, a counterweight liquid tank in each side section, means in each side section guiding the corresponding liquid tank for elevation and descent therein, lift cables for connection to a sunken vessel or other object to be raised to the dock, means for connecting said lift cables to the respective counterweight liquid tanks in elevated position of said tanks, liquid storage means in said dock for storing liquid for filling said counterweight tanks in elevated position thereof, pump means operable to transfer liquid from said storage means to said counterweight tanks to increase the weight of said tanks for hauling in the lift cables by descent of said tanks, means for draining said tanks into said storage means when said tanks are in descended position, and means operable to elevate said counterweight tanks thus drained of weight liquid for a succeeding incremental hoisting operation.

6. The ship salvage device defined in claim 5, wherein the means interconnecting the lift cable and the counterweight liquid tank comprises a lift cable drum for reeling in lift cable by driven rotation of said drum, a drive sheave rotatively connected to said drum, a drive cable connected at one end to the counterweight liquid tank and at its opposite end to a point on the periphery of the drive sheave, the portion of said drive cable adjoining said latter end thereof wrapping around the drive sheave to take up slack in such drive cable, descent of the counterweight tank causing rotation of the drive sheave by unwrapping of the drive cable thereon, hence driving rotation of the lift cable drum to raise the sunken vessel by an incremental amount, and holding means operable to prevent counter-rotation of the lift cable drum after each incremental hoisting operation effected by descent of the counterweight tank.

7. A ship salvage device comprising a pontoon dock, and hoisting means operable to raise sunken vessels to said dock, said hoisting means comprising a plurality of lift cables for securement to a sunken vessel, individual lift cable haul-in mechanisms cooperating individually with the respective lift cables and located at spaced intervals along a side of said dock, said mechanisms having releasable holding devices normally operable to hold the lift cables against paying out but permitting operation of said mechanisms to haul in such cables, and means for driving said haul-in mechanisms to raise the sunken vessel connected to the lift cables, said drive means comprising a plurality of counterweights each associated with a different haul-in mechanism, means guiding said counterweights individually for direct elevation and descent movement in said pontoon dock, and means forming a drive connection between individual counterweights and the respective haul-in mechanisms for driving operation of the latter upon descent of said counterweights thereby to raise the sunken vessel by an increment, means operable to hold said counterweights in elevated position therein, means actuating said means holding the counterweights in elevated position, to release the same for simultaneous descent thereof by gravity to effect such incremental hoisting operation, and means operable to elevate said counterweights for a succeeding incremental hoisting operation.

8. The ship salvage device defined in claim 2, wherein the means operable to hold the tanks in elevated position comprise a plurality of tank supporting hydraulic units associated with the respective tanks, each such unit comprising piston and cooperating cylinder elements, one such element being fixed to the dock and the cooperating element being supportingly connected to the associated tank for displacing hydraulic liquid from the cylinder accompanying descent movement of such tank, and further wherein the actuating means comprise a plurality of normally closed cylinder control valves preventing discharge of hydraulic liquid from the respective cylinders, and means operable to open said control valves for all the tank hydraulic units simultaneously.

9. The ship salvage device defined in claim 8, and means to contain hydraulic liquid and conduit means interconnecting said container means and the discharge sides of a plurality of

the control valves to permit free flow of hydraulic liquid therebetween.

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