ABSTRACT

Reversely forcing water through a recovery head closes a valve in an intake tube and jets water out of the bottom of the head, burrowing the head downward along a guide pipe deep into a sand deposit. Crusher rollers at a sand intake break large objects, and sand flows through a control valve into a mixing box at the bottom of the head. Water flows downward through a tube into the mixing box, and a slurry is drawn out by a suction pump at the end of a long flexible tube. The slurry is discharged on a sand accumulation point. After a large crater-like volume of sand is removed, the head is moved by lifting it with a drum-like crane, which is controlled by selectively balancing air and water within the drum.

11 Claims, 6 Drawing Figures
LOOSE MATERIAL RECOVERY SYSTEM HAVING A MIXING BOX

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BACKGROUND OF THE INVENTION

As land based sources of sand are being diminished, man is looking toward the vast ocean floor deposits to satisfy the need for sand in the construction industry and for the restoration and maintenance of beaches.

Although much sand has been located off coastlines, several factors have restricted the recovery of this resource. One is the lack of adequate technology. Efforts to date have centered about the adaptation of conventional harbor and channel dredges to use in the open ocean. Downtime and equipment failures caused by heavy seas make ocean operations with such vessels uneconomical. In addition, harmful effects to the environment result from the turbidity and sedimentation caused by these dredges.

Generally, hydraulic suction dredges are used to remove unconsolidated materials such as sand. Dredges of that type usually employ a rigid suction pipe leading to a suction head which must be kept at or near the bottom. Since water is drawn in around the sides of the head to form a slurry with the sand, care must be taken not to allow the head to bury itself causing the sand percentage to rise, eventually choking off the flow. Similarly, if the head is held too far above the bottom, the sand percentage will diminish. The task of maintaining the elevation of the suction head with respect to the ocean bottom becomes increasingly difficult as the sea state increases, and furthermore, the suction head strikes the bottom resulting in severe stresses to the equipment with failures likely. Although these problems can be alleviated somewhat through the addition of automated control devices, the result is a more sophisticated and expensive system which requires greater costs to build and operate.

SUMMARY OF THE INVENTION

This invention provides a new and simpler means of extracting ocean sand whereby the suction head or probe is buried in the sand and through the use of flexible hose to the surface the relative motion problem is avoided. It is designed for operation from a small vessel while at anchor with no crew members resulting in less expense and a cheaper product. By eliminating the rigid coupling between the suction head and the vessel, operations can be carried out in heavier seas. By creating a suction head that can be buried in the sand, less turbidity results.

The system of the present invention makes it possible to mine sand from thick deposits on the ocean bottom from a small vessel without need of a large crew. It consists principally of a suction probe which first burrows into the sand by hydro-jet action and then draws out the sand from this buried position. Important to the proper functioning of this invention are double tubes, one to carry clear water down beneath the sand surface and the other to bring up the sand-water mixture, and a hydraulically powered roller crusher mounted at the sand inlet to grind up coral, shells and rocks in the sand. Some advantages that it can be operated in heavy sea, creates little turbidity and thus less environmental disturbance, and requires little vessel maneuvering.

The sand recovery system is designed for operation in a thick sand deposit, 20 feet or thicker, and is most useful for small operations such as a beach nourishment project requiring 20,000 to 30,000 cubic yards where mobilization costs for a large seagoing dredge would be prohibitive. The system consists principally of a suction probe which buries itself in a deposit of sand. The probe is composed of two tubes or pipes which attach to a mixing box, a roller crusher powered by a hydraulic motor which is mounted on top of the mixing box, and various valves and fittings.

The device is operated by first burrowing or "jetting" it into a thick deposit of sand by pumping water down through one of the tubes and out the jetting nozzle. Divers are generally used to help accomplish this step. Once in place below the sand, suction from the pump is applied to one tube through flexible hose, water is drawn down the other tube to the mixing box while sand is drawn in through an opening in the top of the mixing box. The sand mixes with the intake water and is drawn up the first tube in a slurry.

An important feature is the roller crusher which grinds up coral, rock and shell fragments in the sand to prior to entry into the mixing box to prevent clogging at the sand inlet. As the sand is removed a crator, or inverted cone, forms above. The volume of sand removable from a 50-foot deep crater is about 12,000 cubic yards. The probe may be jetted to the bottom of the deposit for a one-shot removal or it may be jetted in increments as will be shown later.

A chief object of the invention is to provide an effective means of recovering or removing sand from thick deposits on the ocean floor from a relatively small vessel in a way which results in several advantages over conventional dredging methods.

Another object is to provide such a means which eliminates the need for continual control of the elevation of the suction head with respect to the bottom thereby reducing crew and equipment costs and the chance of plugging the suction and discharge pipes.

Another object is to eliminate the rigid connection between the vessel and the suction head in order to reduce wear and damage to equipment in heavy seas.

Another object is to reduce turbidity and sedimentation at the suction head in order to minimize environmental impact. Another object is to reduce vessel maneuvering in order to reduce costs and simplify direct pumping to shore. Another object of the invention is to minimize chances of physical damage to surrounding coral.

The invention has as another object the provision of methods and apparatus for sand recovery using a head which is driven into a sand deposit. An object of the invention is the provision of method and apparatus for burrowing a sand recovery head into a sand deposit. A further object of the invention is the provision of methods and apparatus which draw water from above a sand deposit downward through a tube, move sand into the tube and pull slurries of sand and water toward water surfaces.

The invention has as another object the recovery of loose material from a deposit by burrowing a recovery head into the deposit, flowing loose material into a tube near a bottom of the head, drawing fluid into the head.
from beyond a surface of the deposit and pumping a slurry of the fluid and the material to a predetermined position.

The invention has as a further object the recovering of loose material from a deposit using a head which has a roller crusher, communicating through a valve to a mixing box, an inlet tube communicating with the mixing box, and a suction tube communicating with the mixing box for drawing loose material in a slurry away from the mixing box.

A further object of the invention is the provision of a loose material recovery head having an implanting check valve and nozzle for moving the head into a deposit of loose material by reversing flow through a suction line.

These and other objects and features of the invention are apparent in the disclosure which includes the drawings and the foregoing and ongoing specification with the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of sand recovery apparatus of the present invention.

FIG. 2 is a schematic drawing of the system which includes a vessel, slurry lines and pump and recovery heads shown in FIG. 1.

FIG. 2A is a detail of a reversed pump connection.

FIG. 3 is a detail of a burrowing jet.

FIG. 4 is a partial detail of the roller crushers, sand inlet and mixing box.

FIG. 5 is a detail of guide pipe setting.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1, a sand recovery head is generally indicated by the numeral 1. Intake pipe 3 carries water downward into a mixing box 5, and slurry pipe 7 carries a mixture of sand and water upward toward flexible hose 9. The flexible hose is connected to a suction pump which discharges the slurry to a predetermined sand collection point.

At the beginning of the sand recovery operation, the pump connection shown in FIG. 2 is reversed as shown in FIG. 2A, and water is forced downward through flexible hose 9 into slurry pipe 7 and mixing chamber 5. Water flows outward through nozzle 11 when the pressure in mixing box 5 exceeds external pressure and opens check valve 13. At that time, sliding vane valve 15 is closed to prevent upward egress of water through the sand inlet. Check valve 17, which permits flow only into intake pipe 3, automatically closes upon the reversing of flow. The water jetting downward from nozzle 11 forces the sand downward and outward and softens the sand, displacing the sand and permitting the weight of the recovery head 1 to drive the recovery head downward into the sand. The downward pumping of water is terminated just before the supply water intake at the top of pipe 3 reaches the sand.

Valve 15 is opened or is partially opened, permitting sand to flow between rollers 19 and 21 and into the mixing box 5. At the same time, the pump draws a suction on slurry pipe 7, moving the sand and water toward the pump. Crushing rollers 19 and 21 have projections which break shells and coral and other large pieces of material having a size over a predetermined limit for preventing clogging of the sand intake, mixing box 5 and slurry pipe 7. Valve 15 precisely controls the sand-water slurry mixture. The rollers are mounted on vertical shafts 23 interconnected by gears 25 and are driven by a hydraulic motor 27. Hydraulic supply lines 29 drive the motor from a power source on a boat.

As shown in FIG. 2, after the head 1 has created a crater, it is moved downward in successive increments of approximately ten feet, keeping the water intake clear, so that successively greater amounts of sand may be recovered, forming craters of increasing size.

The downward movement of the head 1 is controlled by guide pipe 31 which is vertically set in the sand. Hinged and locking sleeves at the top and the bottom of head 1 are connected loosely around the guide pipe to ensure vertical downward movement of the head whenever water is jetted from nozzle 11 by reversing flow in suction hose 9.

FIG. 2 shows the small recovery vessel 33 which has a crane 34 for lifting the recovery head from the water. A pump 35 has a suction connected to suction hose 9. Discharge hose 37 leads from pump 35 to a predetermined sand collection point at end 39 of the hose. The slurry is discharged from the hose, and water is run off while the sand is accumulated. Suction is applied by a centrifugal dredge pump. In deeper depths a jet pump or an air lift may be installed in the slurry hose near the bottom.

FIG. 3 is a detail of a preferred form of nozzle 11. A check valve housing 13 is fitted on the bottom of mixing box 5. Nozzle 11 has an end opening 41 approximately 6 inches in diameter. Radial openings 43 are cut through the opposite sides of nozzle 11 which face in the elongated direction of the mixing box 5 for facilitating the removal of sand to accommodate the elongated rectangular cross-sectional shape of the mixing box. Radial holes 45 may be approximately three-quarters of an inch in size.

FIG. 4 is a detail of sand flow through crushing rollers into a rectangular opening which leads to a mixing box. Cone, hammer or jaw crushers may be used. Rollers 19 and 21 having opposed radially extending crushing lugs are rotated by gears 25 toward each other in directions indicated by arrows 45 and 47. Sand in which the head and rollers are buried flows inward between the rollers in the direction indicated by arrow 49. Large pieces of material such as shells and coral are crushed by the roller as the sand continues in a direction indicated by arrow 51 beyond the rollers and down through a rectangular opening 53. The effective size of opening 53 is controlled by a sliding vane valve 15, shown in FIG. 1, which is positioned between the opening and the mixing box. The sliding vane valve 15 is operated by any convenient well-known means.

To ensure vertical placement of the recovery head 1, a guide pipe 31 is first driven into the sand. Pipes 31 may be assembled in 10, 15 or 20-foot lengths. Ends of the pipes are oppositely threaded for adding additional pipes.

As shown in FIG. 5 a tripod arrangement is employed to ensure vertical positioning of the pipes.

Pipes 31 have connections 53 which link the pipes together. The top of a pipe 31 is joined by fitting 59 to a hose 61 for supplying water to the pipes and jetting water downward and outward from a lower open end of the pipes so that the pipes may be easily slid into sand deposits. A tripod for vertically aligning the pipes is generally indicated by numeral 63. The tripod has three legs 65 joined at the top by a sleeve 67 which loosely fits around pipe 31. A cross member 69 joins...
the legs 65 of the tripod at midpoints and supports a second loose-fitting sleeve 71 to keep pipes 31 in vertical alignment. In a preferred form of the invention, one-inch pipes are employed and are supplied by a two-inch water hose.

A string of pipes is driven all of the way to the bottom of a sand deposit before a head is attached laterally to the uppermost pipe and watter is jetted from the head to begin its burrowing into the sand.

Any convenient size apparatus may be employed according to the depth of recovery and the size of available auxiliary apparatus. A recovery head with six-inch diameter intake pipes and suction pipes is a convenient form of the invention. A sand recovery box useful in such a system may have a rectangular cross-section roughly 32 inches by 18 inches and a depth at its central point of about 20 inches. Usually, a smooth semicircular mixing box is preferred. The jetting nozzle at the bottom of the mixing box for burrowing the head into the sand may have a dimension of 6 inches. The intake and suction pipes have lengths of approximately ten feet, which limits the distance of burrowing into a sand deposit. An extension of the intake pipe provides additional burrowing distances. The device may be increased up to any convenient size for which equipment is available. Eight-inch, 16-inch, 32-inch or other suction dredge pumps, hoses and pipes may be employed with commensurate increases in mixing box dimensions. Four to six-inch or great diameter crushers driven at relatively slow speeds of, for example, ten to twenty rpm's and capable of exerting 25,000 or more inch-pounds of torque are suitable for use with the equipment of the present invention. The equipment operates well with a sand valve opening which permits a flow of sand providing a concentration of from ten to twenty percent sand by volume in the slurry. The equipment described conveniently pumps 50 cubic yards of sand and more per hour. In the initial increment of head placement approximately one hundred yards of sand may be removed. In the next incremental drop of the head approximately 800 cubic yards of sand are removed. In the next incremental drop of the head, assuming 10-foot increments, approximately 2,700 yards of sand may be removed. When the head is dropped the next increment to forty feet deep within the sand deposit, approximately 6,400 cubic yards of sand may be removed. When walls of the crater formed within the sand deposit are disturbed by divers, additional sand may be removed without deepening the head.

Although the invention has been described with reference to specific embodiments, it will be obvious that modifications and variations of the invention can be constructed without departing from the spirit and scope of the invention. The scope of the invention is described in the following claims.

I claim:

1. A loose material recovery apparatus comprising a mixing box, a loose material opening in a middle portion of the mixing box, a fluid supply inlet opening along one side of the box and a slurry outlet opening in another portion of the box remote from the fluid inlet, means for flowing fluid into the fluid inlet opening, and means for withdrawing slurry of the fluid and loose material through the slurry outlet opening, jetting means connected to the mixing box opposite the loose material opening, wherein the jetting means comprises a valve mounted on the mixing box, an outwardly directed nozzle mounted on the valve and communicating with the mixing box through the valve, a second valve connected to the fluid supply opening, and a closure means connected to the loose material opening for jetting fluid from the mixing box through the first valve and nozzle when the first valve is opening, when the second valve is closed, when the closure seals the loose material opening, and when fluid is flowed into the mixing box through the slurry outlet opening, for flowing loose material away from the mixing box and thereby permitting the driving of the mixing box deep into a deposit of the loose material.

2. The sand recovery apparatus of claim 1 further comprising a fluid supply pipe extending outward from the fluid inlet opening and a slurry suction pipe extending from the slurry outlet opening spaced laterally from and extending substantially parallel to the fluid supply pipe.

3. The apparatus of claim 1 further comprising closely spaced parallel crusher rollers mounted outside of the mixing box adjacent the loose material opening for crushing large pieces in loose material flowing into the opening.

4. The apparatus of claim 1 wherein the loose material opening is in an upward facing portion of the mixing box whereby loose material gravitationally flows through the loose material opening into the mixing box.

5. The apparatus of claim 1 further comprising crusher means mounted adjacent the loose material opening of the mixing box for crushing large pieces of material flowing into the opening.

6. Loose material recovery apparatus comprising a mixing box, a loose material opening in the mixing box, a fluid supply inlet opening along one side of the box and a slurry outlet opening in another portion of the box, means for flowing fluid into the fluid inlet opening, and means for withdrawing slurry of the fluid and loose material through the slurry outlet opening, wherein the mixing box comprises a box having a semi-circular bottom and a relatively flat elongated top, wherein the loose material opening is positioned medially between longitudinal extremities of the top and wherein the fluid supply and slurry openings are positioned in the top at longitudinal extremities thereof on opposite sides of the loose material opening, and further comprising a water supply inlet pipe connected to the fluid supply opening and extending upward therewith generally parallel to the water supply pipe, and means for attaching a flexible suction hose to an upper distal end of the slurry pipe.

7. The apparatus of claim 6 further comprising jet means connected to the mixing box opposite the loose material opening for flowing fluid outward from the mixing box into a deposit of loose material and moving loose material away from the mixing box for permitting the movement of the mixing box deep into a deposit of loose material.

8. The apparatus of claim 7 further comprising a flexible suction hose connected to the upper end of the slurry suction pipe and a suction pump connected to a remote end of the suction hose, a discharge line connected to the pump, and an opening in the discharge line remote from the pump for releasing slurry at a predetermined point.
9. The apparatus of claim 7 further comprising parallel rollers mounted on the mixing box adjacent the loose material opening, gears connected to the rollers and inter-meshing for driving the rollers in opposite rotation toward the loose material opening, and motor means connected to the rollers for driving the rollers, power communication means connected to the motor means and extending upward therefrom, and a power supply connected to the communication means for supplying power to the motor and driving the rollers to crush large pieces in loose material passing into the opening.

10. The apparatus of claim 7 further comprising collar means laterally mounted on the mixing box and pipes, the collar means having aligned vertical axes, and a guide pipe extending loosely through the collar means and into the deposit for aligning the mixing box and pipes and for permitting straight movement of the mixing box into the deposit.

11. The apparatus of claim 7 further comprising a jet opening mounted in the bottom of the mixing box, a first valve connected to the jet opening, a nozzle extending downward from the first valve and opening downwardly for flowing water outward from the mixing box when the first valve is opened, a second valve connected to the water supply pipe for closing the water supply pipe when jetting water from the nozzle, and a closure selectively positionable adjacent the loose material opening for closing the loose material opening, and a water pressure source connected to the slurry pipe for flowing water into the mixing box and outward through the jetting nozzle for permitting movement of the mixing box deep into a deposit of loose material.

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