

Feb. 28, 1967

I. L. HIRSHMAN ETAL

3,305,950

UNDERWATER MINING

Filed April 14, 1964

4 Sheets-Sheet 1

FIG. 1

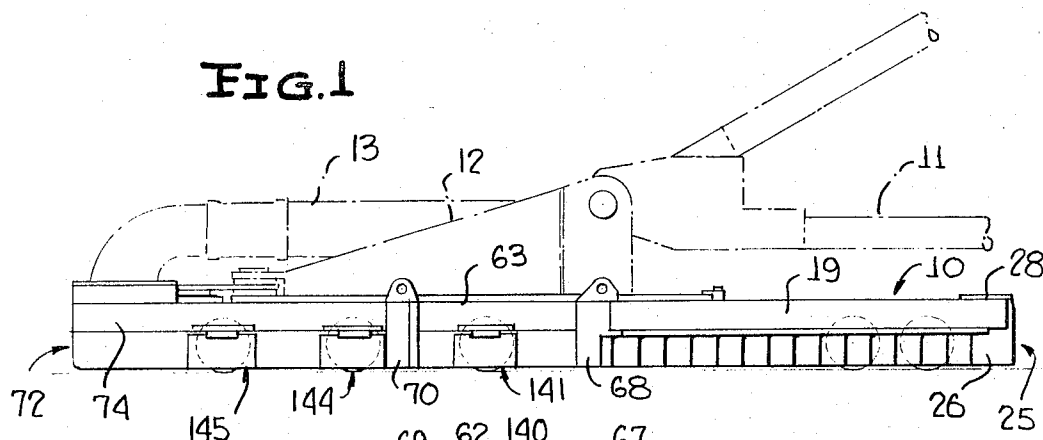
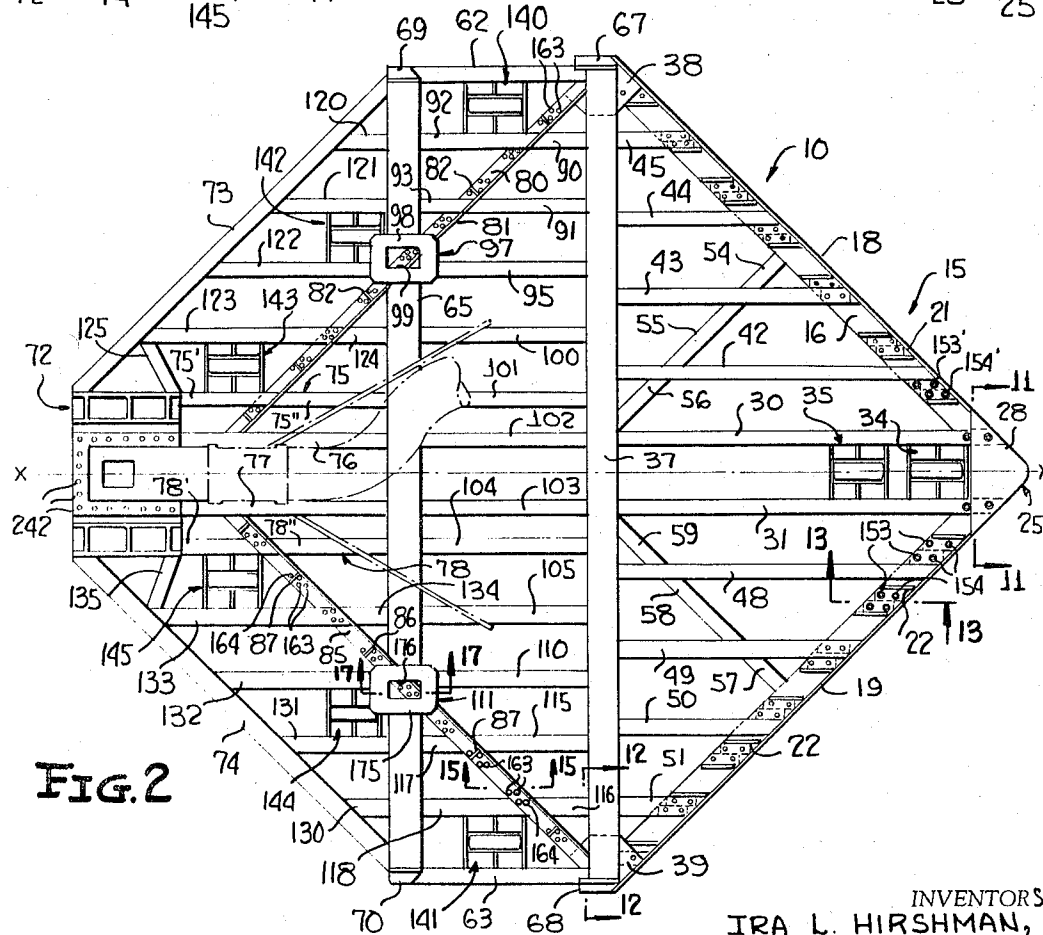


FIG. 2



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FIG. 3

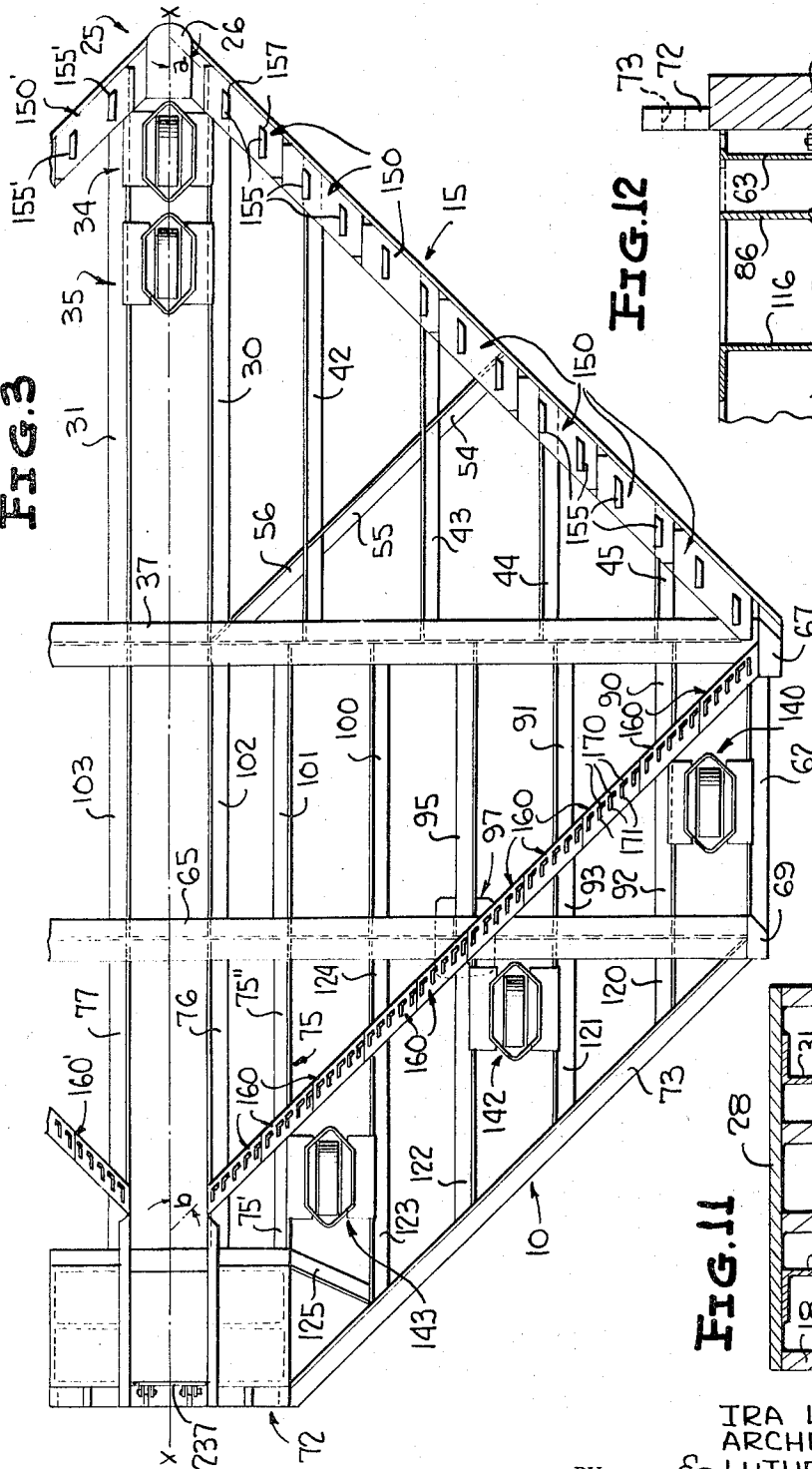


FIG. 12

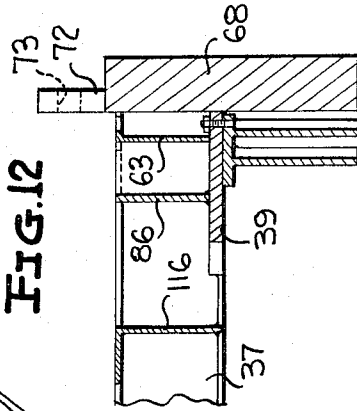
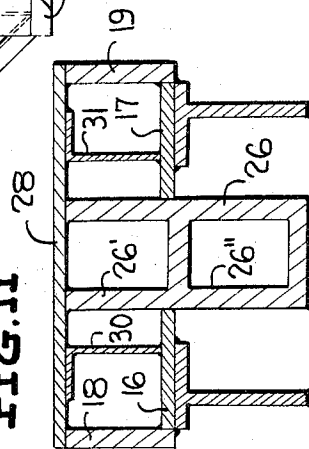


FIG. 11



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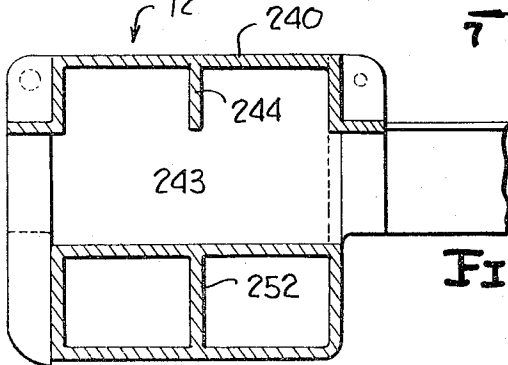
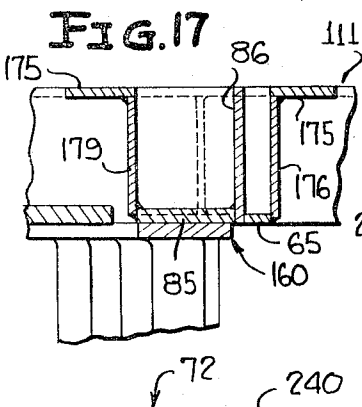
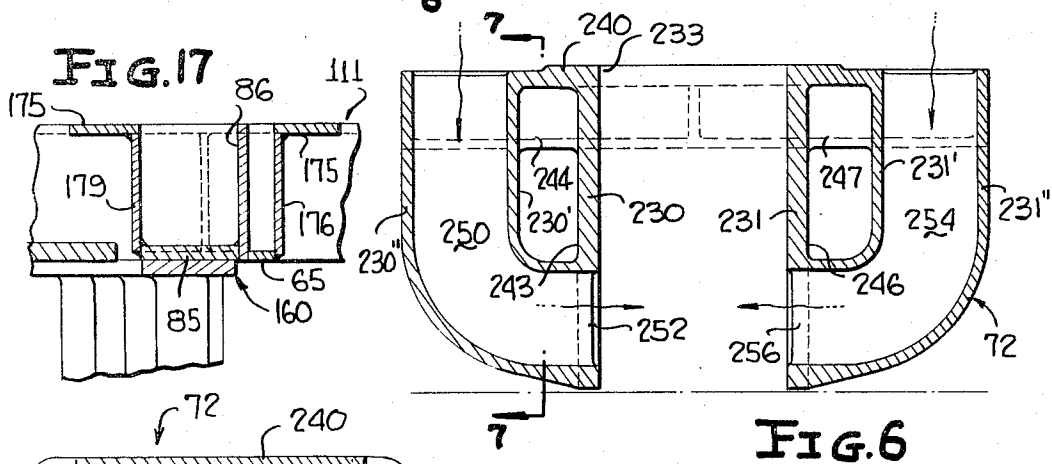
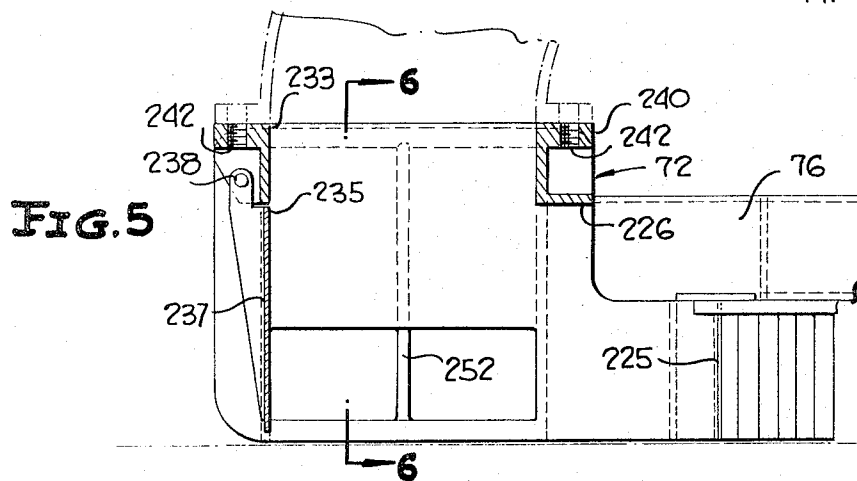
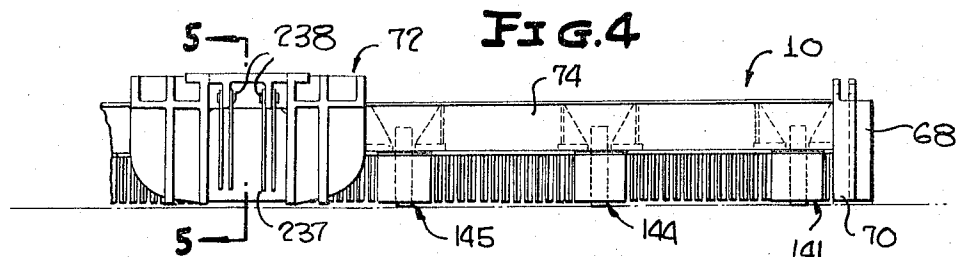
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FIG. 8

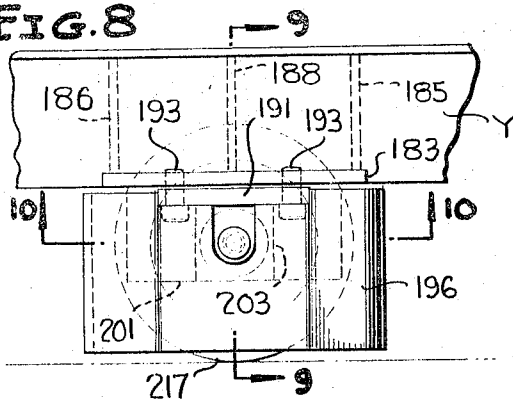


FIG. 9

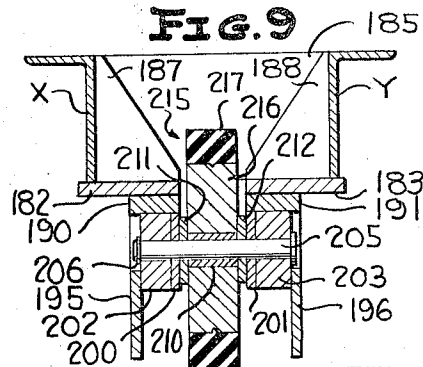


FIG. 10

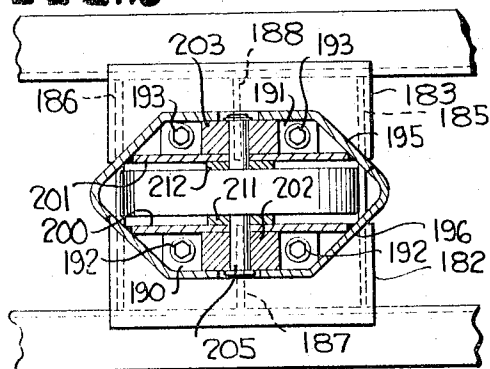


FIG. 13

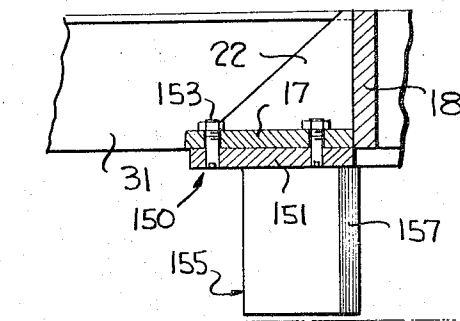


FIG. 15

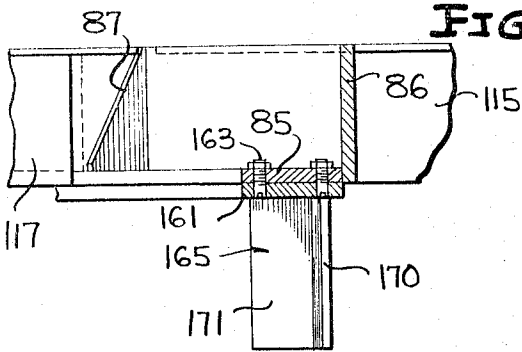


FIG. 14

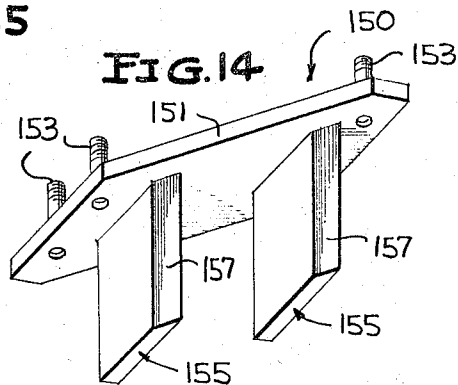
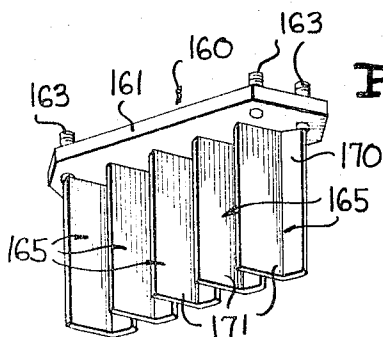


FIG. 16



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18 Claims. (Cl. 37—58)

The present invention relates to underwater mining, and more particularly to mining operations which are carried out at great depths beneath the surface of the water. The underwater mining operations contemplated in the present invention are particularly concerned with the mining and recovering of solid substances from the floors and subfloor regions of the sea.

The apparatus as illustrated in detail in the present application is also generally illustrated and described in co-pending U.S. Patent application Serial No. 332,999 wherein the specific structure as illustrated in the instant application is shown in combination with other components employed in an over-all underwater mining operation.

While the apparatus of the present invention may be utilized in other applications, it is especially adapted for use in underwater mining operations for recovering materials such as manganese nodules or other solid materials which generally are present at depths from about 400 feet to 12,000 feet or more beneath the surface of the sea.

This type of mining operation is carried out from a ship which moves along the surface of the sea with a hollow conduit means or pipe means suspended therefrom in a generally vertical direction and having a collecting means at the lower end thereof for sweeping or traversing a particular area of the sea bottom and collecting the desired material. This material is then suitably raised to the ship as by the utilization of pumping means which produces movement of a stream of liquid from the collecting means to the ship of sufficient velocity to entrain the solid material and carry the solid material to the ship.

The present invention is particularly directed to the collecting means at the lower end of the conduit means in an underwater mining operation as discussed above. The solid substance which the present invention is especially suited to collect comprises manganese nodules which are solid generally spherical bodies normally ranging in size from small ones about the size of a toy marble to large ones the size of basketballs or even larger. As a practical matter, it is considered that mining of nodules from about three quarters of an inch in diameter to about 6 inches in diameter is the most economical and efficient arrangement, and accordingly, the collecting means of the present invention is provided with separating means for eliminating or rejecting any solid bodies which do not fall within the desired size range.

Manganese nodules are usually found in areas where the sea bottom is relatively smooth and flat, since these bottom conditions are most conducive to formation of such nodules. It is accordingly necessary to provide a collecting means including means for supporting the collecting means for ready movement along the sea bottom with a minimum amount of drag and which at the same time will ensure that the collecting means will contact and collect all of the desired nodules in its path as the apparatus sweeps through a given area. In the present invention, the support means takes the form of heavy-duty wheels which are rotatably mounted on the body means of the collecting means and which are adapted to roll along the sea bottom. It is apparent that other means may be provided for supporting the body means of the present invention, although the heavy-duty wheels are

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considered the most practicable and suitable for the purposes of the present invention.

The body means of the present invention in order to provide maximum rigidity and yet at the same time minimize weight is formed as an open framework comprised of rigid elongated members which are interconnected with one another. The body means is provided with a throat portion, this throat portion having a first collecting opening formed therein for receiving all of the collected solid bodies within the desired size range. The throat portion also includes a relief opening which is substantially aligned with the collecting opening and which is normally closed by a movable means, this movable means being movable into an open position so as to permit discharge of collected solid bodies through the relief opening when the throat portion may for one reason or another become overloaded or jammed with solid bodies. This prevents permanent jamming and interruption of movement of the solid bodies from the collecting means and through the throat portion.

The throat portion is additionally provided with a discharge opening which is operatively interconnected with the lower end of the conduit means through which the collected solid bodies are transported to the ship traveling along the surface of the sea.

The body means is also provided with passage means formed therethrough, this passage means having opposite open end portions, and a pair of passages being preferably provided and opening at one open end thereof on opposite sides of the throat portion. The opposite open ends of each of the passages are open to the surrounding water, the arrangement being such that when the apparatus is in operation, the flow of water caused by the pumping means or the like through the discharge opening and upwardly through the conduit means will serve to additionally entrain fresh water through the passage means and into the side portions of the throat portion. This entrainment of fresh water into the side portions of the throat portion is of a sufficient quantity such that about half of the total volume of water sucked up through the discharge opening of the throat portion will comprise fresh water entrained through said passages.

This entrainment of fresh water, or in other words, clean, sand-free water into the side portions of the throat portion serves a dual purpose. Firstly, it helps to move nodules away from the side portions of the throat portion thereby preventing an excessive buildup of nodules along the side areas of the throat portion. This assures that the distribution of nodules will be substantially uniform within the throat portion and prevents an excessive buildup in any one location. Additionally, the entrainment of fresh water in a lateral direction into the throat portion of the collecting means substantially reduces the amount of sand which will be sucked up from the sea bottom immediately adjacent the throat portion. This is, of course, a desirable feature since it is only desired to suck up the nodules collected within the throat portion of the apparatus, and it is desirable to bring up as little sand from the sea bottom as possible.

The means for eliminating solid bodies which are too large and too small takes the form of first and second separating means, the first separating means being disposed adjacent the forward portion of the body means, while the second separating means is positioned rearwardly of and spaced from the first separating means. Each of these separating means takes the form of laterally spaced tooth members the leading edges of which are disposed in a particular angle with respect to the longitudinal axis of the body means as hereinafter described.

It is apparent that the separating tooth members of

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the present invention will be subjected to severe wear conditions in use since they are continuously contacting the relatively hard solid bodies as the body means of the present invention is moved along the sea bottom. The tooth members are preferably formed of a wear resistant material such as a high nickel steel and the like, and the tooth members are particularly formed such that they may be quickly and easily removed and replaced as required due to the wear and tear occurring thereto. In order to provide this quick and easy replacement feature, the tooth members of the present invention are formed in small units including an integral casting wherein two or more tooth members may be formed on a single casting, these castings being readily removable and replaceable as required.

Another feature of the present invention is the particular construction and configuration of the tooth members of the second separating means of the present invention. These tooth members are specifically designed to permit solid bodies which are too small to pass therebetween and to be eliminated from the collecting means while larger bodies which have been admitted to the collecting means by the first separating means are caused to then be moved to the throat portion of the apparatus. The tooth members of the second separating means are accordingly provided with a relatively narrow spacing between the leading edge portions thereof while the portions of these tooth members extending rearwardly of the leading edge portions are spaced apart a substantially wider distance than the leading edge portions. This provides an expansion area between the tooth members immediately rearwardly of the leading edge portions thereof so that the smaller solid bodies passing between the leading edge portions of these tooth members will not become jammed in this relatively small space, but will move freely to the rear of these tooth members as the body means progresses in its normal path of movement, the expansion area preventing jamming of the smaller solid bodies between the tooth members of the second separating means.

An additional feature of the present invention is the provision of a novel protective bumper means disposed at the forward central portion of the body means, this protective bumper means serving to prevent excessive damage to the body means should it encounter any sort of solid debris at the sea bottom such as an old ship wreck and the like. This bumper means mounted at the forward central portion of the body means not only serves as a protective device against physical damage but also serves somewhat as a plow member in conjunction with a pair of supporting wheels disposed immediately rearwardly thereof, this plow arrangement serving to plow out the sand along the center line of the body means as it moves along the sea bottom thereby diminishing the amount of loose sand which will be present adjacent the throat area of the body means.

An object of the present invention is to provide new and novel collecting means which is especially adapted for use in underwater mining operations for collecting solid bodies or masses of material.

Another object of the invention is the provision of collecting means including support means whereby the collecting means is readily movable along the bottom of the sea and including a heavy-duty wheel construction for this purpose.

A further object of the invention is to provide collecting means including separating means for ensuring that solid bodies are collected only within certain size limits, the solid bodies which are too large or too small being automatically rejected by the apparatus.

Still another object of the invention is the provision of collecting means including means for directing all of the collected solid bodies to a single throat portion from where the bodies are raised to a ship and the like, and including means at the throat portion for entraining fresh

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surrounding water to prevent accumulation of the solid bodies at the side portions of the throat portion and to cause less sand from the sea bottom to be sucked up and entrained along with the solid bodies.

A still further object of the invention is to provide collecting means wherein said throat portion includes movable relief means at the throat portion to prevent jamming of solid bodies within the throat portion.

A still further object of the invention is the provision of collecting means including separating teeth which can be quickly and easily removed and replaced as required.

Still another object of the invention is to provide collecting means wherein the second separating means for eliminating bodies which are too small includes a special tooth construction which prevents jamming of the smaller bodies between the tooth portions.

Yet another object of the invention is the provision of collecting means including a novel front end construction which provides a reinforced bumper means to prevent damage to the body means of the apparatus and which also cooperates with certain support portions of the apparatus to plow out loose sand of the sea bottom along the center line of the apparatus to diminish the amount of loose sand adjacent the throat area.

A still further object of the invention is to provide collecting means which is quite simple and inexpensive in construction and yet which is sturdy and reliable in operation.

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

FIG. 1 is a side view of the collecting means of the present invention illustrating in phantom lines the manner in which the collecting means may be attached to the conduit means and suitable apparatus for towing the collecting means;

FIG. 2 is a top view of the collecting means of the present invention which also shows in phantom lines a portion of the conduit means connected with the collecting means;

FIG. 3 is a bottom view of a portion of the structure shown in FIGS. 1 and 2;

FIG. 4 is a rear view of the structure shown in FIG. 2 partly broken away;

FIG. 5 is a sectional view taken substantially along line 5—5 of FIG. 4 looking in the direction of the arrows;

FIG. 6 is a sectional view taken substantially along line 6—6 of FIG. 5 looking in the direction of the arrows;

FIG. 7 is a sectional view taken substantially along line 7—7 of FIG. 6 looking in the direction of the arrows;

FIG. 8 is a side view of one of the rotatable support wheel assemblies of the present invention;

FIG. 9 is a sectional view taken substantially along line 9—9 of FIG. 8 looking in the direction of the arrows;

FIG. 10 is a sectional view taken substantially along line 10—10 of FIG. 8 looking in the direction of the arrows;

FIG. 11 is a sectional view taken along line 11—11 of FIG. 2 looking in the direction of the arrows;

FIG. 12 is a sectional view taken substantially along line 12—12 of FIG. 2 looking in the direction of the arrows;

FIG. 13 is a sectional view taken substantially along line 13—13 of FIG. 2 looking in the direction of the arrows;

FIG. 14 is a bottom perspective view of a casting including a plurality of separating tooth portions of the first separating means of the apparatus;

FIG. 15 is a sectional view taken substantially along line 15—15 of FIG. 2 looking in the direction of the arrows;

FIG. 16 is a bottom perspective view of a casting including a plurality of tooth portions of the second separating means of the apparatus; and

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FIG. 17 is a sectional view taken substantially along line 17—17 of FIG. 2 looking in the direction of the arrows.

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, the body means of the present invention is indicated generally by reference numeral 10, and as seen particularly in FIG. 1, a suitable truss portion indicated by phantom line 11 is provided for towing the body means along the sea bottom, this truss means being interconnected with the body means by a suitable hinge connection indicated by phantom lines 12, a conduit means indicated by phantom line 13 being interconnected with the throat portion of the body means hereinafter described. Members 11, 12 and 13 form no part of the present invention and have been illustrated for the purpose of illustrating the general arrangement of the components and the manner in which the body means of the present invention is adapted to be interconnected with the other components of the mining apparatus.

The body means of the present invention is composed of a plurality of rigid interconnected members so disposed as to provide an open framework of maximum strength and at the same time being of relatively light weight construction. The body means includes a forward end portion 15, this forward end portion including a pair of elongated substantially horizontally disposed members 16 and 17 elongated substantially vertically extending members 17 and 18 being rigidly affixed to the forward portions of members 16 and 17 respectively as by welding or the like and extending vertically upwardly therefrom. Gusset plate reinforcing members 21 are provided at spaced intervals between members 16 and 18 and are rigidly affixed thereto, and the corresponding members 22 are rigidly affixed between members 17 and 19 to reinforce the structure.

A protective bumper means is provided at the central forward portion of the body means and is indicated generally by reference numeral 25, this bumper means including as seen particularly in FIG. 11 a large casting 26 having a pair of cavities 26' and 26'' formed therein as seen in the drawings to provide a light weight construction. In actual practice, this casting may be on the order of 18 inches in height with the over-all front portion of the body means being approximately 19½ inches in height, the over-all body means having a width of approximately 18½ feet and an over-all length of approximately 21 feet. A top plate 28 is secured to the upper portion of casting 26 as by welding and the like and is also fixedly secured in a similar manner to members 18 and 19 previously described.

The forwardmost end portions of members 16, 17, 18 and 19 are all welded or similarly fixed to the side edges of the casting 26 so as to provide a rigid protective bumper means at the forward end of the body means. As seen in FIG. 11, a pair of channel members also extend forwardly and are secured to the bumper assembly, these channel members 30 and 31 extending rearwardly as seen in FIGS. 2 and 3 to support therebetween a pair of support means or rotatably mounted wheel assemblies which will be hereinafter described in detail.

Channel members 30 and 31 are connected at their rearward ends to an H-beam 37 which extends laterally of the body means and is secured at its opposite ends to the rearmost ends of members 16 and 18 through the intermediary of a horizontal plate 38, and to the rearmost ends of members 17 and 19 by a horizontal plate 39. A plurality of substantially parallel longitudinally extending channel members 42, 43, 44 and 45 are disposed in spaced relationship with one another and parallel with channel member 30, each of members 42 through 45 inclusive having the forward ends thereof secured to members 16 and 18 while the rearward ends thereof are fixed to the H-beam 37. A plurality of parallel longitudinally extending channel members 48, 49, 50 and 51 are provided parallel with

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channel member 31, each of members 48 through 51 inclusive having the forward ends thereof fixed to members 17 and 19, while the rearward ends thereof are fixed to H-beam 37. Cross brace members 54, 55, 56, 57, 58 and 59 are provided as illustrated for bracing and reinforcing the structure of the forward portion of the body means.

A pair of opposite lateral channel members 62 and 63 extend longitudinally rearwardly from the opposite ends of the H-beam 37, these members being connected with the opposite ends of an H-beam 65 which extends laterally across the body means in parallel relationship with the H-beam 37. A pair of lifting members 67 and 68 are fixed to the body structure at the opposite ends of H-beam 37, and a second pair of lifting members 69 and 70 are fixed to opposite sides of the body structure at opposite ends of the H-beam 65. These lifting members comprise heavy rigid members having eyes or holes formed in the upper reduced portions thereof for receiving lifting hooks and the like whereby the body means may be readily handled with the use of a crane or similar structure. For example, as seen in FIG. 12, lifting member 68 includes a reduced upper portion 72 having a hole 73 formed there-through. It will be understood that the remaining lifting members are of similar construction.

A throat portion casting is indicated generally by reference numeral 72, this casting being connected with one end of elongated channel members 73 and 74 the opposite ends of which are connected with the opposite outer ends of the H-beam 65. A plurality of parallel longitudinally extending channel members 75, 76, 77 and 78 have the rearward ends thereof connected with the forward portion of the throat portion casting, the opposite forward ends of these channel members being connected with the H-beam 65.

An elongated member 80 disposed substantially parallel with member 73 has one end portion thereof connected with the outer end of H-beam 37 and plate 38, the opposite end of member 80 being connected with channel member 76. A substantially vertically extending member 81 is secured to the forward portion of member 80 and extends vertically upwardly thereof, member 81 also having the opposite ends thereof connected with the outer end of H-beam 37 and plate 38 and with channel member 76. A plurality of spaced gusset reinforcing members 82 are rigidly interconnected between members 80 and 81 to rigidify the structure. A substantially horizontally extending member 85 is disposed substantially parallel with channel member 74 and has one end thereof connected to the outer end of H-beam 37 and plate 39 while the opposite end thereof is connected with channel member 77. A substantially vertically extending member 86 is secured to the forward portion of member 85 and extends upwardly therefrom, one end of member 86 being rigidly secured to the outer end of H-beam 37 and plate 39 while the opposite end thereof is fixed to channel member 77. A plurality of spaced reinforcing gusset plates 87 are secured between members 85 and 86 for rigidifying the structure.

A pair of channel members 90 and 91 are connected between H-beam 37 and member 81. A pair of aligned channel members 92 and 93 are connected between members 81 and 82 and H-beam 65. A channel member 95 is connected between H-beam 37 and a reinforced access portion 97 hereinafter described. A plurality of parallel longitudinally extending channel members 100, 101, 102, 103, 104 and 105 are connected between H-beams 37 and 65.

A channel member 110 is connected between H-beam 37 and reinforced access means 111 similar to means 97 and hereinafter more fully described. A pair of channel members 115 and 116 are connected between H-beam 37 and member 86. A pair of aligned channel members 117 and 118 are connected between members 85, 86 and the H-beam 65.

A pair of parallel channel member 120 and 121 have first end portions thereof connected with H-beam 65 and the opposite end portions thereof connected with channel member 73. A channel member 122 has a forward end thereof connected with the reinforced access means 97 and the rearward end thereof is connected with channel member 73. A channel member 123 has a forward end thereof connected with members 80 and 81 while the rearward end thereof is connected with channel member 73. A channel member 124 is aligned with channel member 123 and has the forward end thereof connected with H-beam 65 and the rearward end thereof connected with member 81. A channel member 125 has the forward end thereof connected with a side portion of the throat portion casting, while the rearward end thereof is connected with channel member 123. It will be noted that channel means 75 includes a first channel member 75' connected between the forward portion of the casting 72 and members 80 and 81, while the second portion 75'' of channel member 75 is connected between member 81 and the H-beam 65.

A pair of parallel channel members 130 and 131 have the forward ends thereof connected with H-beam 65 while the rearward ends thereof are connected with channel member 74. A channel member 132 has the rearward end thereof connected with channel member 74 and the forward end thereof connected with the reinforced access means 111. A channel member 133 has the forward end thereof connected with members 85 and 86 and the rearward end thereof is connected with channel member 74. A channel member 134 is aligned with channel member 133, channel member 134 having the forward end thereof connected with H-beam 65 and the rearward end thereof connected with member 86. A channel member 135 has the forward end thereof connected with the side portion of the casting 72 while the rearward end thereof is connected with channel member 133. It will be noted that channel means 78 includes a first channel member 78' having the forward end thereof connected with members 85 and 86 and the rearward end thereof connected with the forward facing surface of casting 72. The portion 78'' of channel means 78 has the forward end thereof connected with H-beam 65 and the rearward end thereof connected with member 86.

A wheel assembly 140 is mounted between channel members 62 and 92 at one lateral midportion of the body means, and a corresponding wheel assembly 141 is connected between channel members 63 and 118 at the opposite side of the body means. A wheel assembly 142 is mounted between channel members 121 and 122, and a wheel assembly 143 is mounted between channel members 123 and 75'. A wheel assembly 144 is mounted between channel members 131 and 132, and a further wheel assembly 145 is connected between channel members 133 and 78'. It will be noted that the first described pair of wheel assemblies 34 and 35 are mounted along the longitudinal axis X—X of the body means, and that the body means is additionally substantially symmetrical about this longitudinal axis. These two forward wheel assemblies serve in conjunction with the protective bumper means 25 to provide a plowing effect as previously discussed. It will be noted that the remaining wheel assemblies 140 through 145 inclusive are mounted on opposite sides of the longitudinal axis X—X and are staggered in a rearward direction to provide an effective stable support for the body means when moving over the sea bottom.

The body means includes along the forward portion thereof a first separating means, this separating means disposed on either side of the longitudinal axis of the body means. The separating means of the present invention takes the form of a plurality of depending spaced tooth members or portions which extend downwardly and in the normal operative position of the device are

spaced slightly from the underlying sea bottom. It should be noted at this point that in the various figures of the drawing wherein a phantom line is illustrated spaced slightly below the structure, this phantom line represents the bottom of the sea, the remaining structure except for the wheels being spaced slightly above the sea bottom so as not to be in contact therewith as the apparatus moves along the sea bottom.

As discussed previously, it is highly desirable to provide tooth portions which can be readily removed and replaced as desired, and in order to accomplish this purpose in the present invention, the tooth portions of the first separating means are formed as integral castings as seen for example in FIG. 14 wherein the casting in general is indicated by reference numeral 150. This casting includes a flat plate-like portion 151 from which extends a pair of upwardly spaced studs 153 at opposite ends of the plate, three of these studs being visible in FIG. 14. A pair of tooth members 155 formed integral with the plate 151 depend from and include leading edge portions 157 which are disposed at an angle with respect to the side surfaces of the tooth members or portions. It will be understood that the side surfaces of these tooth members are spaced apart a certain predetermined distance, which in the present instance may be 6 inches so as to permit only solid bodies 6 inches in diameter or smaller to pass therebetween.

As seen particularly in FIG. 3, seven of these castings 150 are disposed on either side of the longitudinal axis of the body means, the seven disposed on one side being illustrated by reference numeral 150, and seven similar castings 150' are mounted on the opposite side of the longitudinal axis, one of these castings being visible in FIG. 3 and including depending tooth portions 155' identical with the tooth portions 155. It will also be understood that the size of the castings is such that adjacent tooth portions on different castings will also be spaced apart the predetermined distance such as 6 inches so that the spacing is uniform along the forward portion of the apparatus.

The leading edge portions 157 of the tooth members 155 are so disposed that they lie in a plane and define an angle α as illustrated in FIG. 3 of approximately 45 degrees with respect to the longitudinal axis X—X of the body means. It will be understood that the leading edge portions of the tooth members 155' of the castings 150' on the opposite side of the longitudinal axis are similarly disposed. This angularity of the leading edge portions of the tooth members is such as to cause any solid bodies which are contacted during movement of the body means to be shunted to the side such that solid bodies which are too large will eventually be carried outwardly to the side edge portions and pass around the body means. It will be understood that in normal operation of the apparatus, the body means will be movable along a direction corresponding with the longitudinal axis X—X of the body means, the previously described forward edge portion of the apparatus being movable and facing in such forward direction of normal operative movement.

The castings 150 are mounted in operative position by inserting the studs 153 of the castings upwardly through suitable openings provided in member 17 or member 16 at the other side of the body means, whereupon suitable nuts are threaded onto the upper ends of the studs and wired in position to secure them in place. The nuts are indicated by reference numerals 154 and 154' in FIG. 2 of the drawings. It is apparent that this arrangement permits quick and easy replacement of the castings and the tooth portions of the first separating means as required.

Referring now to FIG. 16 of the drawings, a typical casting employed for providing the tooth portions of the second separating means of the present invention is illustrated. This casting is indicated generally by reference

numeral 160 and includes a plate-like body portion 161 from which extends upwardly a pair of threaded studs 163 at each end thereof, three of these studs being visible in FIG. 16. A plurality of spaced depending tooth portions 165 shown as being five in number are provided integral with the casting and serve as the separating tooth members for eliminating solid bodies which are too small and ensuring that only solid bodies within the desired size range are accumulated and passed through the throat portion of the body means.

Castings 160 are mounted in operative position by inserting the studs 163 upwardly through suitable openings provided in member 85, nuts 164 being threaded on the upper ends of studs 163 and wired in place to hold the castings in their proper operative position. It will be understood that corresponding castings 160' will be provided on the opposite side of the longitudinal axis X—X of the body means, castings 160' being the reverse arrangement of castings 160 in a similar manner to that in which the castings 150' are the reverse arrangement of castings 150.

As seen particularly in FIG. 3, each of the tooth portions 165 of castings 160 includes a leading or forward edge portion 170 and a rearward portion 171. It will be noted that the leading or forward edge portions 170 are closely spaced to one another so as to provide an opening of approximately three quarters of an inch therebetween so that solid bodies three quarters of an inch in diameter or smaller will pass therebetween and rearwardly of the apparatus so as not to be collected thereby. On the other hand, any bodies larger than three quarters of an inch in diameter will not pass between the leading edge portions of these tooth members and will be directed inwardly to the throat portion of the body means. By spacing the rearward or trailing edge portions 171 of each of the tooth members 160 a substantially greater distance apart than the leading edge portions thereof, an expansion space is provided between the tooth members immediately rearwardly of the leading edge portions thereof which prevents jamming of the small particles between these tooth portions to ensure that they will not become clogged and jammed during operation of the apparatus.

Furthermore, as seen in FIG. 3, the leading edge portions 170 of the tooth portions 165 lie substantially in a plane and define an angle b of approximately 45 degrees with respect to the longitudinal axis X—X of the body means. This angularity ensures that the solid bodies which pass between the first separating means tooth portions and which do not pass outwardly between the tooth portions 165 will be directed laterally inwardly to the central or longitudinal axis of the body means as the body means moves forwardly.

Referring now more particularly to FIGS. 2 and 17 of the drawings, the construction of the reinforced access means 111 will be clearly understood, the access means 97 being of identical construction, and the description of means 111 sufficing to define the structure of each of these arrangements. A flat plate means 175 having a central opening 176 formed therethrough is secured to the upper surface of members 86, 65, 110 and 132. From this plate depend a plurality of plates 176, 177, 178 and 179 which define a substantially rectangular enclosing structure. These members are rigidly secured to members 110, 65 and 85 respectively, it being understood that the H-beam means 65 is cut away at this portion to receive members 85 and 86 which extend therethrough. The central opening 176 formed in plate 175 permits access to the nuts 164 whereby the castings therebeneath can be readily attached and removed when desired. It will be understood that reinforce access means 97 includes a plate 98 similar to plate 175, plate 98 being provided with a central access opening 99 for gaining access to the nuts disposed therebeneath.

Referring now to FIGS. 8, 9 and 10 of the drawing, a typical rotatable wheel assembly is illustrated, and the

description of this typical assembly will suffice for describing the structure of each and every one of the wheel assemblies previously referred to herein. As seen in these three figures, a pair of supporting channel members are indicated by X and Y, these channel members representing any adjacent pair of channel members which support one of the wheel assemblies of the present invention. A pair of plates 182 and 183 may be provided in suitable cutouts provided in the vertical web portion of the channel members X and Y, these plate members being suitably secured in operative position as by welding or the like. A pair of cross brace members 185 and 186 extend completely across between the vertical webs of the flange members, and a pair of reinforcing gusset members 187 and 188 are disposed between plates 182 and 183 and the associated channel members X and Y respectively.

A pair of flat plates 190 and 191 are each provided with a pair of spaced openings which receive cap screws 192 and 193 respectively which extend upwardly through the openings provided in members 190 and 191 and are threaded into correspondingly threaded openings provided in the plate members 182 and 183 respectively. A pair of protective plate members 195 and 196 are welded together to provide a six-sided cross-sectional configuration as seen in FIG. 10, these plate members depending in completely surrounding relationship to the remainder of the wheel assembly so as to provide protection thereto and ensure that the wheel assembly will not be damaged by contact with external objects. Plate members 195 and 196 may be provided with suitable cutouts for receiving plates 190 and 191 respectively.

A pair of plates 200 and 201 extend longitudinally of the wheel assembly, plate 200 being secured at its opposite ends to spaced portions of plate 196, while plate 201 is connected at opposite ends thereof to spaced portions of plate 195. Support member 202 is secured between plate 200 and plate 196, while a support member 203 is secured between plate 201 and plate 195. Support members 202 and 203 as well as plates 200 and 201 are provided with aligned openings for receiving a pin 205, this pin being received at opposite ends thereof within cutouts provided in plates 195 and 196, the pin being held in operative position by a snap ring 206 or the like.

A suitable bushing 210 of an antifriction material is supported on pin 205, and a pair of washers 211 and 212 of a similar material to that of bushing 210 are also supported on the pin. The wheel itself is indicated generally by reference numeral 215 and includes a central portion 216 which may comprise cast aluminum or the like with a tread 217 of a suitable material such as rubber or the like. It is apparent that the wheel assembly of the present invention provides a very heavy-duty and rugged construction, the entire assembly being rigidly mounted in place and yet the wheels may readily removable, while the entire assembly is also adequately protected during use so as to prevent damage thereto.

Referring now to FIGS. 5, 6 and 7 of the drawings, the details of construction of the casting 72 or throat portion of the body means are illustrated. As seen in these figures, the casting 72 includes a forwardly directed collecting opening 225 which receives all of the collected solid bodies which have been separated by the tooth portions previously described. These collected bodies pass inwardly through the forwardly facing collecting opening 225 into the throat portion which includes inner side wall portions 230 and 231 as seen in FIG. 6. These side wall portions extend upwardly and define at the upper end thereof an upwardly facing discharge opening 233 through which all of the collected bodies move upwardly into the conduit means connected with the collecting means of the present invention.

The throat portion is also provided with a relief opening 235 which is substantially aligned with the collecting opening 225. This relief opening 235 is normally

closed by a movable relief means or gate 237 which is mounted for pivotal movement about the pivotal axes indicated at 235. It is apparent that the gate member 237 will normally drop down into the position illustrated in FIG. 5 to close off the relief opening, and furthermore the suction of the water being entrained upwardly through the discharge opening 233 will normally tend to hold the member 237 in its closed position. On the other hand, if for some reason the solid bodies should accumulate within the throat portion to such an extent that they apply a substantial pressure to the inwardly facing surface of member 237, this member may then swing into its open position to permit discharge of solid bodies through the relief opening so as to prevent the jamming or excessive clogging of solid bodies within the throat portion.

Casting 72 includes a top wall portion 240 which defines a laterally extending peripheral flange around the discharge opening 233, this flange having a plurality of spaced threaded openings 242 provided therethrough for attaching the conduit means to the throat portion of the collecting means of the present invention.

The casting includes an intermediate wall portion 230' and 231' disposed between an outer wall portion 230'' and 231'', wall portions 230 and 230' defining a cavity 243 therebetween and including a bracing wall portion 244 extending between these two wall portions. Wall portion 231 and 231' define a cavity 245 therebetween, a bracing wall portion 247 extending between wall portions 231 and 231'.

A passage means 250 is defined between intermediate wall portion 230' and an outer wall portion 230'', this passage means being divided in half by a laterally extending wall portion 252. A corresponding passage means 254 is provided between wall portions 231' and 231'', this passage means being divided in half by an intermediate laterally extending wall portion 256.

It will be noted that the upper end portions of each of the passages 250 and 254 open upwardly to the surrounding water, while the lower open end portions of each of the passage means open into opposite lateral sides of the throat portion. During operation of the apparatus, fresh water will be entrained through these two passage means as indicated by the arrows and will discharge into lateral side portions of the throat area so as to prevent the accumulation or build-up of solid bodies at such side portions. In addition, as discussed previously this lateral entrainment of fresh water reduces the amount of sand which is sucked upwardly through the discharge outlet 233.

It is apparent from the foregoing that there is provided according to the present invention new and novel collecting means which is especially adapted for use in underwater mining operations for collecting solid masses or bodies of material. The collecting means may be readily moved along the bottom of the sea and includes novel heavy-duty wheel assemblies which permit ready movement of the body means and at the same time can be disassembled with ease while providing adequate protection to ensure that the wheel assemblies are not damaged by external objects. The first and second separating means of the apparatus ensure that only solid bodies within certain size ranges will be collected while larger and smaller bodies are eliminated and rejected by the apparatus. The apparatus includes means for directing all of the collected solid bodies to a single throat portion from where the bodies are raised to a ship or the like. Means is provided at the throat portion of the body means for entraining fresh surrounding water to prevent accumulation of solid bodies at the side portions of the throat area and to cause less sand from the sea bottom to be sucked up and entrained along with the solid bodies. This throat portion also includes a movable relief means in the form of a gate or the like which is normally closed during operation but which may swing into open position

to permit the discharge of solid bodies should the solid bodies accumulate to an excessive degree in the throat portion. The tooth means of the present invention are formed as separate and individual castings which permits these various tooth portions to be quickly and easily removed and replaced as required. The tooth construction of the second gathering means is of special interest since it includes an expansion area between the tooth members immediately rearwardly of the leading edge portion thereof so as to ensure that there will not be jamming between these adjacent tooth portions. The body means of the present invention also incorporates a novel front end construction which provides reinforced bumper means to prevent damage to the body means and which also cooperates with a pair of support wheels immediately rearwardly thereof to plow out sand along the center line of the body means as it moves along in operation to diminish the amount of loose sand in the throat area of the apparatus. It is also apparent that the collecting means of the present invention is quite simple and inexpensive in construction and yet at the same time is quite sturdy and reliable in operation.

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

We claim:

1. Collecting means comprising a body means, support means operatively connected with said body means for supporting said body means for movement along a supporting surface, said body means including a forward portion and a rearward portion, first separating means mounted at the forward portion of said body means and comprising a plurality of spaced members, second separating means disposed rearwardly of said first separating means and comprising a plurality of spaced members, the spacing of the members of the first separating means serving to eliminate solid bodies which are too large and the spacing of the members of the second separating means being spaced so as to eliminate solid bodies which are too small, whereby the collecting means serves to collect only solid bodies within a certain size range, said body means including a portion for receiving all of the collected solid bodies within said size range from where the solid bodies are removed from the collecting means.

2. Collecting means comprising a body means, means supporting said body means for movement along the bottom of the sea, said body means including a forward portion and a rearward portion, first separating means mounted at the forward portion of said body means and facing forwardly in the direction of movement of said body means along the bottom of the sea, said first separating means comprising a plurality of spaced depending tooth members spaced apart a certain distance so as to receive solid bodies therebetween which are no larger than a predetermined size thereby eliminating solid bodies which are too large, second separating means supported by said body means rearwardly of said first separating means, said second separating means being spaced from said first separating means, said second separating means comprising a plurality of spaced depending tooth members, said tooth members of said second separating means being spaced apart from one another a predetermined distance so as to permit solid bodies to pass therethrough which are undesired and which are too small thereby ensuring that only particles within a predetermined size range are collected by the collecting apparatus, said body means including a throat portion having an opening facing in a generally forward direction for receiving the collected solid bodies within said size range, said throat

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portion also including a discharge opening through which the collected bodies are removed from the collecting means.

3. Collecting means comprising a body means, said body means including a forward portion and a rearward portion and being movable in a direction generally corresponding with a longitudinal axis of the body means extending from the central rearward portion of the body means to the central forward portion of the body means, means supporting said body means for movement along a supporting surface, first separating means supported by said body means at the forward portion thereof and comprising a plurality of laterally spaced tooth members, said tooth members being spaced apart a predetermined distance so as to receive therebetween only solid bodies which are less than a given dimension so as to eliminate solid bodies which are too large, said tooth members having leading edge portions facing in the direction of movement of said body means, said leading edge portions forming an acute angle with respect to the said longitudinal axis of said body means, second separating means supported by said body means rearwardly of said first separating means and comprising a plurality of spaced tooth members spaced apart a predetermined distance so as to permit solid bodies which are too small to pass therebetween so as to prevent the collection of solid bodies which are too small, whereby solid bodies only within a predetermined size range are collected by the apparatus, said tooth members of said separating means including leading edge portions facing in the direction of movement of the body means, said last-mentioned leading edge portions forming an acute angle with respect to said longitudinal axis of the body means, said body means including a throat portion at the rear portion thereof for receiving all of the solid bodies collected by said first and second separating means, said throat portion also including a discharge opening through which the solid bodies are removed from the collecting means.

4. Apparatus as defined in claim 3 wherein the tooth members of each of said first separating means and said second separating means are detachably secured to said body means for ready removal and replacement as required.

5. Apparatus as defined in claim 3 wherein the leading edge portions of the tooth members of each of said separating means define an angle of approximately 45 degrees with respect to the longitudinal axis of said body means, the leading edge portions of said first separating means defining an angle of approximately 90 degrees with respect to the leading edge portions of said tooth members of the second separating means.

6. Collecting means comprising body means including a forward portion facing in the direction of movement of said body means during normal operation, said body means also including a rearward portion, means supporting said body means for movement along the bottom of the sea, first separating means mounted at the front portion of said body means and including a plurality of laterally spaced members spaced apart at a predetermined distance so as to permit only solid bodies of a predetermined size to pass therebetween thereby eliminating solid bodies which are too large, second separating means supported by said body means rearwardly of said first separating means and spaced therefrom, said second separating means including a plurality of laterally spaced members spaced apart a predetermined distance so as to permit solid bodies which are too small to pass therebetween thereby retaining in the collecting means only solid bodies within a certain predetermined size range, said body means including a throat portion disposed at the rear portion thereof, said throat portion including a generally forwardly directed opening for receiving all of the solid bodies collected by said first

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and second separating means within said predetermined size range, means directing all of the collected solid bodies into and through the said opening of said throat portion, said throat portion also including a discharge opening extending in a generally upward direction through which the collected solid bodies are removed from the collecting means.

7. Apparatus as defined in claim 6 wherein said throat portion includes a movable relief means, said throat portion including a relief opening substantially aligned with the opening which receives said collected solid bodies, said relief means being mounted in position so as to normally close said relief opening and being movable to an open position for opening said relief opening and discharging solid bodies from said throat portion upon the accumulation and pressure on said relief means of solid bodies within said throat portion.

8. Apparatus as defined in claim 7 wherein said movable relief means comprises a pivotally mounted closure member which is supported from said throat portion and normally closes said relief opening under the influence of gravity plus pressure differentials operating thereon and being swingable into open position upon the accumulation and pressure thereon of solid bodies within said throat portion.

9. Apparatus as defined in claim 6 wherein said body means includes auxiliary passage means formed therein, opposite ends of said passage means being open, one of said open ends of said passage means opening into the surrounding water, the opposite open end of said passage means opening into said throat portion at a lateral portion thereof for entraining fresh water into the lateral portion of said throat portion.

10. Collecting means comprising a body means including a plurality of interconnected rigid members to define an open framework, support means for supporting said body means for movement along the bottom of the sea, said body means including a longitudinal axis with the body means being movable in a direction substantially coincidental with said longitudinal axis, said body means extending laterally to either side of said longitudinal axis, said body means including a forward portion facing in the direction of movement of said body means and an opposite rearward portion, first separating means mounted at the forward portion of said body means, said first separating means comprising a plurality of spaced tooth members disposed in depending relationship from said body means and removably attached thereto for ready replacement as required, each of said tooth members including leading edge portions facing in the direction of movement of said body means, said leading edge portions defining an angle of approximately 45 degrees with respect to the longitudinal axis of said body means, second separating means supported by said body means rearwardly of said first separating means and spaced from said first separating means, said second separating means comprising a plurality of spaced tooth members disposed in depending relationship to said body means and being removably attached thereto, each of the tooth members of said second separating means including leading edge portions which are disposed at an angle of approximately 45 degrees to the longitudinal axis of said body means, the leading edge portions of the tooth members of said first separating means being disposed at approximately an angle of 90 degrees with respect to the leading edge portions of the tooth members of said second separating means, the tooth members of said first and second separating means being spaced apart from one another predetermined distances so as to respectively eliminate solid bodies which are too large and solid bodies which are too small so as to ensure the collection of solid bodies only within predetermined size ranges, said body means including a throat portion disposed at the central rearward portion of said body means, said

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throat portion including a collecting opening facing in a generally forward direction so as to receive all of the collected solid bodies which are collected by said first and second separating means, said throat portion also including a discharge opening through which all of the collected solid bodies are removed from the collecting means, said throat portion also including a relief opening through which solid bodies may be discharged from said throat portion, means normally closing said relief opening and being movably supported by said body means for movement to an open position to permit discharge of solid bodies from said throat portion, and said body means having passage means formed therein with opposite open ends, one open end of said passage means being in communication with the surrounding water while the opposite open end of said passage means opens at a lateral portion of said throat portion whereby fresh water is entrained into the side portions of said throat portion during normal operation of the collecting means.

11. Apparatus as defined in claim 10 wherein said means supporting said body means for movement along the sea bottom comprises a plurality of wheels rotatably supported by said body means and being longitudinally and laterally spaced with respect to one another.

12. Apparatus as defined in claim 11 wherein said wheels comprise a pair of wheels mounted along said longitudinal axis at the forward portion of said body means, and a plurality of laterally spaced wheels mounted adjacent the rearward portion of said body means and spaced a substantial distance rearwardly of said first-mentioned wheels.

13. Apparatus as defined in claim 12 wherein said body means includes a protective bumper means mounted along said longitudinal axis of the body means and disposed at the forward portion of the body means forwardly of said pair of wheels disposed along said longitudinal axis.

14. Apparatus as defined in claim 10 wherein the tooth members of said first separating means as well as the tooth members of said second separating means are formed as castings wherein each casting includes a plurality of integral tooth members, said castings being removably attached to said body means for ready removal and replacement.

15. Collecting means comprising a body means formed of a plurality of elongated substantially rigid members secured to one another to provide a reinforced open framework, said body means including a forward portion facing in the direction of normal movement of said body means during operation and an opposite rearward portion, said body means being formed substantially symmetrically about a longitudinally extending axis extending from the central rearward portion of said body means to the central forward portion thereof, support means supporting said body means for movement along the sea bottom, said support means comprising a plurality of wheels rotatably supported by said body means, said wheels serving to support said body means in slightly spaced relationship with respect to the supporting sea bottom in normal operation, said wheels including a first pair of wheels disposed along said longitudinal axis and disposed at the forward portion of said body means, said wheels also including a plurality of laterally spaced wheels disposed on opposite sides of said longitudinal axis and spaced rearwardly of said first-mentioned wheels, said body means including a protective bumper means disposed at the forward central portion thereof immediately in front of said first-mentioned pair of wheels, first separating means supported at the forward portion of said body means and depending therefrom, said first separating means including a plurality of spaced tooth members, said tooth members being disposed in laterally spaced relationship with one another with each tooth member disposed outwardly of an adjacent tooth member with respect to

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said longitudinal axis also being disposed rearwardly of said adjacent tooth member, the leading edge portions of said tooth members facing in the direction of movement of said body means lying substantially in a plane and defining an angle of approximately 45 degrees with respect to the said longitudinal axis of said body means, said tooth members being removably mounted on said body means, said tooth members being spaced from one another in a lateral direction with respect to said longitudinal axis so as to define forwardly facing openings between the tooth members of said first separating means of a dimension to receive solid bodies which are less than a predetermined dimension so as to eliminate solid bodies which are too large, second separating means supported by said body means rearwardly of said first separating means and spaced therefrom, said second separating means comprising a plurality of depending laterally spaced tooth members, said last-mentioned tooth members being so arranged that each tooth member spaced inwardly of an adjacent tooth member with respect to said longitudinal axis is also spaced rearwardly of said adjacent tooth member with the leading edge portions of said last-mentioned tooth members lying substantially in a plane and defining an angle of approximately 45 degrees with respect to said longitudinal axis and an angle of approximately 90 degrees with respect to the leading edge portions of said tooth members of the first-separating means, the tooth members of said second separating means being movably mounted on said body means, said body means including a throat portion disposed at the central rearward portion of said body means, said throat portion including a collecting opening, a discharge opening and a relief opening, said collecting opening facing in a forward direction so as to receive all of the solid bodies collected by said collecting means, the tooth members of said second separating means being spaced from one another a predetermined distance so as to permit solid bodies smaller than a predetermined dimension to pass therebetween thereby eliminating solid bodies which are too small and whereby the collecting means serves to collect solid bodies only within a certain size range, the relief opening of said throat portion being substantially aligned with said collecting opening and facing rearwardly of said throat portion, movable means normally closing said relief opening and being movable into a position for opening said relief opening to discharge solid bodies there-through, said discharge opening facing substantially in an upward direction and providing an opening through which all of the collected bodies are removed from the collecting means, said body means including a pair of passage means disposed on opposite sides of said throat portion, each of said passage means including a first open end which opens into the surrounding water, each of said passage means including an opposite open end which opens into one side portion of said throat portion for entraining fresh water into said throat portion during operation of the apparatus.

16. Apparatus as defined in claim 15 including means mounted at opposite lateral side portions of said body means for receiving lifting means to facilitate handling of the collecting means.

17. Apparatus as defined in claim 15 wherein each of the tooth members of said second separating means includes a leading edge portion which is closely spaced to the leading edge portion of the adjacent tooth member, the remaining rearwardly extending portions of said tooth members being spaced apart a substantially greater distance to provide an expansion area between the adjacent tooth members rearwardly of the leading edge portions thereof.

18. Apparatus as defined in claim 15 wherein said means for closing said relief opening comprises a gate member pivotally supported at the upper portion thereof by said body means and swingable downwardly under

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the influence in gravity into a position so as to close off said relief opening, said gate means being swingable into an open position upon application of pressure to the inwardly facing surface thereof by solid bodies accumulated within said throat portion.

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