Jan. 30, 1968 R. VOGT 3,365,823

OCEAN FLOOR MINING SYSTEM

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FIG. 1.

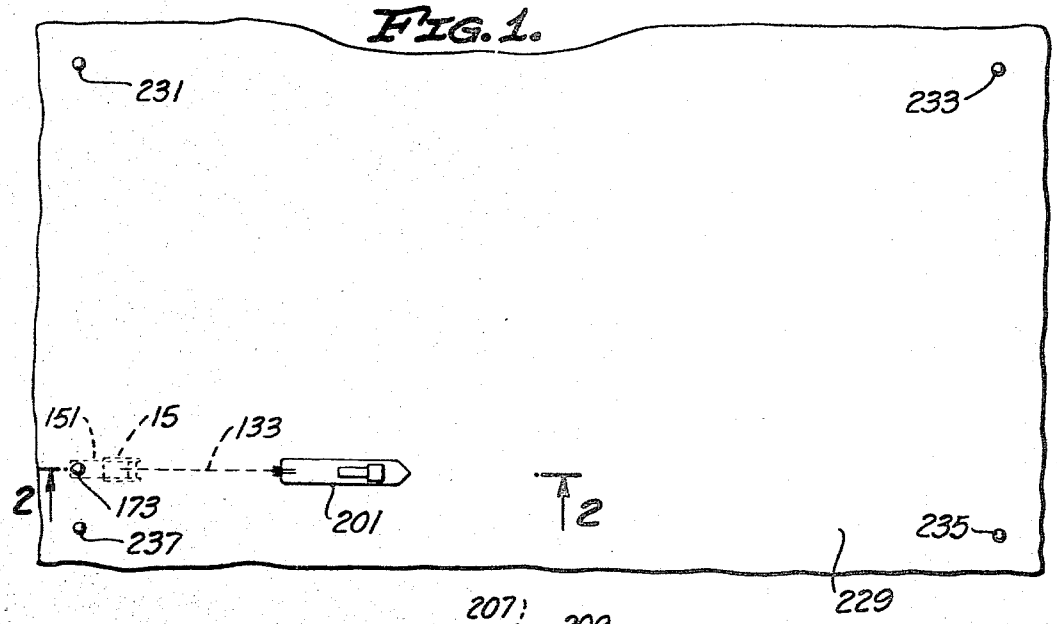


FIG. 2.

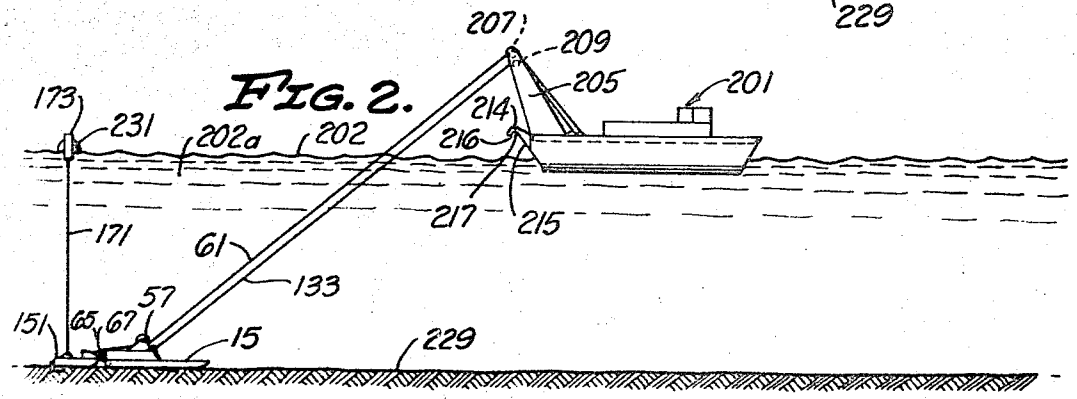
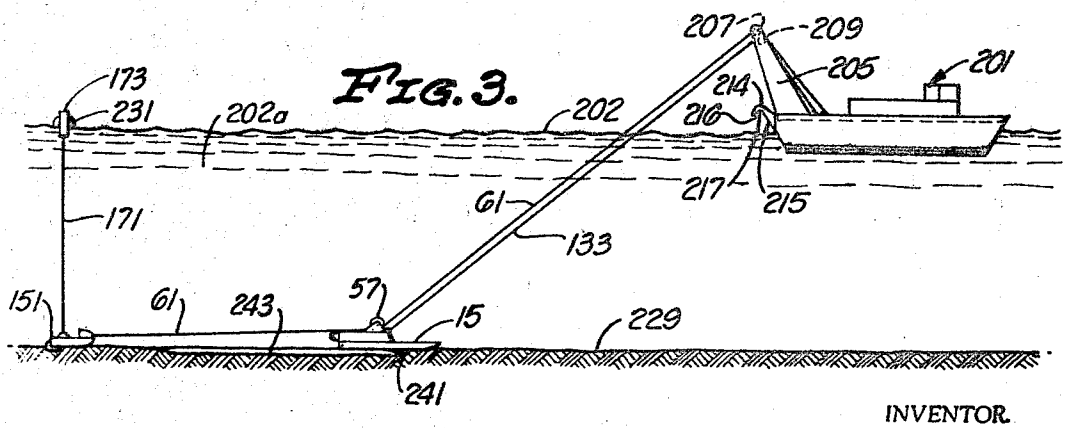


FIG. 3.



INVENTOR.
RICHARD VOGT
BY HIS ATTORNEYS
HARRIS, KIECH, RUSSELL & KERN

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FIG. 4.

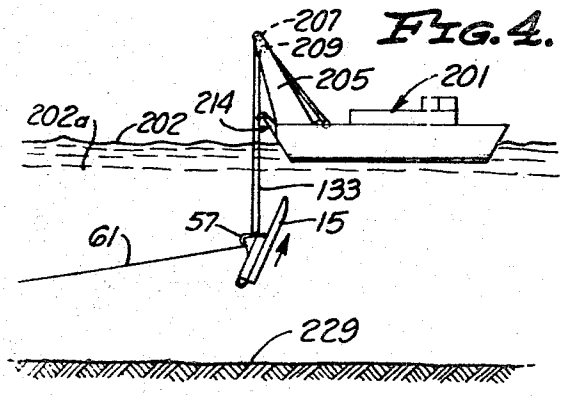


FIG. 5.

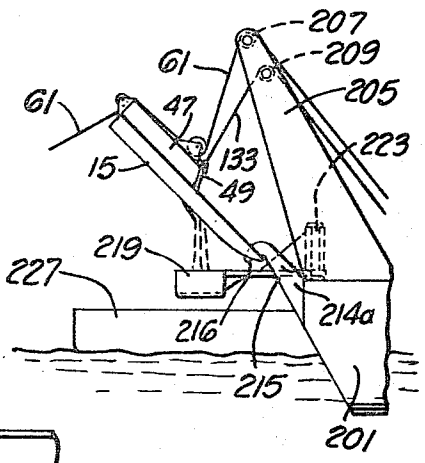


FIG. 6.

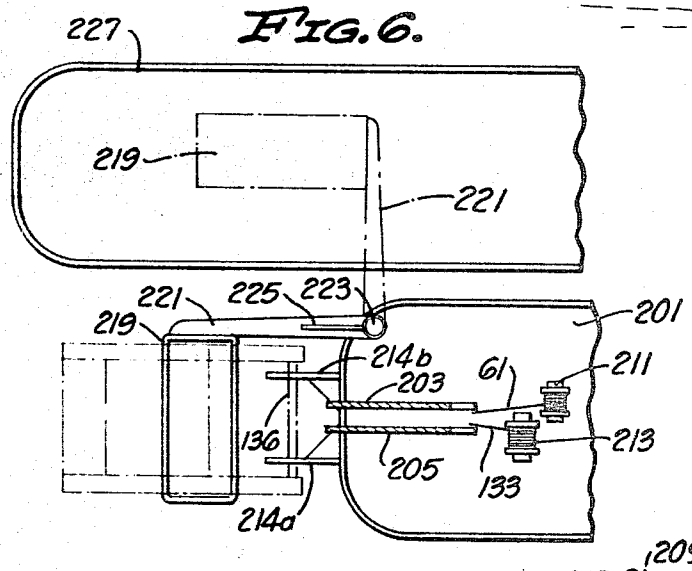
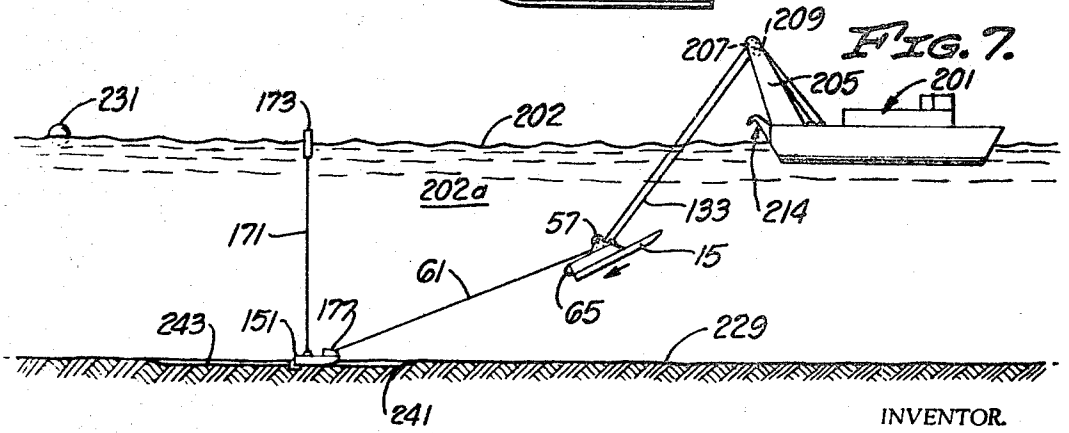


FIG. 7.



INVENTOR.

RICHARD VOGT

BY HIS ATTORNEYS

HARRIS, KIECH, RUSSELL & KERN

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FIG. 8.

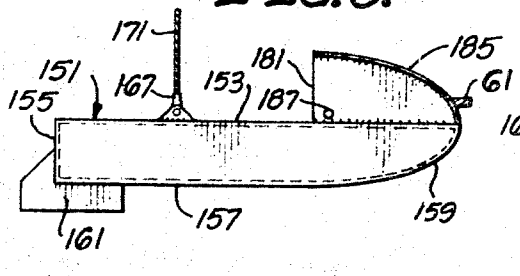


FIG. 9.

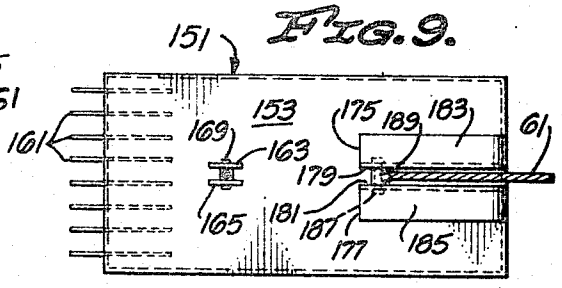


FIG. 10.

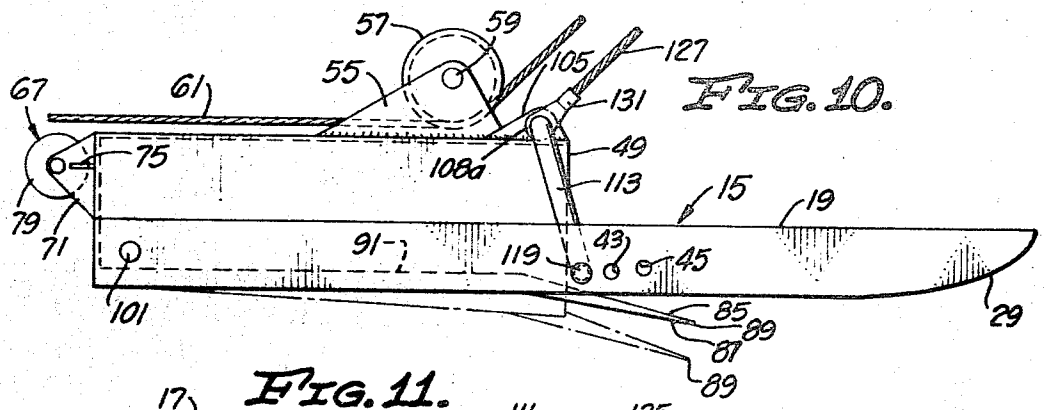
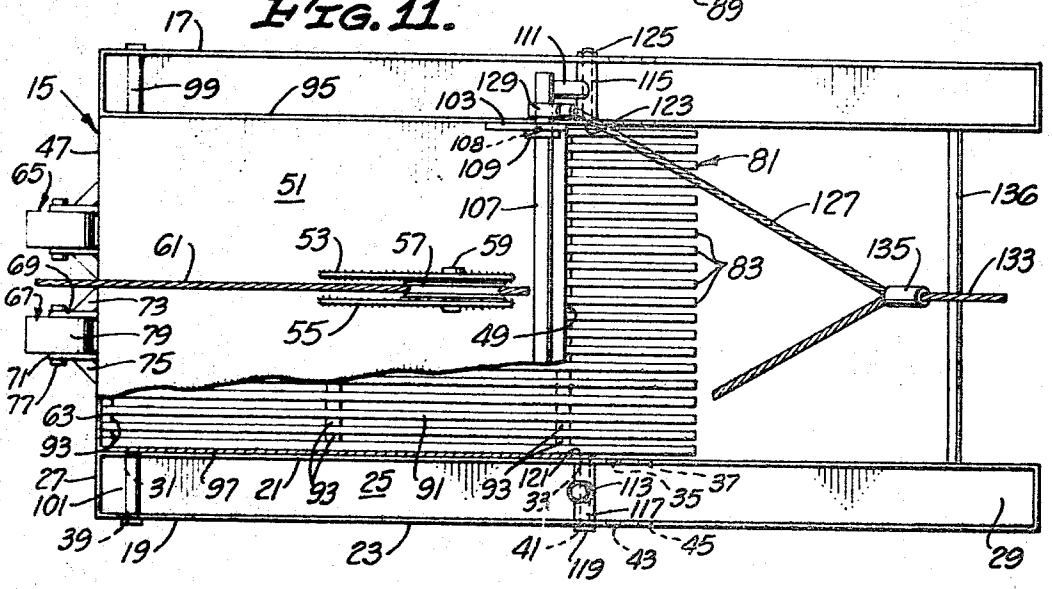


FIG. 11.



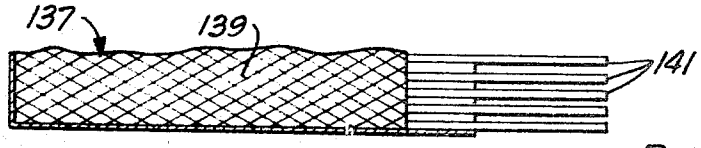


FIG. 12.

INVENTOR.
RICHARD VOGT
BY HIS ATTORNEYS
HARRIS, KIECH, RUSSELL & KERN

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OCEAN FLOOR MINING SYSTEM

Richard Vogt, Santa Barbara, Calif., assignor to Scientia Corporation, Santa Barbara, Calif., a corporation of California

Filed Nov. 23, 1964, Ser. No. 413,131
18 Claims. (Cl. 37—71)

ABSTRACT OF THE DISCLOSURE

An ocean floor mining system and method which includes a movable position-indicating anchor which is interconnected with a dredge vessel by a guide cable, and a novel dredge bucket which is guided along the guide cable and which is also interconnected with the dredge vessel by an operating cable. With the anchor in a first position, the operating cable can pull the dredge bucket along the ocean floor in engagement with the guide cable to a second position, and thence up to the vessel along the guide cable, where the bucket can engage abutment means and dump its contents. The anchor can be moved to the second position and the dredge bucket returned to the ocean floor along the guide cable until it contacts the anchor at the second position. The bucket can then be pulled to a third position and the cycle repeated.

This invention relates to an ocean floor mining system and an improved dredge bucket for use in such a system.

Extensive areas of the ocean floor in various parts of the world are covered with valuble deposits such as phosphorite nodules. On certain sections of the ocean floor, these deposits occur at depths of 400 to 1000 feet, which makes dredging economically feasible. These deposits could become a valuable source of ore for producing, for example, phosphate fertilizers and other phosphate chemicals if a recovery method can be found which is competitive with the cost of mining comparable quantities of materials from mines on land. Accordingly, there is a need for an ocean floor mining system which will economically gather these ocean floor deposits.

Conventional drag dredging systems usually include a bucket which is dragged along the floor of the ocean. Such a system is not suitable for mining the ocean floor because its horizontal movement cannot be accurately controlled, thereby giving rise to spotty dredging which is both wasteful and costly. Another difficulty with the conventional drag dredging system is that the dredging depth of the dredge bucket is uncontrollable. It is important that the dredging depth be adjustable because the thicknesses of the layers of nodules vary widely at different prospective mining fields and, accordingly, it is desirable to dredge at different depths in these different mining fields. Another problem with other prior art dredge buckets is that they frequently tend to dig in the ground and act like an anchor, or jump over the ocean floor under the spring-like action of the long dredging cable.

Accordingly, it is an object of this invention to provide an ocean floor mining system which will mine the floor of the ocean or other body of water at a low cost and generally overcome the problems of the prior art systems.

A further object of this invention is to provide a dredge bucket which will not dig into the ocean floor and act as an anchor, or jump over the ocean floor. According to another object of the invention, a dredge bucket is provided which will both pick up distributed nodules and slice off thick layers of densely packed material, this being accomplished by providing a dredge bucket with a pair of spaced elongated runners adapted to slide along the ocean floor and a receptacle having an open forward

end secured to the runners. Preferably, the runners extend a substantial distance beyond the open forward end of the receptacle. Blade means are secured to the receptacle adjacent the open forward end thereof for scraping and cutting material from the ocean floor as the runners slide therealong. Thus, as the dredge bucket is dragged along the ocean floor, the blade scrapes and cuts the material which is to be mined from the ocean floor and stores it temporarily in the receptacle.

Another object of this invention is to provide a dredge bucket which easily cuts the material to be mined and then sifts out sand and gravel which are below a predetermined size. This object of the invention may be accomplished by providing blade means which include a plurality of relatively narrow spaced, cutting elements. These cutting elements very effectively cut the deposits which are to be mined and allow sand and gravel to sift through the spaces between adjacent cutting elements. The sifting action of the dredge bucket may be further improved by extending the relatively narrow spaced cutting elements rearwardly so that they form the floor of the receptacle or by otherwise providing a perforated receptacle floor.

According to a further object of the invention, the dredge bucket is provided with means for varying the depth to which the blade scrapes and cuts. Such means may be provided by pivotally mounting the rear of the receptacle to the runners so that by pivoting of the receptacle the cutting edge at the forward end of the receptacle may be either raised or lowered.

Another object of this invention is to provide an ocean floor mining system in which the travel of the dredge bucket is accurately controlled. The ocean floor mining system of this invention includes, in addition to the dredge bucket, a sled anchor which is connected by a guide cable that passes beneath a pulley on the dredge bucket to a dredge vessel. An operating cable connects the dredge bucket to the dredge vessel. Initially, the dredge bucket is in front of the sled anchor. By moving the dredge vessel forward and simultaneously reeling out the guide cable, the sled anchor remains stationary while the dredge bucket is pulled along the ocean floor. When the dredge bucket is full, it is hoisted to the surface and the contents thereof are poured into an appropriate container. Then the guide cable is reeled in to pull the sled anchor forward to a new position and simultaneously the dredge bucket is released to roll down to the ocean floor on the guide cable to be positioned again in front of the sled anchor. By repeating this cycle many times, the mining of a large section of the ocean floor may be accurately controlled and spotty dredging is eliminated.

Still another object of the invention is to provide means for emptying the dredge bucket and transferring the contents directly to a barge, thereby eliminating interim storage in a dredging vessel. This is accomplished by providing a pivotally mounted transfer bucket and a suitable abutment on the dredging vessel. In hoisting the dredge bucket to the surface, the guide cable and the operating cable are operated so that the forward ends of the runners extend upwardly and a crossbar disposed between the forward ends of the runners ultimately engages the abutment. As hoisting of the bucket continues, it pivots about the point of engagement of the crossbar and the abutment until the contents of the bucket slide into the pivotally mounted transfer bucket which has been suitably positioned beneath the dredge bucket. The transfer bucket is then pivoted over a barge which may be alongside the dredging vessel and dumped.

Further objects and advantages will appear in the course of the following description.

In the drawings:

FIG. 1 is a diagrammatic representation of a section

of the ocean which has been suitably marked for mining by the ocean floor mining system of the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1, showing a dredging vessel, a dredge bucket, a sled anchor, and a marker in position to begin dredging;

FIG. 3 is a view similar to FIG. 2 showing the components of the ocean floor mining system shortly after the dredging cycle has begun;

FIG. 4 is a fragmentary view in elevation showing how the dredge bucket is hoisted toward the surface of the water and toward the dredging vessel;

FIG. 5 is a fragmentary elevational view of the dredging bucket as it dumps its contents into a transfer bucket;

FIG. 6 is a fragmentary plan view showing two positions of the transfer bucket;

FIG. 7 is an elevational view similar to FIGS. 2 and 3 showing the return of the dredge bucket to the ocean floor;

FIG. 8 is a side elevation of a sled anchor;

FIG. 9 is a plan view of the sled anchor;

FIG. 10 is a side elevation view of a dredge bucket employed in the ocean floor mining system;

FIG. 11 is a plan view of the dredge bucket with the top thereof partially broken away to show the floor of the dredge bucket; and

FIG. 12 is a fragmentary view partially in section showing another embodiment of the dredge bucket.

A dredge bucket **15**, which is the most important piece of equipment in a dredging operation is shown in FIGS. 10 and 11. The dredge bucket **15** includes a pair of elongated parallel runners **17** and **19**. The runner **19** is channel shaped and includes upwardly extending flanges **21** and **23** which are secured together by a web **25** and a back portion **27**. The runner **19** at its forward end has a curved portion **29** which curves upwardly to facilitate sliding of the runner along the ocean floor. A plurality of apertures **31**, **33**, **35** and **37** extends through the flange **21** and another group of apertures **39**, **41**, **43** and **45** extends through the flange **23**. Pairs of these apertures are aligned as shown in FIG. 11. The runner **17** is identical to the runner **19**. The runners **17** and **19** are preferably formed integrally of a suitable rust-resistant metal.

A receptacle **47** having an open forward end **49** is suitably positioned between the runners **17** and **19**. The receptacle **47** is preferably rectangular as shown and is formed of a suitable corrosion-resistant material. The receptacle **47** has a top **51** to which is secured, as by welding, a pair of parallel triangular plates **53** and **55**. A pulley **57** is rotatably mounted on a shaft **59** which is suitably supported by the plates **53** and **55**. The pulley **57** is adapted to be rotated by a guide cable **61** which engages the underside of the pulley.

The receptacle **47** has a rear wall **63** to which there is secured a pair of bumpers **65** and **67** which are located to engage a sled anchor which is subsequently described. The bumpers **65** and **67** are identical so only the bumper **67** will be described in detail. The bumper **67** includes a pair of identical triangular parallel plate members **69** and **71** which are suitably secured as by welding to the back wall **63**. A pair of braces **73** and **75** is secured to the back wall **63** and to the plate members **69** and **71**, respectively, to render the plate members more rigid. A shaft **77** which is suitably supported by the triangular plate members **69** and **71** has a roller **79** mounted for rotation thereon.

Attached to the forward end of the receptacle **47** at the bottom of the open forward end **49** is a blade **81**, which in the embodiment shown in FIG. 11 includes a plurality of relatively narrow spaced cutting members **83** extending outward from the open forward end. Each of the cutting members **83**, which is formed of a strong, rigid, corrosion-resistant material, has a top surface **85** and a bottom surface **87** which taper to form a cutting edge **89**. As shown in FIG. 11, the cutting members **83** extend rearwardly to form a floor **91** of the receptacle. The cutting members **83** are secured together at various positions by a plurality

of tabs **93** and are suitably rigidly secured to the back wall **63**.

The cutting members **83** are spaced as shown to allow small particles of sand, gravel, and other unwanted material to sift out of the receptacle during the dredging operation. It should be understood that the cutting members **83** need not form any or all of the floor **91** of the receptacle **47**; however, unless some provision for perforating the blade **81** or the floor **91** is made, the small particles of unwanted sand and gravel will not be suitably sifted from the receptacle.

Although the tabs **93** which serve to space the cutting members **83** are shown forming three lines along the cutting members, additional or fewer lines may be provided as desired. For example, it may prove desirable to position a line of the tabs **93** more closely adjacent to the cutting edge **89**. The tabs **93** may be secured to the adjacent cutting members **83** by welding. Alternatively, the tabs **93** may be washers which are mounted on an elongated bolt (not shown) which extends transversely through the floor **91** of the receptacle **47**.

The receptacle **47** is suitably secured to the runners **17** and **19** by means which allow adjusting of the depth to which the blade **81** cuts. The receptacle **47** has side walls **95** and **97**. The rear of the receptacle is pivotally secured to the runners **17** and **19** by a pair of rods **99** and **101** which are rigidly secured to, and extend outwardly from, the sides **95** and **97** respectively. The rod **101** extends through the aligned apertures **31** and **39** in the runner **19** and is free to rotate therein, and the rod **99** pivots in the corresponding apertures in the runner **17**. The rods **99** and **101** are preferably secured to their respective runners **17** and **19** by any suitable means such as a nut or pin (not shown).

The receptacle **47** is also secured to the runners **17** and **19** at its forward end. The top **51** of the receptacle **47** is provided with a pair of upwardly extending brackets **103** and **105** at the outer extremities of its forward end. A rod **107** extends through a pair of apertures **108** and **108***a* in the brackets **103** and **105**, respectively, the ends of the rod **107** extending slightly beyond the brackets. The rod **107** is free to rotate in the apertures **108** and **108***a* in the brackets **103** and **105**. The rod **107** is held in position by a collar **109** which is formed thereon adjacent the bracket **103** and a similar collar (not shown) which is similarly disposed adjacent the bracket **105**. A pair of links **111** and **113** are secured to the ends of the rod **107** and extend downwardly therefrom. A pair of bushings **115** and **117** are rigidly secured to the lower ends of the links **111** and **113**, respectively. A bolt **119** extends through the aperture **41**, the bushing **117** and the aperture **33** to rigidly secure the forward end **49** of the receptacle **47** to the runner **19**. A nut **121** holds the bolt in place. A bolt **123** and a nut **125** pass through the corresponding apertures in the runner **17** and the bushing **115** to firmly secure the forward end **49** of the receptacle **47** to the runner **17**. With the open forward end **49** secured to the runners **17** and **19**, the cutting edge **89** is positioned at a given distance beneath the bottom of the runners, i.e., at a given cutting depth. To lower the cutting edge **89** to the position shown in phantom in FIG. 10, the nuts **121** and **125** are removed from the bolts **119** and **123**, respectively, the bolt **119** is positioned through a succeeding pair of apertures such as the apertures **43** and **35**, and the bolt **123** is inserted in the corresponding apertures in the runner **17**. Thus, by using the various pairs of apertures provided in the runners **17** and **19**, the cutting edge **89** may be either raised or lowered. Of course, any number of pairs of apertures extending through the sides of the runners **17** and **19** may be provided, depending upon the amount of adjustment desired.

A suitable cable **127** is secured by a clamp **129** to one end of the rod **107** and to the other end of the rod by a similar clamp **131**. The cable **127** is preferably clamped to the rod **107** between the link **111** and the bracket **103**

and between the link 113 and the bracket 105. The cable 127 is preferably rather loose as shown in FIG. 11 and is connected to an operating cable 133 by a suitable coupling 135. The operating cable 133 serves to drag the dredge bucket 15 along the floor of the ocean.

The runners 17 and 19 preferably extend a substantial distance beyond the open forward end 49 of the receptacle 47 and beyond the cutting edge 89. A crossbar 136, which may be a tube, is secured to the forward ends of the runners 17 and 19 for a purpose which will be subsequently described. The receptacle 47 may be positioned with respect to the runners 17 and 19 so that the entire bottom surface thereof is in sliding contact with the ocean floor or it may be so positioned that only the blade 81 engages the ocean floor. The rear portions of the runners 17 and 19 may be perforated if desired to allow for drainage of water therefrom when the dredge bucket 15 is hoisted above the surface of the water.

FIG. 12 shows another embodiment of a dredge bucket 137. The dredge bucket 137 has a perforated floor 139 formed of wire mesh or perforated sheet metal. The dredge bucket 137 has a plurality of relatively narrow elongated spaced cutting members 141 which extend rearwardly to the perforated floor 139. In all other respects the dredge bucket 137 shown in FIG. 12 is exactly the same as the dredge bucket 15 shown in FIG. 11. The cutting members 141 are suitably secured to the floor 139 and to the other portions of the dredge bucket 137 as by welding or by a rod (not shown) extending through the cutting members and the sides of the dredge bucket. Of course, the tabs 93 may be employed with the cutting members 141 in the same manner as they were employed in connection with the cutting members 83. Thus, the embodiment of FIG. 12 illustrates an alternate manner of perforating the dredge bucket floor for allowing sand and gravel to sift therethrough.

The ocean floor mining system also includes a sled anchor 151 which is shown most clearly in FIGS. 8 and 9. The sled anchor 151 is a hollow welded steel box having a top wall 153, a rear wall 155, a bottom wall 157, and an upwardly curving portion 159 adjacent its front end. The sled anchor 151 must be sufficiently heavy to remain stationary when the dredge bucket 15 is being pulled along the ocean floor, and, accordingly, it is desirable to fill it with a heavy material such as concrete or gravel.

The sled anchor 151 includes a plurality of spaced parallel fins 161 rigidly secured as by welding to the rear wall 155 and the bottom wall 157. The fins 161 increase the friction between the sled anchor and the ocean floor and also stabilize the sled anchor while it is being dragged from one operating position to the next.

Secured to the top wall 153 near the center thereof is a pair of triangular brackets 163 and 165. A clamp 167 is secured at one end to a pin 169 which is mounted on the brackets 163 and 165 and at its other end to a marker cable 171. The marker cable 171 is connected to a marker 173 (FIGS. 2, 3, and 7) which floats at the surface of the water to indicate the position of the sled anchor 151.

A pair of spaced parallel guide plates 175 and 177 are secured to the top wall 153 of the sled anchor 151 at the forward end thereof. The guide plates 175 and 177 are curved so that their upper and forward peripheries form generally a quadrant of an ellipse. The guide plates 175 and 177 include vertical plates 179 and 181, respectively, and flanges 183 and 185, respectively, which are generally perpendicular to their respective vertical plates. A bolt 187 is suitably attached to the vertical plates 179 and 181 at lower rearward portions thereof. A clamp 189 is suitably secured to the bolt 187 between the vertical plates 179 and 181 and to the guide cable 61.

The flanges 183 and 185 of the guide plates 175 and 177 receive the downcoming bumpers 65 and 67 of the dredge bucket 15. Specifically, the roller 79 and the corresponding roller of the bumper 65 are guided to engage the flanges 183 and 185 and roll down these flanges into position in front of the sled, thereby accurately positioning the dredge bucket. The system for moving the dredge bucket so that its bumpers 65 and 67 will contact the guide plates 175 and 177 is subsequently described.

The width of the anchor sled 151 will depend somewhat upon the width of the dredge bucket 15. If a wide dredge bucket is employed, it is preferred that the anchor sled be sufficiently narrow so that it can run inside of the dredged strip. If a narrow dredge bucket is chosen, as for instance for a pilot operation, the sled should be sufficiently wide to straddle the dredged strip to provide adequate stability therefor.

The ocean floor mining system also includes a dredging vessel 201 (FIGS. 2, 3, and 7) which floats on a surface 202 of an ocean or other body of water 202*a*. The dredging vessel 201 has a pair of support members 203 and 205 (FIG. 6) which support a pair of pulleys 207 and 209 for the guide cable 61 and the operating cable 133, respectively. The guide cable 61 and the operating cable 133 pass over the pulleys 207 and 209 and connect to winches 211 and 213, respectively (FIG. 6). Although the pulleys 207 and 209 are shown diagrammatically as single pulleys, it should be understood that any suitable system of pulleys for obtaining any desired mechanical advantage may be employed.

An abutment 214 is secured at one end of the dredging vessel 201. The abutment 214 is essentially a pair of parallel downwardly opening hook members 214*a* and 214*b* each having a pair of sloping side walls 215 and 216 which converge upwardly to form a narrow end wall 217. The abutment 214 is adapted to be engaged by the crossbar 136 of the dredge bucket 15 as the latter is hoisted above the surface 202 of the ocean 202*a*. The side walls 215 and 216 slope so that the crossbar 136 can be guided to the end wall 217 thus compensating for slight positioning errors in hoisting the dredge bucket.

The dredging vessel 201 is also provided with a container or transfer bucket 219 for receiving the material from the dredge bucket 15 (FIGS. 5 and 6). An arm 221 suitably pivoted to a shaft 223 which is secured to the dredging vessel 201, pivotally supports the transfer bucket 219. The arm 221 may be provided with a suitable brace 225. As shown in FIG. 6, the transfer bucket 219 may be suitably positioned beneath the hoisted dredge bucket to receive the contents of the dredge bucket. After the contents of the dredge bucket 15 have been dumped into the transfer bucket 219, the transfer bucket may be pivoted by any suitable means (not shown) to the position shown in phantom in FIG. 6. In this position, the transfer bucket 219 is positioned over a storage means or barge 227. The contents of the transfer bucket 219 are then removed from the transfer bucket onto the barge 227 in any conventional manner such as by pivoting the transfer bucket to dump the contents thereof, or by providing a releasable trap door in the bottom of the transfer bucket.

Prior to using the ocean floor mining system, a suitable area of the ocean floor believed to contain deposits of material such as phosphorite is staked out. As shown in FIG. 1, an area 229 of the ocean floor is suitably marked by markers 231, 233, 235, and 237. These markers float on the surface of the water and are suitably anchored to define the boundaries of the area which is to be mined.

At the beginning of the dredging operation, the dredge bucket 15 and the sled anchor 151 are positioned in a first position as shown in FIG. 2 with the bumpers 65 and 67 of the dredge bucket contacting or closely adjacent the guide plates 175 and 177 of the sled anchor. The guide cable is connected at one end to the sled anchor 151 and passes beneath the pulley 57 of the dredge bucket 15 to the winch 211 on the dredging vessel 201. The operating cable 133 is connected at one end to the cable 127 on the dredge bucket 15 and at the other end to the winch 213 on the dredging vessel 201. With the winch 213 secured against rotational movement, the dredging

vessel 201 moves to the right in FIG. 2 thereby dragging the dredge bucket 15 along the ocean floor by means of the operating cable 133. Alternatively, the dredging vessel may be anchored and the winch 213 used to reel in the operating cable 133 to move the dredge bucket 15 along the ocean floor. Simultaneously with the moving of the dredge vessel 201, the winch 211 is allowed to reel out a sufficient length of the guide cable 61 to allow the sled anchor 151 to remain stationary at the first position shown in FIG. 2. As the dredge bucket 15 slides along the ocean floor, the cutting edge 89 cuts and scrapes material such as phosphorite nodules from the floor of the ocean. This material will slide rearwardly onto the floor 91 of the receptacle 47 and much of the smaller sand and gravel particles will sift through the spaces between the adjacent cutting members 83. When the receptacle 47 is full, the dredge bucket 15 will have reached a second position shown in FIG. 3. The second position is defined by an area of ocean floor closely adjacent an end 241 of a cut 243 made by the dredge bucket 15. The length of the guide cable 61 which has been reeled out will correspond to the distance between the first position shown in FIG. 2 and the second position.

The operating cable 133 is then reeled in by the winch 213 to raise the dredge bucket 15 toward the surface 202 of the water as shown in FIG. 4. Prior to raising the dredge bucket 15 from the ocean floor, it will be necessary to reel in some of the guide cable 61 to break the dredge bucket loose from the ocean floor. Because most of the weight of the dredge bucket 15 including the contents in the receptacle 47 is disposed rearwardly of the clamps 129 and 131 which secure the cable 127 and the operating cable 133 to the dredge bucket, the dredge bucket tends to rise toward the surface of the water in a generally vertical position as shown in FIG. 4. Because the guide cable 61 engages the pulley 57 rearwardly of the clamps 129 and 131, the bucket 15 could be maintained in a position which is more nearly horizontal if the guide cable were maintained in a taut position. However, the guide cable 61 is maintained sufficiently loose to allow the dredge bucket 15 to assume the position shown in FIG. 4.

As the dredge bucket 15 is lifted out of the water the crossbar 136 ultimately contacts at least one of the sloping side walls 215 and 216 of the abutment 214. The sloping side walls 215 and 216 guide the crossbar 136 to the end wall 217 of the abutment 214. When the crossbar 136 reaches the end wall 217 its upward movement is halted by the end wall 217. As the operating cable 133 is reeled in further, the dredge bucket 15 pivots about the point of engagement of the crossbar 136 and the end wall 217 as shown in FIG. 5. Prior to this time the transfer bucket 219 has been pivoted to a position bereath the dredge bucket 15 as shown in FIGS. 5 and 6. When the dredge bucket 15 reaches the appropriate angle with respect to the horizontal, the contents thereof will slide out of the open forward end 49 into the transfer bucket 219. It should be understood that during the movement of the dredge bucket 15 the guide cable 61 has also served to stabilize same. When the receptacle 47 of the dredge bucket 15 is empty, the transfer bucket 219 is pivoted over the barge 227 and the contents thereof are removed preferably by dumping.

The guide cable 61 is then reeled in on the winch 211 to move the sled from the first position shown in FIG. 2 to the second position near the end 241 of the cut 243, FIG. 7. Because the amount of the guide cable 61 reeled out in moving the dredge bucket 15 from the first position shown in FIG. 2 to the second position is known, the sled anchor 151 may be pulled forwardly a corresponding distance to thereby precisely mark the second position. With the sled anchor 151 positioned as shown in FIG. 7 to mark the second position, the operating cable 133 is reeled out to allow the dredge bucket 15 to roll down the guide cable 61 on the pulley 57. In returning dredge bucket 15 to the ocean floor, the guide cable 61 is preferably operated so that the dredge bucket assumes the generally horizontal position shown in FIG. 7. The dredge bucket 15 continues its movement along the guide cable 61 until the bumpers 65 and 67 contact the guide plates 175 and 177. The roller 79 of the bumper 67 contacts the flange 185 of the guide plate 177 and the corresponding roller of the bumper 65 contacts the flange 183 of the guide plate 175. Thus the dredge bucket 15 by means of its rollers rolls down the flanges 183 and 185 of the sled anchor 151 to accurately position the dredge bucket at the second position. The mining operation is then continued by moving the dredge bucket 15 toward a third postion to dredge additional material from the floor of the ocean. This cycle is repeated many times until the entire area 229 of ocean floor has been mined.

It should be understood that the steps of sliding the dredge bucket down the guide cable from the dredging vessel 201 back to the second position and the step of reeling the guide cable to move the sled anchor adjacent the second position may be accomplished simultaneously. Although the mining system has been described in connection with the ocean it should be understood that it may be used to mine the floor of any suitable body of water.

Thus it is evident that the ocean floor mining system of the present invention accurately controls the mining operation by returning the dredge bucket to an accurately controlled point. It is also apparent that the dredge bucket of the present invention possesses many advantages including the capability of sifting sand and gravel particles from the material to be mined and an adjustable cutting depth. Likewise, the transfer of the contents of the dredge bucket to a barge may be quickly and easily accomplished.

In the light of the above teachings, many changes and modifications may be made by those having ordinary skill in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A system for mining the floor of a body of water comprising:
   - a dredge bucket for gathering material from the floor of said body of water including a receptacle with a forward open end, a crossbar extending transversely of said receptacle, and cable attachment means on said bucket rearwardly of the crossbar;
   - cable means connected to said attachment means for raising said bucket out of said body of water;
   - abutment means adjacent the surface of said body of water for providing an abutment for engagement by said crossbar as the bucket is raised out of the body of water; and
   - transfer bucket means adjacent said abutment for receiving the material from said dredge bucket whereby as said cable means raises said dredge bucket said crossbar engages said abutment to pivot said dredge bucket to dump the material therein into said transfer bucket means.

2. A system as defined in claim 1 wherein said abutment means has sloping side walls which converge upwardly to form a narrow end wall.

3. A system as defined in claim 1 further comprising:
   - storage means adjacent said abutment means;
   - means for moving said transfer bucket means over said storage means; and
   - means for moving the material in said transfer bucket means onto said storage means.

4. A system for mining the floor of a body of water comprising:
   - a dredge bucket for gathering material from the floor of said body of water including a receptacle having an open forward end, said dredge bucket having a crossbar forward of said open forward end;
   - a dredge vessel;
   - cable means secured to said dredge vessel and to said receptacle adjacent the open forward end thereof for raising said bucket out of said body of water with

said open forward end pointing generally upwardly;
an abutment secured to said vessel and normally disposed above said crossbar for engagement by said crossbar; and
transfer bucket means secured to said dredge vessel adjacent said abutment for receiving material from said dredge bucket whereby as said cable means raises said dredge bucket said crossbar engages said abutment to pivot said dredge bucket to dump the material therein into said transfer bucket means.

5. A dredging system for use in mining the floor of a body of water comprising:
an anchor on the floor of said body of water;
a dredge bucket on the floor of said body of water;
a dredge vessel on the surface of said body of water;
guide cable means attached to said anchor and said vessel;
means for movingly securing said guide cable means to said dredge bucket;
operating cable means secured to said dredge bucket and said dredge vessel;
means to propel said vessel to pull said dredge bucket along said floor of said body of water to gather material therefrom; and
means to increase the length of said guide cable means between said vessel and said anchor so that said anchor remains fixed while said vessel is being propelled.

6. In a method of mining the floor of a body of water employing a dredge vessel connected to an anchor by a guide cable, the steps of:
positioning said anchor on the floor of said body of water;
moving a dredge bucket along said guide cable from a position adjacent said dredge vessel toward said anchor until said dredge bucket engages said anchor to thereby accurately position said dredge bucket closely adjacent said anchor; and
moving said dredge bucket along the floor of said body of water to dredge material therefrom.

7. A method of mining the floor of a body of water comprising:
moving a dredge bucket along said floor from a first position to a second position to gather material therefrom;
raising said dredge bucket above the surface of said body of water;
removing the material from said dredge bucket;
positioning an anchor to mark said second position;
accurately returning said dredge bucket to said second position; and
moving said dredge bucket along said floor from said second position to a third position to gather additional material from said floor.

8. A method of mining the floor of a body of water comprising:
positioning an anchor on the floor of said body of water;
positioning of a dredge bucket closely adjacent said anchor;
moving said dredge bucket along said floor from a first position to a second position to gather material therefrom;
raising said dredge bucket above the surface of said body of water;
removing the material from said dredge bucket;
moving said anchor to said second position to mark said second position;
lowering said dredge bucket into the water toward said second position until it contacts the anchor; and
moving said dredge bucket along said floor from said second position to a third position to gather additional material from said floor.

9. In a method of mining the floor of a body of water employing a dredging vessel having first and second winches thereon connected to a guide cable and an operating cable respectively, the steps of:
connecting an anchor on the floor of said body of water to said first winch on said dredging vessel with said guide cable;
connecting a dredge bucket to said second winch on said dredging vessel with said operating cable;
securing said guide cable to said dredge bucket to allow relative movement therebetween;
moving said dredge bucket down said guide cable until it abuts said anchor at the floor of said body of water to define a first position;
simultaneously moving said dredge vessel and reeling out a given length of said guide cable so that said anchor remains stationary and said dredge bucket moves along said floor from said first position to a second position to gather material from said floor;
reeling in said operating cable to raise said dredge bucket above the surface of said body of water;
removing the material from said dredge bucket;
reeling in said given length of guide cable to move said anchor adjacent said second position;
moving said dredge bucket down said guide cable until it abuts said anchor at said second position, whereby said dredge bucket is accurately positioned at said second position; and
moving said dredge bucket along said floor from said second position to a third position to gather additional material.

10. A method as defined in claim 9 wherein the steps of reeling in said given length of guide cable and moving said dredge bucket down said guide cable are performed simultaneously.

11. A dredging system for use in mining the floor of a body of water comprising:
movable anchor means with position-indicating means on the floor of said body of water;
a dredge vessel on the surface of said body of water;
a dredge bucket intermediate the dredge vessel and the anchor means for dredging material from the floor;
guide cable means extending between the vessel and the anchor means for moving said anchor means along the floor of said body of water;
means on the dredge bucket for movable engagement with the guide cable means for movement of the dredge bucket along said guide cable means between the anchor means and the vessel; and
operating cable means between the dredge bucket and the vessel for moving said bucket along the floor of the body of water and up through the body of water to the vessel.

12. A dredging system as defined in claim 11 further comprising means on the dredge vessel for independently reeling in and paying out the guide cable means and the operating cable means, respectively.

13. A dredging system as defined in claim 11 further comprising abutment means on the vessel for engagement with the dredge bucket to upend the latter for dumping purposes.

14. A dredging system as defined in claim 11 further comprising:
abutment means on the vessel for engagement with the dredge bucket to upend the latter for dumping purposes;
storage means adjacent said abutment means; and
transfer bucket means movable between the storage means and a position adjacent the abutment means for receiving dredged material from the upended dredge bucket and conveying it to the storage means.

15. Sled anchor for use with a dredge vessel in an ocean floor mining system comprising:
a runner having forward and rearward ends adapted to slide along the ocean floor;
means on the anchor for connecting thereto one end of

a marker cable which has a marker buoy at the other end thereof;

means adjacent the forward end of the runner for connecting thereto one end of a guide cable; and

a pair of spaced-apart upwardly extending guide members adjacent the forward end of the runner, the upper surfaces of the guide members curving forwardly and downwardly toward the front end of the runner, the guide members being positioned to receive the guide cable therebetween.

16. A sled anchor as defined in claim **15** further comprising spaced-apart fin means extending downwardly from the runner adjacent the rearward end thereof for stabilizing the movement of the anchor as it slides along the ocean floor.

17. A dredge bucket for use with a dredge vessel in an ocean floor mining system comprising:

at least two spaced-apart runners for sliding along the ocean floor;

a receptacle secured to said runners and having an opening adjacent the forward end thereof with blade means for scraping material from the ocean floor as the runners slide therealong, the opening and blade means being positioned rearwardly of the forward ends of the runners;

a crossbar extending transversely of the runners forwardly of said opening and blade means;

operating cable means connected to the bucket rearwardly of the crossbar and extending forwardly above the crossbar for moving the dredge bucket along the ocean floor and for raising it from the ocean floor to the dredge vessel, said cable means being connected

relative to the center of gravity of the bucket such that the runners will be tilted upwardly as the bucket is raised toward the dredge vessel; and

a pulley mounted on the top of the dredge bucket adjacent the center thereof and rearwardly of the operating cable for receiving a guide cable along which the bucket can be moved, the guide cable to extend forwardly and rearwardly of the bucket.

18. A dredge bucket as defined in claim **17** further comprising a pair of spaced-apart roller bumpers extending rearwardly of the bucket, said roller bumpers being spaced relatively close together and positioned to receive the rearwardly extending portion of the guide cable therebetween.

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ABRAHAM G. STONE, *Primary Examiner.*

R. L. HOLLISTER, *Assistant Examiner.*