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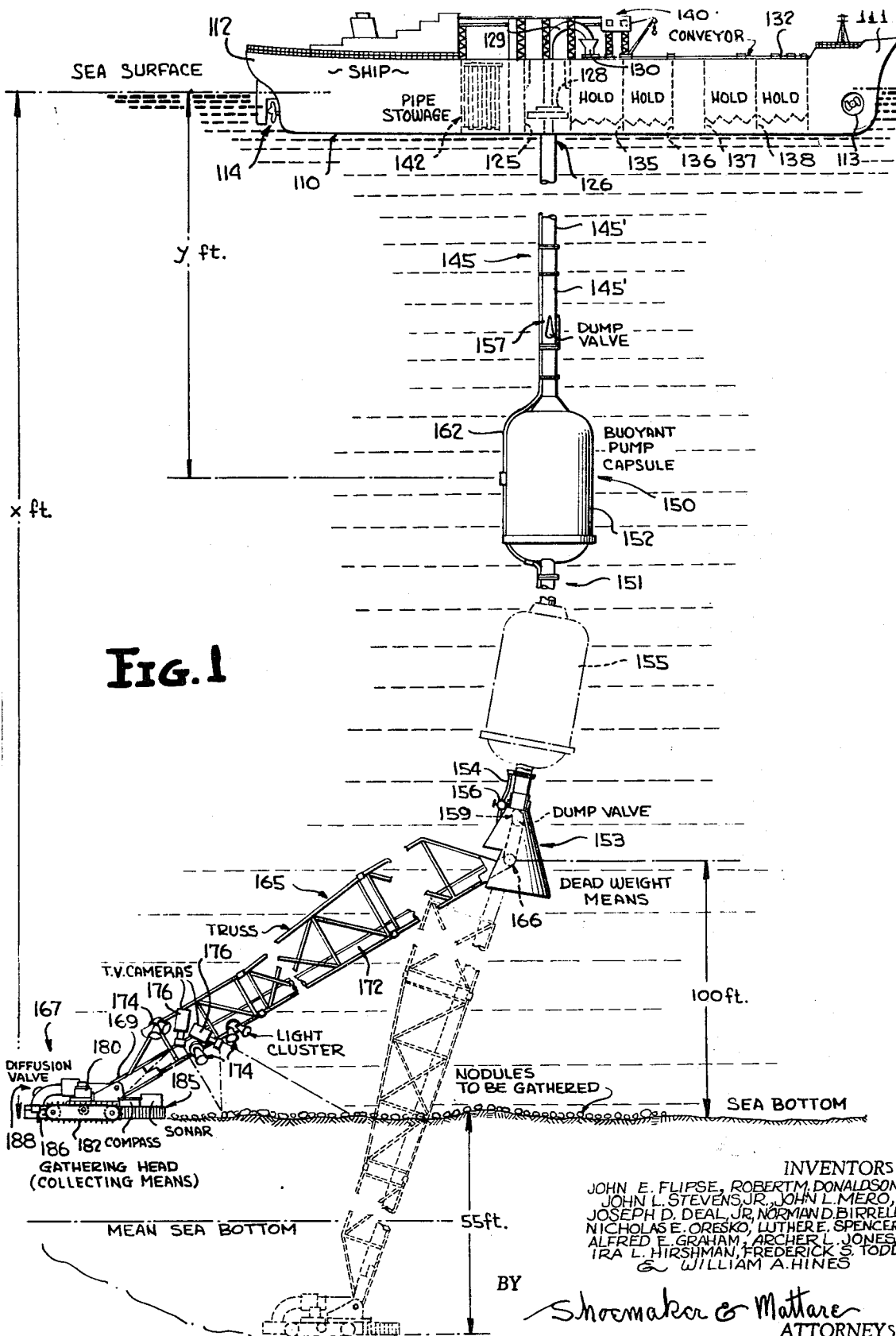
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FIG. 2

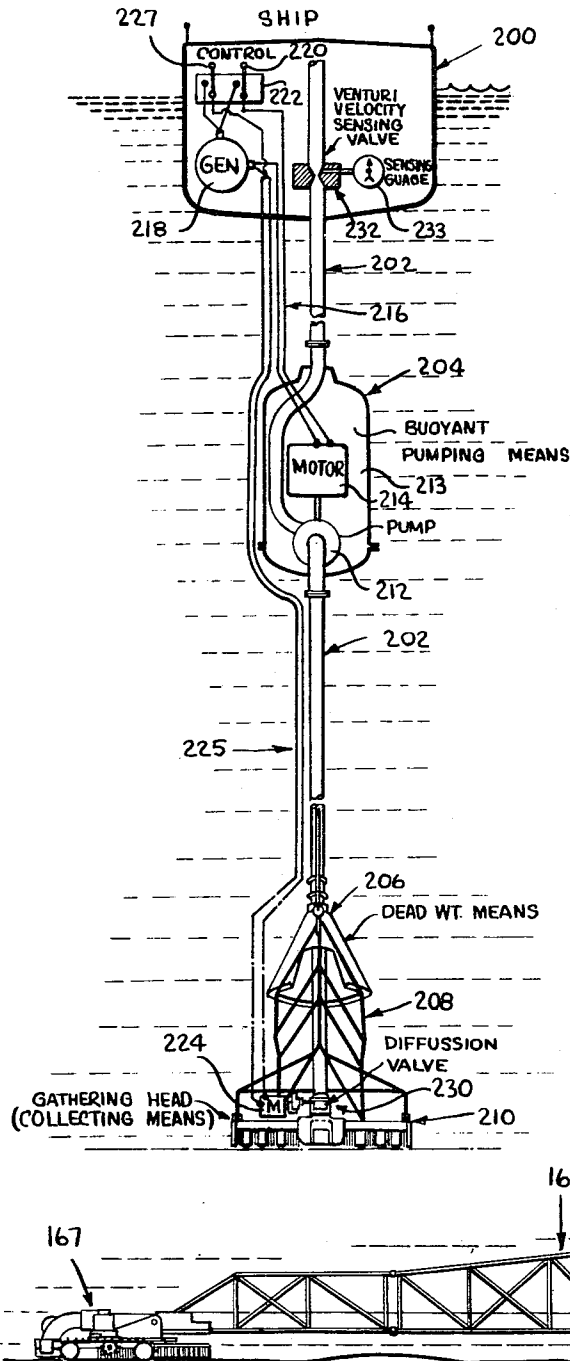
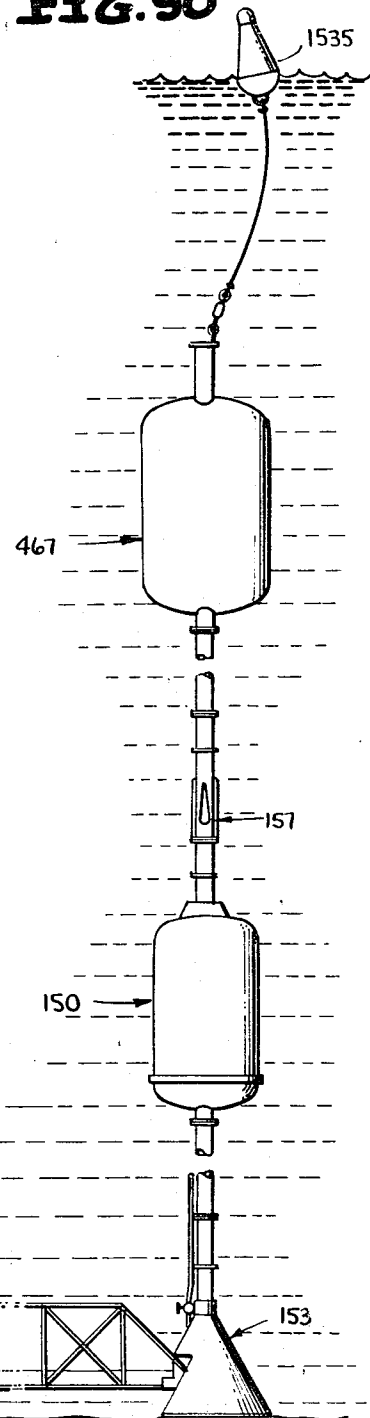


FIG. 90



INVENTORS
JOHN E. FLIPSE, ROBERT M. DONALDSON,
JOHN L. STEVENS, JR., JOHN L. MERO,
JOSEPH D. DEAL, JR., NORMAN D. BIRRELL,
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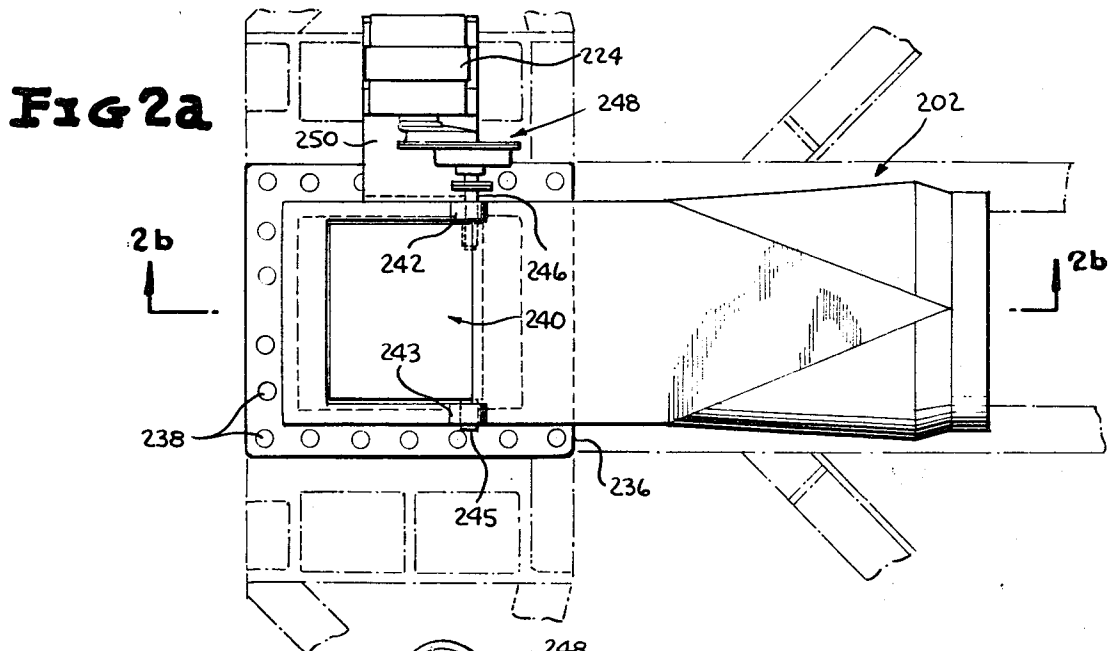
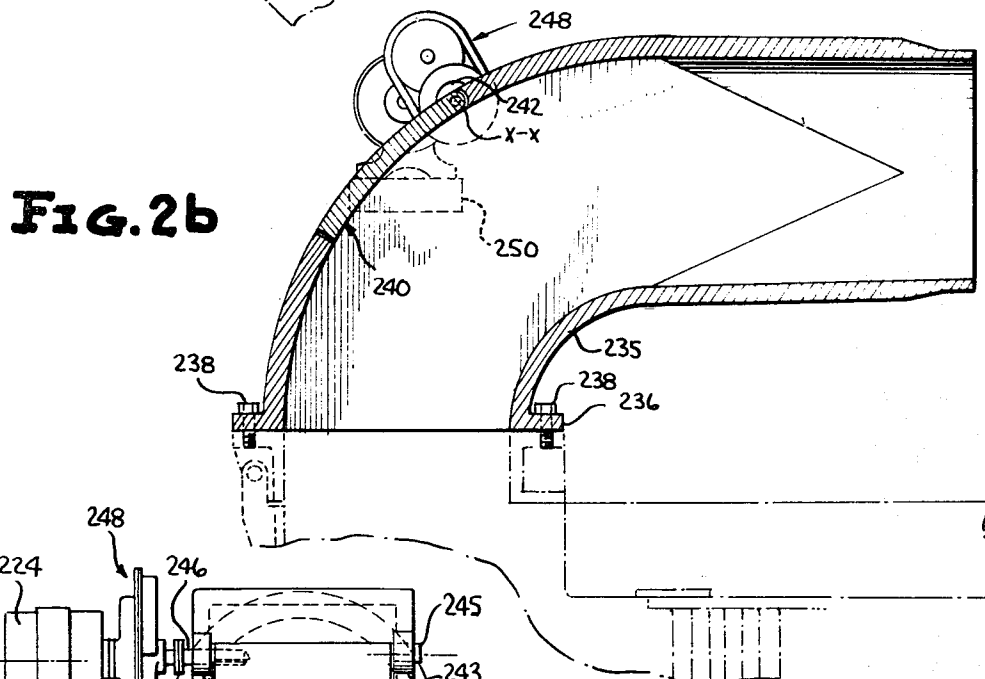
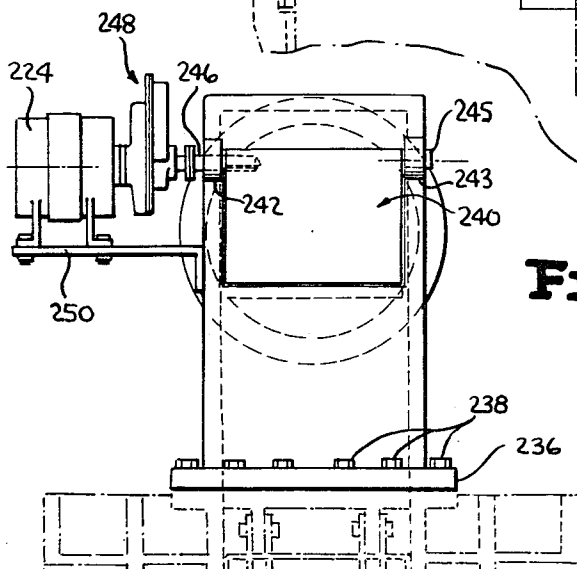


FIG. 2c

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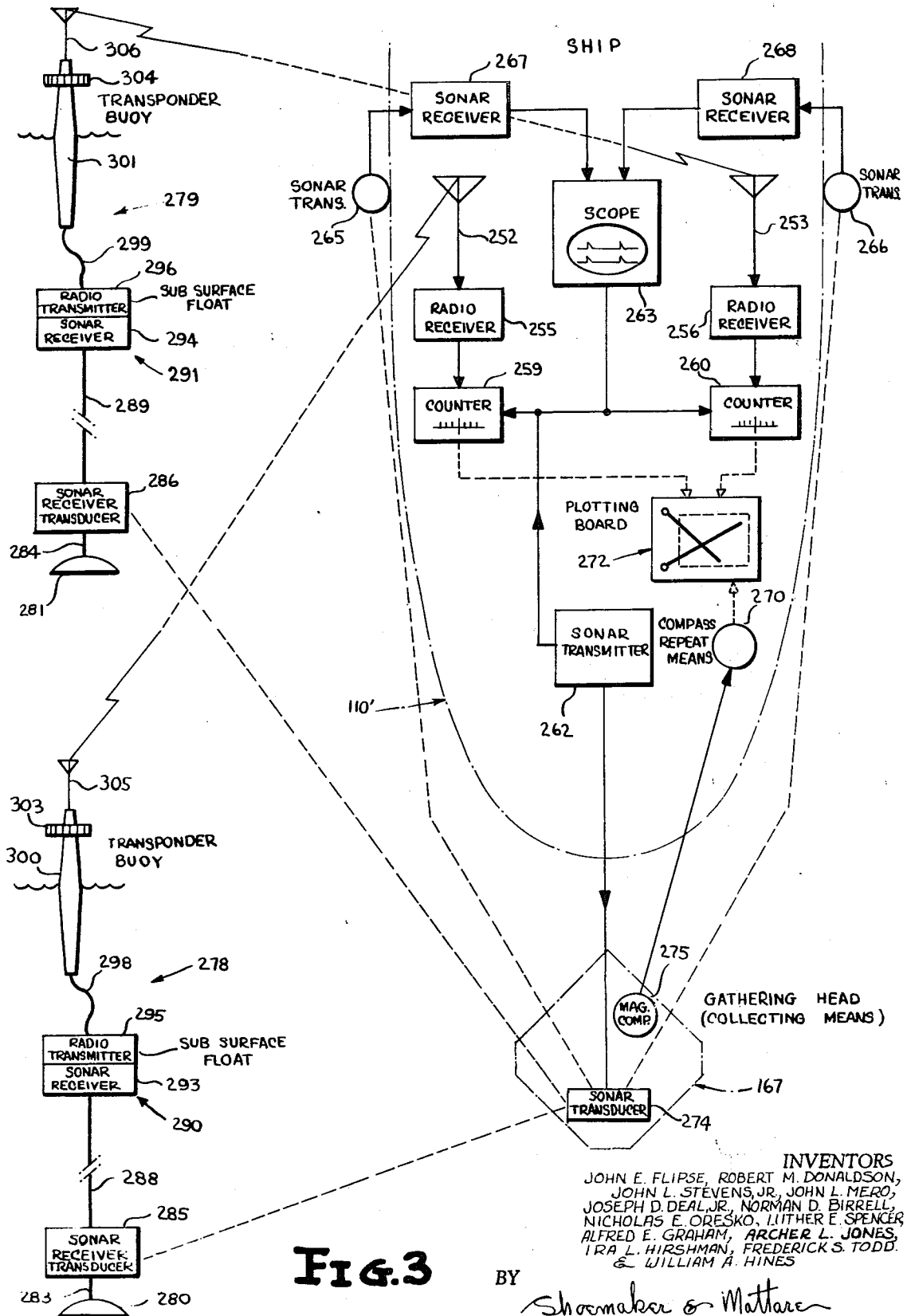


FIG. 3

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FIG. 5

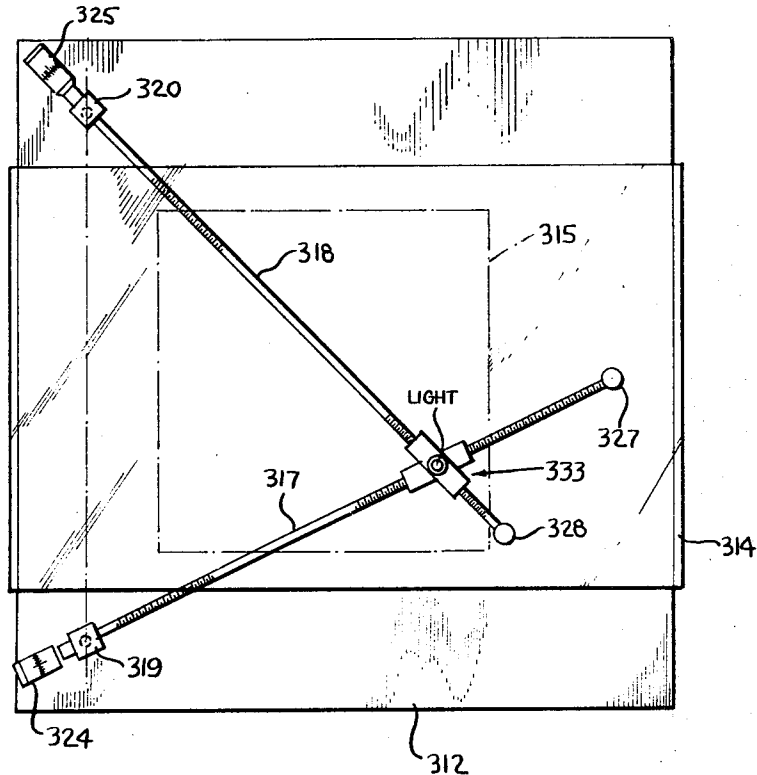


FIG. 6

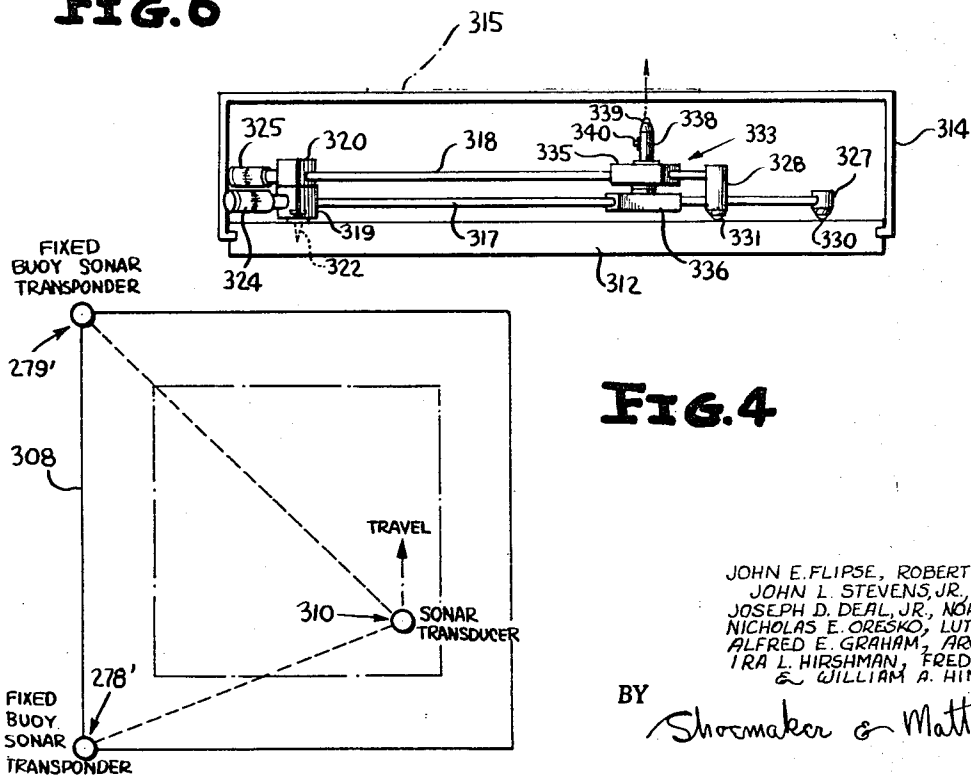


FIG. 4

INVENTORS
JOHN E. FLIPSE, ROBERT M. DONALDSON,
JOHN L. STEVENS, JR., JOHN L. MERO,
JOSEPH D. DEAL, JR., NORMAN D. BIRRELL,
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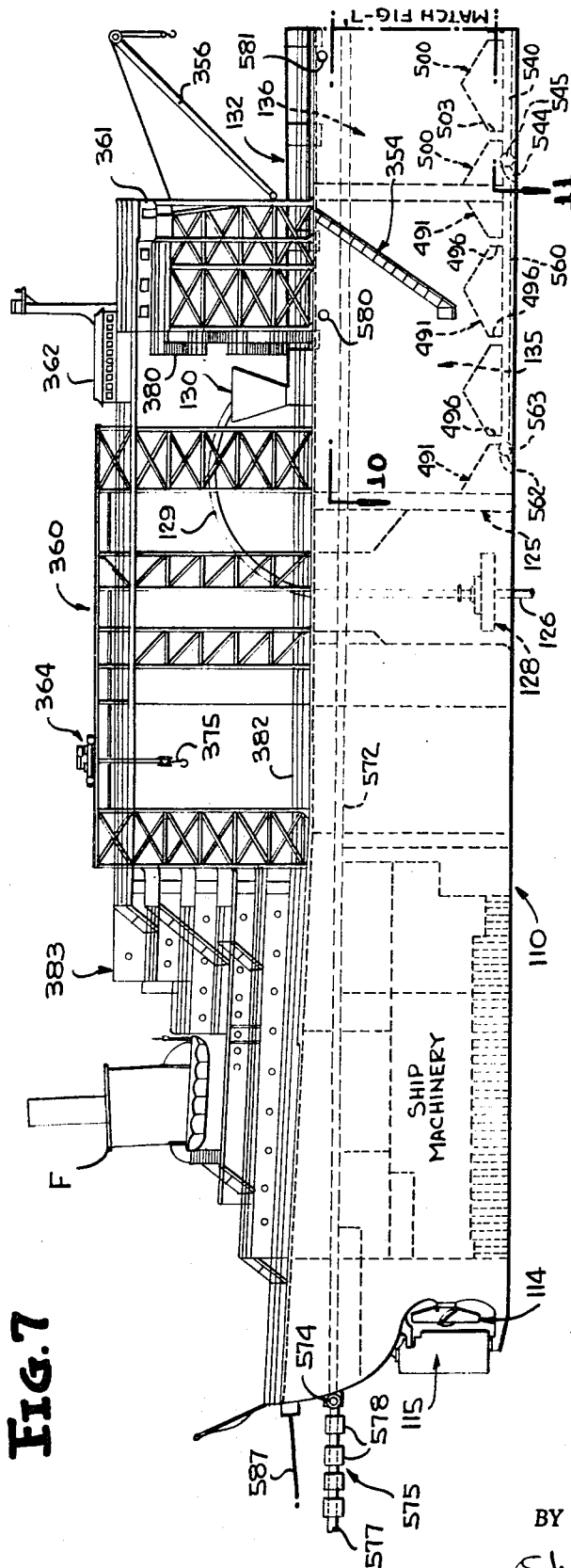


Fig. 7

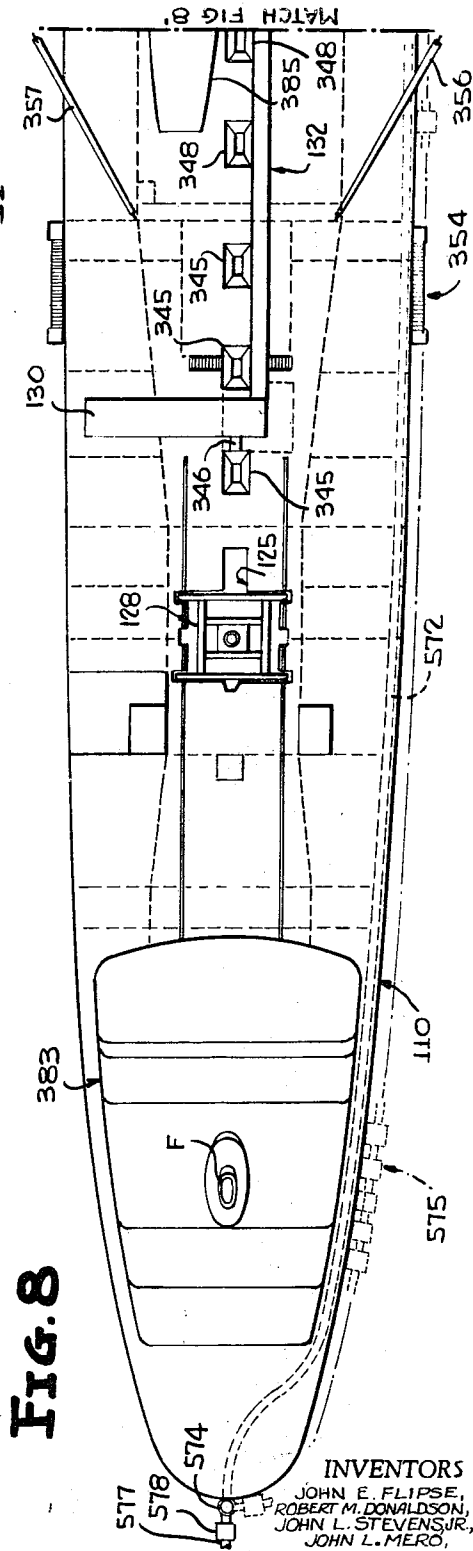


Fig. 8

INVENTORS
JOHN E. FLIPSE,
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JOHN L. STEVENS, JR.,
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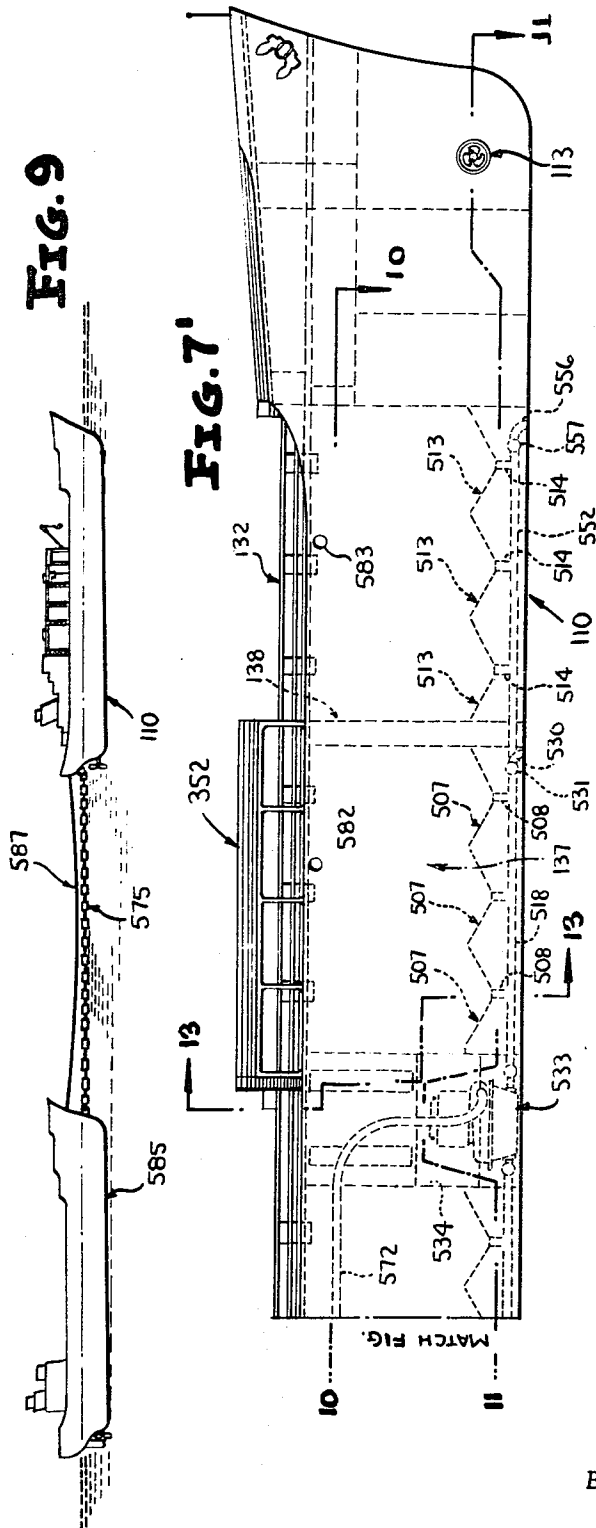
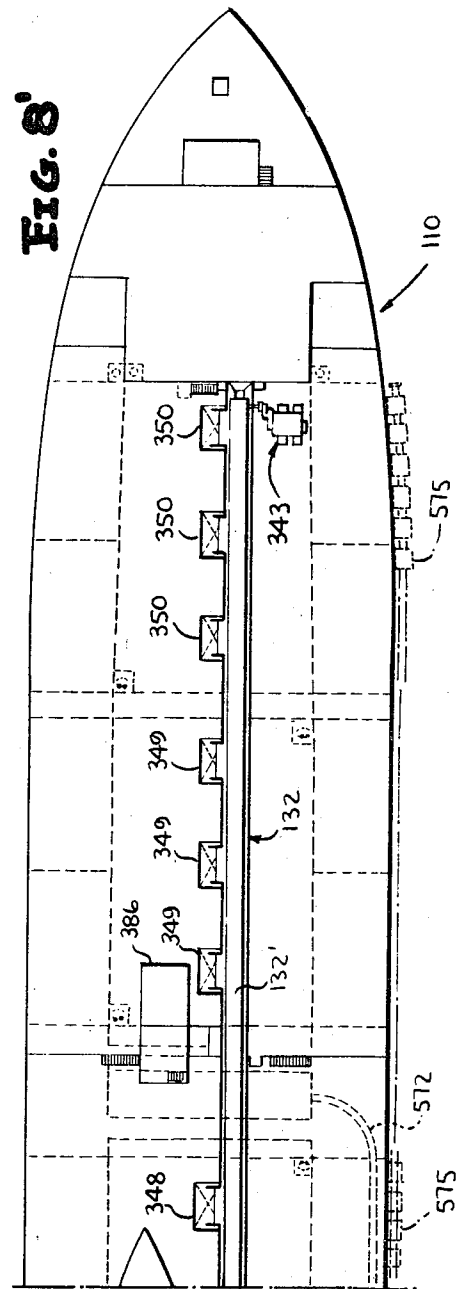
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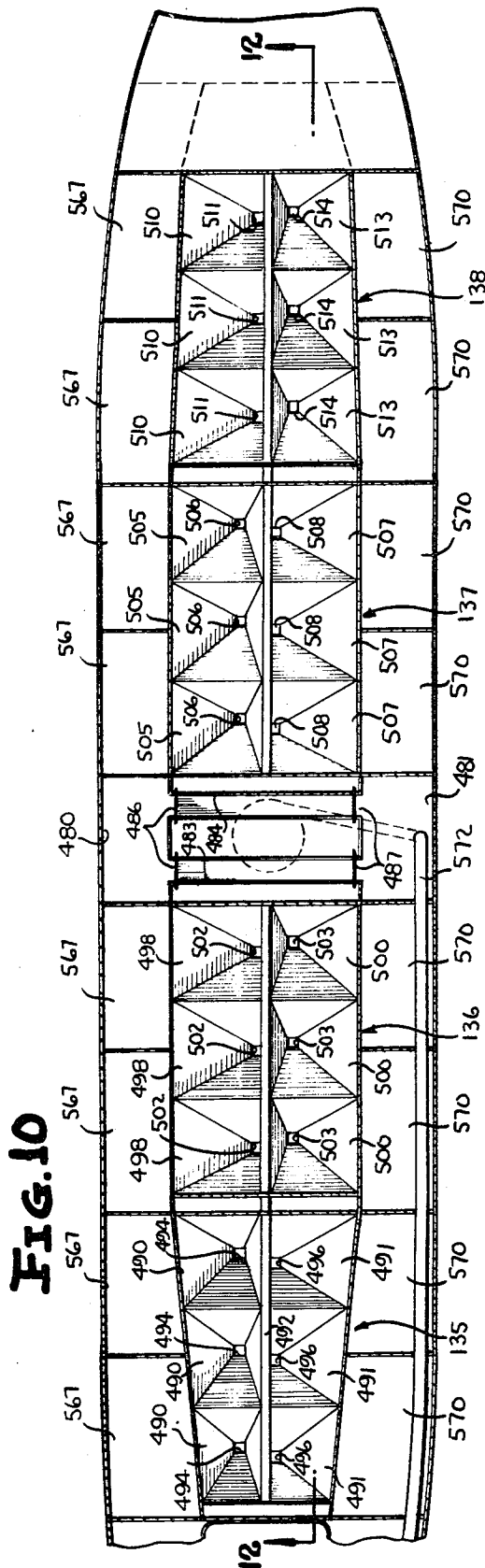
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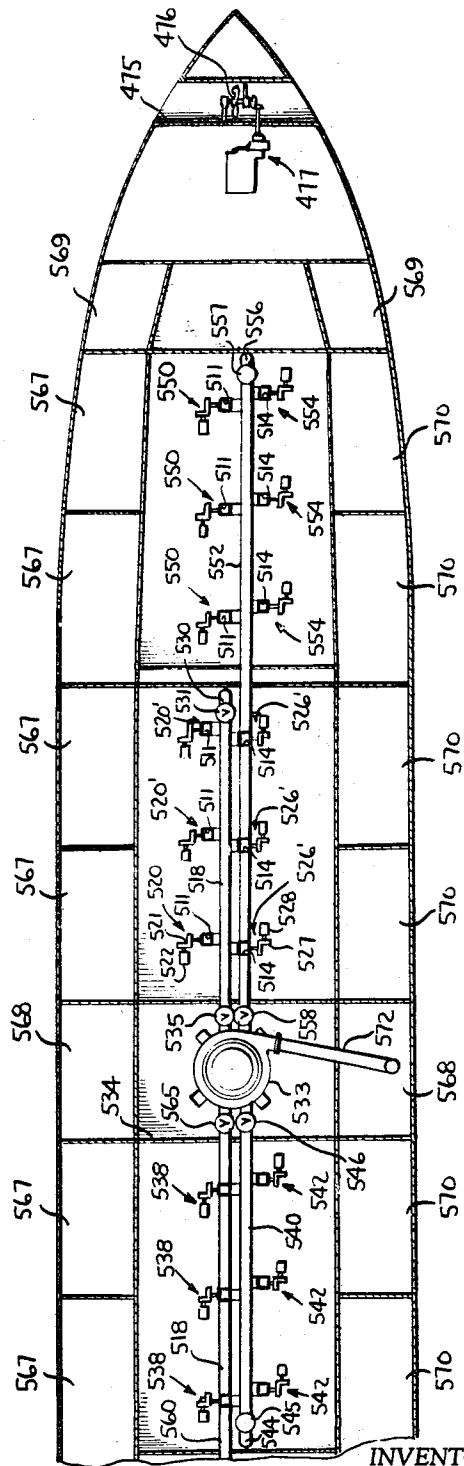
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FIG. 12

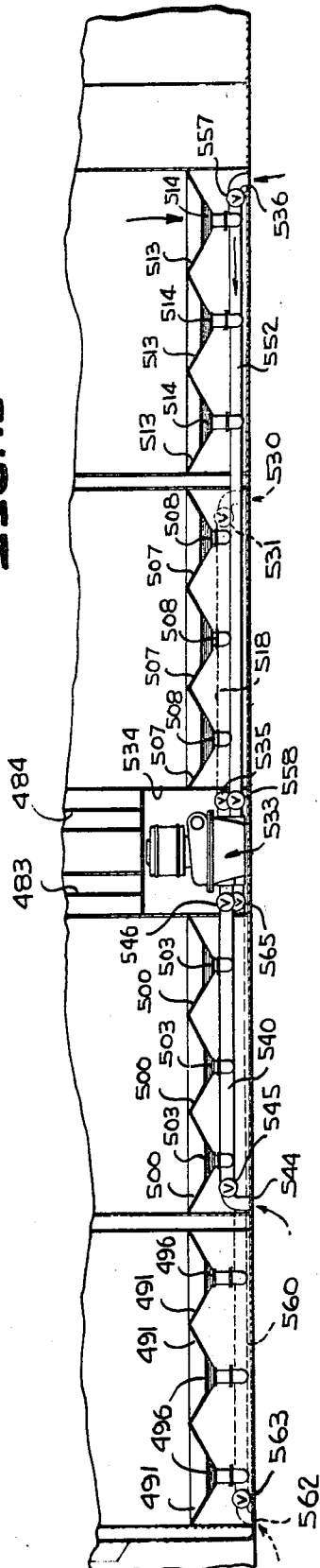
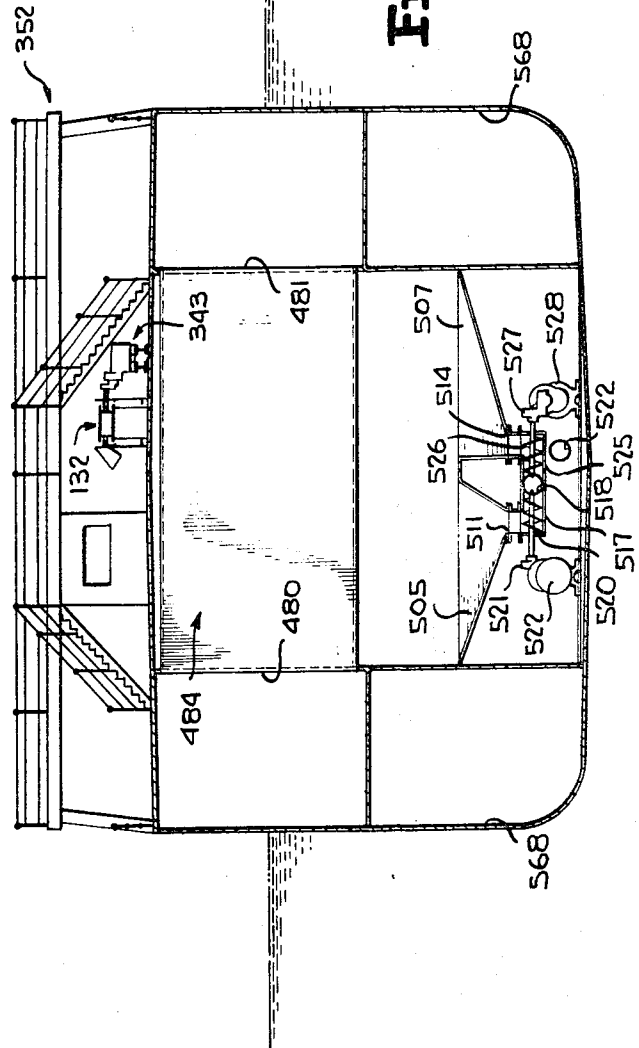


FIG. 13



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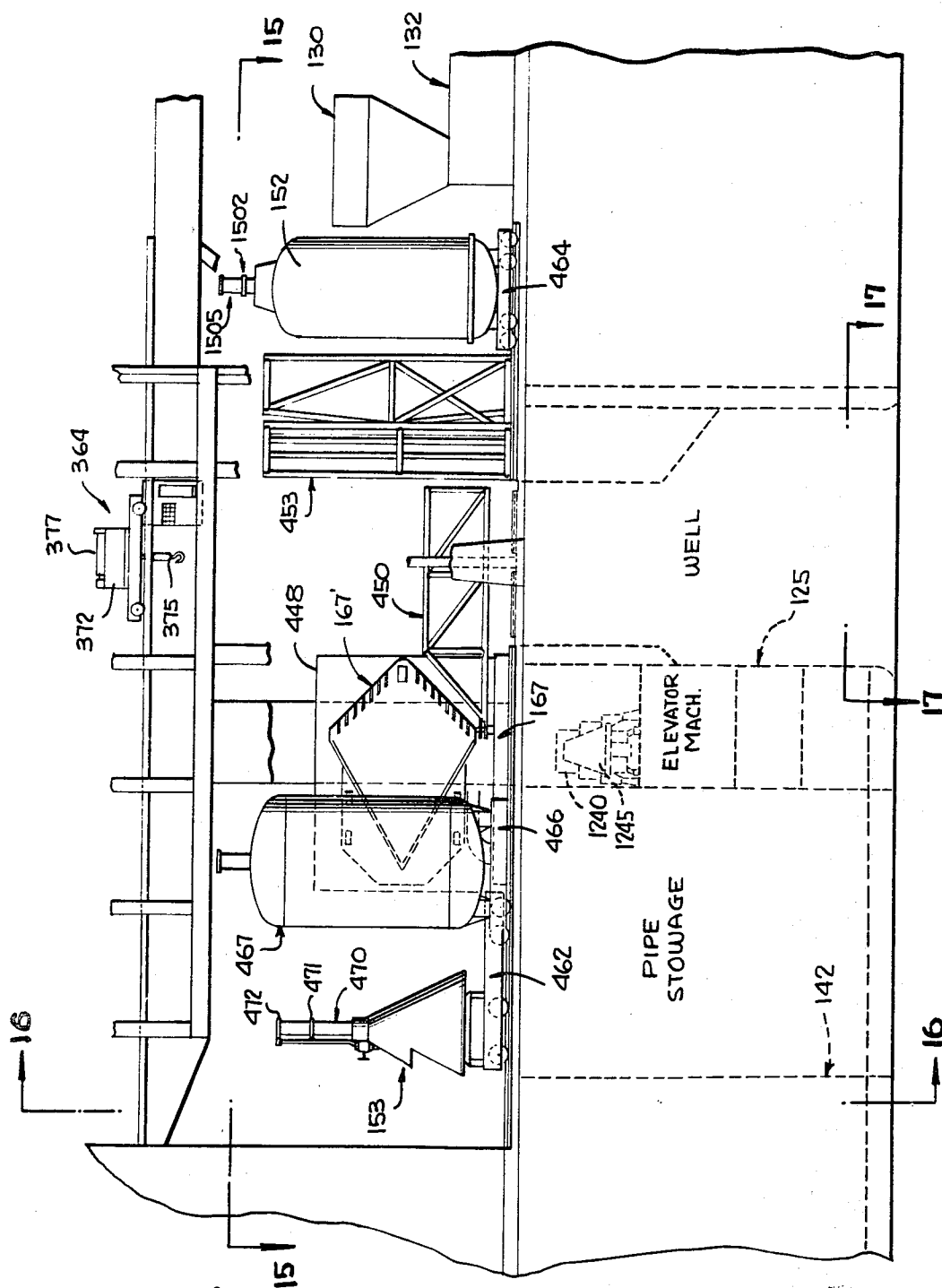


FIG. 14

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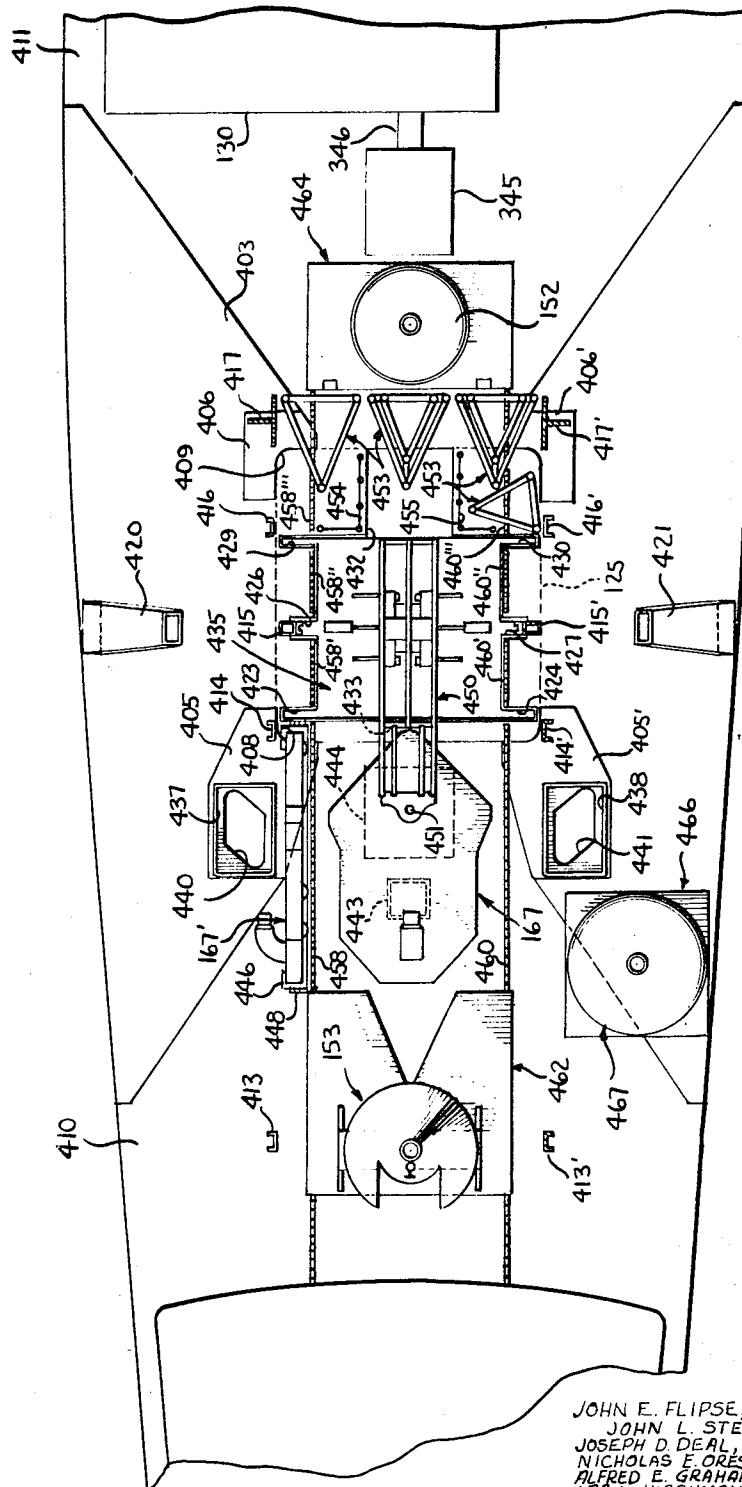


FIG. 15

INVENTORS
JOHN E. FLIPSE, ROBERT M. DONALDSON,
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JOSEPH D. DEAL, JR., NORMAN D. BIRRELL,
NICHOLAS E. ORESKO, LUTHER E. SPENCER,
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FIG. 16

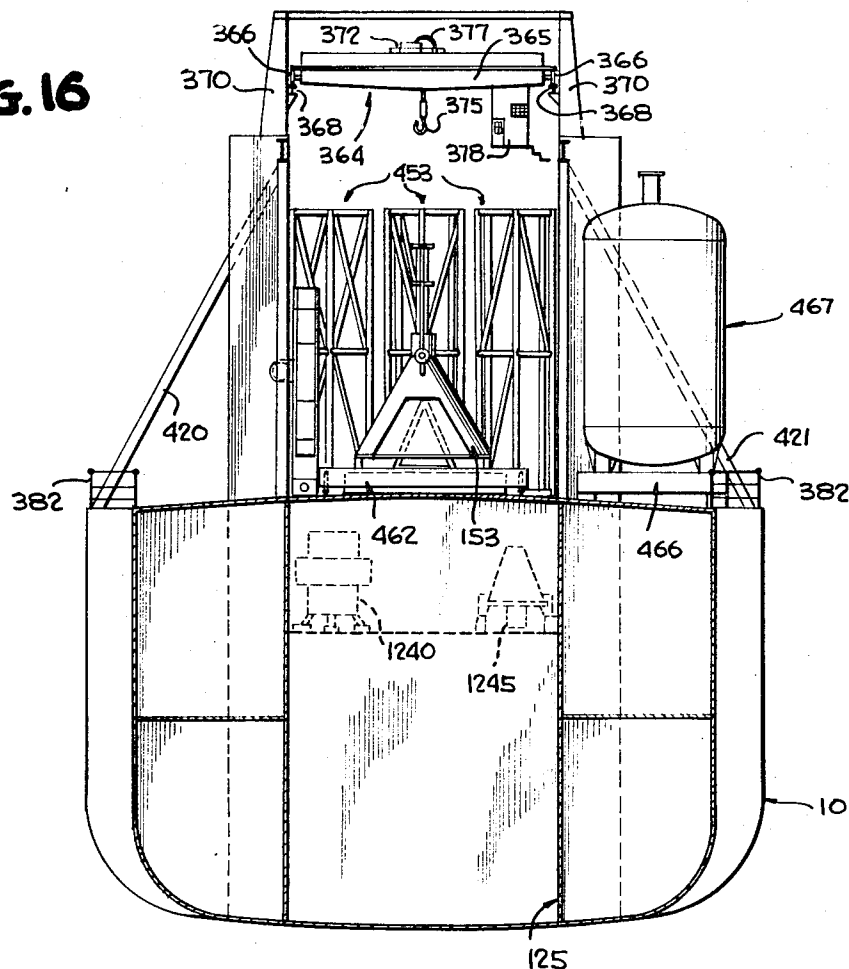
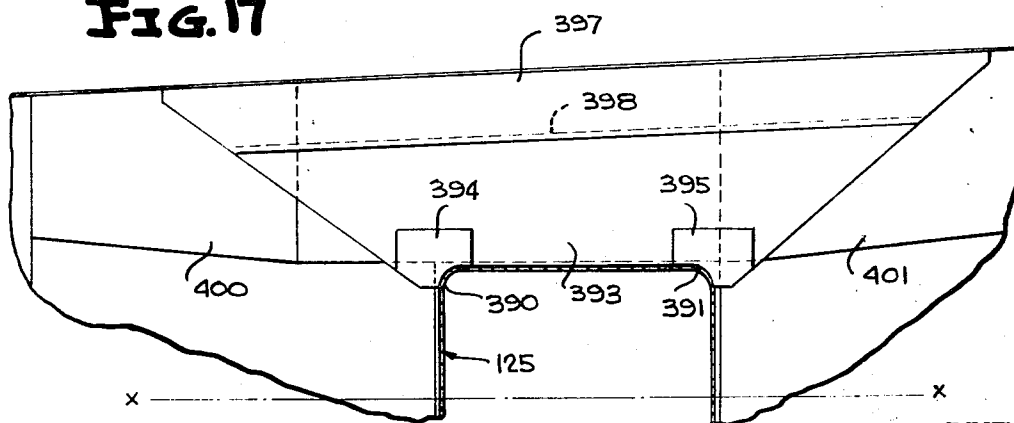


FIG. 17



INVENTORS
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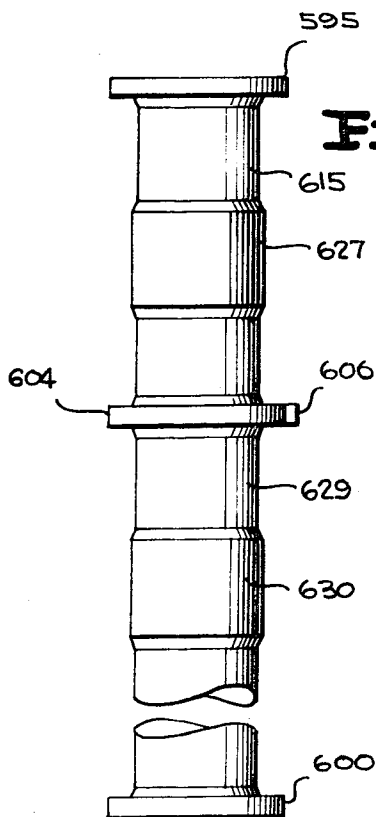


FIG. 19

FIG. 18

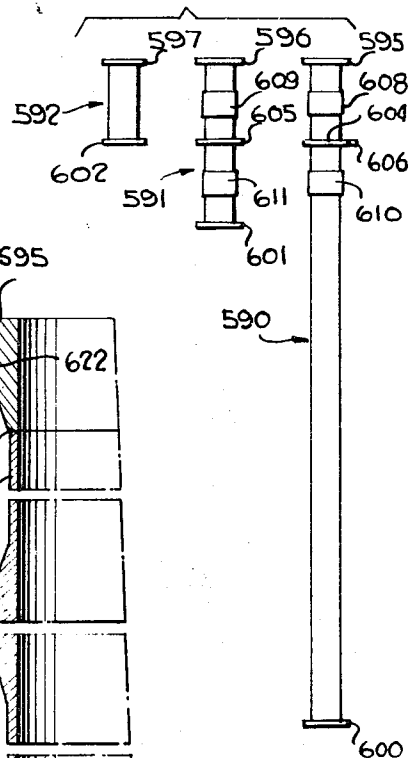
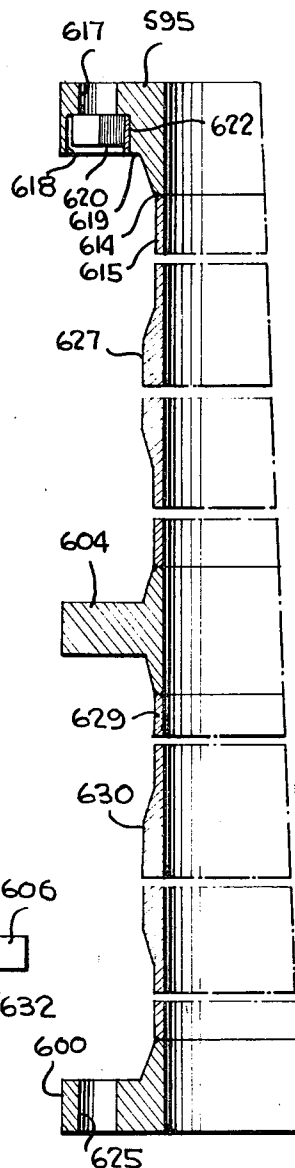


FIG. 21

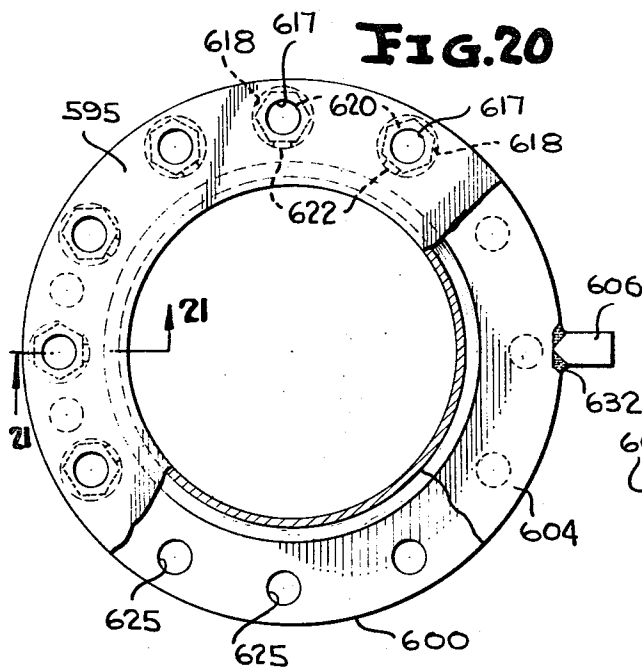


FIG. 20

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NICHOLAS E. ORESKO, LUTHER E. SPENCER,
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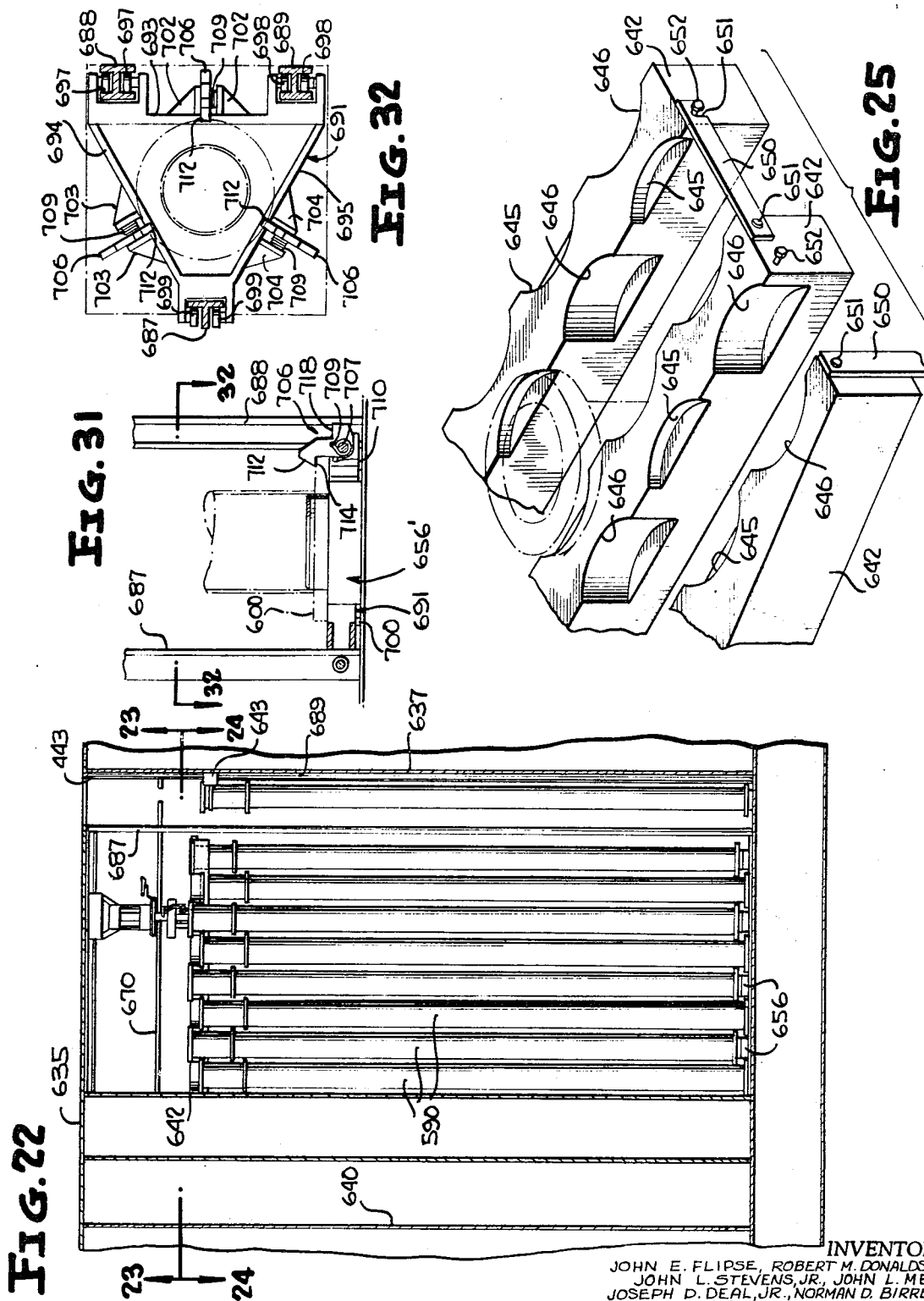
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FIG. 24

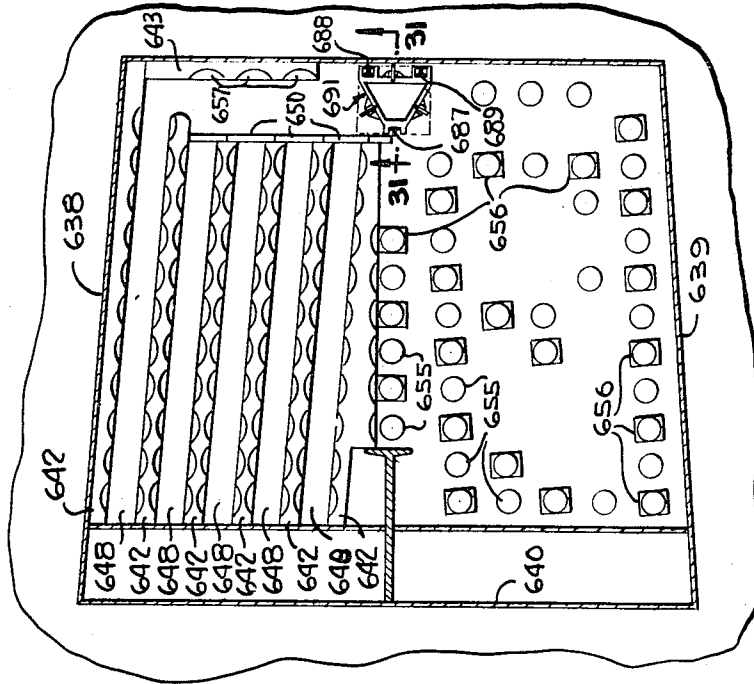


FIG. 23

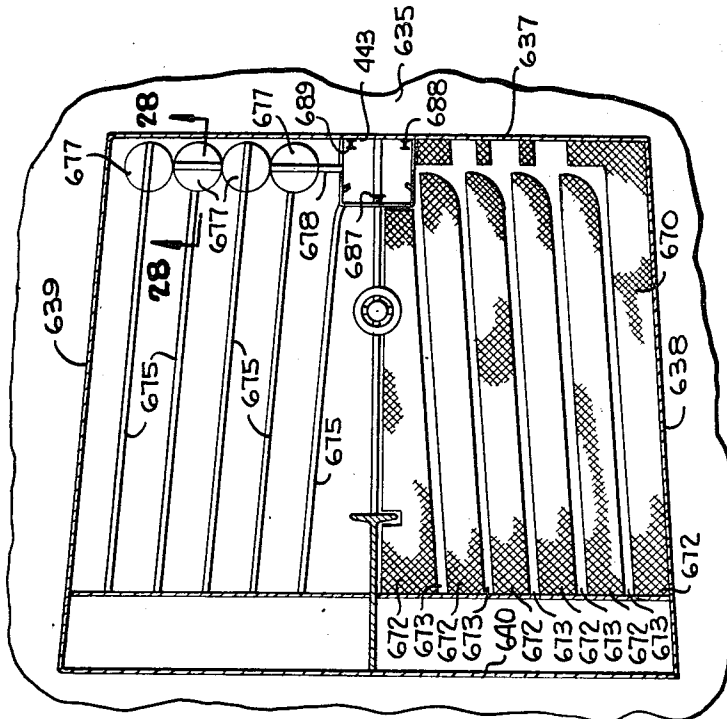
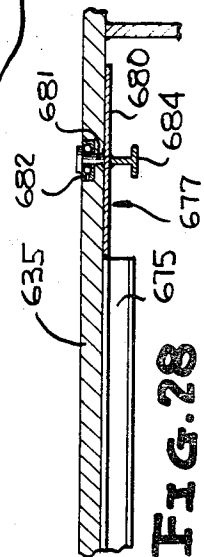


FIG. 28

FIG. 26

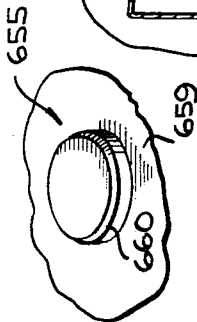
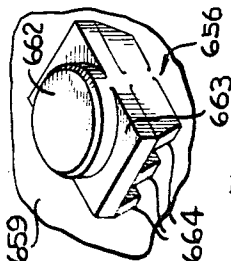


FIG. 27



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FIG. 29

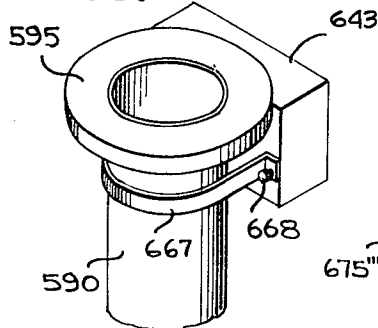


FIG. 30

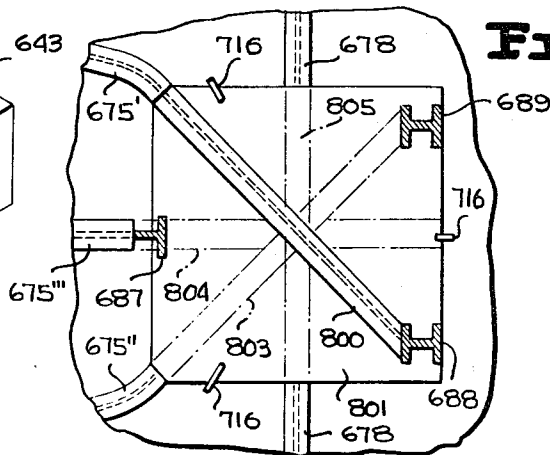
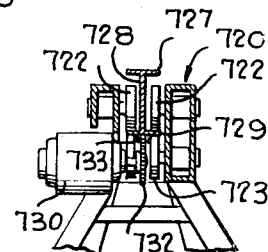


FIG. 35

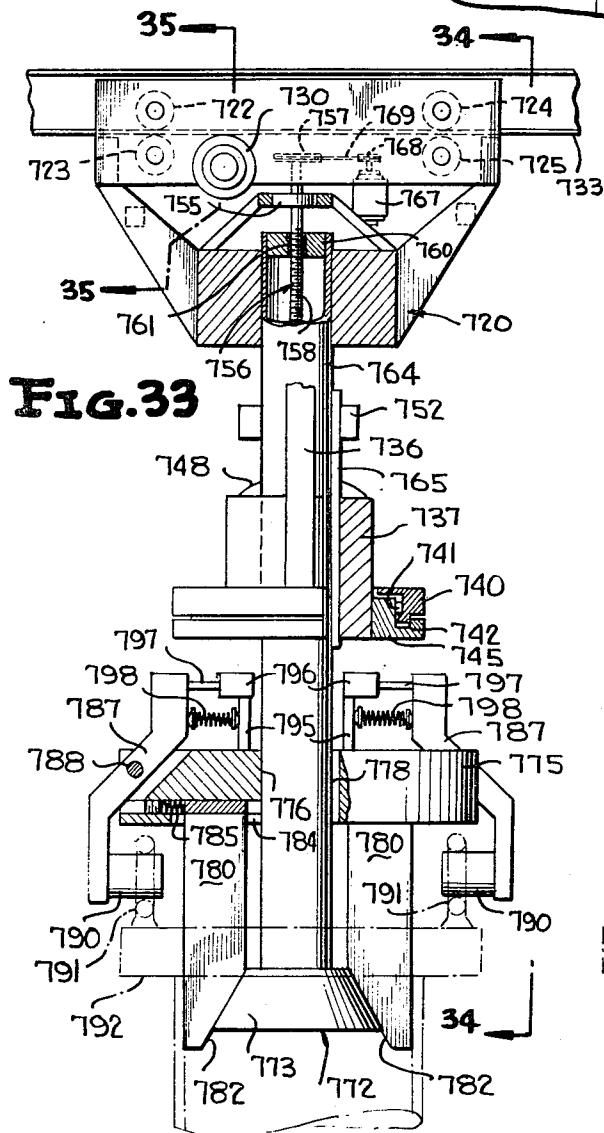


FIG. 33

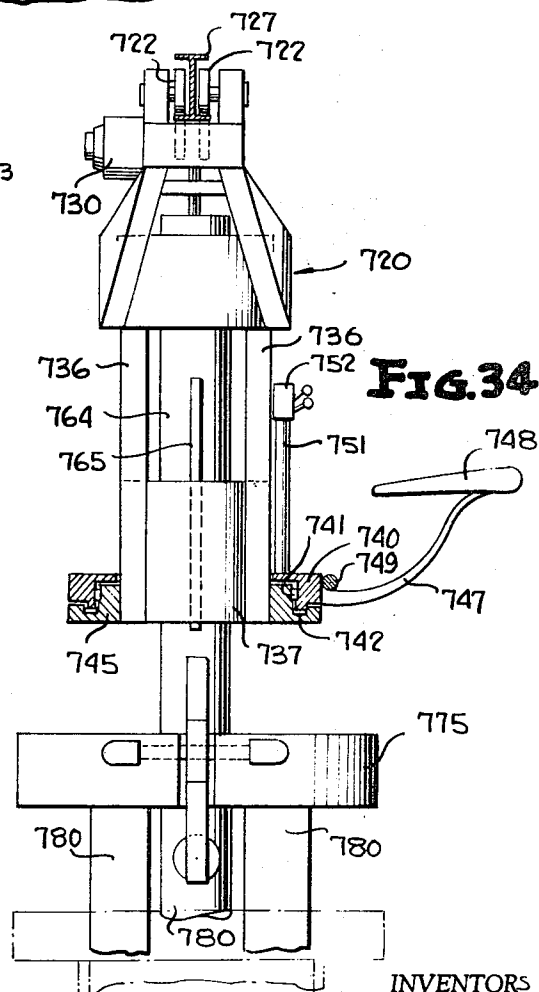


FIG. 34

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JOHN E. FLIPSE, ROBERT M. DONALDSON,
JOHN L. STEVENS, JR., JOHN L. MERO,
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NICHOLAS E. ORESKO, LUTHER E. SPENCER,
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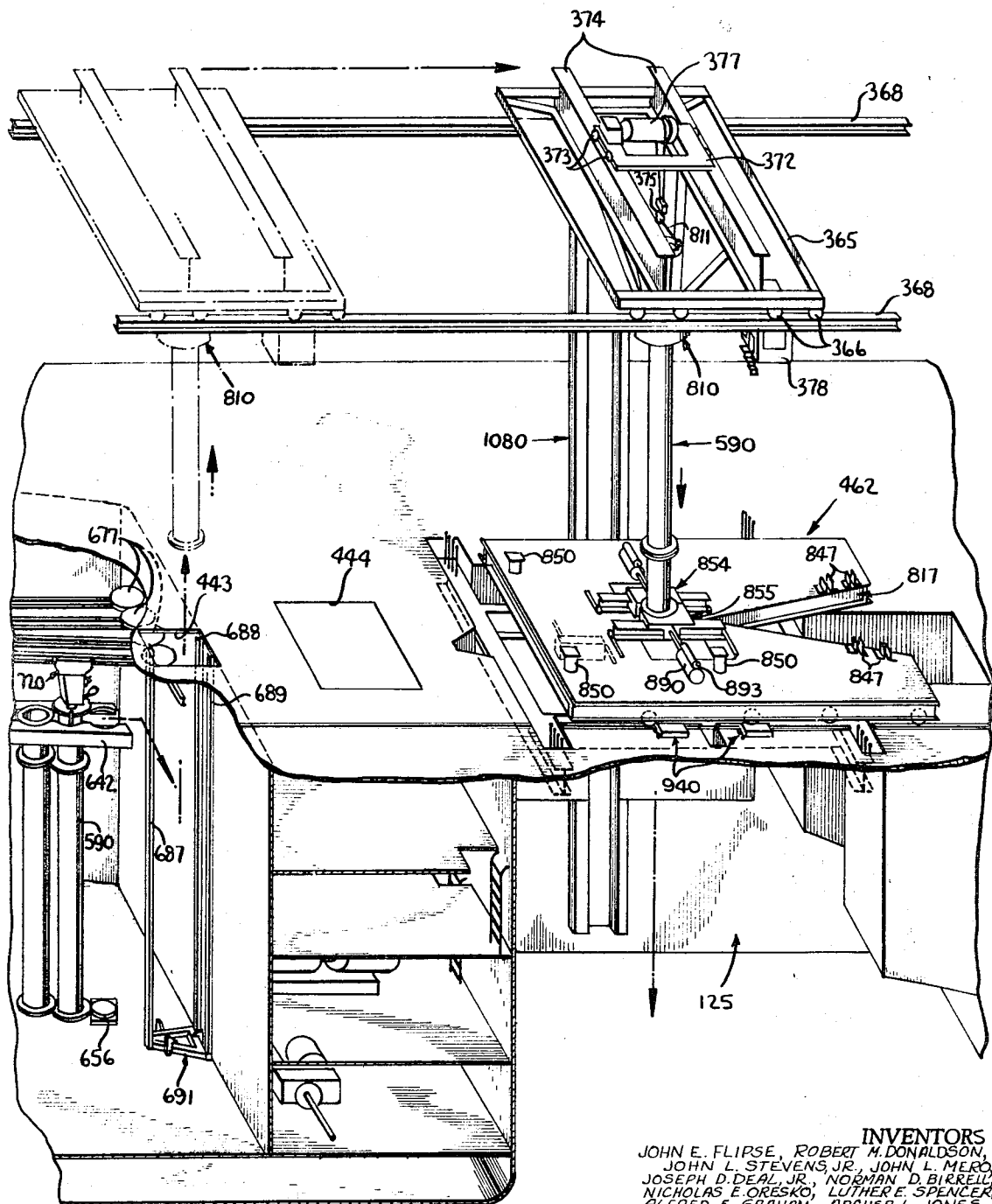
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FIG. 36



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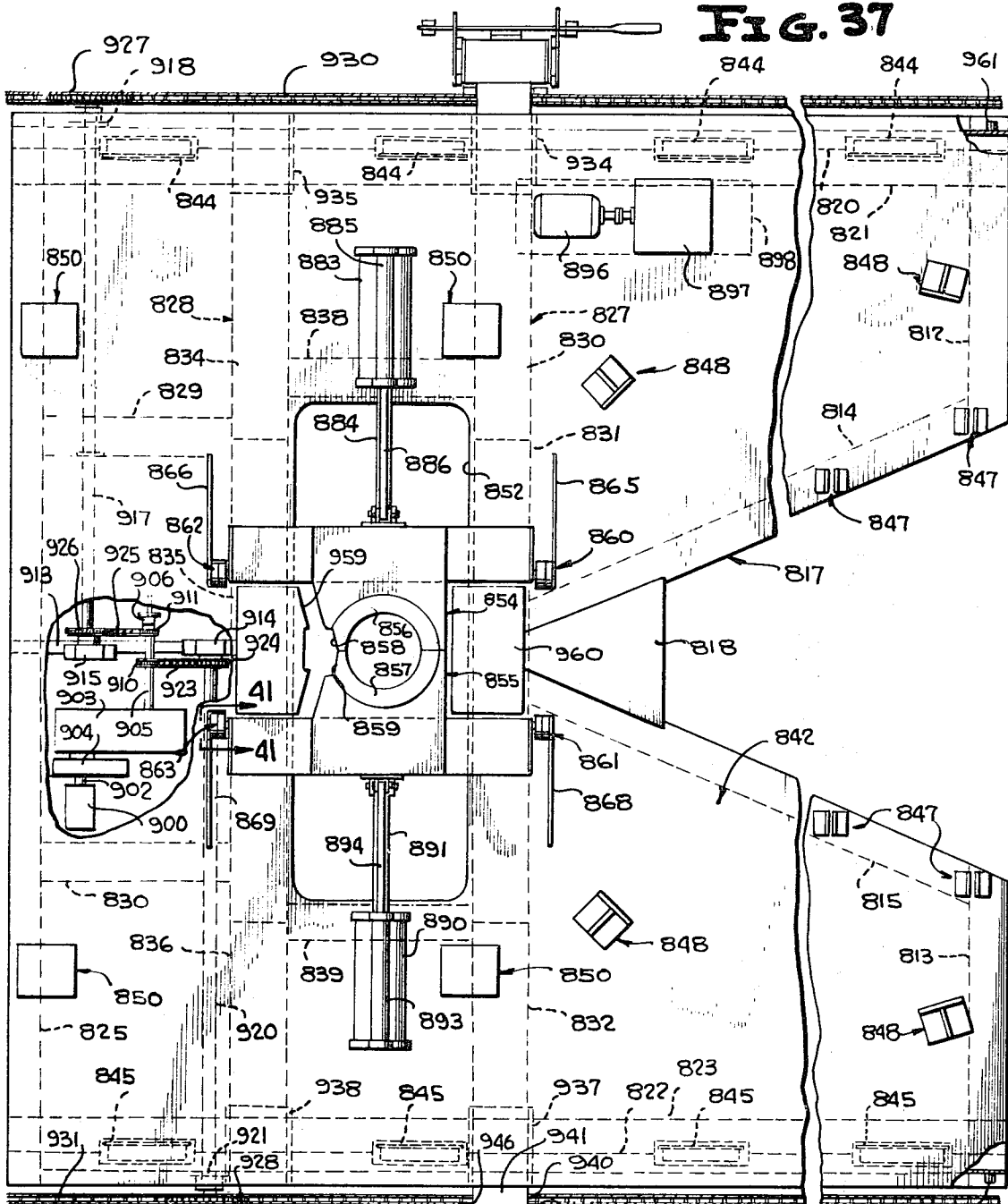


Fig. 37

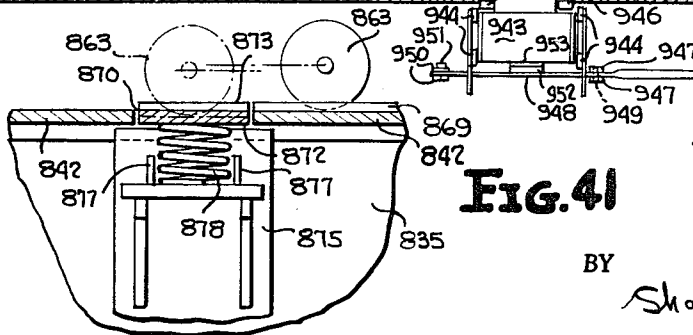


Fig. 41

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JOHN E. FLIPSE, ROBERT M. DONALDSON,
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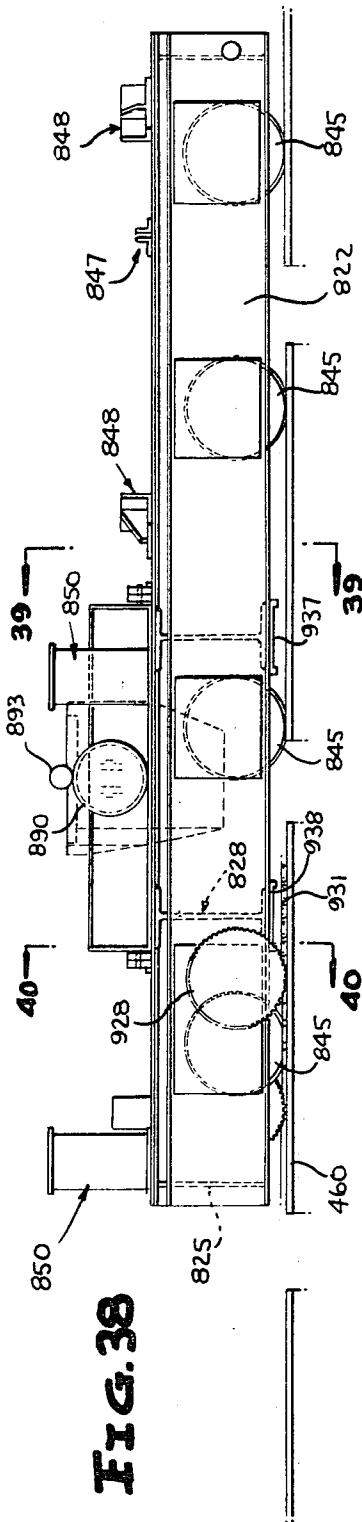


FIG. 38

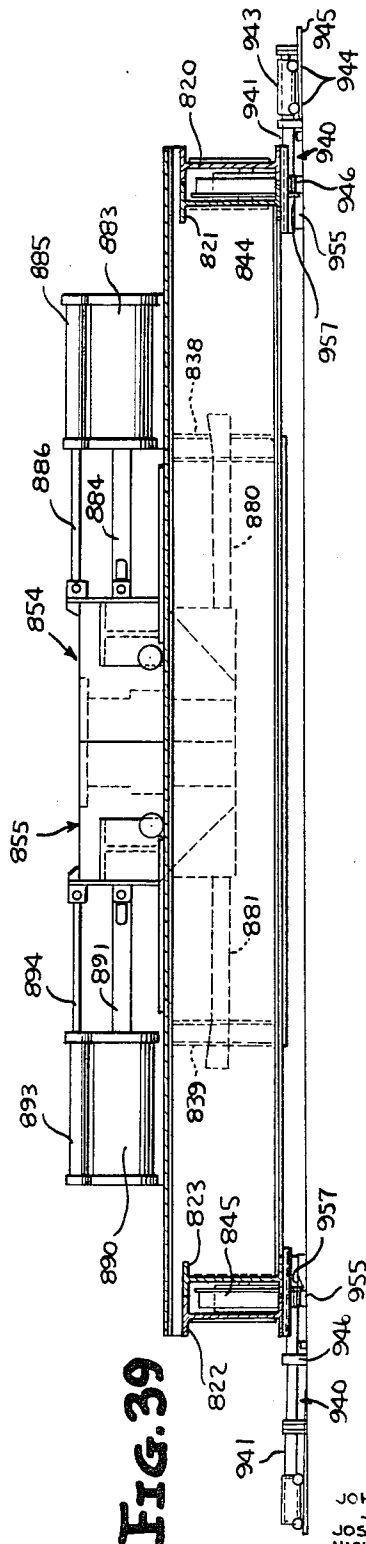


FIG. 39

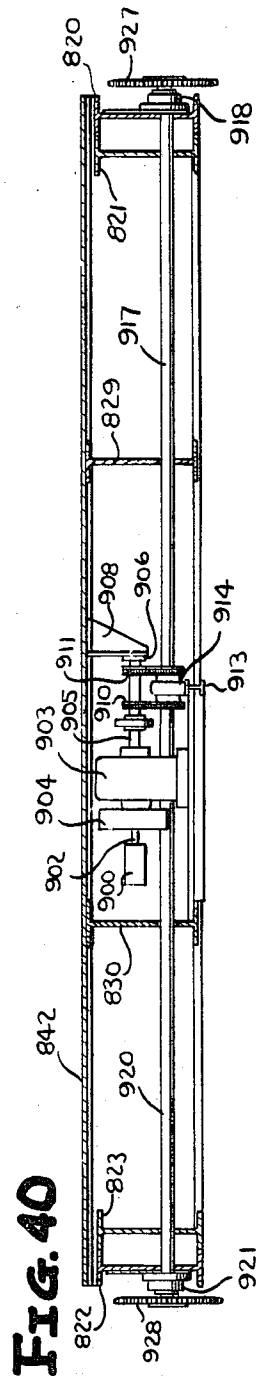


FIG. 40

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JOHN L. STEVENS, JR., JOHN L. MERO
JOSEPH D. DEAL, JR., NORMAN D. BIRRELL,
NICHOLAS E. ORESKO, LUTHER E. SPENCER,
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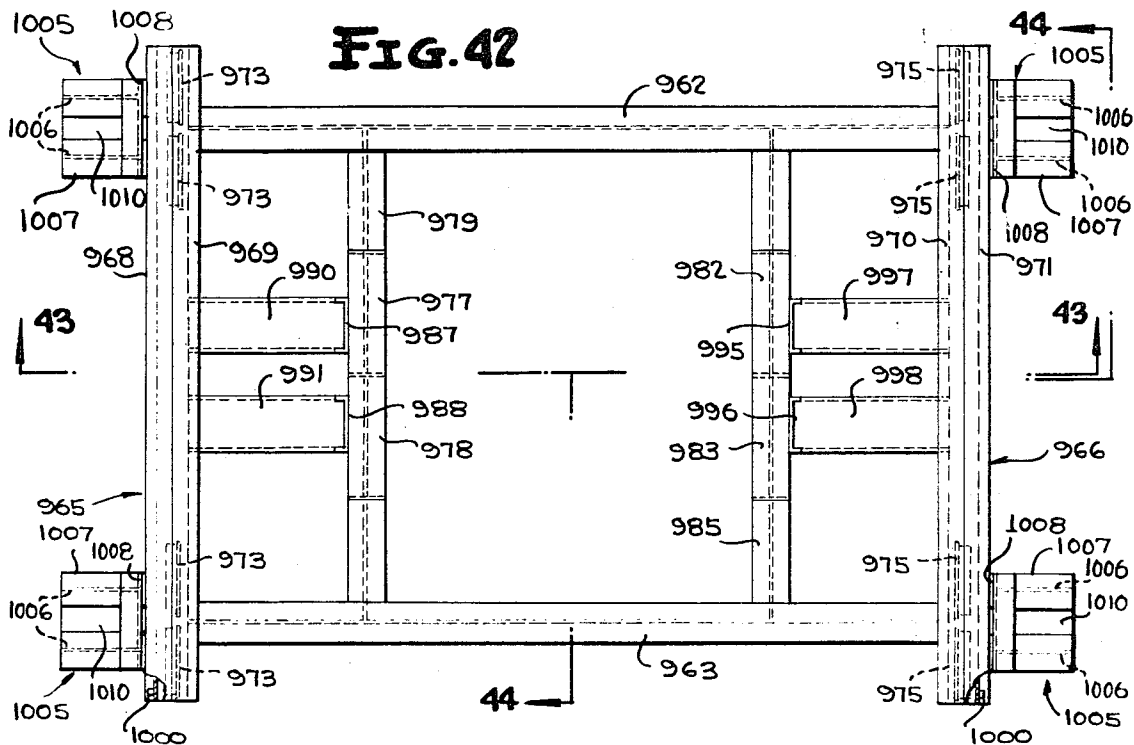
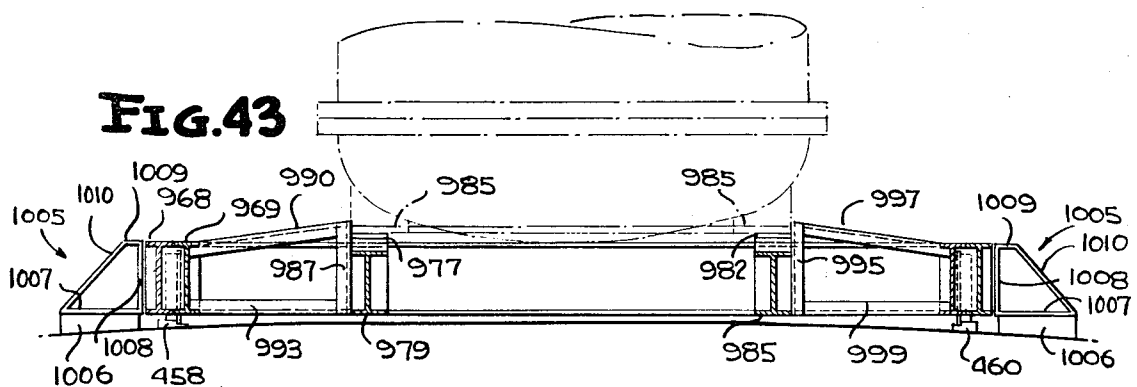
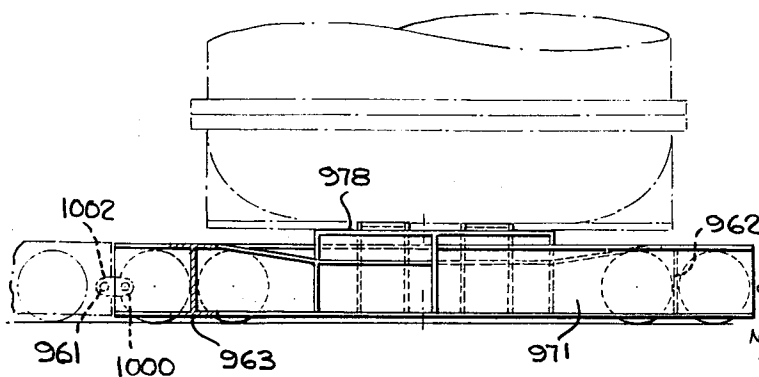
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FIG. 45

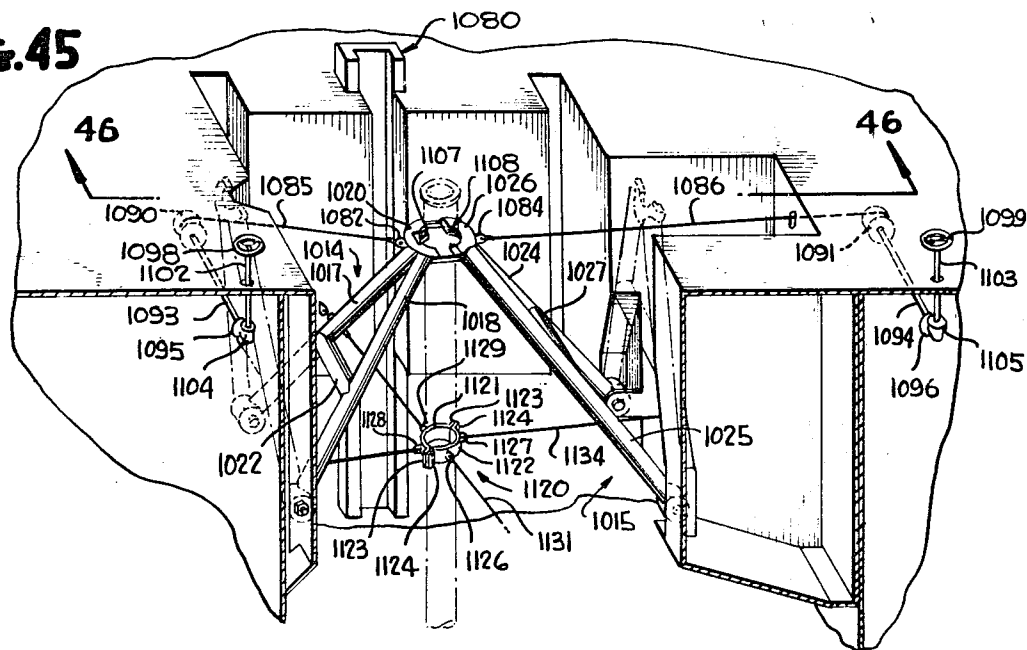
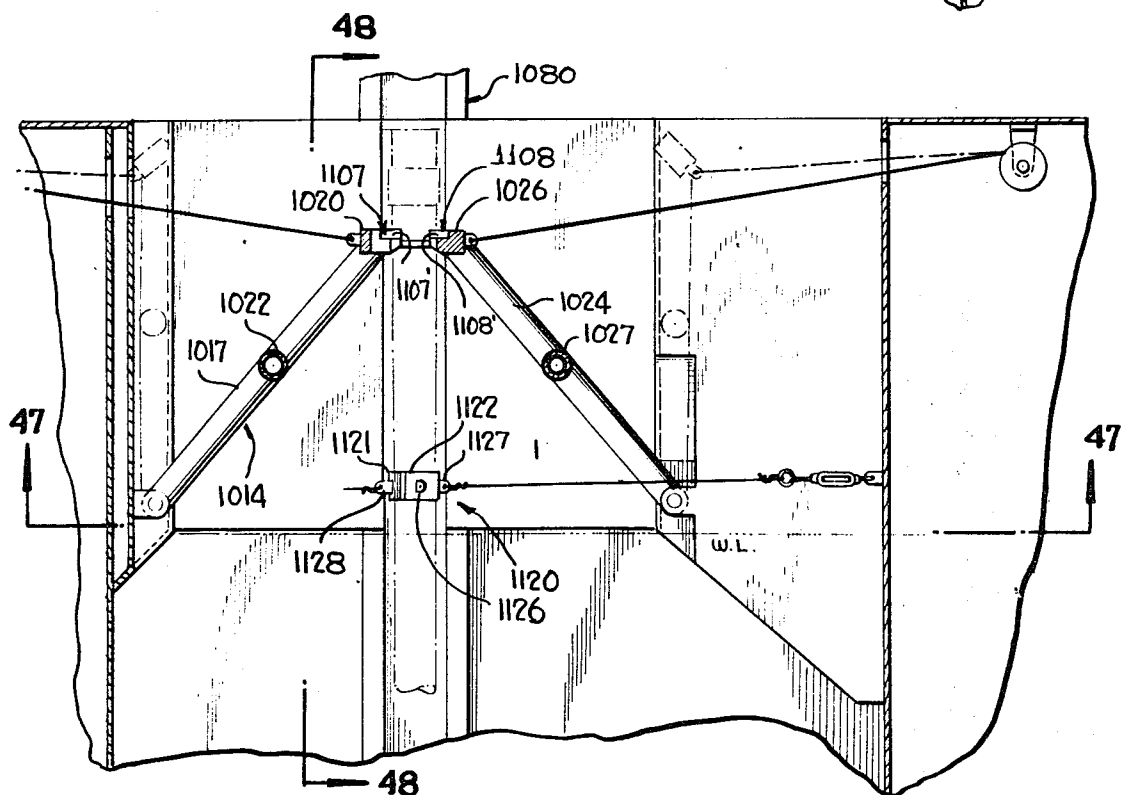


FIG. 46

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JOHN E. FLIPSE, ROBERT M. DONALDSON,
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NICHOLAS E. ORESKO, LUTHER E. SPENCER,
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FIG. 47

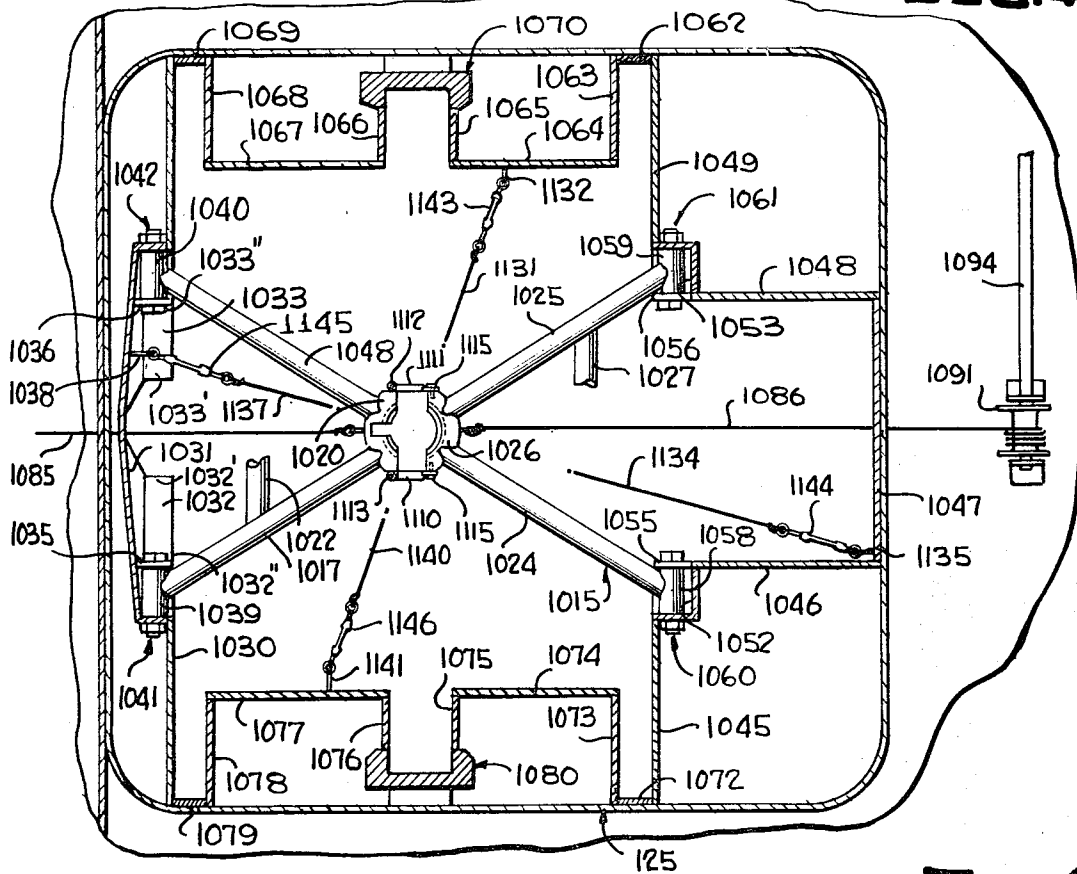
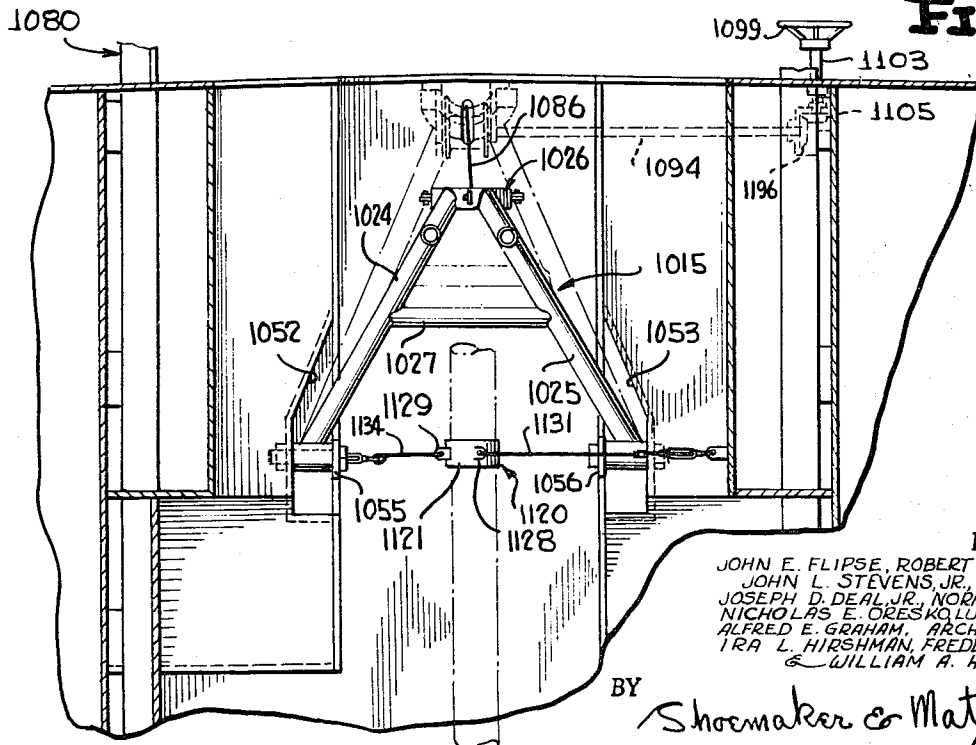


FIG. 48



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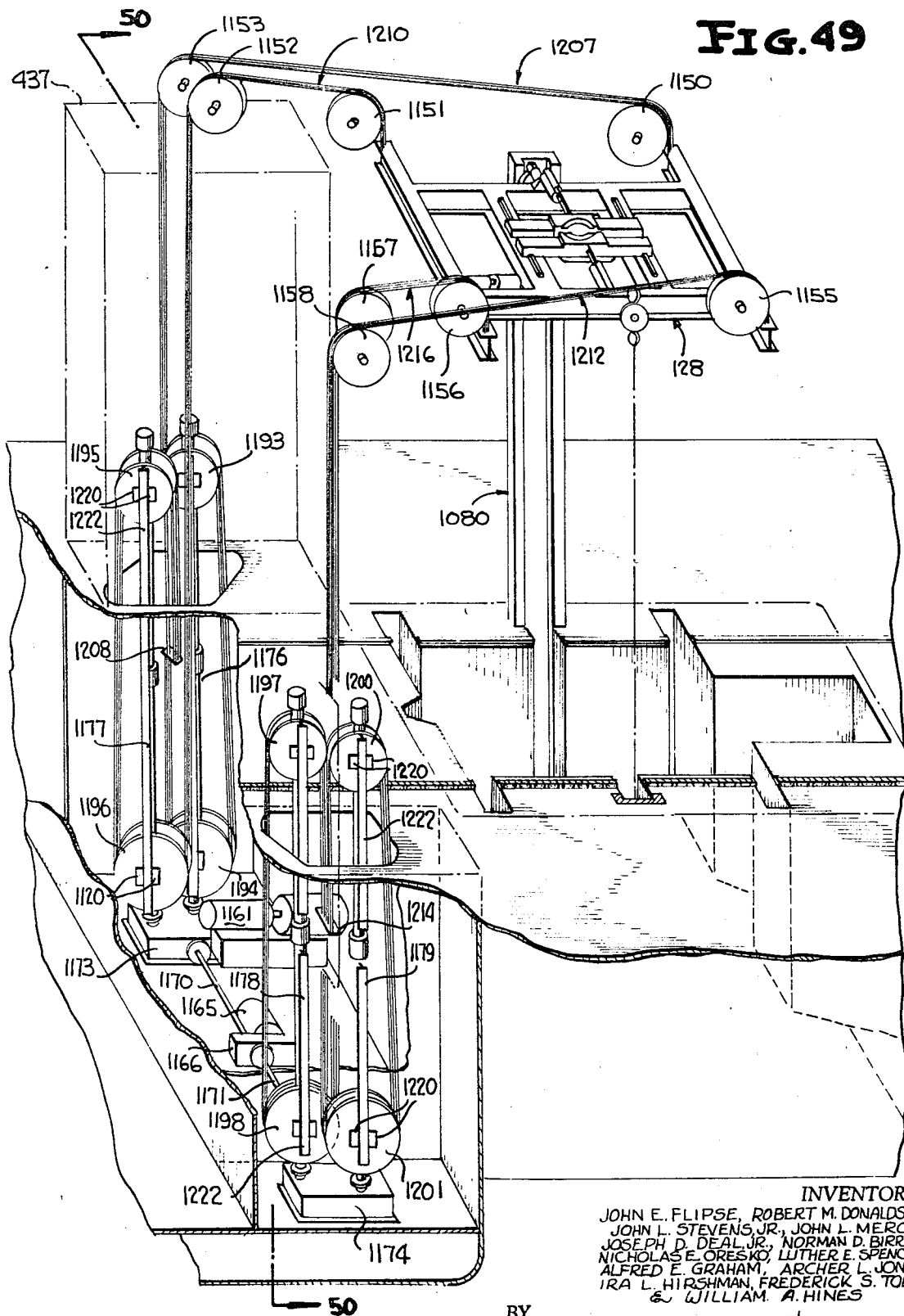
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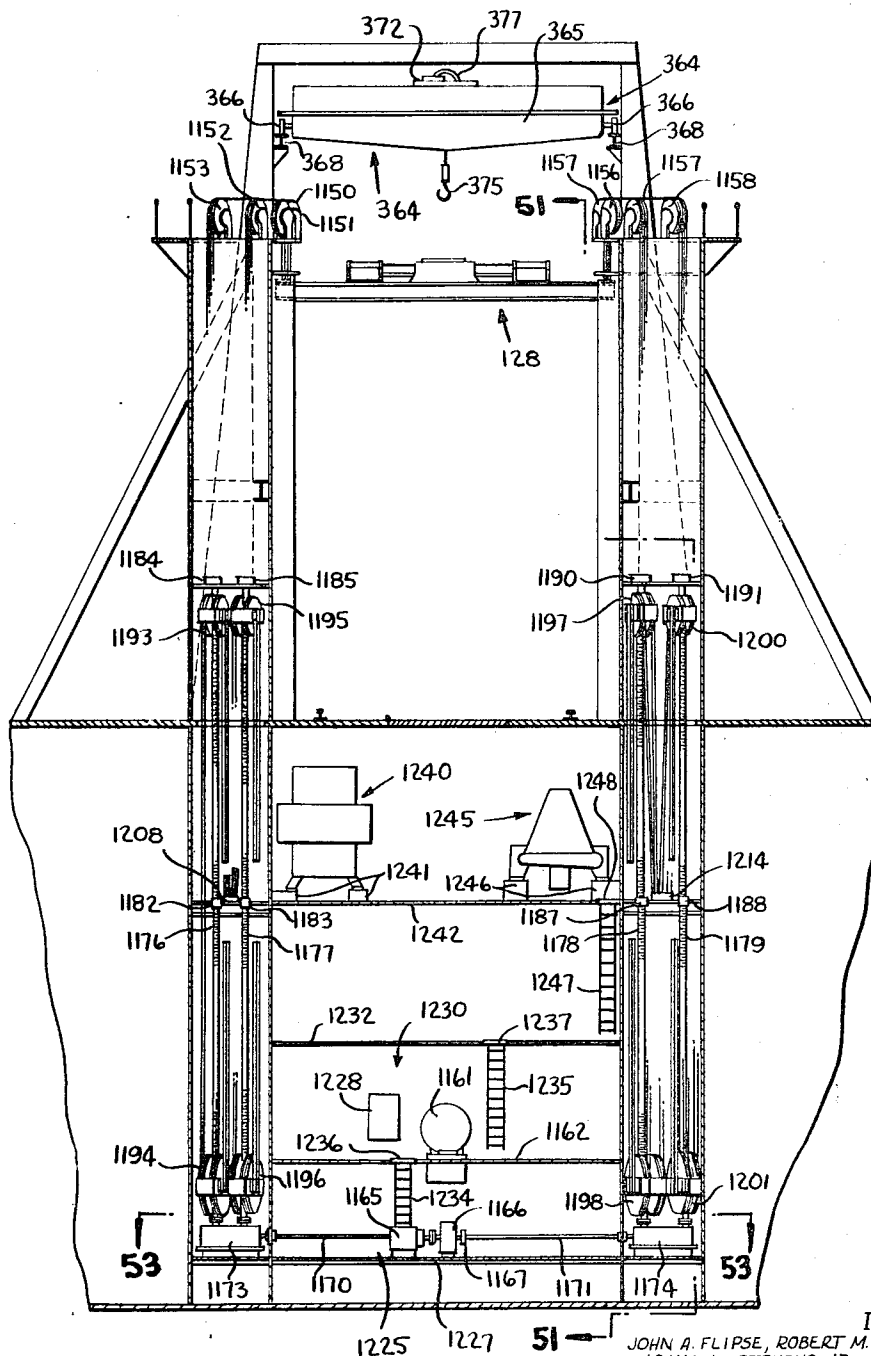
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FIG. 50



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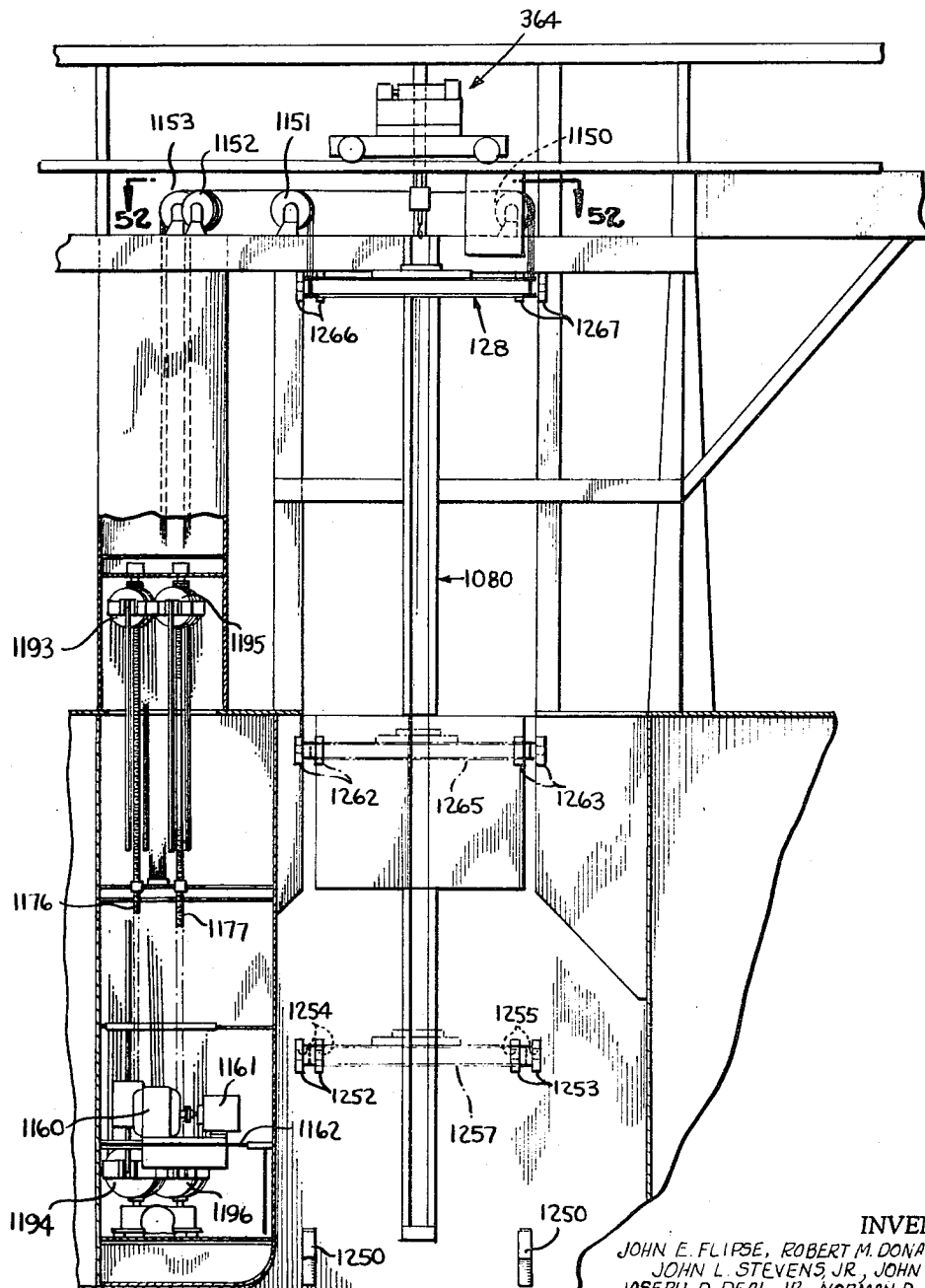
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FIG. 51



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FIG. 52

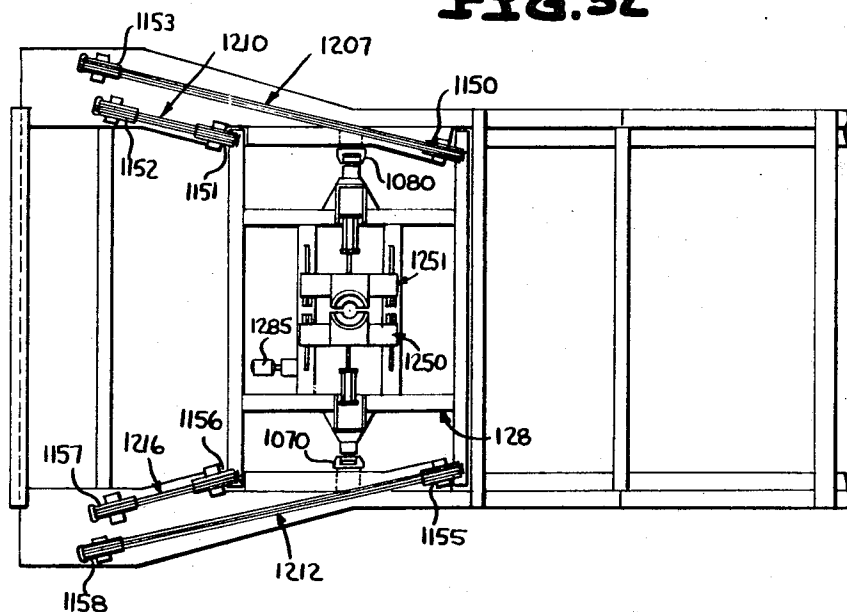


FIG. 53

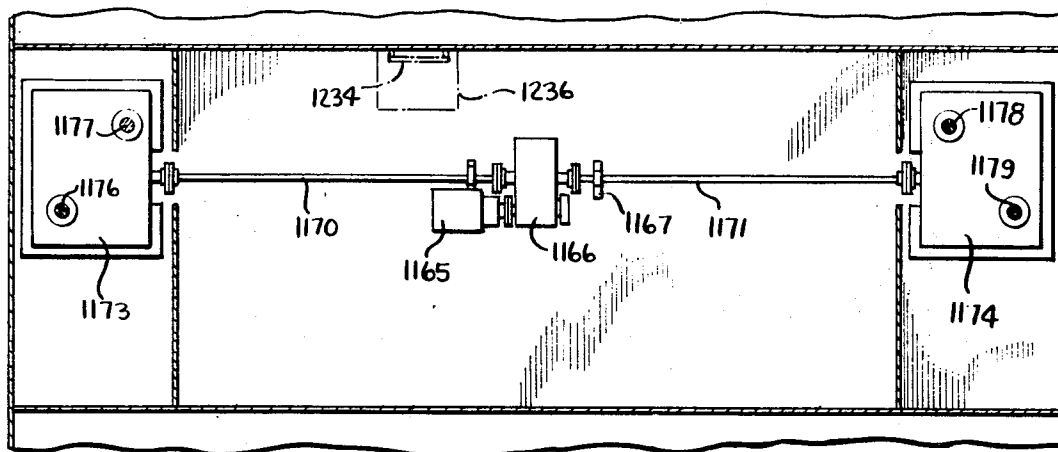
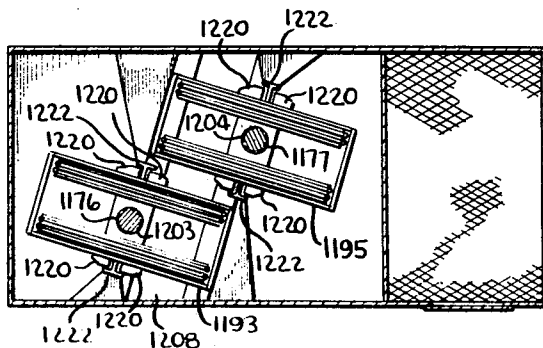


FIG. 54



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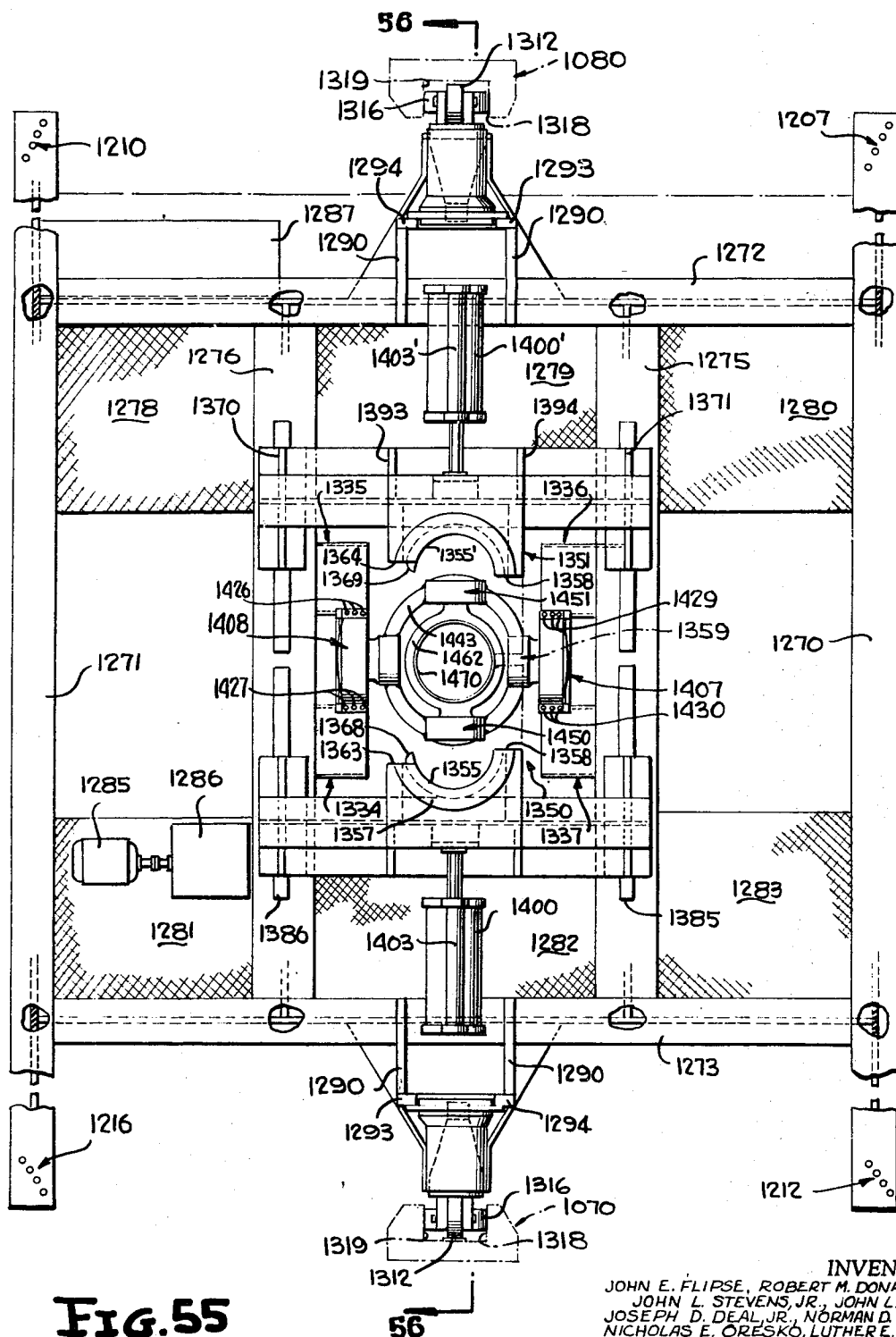


FIG. 55

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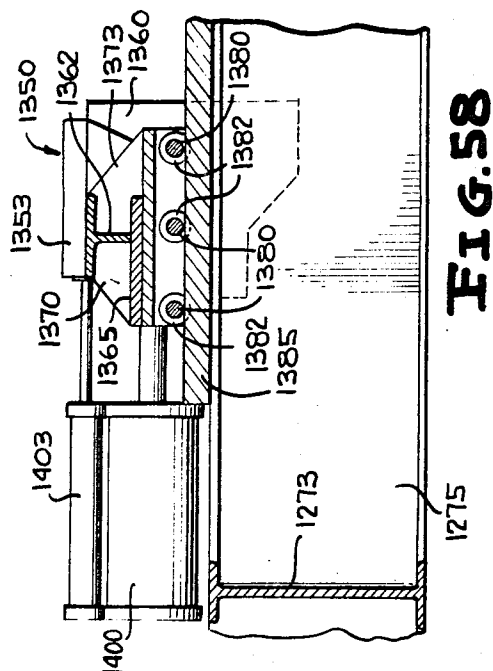
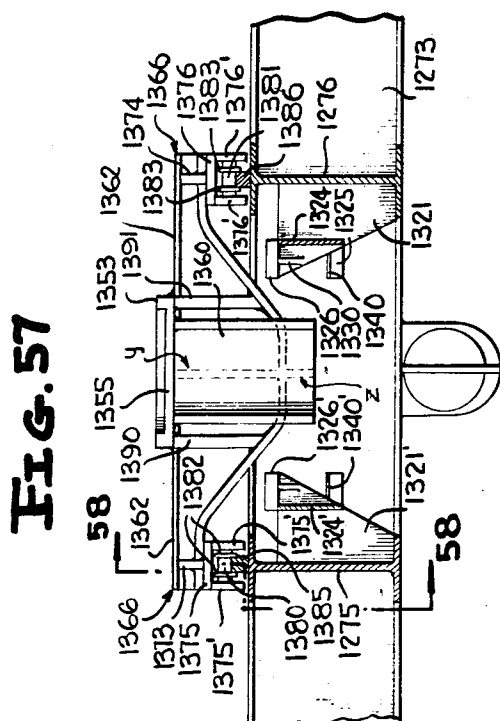
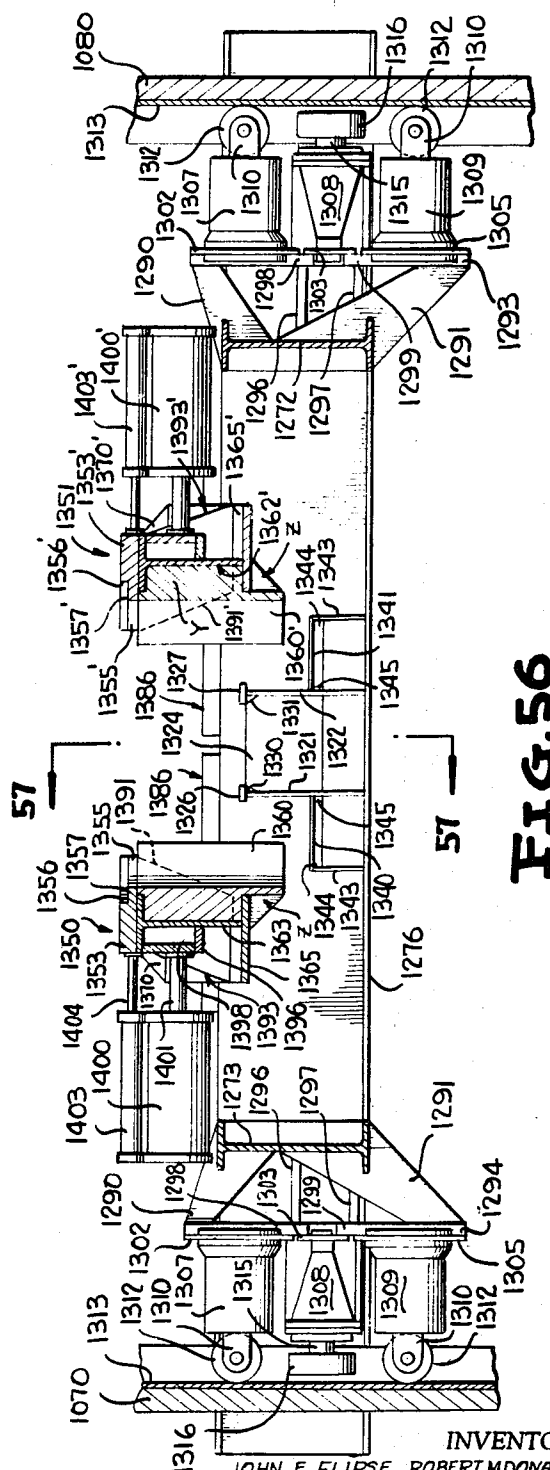


FIG. 50



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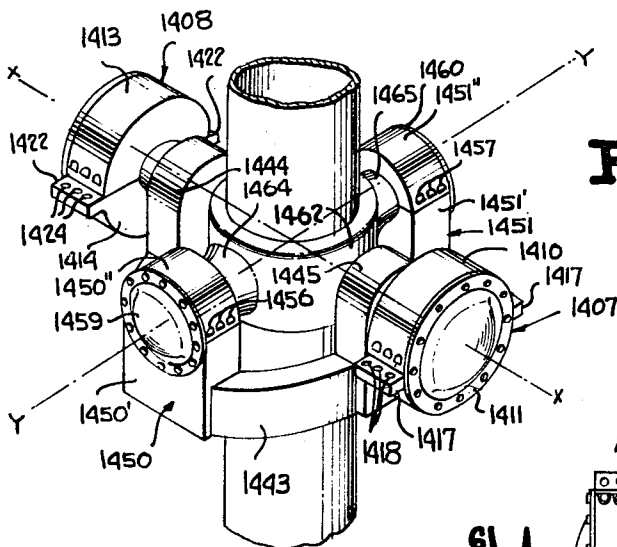
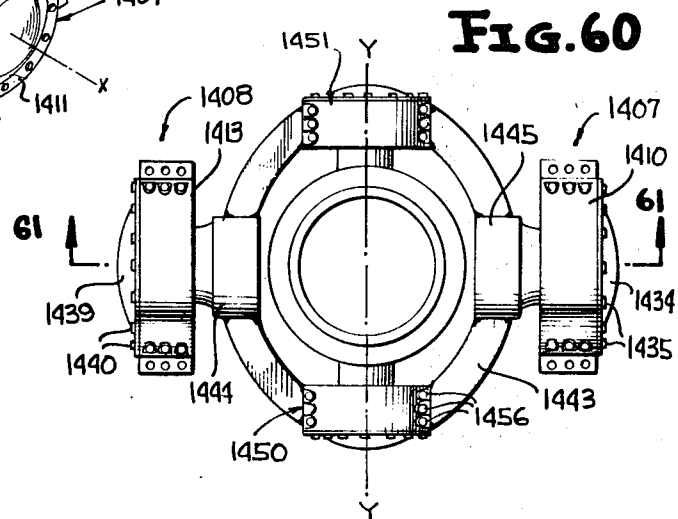
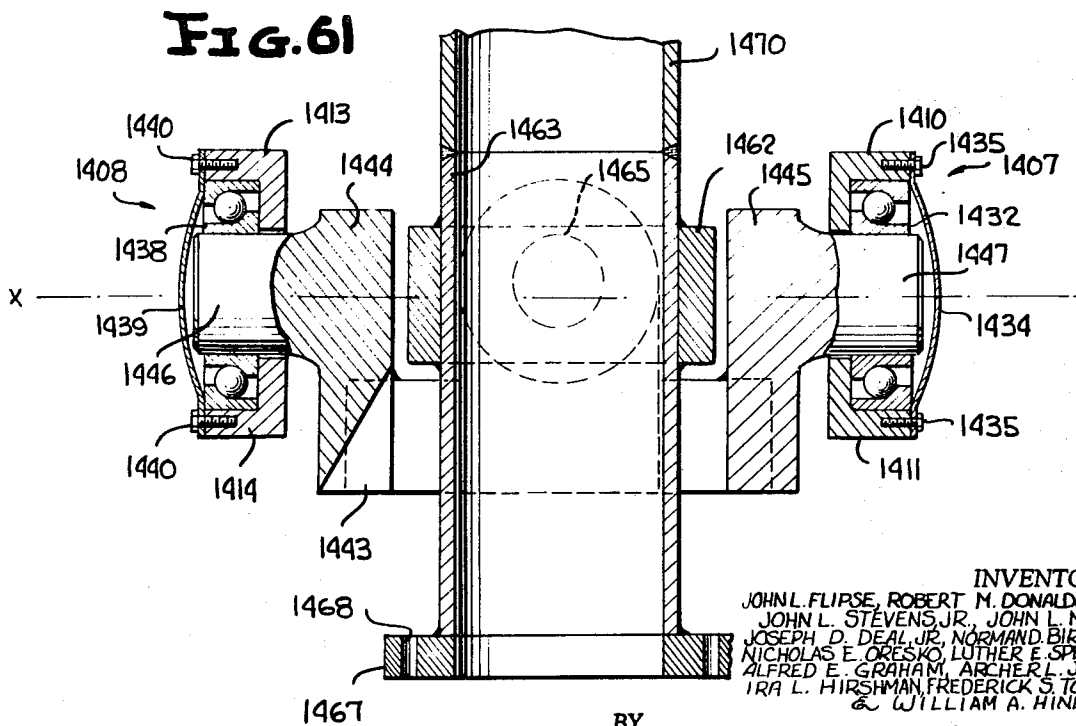
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FIG. 62

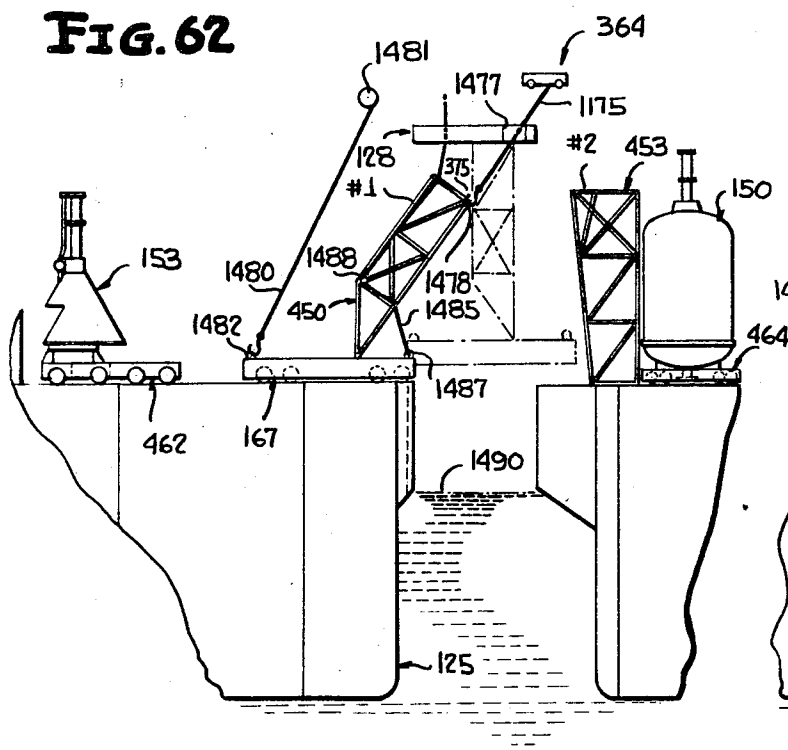


FIG. 63

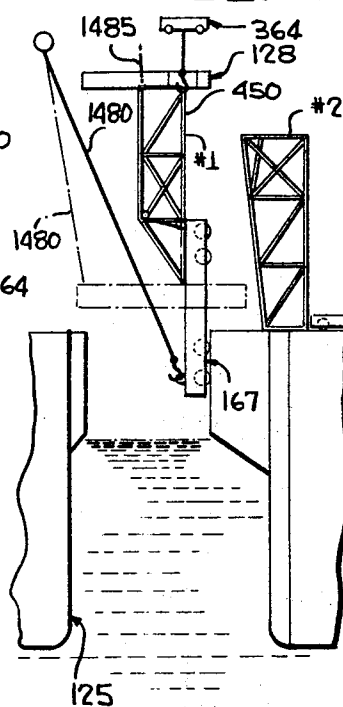


FIG. 64

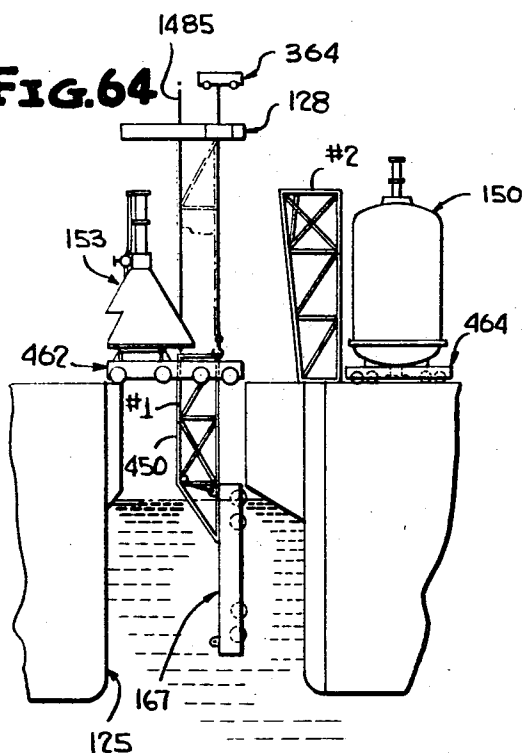
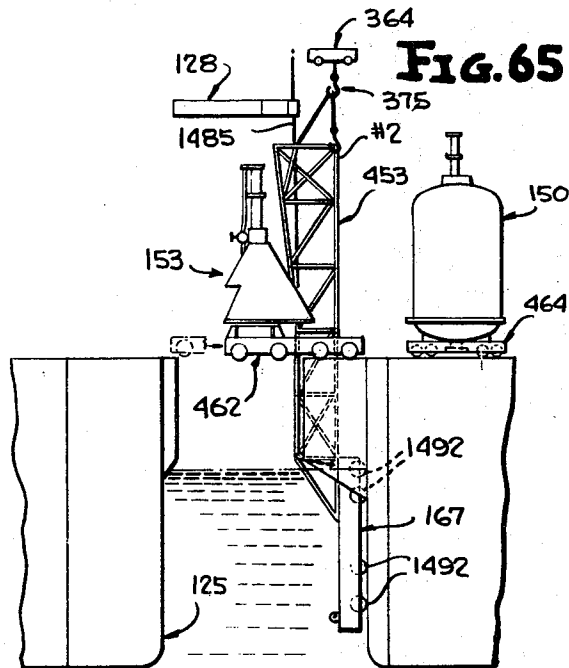


FIG. 65



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FIG. 66

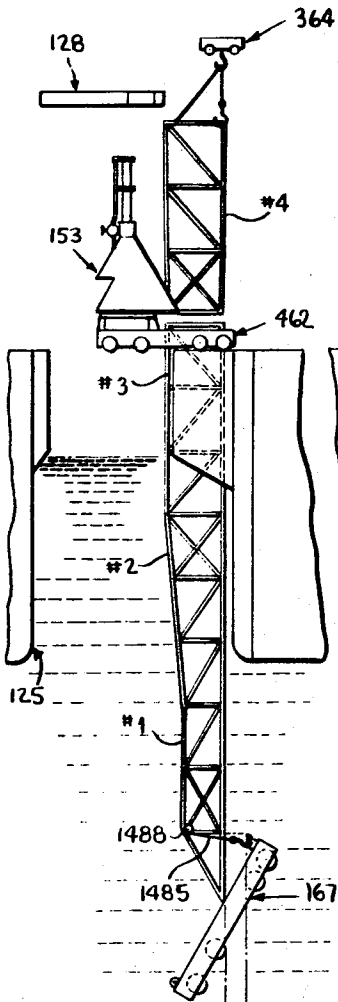


FIG. 67

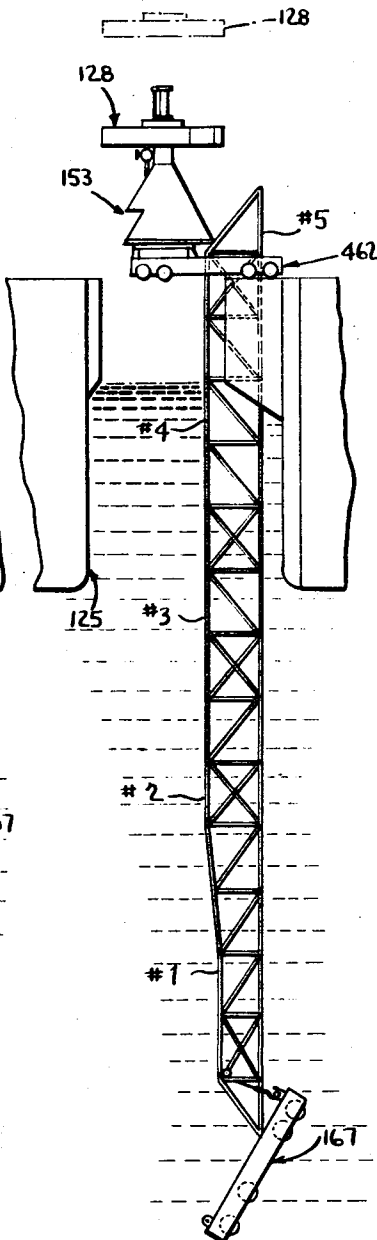
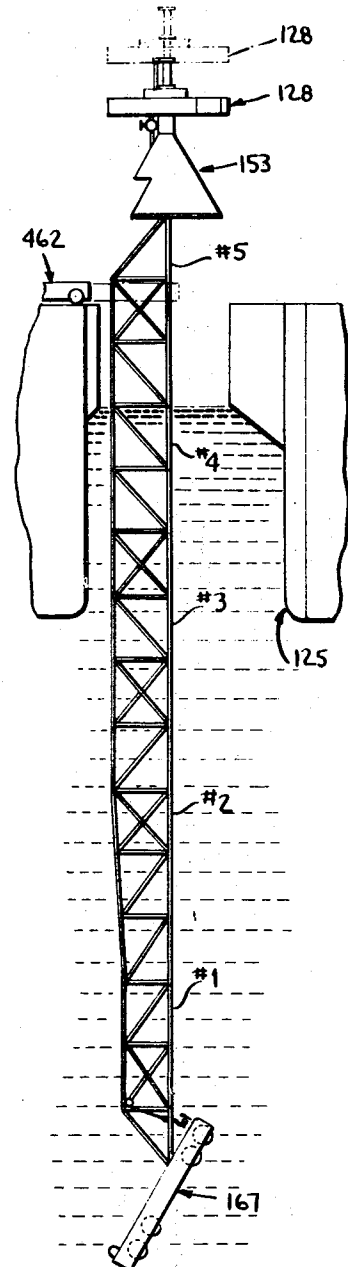


FIG. 68



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FIG. 76

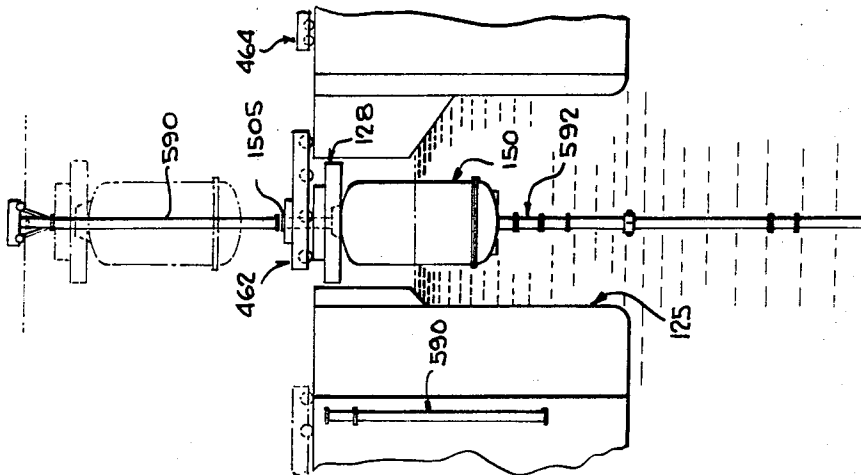


FIG. 75

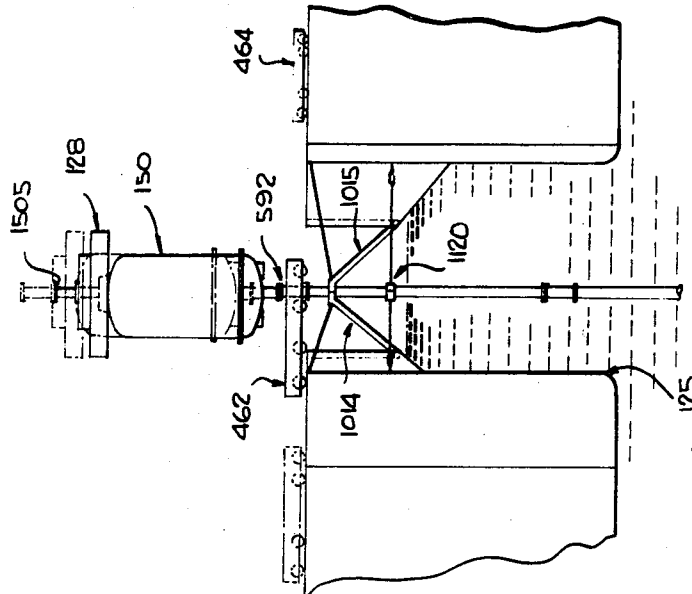
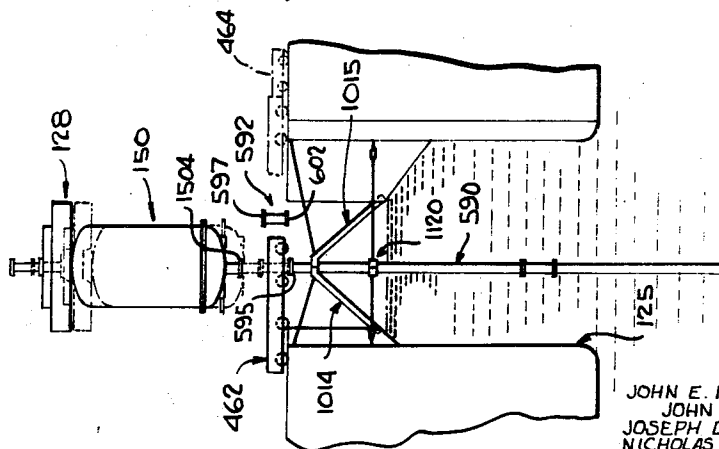


Fig. 74



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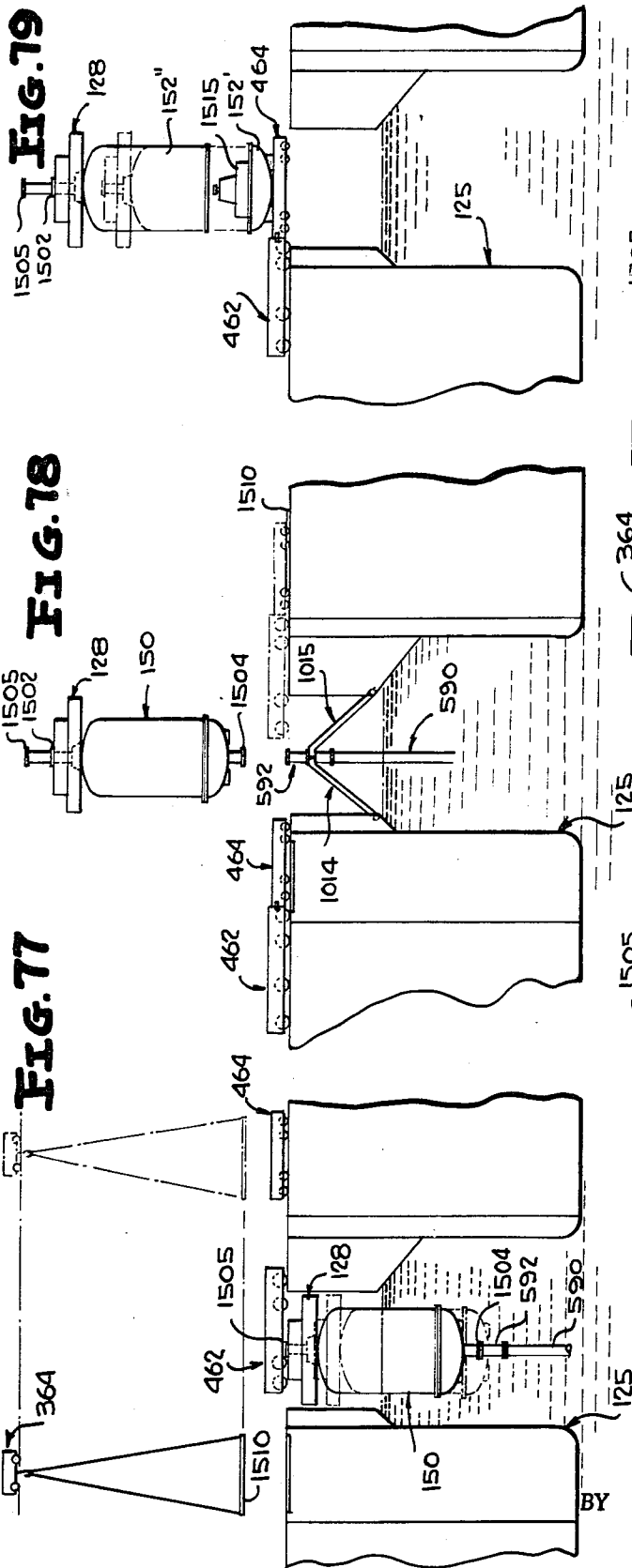
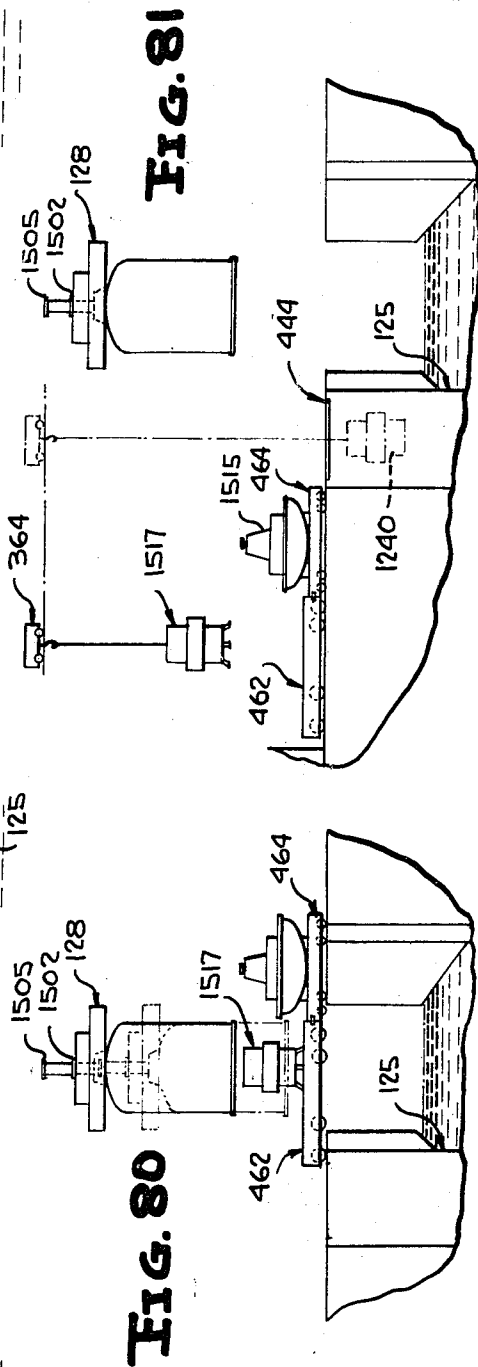
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3,522,670

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Fig. 84

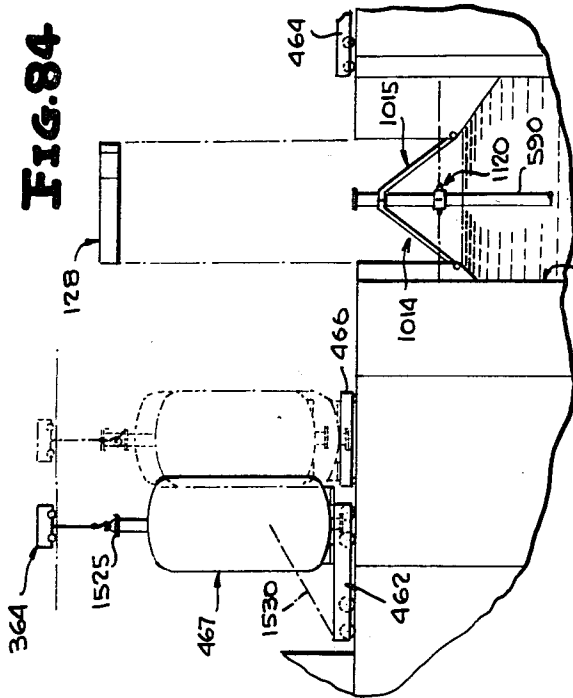


Fig. 85

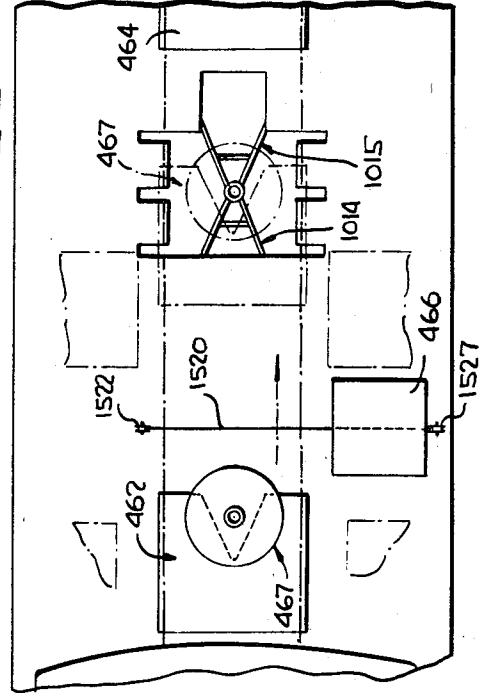


Fig. 82

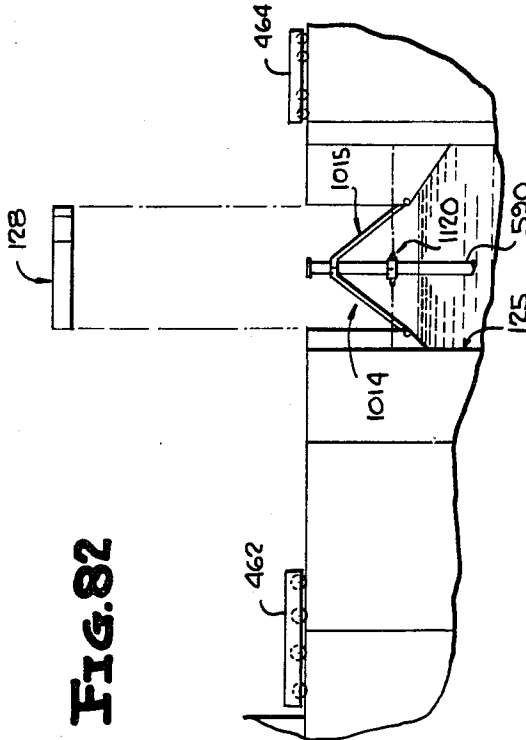
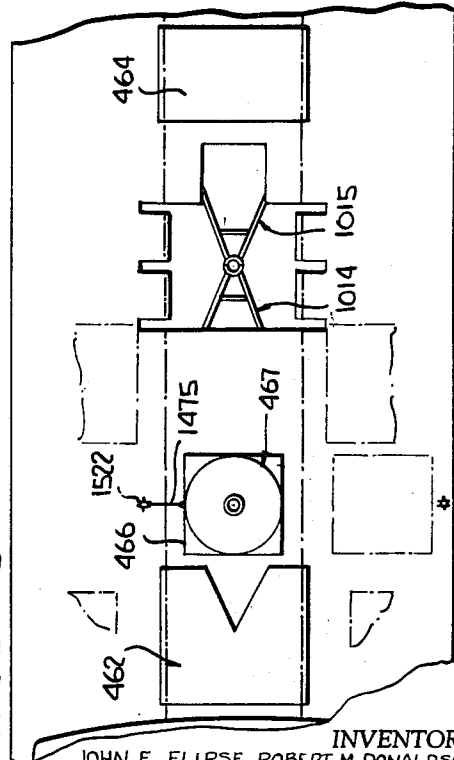


Fig. 83



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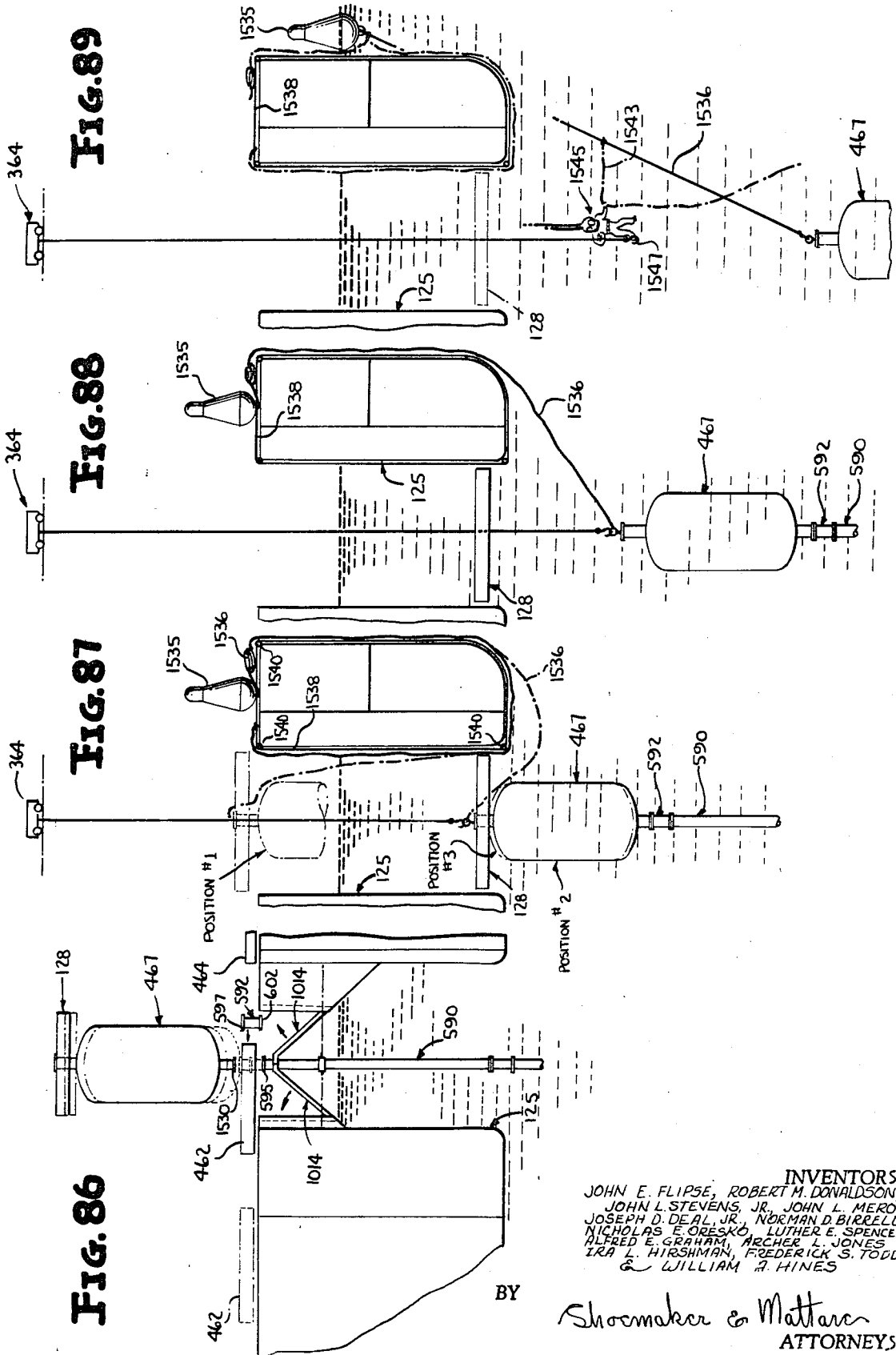
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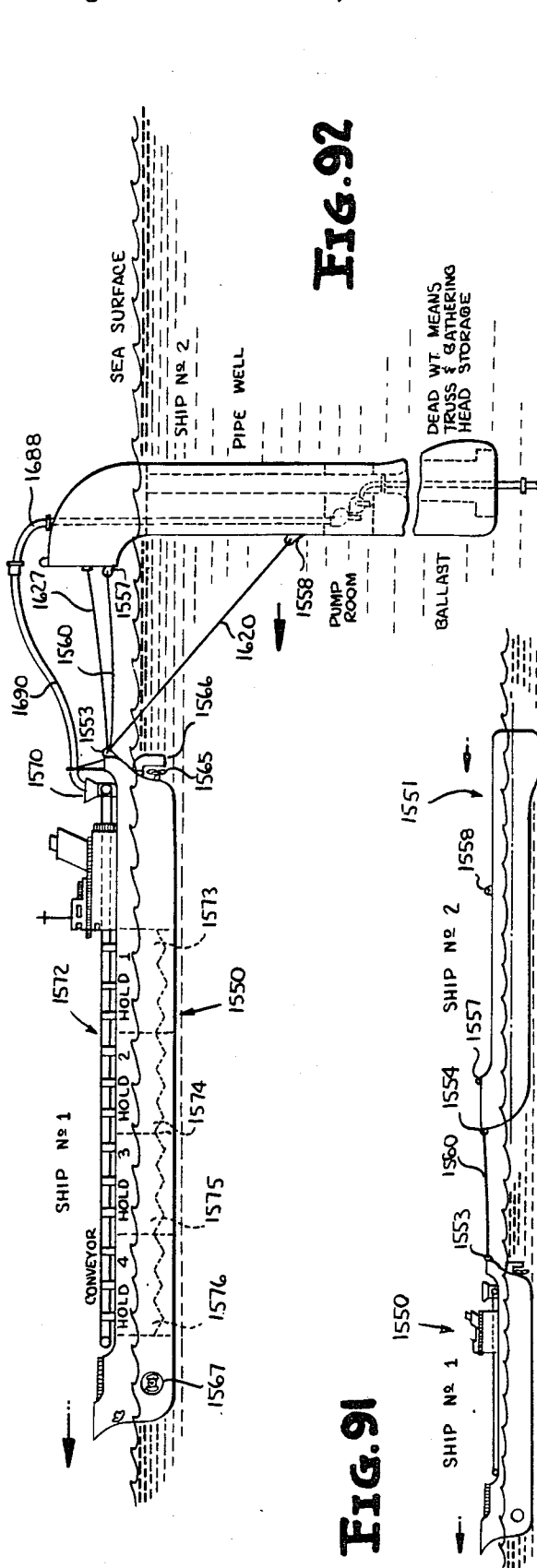
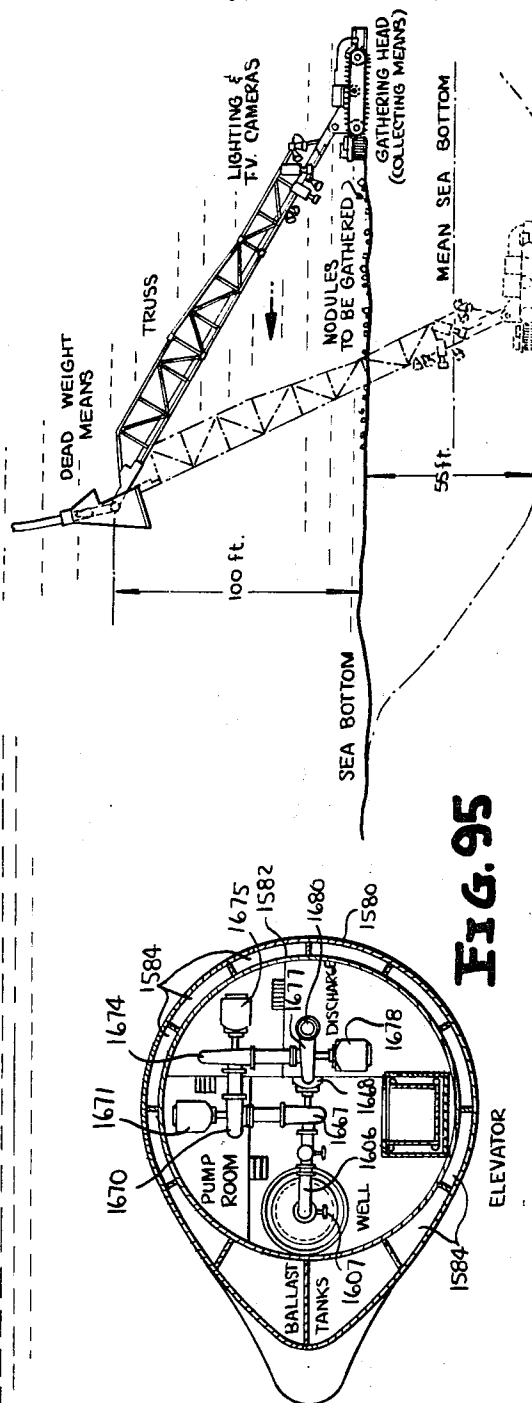
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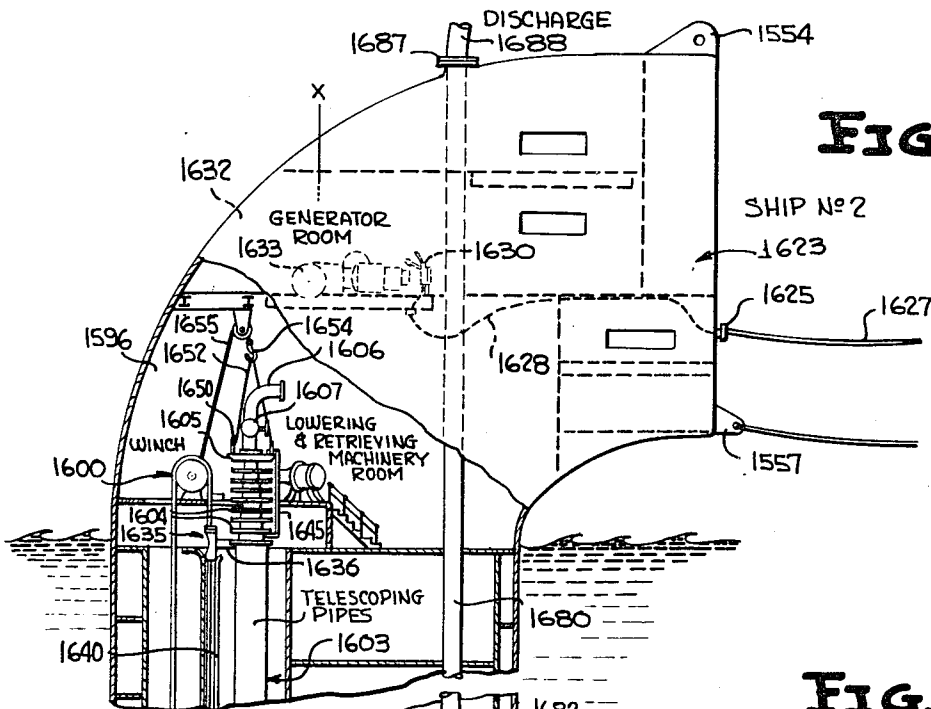


FIG. 93

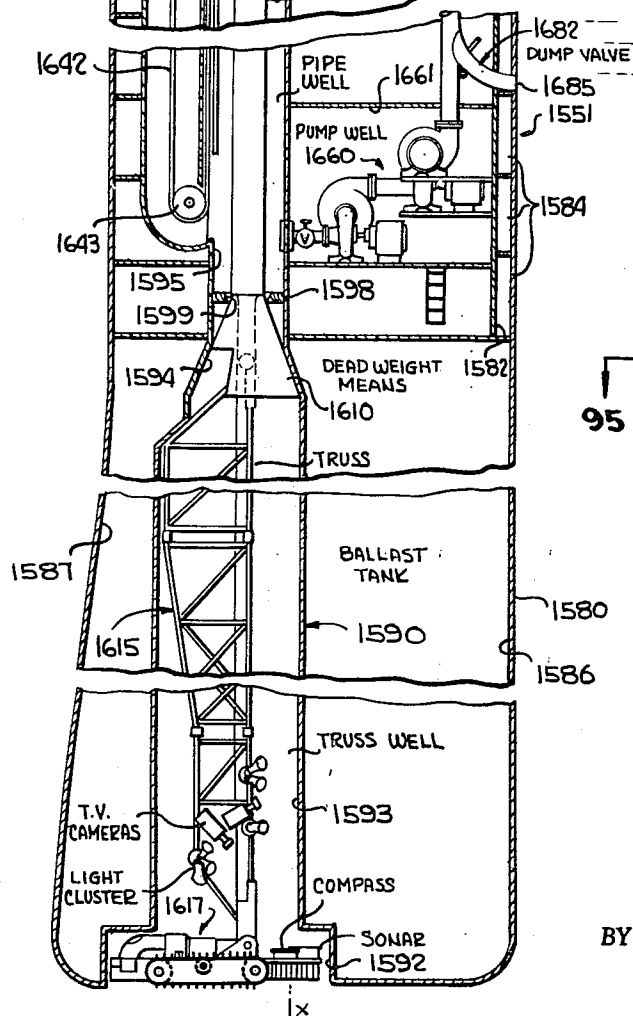
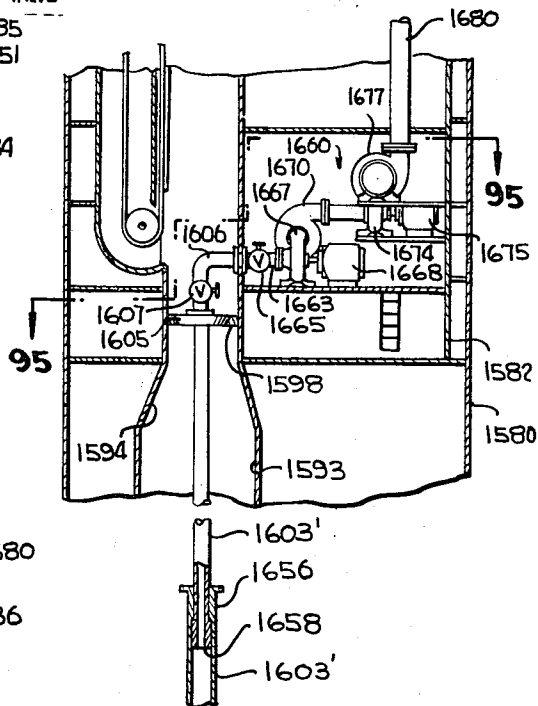


FIG. 94



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3,522,670

APPARATUS FOR UNDERWATER MINING

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Continuation of application Ser. No. 332,999, Dec. 24, 1963. This application July 11, 1967, Ser. No. 652,622

Int. Cl. E02f 3/92; B63b 35/02; G01s 9/68

U.S. Cl. 37—58

11 Claims

ABSTRACT OF THE DISCLOSURE

A unique seagoing vessel especially constructed and having stored thereon unconnected unique components of an underwater mining apparatus for mining valuable solid materials from the bottom of the sea assembled components of the apparatus are used for actual underwater mining at varying depth in excess of about 400 feet beneath the surface of the sea to adjacent the sea bottom. The ship is provided with equipment for handling and operatively assembling individual components of the apparatus one-by-one and for lowering the same from the ship to a mining operation adjacent the sea bottom. When the ship with its properly assembled and uniquely depended and attached apparatus, is moved relative to the sea surface a successful mining operation of solids is effected. When necessary assembled components may be disassembled and recovered.

This application is a continuation of application Ser. No. 332,999, filed Dec. 24, 1963, which was a continuation-in-part of application Ser. No. 308,120, filed September 11, 1963, both now abandoned.

The present invention relates to a new and novel method and apparatus for underwater mining, and more particularly to mining operations which are carried out at great depths beneath the surface of the water.

The present invention is directed to the recovery of solid substances disposed at the bottom of the sea, and it is a particular object of the present invention to provide method and apparatus for gathering solid bodies such as manganese nodules which are resting on the sea bottom, and which are found in quantities sufficient for commercial mining at depths ranging generally from 400 feet to 12,000 feet or more beneath the surface of the sea.

The existence of manganese nodules on the sea bottom has been known and documented since the latter part of the 19th century, such manganese nodules having been formed over eons of time due to settling out of certain substances in the sea. These nodules consist essentially of iron oxide, manganese oxide, copper, cobalt and nickel, these nodules being particularly rich sources of the latter three substances, and even more particularly being one of the great untapped sources of nickel in the world today.

These nodules are generally found on areas of the sea wherein the floor is relatively hard and flat since such sea bottom conditions are conducive to the formation of the manganese nodules. Although the nodules are known to be a very rich source of certain substances they have not been commercially exploited at depths of 400 to 12,000 feet and more, due to the unique and peculiar problems involved in underwater mining at such depths. Some nodules have been mined manually by lowering divers into

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the water at depths of 100 to 200 feet below the surface, but these type of operations simply are not suitable for use in the major areas where the manganese nodules are found at great depths in the sea.

The difficulties involved in underwater mining at great depths beneath the sea have heretofore been considered to be so great as to make such operations economically unfeasible. The areas in which the nodules are found in sufficient quantities are generally more than 200 miles off shore thereby necessitating operation on the high seas. The method and apparatus employed must be capable of operating under tremendous pressures and under varying environmental factors such as the prevailing winds, sea currents and sea conditions which occur at sea. In addition, in order to be economically feasible, the apparatus employed must be capable of raising a substantial amount of nodules from the sea bottom, and for example it is anticipated that a successful commercial operation must raise as much as 4,000 tons or more of nodules per day. It is accordingly clear that the nature of the operation and the problems involved require the employment of completely new methods and apparatus and the utilization of basically new concepts in order to provide the desired results.

The present invention employs the basic combination of a ship which is adapted to move through the water over a particular mining area of the sea bottom along with a collecting means which is adapted to move along the sea bottom to collect the solid manganese nodule bodies, and a conduit means is provided for transporting the collected solid bodies from the collecting means up to the ship whereat the collected bodies are stored. The collecting means is caused to move along the sea bottom through a particular mining area, the collecting means being moved and preferably guided in such a manner as to traverse or sweep through the mining area so as to gather the maximum number of nodules in an efficient manner.

The manganese nodules to be mined according to the present invention are solid generally spherical bodies normally ranging in size from small ones about the size of a toy marble to large ones the size of basketballs or even larger. As a practical matter, it is considered that mining of nodules from about 3/4 of an inch in diameter to about 6 inches in diameter may be the most economical and efficient arrangement, and accordingly the collecting means of the present invention is preferably provided with separating means for collecting only solid bodies which are within the desired size range. It is of course apparent that the various examples as to size, depth and other characteristics of the apparatus as presented herein are illustrative only in order to provide an idea as to the size and scope of the operation, it being apparent that these quantities are in no way limiting and that they may be varied in accordance with the type of operation and particular conditions existing in any certain situation.

In the general combination as discussed above, two fundamental concepts are envisioned. In a first arrangement, the ship moves under accurate guidance and at an accurate speed through the water with the conduit means depending therefrom and with the collecting means being towed by the lower end portion of the conduit means, the collecting means following the contour of the sea bottom. In a second arrangement of the present invention, means is provided on the collecting means itself for propelling or moving the collecting means along the sea bottom preferably at a particular rate and being remotely guided, and in this case the ship is manoeuvred so as to remain in the proper operative relationship with respect to the collecting means.

According to one modification of the present invention,

a completely self-contained ship is provided which is adapted to carry out the underwater mining operations far out at sea, the ship being designed to operate for extended periods of time with all of the equipment required for the underwater mining operation being carried by the ship and stowed on board. In addition, the ship includes storage means for storing the collected nodules at sea.

In a second modification of the invention, a pair of ships are employed operating in conjunction with one another, the first of the two ships providing storage means and propulsion means for towing the other ship, the other of said ships serving primarily as a support and storage means for the underwater mining equipment which is lowered from the ship downwardly to operate along the sea bottom. The first of the two ships is adapted to tow the second of the two ships through the water over a particular mining area of the sea bottom, a collecting means being provided and adapted to move along the sea bottom to collect solid manganese nodule bodies and the like. A novel conduit means is provided for transporting the collected solid bodies from the collecting means upwardly to the storage means on the first of the two ships.

In each instance, in both of the modifications of the present invention, the ship supporting the underwater mining equipment is provided with a novel well portion located in a central part of the ship such that when the ship is in operative mining position, the well portion opens downwardly into the sea and facilitates handling of the mining equipment which depends through this well portion from the ship downwardly to the sea bottom.

In both modifications of the invention, the depending conduit means includes a lower portion which is articulated with respect to the upper portion, the lower portion of the conduit means being so interconnected with the upper portion as to permit movement thereof in a manner to accommodate for variations in the depth of the sea bottom from the surface. In other words, the collecting means which is connected with the lower end of the lower portion of the conduit means may accordingly rise and fall and follow the contour and undulations of the sea bottom while the ship moves along through the water in a more or less steady path. The lower portion of the conduit means is also preferably provided with means for illuminating the bottom and for remotely viewing the bottom whereby personnel on the ship can observe the progress of the mining operation and can cause the collecting means to move in a proper path along the sea bottom for maximum efficiency of operation.

The articulated lower portion of the conduit means includes a dead weight means to which a truss portion is pivotally connected in a unique manner. The details of construction of the dead weight means and its pivotal interconnection with the truss means is shown in U.S. patent application Ser. No. 358,877, filed Apr. 10, 1964, now U.S. Pat. No. 3,302,315.

The truss construction in each of the modifications may be substantially identical and includes a plurality of individual sections which can be selectively interconnected with one another particularly in the case where the first modification is concerned, whereas in the second modification the truss may be formed as a single unit. The reason for this difference is the fact that in the first modification, it is desired to disassemble the over-all truss into a plurality of individual sections for the purpose of stowage, whereas in the second modification the entire truss unit may be stowed within the ship without disassembling the truss.

The collecting means in each modification of the present invention may be substantially identical, and the details of construction of this type of collecting means are illustrated in U.S. patent application Ser. No. 359,742, filed Apr. 14, 1969, now U.S. Pat. No. 3,305,950, the only difference being that in the present invention the collecting means is illustrated as including a unit for propelling the collecting means along the sea bottom, where-

as in the aforesaid U.S. patent application disclosing a similar collecting means, the collecting means is adapted to be towed and accordingly merely includes supporting wheels for movement along the sea bottom.

The collecting means of the present invention is particularly designed for movement along the sea bottom, and as mentioned above may either be towed along the bottom or may be provided with a propelling system for moving the collecting means in the desired manner. Various arrangements may be provided for facilitating movement of the collecting means along the sea bottom such as wheels, endless tracks or runners and the like, and various forms of propelling means may be utilized for moving the collecting means where this arrangement is desired.

The collecting means employs size discriminating means in the form of spaced teeth and the like which are adapted to reject nodules which are not of the desired size so that the collecting means can collect only solid bodies of a size which is considered desirable. The collecting means also includes a collecting throat portion to which all of the collected bodies are directed, the lower end of the conduit means being operatively connected with this throat portion for entraining the collected nodules and moving them upwardly through the conduit means to the ship.

A pumping means is provided in each modification of the invention, this pumping means being connected in the conduit means for creating a flow of water through the conduit means sufficient to entrain the nodules and to carry the nodules upwardly from the collecting means to the ship. A particular feature of the present invention is the fact that the pumping means is connected at an intermediate point in the conduit means which is disposed a substantial distance below the surface of the sea. With this arrangement, the water and the nodules are in effect sucked upwardly within the conduit means from the collecting means to the pumping means, whereupon the water and the nodules are then pumped positively from the pumping means the remaining distance to the ship. This arrangement is considered essential in order to enable proper hydraulic performance of the pumping means, and the pumping means is preferably disposed a distance below the surface of the sea which is approximately 10 percent or more of the distance from the surface of the sea to the collecting means at the sea bottom. While the disposition of the pumping means may be varied to a certain extent, it must be located a distance below the surface of the sea sufficient to prevent cavitation in the pump.

The collecting means and the conduit means associated therewith as well as the pumping means for inducing the flow of the liquid and solid body mixture through the conduit means are interrelated with one another and designed so as to operate at peak efficiency at a particular solids to liquid ratio of such mixture. In order to ensure that the apparatus operates at optimum efficiency, a remotely controlled valve means is connected in the conduit means and a variable speed pump means is connected in the conduit means which can also be remotely controlled to maintain a substantially constant ratio of solids to liquid of the mixture formed through the conduit.

In order to perform the most economical mining operation, it is essential to maintain a substantially steady course of movement of the collecting means through a particular mining area. Especially in the case where the collecting means is being towed, special attention must be given to current conditions at the mine site. In an area where tidal currents prevail, it will probably be necessary to set up a scheduled ship's heading to change course with each tide change making appropriate adjustments for wind and sea conditions to avoid zigzagging across the mine field.

All of this emphasizes that it is necessary to provide exacting navigational techniques to accurately locate the

collecting means and determine its direction of travel and movement along the sea bottom. Accordingly, the present invention provides novel navigation equipment which provides means for determining the position of the collecting means of the underwater mining apparatus with respect to a fixed reference base line whereby the necessary information is obtained at all times. Furthermore, in order to properly direct the mining operation, means is provided for plotting the position and heading of the collecting means with respect to such base line. Means is also provided for determining the relative position of the collecting means with respect to the ship and the linear distance therebetween so that the ship can be properly manoeuvred in order to maintain its correct operating position relative to the collecting means.

The mining ship employed in the first modification of the present invention is of a unique construction and includes a central well portion which permits ready access to the sea for lowering large heavy components of the underwater mining equipment into the sea and for lifting such equipment out of the sea, this well portion being so positioned as to facilitate handling of the equipment on the ship and positioning of the ship properly for lowering operations.

The ship is also provided with means which provides a stable ship for supporting the underwater mining equipment and which permits the ship to be precisely controlled and accurately manoeuvred into proper position. Since the mining operation or movement of the collecting means will nominally be at speeds less than 5 knots, a controllable reversible pitch propeller is provided for obtaining the necessary control. In order to assure a reasonably steady ship's heading, a bow thruster means is installed in the bow portion of the ship to counter the effects of wind and sea. In a typical example, the ship should be designed for a free route speed of about 14 knots for travel between port and the mine site with cargo and wing tanks ballasted as required to maintain a draft of about 30 feet with the underwater mining equipment stowed as illustrated in the drawings. Anti-roll tank means is also incorporated in the ship to minimize roll and to provide the maximum degree of stability.

Since all of the underwater mining equipment is adapted to be carried to the mining site by the ship, the ship must include means for stowing all of the equipment on board and for handling the equipment to move it from its stowed position into operative mining position and to return it to its stowed position when required.

The underwater mining equipment when supported in operative mining position is suspended downwardly through the well portion formed in the ship, and since the collecting means is travelling along the bottom of the sea while the ship is moving to a certain degree on the surface of the sea with respect to the underwater components, it is necessary to permit a certain degree of relative movement between the conduit means and the ship. Accordingly, means is provided for supporting the conduit means from the ship so that such relative movement may occur.

The mining ship of the present invention is adapted to store a substantial quantity of solid bodies of collected material within hold means provided therein, and the hold means of the present invention is of a particular construction so as to receive such solid bodies of material. In addition, since the storage means on the ship is limited, it is essential in order to provide an economical operation to be able to transfer the solid bodies from the holds of the mining ship to an auxiliary cargo ship while the mining ship is at sea and conducting substantially continuous mining operations. Accordingly, the present invention also provides a unique transfer system which permits the cargo stored within the holds of the mining ship to be transferred to another ship on the high seas. A principle involved here is to tow a cargo ship about 600 feet astern of the mining ship and to float a suitable conduit means between the two vessels. The cargo is fluidized and pumped to the cargo

ship by means of the novel transfer system incorporated in the mining ship itself.

The conduit means employed in the first modification of the invention includes a plurality of separate sections of such a construction that they may be readily and quickly assembled and disassembled and which provide an effective joint between the individual section when assembled. These conduit sections furthermore are constructed so as to permit ready handling by the ship handling apparatus for lifting and lowering the conduit sections as required, the conduit sections also being of reinforced construction so as to afford adequate strength and rigidity adjacent to the handling portions thereof. Means is also provided on the conduit sections for assisting in properly aligning the conduit sections when assembling them for lowering into operative mining position.

The mining ship according to the first modification of the invention includes a unique stowage means for stowing the individual sections of the conduit means in as compact a space as possible, the individual sections being maintained in proper stowed position by suitable guide portions provided within the stowage area which also ensure that the conduit sections are properly guided when being removed from the stowage area or returned thereto.

Means is also provided within the stowage area on the ship in the form of a manoeuvrable vehicle which permits a single operator to move about within the stowage area and to effectively lift and lower the large conduit sections and move them into the desired position.

Suitable handling means is provided on the ship to enable the handling of the underwater mining components. An overhead bridge crane means arranged for bridge travel in a fore and aft direction and trolley travel athwartships is provided for lifting and lowering the components as required.

In addition, a movable support means is mounted for movement in a fore and aft direction along the deck of the ship, this support means including its own driving means and power operated clamping means which is adapted to engage and support certain of the underwater mining components. Means is also provided for locking the movable support means against movement relative to the deck and further for locking the clamping means in operative position when under load.

A further movable support means is provided for particularly supporting the pumping means on the deck of the ship, this last-mentioned support means also being movable fore and aft along the deck.

Elevator means is provided which is movable into the well portion and thereabove for manoeuvring various components of the underwater mining apparatus into the desired position. This elevator means also includes clamping means for clamping and holding portions of the underwater mining equipment. Means is provided for locking this elevator means in several different operative positions as the case may be, and gimbal means is provided for permitting the necessary degree of relative movement between the conduit means and the ship during the mining operation, this gimbal means being operatively supported in a central part of the elevator means.

In addition to the elevator means which is adapted to clamp and hold certain components within the well portion, an auxiliary support means is also provided which is selectively movable into operative position within the well portion for supporting certain components therewithin. The first modification of the invention also contemplates a novel method of lowering certain portions of the underwater mining equipment into operative position and lifting them back into stowed position on the ship. A novel method is also provided for connecting and lowering and pumping means into operative position along with the conduit means of the invention.

A further novel method of the invention includes a procedure for lifting the pumping means and separating the two portions thereof for handling the internal com-

ponents thereof as necessary for servicing or replacing certain ones of these components.

The invention further includes a novel method of rigging the underwater mining equipment for jettisoning from the ship and recovery thereof. This involves completely releasing the underwater mining equipment from the ship so that it is adapted to rest on the bottom of the sea whereby the ship may steam away and return at a later date. Means is provided for guiding the ship back to the proper location and for facilitating recovering of the underwater mining equipment whereby it may be again connected in operative relationship with the mining ship.

Considering now the second modification of the invention wherein two different ships are employed, these ships are of basically different construction. Firstly, a relatively conventional ship construction is provided wherein the ship is provided with the usual propulsion and steering mechanism and is further provided with suitable storage means for storing collected solid bodies. Means is provided for attaching this more-or-less conventional ship construction to the other of the two ships utilized in the mining operation.

The second of the two ships involved in the operation is of a unique construction. This ship is of the type which is elongated about a longitudinal axis, the ship being adapted for normal movement along the surface of the sea in a direction wherein the longitudinal axis thereof is substantially horizontal. Means is further provided in this second ship construction to move the ship into a position wherein the longitudinal axis thereof is disposed in a substantially vertical position with the major portion of the ship extending downwardly below the surface of the sea. In this position, the latter mentioned ship construction is adapted to be towed and guided in its movement through the water by the first mentioned ship construction of relatively conventional design.

The second mentioned ship construction includes all of the equipment required for performing that portion of the mining operation involved in collecting the solid bodies of material and lifting these bodies of material to the surface. The first mentioned ship construction may include means for separating out the solid collected bodies from undesirable materials and for distributing and storing the collected bodies. The ship containing the underwater mining equipment is a completely self-contained independent unit insofar as controlling and operating the mining equipment is concerned, it only possibly being necessary to provide an auxiliary source of power to the ship if such should be required.

The second ship construction which supports and stores the mining equipment is of a novel arrangement in including a well portion which extends substantially parallel with the longitudinal axis thereof and within which the major components of the underwater mining equipment may be stored when not in operative mining position. The well portion opens through one end portion of the associated ship, and this opening actually may comprise an enlarged recess portion within which the collecting means is normally stored while the ship is in transit and which further facilitates lowering of the collecting means into operative mining position.

The conduit means in the present invention comprises a plurality of separate independent sections which are disposed in telescoping arrangement with one another and which include portions adapted to engage each other to retain the sections in operative mining position. This telescoping arrangement enables the conduit means to be stored in the most compact arrangement possible and further facilitates lowering and lifting of the mining equipment into and out of operative mining position. Since the conduit sections are stored lengthwise or parallel with the longitudinal axis of the ship, very long lengths of conduit may be employed thereby reducing the number of indi-

vidual sections necessary for achieving any particular length of conduit as required.

The conduit means employed in this particular modification in addition to the telescoping conduit sections described above also includes a dead weight means in combination with a truss portion pivotally interconnected with the collecting means so as to provide an articulated lower portion of the conduit means for the same purpose as previously discussed.

It should be noted at this point that all of the aforementioned structure including the telescoping conduit sections, the articulated lower portion of the conduit means and the collecting means are stored in such a position that when the associated ship is disposed in operative mining position, these elements may be simply lowered out of the ship thereby decreasing to a minimum the time and effort required in moving the mining equipment into its operative position. It will be readily apparent that this same arrangement thereby facilitates lifting of the mining equipment back into its stored position, and accordingly, a very efficient and reliable over-all arrangement is provided.

Pumping means is also connected in the conduit means of this modification at an intermediate point in the conduit means disposed a substantial distance below the surface of the sea and again being disposed a distance below the surface of the sea sufficient to prevent pump cavitation.

In order to permit the pumping means to be mounted at the desired intermediate point in the conduit means as described above, the pumping means is mounted within the ship containing the mining equipment at a lower portion thereof and is connected with the upper end of the conduit means normally stored within the ship. A conduit portion extends upwardly from the pumping means to the uppermost portion of the associated ship when in its operative mining position, suitable means being provided for transferring the collected nodules from the upper end of this upper conduit portion to the storage means on the other ship.

The pumping means may be disposed at approximately the desired relationship beneath the surface of the water since the ship itself may be of considerable length whereby the pumping means mounted in the lower portion thereof will be disposed at a very substantial distance below the surface of the sea. A particular advantage of this arrangement is the fact that the pumping means while being disposed a substantial distance beneath the sea surface is at the same time readily accessible to personnel in order that repairs and replacement of parts can be effected in the most efficient manner. It is evident that it is much simpler to maintain the pumping means in the dry confines of the ship wherein it is not necessary to raise or lower the pumping means nor at any time is it necessary for the pumping means to be submerged in an inaccessible position in the water. Accordingly servicing of the pumping means with this particular arrangement may be accomplished under more-or-less ideal conditions.

It is also considered desirable and perhaps essential that pumping means employed with mining operations at depths of 12,000 feet or more beneath the surface of the sea be constructed as a multi-stage pumping arrangement in order to obtain the desired amount of lifting force so as to raise the nodules from such great depths to the surface. By mounting the pumping means within the ship, a multi-stage pumping arrangement is facilitated since the ship itself is of sufficient dimensions so as to permit the proper spacing and interrelationship of the pump stages with respect to one another in order to obtain the desired degree of efficiency of operation. Accordingly, the disposition of the pumping means within the ship itself enables of the ready employment of a multi-stage pumping means.

In the general scheme of the mining operations to

be carried out with the ships according to the present invention, it is anticipated that once the ship supporting the mining equipment is in operative position, it may remain in such operative position for extended periods of time. On the other hand, the storage ship associated therewith and which normally tows the mining equipment supporting ship through the water will be periodically filled with collected solids bodies, and upon reaching its capacity will of course have to return to port to discharge its cargo. It is accordingly anticipated that the first or conventional ship construction will ferry back and forth between port and the second ship construction. Accordingly, a plurality of such first ship constructions may be employed with a single second ship construction as discussed above, the conventional storage ship constructions plying back and forth and replacing one another in rotation in order that the mining equipment can remain in substantially continuous operation.

An object of the present invention is to provide a new and novel method and apparatus for underwater mining to be carried out on the high seas and for collecting or gathering solid bodies or masses of material from the sea bottom.

Another object of the invention is the provision of a method and apparatus for underwater mining which is particularly adapted for mining operations at great depths beneath the surface of the sea under varying environmental factors such as prevailing winds, sea currents and sea conditions.

A further object of the invention is to provide apparatus for underwater mining including suitable fluid operated means for lifting the collected solid bodies from the collecting means upwardly a great distance to the associated ship.

Still another object of the invention is the provision of apparatus for underwater mining including collecting means which is adapted for movement along the sea bottom and which includes means for collecting only certain size solid bodies.

Another object of the invention is to provide a novel method of underwater mining including a ship, a depending conduit means and a collecting means connected to the lower end of the conduit means and which is towed along the sea bottom by the ship.

Still a further object of the invention is to provide a novel method of underwater mining including a ship having a depending conduit means connected therewith and a collecting means connected with the lower end portion of the conduit means, and wherein means is provided for propelling the collecting means along the sea bottom, and the ship is manoeuvred in such a manner as to remain in proper operative position with respect to the collecting means.

Another object of the present invention is to provide means for controlling the solids to liquid ratio of the mixture flowing through the conduit means to obtain optimum efficiency of operation.

A further object of the invention is the provision of underwater mining apparatus including remotely controlled valve means disposed in the conduit means thereof and a variable speed pump means connected in the conduit means which is also remotely controllable to maintain a substantially constant ratio of solids to liquid of the mixture flowing through the conduit.

Another object of the invention is to provide means for determining the position of the collecting means of the underwater mining apparatus with respect to a fixed reference base line.

A further object of the invention is the provision of means for plotting the position and heading of the collecting means with respect to a base line.

Another object of the invention is to provide means for determining the relative position of the collecting means with respect to the ship and the linear distance therebetween.

A further object of the present invention is to provide a mining ship including means which permits ready access to the sea for lowering large heavy components of the mining equipment into the sea and for lifting such equipment out of the sea, and which is so positioned as to facilitate handling of the equipment on the ship and positioning of the equipment properly for lowering operations.

Another object is to provide a ship for use in underwater mining operations including means which provides a stable ship for supporting the underwater mining equipment, the ship being capable of being precisely controlled and accurately manoeuvred into any desired position for carrying out underwater mining operations.

A further object of the invention is to provide a unique ship for use in underwater mining operations which is a self-contained unit and which includes means for storing all the equipment on board the ship and for handling the equipment as required to move it into or out of operative mining position.

A further object of the invention is to provide a ship for use in underwater mining operations including means for supporting conduit means utilized in the underwater mining operation in operative mining position and permitting a certain degree of necessary relative movement between the conduit means and the ship.

Another object of the invention is the provision of a ship for use in underwater mining operations including novel cargo storage means and incorporating a unique transfer system for transferring the cargo from the storage means to a cargo ship while the mining ship is conducting underwater mining operations.

A further object of the present invention is to provide a conduit section construction which permits the conduit means to be readily and quickly assembled and disassembled and which provides an effective joint between the sections when assembled.

Another object is to provide a conduit section construction which permits ready handling by the ship handling apparatus for lifting and lowering the conduit sections as required and wherein the conduit sections are of reinforced construction so as to afford adequate strength and rigidity adjacent the handling portions provided on the conduit section.

A further object of the invention is to provide a conduit section construction including means for enabling proper alignment of the conduit sections with respect to one another.

Another object of the invention is the provision of conduit means including means for permitting rise and fall of the collecting means connected to the lower end of the conduit means to accommodate for variations in the depth of the sea bottom from the sea surface.

A further object of the present invention is to provide a ship for use in underwater mining operations including stowage means for stowing individual conduit sections in as compact a space as possible.

Another object is to provide stowage means which effectively holds the individual conduit sections in proper stowed position and which also provides means for properly guiding the individual sections out of the stowage area when the sections are being lifted therefrom.

A further object of the invention is the provision of handling means which allows a single operator to effectively move and position large conduit sections within the stowage area.

A still further object of the present invention is to provide a movable support means which is adapted to support components of the underwater mining equipment and to move relative to the supporting deck surface for transferring components from one position to another.

Another object is the provision of a movable support means which comprises a self-contained unit including its own driving means and power operated clamping means.

A further object of the invention is to provide a

movable support means adapted to move relative to a supporting deck surface and including means for holding the movable platform means in fixed position relative to said deck means and also to provide means for holding the movable clamping means of the support means in its operative clamping relationship when the clamping means is under load.

Another object of the invention is to provide novel dolly means which is adapted to move along the deck of the ship and to support components of underwater mining equipment and which further is adapted to be coupled to a movable means for moving the dolly means into a desired operative position.

A further object of the present invention is to provide underwater mining equipment including a ship having a well portion therein opening downwardly into the sea and including auxiliary support means having separate support portions which are movable into supporting position to support underwater mining equipment components at the central part of the well, these movable support portions also being movable out of the well portion to provide a substantially unobstructed well area through the ship.

Another object of the invention is the provision of auxiliary support means as defined in the previous object and including an additional means therebelow for engaging and holding certain portions of underwater mining equipment in fixed spaced relation to the walls of the well portion.

A further object of the present invention is to provide apparatus for underwater mining at great depths beneath the surface of the sea including a ship having a well portion therein opening both in an upward and in a downward direction and elevator means associated with said well portion and movable so as to lower components of underwater mining equipment into said well portion and to lift such components out of said well when desired.

Another object is to provide elevator means as aforesaid including means for selectively clamping and holding underwater mining equipment components in position while the elevator means itself is lifted or lowered as the case may be.

A further object of the invention is to provide elevator means as described above which includes gimbals means for supporting mining equipment in operative position and which permits the necessary relative movement between the underwater mining equipment and the ship.

Still another object of the invention is the provision of elevator means movable in an up and down direction as aforesaid and providing lock and stop means for locking the elevator means in particular operative positions and to limit movement of said elevator means in a downward direction.

A further object of the present invention is to provide a new and novel method of underwater mining including a ship movable through the water and having a central well portion and wherein all of the underwater equipment is stowed on the ship, the method including steps for interconnecting all of the components and lowering the components through the well portion of the ship into operative mining position for underwater mining at great depths beneath the surface of the sea.

Another object is to provide a method as defined in the foregoing object including additional method steps for lifting all of the underwater mining equipment back upwardly through the well portion and stowing the components on the ship.

Still another object of the present invention is to provide a novel method of handling the internal components of the pumping means so as to be able to readily gain access to such internal components for servicing or replacement thereof as required.

A further object of the invention is to provide a novel

method of rigging the underwater mining equipment for jettisoning from the ship and for lowering the so rigged mining equipment such that the mining equipment may be left at the mining area with portions thereof resting on the sea bottom and with the conduit means maintained in a substantially erect position by an attached buoyancy means which allows the mining ship to leave the mining area, and wherein the equipment may be subsequently relocated, recovered and lifted back into operative mining position or into stowed position on the ship as desired.

A further object of the invention is to provide two types of mining ship constructions, a first ship construction including the main propulsion means and storage means for carrying out the mining operation, while the second ship construction incorporates an arrangement for storing, lifting and lowering the mining equipment into and out of operative mining position.

Still another object of the invention is the provision of conduit means arranged in individual sections of great length which are telescoped with respect to one another to provide maximum facility of lifting and lowering into and out of operative position and further which also includes means to permit the rise and fall of the collecting means connected to the lower end portion of the conduit means to accommodate for variations in the depth of the sea bottom from the sea surface.

Yet another object of the invention is to provide apparatus for underwater sea mining including a novel ship construction wherein the collecting means is mounted within a recess at one end of the ship construction so as to facilitate moving of the collecting means into and out of its operative mining position.

A still further object of the invention is to provide apparatus for underwater mining including suitable pumping means for lifting the collected solid bodies from the collecting means upwardly a great distance to the storage means, the pumping means being enclosed within the ship and readily accessible for servicing and also being mounted in such a manner as to enable a multi-stage pumping arrangement.

Yet another object of the invention is to provide novel apparatus for underwater mining which is relatively massive in size due to the quantities of material being handled and which is designed to be as compact as possible, and which is quite efficient and reliable in operation.

Other objects and many attendant advantages of the invention will become more apparent when considered in connection with the specification and accompanying drawings wherein:

FIG. 1 is a somewhat schematic view illustrating the over-all arrangement of the apparatus employed in the underwater mining operation according to the present invention;

FIG. 2 is a schematic representation of a form of the mining apparatus according to the present invention incorporating means for controlling the solids to liquid ratio of the mixture flowing through the conduit means to obtain optimum efficiency of operation;

FIG. 2a is a top view of the bottommost portion of the conduit means illustrating the manner in which it is connected with a portion of the collecting means and also showing the diffusion valve means disposed in said conduit means;

FIG. 2b is a sectional view taken substantially along line 2b—2b of FIG. 2a looking in the direction of the arrows;

FIG. 2c is a rear view of the structure shown in FIG. 2a;

FIG. 3 is a schematic illustration of the navigation system employed in the present invention;

FIG. 4 is a diagrammatic illustration of the basic arrangement and interrelationship of certain components of the navigation system illustration in FIG. 3;

FIG. 5 is a top view of a plotting means for plotting the position and heading of the collecting means with respect to a base line;

FIG. 6 is a front elevation of the structure shown in FIG. 5;

FIG. 7 is a side elevation of the rear or stern half of a ship;

FIG. 7' is a side elevation of the front or bow half of the ship shown in FIG. 7, it being understood that FIG. 7' is to be matched with FIG. 7 so as to provide an illustration of the over-all ship;

FIG. 8 is a top view of that portion of the ship shown in FIG. 7, with certain portions removed for the sake of clarity of illustration;

FIG. 8' is a top view of that portion of the ship shown in FIG. 7', it being understood that FIG. 8' is to be matched with FIG. 8 so as to provide a top view of the over-all ship, with certain portions removed for the sake of clarity of illustration;

FIG. 9 is a view illustrating the manner in which collected solid bodies of material are transferred from the mining ship to another ship;

FIG. 10 is a sectional view taken substantially along line 10—10 of combined FIGS. 7-7' looking downwardly in the direction of the arrows;

FIG. 11 is a sectional view taken substantially along line 11—11 of combined FIGS. 7-7' looking downwardly in the direction of the arrows;

FIG. 12 is a sectional view taken substantially along line 12—12 of FIG. 10 looking in the direction of the arrows;

FIG. 13 is a sectional view taken substantially along line 13—13 of FIG. 7' looking in the direction of the arrows;

FIG. 14 is an enlarged side elevation of a portion of the ship with certain parts removed or broken away for the sake of clarity;

FIG. 15 is a view taken substantially along line 15—15 of FIG. 14 looking downwardly in the direction of the arrows;

FIG. 16 is a sectional view taken substantially along line 16—16 of FIG. 14 looking in the direction of the arrows;

FIG. 17 is a sectional view taken substantially along line 17—17 of FIG. 14 looking downwardly in the direction of the arrows;

FIG. 18 illustrates three different types of conduit sections employing the novel construction of the present invention;

FIG. 19 is an enlarged view partially broken away of one of the constructions illustrated in FIG. 18;

FIG. 20 is a top view of the construction shown in FIG. 19 broken away in certain portions to illustrate certain details of construction;

FIG. 21 is a sectional view taken substantially along line 21—21 of FIG. 20 looking in the direction of the arrows;

FIG. 22 is a sectional view partly broken away through the stowage area for the individual conduit sections according to the present invention;

FIG. 23 is a sectional view taken substantially along line 23—23 of FIG. 22 looking in the direction of the arrows;

FIG. 24 is a sectional view taken substantially along line 24—24 of FIG. 22 looking in the direction of the arrows;

FIG. 25 is a top perspective view illustrating the details of construction of the upper support means;

FIG. 26 is a top perspective view of a first form of the lower support means;

FIG. 27 is a top perspective view of a second form of the lower support means;

FIG. 28 is a sectional view taken substantially along line 28—28 of FIG. 23 looking in the direction of the arrows;

FIG. 29 is a top perspective view illustrating the manner in which the conduit sections are secured in place on certain of the upper support means portions;

FIG. 30 is a view looking upwardly within the stowage area illustrating the portable rail section arrangement of the present invention;

FIG. 31 is an enlarged sectional view taken substantially along line 31—31 of FIG. 24 looking in the direction of the arrows;

FIG. 32 is a sectional view taken substantially along line 32—32 of FIG. 31 looking in the direction of the arrows;

FIG. 33 is a front view partially broken away and partially in section of the handling means employed in the stowage area for lifting, lowering and transporting the individual conduit sections;

FIG. 34 is a view taken substantially along line 34—34 of FIG. 33 and illustrating certain portions in section;

FIG. 35 is a sectional view taken substantially along line 35—35 of FIG. 33 looking in the direction of the arrows;

FIG. 36 is a top perspective view partially broken away and with certain parts removed for the sake of clarity illustrating a portion of the stowing area, two different operative positions of the overhead crane mechanism and showing the movable support means in operative position overlying the well portion of the ship;

FIG. 37 is a top view of the movable support means according to the present invention;

FIG. 38 is an elevation of the movable support means illustrated in FIG. 37;

FIG. 39 is a sectional view taken substantially along line 39—39 of FIG. 38 looking in the direction of the arrows;

FIG. 40 is a sectional view taken substantially along line 40—40 of FIG. 38 looking in the direction of the arrows;

FIG. 41 is a sectional view taken substantially along line 41—41 of FIG. 37 looking in the direction of the arrows;

FIG. 42 is a top view of the dolly means of the present invention which is particularly adapted for supporting the pumping means;

FIG. 43 is a sectional view taken substantially along line 43—43 of FIG. 42 looking in the direction of the arrows;

FIG. 44 is a sectional view taken substantially along line 44—44 of FIG. 42 looking in the direction of the arrows;

FIG. 45 is a top perspective view partially broken away and with parts removed for the sake of clarity illustrating the manner in which the auxiliary support means of the present invention is mounted with respect to the well portion of the ship;

FIG. 46 is a sectional view taken substantially along line 46—46 of FIG. 45 looking in the direction of the arrows;

FIG. 47 is a sectional view taken substantially along line 47—47 of FIG. 46 looking in the direction of the arrows;

FIG. 48 is a sectional view taken substantially along line 48—48 of FIG. 46 looking in the direction of the arrows;

FIG. 49 is a top perspective view partly broken away and with certain parts removed for the sake of clarity which illustrates the general arrangement and interrelationship of the well portion of the ship, the elevator means, and the means for lifting and lowering the elevator means;

FIG. 50 is a sectional view taken substantially along line 50—50 of FIG. 49 looking in the direction of the arrows;

FIG. 51 is a sectional view taken substantially along line 51—51 of FIG. 50 looking in the direction of the arrows;

FIG. 52 is a view looking downwardly in the direction of the arrows along the line 52—52 of FIG. 51;

FIG. 53 is a sectional view taken substantially along

line 53—53 of FIG. 50 looking in the direction of the arrows;

FIG. 54 is a sectional view taken substantially along line 54—54 of FIG. 51 looking in the direction of the arrows;

FIG. 55 is a top view partly broken away of the elevator means itself;

FIG. 56 is a sectional view taken substantially along line 56—56 of FIG. 55 looking in the direction of the arrows;

FIG. 57 is a sectional view taken substantially along line 57—57 of FIG. 56 looking in the direction of the arrows;

FIG. 58 is a sectional view taken substantially along line 58—58 of FIG. 57 looking in the direction of the arrows;

FIG. 59 is a top perspective view illustrating the construction of the gimbal means of the present invention;

FIG. 60 is a top view of the gimbal construction shown in FIG. 59;

FIG. 61 is a sectional view taken substantially along line 61—61 of FIG. 60 looking in the direction of the arrows;

FIGS. 62 through 76 inclusive illustrate method steps involved in lowering the components of the underwater mining equipment through the well portion of the ship downwardly into operative mining position and also certain steps involved in lifting the mining equipment back upwardly through the well portion of the ship.

FIGS. 77 through 81 inclusive illustrate in a somewhat schematic manner the steps involved in the procedure for lifting the pumping means and the attached depending conduit means through the well portion and for handling the internal components of the pumping means.

FIGS. 82 through 89 inclusive illustrate in somewhat schematic manner certain procedural steps involved in rigging the equipment for jettisoning and illustrating the manner in which the so rigged equipment is lowered into operative position;

FIG. 90 is a view illustrating the underwater mining equipment resting in its jettisoned position with the collecting means and the dead weight means resting on the sea bottom and with the buoy means disposed at the surface of the sea.

FIG. 91 indicates schematically the position and interconnecting of the two ship constructions when moving through the water along the sea surface when either going to or from a particular mining area;

FIG. 92 illustrates the over-all arrangement of the apparatus employed in the underwater mining operation according to the present invention;

FIG. 93 is a longitudinal section partially broken away through the ship containing the underwater mining equipment when the ship is in its normal operative mining position and with the mining equipment in its elevated or stored position;

FIG. 94 is an enlarged view of a portion of the ship shown in FIG. 93 and illustrating the manner in which the conduit means is operatively connected with the pumping means when in operative mining position, and

FIG. 95 is a sectional view taken substantially along line 95—95 of FIG. 94 looking in the direction of the arrows.

Referring now particularly to FIG. 1 of the drawing, the over-all arrangement of the invention is schematically illustrated, the details thereof being hereinafter more fully described. As seen in this figure, a ship indicated generally by reference numeral 110 is illustrated, and in a typical example the ship may have an over-all length of about 625 feet with a displacement at operating draft of about 32,000 tons. The ship includes a bow portion 111 and a stern portion 112, a bow thruster mechanism being indicated generally by reference numeral 113 for providing accurate control of the direction of movement

of the ship, a controllable reversible pitch propeller 114 being provided at the stern of the ship.

The ship is provided with a well portion indicated by reference numeral 125, this well portion being disposed substantially midway between opposite side portions of the ship thereby providing a centrally located well which opens upwardly and also opens downwardly into the sea and which in fact is open completely through the ship so as to provide a means for readily lowering or streaming the conduit means downwardly in initially setting up the underwater mining equipment and further to facilitate lifting or retrieval of the mining equipment into the ship when desired.

The upper end portion of the conduit means more fully hereinafter described is indicated generally by reference numeral 126, it being noted that such upper end portion of the conduit means extends into the well portion. This upper portion of the conduit means is suitably supported within the well portion by some means such as indicated by reference numeral 128 which may take the form of an elevator mechanism or the like. In any event, means 128 serves to interconnect the conduit means with the ship and to at least partially support the weight of the conduit means therebelow.

The conduit means continues upwardly, and an arcuate portion 129 extends forward into such a position as to discharge into a separator mechanism 130. The separator mechanism is adapted to separate out the collected solid bodies or manganese nodules while rejecting the sea water and any superfluous material of an undesirable nature.

After the solid bodies have been separated by mechanism 130, they are discharged onto a longitudinally extending conveyor mechanism 132 which is adapted to carry the nodules forwardly over the holds indicated respectively by reference numerals 135, 136, 137 and 138. Suitable means is provided for discharging the collected nodules from the conveyor mechanism downwardly into the holds or storage means 135—138.

The ship is provided with a suitable superstructure 140 which may include a travelling crane and similar handling mechanism for handling the underwater mining equipment as required. The ship also includes a pipe stowage area 142 within which the individual sections 145' of the pipe or conduit means is supported when not in use in depending relationship from the ship. The pipe stowage areas are sufficient to store all of the individual sections 145' of the conduit means.

The conduit means is indicated generally by reference numeral 145, the conduit means comprising a plurality of individual sections of pipe which may be formed of steel or similar material and which in a typical example may include individual sections approximately 36 feet in length and having an inner diameter of approximately 19 inches. The various sections of pipe of the conduit means are secured to one another by means of suitable flanges being provided at the ends of the sections as hereinafter described, these flanges being fixed to one another by conventional nut and bolt assemblies.

A buoyant pumping means 150 is provided at an intermediate point in the conduit means, this pumping means including a watertight capsule 152 serving to house the pump of the present invention. The pump may in a typical example take the form of a large centrifugal pump which may have a capacity of about 14,000 gallons per minute or more and a weight in excess of 30,000 lbs. A driving motor for the pump is also mounted within the capsule 152, the driving motor in such a typical example having a 2,100 H.P. rating at 550 r.p.m. and a weight in excess of 26,000 lbs. The specific details of the pumping means of the present invention are disclosed in U.S. patent application Ser. No. 359,877, filed Apr. 14, 1964, now U.S. Pat. No. 3,325,672.

The conduit means includes a portion 151 extending

downwardly from the pumping means 150 and being connected with a dead weight means 153. This dead weight means as seen in FIG. 1 may have a substantially frusto-conical configuration and a relatively flat bottom edge portion which is adapted to rest upon the bottom of the sea. This configuration permits the conduit means to drop downwardly into such a position that the bottom portion of the dead weight means rests upon the bottom of the sea while the conduit means extending upwardly thereupon will be supported in a substantial vertical position due to the buoyancy of the pump capsule 152. The specific details of construction of the dead weight means 153 and the manner of pivotal interconnection with the truss mechanism hereinafter described is illustrated in U.S. patent application Ser. No. 358,877, filed Apr. 10, 1964, now U.S. Pat. No. 3,302,315.

A small pipe 154 has the lower end thereof in communication with the interior of the frusto-conically shaped dead weight means, this pipe extending upwardly along the associated conduit means for a distance of approximately 500 feet, the pipe being suitably secured to the conduit means as by means of clamps or the like fixed to the collars on the conduit sections. This pipe is preferably made up of a plurality of sections which can be manually assembled and disassembled when lowering and lifting the apparatus with respect to the mining ship. A valve means 156 is connected in pipe 154 for controlling the flow of fluid therethrough. Pipe 154 is adapted to be connected with a suitable source of air pressure and the like on the mining ship as hereinafter explained. The upper end of pipe 154 may be provided with suitable cap means or the like for closing off the upper end of the pipe when it is submerged in the water, and this procedure will be set forth hereinafter.

In many instances it may be necessary or desirable to provide a multi-stage pumping arrangement rather than providing a single pump in a single pump capsule as illustrated. For example, where the mining operation is to be carried out at relatively great depths of more than 3,000 feet for example, it may be necessary to provide one or more additional pumping means in addition to the pumping means 150 with the attendant pump and motor equipment therewithin. One such pumping means has been indicated in phantom line as indicated by reference numeral 155, it being understood that any suitable number and spacing of pumping means along with the pump and motor equipment therewithin may be employed as required. It will also be noted that the conduit means has been broken away, and that the distance from the buoyant pumping means 150 to the dead weight means 153 is generally much greater than the distance from means 150 to the ship.

A first dump valve mechanism indicated generally by reference numeral 157 is connected in the conduit means above the pumping means 150, and a second dump valve mechanism 159 is connected in the conduit means adjacent to the dead weight means. Each of these dump valve means operates in a similar manner such that the dump valve means will be ordinarily closed during normal pumping operations when the flow of water and nodules within a conduit means is in an upward direction. On the other hand, if for some reason, such as failure of the pumping means, the nodules should tend to move downwardly within a conduit means, the dump valve means 157 and 159 will open so as to cause the downwardly falling nodules or any other solid bodies to pass outwardly of the conduit means into the surrounding sea water. These dump valve means prevent the solid bodies from falling downwardly within the conduit means and accumulating at the bottom thereof which would tend to clog and jam up the conduit means. Dump valve means 157 may be identified as a pressure line dump valve means since the mixture in this portion of the conduit means is under pressure from the pumping means 150, the details of construction of this particular dump valve means 157

being illustrated in U.S. patent application Ser. No. 358,894, filed Apr. 10, 1964, now U.S. Pat. No. 3,307,576. The dump valve means 159 may be identified as the suction line dump valve means since it is inserted in that portion of the conduit means wherein the liquid mixture is moving upwardly under suction induced by the pumping means 150. The details of construction of dump valve means 159 are illustrated in U.S. patent application Ser. No. 358,895, filed Apr. 10, 1964, now U.S. Pat. No. 3,318,327.

A power cable connection is indicated by reference numeral 162, this power connection extending from the ship downwardly and being connected with the equipment within the pump capsule. This means 162 is employed for transmitting suitable electrical power to the pump capsule and may also include certain control leads for controlling the operation of the pumping means remotely from the ship. It will of course be understood that similar power means may be extended downwardly to any additional pump capsules employed in the conduit means as well as to the various power operated components supported at the lower end of the conduit means, such as the collecting means, illuminating means, cameras, etc. hereinafter described.

A truss assembly is indicated generally by reference numeral 165, this truss assembly being connected as indicated generally by reference numeral 166 with the dead weight means, the interconnection being such as to permit free swinging movement of the truss structure through an angle of at least 90° with respect to the dead weight means.

A collecting means is indicated generally by reference numeral 167, this collecting means or gathering head being connected as indicated generally by reference numeral 169 with the lower end of the truss structure. The interconnection 169 may be of a universal arrangement so as to permit free movement of the collecting means about two mutually perpendicular axes thereby allowing the collecting means to closely follow the contour of the sea bottom while being operative interconnected with the truss structure.

The truss structure may comprise a more-or-less conventional type open framework which provides a relatively lightweight arrangement of high rigidity, this truss structure serving to support a conduit portion 172 which may be a flexible pipe. It will be noted that the conduit means accordingly includes a major upwardly extending portion which extends from the dead weight means upwardly, the lower portion of the conduit means adjacent the truss 165 being articulated for permitting pivotal movement thereof whereby the collecting means connected to the lower end of the truss can move in a vertical direction to compensate for variations in the level of the sea bottom.

Suitable illuminating means such as electric underwater lights 174 are mounted on the truss structure, and suitable remote viewing means such as television cameras 176 are also supported on the lower portion of the truss structure adjacent to the lights. With this arrangement, the sea bottom and the collecting means may be illuminated and viewed remotely from the ship whereby personnel are enabled to observe the progress of the mining operation and can suitably guide the collecting means so as to move it along a desired path.

The collecting means 167 is provided with a suitable driving electric motor or the like 180 which is adapted to drive a propelling means 182 provided on the collecting means whereby the collecting means may be driven and guided along the sea bottom. As pointed out previously, this self-propelling feature is provided in one form of the invention, whereas in another form of the invention it may be eliminated where the collecting means is towed by the ship. The collecting means may either ride along the endless tracks as illustrated or may be provided with auxiliary wheels or runners if desired to facilitate

movement of the collecting means along the sea bottom.

It will be understood that suitable electrical power and television cables extend downwardly from the ship along the conduit means and thence to the dead weight means, along the truss means and such cables being connected with the driving motor on the collecting means as well as to the illuminating means and the television cameras. These cables are suitably secured to the various components of the underwater equipment by means of suitable clamps or similar means. The electrical power cables are also suitably interconnected with the pump motor disposed within the pump capsule.

The collecting means is also provided with a plurality of spaced depending tooth members 185 which are spaced apart a particular distance so as to permit the entry into the collecting mechanism of solid particles of certain particular sizes. These tooth members assure that solid bodies which are not desired to be collected will be rejected by the collecting means.

The solid bodies which are collected within the collecting means are all directed to a suction throat portion indicated by reference numeral 186 which is interconnected with the lowermost end of the flexible conduit portion 172 whereby the collected nodules may be sucked upwardly within the conduit means to the ship. A diffusion valve 188 is provided which is adapted to open and to allow surrounding sea water to be entrained into the lowermost end of the conduit means for controlling the ratio of solids to liquid within the conduit means. The operation of this diffusion valve may be remotely controlled from the ship as hereinafter explained. The details of construction of the collecting means are illustrated in copending U.S. patent application Ser. No. 359,742, filed Apr. 14, 1964, now U.S. Pat. No. 3,305,950.

The collecting means or gathering head may also be provided with a compass and sonar means as indicated on the drawing to facilitate navigation of the ship with respect to the collecting means.

It should be understood that the truss structure 165 may be formed in separate sections to facilitate assembly and disassembly thereof, and that the entire truss structure may be disconnected from the dead weight means and from the collecting means so as to enable storage of all of this equipment on the ship as hereinafter described.

Certain distances have been indicated on the drawing, and in a typical mining operation, the distance X may comprise 3,000 feet while the distance Y may comprise approximately 450 feet. It will be noted that the dead weight means in such an arrangement may be normally positioned approximately 100 feet above the sea bottom and that the swinging movement of the truss portion as indicated in dotted lines in FIG. 1 permits the collecting means or gathering head to rise and fall with variations in the depth of the sea bottom, variations of 55 feet or more being readily compensated for with this arrangement.

It is again emphasized that the various distances and sizes set forth herein are merely for the purpose of illustrating a typical example, and that the actual dimensions may vary widely in underwater mining operations.

MIXTURE CONTROL MEANS

Referring now particularly to FIG. 2 one form of the underwater mining apparatus is indicated schematically, this form including means for controlling the solids to liquids ratio of the mixture flowing through the conduit means.

As seen in FIG. 2, a ship indicated generally at 200 may be of the same general construction as the ship 110 illustrated in FIG. 1 as previously described. Connected with and depending from the ship is a conduit means indicated generally by reference numeral 202, this conduit means being of similar construction to that previously described. A buoyant pumping means indicated by reference numeral 204 is similar to the pumping

means 150 previously described, the conduit means extending downwardly therefrom and being connected with a dead weight means 206 similar to the dead weight means 153 previously discussed. The dead weight means is in turn connected with a truss means indicated schematically by reference numeral 208 similar to the truss means 165 previously described which in turn is connected with a collecting means 210 similar in construction to the collecting means 167 illustrated in FIG. 1 of the drawings.

It will be noted that a pump 212 is disposed within the buoyant pump capsule 213 and connected in the conduit means, this pump being operatively connected with and driven by a motor 214 also mounted within the pump capsule. The motor is connected by suitable electrical leads indicated schematically at 216 with the generator 218 supported within the ship and with a control switch means 220 mounted on a control panel 222 also supported within the ship. Control switch means 220 is adapted to be operated in such a manner as to adjust the speed of the motor 214 to thereby control the output of the pump connected therewith. One possible manner of varying the speed of the motor is to employ a variable frequency generator and to vary the frequency of the generator so as to speed up or slow down the motor as the case may be.

As seen at the lower portion of FIG. 2, a motor 224 is mounted on the collecting means for a purpose hereinafter described and is connected by suitable electrical leads as indicated schematically at 225 with the generator 218 and with a control switch means 227 mounted on the control panel within the ship. Control switch means 227 is adapted to control the starting and stopping and the direction of movement of the driving motor mounted on the collecting means.

As discussed previously, the pump and the conduit means is preferably designed for optimum efficiency of operation at a particular solids to liquid ratio of the mixture passing through the conduit means. In a typical example, the solids to liquid ratio may be about 1 to 30 by volume. The solids to liquid ratio may be controlled by operation of the two switch means 220 and 227 which respectively are adapted to control the speed of motor 214 and the operation of motor 224. As mentioned previously, motor 214 controls the speed of operation of the pump means, and motor 224 controls the opening and closing movements of a diffusion valve indicated generally by reference numeral 230 and which will be hereinafter more fully described. By controlling the speed of the pump and the position of the diffusion valve, the solids to liquid ratio can be readily maintained at a substantially constant desired ratio. However, in order to enable proper operation of the control switch means 220 and 227, it is necessary to provide a sensing means for determining and indicating what the solids to liquid ratio is at any particular point during the mining operation.

As seen in FIG. 2, a venturi velocity sensing valve indicated generally by reference numeral 232 or any other suitable type of sensing means is provided for measuring a characteristic which is proportional to the solids to liquid ratio. In this case, the velocity of the liquid flowing through the conduit means is measured, this velocity measurement provides an indication of the solids to liquid ratio which is indicated on a gauge 233 suitably calibrated to indicate the desired characteristic of the mixture. Accordingly, if the gauge means 233 indicates that the solids to liquid ratio is varying appreciably from the desired ratio, the two control switches 220 and 227 may be selectively operated so as to either speed up or slow down the pump motor, or to open or close the diffusion valve thereby allowing a greater or less amount of surrounding sea water to enter the conduit means.

Referring now to FIGS. 2a, 2b and 2c, the conduit means 202 includes at the lowermost end thereof a curved portion 235 terminating in an end having an outwardly

peripherally extending flange 236 having suitable holes therein for receiving bolt members 238 for securing the lower end of the conduit means to the upper portion of the collecting means. The collecting means is illustrated in phantom lines and has a cooperating flange for securing these two components together.

A diffusion valve portion 240 is mounted in the curved lower end portion of the conduit means and is mounted for pivotal movement about a pivot axis $x-x$. A pair of ears 242 and 243 extend outwardly from the conduit means and have holes formed therethrough. The diffusion valve portion 240 includes a laterally extending cylindrical portion 245 extending through the hole in ear 243, and a pin means 246 fixed to the diffusion valve portion extends through the hole in ear 242. Pin means 246 is in turn connected with a drive train indicated schematically by reference numeral 248 which is driven by motor 224 previously described and which is mounted upon a bracket 250 secured to the outer surface of the lower portion of the conduit means.

It is apparent that by remotely controlling the operation and direction of rotation of motor 224, the opening and closing movement of the diffusion valve means can be controlled. It is evident that when the diffusion valve means is open, more sea water will be drawn in through the diffusion valve means thereby increasing the amount of liquid of the mixture and reducing the proportion of solids to liquid. On the other hand, closing of the diffusion valve means will have the reverse effect as will be apparent.

NAVIGATION SYSTEM

Referring now to FIG. 3 of the drawings, the ship 110 previously described is indicated schematically by reference numeral 110', a pair of conventional radio antennas 252 and 253 being supported by the ship and being connected with radio receivers 255 and 256 which have the outputs thereof connected with conventional decade electronic counter mechanisms 259 and 260. A conventional sonar transmitter 262 is mounted in a suitable location near the bottom portion of the ship and is connected with the counter mechanism 259 and 260 as well as with a dual channel oscilloscope 263 of conventional construction.

A pair of conventional sonar transducer means 265 and 266 are mounted at opposite side portions of the ship so as to receive sonar signals from the surrounding water, these spaced sonar transducers being connected with sonar receiver means 267 and 268 respectively which are in turn connected with the oscilloscope 263. A compass repeat means 270 is supported by the ship, and a plotting board indicated generally by reference numeral 272 is provided on the ship for plotting the position and heading of the collecting means with respect to a base line as hereinafter more fully described.

The collecting means indicated in phantom line at 167 is of the same construction as previously described, the collecting means in this figure being shown in a schematic manner, it being understood that the collecting means and ship are interrelated as described in connection with the previous description of the underwater mining apparatus. A conventional sonar transducer 274 is supported and mounted upon the collecting means as is a conventional magnetic compass means 275 which is in turn suitable connected with compass repeat means 270 on the ship through a cable connection or the like.

A pair of similar buoy means are indicated generally by reference numerals 278 and 279, these two buoy means being mounted in spaced relationship and in a substantially fixed position relative to the sea bottom. The buoy means include anchor portions 280 and 281 respectively which are relatively heavy and adapted to rest on the sea bottom, these anchor portions being connected by means of wire ropes 283 and 284 with sonar receiver transducers 285 and 286 respectively. The length of the

wire rope in a typical example may be 20 feet. Long lengths of conventional coaxial cable 288 and 289 are connected between the sonar receiver transducers and subsurface floats 290 and 291. Each of these subsurface floats includes a sonar receiver indicated respectively by reference numerals 293 and 294 and a radio transmitter indicated respectively by reference numerals 295 and 296.

The radio transmitters are in turn connected by lengths of coaxial cable 298 and 299 with transponder buoys 300 and 301 respectively. The transponder buoys include circumferentially extending portions 303 and 304 of radar reflecting material, and conventional radio antenna means 305 and 306 extend upwardly from the buoys.

Referring now to FIG. 4 of the drawings, a schematic illustration of the general set up of the navigation system is illustrated. As seen in this figure, a particular surface area of the sea or the sea bottom is illustrated schematically and the positions of the two buoy means 278 and 279 are illustrated by similar reference numerals primed. A base line extending between these buoys is indicated by reference numeral 308, the collecting means and its associated sonar transducer are indicated by reference numeral 310, and the direction of travel of the sonar transducer is indicated by an appropriate arrow. The dotted lines between the sonar transducer and the buoy means indicate the path along which signals from the sonar transducer will travel to the two buoy means, it being noted that the path to the buoy means 278' is shorter than to the other buoy means 279' whereby less time will be required for the signal to travel from the transducer to the buoy means 278' than from the transducer to the buoy means 279'. In this typical example as illustrated in this figure, the outer square as defined by the solid lines may include an area of 15 miles by 15 miles, while the inner square indicated in phantom lines may encompass an area having sides of 10 miles. These figures represent the area within which the navigation system is expected to operate with the desired degree of accuracy.

In order to determine the position of the collecting means with respect to a base line extending between the two fixed buoy means, the operation as set forth hereinafter will provide satisfactory results assuming that for all intents and purposes the two buoy means are in fact stationary with respect to the sea bottom, and further assuming that the velocity of sound at the sea bottom will be substantially constant over the 15 mile x 15 mile working area as seen in FIG. 4, and furthermore that with the collecting means travelling at a maximum speed of 5 knots along the sea bottom, Doppler effects will be negligible.

A suitable keying pulse such as a 1 kilocycle pulse is generated by the sonar transmitter 262 on the ship and may be repeated at a rate of 2 pulses per minute in a typical example. This keying pulse triggers the two electronic counters 259 and 260 on the ship and also triggers the sonar transducer 274 on the collecting means. The sonar transducer 274 creates a sound pulse which radiates symmetrically from the collecting means, this sound pulse being received by the sonar receiver transducer means 285 and 286 of the two fixed buoy means after a period of time depending on the distance between the collecting means and the fixed buoy means, and also according to the speed of sound in this environment.

The sonar receivers then in turn trigger the radio transmitters 295 and 296 which then send radio pulses back to the antennas 252 and 253 on the ship at the speed of light. The received radio pulses then gate the associated counters 259 and 260 which then register the total time from the initial keying pulse to the gating pulse. Since the time required to transmit the signal through the electrical cables and leads and the air is negligible compared to the amount of time involved in transmitting the signals through the water, the counters 259 and 260 essentially

register the acoustic transit time from the sonar transducer 274 on the collecting means to the sonar receiver transducers 285 and 286 of the fixed buoy means.

Accordingly, the two counters 259 and 260 provide a reading indicative of the distance of the collecting means from each of the fixed buoy means. At the same time, a signal from the magnetic compass means 275 to the compass repeat means 270 provides a heading reading for the collecting means, and accordingly a plot of the collecting means position and heading with respect to a base line may be obtained with suitable plotting mechanism hereinafter described.

The location of the collecting means with respect to the ship can also be determined by utilization of the sonar transducers 265 and 266 which are mounted at equidistant positions on either side of the center line of a ship whereby an indication may be obtained of the position of the collecting means relative to the center line of the ship.

The initial keying pulse of the sonar transmitter 262 also provides a keying pulse to the oscilloscope 263. The transducers 265 and 266 at either side of the ship will receive a sound pulse from the sonar transducer 274 on the collecting means and produce a pip on the two channels of the dual channel oscilloscope. The helmsman by observing the pips on the oscilloscope may manoeuvre the ship to position the ship such that the vehicle is aligned with the center line of the ship regardless of whether the collecting means should happen to be directly under the ship, forward of the ship, or behind the ship. This can be accomplished by keeping the received pips on the dual channels of the oscilloscope aligned with one another which indicates that the signals from transducer 274 on the collecting means are being received at the same time by the two sonar transducers 265 and 266 on opposite sides of the ship.

The linear distance from the ship to the collecting means can be read directly from the oscilloscope by determining the time separation between the keying pulse and either of the received pips or pulses.

In case either of the floating portions 300 or 301 of the buoy means should break loose, these floating portions can be retrieved by use of the shipboard radar ranging on the buoy's passive radar reflector previously described.

The subsurface float means will be close enough to the surface to be serviced by a skin diver. The subsurface float can be located if the floating portion of the fixed buoy means is carried away by use of the shipboard fathometer.

Referring now to FIGS. 5 and 6 of the drawing, the plotting means of the present invention is illustrated. A suitable support or base means 312 is provided which in turn supports a transparent shield member 314 formed of plastic or a suitable material which is adapted to support a sheet of plotting paper or a chart thereon as indicated by phantom line 315.

A pair of precision lead screws having precision screw threads formed thereon are indicated by reference numerals 317 and 318, these lead screws being threaded within complementary threaded holes provided in support members 319 and 320 respectively. The two support members are each mounted for pivotal movement about a vertically extending axis as seen in FIG. 6, the two support members being indicated as being held in operative position by tapered pin means such as illustrated at 322 extending downwardly into the support means 312. It will accordingly be apparent that the lead screws 317 and 318 are adapted to swing about pivot axes extending vertically upwardly through the central part of the support members 319 and 320, and the two lead screws can each be rotatably adjusted for movement through the support members.

Micrometer dial means 324 and 325 are mounted at the outer ends of the two lead screws 317 and 318 respectively, these two micrometer dial means being calibrated

in suitable time intervals such as seconds, and utilizing the information of the counters 259 and 260, the micrometer dial means of the two lead screws may be adjusted to indicate the suitable time interval as indicated by the counter means.

Bearing means 327 and 328 are mounted at the outer ends of lead screws 317 and 318 respectively, these bearing means including roller bearings 330 and 331 extending downwardly therefrom and adapted to rest upon and glide along the upper surface of the support means 312 whereby the lead screws can be readily adjusted in position.

A movable cross head is indicated generally by reference numeral 333 and includes an upper portion 335 and a lower portion 336, these two portions being pivotally interconnected with one another and each having a hole formed therethrough having precision threads thereon for receiving therein the lead screws 318 and 317 respectively.

A small upwardly projecting portion 338 serves to support an illuminating means such as a light bulb 339 which may be turned on or off with a conventional switch means 340. It is apparent that the upwardly directed light bulb will serve to provide a small point of light which will shine upwardly through the transparent shield means 314 and through the chart or plotting paper 315.

It should be understood that the fixed pivot axes of the support means 319 and 320 of the two lead screws 317 and 318 respectively represent the fixed positions of the buoy means 278' and 279' as for example illustrated in FIG. 4, while the position of the light bulb 339 of the movable cross head represents the position of the sonar transducer or the collecting means 310 as seen in FIG. 4.

It is accordingly apparent that after obtaining suitable readings from the two counter means 259 and 260, an operator will adjust the micrometer dials 319 and 320 which will cause the movable cross head to move into such a position that the small light shining upwardly therefrom will produce a dot on the plotting paper indicating the position of the collecting means. The operator may then place a small arrowhead on the chart, this arrowhead being positioned over the dot of light on the chart and extending in a direction representing the heading of the collecting means, this heading being obtained by reading the compass repeat means 270.

MINING SHIP CONSTRUCTION

Referring now particularly to FIGS. 7-7' and 8-8', the mining ship previously described in connection with FIG. 1 is disclosed in more detail. As seen in these figures, the over-all ship 110 is provided with a controllable reversible pitch propeller 114 at the stern portion thereof, and a steering rudder 115 is provided for steering the ship. The well portion 125 receives the upper end portion 126 of the conduit means, and the elevator mechanism is indicated by reference numeral 128. This elevator mechanism is adapted to be lowered down into the well portion and to be raised thereabove as will be hereinafter more fully described.

The four main cargo holds are indicated generally by reference numerals 135, 136, 137 and 138, the separator mechanism 130 being mounted on the upper deck for receiving the mixture discharge from the upper end portion 129 of the conduit means which is of flexible construction. The conveyor mechanism indicated generally by reference numeral 132 includes a longitudinally extending portion 132' as most clearly seen in FIGS. 8-8', this longitudinally extending portion comprising a conventional belt conveyor which may be driven in the usual manner by a driving motor indicated at 343, this endless belt conveyor receiving solid bodies of material discharged from the separator means and carrying these solid bodies of material longitudinally of the ship.

A first plurality of spaced similar hatches 345 shown as being three in number and spaced longitudinally

from one another are adapted to receive solid bodies of material to be stored in hold 135. It will be noted that the aft hatch of these three hatches is disposed aft of the separator mechanism 130, and a separate conveyor portion 346 may be provided for feeding solid bodies of material to this particular hatch. A second plurality of spaced similar hatches 348 shown as being three in number are adapted to receive solid bodies of material for storage in hold 136. A third plurality of hatches 349 are adapted to receive solid bodies of material from the conveyor portion 132' for storage in hold 137. A fourth plurality of hatches 350 are adapted to receive solid bodies of material from conveyor portion 132' for storage within hold 138. Suitable gate mechanisms of conventional construction may be provided for diverting the solid bodies of material from the conveyor portion 132' into the various hatches in a well known manner. It is apparent that any suitable type of conveyor mechanism may be employed for transferring the collected solid bodies of material from the separating mechanism 130 to the various hatches associated with the individual holds. The details of construction of the various holds will be set forth in detail hereinafter.

As seen particularly in FIG. 7', a heliport indicated generally by reference numeral 352 is supported in spaced relationship above the deck and the conveyor mechanism, this heliport serving to provide a landing platform for a helicopter which may be utilized for travelling to and from the mining ship.

Also as seen in FIG. 7', the bow thruster mechanism is indicated by reference numeral 113 and the details of construction of this bow thruster mechanism will be described hereinafter.

Referring now particularly to FIGS. 7 and 8 a conventional boarding ladder is indicated by reference numeral 354. A pair of booms 356 and 357 are mounted at the starboard and port sides respectively of the ship, and in a typical example, boom 356 may comprise a five-ton boom and boom 357 may comprise a 20-ton boom.

A supporting superstructure is indicated generally by reference numeral 360, this superstructure comprising a plurality of interconnected beam members which provides sufficient strength for supporting the overhead crane mechanism and the bridge structures hereinafter described, this superstructure comprising a framework supported at the outboard portions of opposite sides of the ship and including transverse portions at the upper part thereof for supporting the mechanism referred to. The navigating bridge supported by the superstructure is indicated generally by reference numeral 361, and the underwater mining control station is indicated generally by reference numeral 362 from which the over-all operation of the underwater mining procedure can be coordinated.

An overhead travelling crane is indicated generally by reference numeral 364, and as seen particularly in FIG. 16, the overhead crane mechanism includes a transversely extending body portion 365 having wheels or rollers 366 mounted at the opposite sides thereof and which are supported upon rails 368. These rails extend substantially parallel with the center line of the ship and longitudinally thereof, and are supported by portions 370 of the superstructure. The wheels 366 of the crane mechanism preferably have positive engagement with the track portions 368 to prevent fore and aft runaway of the crane mechanism.

A trolley means 372 as seen most clearly in FIG. 36 is mounted for movement athwartship by means of wheels 373 mounted upon suitable transversely extending track portions 374. The trolley wheels also preferably have positive engagement with the associated tracks to prevent athwartship runaway. Suitable conventional means is provided for driving the main crane body portion 365 and the trolley 372 so as to properly operatively

position a depending hook mechanism indicated by reference numeral 375. A winch or other suitable lifting and lowering means is indicated by reference numeral 377 and is operatively connected with the hook means and supported by the trolley means whereby the hook means may be operatively positioned in any desired location. The crane cab within which an operator is supported is indicated by reference numeral 378.

Referring again to FIG. 7, suitable ladder means 380 is provided for enabling personnel to climb from the upper deck to the navigating bridge and the control station. A portable rail means 382 is provided around the outer portion of the ship. The living quarters of the officers and crew men are indicated generally by reference numeral 383, and a conventional funnel is indicated by reference character F. As seen in FIGS. 8-8' a work boat 385 is supported on the deck, and a diving gear locker 386 is disposed forwardly of the work boat.

Referring now particularly to FIGS. 14, 15, 16 and 17, certain details of the construction of the ship adjacent the well portion and the general arrangement of the mining components stored on the deck may be more fully understood. Referring firstly to FIG. 17, a top view of the ship construction at the bottom shell is indicated. As seen in this figure, the well portion 125 is of generally rectangular configuration, and in a typical example a dimension along the center line of the ship as indicated by line x-x of approximately 34 feet, while the dimension perpendicular to the center line may be approximately 30 feet. The corner portions of the well are preferably of arcuate configuration as indicated by reference numerals 390 and 391 and in a typical example may have a three foot radius, these curved corner portions serving to relieve the stress concentrations at these points.

In order to provide sufficient strength and rigidity to this portion of the ship, an extra heavy bottom plate indicated by reference numeral 393 is provided, this bottom plate in a typical example being a 66.3 lb. plate. A pair of inset plates 394 and 395 which also may be 66.3 lb. plates are provided adjacent the two corner portions of the well as indicated in FIG. 17, these plates including arcuate edge portions adapted to conform to the configuration of the arcuate corners of the well portion.

A bilge plate 397 is provided adjacent the bottom plate 393, a riveted joint 398 being provided between these two plates, the bilge plate may also be of heavy-duty construction and may for example be a 56.1 lb. plate. The adjacent plate means indicated by reference numerals 400 and 401 may be of the usual construction, and in a typical example may be 40.8 lb. plates. It should be understood that the construction at the opposite side of the wall is identical with that shown in FIG. 17 at one side of the well thereby providing a reinforced bottom shell of the ship adjacent to the lower portion of the well which opens downwardly into the sea during normal operation of the ship.

Considering now FIG. 15, the reinforced construction at the upper deck may be seen. A plate 403 is provided of heavy-duty construction and in a typical example may be a 56.1 lb. plate. A pair of insert plates 405 and 406 are provided, these plates being of a similar weight to plate 403 and being provided at the corner portions of the well portion and having arcuate edge portions adapted to conform to the arcuate corners of the well portion, these arcuate corners being indicated by reference numerals 409 and 409. The adjacent plates are indicated by reference numerals 410 and 411 may be of usual upper deck construction and in a typical example may comprise 38.25 lb. plates.

It is apparent from the foregoing that the ship is provided with a reinforced bottom shell and upper deck adjacent to the lateral portions and corners of the well portion so as to reinforce these portions and to provide adequate rigidity and strength to the ship adjacent the well portion which extends completely through the ship

in a vertical direction from the bottom shell to the upper deck.

A plurality of vertically upstanding members 413, 414, 415, 416 and 417 are provided at one side of the well portion and a corresponding plurality of upstanding vertical members 413', 414', 415', 416' and 417' similar to the first mentioned support members are provided at the opposite side of the well portion. It will be understood that these vertically upstanding members are portions of the superstructure which supports the overhead crane structure previously described. A pair of support members 420 and 421 extend upwardly from the outer lateral portions of the ship and slope inwardly to join with the superstructure at a point spaced a considerable distance above the deck to provide lateral stability for the superstructure.

The generally rectangular outline of the well portion 125 is indicated in dotted lines in FIG. 15, but the well portion is not of this configuration completely from the bottom shell to the upper deck, but is only of such generally rectangular configuration from the bottom shell to an intermediate portion of the well portion whereat certain inwardly extending bulkheads are provided as hereinafter described. The upper deck area is provided with recessed portions so as to provide clearance for the elevator structure and auxiliary support structure hereinafter described, and as seen in FIG. 15 the upper deck is provided with a main generally rectangular recessed portion from which extend a first pair of rectangular recessed portions 423 and 424 at the aft portion of the main recessed portion, a second pair of rectangular recessed portions 426 and 427 extending laterally from an intermediate portion of the main recessed portion, and a third pair of rectangular recessed portions 429 and 430 extending outwardly from opposite sides of the forward portion of the main recessed portion. A recessed portion 432 extends forwardly of the well portion and is of generally rectangular configuration and a recessed 433 of substantially V-shaped configuration extends aft of the well portion and will be more fully discussed hereinafter.

The elevator means is indicated generally by reference numeral 435 and has laterally extending portions thereof which fit within the recessed portions 423, 424, 426, 427, 429 and 430 previously described, the structure of the elevator mechanism being more fully set forth hereinafter.

Elevator sheave trunk portions 437 and 438 extend vertically upwardly from plate 405 and a similar plate 405' for receiving and protecting the sheaves and cables employed for lifting and lowering the elevator mechanism as hereinafter set forth. Holes 440 and 441 are provided in plates 405 and 405' respectively for allowing movement of the operating mechanism for the elevator mechanism therethrough.

Various components of the underwater mining equipment are illustrated in their normal stowed position on the upper deck of the ship as seen in FIG. 15, a collecting means 167 being supported on the deck in the position illustrated, this collecting means being substantially identical with the collecting means previously discussed. The collecting means in this stowed position is disposed in overlying relationship to a first recessed hatch 443 which provides access to the stowage area for the individual sections of the conduit means. This collecting means is also in overlying relationship to an unshipping opening 444 to the elevator machinery room as hereinafter described.

It will be understood that the collecting means 167 as seen in FIG. 15 is disposed flat upon the deck, and an additional or reserve collecting means of substantially identical configuration is indicated at 167', this collecting means being stowed on end or at a substantially right angle position to that of collecting means 167, the reserve collecting means 167' being supported by a suitable support frame 446 which is preferably mounted for pivotal movement about an axis 448 with respect to the deck.

With this arrangement, the support frame 446 can be pivoted up into the stowed position as shown, or can be pivoted downwardly so as to place the reserve collecting means 167' in position for lowering it into operative mining position if so required. In addition, a further collecting means (not shown) may be stowed at the opposite side of the collecting means 167 as shown in a manner similar to the reserve collecting means 167'.

As illustrated in FIG. 15, it is assumed that the truss construction is such that the over-all truss means is formed of a plurality of individual truss sections which can be readily interconnected and disconnected as required. In FIG. 15, the first truss section is indicated generally by reference numeral 450, thus truss section being pivotally interconnected as indicated at 451 with the collecting means 167. With this arrangement, the first truss section which is connected with the collecting means may remain pivotally interconnected therewith at all times, and the remaining truss sections are stowed in vertically extending positions, these remaining truss sections being indicated by reference numerals 453, the various sections being interconnected with one another and lowered into operative position as hereinafter described. It is apparent that the truss sections occupy as little deck space as possible when stowed in such vertically extending position, and a portion of one of the truss sections may extend over the recessed portion 432 in the deck as illustrated. Portable guard rails 454 and 455 are provided adjacent the well portion and the recessed portion 432 in the main deck to prevent personnel from accidentally falling into these recessed portions.

A pair of longitudinally extending tracks are provided for supporting certain movable equipment hereinafter described, the port track means including sections 458, 458', 458'' and 458''', and the second rail means including sections 460, 460', 460'' and 460'''. It will be noted that the two track means are substantially parallel with one another and that the various sections thereof are interrupted by the recessed portions formed in the main deck, but however, the spacing between the various track sections as occasioned by these recessed portions is such that the movable equipment which is provided with wheels is continuously supported and guided by the tracks, or in other words some of the wheels are maintained in contact with the track sections at all times in order to maintain the proper degree of support and guidance.

A first movable support means or platform dolly 462 is provided, this platform dolly being provided with wheels as hereinafter described which are movable along the tracks on the deck so that the platform dolly can move longitudinally back and forth as hereinafter described. The platform dolly is illustrated as supporting in stowed position thereon the dead weight means 153 as previously discussed.

A second movable support means or capsule dolly is indicated generally by reference numeral 464, this dolly being provided with wheels as hereinafter discussed and being movable along the tracks on the deck. This capsule dolly is illustrated as supporting thereon in stowed position the pump capsule 152 which may be substantially identical with the pump capsule construction previously discussed.

A third support means is indicated generally by reference numeral 466, this support means being movable athwartships as hereinafter discussed and serving to support in the stowed position a buoyancy capsule indicated generally by reference numeral 467. This buoyancy capsule is simply a large water-tight container which is adapted to be attached to the conduit means to provide buoyancy thereto as will be more fully discussed hereinafter.

As seen in FIG. 14, the dead weight means 153 includes a small conduit portion 470 extending upwardly therefrom including an intermediate collar portion 471 for facilitating handling of the dead weight means. An

upper flange portion 472 is provided at the top of the conduit portion 470 and includes suitable holes formed therein for bolting this flange to a cooperating flange of a conduit section as hereinafter described.

Referring now particularly to FIGS. 7 through 13 inclusive, the bow thruster mechanism details may be seen most clearly in FIG. 11 wherein it will be seen that a passage 475 extends laterally from one side of the ship to the other, and opens at opposite sides of the ship. A controllable pitch propeller 476 is supported within the central portion of the passage and is operatively connected with suitable driving mechanism indicated at 477. By controlling the pitch and therefore the direction and amount of thrust of the propeller 476, the heading of the bow of a ship can be very accurately controlled so as to enable proper manoeuvring of the ship during mining operation.

As seen especially in FIG. 10, stabilizing means in the form of anti-roll tank means includes a pair of anti-roll tanks 480 and 481 disposed at opposite sides of the ship. A pair of passages 483 and 484 extend athwartships and serve to interconnect the two anti-roll tanks. Liquid is disposed in the anti-roll tanks and in the connecting passages, the tanks and passages being less than full such that liquid is adapted to move back and forth between the tanks through the passages. Suitable control means is provided for controlling the movement of the liquid through these passages and this control means is indicated as selectively controllable gate means indicated by reference numerals 486 and 487 whereby the amount of liquid flowing through the connecting passages may be selectively adjusted. This over-all arrangement provides a very effective means for stabilizing the ship and for maintaining the ship in the proper attitude for effective mining operations.

Referring particularly to FIG. 10, hold 135 is divided into six individual hopper portions, the three hopper portions at the port side of the ship being indicated by reference numeral 490, and the three hopper portions at the starboard side of the ship being indicated by reference numeral 491. A central ridge portion 492 serves to separate the three port hopper portions from the three starboard hopper portions. Each of the port hopper portions 490 comprises a four-sided hopper, the sides each being of a smooth construction such as metallic sheets, the four sides tapering downwardly from a portion spaced above the lower part of the hold to a discharge opening 494. As seen in FIG. 12, as well as in FIGS. 7-7', the major portion of the hold is unobstructed, the hopper portions being provided only in the lower minor portion of the hold so as to direct the collected solid bodies of material in the hold to the discharge openings for a purpose hereinafter described.

The three starboard hopper portions 491 each include three sloping portions as seen in FIG. 10, the fourth side portion being substantially vertical along one side of the ridge portion 492. The three sloping side portions of each of the starboard hoppers 491 slope downwardly to a discharge opening 496.

Hold 136 also includes three port hopper portions 498 and three starboard hopper portions 500, the port hopper portions 498 including three sloping side portions such that these hopper portions are similar in construction to the hopper portions 491 previously described. The three starboard hopper portions 500 of hold 136 include four sloping side portions and are accordingly of similar construction to the hopper portions 490 perviously described. The sloping sides of the port hopper portions 498 terminate at discharge openings 502, while the sloping side portions of the starboard hopper portions 500 terminate in discharge openings 503.

Hold 137 includes three port hopper portions 505 including four sloping sides similar to those previously discussed, these sloping sides terminating in discharge openings 506. Hold 137 also includes three starboard

hopper portions 507 including three sloping side portions similar in construction to those previously discussed, these sloping side portions terminating in discharge openings 508.

The hold 138 includes three port hopper portions 510 having three sloping sides which terminate in discharge openings 511. Hold 138 also includes three starboard hopper portions 513 having four sloping sides which terminate in discharge openings 514.

Referring now particularly to FIG. 13, the hopper portions 505 and 507 of hold 137 are illustrated, and it will be noted that the discharge opening 506 of hopper 505 is in communication with a transversely extending conduit portion 517 which opens into a longitudinally extending conduit portion 518. A screw conveyor means 520 is mounted within the transversely extending conduit portion 518 and is connected through a speed reducing means 521 with a suitable driving motor 522.

The screw conveyor means serves to provide a means for positively moving collected nodules and the like from the discharge opening 506 of hopper portion 505 into the longitudinally extending conduit portion.

The discharge opening 508 of the hopper portion 507 opens into a transversely extending conduit portion 525 which also opens into the longitudinally extending conduit portion 518. A screw conveyor means 526 is disposed in the transversely extending conduit portion 525, and is connected through a speed reducing mechanism 527 with a driving motor 528. This last-mentioned screw conveyor means serves to positively displace collected nodules from the discharge opening of the hopper portion 507 into the longitudinally extending conduit portion 518.

The interrelationship of the screw conveyor drive means with respect to the longitudinally extending conduit portion 518 may be seen in FIG. 11, and it will be noted that similar screw conveyor feed means indicated generally by reference numerals 520' are provided for the discharge openings 506 of the remaining hopper portions 505. Similar screw conveyor feed means 526' are provided in association with the discharge openings 508 of the remaining hopper portions 507. The various screw conveyor means in each instance will be substantially identical in construction with that described in connection with FIG. 13.

As seen in FIGS. 11, 12 and 7' in particular, the longitudinally extending conduit portion 518 includes an open end portion 530 which opens downwardly into the sea, a valve 531 being provided for controlling the flow of sea water into the conduit portion. The aft end of the conduit portion 518 opens into a large pump means 533 disposed in a pump room 534 as seen particularly in FIGS. 11, 12 and 7'. A valve 535 is provided for controlling the flow of the sea water and a solid body mixture into the pump means.

Referring particularly to FIG. 11, three screw conveyor mechanisms indicated generally by reference numerals 538 are provided in association with the discharge openings of the port hopper portions 498 of hold 136, these screw conveyor mechanisms serving to positively displace solid bodies of collected material from these latter mentioned hopper portions into a longitudinally extending conduit portion 540.

Three screw conveyor mechanisms 542 are operatively associated with the three starboard hopper portions 500 of hold 136 and serve to positively displace solid bodies of material from the discharge openings into the longitudinally extending conduit portion 540.

Again referring particularly to FIGS. 11, 12 and 7, it will be noted that the longitudinally extending conduit portion 540 includes a downwardly facing inlet portion 544 open to the sea, a valve means 545 being provided for controlling the flow of sea water into the conduit portion. This last-mentioned conduit portion also is operatively connected with the pump means 533 previously

described, a valve means 546 being provided for controlling the flow of sea water and solid body mixture into the pump means.

Referring again particularly to FIG. 11, three screw conveyor mechanisms 550 are operatively associated with the discharge openings of the hopper portions 510 of hold 138, these screw conveyor mechanisms being adapted to positively displace solid bodies of material from the hopper portions into a longitudinally extending conduit portion 552.

Three similar screw conveyor mechanisms 554 are operatively associated with the discharge openings of the starboard hopper portions 513 of hold 138 and are adapted to positively displace the solid bodies of material from hopper portions 513 into the longitudinally extending conduit portion 552.

Again referring particularly to FIGS. 11, 12 and 7', longitudinally extending conduit portion 552 is provided with a downwardly opening portion 556 which opens into the sea, a valve means 557 being provided for controlling the flow of sea water into this conduit portion. This latter mentioned conduit portion is also in communication with the pump 533, a valve 558 being provided for controlling the flow of the sea water and solid body mixture into the pump.

A fourth longitudinally extending conduit portion 560 is provided for receiving the collected solid bodies of material from the hoppers 490 and 491 of hold 135. Screw conveyor mechanisms (not shown) similar to those previously described are operatively associated with the discharge openings of hopper portions 490 and 491 for positively displacing the solid bodies of material from the hopper portions to conduit portion 560.

As seen particularly in FIGS. 12 and 7-7', conduit portion 560 includes a downwardly facing open end 562 which is open to the sea water, a valve 563 being provided in this conduit portion for controlling the flow of sea water therethrough. The opposite end portion of conduit portion 560 is in communication with the pump 533, a valve 565 being provided for controlling the flow of the sea water and solid body mixture therethrough.

As seen in FIG. 11, the port tanks 567 correspond to those shown in FIG. 10 and contain salt water ballast. The tanks 568 on opposite sides of the ship adjacent to the pump room comprise fuel oil tanks as do the tanks 569 on opposite sides of the ship adjacent the bow portion. The starboard tanks 570 correspond to those shown in FIG. 10 and contain salt water ballast.

The pump 533 is provided with a discharge conduit line 572 which as seen most clearly in FIGS. 7-7' and 8-8' extends upwardly from the pump means at the starboard side of the ship and then extends along the starboard portion of the hull to a fitting 574 provided at the stern of the ship. This fitting is interconnected with a floating conduit means indicated generally by reference numeral 575, this floating conduit means including a flexible hose portion 577 formed of a suitable abrasion resistant water-proof material such as rubber or the like, this hose being surrounded by spaced float members 578 formed of a suitable buoyant material such as polyurethane or the like which may be covered with rubber or a similar material. This floating conduit means is adapted to float on the surface of the water when in operative position and is adapted to be stowed when in its inoperative position along the starboard portion of the ship as indicated particularly in FIGS. 8-8' at approximately the upper deck level, and being maintained in such operative position by any suitable attaching means.

OPERATION OF MINING SHIP STORAGE SYSTEM

During normal mining operations, the mixture of solid collected bodies and sea water will be continuously moved upwardly through the conduit means 145 from the collecting means travelling along the sea bottom and this

mixture will be discharged into the separating means 130. The solid bodies which are separated out by means 130 are then moved forwardly along the conveyor means 132 or rearwardly along conveyor portion 346 to the hatch means 345, 348, 349 or 350 as the case may be. The various cargo holds are initially filled with salt water, and one cargo hold receives the collected solid bodies at a time. Assuming that it is first desired to fill the art cargo hold 135, the solid bodies separated out by separation means will be transferred by the conveyor portions to the hatch means 345, from whence the solid bodies will drop downwardly into the mold 135.

The water within the hold will serve to cushion the fall of the solid bodies of material such that they will not have a tendency to shatter against the hard surfaces of the hopper portions at the lower part of the hold, and overflow means 580 as seen in FIG. 7 is provided for permitting the water within hold 135 to overflow as it becomes filled with solid bodies of material. Similar overflow means 581, 582 and 583 are associated with holds 136, 137 and 138 respectively.

After hold 135 has been substantially completely filled with solid collected bodies, the solid bodies are then carried by the conveyor means forwardly to the next hold 136, and suitable gate means is then provided for discharging the solid bodies from the conveyor means 132 into the hatch means 348. This procedure is followed until all of the holds have been filled in succession. A further advantage of the provision of sea water in each of the holds which is adapted to overflow as the holds are filled is the fact that the draft of the ship will remain substantially constant with a minimum amount of deballasting of tanks 567 and 570 during this filling operation which is of course a very desirable feature. In other words, the draft of the ship will not be substantially altered as it becomes loaded with collected solid bodies of material.

OPERATION OF CARGO TRANSFER SYSTEM

The mining ship 110 previously described will periodically become substantially completely filled with solid collected bodies, and in order to maintain continuous mining operation, it will be necessary to transfer the collected bodies to another ship. The discharge system including the various screw conveyor mechanisms and the associated conduits which are connected with the pump means are utilized for emptying the various holds and for transferring the collected solid bodies of material to an associated ship.

Referring now particularly to FIG. 9, the general arrangement for transfer of the cargo from the ship 110 previously described to a suitable cargo ship 585 is illustrated. In order to carry out the transfer operation, the cargo ship 585 which may be of conventional construction and provided with a large cargo carrying capacity is operatively connected with the mining ship 110 by means of a towing cable 587 of conventional construction. The mining ship may continue its usual mining operation while towing the cargo ship therebehind through the intermediary of the towing cable. The floating conduit means 575 previously described is connected between the mining ship and the cargo ship and is adapted to float on the surface of the sea.

It will be understood that the cargo ship 585 is provided with a suitable conduit system such that it is adapted to receive a mixture of sea water and solid collected bodies from the floating conduit means and to transfer this mixture to various holds where the major portion of the sea water will be eliminated and the solid bodies will be collected.

Once the mining ship and the cargo ship have been operatively connected as indicated in FIG. 9, the transfer operation can commence. One hold at a time will be emptied from the mining ship, and assuming that it is first desired to empty hold 138, valves 557 and 558 are opened and the pump 533 is energized so as to suck sea

lized for properly aligning adjacent sections of the conduit means in order to ensure that the conduit sections are properly oriented when bolting them together.

While the flange and collar portions have been illustrated as being formed of separate forging, it is also apparent that the flange portions and collar portions may comprise integral portions of the same casting if desired. In addition, the thickened portions provided in the tubular parts of the conduit section may either comprise integral portions as shown, or may also take the form of separate sleeve portions which are welded in place about the outer surface of the tubular portions. In any event, the over-all construction will be such as to facilitate handling of the conduit sections by the handling mechanism on the ship and to also provide sufficient strength and rigidity to the conduit section when subjected to stress and loadings involved in the handling procedures.

In a typical example, conduit sections 590, 591 and 592 may have a length of approximately 36 feet, 11 feet and 4½ feet respectively. The distance from the top of the upper flange of each of sections 590 and 591 to the bottom of the collar portions thereof may also be approximately 4½ feet.

CONDUIT SECTION STOWAGE MEANS

Referring now particularly to FIGS. 22, 23 and 24, the general arrangement and layout of the stowage area may be most clearly understood. As seen in these figures, the upper deck of the ship is indicated by reference numeral 635 and the access hatch to the stowage area is indicated by reference numeral 443. The stowage area itself is defined by a forward wall portion 637, a pair of side wall portions 638 and 639 and a rear wall portion indicated generally by reference numeral 640. Upper support means is provided for supporting an upper portion of the individual conduit sections, this upper support means including a plurality of spaced portions indicated by reference numerals 642 which extend substantially longitudinally of the ship, and a pair of transversely extending portions 643 are provided for a purpose hereinafter described. It should be understood that only half of the upper support means is seen in FIG. 24, the other half having been broke away to disclose the underlying lower support means.

Referring particularly to FIG. 25, the construction of the upper support portions may be more clearly understood. As seen in FIG. 25, the spaced portions 642 are provided with a first plurality of substantially arcuate cutout portions 645 which extend downwardly from the upper surfaces of the support portions only a minor portion of the thickness of the support portions.

Each of the spaced support portions is also provided with a plurality of substantially arcuate cutout portions 646 which extend downwardly from the upper surface of the support portions a substantially greater distance than the cutout portions 645. It will be noted that adjacent spaced portions thereby include pairs of opposed cutout portions, adjacent pairs of such cutout portions extending downwardly different distances from the upper surfaces of the support portions.

These pairs of opposed cutout portions are adapted to receive the upper flange of individual conduit sections as indicated in phantom line in FIG. 25. By providing adjacent pairs of recesses of different vertical depth from the top of the support portions, it is possible to store the conduit sections in staggered relationship with the flanges of adjacent ones of the conduit sections disposed in overlapping relationship with one another as will be most clearly understood from inspection of FIG. 22.

This permits the conduit sections to be stored in rows in the spaces defined between adjacent spaced portions of the upper support means, with the conduit sections disposed in as compact a relationship as possible thereby minimizing the amount of space required to stow a desired number of conduit sections.

The spaces adapted to receive the rows of conduit sections are indicated by reference numerals 648 in the upper portion of FIG. 24, it being understood that the support means is empty as shown.

Referring to FIG. 25, movable support means 650 are pivoted at one end thereof as indicated at 651 to the support means and are adapted to swing across the open end of the spaces defined between the portions of the upper support means into a position as shown in the upper part of FIG. 25 wherein the movable support means is blocking off the space. On the other hand, the movable support means may be swung into the position at the lower part of FIG. 25 so as to open the space. These movable support means are adapted to close off certain of the spaces and to retain the conduit sections in the rows which they normally occupy when in stored relationship. When it is desired to remove the conduit sections from any particular row, the movable support means 650 is swung into a position so as to open the space as illustrated in the lower portion of FIG. 25. It will be noted that each of the movable support means is provided with a cutout portion 651 in the lower edge thereof which is adapted to fit over a bolt or the like 652 extending outwardly from the outer end of the associated portion of the upper support means.

Referring now to the lower portion of FIG. 24, a first plurality of lower support member means is indicated by reference numerals 655 and a second plurality of lower support means is indicated by reference numeral 656. It will be understood that not all of the lower support means have been illustrated in FIG. 24, and that there is a lower support means to correspond with each supported conduit section, it being noted that there is a lower support means directly beneath each opposed pair of cutout portions in the upper support means, there also being provided three lower support means to correspond for each of the three cutout portions 657 formed in the transversely extending upper support portions 643.

Referring to FIG. 26, the construction of the first support means 655 is illustrated, and it will be noted that this simply comprises a substantially disc shaped member which extends upwardly a small distance above the supporting deck surface 659, and which includes an upper tapered edge 660 to facilitate entry of this portion into the lower open end of a conduit section.

Referring now to FIG. 27, the construction of the support means 656 is illustrated, and it will be noted that this particular form of support means includes a substantially disc like portion 662 supported on a plate 663 which in turn is supported by three transversely extending rib portions 664 which in turn are supported upon the underlying deck support surface 659. An upper tapered edge 665 is provided to facilitate entry of this portion into a conduit section.

It is apparent that the support means 656 extend upwardly from the supporting deck surface 659 a distance which is substantially greater than that which the support means 655 extend upwardly therefrom. The support means 655 which is of lesser height is disposed beneath the opposed cutout portions 646, whereas the support means 656 is disposed below the cutout portions 645 in the upper support means. With this arrangement, the upper and lower support means are adapted to engage and support the upper and lower portions of associated conduit sections as will be well understood.

Referring now particularly to FIG. 29, the manner in which the conduit means are supported on the upper support portions 643 is illustrated. As seen in this figure, one of the three conduit sections supported by each of the support portions 643 is illustrated, the conduit section being indicated by reference numeral 590 and including an upper flange 595. In order to retain this upper flange in its operative position within the arcuate cutout portion formed in support portion 643, a strap means 667 is disposed around the outer surface of the conduit

water in through the intake portion 556 of conduit portion 552.

At the same time, the collected solid bodies are transferred from the hopper portions 510 and 513 of hold 138 to the longitudinally extending conduit portion 552 by means of the screw conveyor mechanisms 550 and 554 which are continuously operated at a metered rate. In other words, the six screw conveyors operatively associated with hold 138 are operated to provide uniform discharge of the solid bodies from the hold into the conduit portion 552.

The flow of sea water induced through the conduit portion 552 by the pump will cause the solid bodies to be entrained in the sea water, this mixture of sea water and solid bodies will then be transferred through the discharge line 572 to the floating conduit means 575 and thence to the cargo ship 585.

After hold 138 has been emptied of solid collected bodies, the hold is again filled with sea water and is ready to receive newly collected bodies of solid material from the conveyor mechanism 132 on the deck of the mining ship.

It is apparent that the various holds in the mining ship can be emptied in the foregoing manner and transfer of the collected solid bodies within the holds can be effected to the cargo ship through the intermediary of the various conduit portions associated with the hopper portions of each of the holds. It is of course evident that the valve means associated with these conduit portions will be selectively adjusted so as to cause the holds to be evacuated in the desired sequence, and the flow of the mixture through the conduit means may be controlled through the intermediary of these valve means.

The present invention also contemplates another concept in the manner of storing and transferring the collected solid bodies of material. In this second concept, suitable equipment is provided on the mining ship for crushing and drying the solid bodies of material as they are brought up to the ship and are separated from the sea water. A suitable crushing mill mechanism and drying oven or the like may be utilized for accomplishing this end result. The crushed and dried particles may then be transferred to the holds of the mining ship by means of a suitable conveying mechanism.

When it is desired to subsequently transfer the crushed and dried particles to a cargo ship, a fluidized system will be provided with suitable pump means whereby the dry particles may be pumped in a fluidized state through suitable conduit means to the cargo ship.

CONDUIT SECTION CONSTRUCTION

Referring now particularly to FIGS. 18 through 21 inclusive, there is shown in FIG. 18 three different conduit section constructions indicated respectively by reference numerals 590, 591 and 592. Each of these different constructions is utilized in certain procedures involved in the mining operation as hereinafter explained, and the construction indicated by reference numeral 590 is a typical conduit section from which the major portion of the conduit means is assembled.

Each of the individual conduit sections 590, 591 and 592 is provided with an upper flange indicated by reference numerals 595, 596 and 597 respectively. Each of these individual sections is also provided with a lower flange indicated by reference numerals 600, 601 and 602 respectively. The construction of the upper flanges of each of the individual sections may be substantially identical with one another, and the construction of the lower flanges of each of these individual sections may also be substantially identical with one another as hereinafter described.

In each instance, the conduit sections 590, 591 and 592 include main tubular portions having the upper and lower flanges disposed at the upper and lower ends thereof respectively. The two conduit sections 590 and 591 addi-

tionally include intermediate collar portions indicated by reference numerals 604 and 605 respectively. The collar portions are of substantially identical construction as hereinafter described, the only difference being that the collar portion 604 is provided with an additional boss 606 as hereinafter described.

The conduit sections 590 and 591 also include first thickened portions 608 and 609 respectively disposed between the upper flanges and the intermediate collar portion. Additional thickened portions 610 and 611 are provided between the intermediate collar portion and the lower flanges of the two conduit sections. The construction of these thickened portions may be substantially identical as hereinafter described.

Referring now particularly to FIGS. 19, 20 and 21, the constructional details of the conduit section 590 are illustrated, as an example, it being understood that conduit sections 591 and 592 are of similar construction. The upper flange 595 of conduit section 590 may comprise a separate forging which is welded as indicated at 614 to the tubular portion 615. Flange 595 is provided with a plurality of spaced holes 617 formed therethrough and shown as being 12 in number. Each of holes 617 is in communication with the central portion of a counterbored portion 618 formed in the undersurface 619 of the flange. A nut 620 is press fitted within each of the counterbored portions formed in the undersurface of the flange, and a plug member 622 is spot welded in the counterbore and is also welded to the nut so as to positively prevent rotation of the nut with respect to the counterbored portion. The nut provides a screw threaded means for receiving the threads on a suitable attaching means such as a cap screw or the like for rigidly attaching flange 595 to the flange of an associated conduit section.

The lower flange 600 of conduit section 590 is also provided with a plurality of spaced holes 625 formed therethrough, these holes being shown as 12 in number. It is apparent that the bottom flange of each individual conduit section is adapted to be fixed to the top flange of an adjacent conduit section by passing suitable attaching means such as cap screws through the holes in the bottom flange of one of the sections, with such screws being threaded into the nuts provided at the bottom portion of the holes provided in the top flange of the next adjacent section. This arrangement permits the conduit sections to be readily and quickly assembled and disassembled with respect to one another and at the same time provides an effective joint therebetween when in assembled position.

As seen particularly in FIGS. 19 and 21, the tubular portion 615 of the conduit section is provided with a circumferentially extending thickened portion 608, and a tubular portion 629 of the conduit section also includes a similar circumferentially extending thickened portion 610. The flange 600 of conduit section 590 may comprise a separate forging as is the upper flange 595 previously mentioned. The collar portion 604 may also comprise a separate forging welded to the tubular portions 615 and 629 of the conduit section and being disposed intermediate the two thickened portions 627 and 630.

During handling of the conduit sections as entailed in lifting and lowering the conduit sections into operative mining position and into stowed position as the case may be, certain components of the handling mechanism on the ship are adapted to engage the undersurfaces of upper flange 595 and collar portion 604. The thickened portions of the conduit sections disposed immediately below the upper flange and the collar portion respectively serve to reinforce the conduit section and to provide adequate strength and rigidity adjacent to these handling portions on the conduit section.

As seen particularly in FIG. 20, a radially outwardly extending boss 606 is suitably secured as by welding as indicated at 632 to the outer surface of the collar portion 604. This radially outwardly extending boss may be uti-

section 590, opposite ends of the strap means being held in operative position by suitable means such as bolts 668, one of which is visible in FIG. 29. It will be understood that the conduit sections supported by each of the upper support portions 643 are held in normal stowed position by similar means, lower support means 655 being disposed therebeneath for engaging and supporting the lower end portions of these conduit sections.

Referring now particularly to FIGS. 22 and 23, a catwalk means 670 is supported within the stowage area by the wall portions previously described which define the stowage area, this catwalk means being disposed in overlying relationship to the upper support means and also being spaced a substantial distance below the upper deck 635.

As seen particularly in FIG. 23, this catwalk means is composed of a plurality of portions 672 defining spaces 673 therebetween. These spaces are substantially aligned with the central portions of the spaces defined between the upper support means portions previously described such that the spaces 673 defined by the catwalk means are adapted to receive part of the conduit section handling means hereinafter described. The catwalk means of course permits personnel to walk around and to permit an operator to readily gain access to the handling means as hereinafter set forth.

Track means is supported beneath the upper deck 635 for supporting the handling means, this track means consisting of a plurality of main track portions 675 each of which is of a substantially I-beam cross sectional configuration for supporting the handling means. These main track portions are supported substantially over the center lines of the spaces between the upper support means portions previously described such that the handling means is adapted to move over these spaces and to permit engagement of the conduit sections supported within these spaces for lifting and lowering the conduit sections when removing them from stowage or returning them to stowage.

It will be understood that in both FIGS. 23 and 24, the upper and lower portions thereof represent different vertical levels, and that in FIG. 24 the upper support means has been broken away at the lower half of the figure to illustrate the lower support means whereas in FIG. 23, the catwalk means has been broken away in the upper half of the figure to illustrate the track means. In each case it should also be fully understood that the upper and lower support means as well as the catwalk and the track means is symmetrical on either side of the centerline of the ship which is equivalent to a centerline drawn horizontally through these figures.

The track means includes a plurality of turntable track portions 677 one of which is illustrated in detail in FIG. 28. As seen in FIG. 28, each of the turntable track portions includes a substantially disc shaped portion 680 having a shaft means 681 extending upwardly therefrom and supported by suitable bearing means indicated at 682 supported by the upper deck. With this arrangement, the disc like portion 680 is mounted for rotation through an angle of 360°. A track means 684 in the form of a member having a substantially inverted T-shaped cross-sectional configuration is secured to the undersurface of the disc means and is adapted to be swung into position so as to be aligned with one of the main track portions 675 or to be aligned with an adjacent track portion of a turntable track portion as hereinafter described.

As seen particularly in FIGS. 22, 23 and 24, guide means for guiding the vertical movement of the conduit sections out of the stowage means includes guide rail means comprising three spaced guide rails 687, 688 and 689 which extend substantially vertically within the stowage area to a point closely adjacent the access hatch 443. The guide rails 688 and 689 are of substantially H-shaped cross sectional configuration as seen particularly in FIG. 32, while the remaining guide rail portion 687 is of sub-

stantially T-shaped configuration. This guide rail 687 is also removable so as to enable access of the handling means hereinafter described to a particular space between the portions of the upper support means as will be hereinafter explained.

A movable guide portion is indicated generally by reference numeral 691, this guide portion having a substantially triangular shaped configuration including the side portions 693, 694 and 695 as seen in FIG. 32. A first plurality of guide rollers 697 are rotatably supported by spaced portions of the movable guide portions and are adapted to engage parts of the guide rail 688 to guide vertical movement of the movable guide portion. A similar plurality of rollers 698 are rotatably supported by the movable guide portion and cooperate with guide rail 689 to guide vertical movement. A third plurality of guide rollers 699 are rotatably supported by the movable guide portion and engage parts of the movable guide rail 687 for guiding the movement of movable guide portion 691. It is apparent that the movable guide portion will be accurately guided in its vertical movement by the inter-engagement of the guide rollers with the guide rails. As seen in FIG. 31, a bumper means 700 is provided on the lower portion of the movable guide portion in order to prevent damage to the undersurface thereof and to cushion the fall of the movable guide portion as hereinafter described.

As seen particularly in FIG. 32, the side portion 693 of the movable guide portion is provided with a pair of spaced bosses 702, side portion 694 of the movable guide portion being provided with a pair of similar bosses 703, and the remaining side portion 695 of the movable guide portion being provided with a pair of spaced bosses 704. Three similar detent members indicated generally by reference numerals 706 are provided, each of these detent members being pivotally supported upon pin means 707, the three pin means being mounted between adjacent pairs of bosses 702, 703 and 704.

The pivotally mounted detent members comprise a means for engaging a lower portion of a conduit section for interconnecting the movable guide portion with a lower portion of the conduit section as hereinafter described. Each of the detent members 706 is constantly urged into the operative position shown in FIGS. 31 and 32 by associated spring members 709 which are wrapped around the pin means upon which the detent members are mounted, the spring means engaging the detent members for urging them in the desired direction of rotation about the supporting pin means. Suitable means such as a lug 710 as seen in FIG. 31 may be connected with the associated bosses 702, 703 and 704 for engaging the detent members and limiting inward pivotal movement thereof.

As can be seen most clearly in FIG. 31, each of the detent members 706 is provided with an upwardly facing cam surface 712. A lower flange of a conduit section is indicated by the phantom line 600, this conduit section being lowered into position by the handling means hereinafter described. A support means 656' which is substantially identical with the support means 656 previously described in connection with FIG. 27 is fixed to the supporting deck surface and is adapted to guide the lower portion of the conduit section into proper operative position. It will be apparent that as the conduit section is lowered into the operative position shown, the lower flange of the conduit will engage the upwardly facing cam surfaces 712 of each of the detent members and will cause the detent members out of the way so that the conduit section may be lowered into the position shown with the bottom flange of the conduit section supported on the support means 656'. When the conduit section reaches this position, the spring means 709 will cause each of the detent members to pivot back into its operative position shown whereupon the downwardly facing lower surface 714 formed on the upper portion of each of the

detent members will be adapted to engage the upper surface of the lower flange on the conduit section. When the detent members are in this position, it is apparent that the movable guide portion will be operatively interconnected with the lower flange of the conduit section.

When the movable guide portion has been operatively connected with the lower flange of the conduit section as discussed above, the conduit section can then be raised in a vertical direction carrying the movable guide portion 691 along therewith. The guide rollers on the movable guide portion will cooperate with the guide rail means previously described so as to accurately guide the conduit section in its upward vertical movement.

Referring now to FIG. 30, three spaced projections 716 are supported from the undersurface of the main deck, these projections being spaced in overlying relationship to the detent members 706 and being adapted to engage surfaces 718 on the detent members. As seen in FIG. 31, each of last-mentioned surfaces 718 are disposed in a substantially horizontal position when in the operative connected relationship as shown, and accordingly as the movable guide portion is carried upwardly by an associated section, the projections 716 will engage the surfaces 718 on the detent members so as to cause them to pivot out of the operative connected relationship with the lower flange of an associated conduit section whereby the movable guide portion will be released from the associated conduit section. The conduit section may then be raised further above the main deck and manoeuvred into the desired position for lowering into mining relationship as hereinafter described.

When the movable guide portion is so released from an associated conduit section, it will drop under the influence of gravity down along the associated guide rail means, and the bumper means 700 at the bottom thereof will cushion the fall of the movable guide portion and prevent damage thereto. The movable guide portion will then be in the position as seen in FIG. 31 adapted to receive the lower flange of another conduit section.

STOWAGE AREA HANDLING MEANS

Referring now particularly to FIGS. 33, 34 and 35, the handling means for handling the individual conduit sections to move these sections into and out of the stowage position within the stowage means is illustrated. This handling means includes a body means indicated generally by reference numeral 720, this body means having a channel-like cross sectional configuration as seen in FIG. 35 and serving to rotatably support a first pair of upper and lower rollers 722 and 723 at either side thereof at one end of the body means and a second pair of upper and lower rollers 724 and 725 at opposite sides thereof at the other end of the body means. These pairs of rollers are adapted to engage the upper and lower surfaces of the lower flange of a supporting overhead track means as previously described which is of substantially I-beam cross sectional configuration. As seen in FIG. 35, the particular track portion shown includes an upper flange 727, a central web portion 728 and a lower flange 729. It will be apparent that the rollers aforescribed serve to support the body means for movement along the track, and further that the body means will be guided for movement along such track and cannot escape therefrom.

A drive motor 730 is supported by the body means, this drive motor as seen particularly in FIG. 35 including a driving sprocket 732 which is adapted to positively cooperate with a chain belt 733 or the like, which can be suitably secured as by welding to the undersurface of the track means. It is apparent that by controlling the speed and direction of rotation of the drive motor, the speed and direction of movement of the body means can be controlled, a positive driving connection being provided for this purpose.

A plurality of spaced depending arms 736 extend downwardly from the body means, and a substantially cylin-

drical portion 737 is connected with the lower ends of these arm portions. A substantially annular support portion 740 is supported by bearing means 741 and 742 for rotation through 360° of movement about the lower part of the cylindrical portion 737, an outwardly projecting portion 745 serving to support this rotatable cylindrical portion. The portion 745 may be formed integral with or separate from the cylindrical portion and is fixed with respect thereto. The support means 740 includes an outwardly and upwardly extending portion 747 upon which an operator's seat 748 is supported, a foot rest 749 also being provided to enable an operator to sit on the seat and to move about the handling means as required to properly direct the handling means. An upwardly extending portion 751 supported by the support means 740 serves to support a control panel 752 including suitable controls for controlling the operation of the handling means.

A bearing means 755 is supported by the body means and serves to rotatably journal a shaft 756 having a pulley 757 connected to the upper end thereof, the lower portion of said shaft having suitable screw thread means 758 formed thereon. The screw thread means is adapted to cooperate with a nut portion 760, rollers or balls 761 being provided for engaging the screw thread means 758 of shaft 756 to provide a so-called ball-screw interconnection.

Nut 760 is fixedly connected to the upper portion of a tubular member 764 which is adapted to move upwardly and downwardly with respect to the body means. A key 765 is provided on the outer surface of the tubular member or movable support means 764 and is adapted to engage a suitable keyway provided in the cylindrical member 737 for preventing relative rotation between the tubular member 764 and the cylindrical member and body means. An operating motor 767 is provided with a pulley 768 and is interconnected by a suitable driving belt or the like 769 for controlling the rotation of shaft 756.

An enlarged portion 772 is provided at the lower end of the tubular member 764, this enlarged portion including a substantially frusto-conically shaped outer cam surface 773. A support member 775 which is of generally disc-like configuration includes a central opening 776 through which the tubular member 764 extends and is movable with respect thereto. A second key means 778 is provided on the outer surface of tubular member 764 and is adapted to engage in a suitable keyway provided in the support member 775 for preventing relative rotation between the support member and the tubular member.

Movable clamp means includes a plurality of movable clamping members 780 of similar construction which may be four in number, the detail of construction and mode of mounting the individual clamping members being most clearly seen in FIG. 33. As seen in this figure, it will be noted that each of the clamping members includes a lower sloping cam position 782 which is disposed at an angle so as to be complementary to the outer cam surface 773 provided at the lower end of the tubular member 764. The upper portion of each of the clamping members extends through a suitable radially extending slot means 784 provided in the undersurface of support member 775 whereby each of the clamping members is movable inwardly and outwardly in a radial direction. The upper portion of each of the clamping members may be of substantially T-shaped cross sectional configuration, and the slot means may be of complementary configuration so as to receive the clamping members, to support the clamping members and prevent them from falling downwardly out of the support member, and to additionally guide radial movement thereof as will be well understood.

A resilient compression spring means or the line 785 is provided in engagement with each of the individual clamping members for normally urging the clamping members in a radially inward direction as will be apparent.

A pair of diametrically opposite arm members 787 are provided, each of these arm members being mounted for pivotal movement about pin means 788 supported by the support member 775. The lower ends of each of these arm members are provided with radially extending substantially cylindrical pin means 790 which are adapted to cooperate with eye-bolts or the like indicated by phantom lines 791 which are connected with the upper flange of an associated conduit section as indicated by phantom line 792.

Upwardly extending support means 795 are provided on support member 775 at diametrically opposite sides of the tubular member 764, these support members supporting solenoid means 796 each of which is adapted when energized to pull the armature means 797 thereof radially inwardly so as to pivot the upper ends of the arm member. Compression spring means 798 is operatively connected between each of the support members 795 and the adjacent upper portions of the associated arms so as to normally pivot each of the arms such that the upper portions thereof tend to move radially outwardly and the lower portions thereof tend to move radially inwardly.

CONDUIT SECTION REMOVAL AND STOWAGE PROCEDURE

All handling operations concerning the conduit sections when removing or stowing them with respect to the stowage area should be carried out with the ship on as near even keel as possible.

The forward six conduit sections disposed in a row extending athwartships are the first and last to be handled in the removal and stowage procedures respectively. Firstly, the procedure to be followed in removing the forward six conduit sections will be described.

An operator mounts the operator's seat of the handling means and maneuvers the handling means apparatus through the intermediary of the controls provided at the operator's seat so as to position the handling means apparatus on one of the turntable track portions over the center line of a first conduit section either to the starboard or port of the access hatch 443 to the stowage means. Short fixed track portions 678 are supported adjacent the inboard turntable track portions as seen in FIG. 23 to permit the handling means to travel from the access hatch 443 to the turntable track portions.

The motor 767 of the handling means is then energized so as to lower the tubular member 764 with respect to the body means through the intermediary of the ball screw means previously described until the arm members 787 are supported in such a position as to move into operative relationship with eye-bolts or the like secured to the upper flange of the conduit section.

The operator then de-energizes the solenoids 796 and the arms 787 are automatically moved inwardly by means of the spring means 798 and the pin means 790 enter the holes in the eye-bolts and assume the operative lifting position as shown in FIG. 33. The operating motor 767 is again energized except in a reverse direction to that previously described so as to cause tubular member 764 to start to rise. As the tubular member rises, the cam surface 773 formed on the lower enlarged portion thereof interacts with the cam surface on the clamping members 780 which cannot move upwardly due to the interengagement of the pin means with the eye-bolts on the associated conduit section. The aforementioned interengagement of these cam surfaces causes the clamping members to be moved radially outwardly such that the outer surfaces thereof engage the inner surface of the bore within the associated conduit section.

When the clamping members have been so interengaged with the conduit section, further upward movement of the tubular member will cause the conduit section to move upwardly therewith. As soon as the conduit section starts to rise, upward travel of the tubular member 764 is stopped by deenergizing the driving motor 767.

At this point, the strap 667 as seen for example in FIG. 29 is removed from around the conduit section such that the conduit section is then free to move upwardly. The conduit section is then further raised by raising tubular member 764 of the handling means until the lower end portion of the conduit section clears the lower support means upon which it has been resting.

The handling means apparatus is then moved by the operator along the associated turntable track portion and thence onto one of the athwartships track portions 678 to a point adjacent the access hatch 443. Referring to FIG. 30, which is a view looking upwardly at the access hatch, a portable rail section 800 is supported on the undersurface of a member 801 which is adapted to fit within the access hatch and to be supported at such point. As shown, the portable rail section 800 is illustrated as being aligned with a particular main track portion 675'. A first phantom line 803 indicates the manner in which another member similar to the member 801 can be provided with a portable rail section aligned with a main track section 675''. In a similar manner, phantom lines 804 and 805 illustrate arrangements wherein a member similar to member 801 may be provided with rail sections aligned either with the main rail section 675'' or with the athwartships sections 678. It will accordingly be understood that in the procedure presently being discussed, a member having a rail section is positioned in the access hatch 443 so that the handling means may be moved into such a position that it is centered over the support means 656' disposed at the bottom central portion of the vertically extending guide means previously described.

After the conduit section has been moved into this position, the conduit section is lowered by lowering tubular member 764 of the handling means until the lower portion of the conduit section is supported on the support means 656' as illustrated in FIG. 31.

As the conduit section moves downwardly, the detent members 706 previously discussed in connection with the guide means will first be cammed out of the way and then will snap into operative position as shown in FIG. 31. After these detent members have engaged the lower flange on the conduit section, the conduit section is strapped in position by providing a strap around the upper portion thereof in a manner similar to that previously discussed in connection with FIG. 29.

With the conduit section strapped in such position, the tubular member 764 is again lowered. As the tubular member moves downwardly, the cam surface 773 at the lower end thereof will move down thereby permitting the spring means 785 to force the clamping members 780 radially inwardly. The solenoids 796 are then energized to move the arms 787 such that the pins 790 will be moved outwardly out of operative relationship with respect to the eye-bolts secured to the conduit section.

The tubular member 764 is then again raised so as to lift the entire apparatus clear of the conduit section whereupon the handling means may be maneuvered into position for handling another conduit section. It will be understood that the procedure as described above is followed until all of the first six conduit sections extending in a row athwartships in the stowage area have been removed.

The removal of conduit sections from any of the various fore and aft rows involves a procedure similar to that described above except for certain exceptions as described hereinafter. When removing conduit sections from either of the last four port or starboard rows of conduit sections, it is necessary to employ the turntable track portions in order to transfer the handling means from an athwartships position to a fore and aft position. In other words, if the handling means is moving in an athwartships direction, and it is desired to move it onto one of the main track portions extending fore and aft, the handling means is positioned on the turntable track portion and stopped in such position whereupon the disc-like turn-

table portion thereof is rotated so as to properly align the track portion thereof with the fore and aft track portion, whereupon the handling means can be moved onto such main track portion. It is believed that the manner of operation of the turntable track portions will be apparent from a consideration of FIG. 23 in connection with the above description.

Before the handling means can enter any of the rows of conduit sections, which are provided with the movable supports, it is of course necessary to swing such movable support into the position as shown at the lower part of FIG. 25 in order for the handling means to move into operative position. The movable supports will then of course be replaced when the desired number of conduit sections have been removed.

When removing conduit sections from the center row of conduit sections extending fore and aft within the stowage means, it is necessary to remove the aft guide rail 687 which of course is replaced prior to lifting a conduit section vertically out of the access hatch 443.

It will of course be understood that when removing conduit sections from either the central fore and aft row or from either of the first rows port and starboard of this central row, it is necessary to employ a portable track means as shown in FIG. 30 aligned with the main track means disposed over such row in order that the conduit sections may be moved to the central portion beneath the access hatch.

It should be understood that stowage of the conduit sections within the stowage area involves a procedure which is the reverse of the removal procedure described above.

Referring now to FIG. 36, after the conduit section is positioned beneath the center line of the access hatch 443, a hook 375 is lowered by the bridge crane and engages a cable or the like 811 connected between the eye-bolts at the upper flange of the conduit section. All slack is removed from the cable until the conduit section starts to rise whereupon the strap around the conduit section is removed. The conduit section is then raised through the access hatch by the bridge crane.

When the lower flange of the conduit section nears the main deck level, the detent members 706 of the movable guide portion engage the projections 716 as seen in FIG. 30 thereby releasing the detent members such that the movable guide portion falls back to its initial position ready to receive another conduit section from the handling means.

The bridge crane continues to raise the conduit section until it clears the main deck and is snub in a bridge crane pipe guide means indicated by reference numeral 810. The bridge crane then travels forwardly from the dotted line position as seen in FIG. 36 to the full line position as seen in this figure until it is over the movable support means or platform dolly 462. The conduit section is then lowered until the lower flange thereof is bolted to a mating flange on a conduit section supported by dolly 462. The bridge crane holds and guides the conduit section until it clears the guide 810, whereupon the bridge crane is adapted to move aft into the phantom line position whereupon it is adapted to handle another conduit section.

It will be understood that the stowage procedure in connection with operation of the bridge crane is just the reverse of the removal procedure as set forth above.

MOVABLE SUPPORT MEANS

Referring particularly now to FIGS. 36 through 41 inclusive, the movable support means includes a body means of rigid heavy-duty construction, this body means comprising a plurality of frame members which may be of I-beam cross sectional configuration, these various frame members being rigidly interconnected with one another as by welding or the like. As seen most clearly in FIG. 37, the framework of the body means is made up of a pair of forward frame members 812 and 813, and a

pair of frame members 814 and 815 being connected respectively with one end of the frame members 812 and 813 and converging toward one another and interconnected with one another at the opposite end thereof. Frame members 814 and 815 define a substantially V-shaped cutout portion as indicated by reference numeral 817 at the forward part of the movable support means, this V-shaped cutout portion being adapted to receive a part of the truss means as will hereinafter appear while lifting and lowering the truss means into and out of operative mining position. As seen in FIG. 37, a removable plate member 818 is disposed at the apex portion of the V-shaped cutout in the body means and may be removed when desired.

A first pair of frame members 820 and 821 extend along the port side of the support means, and a similar pair of frame members 822 and 823 extend along the starboard part of the support means. A rear cross frame member 825 extends between the end portions of the frame members 821 and 823.

A pair of cross frame means are indicated generally by reference numerals 827 and 828 and may comprise a single cross frame member or a plurality of sections as illustrated, cross frame means 827 including three sections 830, 831 and 832 as illustrated, and cross frame means 828 including three sections 834, 835 and 836 as illustrated.

A first pair of longitudinally extending brace frame members 838 and 839 extend between the cross frame means 827 and 828, while a second pair of longitudinally extending cross brace members 829 and 830 extend between the cross frame means 828 and the rear cross frame member 825. This over-all arrangement provides a very substantial and rigid framework, the entire framework being covered by a top plate means indicated generally by reference numeral 842.

Four flanged wheels indicated by reference numerals 844 are disposed at the port side of the support means, and four similar wheels 845 are disposed at the starboard side of the support means. These wheels are all rotatably journaled in a conventional manner for rotation with respect to the support means, these wheels being suitably spaced with respect to the spaced portions of the guide track means on the deck such that the movable support means will always remain in supported guided relationship with respect to the guide track means.

A first plurality of bracket means indicated by reference numerals 847 are provided on the upper surface of the top plate means of the movable support means for interconnection with and supporting certain parts of the truss means when moving the truss means into or out of operative mining position. A second plurality of bracket means indicated by reference numerals 848 are provided on the upper surface of the plate means and are adapted to engage certain portions of other parts of the underwater mining equipment such as the buoyancy capsule and the like. In addition, a plurality of foundation members indicated by reference numerals 850 are provided on the upper surface of the top plate means for supporting a part of the underwater mining equipment as for example the dead weight means.

A central hole 852 is provided through the upper plate means, and it will be noted that the various frame members are offset with respect to this hole such that an opening is provided through the central portion of the body means through which certain parts of the mining equipment may extend. Clamping means is mounted in overlying relationship to this opening through the body means, the clamping means including a pair of clamping members indicated generally by reference numerals 854 and 855. The clamping members include upper engaging portions 856 and 857 respectively which are adapted to engage and support portions of the underwater mining equipment, these engaging portions being illustrated as comprising substantially semicircular portions which in

the present invention are adapted to engage the outer portions of an associated conduit section for holding the conduit section in the operative relationship as will hereinafter appear.

As seen in FIG. 37, the uppermost portions of clamping members 854 and 855 terminate at points 856 and 857 to define a gap therebetween while the upwardly facing engaging portions 856 and 857 extend to substantially abutting relationship with one another and define side surfaces 858 and 859 which as seen in this figure taper inwardly toward one another. The space between portions 856 and 857 is adapted to receive the electrical power and television cables associated with the underwater equipment as well as the air pipe extending upwardly from the dead weight means as described hereinbefore. The sloping surfaces 858 and 859 will serve to cam the flexible cables outwardly as the clamping portions are moved together and ensure that the cables will not be pinched between the clamping portions as they come together.

Guide means is provided for guiding the movement of said clamping members toward and away from one another, the guide means including first pairs of rollers 860 and 861 at one side of the clamping members 854 and 855 respectively, and second pairs of rollers 862 and 863 provided at the opposite side of the clamping members 854 and 855 respectively. A first pair of guide rails 865 and 866 supported on plate 842 are provided for operatively cooperating with the guide rollers 860 and 862 of clamping member 854 to guide the movement of this clamping member with respect to the body means. A second pair of guide rails 868 and 869 are provided for cooperating with the rollers 861 and 863 of the clamping member 855 to guide the movement of the clamping member with respect to the body means.

Referring now particularly to FIG. 41, a means for locking the rollers of the clamping members in operative position is illustrated, it being understood that one of these locking mechanisms is associated with each of the roller means, the particular locking mechanism illustrated being associated with the rollers 863.

As seen in FIG. 41, a cutout portion 870 is provided in the upper plate means 842 and a support portion 872 is disposed within this cutout portion and has a clearance therewith for movement in an upward and a downward direction. Support portion 872 also includes an upwardly extending guide rail 873 which is aligned with the guide rail 869 supported on the upper plate means 842.

A bracket means 875 is disposed in depending relationship from the adjacent frame member 835, this bracket member including wall portions 877 within which is seated a compression spring 878. It is apparent that the spring 878 will normally hold the support portion 872 in its position as shown in FIG. 41 wherein the upper surface thereof is substantially flush with the upper surface of the adjacent plate means 842. The spring means such as 878 of the various locking mechanisms is of sufficient strength to maintain the associated support portions such as 872 in their up position as shown when the rollers are supported thereon, and accordingly, the springs will normally support the weight of the clamping members. On the other hand, when the clamping members are under load when supporting a part of the underwater mining equipment, the support portion 872 will be moved downwardly into the dotted line position. It is apparent that when the support portion has been so moved downwardly, the associated supported roller means 863 will be prevented from rolling back toward the inoperative position and will accordingly be maintained in its forward clamping position until the load is removed from the clamping members, whereupon the spring means will again urge the support portion 872 upwardly to its original upward position and the clamping members can be withdrawn.

Additional guide means for the clamping members as seen most clearly in FIG. 39 include a pair of guide rods

880 and 881 operatively connected with clamping members 854 and 855 respectively. These guide rod means are slidably supported within cooperating holes provided in the longitudinally extending frame members 838 and 839 respectively, the intercooperation between these guide rod means and such frame members serving to additionally guide the clamping members in their movement into and out of clamping position.

Power operated means in the form of hydraulic ram means includes a lower hydraulic cylinder 883, the piston of which is connected with clamping member 854 by means of a connecting rod 884. An upper hydraulic cylinder 885 includes a piston which is connected with clamping member 854 by a connecting rod 886. Similar hydraulically operated means is operatively connected with clamping member 855 and includes a lower hydraulic cylinder 890, the piston of which is connected by means of connecting rod 891 with clamping member 855. An upper hydraulic cylinder 893 includes a piston which is connected with the clamping member 855 by a connecting rod 894. It will be noted that the lower hydraulic cylinders 883 and 890 are much larger than the upper hydraulic cylinders 885 and 893. The upper hydraulic cylinders 885 and 893 are fast acting cylinders adapted to move the clamping members through a substantial distance of travel rather quickly, while the lower cylinders 883 and 890 are slow acting cylinders adapted to apply clamping pressure to hold a supported underwater mining equipment component in operative clamped position between the clamping members.

It is apparent that the power operated hydraulic ram means are adapted to move the clamping members into and out of operative clamping relationship with respect to one another, any suitable control means being provided for controlling the operation of these hydraulic rams.

As seen particularly in FIG. 37, an electric motor 896 is supported by the body means and is operatively connected with a hydraulic pump 897 which in turn is connected in the usual manner with the sump tank 898. The pump 897 is operatively connected by suitable conduit means with each of the hydraulic ram means, the aforementioned control means being connected in such conduit means for controlling the operation of the ram means. The hydraulic pump 897 is also connected with a conventional hydraulic motor 900.

Hydraulic motor 900 is supported beneath the top plate means of the body means and is connected by a drive shaft means 902 with a speed reducer means 903. A conventional brake mechanism is indicated at 904 and may be controlled by hand for applying the brake when desired.

The output of the speed reducer means 903 is connected with a driving shaft 905 the opposite end of which is rotatably supported in a bearing means 906 supported by a downwardly extending bracket 908. A pair of drive sprockets 910 and 911 are connected with space portions of the drive shaft 905.

A longitudinally extending frame support member 913 is supported between cross frame means 828 and rear cross frame member 825 and supports a pair of spaced bearings 914 and 915. A drive shaft 917 is supported between bearing 915 and a bearing 918 supported at the port side of the movable support means, and a similar drive shaft 920 is supported between bearing 914 and a bearing 921 provided at the starboard side of the movable support means.

Sprockets 910 and 911 are operatively connected respectively with the drive shafts 920 and 917. A first chain driving connection 923 is provided between sprocket 910 and a sprocket 924 fixed to shaft 920, and a second driving chain connection 925 is provided between sprocket 911 and a sprocket 926 fixed to shaft 917. In this manner, drive is transmitted from the drive shaft 905 to each of the drive shafts 917 and 920 which have respectively the sprockets 927 and 928 operatively secured to the outer ends thereof.

The sprockets 927 and 928 at opposite sides of the movable support means are adapted to cooperate with means such as lengths of roller chain indicated by reference numerals 930 and 931 which can be suitably secured as by welding to the upper surface of the deck means. The intercooperation between the fixed roller chain means and the rotating sprockets 927 and 928 serves to provide a means for positively driving the movable support means fore and aft of the ship.

The guide track means 458 and 460 previously described are provided at the port and starboard sides respectively of the movable support means and serve to support and guide the wheels of the movable support means in the movement of the movable support means fore and aft of the ship.

Wedge locking means is provided for selectively locking the movable support means in a particular position relative to the deck. A first pair of spaced wedge bearing portions 934 and 935 are provided at the port side of the body means and a second pair of spaced wedge bearing portions 937 and 938 are provided at the starboard side of the body means. Each of these wedge bearing portions has a substantially channel-shaped cross sectional configuration as seen in FIG. 38 and further as seen in FIG. 39, the downwardly facing surface of the central portion of each of these channel-shaped bearing portions slopes downwardly from the outer side of the movable support means toward the inner portion of the movable support means.

The wedge locking means also includes a plurality of wedge members 940 each of which has been given the same reference numerals since these wedge members are of identical construction. The wedge members each include an upwardly facing surface 941 which slopes downwardly and inwardly toward the inner portion of the associated movable support means so as to fit snugly against the aforementioned downwardly facing surface of the wedge bearing portions. These wedge members are each connected with an enlarged body portion 943 which in turn is supported for movement along the deck by means of four roller members 944 rotatably supported at spaced side portions of this wedge portion. The rollers are adapted to roll along inclined portions 945 supported by the deck.

A pair of spaced upwardly extending guide members 946 are provided on the deck in association with each of the wedge members and is adapted to engage opposite sides of the wedge members for guiding them in their movement into and out of wedging locking relationship with the wedge bearing portions on the body means.

As seen particularly in FIG. 37, a first pair of upstanding lugs 947 are supported on the deck and serve to pivotally support a wedge locking lever 948 on a pin means 949 extending between the lugs. A second pair of upwardly extending lugs 950 are supported by the deck and are adapted to receive the opposite end of the locking lever therebetween, the lugs 950 and the locking lever being provided with openings which are adapted to be aligned with one another so as to receive a locking pin 951 therethrough for holding the locking lever in its locking position.

The locking lever is provided with a portion 952 thereon which is adapted to cooperate with a portion 953 on the part 943 of the wedge member, these two interengaging portions 952 and 953 being provided with complementary surfaces. When the locking lever is in the position shown in full line in FIG. 37, the wedge members are at their inner limit of movement in engagement with the wedge bearing portions on the body means, and outward movement of the wedge members is positively prevented. On the other hand, the wedge locking levers may be swung into the phantom line position as shown in FIG. 37 whereupon each of the associated wedge members may be withdrawn outwardly away from the wedge bearing portions on the body means.

The wedge members may be moved into the operative

locking position by any suitable means. As seen particularly in FIG. 39, wedge bearing plates 955 are disposed beneath the wedge members when the wedge members are moved inwardly thereby supporting such wedge members. The intercooperation between the sloping surfaces formed on the wedge bearing portions of the body means and the upper surfaces of the wedge members serves to lift the body means upwardly to lift the wheels of the body means off of the associated track and to also raise the driving sprockets 927 and 928 out of interengagement with the drive portions 930 and 931 secured to the deck. It is accordingly apparent that when the wedge members are in this position, the movable support means will be positively prevented from moving along the deck.

As seen in FIG. 39, each of the wheels 844 and 845 disposed at the port and starboard side respectively of the body means is provided with a vertical flange which normally cooperates with the guide track means to properly guide movement of the movable support means. The wedge bearing plates 955 are each provided with a cut-out portion 957 which is adapted to receive this vertical flange portion of the associated wheels so as to permit the wheels to freely pass over the upper surface of the wedge bearing plate portions, the upper surfaces of which are flush with the adjacent guide track portions.

Referring again to FIG. 37, it will be noted that a pair of removable plate portions 959 and 960 are provided, these removable plate portions being supported on the upper portion of the frame means and permitting operating personnel to gain access to the clamping members and any equipment which may be supported thereby. These removable plate members may be taken away when it is desired or necessary to have a full clearance of the opening provided in the body means.

Also as seen in FIG. 37, the movable support means is provided with laterally extending towing pins 961 extending outwardly from the central web of frame members 820 and 822 at opposite sides of the movable support means. These towing pins are utilized for towing the pumping means dolly hereinafter described.

PUMPING MEANS DOLLY

Referring now particularly to FIGS. 42, 43 and 44, the dolly means utilized for supporting the pumping means in a stowed position and for moving certain components of the equipment into desired operative position is illustrated. This dolly means includes a body means formed of an open framework comprising a plurality of interconnected rigid members which are preferably of I-beam cross sectional configuration. The body means includes two frame members 962 and 963 extending generally athwartships, these two frame members being interconnected by fore and aft frame means 965 and 966, the port frame means 965 including a pair of frame members 968 and 969 of I-beam cross sectional configuration secured to one another, and the starboard frame means 966 including a pair of frame members 970 and 971 of I-beam cross sectional configuration secured to one another.

Four spaced wheels 973 are supported by the port frame means 965, and four similar spaced wheels 975 are supported by the starboard frame means 966. These wheels are adapted to move along the track portions 458 and 460 as seen particularly in FIG. 43 whereby the dolly means is supported and guided in its movement along the deck.

A pair of members 977 and 978 of substantially U-shaped cross sectional configuration are secured to the upper surface of the fore and aft frame member 979 extending between frame members 962 and 963. A pair of similar U-shaped members 982 and 983 are secured to the upper surface of the frame member 985 extending between frame members 962 and 963. These members 977, 978, 982 and 983 are adapted to support leg portions 985 as indicated in phantom line in FIG. 43 extending downwardly from the lower portion of the pump capsule means.

A first upwardly extending pair of channel members 987 and 988 extend upwardly slightly above the upper surfaces of members 977 and 978 and serve to prevent lateral movement of the associated leg portions of the pump capsule. An upper pair of channel members 990 and 991 interconnect the upper portions of channel members 987 and 988 with the member 969 of the port frame means 965. A similar pair of lower channel members 993 are provided for rigidifying the upwardly extending channel members 987 and 988.

A pair of channel members 995 and 996 similar to the previously described channel members 987 and 988 provided for the same purpose adjacent the starboard frame means 966. A pair of upper channel members 997 and 998 are interconnected between the upper ends of channel members 995 and 996 and the member 970 of the starboard frame means 966. A pair of similar lower channel members 999 are provided for rigidifying the vertically upward extending channel members 995 and 996.

It is apparent that the frame work structure of the present invention provides a relatively lightweight arrangement which at the same time is adapted to rigidly support the pump capsule and in addition to support the pump disposed within the pump capsule as hereinafter described.

As seen particularly in FIG. 42, a pair of laterally extending towing pins 1000 extend outwardly from the central web portions of members 968 and 971 at opposite sides of the dolly framework. These towing pins are adapted to be interconnected with the towing pins 961 previously described in connection with the movable support means 462, the towing interconnection being made by suitable towing plates such as illustrated by dotted line 1002 in FIG. 44 shown connected between the towing pin means on the movable support means and the dolly means.

Four spaced anti-roll stop means 1005 of identical construction are secured to the deck of the ship to prevent undesired movement of the dolly means in athwartships direction. Each of these anti-roll stop means includes a pair of spaced supporting members 1006 secured to the deck of the ship, a flat plate 1007 being secured to the upper surfaces thereof. A vertically extending plate 1008 extends upwardly from the inboard portion of plate 1007, and a horizontally extending plate 1009 is secured to the upper edge of plate 1008. An inclined plate member 1010 extends between the outboard edge of the top plate 1009 and the outboard edge of the bottom plate 1007. This construction provides a rigid anti-roll stop means adapted to resist any lateral movement of the dolly means.

AUXILIARY SUPPORT MEANS

Referring now particularly to FIGS. 45 through 48 inclusive, the auxiliary support means of the present invention comprises a pair of movable portions indicated generally by reference numerals 1014 and 1015. Each of these movable portions comprises an open framework type construction formed of heavy tubular members for maximum strength and rigidity, the movable portion 1014 including a pair of members 1017 and 1018 which converge toward one another and which are secured at the upper ends thereof to a support portion 1020. A cross member 1022 is fixed at its opposite ends to an intermediate portion of members 1017 and 1018 to provide a reinforced A-frame construction.

The movable portion 1015 in a like manner includes a pair of members 1024 and 1025 which are secured at the upper ends thereof to a support portion 1026, a cross member 1027 being secured to intermediate portions of members 1024 and 1025 for reinforcing the structure and to provide an A-frame construction. All of the various members of the two movable portions may be suitably fixedly secured to one another as by welding and the like.

Referring now particularly to FIG. 47 which is a view looking up into the well portion from the bottom of the ship means, it will be noted that the substantially rectangu-

lar shaped well portion indicated by reference numeral 125 includes a plurality of walls which define a central well area through which the various underwater components pass during lowering of the equipment into mining position and raising of the equipment from mining position. An aft wall portion 1030 defines the aft part of the well area, and is formed so as to define the cutout portion 1031, it being noted that the side wall portions 1032 and 1033 taper downwardly and outwardly from the top portions 1032' and 1033' respectively thereof to the lower portions 1032'' and 1033'' respectively thereof, outwardly extending portions 1035 and 1036 being provided for supporting in combination with the lower parts of said side wall portions the tubular parts 1039 and 1040. These tubular parts are mounted for pivotal movement by means of suitable bearing means indicated at 1041 and 1042, these tubular portions being connected to the lower ends of members 1017 and 1018 of the movable portion 1014.

At the opposite side of the well portion as seen in FIG. 47, wall portions 1045, 1046, 1047, 1048 and 1049 define the forward extent of the well area, the wall portions 1045 and 1049 being recessed as indicated at 1052 and 1053 respectively to provide clearance for the members 1024 and 1025 of the movable portion 1015. Outstanding portions 1055 and 1056 serve to cooperate with wall portions 1045 and 1049 respectively to rotatably support tubular portions 1058 and 1059 on bearing means indicated at 1060 and 1061. These tubular portions 1058 and 1059 are secured respectively to the lower ends of the members 1024 and 1025 of the movable portions 1015 whereby this movable portion is pivotally supported for movement with respect to the well portion.

The wall portions 1062, 1063, 1064, 1065, 1066, 1067, 1068 and 1069 cooperate with the elevator guide portion 1070 to define the starboard extent of the well area, and the wall portions 1072, 1073, 1074, 1075, 1076, 1077, 1078, and 1079 cooperate with the elevator guide portion 1080 to define the port extent of the well area.

The movable portions 1014 and 1015 are adapted to be pivoted upwardly into the recess portions provided adjacent the well area so as to provide a substantially unobstructed central well area through which the mining equipment can be lifted and lowered. It will be noted however, that each of the movable portions is normally stowed in a recessed portion of the well area as aforescribed, and accordingly the movable portions can be completely removed from the well area by detaching the bearings from the associated tubular portions to thereby permit complete removal of these movable portions.

Means is provided for pivoting the movable portions 1014 and 1015 into and out of operative supporting position. The support portions 1020 and 1026 are provided with radially outwardly extending lugs 1082 and 1084 respectively which are secured to one end of cables 1085 and 1086 respectively. These cables are in turn secured on cable drums 1090 and 1091 respectively which are connected with drive shafts 1093 and 1094 therefor which are in turn connected to bevel gears 1095 and 1096 respectively. The driving shafts are in turn adapted to be driven by hand wheels 1098 and 1099 respectively which are connected with vertically extending shafts 1102 and 1103. These shafts are adapted to be removed and are interconnectable with recessed fittings provided in the deck, these recessed fittings in turn being connected with bevel gears 1104 and 1105 which mesh with the gears 1095 and 1096 respectively.

It is apparent that by inserting the hand wheels and associated shafts into the fittings and turning the hand wheels, the movable portions 1014 and 1015 may be pivoted into the recessed areas provided adjacent the well or they can be pivoted inwardly or lowered into the operative supporting position as illustrated in full lines in the drawings. The movable portions are illustrated in their retracted or inoperative position in phantom lines in FIGS. 45, 46 and 48.

As seen particularly in FIGS. 45 and 46, the support portions 1020 and 1026 are respectively provided with recessed or cutout areas 1107 and 1108 which define upwardly facing surfaces 1107' and 1108' which actually engage and support certain portions of the underwater mining equipment such as the flanges or collars provided on the individual conduit sections. Each of these cutout portions or recesses is substantially arcuate in configuration so as to substantially conform to the shape of the flanges or collars on the conduit sections. A conduit section is illustrated in phantom lines in FIGS. 45 and 46 in a typical supported position with respect to the movable portions of the support means.

Locking means is provided in the form of a pair of arms 1110 and 1111 as seen particularly in FIG. 47 for example, these arms each being pivotally supported as indicated at 1112 and 1113 on the support portion 1020 and being movable into contacting relationship with the support portion 1026 and secured in operative position by suitable lock pins indicated by reference characters 1115. When the locking means is in this locked position, it serves to prevent the support portions from separating from one another thereby holding the support portions in the operative supporting position at the central part of the well. When it is desired to release these locking members, the pins 1115 are removed and the arms are swung away from the support means 1026 thereby permitting free pivotal movement of the movable portions 1014 and 1015.

Supported within the well portion below the auxiliary support means described above is a snubber means indicated generally by reference numeral 1120. This snubber means includes a collar means comprising a pair of substantially semi-cylindrical portion 1121 and 1122 which have radially outwardly extending flanges 1123 and 1124 respectively formed at opposite ends thereof. These flanges are adapted to be placed in abutting relationship with one another and detachably secured together by suitable nut and bolt assemblies in a conventional manner.

The portion 1122 of the collar means is provided with a pair of spaced outwardly extending lugs 1126 and 1127 and the portion 1121 of the collar means is provided with a similar pair of spaced outwardly extending lugs 1128 and 1129.

A first cable means 1131 is connected between lug 1126 and a lug 1132 secured to the fixed wall 1064 previously described as seen in FIG. 47. A cable 1134 is connected between the lug 1127 and a lug 1135 secured to fixed wall 1047 previously described. A cable 1137 is connected between the lug 1128 and a lug 1138 secured to the fixed wall 1030 previously described, and a cable 1140 is connected between the lug 1129 and a lug 1141 secured to the fixed wall 1077 previously described. It will be noted that turnbuckles 1143, 1144, 1145 and 1146 are connected between cables 1131, 1134, 1137 and 1140 and the associated lugs 1132, 1135, 1138 and 1141 so that by adjustment of these turnbuckles the slack may be removed from the cables so as to hold the collar means of the snubber means in fixed position at the central part of the well. It will also be noted that the lugs 1126, 1127, 1128 and 1129 are disposed at substantially 90° angles with respect to one another such that when the over-all arrangement of the snubber means is in its operative position, the cables 1131 and 1140 are aligned with one another and disposed at 90° angles to the cables 1134 and 1137 which are also aligned with one another.

It will be noted that the snubber means is particularly adapted for use for engaging the lower part of the conduit section when such conduit section is supported by auxiliary support means previously described, this over-all arrangement being shown in FIGS. 45 and 46. The two portions of the collar means are adapted to be snugly clamped about the outer surface of the conduit section and to hold its part of the conduit section from movement relative to the walls of the well portion. The par-

ticular manner of use of the auxiliary support means as well as the snubber means will be described in detail hereinafter.

ELEVATOR OPERATING MECHANISM

Referring now particularly to FIGS. 49 through 54 inclusive, the means for lifting and lowering the elevator means 128 may be most clearly understood. The elevator means as seen in FIGS. 49, 50 and 51 is illustrated in its topmost operative position. As seen in these figures, four fixed sheave members 1150, 1151, 1152 and 1153 are supported at the port side of the ship by the superstructure previously described. Four similar fixed sheave members 1155, 1156, 1157 and 1158 are supported at the starboard side of the ship by the superstructure. Any suitable mounting and support means may be employed for supporting these sheave members in the proper operative position, an open type truss framework being provided for this purpose as seen in these figures.

The drive mechanism for the lifting and lowering means includes an electric motor 1160 which drives a hydraulic pump 1161, the motor and pump being supported on the deck means 1162. The hydraulic pump is in turn operatively connected by suitable conduit means with a hydraulic motor 1165. This hydraulic motor is operatively connected with speed reducer mechanism 1166 which also has a hydraulic brake mechanism 1167 associated therewith for stopping the drive mechanism when desired. The output of the speed reducer mechanism is connected with drive shafts 1170 and 1171 which in turn are operatively connected with gear boxes 1173 and 1174.

A first pair of vertically extending ball bearing screw members 1176 and 1177 are rotatably supported by the output of gear box 1173, and a second plurality of vertically extending ball bearing screw members 1178 and 1179 are rotatably operatively supported by the output of gear box 1174. The ball bearing screw members 1176 and 1177 are supported at intermediate points by radial bearings 1182 and 1183 respectively, the upper ends of these ball bearing screw members being supported by thrust bearings 1184 and 1185 respectively. In a similar manner, the intermediate points of ball bearing screw members 1178 and 1179 are supported by radial bearings 1187 and 1188 while the upper ends of these last-mentioned ball bearing screw members are supported within the thrust bearings 1190 and 1191. The radial bearing means in each case may also include in association therewith a ball bearing spline means, the ball bearing screw and ball bearing spline means being of conventional construction and interacting with one another in the usual manner.

A first pair of sheave members 1193 and 1194 is operatively associated with ball bearing screw member 1176, similar pairs of sheave members 1195, and 1196, 1197 and 1198 and 1200 and 1201 being operatively associated with the ball bearing screw members 1177, 1178 and 1179 respectively. In each case, the upper sheave member of the pairs of sheave members is smaller than the lower sheave member, and a typical construction is shown in FIG. 54 wherein it will be seen that the ball bearing screw members 1176 and 1177 extend downwardly through central portions 1203 and 1204 of the sheave members 1193 and 1195 respectively to provide a threaded interconnection therewith. Each of the various sheave members is so interconnected with its ball bearing screw member such that upon rotation of the ball bearing screw members in one direction, the pair of sheave members associated therewith move away from one another, while rotation of the ball bearing screw members in the opposite direction causes the pair of associated sheave members to move toward one another.

A first cable means indicated generally by reference numeral 1207 is connected with one corner portion of the elevator means as seen in FIG. 49 for example, this cable means being reeved over fixed sheave members 1150 and 1153 and thence downwardly within the protecting trunk

portion 437, the cable means passing around the bottom movable sheave 1194 and thence upwardly over the movable sheave 1193, the cable means then being reeved around these sheave means and finally dead ended or fixedly secured to a dead end foundation beam 1208.

A second cable means indicated generally by reference numeral 1210 is connected with a second corner portion of the elevator means and is reeved over fixed sheave members 1151 and 1152 and thence downwardly within the protecting trunk portion 437, the cable means passing around the bottom movable sheave 1196 and thence upwardly over the movable sheave 1195, the cable means then being reeved around these sheave means and finally dead ended or fixedly secured to the dead end foundation beam 1208.

A third cable means indicated generally by reference numeral 1212 is connected to still a third corner portion of the elevator means and is reeved over fixed sheave members 1155 and 1158 and thence downwardly within the protecting trunk portion 438, the cable means passing around the bottom movable sheave 1201 and thence upwardly over the movable sheave 1200, the cable means then being reeved around these sheave means and finally dead ended or fixedly secured to a dead end foundation beam 1214.

A fourth cable means indicated generally by reference numeral 1216 is fixed to the fourth corner portion of the elevator means and is reeved over fixed sheave members 1156 and 1157 and thence downwardly within the protecting trunk portion 438, the cable means passing around the bottom movable sheave 1198 and thence upwardly over the movable sheave 1197, the cable means then being reeved around these sheave means and finally dead ended or fixedly secured to the dead end foundation beam 1214.

Means is provided for guiding the vertical movement of the movable sheave means, this means taking the form of a plurality of guide rails. As seen particularly in FIG. 54, the movable sheave means 1193 is provided with similar outstanding lug portions 1220 at the opposite sides thereof, a pair of such lug portions being provided on each side of the sheave means and defining a space therebetween. These lug portions receive within the space defined therebetween guide rail means indicated by reference numeral 1222 which may be of substantially T-shaped cross sectional configuration as illustrated.

It will be understood that each of the various movable sheave means is provided with similar lug portions 1220 and similar guide rails 1222 are provided for guiding the vertical movement of the sheave members. Accordingly, all of the various lug means and the various guide rails have been given the same reference numerals since they are of identical configuration and serve the same purpose.

Referring now particularly to FIG. 50, the elevator machinery room is indicated generally by reference numeral 1225, it being noted that the hydraulic motor 1165 and the speed reducer 1166 are supported by a deck means 1227. A motor controller mechanism 1228 is illustrated as being supported within the space 1230 of the machinery room between the deck means 1162 and the deck means 1232. The motor controller mechanism is of conventional construction and operatively connected with the motor 1161 previously described for controlling the operation thereof. Ladders 1234 and 1235 are indicated as depending from the hatch portions 1236 and 1237 of the deck means 1162 and 1232 respectively.

The pumping means of the underwater mining equipment as previously referred to employs a separate motor and a separate pump mechanism therein. A spare motor for use in this pumping means is illustrated at 1240 and supported on foundations 1241 which in turn rest upon the deck 1242. A spare pump for use in this pumping means is illustrated by the reference numeral 1245 and is supported upon foundation portions 1246 which in turn rest on deck 1242. A ladder 1247 depends from hatch 1248 provided in deck 1242.

Referring now to FIG. 51, a pair of girders 1250 are illustrated as being secured to the side of the well portion a similar pair of girder members being secured to the opposite side of the well portion. These girder members extend inwardly toward the central portion of the well, and serve as limit stop means for limiting the downward movement of the elevator means within the well portion.

A first pair of inwardly extending lock members 1252 are secured to the bulkhead defining the side of the well portion, and a second pair of spaced lock members 1253 similar to the first pair also extend inwardly from such bulkhead. Aligned holes 1254 and 1255 are formed through the lock members 1252 and 1253 respectively. Similar lock members are disposed in opposing relationship at the opposite side of the well portion to those shown. The aligned openings in the various lock members are adapted to receive lock pins which extend through suitable openings provided in portions of the elevator means adapted to fit between these lock members so as to positively lock the elevator at the level of said lock members. When the elevator is locked in operative position as indicated by phantom line 1257, the elevator is mounted in position for supporting underwater mining equipment therefrom by gimbal means as hereinafter described while the underwater mining equipment is in operation.

Spaced above the lock members previously described are a first pair of similar lock members 1262 and a second pair of similar lock members 1263, opposing similar lock members being provided at the opposite side of the well portion at the same level. These last-mentioned lock members 1262 and 1263 are adapted to cooperate with the elevator means in the same manner as aforedescribed so as to lock the elevator means in its normal stowed position as illustrated by phantom line 1265 when not conducting underwater mining operations.

A further pair of lock members 1266 are supported by the superstructure, and a similar pair of lock members 1267 are also supported by the superstructure. It will be understood that similar opposed pairs of lock members are supported from the superstructure at the opposite side of the well portion. These last-mentioned lock members 1266 and 1267 are adapted to cooperate with the elevator means so as to lock the elevator means in the position shown in full lines in FIG. 51 high above the deck, this position comprising a pumping means repair position for the elevator means as hereinafter described.

ELEVATOR CONSTRUCTION

Referring now particularly to FIGS. 55, 56, 57 and 58, the details of construction of the elevator means itself will be clearly understood. As seen particularly in FIG. 55, the body means of the elevator means comprises a substantially open framework composed of a plurality of members of I-beam cross sectional configuration which are rigidly interconnected with one another as by welding or the like. The framework includes a pair of elongated frame members 1270 and 1271 which extend athwartships and which are interconnected by fore and aft extending frame members 1272 and 1273. The outer ends of the frame members 1270 and 1271 define the four corners of the elevator means referred to hereinbefore, the connection of the cable means 1207, 1210, 1212 and 1216 to these four corner portions being indicated in FIG. 55.

The framework also includes a pair of frame members 1275 and 1276 which extend athwartships and which have the opposite ends thereof connected to the frame members 1272 and 1273 respectively. Grating portions 1278, 1279, 1280, 1281, 1282 and 1283 are supported in their positions shown between the frame members for supporting personnel thereon to enable the components of the elevator means or underwater mining equipment supported thereby to be serviced. An electric motor 1285 is supported by the body means and is drivably interconnected with a hydraulic pump means 1286 also supported by the body

means. A drain sump tank 1287 is suitably interconnected by conduit means with the hydraulic pump means and the hydraulic ram means hereinafter described which is operated by the pump means through suitable conventional control means.

The guide means for guiding vertical movement of the elevator means includes the vertically extending guide portions 1070 and 1080 fixedly supported by the ship adjacent the well portion as previously described, these guide portions being disposed in opposing relationship. The roller means on the elevator which cooperates with the guide portions for guiding vertical movement of the elevator may be seen most clearly in FIGS. 55 and 56, these roller means being mounted at opposite sides of the elevator and the roller construction being substantially identical. Accordingly, the roller support arrangement has been given the same reference numerals at opposite sides of the elevator since the construction is identical and further since these roller mechanisms operate in the same manner.

A first pair of laterally extending plates 1290 are secured to the upper portion of the associated frame members 1272 and 1273 respectively at opposite sides of the elevator and a second pair of spaced lower plates 1291 extend from the lower portions of the associated frame members. A pair of vertically extending plates 1293 and 1294 are fixedly secured to the outer portions of the plates 1290 and 1291 previously described.

A pair horizontally extending plates 1296 and 1297 extend outwardly from the associated frame member to which they are fixed, and horizontally extending bar-like members 1298 and 1299 are secured to the outer ends of plates 1296 and 1297 respectively, the bar members extending between and being secured to the vertically extending members 1293 and 1294.

A first support plate 1302 is secured to members 1293, 1294 and 1298 by any suitable means such as welding or bolts and the like. A second support plate 1303 is secured to members 1298 and 1299 by suitable means such as welding or bolts and the like. A third support plate 1305 is secured to members 1293, 1294 and 1299 by any suitable means such as welding or bolts and the like. These three support plates are provided with openings therein which are adapted to receive and support journal portions 1307, 1308 and 1309 respectively.

The upper and lower journal portions 1307 and 1309 have outwardly extending arm portions 1310 upon which are rotatably supported rollers 1312 of substantially similar construction. These rollers are adapted to engage the bottom surface 1313 of the channel shaped elevator guide portions 1070 and 1080.

The journal portions 1308 supported by plates 1303 include outwardly extending shaft portions 1315 upon which are supported rollers 1316. Rollers 1316 are accordingly rotatably journaled by the journal portions 1308 and engage the side wall portions 1318 and 1319 of the channel shaped elevator guide portions 1070 and 1080, it being apparent that the diameter of rollers 1316 is slightly smaller than the distance between the side wall portions 1318 and 1319 so that the rollers may roll against only one wall portion 1318 or 1319 at any one time.

It is apparent that the rollers 1316 are mounted for rotation about axes which are substantially perpendicular to the adjacent rollers 1312, and it is evident that the rollers will interact with the vertically extending elevator guide portions 1070 and 1080 to assure that the elevator means moves upwardly and downwardly in the proper manner.

As seen particularly in FIGS. 56 and 57, gimbal support means comprises a first pair of plates 1321 and 1322 which extend inwardly from the frame member 1276, a cross plate 1324 being secured between the plates 1321 and 1322 to provide a rigid structure. Attaching plates 1326 and 1327 are secured to the upper surfaces of plates 1321 and 1322, the attaching plates having spaced thread-

ed openings therein for receiving cap screws and the like for attaching the gimbal means hereinafter described to these attaching plates. Small gusset plates 1330 and 1331 are provided beneath the attaching plates to additionally support these plates in operative position.

Catwalk means are indicated generally by reference numerals 1334 and 1335 in FIG. 55 and are disposed on opposite sides of the gimbal support means at the left portion of the elevator means as seen in this figure, and similar catwalk portions 1336 and 1337 are provided at opposite sides of the gimbal support means at the right portion of the elevator means. These catwalk portions each include substantially horizontally extending plate members which are indicated by reference numerals 1340 and 1341 in FIG. 56 upon which personnel are adapted to be supported when servicing the equipment, these plate members extending outwardly from the associated frame members 1275 and 1276 and being additionally supported by similar reinforcing plate members 1343, 1344 and 1345.

It will be understood that the gimbal support structure has been specifically described as supported from frame member 1276. The gimbal support structure supported by frame member 1275 is of identical construction and has been given the same reference numerals primed.

The clamping means on the elevator means includes a pair of clamping portions indicated generally by reference numerals 1350 and 1351, these clamping portions being movably supported with respect to the elevator means and being movable over the central opening defined between the frame members 1275 and 1276 of the elevator framework.

The two movable clamping portions are of substantially identical construction, and accordingly description of one of these movable portions will suffice, similar portions being given the same reference numeral primed in the other clamping portion. As seen particularly in FIGS. 56, 57 and 58 the clamping portion 1350 includes a support portion 1353 at the upper part thereon which comprises a flat horizontal member having an arcuate inner surface 1355 and a substantially L-shaped cross sectional configuration as seen in FIG. 56 such that a substantially arcuate recess portion 1356 defining an upwardly facing surface 1357 upon which various components of underwater mining equipment is adapted to rest and be supported. It should be noted that support portions 1353 and 1353' terminate at points indicated by reference numerals 1358 to define a space indicated at 1359 in FIG. 55 when the clamping portions 1350 and 1351 are in clamping position as indicated in phantom line, this space being adapted to receive the aligning lug 606 on a supported conduit section as aforesaid.

As seen particularly in FIG. 55, clamping members 1350 and 1351 terminate at the points 1363 and 1364 respectively which are adapted to define therebetween when the clamping members are in operative clamping position a space for receiving the electrical power and television cables as well as the aforesaid air pipe. These clamping portions also include the portions 1368 and 1369 respectively which extend toward one another and are adapted to be disposed in substantially abutting relationship when the clamping members are in operative clamped position. These latter portions 1368 and 1369 define sloping side surfaces as seen in FIG. 55 so as to create a camming action when the two clamping portions are moved toward one another so as to avoid pinching the electrical power and television cables therebetween. Fixedly secured in depending relationship to the inner portion of member 1353 is a member 1360 having a substantially arcuate cross sectional configuration complementary to the arcuate inner surface 1355 of the member 1353. The arcuate cross section of member 1360 is adapted to fit snugly against the outer surface of an underwater mining component such as a conduit section to hold the conduit section in operative position with an

upper flange thereon seated within the recess portion 1356 of member 1353.

Members 1362 and 1362' are of substantially T-shaped cross sectional configuration and members 1365 and 1365' as seen for example in FIG. 58 extend between points indicated by numerals 1366 as shown in FIG. 57 and form the support of clamping portions 1350 and 1351. Reinforcing gusset members 1370 and 1371 are connected between members 1362 and 1365. Gusset members 1373 and 1374 are connected between members 1362 and 1365 and 1375 and 1376 respectively. Gusset members 1390 and 1391 are connected between members 1362, 1353 and 1365. Gusset members 1393 and 1394 are connected between members 1362 and 1365. Gusset member y is connected between members 1362, 1365 and 1360. Gusset member z is connected between members 1360 and 1365.

The above-mentioned elongated plates 1375 and 1376 include depending plate portions 1375' and 1376' secured to the undersurfaces thereof between which are rotatably mounted wheel members 1380 and 1381 as seen in FIG. 57. These wheel members are adapted to roll along guide rails 1385 and 1386 secured to the upper surface of frame members 1275 and 1276 of the elevator means, the wheel members being provided with pairs of spaced flanges 1382 and 1383 for guiding and retaining the wheels on these guide rails.

A transversely extending plate 1396 extends rearwardly of member 1362 and is connected with a vertically extending member 1398. Power operated means in the form of hydraulic ram means includes a first lower hydraulic cylinder 1400 the piston of which is connected with a connecting rod 1401 which is connected to member 1398. A second upper hydraulic cylinder 1403 has a piston means which is connected with a connecting rod 1404 which in turn is connected with a rear portion of support member 1353.

It will be noted that hydraulic cylinder 1400 is much larger than hydraulic cylinder 1403. The second mentioned hydraulic cylinder is a fast acting cylinder which is adapted to move the clamping portions through a substantial distance of its travel rather quickly, while the first mentioned hydraulic cylinder is a slow acting cylinder which is adapted to apply clamping pressure to hold a supported underwater mining equipment component in operative clamped position between the clamping portions. Any suitable control means may be provided for controlling the operation of the hydraulic ram means which is operatively connected with the hydraulic pump 1286 previously mentioned.

GIMBAL MEANS

Referring now particularly to FIGS. 59, 60 and 61, the construction of the gimbal means utilized for supporting the conduit means from the elevator means is specifically illustrated.

As seen in these figures, a pair of gimbal support means are indicated generally by reference numerals 1407 and 1408, gimbal support means 1407 including a pair of substantially semi-cylindrical halves 1410 and 1411, while the gimbal support means 1408 includes a similar pair of halves 1413 and 1414. Members 1410 and 1411 are attached to each other by bolts as shown in FIGS. 59 and 60 extending within suitable openings provided in these members. Member 1411 includes a pair of laterally extending flanges 1417 at opposite sides thereof which have holes 1418 formed therethrough for receiving suitable attaching means for securing the gimbal support means on the gimbal attaching members 1326 and 1327 previously described.

Members 1413 and 1414 are attached to each other by bolts b extending within suitable openings provided in these members. Member 1414 includes a pair of laterally extending flanges 1422 at opposite sides thereof

which have holes 1424 formed therethrough for receiving suitable attaching means for securing the gimbal support means on the gimbal attaching members previously described.

Referring to FIG. 55, the gimbal means is illustrated in supported operative position within the elevator means, and it will be noted that bolt assemblies 1426 and 1427 are associated with gimbal support means 1408 for attaching the gimbal support means to the two spaced underlying gimbal support members 1326 and 1327. In a similar manner, the other gimbal support means 1407 is attached to its associated gimbal support members on the elevator means by bolt assemblies 1429 and 1430.

Referring now particularly to FIG. 61, it will be noted that the two members 1410 and 1411 of gimbal means 1407 are of generally L-shaped cross sectional configuration and are adapted to support ball bearing means 1432 therewithin, a retaining plate 1434 being held in position at the ends of these members 1410 and 1411 by means of cap screws 1435.

In a similar manner, the two members 1413 and 1414 of gimbal support means 1408 are also of substantially L-shaped cross sectional configuration and serve to support ball bearing means 1438 which is held in place by the retainer plate 1439 supported on members 1413 and 1414 by cap screws 1440.

The gimbal means includes a first substantially annular portion 1443 which includes upstanding portions 1444 and 1445 from which extend the journal portions 1446 and 1447 respectively which are journaled within ball bearing assemblies 1438 and 1432 of the two gimbal support means. With this arrangement, it is apparent that the annular member 1443 is journaled for rotation about a first pivotal axis indicated by the line x—x.

Annular member 1443 also includes a pair of upstanding portions 1450 and 1451 which are disposed at substantially 90° relation to the portions 1444 and 1445. Each of the portions 1450 and 1451 may include lower and upper halves 1450' and 1450'' and 1451' and 1451'' respectively which are adapted to be secured to one another by suitable nut and bolt assemblies and the like indicated by reference numerals 1456 and 1457. With this arrangement, ball bearing assemblies similar to those previously described may be mounted with these portions and held in place by end plates 1459 and 1460 which are secured in place by suitable cap screws.

As seen particularly in FIG. 61, an annular member 1462 has a cylindrical conduit portion 1463 extending through the center thereof and rigidly secured thereto. The annular member 1462 has a pair of laterally extending journal portions 1464 and 1465 as seen in FIG. 59 which extend within the ball bearing means mounted in portions 1450 and 1451 of the first annular member. It is accordingly apparent that the second annular member 1462 is journaled for rotation about a second axis y—y which is substantially normal to the first axis x—x previously described.

Referring again to FIG. 61, the lower portion of conduit portion 1463 is secured to a flange portion 1467 having spaced holes 1468 formed therein corresponding in number to the holes provided in the upper flange of a typical conduit section such as 590 whereby flange portion 1467 can be rigidly secured to an associated conduit section. This arrangement serves to support the conduit means from the gimbal means.

The upper part of conduit portion 1463 is indicated as being rigidly secured to a portion 1470 which in turn may be connected with the flexible conduit portion 129 which transfers the collected solid bodies of material to the separation means 130 previously described.

It is evident from the foregoing description that the gimbal means is selectively removable from the elevator means and when in operative position therewithin is adapted to support the conduit means and the associated

underwater mining equipment components. When the conduit means and the associated components are so supported, the conduit means is in effect connected with the elevator means by a universal connection due to the fact that the gimbal means permits rotation about two mutually perpendicular axes. This over-all arrangement permits the conduit means to have the necessary movement with respect to the ship as is required during normal mining operations due to relative movements which will unavoidably occur between the underwater mining equipment and the ship thereabove.

METHOD OF LOWERING UNDERWATER EQUIPMENT INTO MINING POSITION

Referring firstly to FIGS. 62 through 70 inclusive, FIG. 62 illustrates the initial steps in the procedure employed for lowering the underwater mining equipment from its stowed position on the ship through the well portion of the ship and downwardly into operative mining position. It will be noted that the auxiliary support means within the well portion is removed at this point, this auxiliary support means being installed in operative position in the well portion after the collecting means, the associated truss means and the dead weight means have been interconnected with one another and lowered through said well portion.

A cable 1475 with a hook portion 375 attached to the lower end thereof is supported from the overhead crane means 364, this cable extending downwardly through a hole or open portion indicated at 1477 in the elevator means 128, the hook portion 375 being secured at point 1478 to a suitable connecting fixture on the truss portion 450 which is permanently pivotally interconnected with the collecting means.

A cable is interconnected between a five-ton chain fall means 1481 suitably supported from the overhead superstructure and a fitting 1482 provided at the aft portion of the collecting means. A line 1485 is interconnected with a fixture 1487 at the forward end of the collecting means, this line being indicated in dotted lines extending about a sheave 1488 mounted on the truss structure and passing upwardly to a suitable location where it can be handled by personnel.

The truss section 450 may be referred to as truss section No. 1 since it is the first truss section to be lowered through the well portion, and a truss section 453 indicated in its normal stowed position on the deck may be referred to as truss section No. 2 since it is the second truss section to be lowered through the well portion. The truss sections which are subsequently interconnected with one another to form the completed truss means will later be referred to as truss sections 3, 4 and 5 indicating the sequence in which these truss members are interconnected in the truss means and lowered through the well portion. The movable support means 462 and its supported dead weight means 153 are illustrated in their normal stowed position as is the support means 464 having the pumping means 150 supported thereon. The normal water level in the well portion is indicated by reference numeral 1490.

Referring now to FIG. 63, the hook of the crane means is raised to the position shown and the crane means itself moves in an aft direction so as to move the truss section 450 forwardly and upwardly until it is snug against the undersurface of the elevator means with the truss means disposed substantially over the central part of the well portion in the ship.

The collecting means is pivoted about the point of attachment to truss section 450 by letting out the aft chain means 1480. In addition, the line 1485 is pulled in an upward direction as seen in FIG. 63 so as to swing the collecting means snugly up against the truss section 450 as shown in full lines in this figure, line 1485 being suitably secured in this position to retain the collecting means in this operative position relative to the truss section until

it is selectively released from this position as hereinafter described.

Referring now to FIG. 64, the next step in the lowering procedure is to move the movable support means 462 forwardly to the position illustrated in FIG. 64 wherein the movable support means is disposed over the well portion. It will be understood that the movable support means is moved in this direction by selectively actuating the drive means thereof as previously described so as to positively drive the movable support means to this operative position.

The next step is to lower truss section 450 and the interconnected collecting means 167 downwardly by means of the bridge crane until the truss section 450 as well as the collecting means supported therefrom is supported on and carried by the movable support means 462. The interconnection between truss section 450 and the movable support means is effected by means of the bracket members 847 previously described in connection with FIG. 37, the truss section being provided with intercooperating portions for securing the truss section to these bracket members.

Referring now to FIG. 65, the crane is detached from truss section No. 1 indicated by reference numeral 450 and is moved forwardly to engage the support truss section No. 2 indicated by reference numeral 453. The movable support means 462 is moved forward into the position shown in FIG. 65 wherein the collecting means is disposed against the forward part of the well portion with the wheels 1492 on the collecting means shown as being in position for riding up and down this forward wall portion. It will be noted that the collecting means as illustrated in this procedural illustration is provided with a plurality of spaced wheels for supporting the collecting means for movement along the sea bottom, this type of construction being suitable when the collecting means is being towed by the mining ship.

The No. 2 section of the truss is then lifted by crane means 364 and then moved aft and lowered into the position shown in FIG. 65 whereat it is interconnected with the No. 1 truss section such that these two truss sections will be rigidly interconnected to each other during normal mining operations beneath the surface of the sea.

It is further noted that with the components interconnected as finally described in connection with FIG. 65, an arrangement is provided which affords a possible stowage position of the collecting means as well as the first truss section while the ship is in transit to a particular mining area. With these components in this operative position, the foregoing steps may be eliminated when initially lowering the mining equipment into operative mining position.

After having assembled the No. 2 truss section to the No. 1 truss section and rigidly interconnected these components as discussed in connection with FIG. 65, the No. 1 truss section can be disconnected from the movable support means 462, whereupon the No. 2 truss section may be lowered by the overhead crane means until it is supported by the movable support means by securing the No. 2 truss section to the support brackets 847 on the movable support means.

Referring now to FIG. 66, it is apparent that a similar procedure may be employed for lifting and lowering the No. 3 and the No. 4 truss sections and interconnecting these truss sections with the previously interconnected truss section. As seen in FIG. 66, the No. 3 truss section has already been lowered into position for support by the movable support means 462 while the No. 4 truss section is being lowered by the overhead crane means into position for connection with the No. 3 truss section.

When the collecting means 167 clears the bottom of the well portion, the line 1485 which has been holding the forward portion of the collecting means snug against the No. 1 truss section is released allowing the collecting

means to pivot into the position illustrated in full lines in FIG. 66. After the collecting means has so cleared the bottom of the well portion, the movable support means 462 is moved forwardly and the No. 5 section of truss is added in a similar manner to the previously added sections of truss.

The No. 5 section of truss is lowered into position for support by the movable support means 462 through the intermediary of the brackets 847 previously described, the complete truss means being shown as supported by the movable support means in FIG. 67. The movable support means is then moved aft into the position shown in FIG. 67 wherein the dead weight means 153 is on the center line of the elevator means 128 which is disposed in the dotted line position illustrated in FIG. 67. The elevator means is then lowered into the full line position shown whereupon the clamping means of the elevator means is adapted to engage the lower collar portion 471 of the conduit portion 470 extending upwardly from the dead weight means such that the elevator means is then in position to lift the dead weight means off of its supporting foundation means on the elevator means.

The elevator means is then lifted into the full line position shown in FIG. 68 wherein the dead weight means is elevated a substantial distance above the level of its foundation means on the movable platform means 462 which is then moved aft until the point at the upper end of truss section No. 5 having a pivotal interconnection thereat is on the center line of the elevator. The upper portion of the truss means is then in position for pivotal interconnection with a cooperating interconnectable portion on the dead weight means, and the interconnection between the dead weight means and the upper portion of the truss means is then made up. The next step is to lift the elevator means into the phantom line position shown in FIG. 68 whereby the entire load of the collecting means, the truss means and the dead weight means will be supported by the elevator means, and the movable support means 462 is moved aft to clear the well portion in the ship.

Referring now to FIG. 69, the elevator means 128 is lowered until the top flange 472 of the dead weight means is below the main deck whereupon the movable support means 462 is moved forwardly into position over the well portion as shown in FIG. 69. The elevator means is then raised until the top flange of the dead weight means extends through the space defined between the clamping means on the movable platform means. The clamping means on the movable platform means as previously described is then actuated by suitable power means such as the hydraulic ram means for clamping the conduit portion 470 of the dead weight means and for supporting the top flange 472 of the dead weight means on the upper surfaces of the support portions of the engaging means. The entire load extending downwardly from the movable support means may then be supported by this movable support means.

A conduit section 590 is then maneuvered by the handling means in the stowage area and the overhead crane means as previously described so that the conduit section is disposed over the well portion as illustrated in FIG. 69. The conduit section may then be lowered so that the lower flange 600 thereof may be fixedly bolted to the upper flange 472 of the dead weight means.

The clamping means on the elevator means may then engage the collar portion 471 of the dead weight means whereupon the clamping means of the movable support means 462 is released. The elevator means is then lowered within the well portion so as to lower the conduit section 590 until the upper flange 595 thereof is adapted to be clamped and supported by the movable support means. The clamping means of the elevator means may then be released such that the elevator means may be raised upwardly to engage the collar 604 of the conduit section 590.

It is apparent that this procedure for adding conduit sec-

tions may be repeated over and over again so as to add as many conduit sections as are required. As seen in FIG. 69, air pipe 154 is closed off by closure of valve means 156 so as to trap air within the frusto-conically shaped interior of the dead weight means 153. As the dead weight means is lowered from the position shown in FIG. 69, this air will remain trapped therewithin so as to assist in supporting the structure suspended therebelow and to buoy up the conduit means thereabove. Additional conduit sections and air pipe sections are added until the dead weight means is approximately 500 feet below the surface of the water. At this time, the valve means 156 is operated by any suitable remote control mechanism for opening the valve and allowing water to enter the chamber defined within the dead weight means thereby forcing the air out of such chamber.

After having allowed the sea water to enter the cavity within the dead weight means, the apparatus is further lowered until it reaches its operative position. When raising the apparatus and the dead weight means again approaches a level of 500 feet below the surface, valve 156 is again remotely operated to open the valve and air pressure is supplied from the ship to the air pipe 154 to force the water out of the cavity within the dead weight means to again provide air within the space for the aforesaid purpose. The apparatus is then raised back upwardly into the mining ship.

The reason for providing the body of air within the dead weight means during its travel between the surface and a point approximately 500 feet below the surface is that somewhere during the travel of the conduit means and the suspended apparatus in this area vibratory forces tend to be produced due to the interaction of the over-all weight of the suspended mass of the structure and the sea currents which would tend to destroy the suspended apparatus. Accordingly, it becomes necessary to provide a body of air in the dead weight means so as to reduce the effective weight of the suspended components and to buoy up the conduit means thereby eliminating this danger. It will be noted of course that it is necessary to provide this body of air both when the apparatus is being lowered as well as being raised while passing through this critical area of the water. It will also be evident that it is desirable to eliminate the body of air when the apparatus is below the depth of approximately 500 feet, and the air pipe along with its remotely controlled valve means provides a means for readily accomplishing this desired end result.

As mentioned previously, a cap means may be applied to the upper end of the air pipe as the air pipe is lowered into the water. A suitable flexible conduit means may be secured to the upper end of the air pipe while compressed air is being fed therinto for evacuating water from the dead weight means when raising the dead weight means as aforesaid.

After the collecting means, the truss means and the dead weight means have been lowered through the well portion, and prior to connecting and lowering the pumping means, the auxiliary support means is mounted in operative retracted position as indicated by the dotted line position shown in FIG. 71.

When raising the conduit sections, the truss means and the collecting means back upwardly through the well portion, the procedural steps as illustrated in FIGS. 62 through 69 in sequence may be simply reversed with the exception that the procedure as illustrated in FIG. 70 replaces the procedural steps illustrated in FIGS. 65 and 66. When raising the conduit sections, the movable portion 1015 of the auxiliary support means is removed prior to raising the dead weight means, the truss means and the collecting means through the well portion. In other words, when raising the truss and collecting means as illustrated in FIG. 70, the cable from the overhead crane means passes through the opening or hole 1477 within the elevator means 128 until the collecting means is in the full line position shown in FIG. 70 whereupon the

line 1485 is employed for moving the collecting means snug up against the No. 1 truss section, the line 1485 being pulled upwardly as aforescribed, thereby moving the collecting means into the phantom line position indicated by reference numeral 167'. The remaining steps as illustrated in FIGS. 62, 63 and 64 can then be carried out in reverse order so as to return the various components of the underwater mining equipment to their initial stowed position.

PROCEDURE FOR CONNECTING AND LOWERING PUMPING MEANS

Considering now FIG. 71 of the drawings, the conduit section 591 previously described in connection with FIG. 18 is illustrated as interconnected with a conduit section 590. It will be noted as seen in dotted lines in this figure that the auxiliary support means is mounted in retracted position whereby the movable portions are adapted to swing into the central portion of the well as hereinafter described. The conduit section 591 is handled with the same procedure as the other conduit sections as previously described. With the central collar portion 605 of conduit section 591 supported by the elevator means in position No. 1 as illustrated in phantom lines, the clamping means on the movable support means 462 is released with the movable support means disposed in a position as indicated in phantom lines, whereupon the elevator means is lowered to a position shown in full lines identified as position No. 2 wherein the upper flange 596 of the conduit section 591 is below the level of the main deck.

The movable support means 462 can then be moved aft to the full line position shown in FIG. 71 wherein it is clear of the well portion. The elevator means is then raised to the position indicated by the phantom line identified as position No. 3. The collar means of the snubber mechanism indicated by phantom line 1120 in FIG. 71 is then mounted on the conduit section 590, the movable support means 462 being moved back into its dotted line position as shown in FIG. 71 to enable personnel to be supported in position for readily applying the collar means in the operative position shown.

Referring now to FIG. 72, the elevator is disposed in position No. 1 as indicated in phantom lines and the portions 1014 and 1015 of the auxiliary support mechanism are lowered into operative position within the well portion. The elevator means is then lowered to position No. 2 as shown in phantom line such that the intermediate collar portion on conduit section 590 rests upon the upper support portions of the two clamping portions 1014 and 1015 of the auxiliary support means. The portable ladder means 1500 is then utilized by personnel to descend and lock the two portions 1014 and 1015 of the auxiliary support means together, and the snubber cable ends are attached to lugs disposed at the sides of the well portion. The turnbuckles are then tightened to take all the slack out of the cables.

With the conduit means firmly supported by the auxiliary support means within the well portion, the clamping means of the elevator means is released from the flange of conduit section 591 and the elevator means is raised to position No. 3 illustrated in solid lines. Conduit section 591 is then detached from the conduit section 590 therebeneath and conduit section 591 is then lifted by the overhead crane means 364 through the central part of the elevator means and then moved aft out of the way as indicated in phantom line in FIG. 72.

Referring now to FIG. 73, with the elevator means at position No. 1 shown in solid lines, the movable support means 462 is moved forwardly to the phantom line position and coupled to the dolly means 464 by the towing pin and towing link means previously described. The dolly means is then towed aft by the support means 462 into the solid line position shown in FIG. 73 such that the dolly means and the pumping means are supported beneath the center line of the elevator means.

The elevator means is then lowered to position No. 2 shown in phantom lines such that the clamping means of the elevator means is adapted to engage the flange portion 1502 of the pumping means whereupon the elevator is raised to position No. 3 shown in phantom lines to lift the pumping means off of its supporting dolly means 464, the movable support means 462 is then employed for returning the dolly means 464 to the dotted line position shown in FIG. 73 which is its normal stowed position.

Referring now to FIG. 74, the movable support means 462 is detached or uncoupled from the dolly means 464 and is moved into the solid line position shown in FIG. 74 to enable the installation of the special conduit section 592. This conduit section 592 is maneuvered into position and the lower flange 602 thereof is bolted to the upper flange 595 of conduit section 590. The elevator means is then lowered into the phantom line position shown in FIG. 74 whereby the lower flange 1504 of the pumping means mates with the top flange 597 of special conduit section 592, and these two mating flanges are then bolted to one another.

The movable support means 462 is then moved aft from the solid line position shown in FIG. 75 to the phantom line position shown therein wherein it is clear of the well to provide an unobstructed well area.

The clamping portions 1014 and 1015 of the auxiliary support means are unlocked. The cables are released from the snubber mechanism and the elevator means is raised to the dotted line position of FIG. 75 to release the load from the auxiliary support means portions 1014 and 1015 whereupon these clamping portions are pivoted into the position shown in phantom lines within recessed areas adjacent the well portion which is the normal stowed position for these clamping members when installed within the well portion.

Referring now to FIG. 76, the elevator means is then lowered until the top flange 1505 of the pumping means is below the main deck, whereupon the movable support means 462 is moved forwardly to the full line position seen in FIG. 76.

The elevator means is then raised until the top flange 1505 of the pumping means extends through the hole in the central portion of the movable support means 462.

A conduit section 590 is then maneuvered into position means of the handling mechanism previously described including the overhead crane means whereupon this conduit sections is lowered into position so that it can be bolted to the top flange 1505 of the pumping means.

The movable support means 462 and the elevator means 128 may then be employed as aforescribed to add as many additional conduit sections as desired in order to lower the collecting means of the underwater mining apparatus to the sea bottom.

As discussed previously, when sufficient conduit sections have been added, the gimbal means is placed in operative position within the elevator means as illustrated in FIG. 55, and the topmost conduit section is operatively connected with the gimbal means whereby the entire underwater mining apparatus is pivotally interconnected with the mining ship for substantially universal movement with respect thereto through the intermediary of the gimbal means.

METHOD OF HANDLING ELECTRICAL POWER AND TELEVISION CABLES

Referring again to FIG. 62 of the drawings, the television and electrical power cables are connected to the proper associated components on the collecting means as well as the truss means. It should be understood that the electrical power cables may be made in discrete lengths of cable as for example lengths of 200 or 300

feet, while the television cable on the other hand is preferably continuous so as to provide adequate transmission characteristics from the television cameras to the mining ship. A separate television cable is provided for each of the television cameras mounted on the truss means, two separate reels being provided for these individual cables. A reel is also provided for the electrical power cable, this latter reel being permanently located on the port side of the main deck while the two television cable reels are temporarily located on the movable support means. At this point, the television cables extend from the two television cable reels (not shown) where are mounted on the movable support means upwardly through a central hole in the elevator means and thence downwardly to the television cameras mounted on the truss means.

With the cables and their associated reels so oriented, the various components of the underwater mining apparatus are lowered as shown in FIGS. 62 through 68 inclusive while the cables are lowered along therewith and secured thereto by clamps or the like, the cables during this procedure passing through the central portion of the elevator means.

Referring now to FIG. 69, after the elevator means has been lowered below the main deck level and the movable support means has been moved into the position shown in FIG. 69, the television cable reels are lifted off of the movable support means and then passed thereunder and upwardly through the central hole therein between the clamping portions thereof, and the television cable reels are then again placed on the upper portion of the movable support means. A suitable junction box may be provided on the dead weight means, and the electrical cable means passes through the central opening in the movable support means and is connected with this junction box.

The various conduit sections are then lowered through the well portion and the cables pass downwardly through the central holes in the movable support means and the elevator means, the cables being secured to the various conduit sections by suitable clamps and the like.

Referring now to FIG. 71, when it is desired to connect the pumping means in the conduit means, the movable support means is disposed in the phantom line position as shown in this figure, and it is desired to move it aft into the full line position shown in this figure. Accordingly, the television cable reels are moved downwardly through the central opening in the movable support means and supported on the elevator means. As seen in FIG. 73, the elevator means is lifted into the full line position and the various cables are then pulled into the spaces defined by the elevator guide rail means whereupon the movable support means may move forwardly to be engaged with the pumping means support means so that the movable support means can move the pumping means into the operative position shown in FIG. 73. The electrical power cables are then attached to a suitable junction box provided on the pumping means.

At this point, the television cable reels are supported on the upper surface of the elevator means. Referring to FIG. 76, the elevator means is subsequently lowered below the level of the main deck and the movable support means is moved into operative relationship thereover. At this point, the television cable reels are moved upwardly through the central opening in the movable support means and supported on the upper surface thereof. The television cable reels then remain in this position while additional sections of conduit means are lowered through the well portion, the cables being lowered therewith and attached thereto as by clamps and the like. The electrical power cables are similarly lowered through the central openings provided in the elevator means and the movable support means and secured to each of the various conduit sections.

After sufficient sections of the conduit means have been

lowered through the well portion, the gimbal means must be installed in operative position in the elevator means. At this point, the television cable reels are passed through the central opening in the movable support means, the final lengths of the electrical power cables being also passed downwardly through the central opening in the movable support means and coiled on the elevator means. After the gimbal means has been installed as described hereinbefore, the cables are provided with sufficient length for freedom of movement of the conduit means below the gimbal means. The cables are then attached to the elevator means out of the way of the gimbal means.

After the flexible conduit portion has been secured in place to the upper end of the conduit means, the electrical power cables are lifted and final connections are made to on-deck junction boxes. The television cable reels are lifted to the underwater mining control station where connection is made to a television monitor for viewing. In lifting the underwater mining equipment back to the mining ship, the above procedure for lowering the various electrical power and television cable means may be reversed.

LIFTING PUMPING MEANS AND HANDLING INTERNAL COMPONENTS THEREOF

Referring now particularly to FIGS. 77 through 81 inclusive, FIG. 77 shows the position of the pumping means 150 as disposed in the well portion of the ship in the position similar to that shown in FIG. 76 wherein the pumping means is supported by the elevator means, and as seen in FIG. 77, the conduit section 590 as seen in FIG. 76 has already been removed from the upper flange portion 1505 of the pumping means.

After having removed this conduit section secured to the upper portion of the pumping means, the elevator means is lowered such that elevator means and the pumping means move from the solid line position shown in FIG. 77 to the phantom line position shown in this figure. The movable support means 462 is then moved forwardly and coupled to the pumping means support means 464 by means of the towing links previously described. The cover 1510 of the unshipping opening 444 is unbolted and the cover is lifted by means of the overhead crane means and moved forwardly from the solid line position seen in FIG. 77 to the phantom line position shown therein above the pumping means support means.

Referring now to FIG. 78, the movable platform means and the pumping means support means coupled thereto are then moved aft of the well portion to the position shown in full lines, and the unshipping opening cover is stowed in the space vacated by the pumping means support means, the cover 1510 being shown in full lines in this figure. The overhead crane means is then moved aft on the elevator opening.

The elevator means is raised and the auxiliary support means clamping portions 1014 and 1015 are moved into their operative supporting position so as to support the uppermost conduit section 590 as seen in full line in FIG. 78. When the uppermost conduit section is so supported by interengagement of the portions 1014 and 1015 with the upper flange of the conduit section, the lower flange portion 1504 of the pumping means is disconnected from the small conduit section 592, and the elevator means is raised into the position shown in full lines in FIG. 78 where in the pumping means is supported in an elevated position as shown.

To service or replace the internal components of the pumping means, the pumping means support means 464 may be moved into the position shown in FIG. 79 in overlying relationship to the well portion and directly beneath the pumping means. The elevator means is then lowered until the pumping means 150 is supported on the support means 464. The capsule shell 152 is divided into two portions 152' and 152'' which are interconnected by a bolted joint. This bolted joint is broken and various

interconnecting joints in the internal plumbing of the pumping means is disconnected as well as the shafting between the pump and the motor of the pumping means to permit separation of the upper and lower portions of the pumping means. The elevator means is then raised into the full line position shown in FIG. 79 so as to raise the upper portion 152' of the pumping means away from the lower portion 152' thereof which is supported on the support means 464. The elevator means is locked in this upper position by means of the locking portions 1266 and 1267 previously described in connection with FIG. 51. The pump 1515 is then in position to be serviced or replaced.

If it is desired to additionally service or replace the motor of the pumping means, the movable support means 462 is moved forwardly into position beneath the suspended upper portion 152' of the pumping means and the elevator means is then lowered into the phantom line position as seen in FIG. 80, the pump motor 1517 then being lowered to the movable support means 462 using chain falls attached to the inside of the upper portion of the pumping means. The upper portion of the pumping means is then again raised into the full line position by means of the elevator means and the elevator means is again locked in this upper position.

When it is desired to replace either the pump or the pump motor of the pumping means, the movable support means 462 and the pumping means support means 464 are moved aft into the full line position shown in FIG. 81. In this position, the support means are both aft of and clear of the unshipping opening 444. If for example, it is desired to replace the pump motor 1517, the pump motor is lifted by means of the overhead crane means into the elevated full line position shown in FIG. 81. This particular motor is then moved forwardly and placed temporarily on the deck to starboard of the unshipping opening.

The spare pump motor 1240 which is stored below the deck in the position as shown in FIG. 50 is then lifted through the unshipping opening by means of the overhead crane means and as indicated in phantom line in FIG. 81. This spare pump motor is then placed on the movable support means 462. The pump motor which is to be replaced is then lower through the unshipping opening to the stowed position.

It will be understood that the pump 1515 can be replaced by the spare pump 1245 in the identical manner as discussed in connection with the pump motor.

The support means 462 and 464 is then moved into the position shown in either FIG. 79 or FIG. 80 depending on whether the pump is being replaced or the pump motor, and the procedural steps aforescribed are simply reversed in order to replace the pump or the pump motor components within the pumping means.

FIGS. 77 and 78 may then be reversed as to the procedural steps involved so as to lower the pumping means within the well portion whereupon as many additional conduit sections as is desired may be in turn connected in position and lowered through the well portion.

METHOD OF RIGGING EQUIPMENT FOR JET-TENSIONING AND RECOVERY THEREOF

Referring now particularly to FIGS. 82 through 89 inclusive, FIG. 82 illustrates the upper portion of the conduit means supported by the auxiliary clamping means including the two clamping portions 1014 and 1015 along with the snubber means 1120. It will be understood that the conduit means has been lifted upwardly into an operative position as shown in FIG. 82 in a manner similar to that involved in the procedural steps illustrated in FIGS. 71 and 72 previously described wherein the conduit means is lifted upwardly and supported on the auxiliary support means. It will further be apparent that in FIG. 82 the special conduit section and the gimbal means have been removed from the elevator means.

Referring now to FIG. 83, it will be noted that the movable support means 462 is moved to its aftermost position, and the buoyancy means 467 supported on the dolly means 466 is moved from its stowage position on the starboard side of the ship to the center line of the ship by running the crane means trolley to its port extremity. The crane cable 1475 is then reeved through a portable sheave 1522 located on the main deck port side and the cable is attached to the inboard side of dolly 466. The overhead crane is then actuated so as to lift the cable thereof which moves the buoyancy means supported on dolly 466 inboard to the desired position as shown in full lines in FIG. 83. Dolly 466 may be provided with suitable runners or the like therebeneath to facilitate movement along the deck.

Referring now to FIG. 84, the overhead crane means as shown in a phantom line position is then adapted to be attached to the top flange 1525 of the buoyancy means whereupon the overhead crane transfers the buoyancy means onto the movable support means 462 as illustrated in full lines in FIG. 84. After the buoyancy means is supported on the movable support means as shown, stay cables such as indicated by the phantom line 1530 are employed for fixing the buoyancy means in operative position on the movable support means as shown.

Referring now to FIG. 85, the dolly 466 is then moved back to its initial stowage position on the starboard side of the ship by snaking the crane cable 1475 under dolly 466 and then reeving it through a second sheave 1527 on the starboard shell, the cable then being attached to the outboard side of the dolly 466. It is apparent that by lifting on the cable, the dolly will be moved back to the full line position illustrated in FIG. 85.

The movable support means with the buoyancy means 467 supported thereon is then moved forwardly into the phantom line position over the central area of the well portion as shown in FIG. 85. The elevator means is then lowered over the top flange of the buoyancy means and clamped by the elevator means whereupon the buoyancy means is lifted up from the movable support means into the elevated position shown in FIG. 86.

With the elevator means in its uppermost position holding the buoyancy means, the conduit section 592 is installed by maneuvering it into position and bolting the bottom flange 602 thereof to the top flange 595 of the conduit section 590 supported by the clamping portions 1014 and 1015 of the auxiliary support means. The buoyancy means is then lowered by the elevator means until the lower flange 1530 of the buoyancy means mates with the top flange 597 of conduit section 592 whereupon these mating flanges are bolted to one another.

The movable support means 462 is then moved aft from the full line position shown in FIG. 86 to the phantom line position shown therein to be clear of the well portion. The clamping portions 1014 and 1015 of the auxiliary support means are then unlocked and the snubber cable means are released. The elevator means then lifts the buoyancy means along with the depending conduit means which releases the load from the auxiliary support means which is then retracted as indicated by the arrows in FIG. 86 into the stowed retracted position as indicated in dotted lines in this figure.

Referring now to FIG. 87, the buoyancy means is lowered into position No. 1 as seen in phantom lines by means of the elevator means. A messenger buoy 1535 is stowed on the deck of the ship and includes a cable 1536 attached thereto. This cable is adapted to be interconnected with an endless cable 1538 which passes over a series of sheaves 1540 supported by the ship, and by attaching the buoy cable to the endless cable, the buoy cable may be moved across the deck of the ship, then downward external to the shell of the ship, then under the ship to the bottom of the well, then to the upper inner portion of the well portion whereupon the buoy cable is

released from the endless cable and attached to the top flange of the buoyancy means, the crane cable also being secured to this top flange.

The buoyancy means is then lowered into position No. 2 as shown in full lines in FIG. 87 by means of the elevator means taking care to lower the crane cable at the same rate. The buoyancy means is then raised to position No. 3 as shown by dotted lines immediately above position No. 2, utilizing the crane cable whereupon the elevator clamping means may be retracted.

The buoyancy means along with the depending conduit means and mining equipment can then be lowered by the crane cable through the central portion of the elevator means as shown in FIG. 88 until the dead weight means rests on the bottom in the operative position shown in FIG. 90 of the drawings. It will be apparent as seen in FIG. 90 that the dead weight means includes a flat bottom portion which serves as a foot and anchor means, the conduit means extending in a generally vertical position therefrom and being held in such position due to the inherent buoyancy of the closed capsule of the pumping means 150 as well as the enclosed capsule of the buoyancy means 467. The articulated arrangement including the truss portion which is pivoted between the collecting means and the dead weight means ensures that the mining equipment will fall downwardly in a foolproof manner into the position shown in FIG. 90, and furthermore it permits the equipment to accommodate any contour of the sea bottom.

When the mining equipment has reached the position indicated in FIGS. 88 and 90, the crane cable is released from the top flange of the buoyancy capsule by any suitable remote operating mechanism. The messenger buoy means 1535 is then released overboard as shown in FIG. 89, the buoy means remaining attached to the upper portion of the buoyancy means and the interconnecting buoy cable being of a length so as to maintain the buoy means at the surface for facilitating relocation of the mining equipment when it is desired to relocate and raise the mining equipment back into operative relationship with the mining ship. It is apparent that after the completion of the step of placing the buoy means 1535 overboard, the ship is free to leave the mining area.

When the mining equipment has been subsequently relocated and it is desired to again lift the mining equipment back into operative relationship with respect to the mining ship, the mining ship pulls alongside the buoy means 1535 and a messenger rope as indicated by reference numeral 1543 in FIG. 89 is attached to the buoy cable 1536 and to the endless cable 1538. The endless cable then is actuated so as to move the bitter end of the rope 1543 up through the well portion.

The crane cable is then threaded downwardly through the central portion of the elevator means, and a deep sea diver as indicated by reference numeral 1545 rides down on a hook indicated by reference numeral 1547 at the lower end of the crane cable. The diver utilizes the rope 1543 to guide him to the buoyancy means, and he rides down until he reaches the upper flange of the buoyancy means whereupon he attaches hook 1547 to the upper flange of the buoyancy means. The diver can then surface in a conventional manner.

The buoyancy means is then lifted upwardly through the well portion and the buoy means is lifted to its initial stowed position as shown in FIG. 88. The remainder of the procedural steps shown in FIGS. 82 through 88 for rigging the equipment for jettisoning may then be reversed so as to again place the mining equipment into operative position relative to the ship so that it can then be either lowered into its mining position or lifted into its stowed position as desired.

MODIFIED MINING SHIP ARRANGEMENT

Referring now to FIGS. 91 and 92, the general arrangement includes a pair of ships 1550 and 1551. The

first ship 1550 is of relatively conventional construction, while the ship 1551 is of a unique construction as hereinafter described. As seen in FIG. 91, ship 1550 is provided with a towing fitting 1553 at the stern thereof, and ship 1551 is provided with a towing fitting 1154 at the bow portion thereof. Ship 1551 is also provided with an additional pair of towing fittings 1557 and 1558 which are employed for moving ship 1551 through the water when it is in its operative mining position.

As seen in FIG. 91, a towing cable 1560 is connected between the towing fittings 1553 and 1554 on the ships 1550 and 1551 respectively whereby ship 1550 is adapted to tow ship 1551 when moving to or from a particular mining area. It will be noted that ship 1151 is of elongated construction and includes a longitudinally extending axis XX. When the ship is being towed to or from a particular mining area, ship 1151 will move through the water in such a relationship that the longitudinally extending axis XX thereof is disposed in a substantially horizontal position, and accordingly the ship moves in a more or less conventional manner along the surface when being towed in this position.

Referring now to FIG. 92, the ship 1150 is provided with a variable pitch and reversible propeller 1565, and the usual rudder mechanism 1566 is provided for steering the ship. In addition, the ship is provided with a bow thruster mechanism 1567 mounted in the bow thereof so as to obtain accurate guidance of the ship in cooperation with accurate speed control as governed by the propeller 1565.

A separator mechanism 1570 is mounted at the stern of ship 1550 on the upper portion thereof and is adapted to receive the discharge from the conduit means of the mining ship 1551. The separator mechanism is adapted to separate out the collected solid bodies or manganese nodules while rejecting the sea water or any superfluous material of an undesirable nature. The solid bodies which have been separated out by mechanism 1570 are discharged onto a longitudinally extending conveyor mechanism 1572 which is adapted to carry the nodules forwardly over the holds indicated respectively by reference numerals 1573, 1574, 1575 and 1576. Suitable means is provided for discharging the collected nodules from the conveyor mechanism downwardly into the holds or storage means 1573-1576.

Referring now particularly to FIG. 93, wherein the ship 1551 is indicated as being in its operative mining position with the axis X-X thereof extending substantially vertically, ship 1551 includes an outer hull portion 1580 and an inner hull portion 1582. As is also seen in FIG. 95, a plurality of radially extending bulkheads serve to divide the space between these inner and outer hull portions into a plurality of chambers 1584 adapted to receive water and identified as ballast tanks. Additional ballast tanks 1586 and 1587 are defined within the outer hull 1580 at the lower portion of the ship as seen in FIG. 93. Conventional means in the form of valves and the like are utilized for controlling the flow of water into these ballast tanks, the ballast tanks being capable of being emptied by introduction of compressed air and the like therewithin. The means for controlling the flow of water into and out of the ballast tanks is not illustrated since this is of conventional construction and well known in the art. It will be apparent that the position of ship 1551 can be controlled by the filling and emptying of the ballast tanks, and that when the ballast tanks 1584, 1586 and 1587 are substantially filled with water, the ship will be caused to move into the operative position as shown in FIG. 93. On the other hand, when these ballast tanks are emptied of water to a substantial extent the ship will again assume the position shown in FIG. 91 for movement along the surface.

Ship 1551 includes a well portion indicated generally by reference numeral 1590 which extends substantially

parallel with the longitudinal axis X—X of the ship. The well portion opens at one end of the ship and includes an enlarged opening portion 1592 for the purpose hereinafter described. The large opening portion 1592 is in communication with a substantially cylindrical portion 1593 of the well which in turn is in communication with a substantially frustoconically shaped portion 1594. Portion 1594 in turn joins with a substantially cylindrical portion 1595 of the well which extends upwardly as seen in FIG. 93 to a lowering and retrieving machinery room indicated generally by reference numeral 1596.

A sealing and support means is indicated by reference numeral 1598 and includes a substantially peripheral radially inwardly extending flange which extends inwardly from the well portion 1595 and which includes a tapered opening 1599 at the central portion thereof for a purpose hereinafter explained. Suitable machinery such as winches and the like indicated generally by reference numerals 1600 are provided in the lowering and retrieving machinery room for lifting and lowering the conduit means hereinafter described. The well portion disposed as on ship 1551 serves as a means for storing the conduit means indicated generally by reference numeral 1603 as well as the associated mining equipment components hereinafter described. The conduit means comprises a plurality of separate individual sections indicated generally by reference numeral 1603, each of these individual sections being telescopically and slidably received within each other, the sections being illustrated as being nine in number, the various sections including upper flange portions 1604, the uppermost flange portion 1605 formed on the innermost conduit section being of enlarged size and including an outer peripheral tapered surface adapted to seat snugly in the tapered opening 1599 of the sealing and support means 1598 disposed in the well portion.

The innermost conduit section is adapted to be connected with the pumping means and for this purpose includes a pipe portion 1606 which forms a right elbow, a valve means 1607 being disposed within this pipe portion for controlling the flow of material through the conduit means and into the pumping means. Means is provided within the room 1596 for selectively lifting and lowering the conduit means as hereinafter more fully described.

A dead weight means 1610 is connected with the lower end of the outermost conduit section, this dead weight means having the same construction as previously described. A truss assembly is indicated generally by reference numeral 1615, this truss assembly being similar to that previously discussed.

A collecting means is indicated generally by reference numeral 1617, this collecting means being similar to that previously discussed.

It will be noted that in the stored position seen in FIG. 93, the collecting means or gathering head 1617 fits neatly within the recess portion 1592 of one end of the ship 1551 and that the collecting means is in such a position that it may be most readily moved into operative mining position simply by lowering it away from the ship when in its position as shown in FIG. 93. It will also be seen that a truss means 1615 is received within the portion 1593 of the well portion, while the dead weight means 1610 having a substantially frusto-conical configuration is adapted to be received within the frusto-conically shaped portion 1594 of the well. The dead weight means may also rest snugly against the sealing and support means 1598 and provide a seal therewith when in this position.

It will be noted that the various telescoping individual conduit sections 1603 are received within the portion 1595 of the well, and in a typical representative example wherein the ship 1551 may extend in a direction parallel with the longitudinal axis thereof in excess of 1,000 feet, the individual pipe sections may be approximately 1,000 feet in length.

After ship 1551 has arrived over a particular mining area, it is moved from the position seen in FIG. 91, to that shown in FIGS. 92 and 93 by suitably filling the ballast tanks with water, and the towing cable 1560 is transferred from the towing fitting 1554 to which it is connected in FIG. 91 to the towing fitting 1557 which is connected as seen in FIGS. 92 and 93. Also as seen in FIG. 92, an additional towing cable 1620 is connected between the fitting 1553 on ship 1550 and fitting 1558 on ship 1551. With this interconnection of the two cables 1560 and 1620 between the two ships, the ship 1550 is adapted to move through the water and to tow ship 1551 in the operative mining position as seen in FIGS. 92 and 93.

Referring again to FIG. 93, the portion indicated generally by reference numeral 1623 in FIG. 93 is adapted to contain the equipment and materials required for operating the ship, and for this purpose pivoting decks may be provided to which all of the various equipment is bolted for movement with the decks. This arrangement permits the ship to be moved into either of its two operative positions as seen in FIG. 91 or as seen in FIG. 93, and in each case the decks may be moved to a position which is substantially horizontal to permit normal operation thereon. This structure has been indicated only schematically since it forms no part of the present invention.

A fitting 1625 is provided on ship 1551 for receiving a power cable 1627 from the ship 1550, this power cable in turn being connected with a power cable 1628 in the ship 1551 which is connected with a control panel means 1630 from whence power may be distributed to any of the various operating components of the structure mounted within the ship. Control panel means 1630 is disposed within a generator room indicated by reference numeral 1632, various generating equipment 1633 being indicated generally within the generator room for generating electrical power for use by the machinery and equipment of the ship.

The means for lifting and lowering the conduit means may include a plurality of similar means one of which is indicated generally by reference numeral 1635 having a radially inwardly extending arm portion 1636 which is adapted to receive the uppermost flange portion 1604 of each of the conduit sections. In the position shown in FIG. 93 the arm 1636 is illustrated as being in engagement with the upper flange of the outermost conduit section. Members 1635 are mounted for guided movement within a guide portion 1640 of the well, each of members 1635 being fixed to an endless cable member 1642 which is connected with a winch as indicated generally by reference numeral 1600, cable 1642 being reeved over a sheave member 1643.

It will be apparent that with the structure just previously described, the outermost conduit section may be lowered from the stored position shown to a down position wherein the collecting means 1617, the truss 1615 and the dead weight means will be lowered out of the bottom portion of the well as seen in FIG. 93.

A suitable retaining means 1645 which as illustrated comprises a substantially U-shaped member is provided for retaining the remaining conduit sections in an up position until each section is sequentially lowered by the arm members 1636 previously described. The retaining member 1645 fits under the upper flange of the next pipe section while one is being lowered, retaining means 1645 also fitting over the upper flange 1605 on the innermost conduit section.

Eye bolts or the like 1650 are affixed to the upper surface of flange portion 1605, and a short loop of cable 1652 is connected with the eye bolts 1650 and supported by a hook member 1654 at the outer end of a cable 1655 which in turn is connected with suitable winch means 1600 for lifting and lowering the innermost conduit section.

In lowering the conduit means out of the well of the ship, each individual pipe section will be lowered in se-

quence starting with the outermost conduit section and proceeding sequentially until finally the innermost conduit section is lowered into operative position. As each conduit section is being lowered, the remaining ones will be held in operative position by a means similar to the retaining means 1645 previously described.

When the innermost conduit section is lowered into operative position, it will move into the position shown in FIG. 94 wherein the upper flange 1605 thereof is seated on the sealing and support means 1598 so as to be readily supported thereby and to provide a fluid-tight seal therewith.

As seen in the lowermost portion of FIG. 94, the upper portion of the lower conduit section 1603' is provided with an inwardly extending enlarged portion 1656 having a downwardly tapered surface. The lowermost portion of the innermost conduit section 1603' is provided with an outwardly extending enlarged portion 1658 having an upwardly tapered portion which is complementary to the tapered part of portion 1656. It is apparent that these enlarged portions 1656 and 1658 are adapted to cooperate in such manner as to hold the adjacent conduit sections in operative mining position when the conduit means is lowered into its working position. All of the various individual conduit sections are provided with similar cooperating enlarged portions at the adjacent upper and lower portions thereof.

It will be apparent that when the conduit sections are lowered out of the well they will automatically assume the proper operative position, and when lifting the various conduit sections back into the well, lifting of one conduit section to the upper portion of the well will, through the cooperation of the enlarged portions thereof, raise the upper portion of the next lower conduit section into the lower part of the well whereupon the conduit section which has just been raised may be clamped in operative position by a suitable means such as the retaining means 1645 whereupon the members 1635 can be lowered to pick up the upper flange 1604 of the next conduit section.

The pumping means of the present invention is indicated generally by reference numeral 1660 and is disposed within a pump room indicated by reference numeral 1661. An inlet conduit means 1663 as seen in FIG. 94 is adapted to be connected with conduit portion 1606, and a valve means 1665 is connected in the inlet conduit portion 1663 for controlling the flow of liquid therethrough. As discussed previously, the pumping means for use in a mining operation at great depths of 12,000 feet or greater beneath the sea is preferably of the multi-stage type, and in the illustrated example the pumping means is illustrated as being a four-stage arrangement.

The inlet conduit means 1663 opens into the inlet portion of a centrifugal pump or the like 1667 which is driven by an electric motor 1668. The pumping means must be of a fairly large capacity and in a particular example a large centrifugal pump having a capacity of about 14,000 gallons per minute or more may be utilized in cooperation with a suitably sized driving motor. The outlet or discharge from pump 1667 is directed to the inlet of a corresponding pump 1670 driven by a driving motor 1671 as shown in FIG. 95. The outlet or discharge from pump 1670 is in turn directed to the inlet of a corresponding pump 1674 driven by a driving motor 1675. The discharge or outlet from pump 1674 is then directed to the inlet of a similar pump 1677 which is in turn driven by a suitable driving motor 1678. The discharge from pump 1677 is directed upwardly within a conduit portion 1680.

As seen particularly in FIG. 93, dump valve means 1682 is mounted within conduit means 1680. This dump valve means is of a construction so as to permit free and ready flow of liquid and nodules upwardly within portion 1680 of the conduit, whereas if the pumping means should fail for some reason and the nodules should drop downwardly within the conduit portion 1680, the dump valve

means will automatically open so as to discharge the solid nodules outwardly through a discharge opening 1685 into the surrounding sea water. This automatic operation will prevent jamming or clogging of the pumping means.

The upper portion of the conduit portion 1680 as seen in FIG. 93 is provided with a fitting 1687 which is in turn connected with a conduit means 1688 which may be of flexible construction which in turn is connected with a further flexible conduit portion 1690 which is provided with a discharge end portion adapted to discharge into the separating means 1570 on ship 1550 as seen in FIG. 92.

While all of the dimensions and sizes as mentioned herein are purely illustrative, in a typical example when the ship 1551 is in excess of 1,000 feet in length, the sealing and support means 1598 may be disposed approximately 1,000 feet beneath the surface when the ship is in operative position whereby the nine sections of the conduit means will permit the collecting means to operate at a distance of approximately 10,000 feet below the surface of the sea. It is of course apparent that if the pipe sections are of greater length than 1,000 feet apiece, the collecting means can operate at 12,000 feet or even greater depths. In such an example wherein the collecting means may be operating at a depth of approximately 10,000 feet, the pumping means will be disposed approximately 1,000 feet beneath the surface of the water, or about 10 percent of the distance from the surface to the collecting means.

It is apparent from the foregoing that there is provided according to the present invention a new and novel method and apparatus for underwater mining which is particularly adapted to carrying out mining operations at great depths beneath the surface.

The invention is particularly directed to the recovery of solid objects such as manganese nodules at the bottom of the sea, and the apparatus and methods are particularly designed to collect bodies of this nature. The present invention provides many unique features which enable underwater mining operations to be carried out at extremely great depths beneath the surface of the sea and to successfully accomplish these results notwithstanding the fact that such mining must be carried out under adverse conditions in most instances.

The present invention provides for the first time in the art apparatus and methods which can economically collect solid bodies of material at these great depths in the sea, and many new basic concepts as disclosed herein are utilized for accomplishing the desired purposes.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, and since the scope of the invention is defined by the appended claims, all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents are therefore intended to be embraced by those claims.

What is claimed is:

1. Apparatus for underwater mining comprising a sea-going ship, said ship carrying the necessary individual components to carry out an underwater mining operation at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the assembled components back from the sea bottom to the

ship, said ship including storage means, said collecting means being disposed adjacent the sea bottom, said components including conduit means operatively connected with said collecting means for transporting solid bodies of material from said collecting means to said storage means, means for raising collected bodies from said collecting means to said storage means, said conduit means including a dead weight means at the lower portion thereof, a relatively rigid truss section, said truss section having one end thereof pivotally connected with said dead weight means, the opposite end of said truss section being pivotally connected with said collecting means, and the lower portion of said conduit means extending between said dead weight means and said collecting means being supported by said truss section.

2. Apparatus for underwater mining comprising a seagoing ship, said ship carrying the necessary individual components to carry out an underwater mining operation at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the assembled components back from the sea bottom to the ship, said ship having a well formed therein, said well opening in a downward direction and being open to the sea, elevator means movably mounted within said well portion for movement in an upward and downward direction, gimbals means supported by said elevator means, conduit means operatively connected with said collecting means, an upper portion of said conduit means being operatively connected with said gimbals means so as to permit the necessary degree of relative movement between said conduit means and said ship.

3. Apparatus for underwater mining comprising a seagoing ship, said ship carrying the necessary individual components to carry out an underwater mining operation at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the assembled components back from the sea bottom to the ship, said ship having a well formed therein, said well opening in a downward direction and being open to the sea, elevator means movably mounted within said well portion for movement in an upward and downward direction, gimbals means supported by said elevator means, conduit means operatively connected with said collecting means, an upper portion of said conduit means being operatively connected with said gimbals means so as to permit the necessary degree of relative movement between said conduit means and said ship, and auxiliary support means mounted within said well portion for supporting a part of said conduit means when lowering said components through said well.

4. Apparatus for underwater mining comprising a seagoing ship, said ship carrying the necessary individual components to carry out an underwater mining opera-

tion at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the assembled components back from the sea bottom to the ship, said ship having a well formed therein, said well opening in a downward direction and being open to the sea, elevator means movably mounted within said well portion for movement in an upward and downward direction, gimbals means supported by said elevator means, conduit means operatively connected with said collecting means, an upper portion of said conduit means being operatively connected with said gimbals means so as to permit the necessary degree of relative movement between said conduit means and said ship, said ship including an upper deck portion, and movable support means being mounted on said deck portion and being movable fore and aft along said deck portion.

5. Apparatus for underwater mining comprising a seagoing ship, said ship carrying the necessary individual components to carry out an underwater mining operation at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the assembled components back from the sea bottom to the ship, said ship having a well formed therein, said well opening in a downward direction and being open to the sea, elevator means movably mounted within said well portion for movement in an upward and downward direction, gimbals means supported by said elevator means, conduit means operatively connected with said collecting means, an upper portion of said conduit means being operatively connected with said gimbals means so as to permit the necessary degree of relative movement between said conduit means and said ship, said ship including an upper deck portion, movable support means being mounted on said deck portion and being movable fore and aft along said deck portion, and overhead crane means supported by said ship and movable fore and aft above said deck portion.

6. Apparatus for underwater mining comprising a seagoing ship, said ship carrying the necessary individual components to carry out an underwater mining operation at varying depths down to about 12,000 feet and more beneath the surface of the sea, and said ship when moving on the surface of the sea effecting a simultaneous moving of the operatively connected components including a collecting means adjacent the bottom of the sea, said individual components including said collecting means operatively connected with said ship, means carried by the ship for removably storing said individual components in disassembled relationship and ready for assembly, means carried by the ship for assembling and disassembling said individual components, means carried by the ship for lowering the assembled components from the ship to the bottom of the sea and for lifting the

assembled components back from the sea bottom to the ship, said ship including a well, said well opening in a downward direction and being open to the sea, an elevator supported within said well and movable in an upward and downward direction therewithin, said components including conduit means the upper portion of which is supported by said elevator, pumping means connected at an intermediate point in said conduit means, dead weight means secured to a lower portion of said conduit means, said conduit means comprising a plurality of relatively rigid interconnected sections, truss means pivotally connected with said dead weight means at one end thereof, the opposite end of said truss means being pivotally connected with said collecting means which is disposed adjacent the sea bottom, and said conduit means including a lower portion supported by said truss means and operatively connected with said collecting means.

7. Apparatus for underwater mining at great depths beneath the surface of the sea comprising a ship adapted to move through the water over a particular mining area of the sea bottom, said ship having a well portion disposed therein, said well portion opening downwardly into the sea, elongated conduit means having upper and lower portions, the upper end portion thereof extending into said well portion and being operatively connected with said ship, collecting means adapted to move along the bottom of the sea for collecting solid bodies of material, said collecting means being operatively connected with the lower end portion of said conduit means, the lower portion of said conduit means being articulated to said upper portion thus permitting the collecting means to move in a vertical direction with respect to the upper portion of the conduit means to accommodate variations in the depths of the sea bottom, and pumping means connected in said conduit means at an intermediate portion thereof and disposed a substantial distance beneath the surface of the sea during normal operation of the apparatus, said conduit means including a dead weight means adjacent the articulation of the upper and lower portion thereof, a relatively rigid truss section, said truss section having one end thereof pivotally connected with said dead weight means, the opposite end of said truss section being pivotally connected with said collecting means, and the portion of said conduit means extending between the dead weight means and the collecting means being supporting by said truss section.

8. Apparatus for underwater mining at great depths beneath the surface of the sea comprising a ship adapted to move through the water over a particular mining area, collecting means adapted to move along the sea bottom and to collect the solid bodies of material at the sea bottom, conduit means operatively interconnected between said collecting means and said ship, and a navigation system, said system including at least two spaced buoy means disposed in substantially fixed relationship with respect to the sea bottom, said collecting means having signal producing means thereon, means on said ship for energizing said signal producing means on said collecting means, each of said buoy means including signal receiving means and signal transmitting means, said ship having signal receiving means thereon for receiving signals from the signal transmitting means of each of said buoy means, means interconnected with the signal receiving means of said ship for determining the distance of said collecting means from each of said buoy means, additional signal receiving means on said ship for receiving signals from the signal transmitting means on said collecting means, and means at opposite side portions of said ship for determining the relative position of said collecting means with respect to the center line of the ship and for additionally determining the linear distance between the collecting means and the ship.

9. Apparatus for underwater mining at great depths beneath the surface of the sea comprising a ship adapted to move through the water over a particular mining

area, collecting means adapted to move along the sea bottom through a particular mining area and adapted to collect solid bodies of material at the sea bottom, conduit means operatively connected between said collecting means and said ship for transmitting collected solid bodies of material from said collecting means to the ship, and a navigation system, said system including sonar transmitter means mounted on said ship, sonar transducer means mounted on said collecting means, a pair of spaced buoy means disposed in substantially fixed relationship with respect to the sea bottom, each of said buoy means including sonar receiving means and radio transmitter means, said ship including radio receiver means for receiving signals from said buoy means and electronic counter means connected with the radio receiver means on said ship for determining the distance of said collecting means from each of said buoy means, said counter means also being interconnected with the sonar transmitter means on said ship, spaced sonar transducer means mounted at opposite side portions of said ship, sonar receiver means connected with said sonar transducer means and a dual channel oscilloscope connected with the output of said sonar receiver means, said oscilloscope also being interconnected with the sonar transmitter means on said ship.

10. Apparatus as defined in claim 9 including magnetic compass means mounted on said collecting means, compass repeat means supported by said ship, and means for transmitting a signal from said magnetic compass means to said compass repeat means.

11. Apparatus for underwater mining at great depths beneath the surface of the sea comprising a ship adapted to move through the water over a particular mining area, collecting means adapted to move along the sea bottom for collecting solid bodies of material, means operatively interconnecting said collecting means with said ship, and a navigation system including a sonar transmitter means mounted on said ship, sonar transducer means mounted on said collecting means, magnetic compass means mounted on said collecting means, a pair of spaced buoy means, each of said buoy means including an anchor means adapted to rest upon the sea bottom, sonar receiving means connected with said anchor, radio transmitter means connected with said sonar receiving means, a floating portion interconnected with said radio transmitter means, said floating portion including a radio antenna means, said ship having radio antenna means for receiving radio signals from the buoy means, radio receiver means connected with the radio antennas on the ship, a pair of electronic counter mechanisms interconnected with the radio receiver means and being interconnected with said sonar transmitter means for indicating the distance of said collecting means from each of said buoy means, said ship having spaced sonar receiving means mounted at opposite side portions thereof, a dual channel oscilloscope interconnected with the output of each of said sonar receiving means and also being interconnected with said sonar transmitter means for determining the relative position of the collecting means with respect to the center line of the ship and also to determine the linear distance between the ship and the collecting means, and compass repeat means on said ship for receiving a signal from the magnetic compass means on said collecting means to provide an indication of the directional heading of the collecting means.

References Cited

UNITED STATES PATENTS

332,228	12/1885	Brainard	37—72 X
2,924,886	2/1960	Cullen	33—222
2,999,549	9/1961	Stratton	175—5
3,063,507	11/1962	O'Neill et al.	175—8
3,143,816	8/1964	Gardner	37—71

(Other references on following page)

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UNITED STATES PATENTS

3,180,040	4/1965	Ballam	37—59	
3,215,976	11/1965	Bascom	340—3	
3,222,634	12/1965	Foster	340—3	
3,224,121	12/1965	Denning	37—58	5
3,226,854	1/1966	Mero	37—58	
3,260,004	7/1966	Brooks	37—59 X	
1,327,651	1/1920	Beaven.		
2,144,743	1/1939	Schulz	37—62 X	10
2,323,253	6/1943	Sperry.		
2,437,506	3/1948	Crosman	33—222	
3,111,778	11/1963	Fonnesbeck	37—58	
3,119,189	1/1964	Hyne	33—222	
3,248,812	5/1966	Gardner	56—9	15
645,660	3/1900	Bell	37—59	
2,566,247	8/1951	Pierce	33—1	
3,043,255	7/1962	Bauer	114—0.5	
2,327,994	8/1943	Briggs	115—35	
1,818,278	8/1931	Siler	214—2.5	20
437,954	10/1890	Werntz	285—405	
2,703,178	3/1955	Corn	211—60	
316,497	4/1885	Stone	37—58 X	
332,228	12/1885	Brainard	37—72 X	
523,960	7/1894	Chaquette	37—54	25
527,762	10/1894	Bates	37—72 X	
626,491	6/1899	Ford	37—64	
813,935	2/1906	Avery	37—56	
885,930	4/1908	Lake	37—56	
900,263	10/1908	Carter	37—58 X	
925,079	6/1909	Carlesimo	37—58	

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934,593	9/1909	Carlesimo	57—59
1,038,049	9/1912	Van Wienen	37—58
1,691,686	11/1928	Vorhies	37—58 X
2,160,761	5/1939	Spadaro	37—58
2,191,424	2/1940	Cardinal.	
2,289,260	7/1942	Gerken.	
2,503,516	4/1950	Shrewsbury	175—8 X
2,889,779	6/1959	Hofer	37—58 X
2,992,497	7/1961	Davis	37—58
3,010,232	11/1961	Shakel	37—57 X
3,103,790	9/1963	Popich	37—54 X

FOREIGN PATENTS

125,763	4/1959	U.S.S.R.
92,054	6/1871	France.
657,289	9/1951	Great Britain.
3,259	1905	Great Britain.
997,304	9/1951	France.

OTHER REFERENCES

Mero, J. L., "Economics of Deep Sea Mining," reprinted from the September 1961 Mining Congress Journal.

Edgerton, H. E., "Uses of Sonar in Oceanography," Electronics, vol. 33, pp. 93-95, June 24, 1960.

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U.S. Cl. X.R.

37—72; 299—1, 8; 340—2, 3; 302—15; 114—.5; 61—69