

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) METHOD AND APPARATUS FOR UNDERWATER MINING

(71) We, NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY, a corporation organised and existing under the laws of Virginia, United States of America of 4101 Washington Avenue, Newport News, Virginia 23607, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method, and an apparatus, for continuous undersea mining. The invention is particularly concerned with a method of continuous undersea mining which is carried out from a seagoing vessel.

The existence of manganese nodules on the sea bed 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, and are particularly rich sources of the latter three substances, constituting one of the great untapped sources of nickel in the world today.

These nodules are generally found beneath areas of the sea wherein the sea bed is relatively hard and flat since such sea bed 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 mined from 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 the water at depths of 100 to 200 feet below the surface, but these types of operations simply are not suitable for use in the major areas where the manganese nodules are found at great depth in the sea.

According to the present invention, there is provided a method of continuous underwater mining below a seagoing vessel, comprising stowing a plurality of conduit sections and a sea bed engaging gathering head within the vessel, homing the vessel upon a particular mining area of the sea bed, securing the conduit sections and the gathering head in end-to-end relationship within the vessel with the lowermost conduit section or sections being pivotally mounted on the other sections, lowering the conduit sections from the vessel until the gathering head engages the sea bed, while continuing to support the conduit sections substantially vertically, engaging the mining area with the gathering head, allowing pivoting the bottom conduit section or sections with respect to the upper conduit sections so that the gathering head can accommodate irregularities of the sea bed, gathering and collecting solid materials within the gathering head, and pumping solid materials being mined and seawater from the sea bed through the gathering head and conduit sections and into the vessel.

The conduit sections may be buoyantly supported within the sea, and may be disengageable from the ship, for example in order that the ship can ride out a storm.

According to another aspect of the invention, there is provided a seagoing vessel adapted to carry out the method of continuous underwater mining set forth in

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the preceding two paragraphs.

The method and apparatus in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic elevation, partly in section, of a suggested seagoing vessel for carrying out the method of the invention;

Figure 2 is a plan view of the vessel;

Figure 3 is a sectional plan view of the vessel; and

Figure 4 is a side elevation of part of the vessel.

Referring now to the drawing, a ship indicated generally by reference numeral 10 is illustrated, and in a typical example the ship may have an overall length of about 625 feet with a displacement at operating draft of about 33,000 tons. The ship includes a bow portion 11 and a stern portion 12, a bow thruster mechanism 13 being provided to permit accurate control of the direction of movement of the ship. A reversible and variable pitch propeller 14 is provided at the stern of the ship.

The ship is provided with a well portion indicated by reference numeral 25, this well portion being disposed substantially midway between opposite side portions of the ship thereby providing a centrally located vertical well which opens downwardly into the sea and which extends the full height of the ship so as to provide a means for readily streaming downwardly, and initially setting up the underwater mining equipment. The well portion 25 also facilitates retrieval of the mining equipment into the ship when desired.

The upper end portion 26 of a conduit 45, more fully described below, extends into the well portion 25. This upper portion 26 of the conduit is suitably supported within the well portion 25 by some mechanism 28 (Figure 3) which may take the form of an elevator mechanism or the like. In any event, the mechanism 28 serves to interconnect the conduit with the ship and to at least partially support the weight of the conduit therebelow.

The conduit continues upwardly, and an arcuate portion 29 (Figure 4) extends forward into such a position as to discharge into a separator mechanism 30. 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 the mechanism 30, they are discharged onto a longitudinally extending conveyor mechanism 32 (Figures 1 and 2) which is adapted to carry the nodules forwardly over the holds indicated respectively

by reference numerals 35, 36, 37 and 38. Suitable means is provided for discharging the collected nodules from the conveyor mechanism downwardly into the holds or storage means 35 to 38.

The ship is provided with a suitable superstructure 40 which may include a travelling crane and similar handling mechanism for handling the underwater mining equipment as required. The ship also includes a pipe storage area 42 within which the individual pipe sections 45' (Figure 1) of the conduit 45 are supported when not in use in depending relationship from the ship. The pipe storage areas are sufficient to store all of the individual sections 45' of the conduit.

The conduit, which is indicated generally by reference numeral 45, comprises a plurality of individual sections of pipe 45' 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 are secured to one another by means of suitable flanges 46 that are provided at the ends of the sections, these flanges being fixed to one another by conventional nut and bolt assemblies.

A buoyant pump capsule 50 is provided at an intermediate point in the conduit, this pump capsule serving to house the pump which may in a typical example take the form of a large centrifugal pump with 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 50, the driving motor in such a typical example having a 2,100 h.p. rating at 550 rpm and a weight in excess of 26,000 lbs.

The conduit includes a portion 51 which extends downwardly from the pump capsule 50 and which is connected with a deadweight 53. This deadweight, as seen in Figure 1, may have a substantially frusto-conical configurations and a relatively flat bottom edge portion which is adapted to rest on the sea bed. This configuration permits the conduit to drop downwardly into such a position that the bottom portion of the deadweight rests on the sea bed while the conduit, which extends upwardly therefrom, will be supported in a substantially vertical position due to the buoyancy of the pump capsule 50.

If necessary, for example during a storm, the conduit 45 may be disconnected at its upper end from the ship, remaining loosely connected to the ship by means of a guide rope or chain (not shown). The buoyant pump capsule maintains the upper end of the disconnected conduit close to the ship,

so that re-connection after the storm is a relatively straightforward matter.

5 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 by reference numeral 50. Thus, when the mining operation is to be carried out at relatively great depths, for example in excess of 3,000 feet, it may be necessary to provide one or more further buoyant capsules, in addition to the pump capsule 50, each containing pump and motor equipment. One such further capsule has been indicated in broken lines by the reference numeral 55, it being understood that any suitable number and spacing of pump capsules, each containing pump and motor equipment, may be employed as required. 10 It will also be noted that the conduit is shown broken away, the distance from the buoyant pump capsule 50 to the deadweight 53 being generally much greater than the distance from the pump capsule 50 to the ship. 25

A first dump valve, indicated generally by reference numeral 57, is connected in the conduit 45 above the pump capsule 50, and a second dump valve 59 is connected in the conduit adjacent to the deadweight 53. Each of these dump valves operates in a similar manner, that is to say in such a way that the dump valves will be ordinarily closed during normal pumping operations, when the flow of water and nodules within the conduit 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 the conduit, the dump valves 57 and 59 will open so as to cause the downwardly falling nodules or any other solid bodies to pass outwardly of the conduit into the surrounding sea water. These dump valves prevent 40 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.

A power cable 62 extends from the ship 50 downwardly and is connected with the equipment within the pump capsule. This cable 62 is employed for transmitting suitable electrical power to the pump capsule and may also include control leads for controlling the operation of the pumping means remotely from the ship. It will of course be understood that similar power and control cables may be extended downwardly to any additional pump capsules employed in the conduit means. 60

A truss assembly, indicated generally by reference numeral 65, is connected by a coupling 66 to the deadweight 53, in such a manner as to permit free swinging movement of the truss structure through an

angle of at least 90° with respect to the deadweight.

23
A gathering head 67 is connected as indicated generally by reference numeral 69 with the lower end of the truss structure. 70 The interconnection 69 may be a universal joint arrangement so as to permit free movement of the gathering head 67 about two mutually perpendicular axes, thereby allowing the gathering head to closely follow the contour of the sea bed while being operatively interconnected with the truss structure. 75

The truss structure 65 may comprise a conventional type open framework which 80 provides a relatively lightweight arrangement of high rigidity, this truss structure serving to support a conduit portion 72 which may be a flexible pipe. It will be noted that the conduit 45 accordingly includes a major upwardly extending rigid portion which extends from the deadweight 53, the bottom section or sections of the conduit adjacent the truss 65 being articulated to the other sections for permitting pivotal movement thereof. In this way the gathering head connected to the lower end of the truss can move in a vertical direction to compensate for variations in the level of the sea bed. 95

Suitable illuminating means, such as electric underwater lights 74, are mounted on the truss structure 65, and suitable remote viewing means such as television cameras 76 are also supported on the lower portion of the truss structure adjacent to the lights. With this arrangement, the sea bed and the gathering head 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 gathering head so as to move it along a desired path. 100

The gathering head 67 is provided with a suitable electric driving motor 80 which is adapted to drive an endless track 82 provided at each side of the gathering head whereby the gathering head may be driven and guided along the sea bottom. This self propelling feature is provided in one form of the invention, whereas in another form of the invention it may be eliminated wherein the gathering head is towed by the ship. The gathering head may either ride along the endless tracks as illustrated or may be provided with auxiliary wheels or runners if it is desired to facilitate movement along the sea bed. 105 115 120

The gathering head is also provided with a plurality of spaced depending teeth 85 which are spaced apart a particular distance so as to permit entry into the gathering head of solid particles of certain particular sizes. These teeth assure the rejection of those solid bodies which are not desired 130

to be collected.

The solid bodies which are collected are all directed to a suction throat portion 86 which is interconnected with the lowermost end of the flexible conduit portion 72 whereby the collected nodules may be sucked up the conduit to the ship. A diffusion valve 88 on the gathering head is adapted to open and to allow surrounding sea water to be entrained into the lowermost end of the conduit for controlling the ratio of solids to liquids within the conduit. The operation of this diffusion valve may be remotely controlled from the ship.

The gathering head 67 may also be provided with a compass and with sonar apparatus to facilitate navigation of the ship with respect to the gathering head.

It should be understood that the truss structure 65 may be formed in separate sections to facilitate assembly and disassembly thereof, and that the entire truss structure may be disconnected from the deadweight and from the gathering head so as to enable storage of all of this equipment on the ship.

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

It is again emphasised 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.

It is apparent from the foregoing that there is provided according to the present invention a new method and apparatus which is specially adapted for underwater mining on the high seas and for collecting or gathering solid bodies or masses of material such as manganese nodules from the sea bed. A ship is provided which is a completely self-contained unit and which incorporates all the equipment and materials required for carrying out the underwater mining operation. The conduit includes a plurality of readily assembled and disassembled primary sections, suitable dump valves being incorporated in certain portions of the conduit for preventing jamming up of the nodules within the conduit which might otherwise occur after a pump failure

or the like. The conduit also includes a bottom section or sections pivotally mounted on the primary sections to the gathering head at the lowermost end of the conduit to rise and fall in accordance with variations in the level of the sea bed.

The pump which is incorporated in the conduit at an intermediate portion thereof substantially below the sea surface, is adapted to suck the water and entrained nodules from the gathering head up to the level of the pump capsule, whereupon the water and the nodules are then pumped under positive pressure upwardly to the ship. This arrangement is especially effective and efficient for use in pumping materials from great depths such as are encountered in mining operations which may be carried out at depths of 12,000 feet or more below the surface of the sea.

The gathering head 67 is adapted for movement along the sea bed and serves to gather up nodules of the desired size which are then sucked upwardly from the collecting throat portion of the gathering head. The overall arrangement of the present invention is specifically designed to operate at great depths under tremendous pressures and under varying environmental factors such as prevailing winds, sea currents and sea conditions. The equipment, while being inherently rather massive in nature, at the same time has been designed to be as compact as possible under the circumstances and to provide an arrangement which is extremely effective and reliable in operation so as to provide a minimum of trouble and maintenance time to reduce down time of the equipment to a bare minimum.

In one method of operation, the ship moves along the surface of the sea with the depending connected conduit trailing therebeneath so as to tow the gathering head at the lower end of the conduit, the gathering head in such a case requiring no self propelling arrangement. On the other hand, a second manner of operation is to provide the gathering head with a self propelling means which may be in the form of an endless track arrangement on either side of the gathering head or some suitable underwater driving mechanism, the gathering head in such a case being remotely driven and guided from the ship, and the ship being manoeuvred so as to maintain it substantially over the gathering head and with the conduit in a substantially vertical position, thereby maintaining the proper operative relationship between the ship and the gathering head.

WHAT WE CLAIM IS:—

1. A method of continuous underwater mining below a seagoing vessel, comprising stowing a plurality of conduit sections and a sea bed engaging gathering head within



to be collected.

The solid bodies which are collected are all directed to a suction throat portion 86 which is interconnected with the lowermost end of the flexible conduit portion 72 where-
5 by the collected nodules may be sucked up the conduit to the ship. A diffusion valve 88 on the gathering head is adapted to open and to allow surrounding sea water to be
10 entrained into the lowermost end of the conduit for controlling the ratio of solids to liquids within the conduit. The operation of this diffusion valve may be remotely controlled from the ship.

15 The gathering head 67 may also be provided with a compass and with sonar apparatus to facilitate navigation of the ship with respect to the gathering head.

It should be understood that the truss
20 structure 65 may be formed in separate sections to facilitate assembly and disassembly thereof, and that the entire truss structure may be disconnected from the deadweight and from the gathering head so
25 as to enable storage of all of this equipment on the ship.

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30 the distance Y may be approximately 450 feet. It will be noted that the deadweight in such an arrangement would normally be positioned approximately 100 feet above the sea bed and that the swinging move-
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45 typical example, and that the actual dimensions may vary widely in underwater mining operations.

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50 invention a new method and apparatus which is specially adapted for underwater mining on the high seas and for collecting or gathering solid bodies or masses of material such as manganese nodules from
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60 plurality of readily assembled and disassembled primary sections, suitable dump valves being incorporated in certain portions of the conduit for preventing jamming up of the nodules within the conduit which
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or the like. The conduit also includes a bottom section or sections pivotally mounted on the primary sections to the gathering head at the lowermost end of the conduit to rise and fall in accordance with variations
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75 nodules from the gathering head up to the level of the pump capsule, whereupon the water and the nodules are then pumped under positive pressure upwardly to the ship. This arrangement is especially
80 effective and efficient for use in pumping materials from great depths such as are encountered in mining operations which may be carried out at depths of 12,000 feet or more below the surface of the sea. 85

The gathering head 67 is adapted for movement along the sea bed and serves to gather up nodules of the desired size which are then sucked upwardly from the collecting throat portion of the gathering head.
90 The overall arrangement of the present invention is specifically designed to operate at great depths under tremendous pressures and under varying environmental factors such as prevailing winds, sea currents and
95 sea conditions. The equipment, while being inherently rather massive in nature, at the same time has been designed to be as compact as possible under the circumstances and to provide an arrangement which is
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In one method of operation, the ship
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110 propelling arrangement. On the other hand, a second manner of operation is to provide the gathering head with a self propelling means which may be in the form of an endless track arrangement on
115 either side of the gathering head or some suitable underwater driving mechanism, the gathering head in such a case being remotely driven and guided from the ship, and the ship being manoeuvred so as to
120 maintain it substantially over the gathering head and with the conduit in a substantially vertical position, thereby maintaining the proper operative relationship between the ship and the gathering head. 125

WHAT WE CLAIM IS:—

1. A method of continuous underwater mining below a seagoing vessel, comprising stowing a plurality of conduit sections and a sea bed engaging gathering head within 130

the vessel, homing the vessel upon a particular mining area on the sea bed, securing the conduit sections and the gathering head in end-to-end relationship within the vessel with the lowermost conduit section or sections being pivotally mounted on the other sections, lowering the conduit sections from the vessel until the gathering head engages the sea bed, while continuing to support the conduit sections substantially vertically, engaging the mining area with the gathering head, allowing pivoting of the bottom conduit section or sections with respect to the upper conduit section, so that the gathering head can accommodate irregularities of the sea bed, gathering and collecting solid materials within the gathering head, and pumping solid materials being mined and sea water from the sea bed through the gathering head and conduit sections and into the vessel.

2. A method according to claim 1 wherein the conduit sections are buoyantly supported within the sea.

3. A method according to claim 2 including disengaging the conduit sections from the ship, the conduit sections remaining buoyantly supported within the sea, then re-connecting the conduit sections to the ship.

4. A seagoing vessel for continuous underwater mining, comprising a hull structure defining a conduit section stowage hold, a mined-material stowage hold, and a downwardly-opening portion communicating with the sea beneath the vessel, the hull structure having mounted thereon a conduit section assembly device interposed between the conduit stowage section and the downwardly opening portion, and a conduit elevator engageable with conduit sections within the downwardly opening portion, so as to raise and lower conduit sections with respect to the vessel; there being provided a plurality of primary conduit sections and at least one further conduit section stowed in the conduit stowage hold and securable by means of the assembly device in end-to-end relationship within the downwardly opening portion, so as to extend downwardly towards the sea bed mining area, the primary conduit sections forming a rigid conduit, a sea bed engaging gathering head

adapted to be pivotally mounted on the further conduit section which, in turn, is adapted to be pivotally connected to the primary conduit sections extending in end-to-end relationship upwardly therefrom to the downwardly opening portion; and a pump connected to the conduit sections, so as to draw sea water and mined material through the gathering head and conduit sections and into the vessel.

5. A seagoing vessel according to claim 4 including at least one buoyant capsule attached to the conduit sections so as to suspend the conduit sections within the sea, both during mining and during disengagement of the conduit sections from the hull structure.

6. A seagoing vessel according to claim 4 or claim 5 wherein the conduit sections contain at least one dump valve, so as to enable discharge of pumped, mined material and sea water from the conduit sections.

7. A seagoing vessel according to any one of claims 4 to 6, including a truss adapted to be pivotally mounted on a bottom primary conduit section, so as to support the further conduit section and the gathering head with respect to the primary conduit sections.

8. A seagoing vessel according to claim 5, or claim 6 or 7 when dependent on claim 5, including a deadweight suspended from a conduit section so as to vertically orient the conduit sections above the sea bed during mining and adapted to rest upon the sea bed during disengagements, while the buoyant capsule supports the upper conduit sections in substantially vertical position.

9. A method of continuous underwater mining substantially as hereinbefore described with reference to the accompanying drawings.

10. A seagoing vessel for continuous underwater mining substantially as hereinbefore described with reference to the accompanying drawings.

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