United States Patent [19]

Kuhlmann-Schaefer et al.

[11] **3,776,593**

[45] **Dec. 4, 1973**

[54] **APPARATUS FOR RECOVERY OF MAGNETIZABLE MATERIALS FROM THE SEA BOTTOM**

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[22] Filed: **Mar. 21, 1972**

[21] Appl. No.: **236,678**

[30] **Foreign Application Priority Data**

Mar. 26, 1971 Germany ..... P 21 14 828.7

[52] **U.S. Cl.** **299/8,** 37/DIG. 8

[51] **Int. Cl.** **E02f 1/00,** E21c 45/00

[58] **Field of Search** 299/8, 9; 37/DIG. 8

[56] **References Cited**

UNITED STATES PATENTS

3,556,598	1/1971	Smith	299/8
3,697,134	10/1972	Murray	299/8
3,210,121	10/1965	Struven	299/8
2,262,038	11/1941	Parker	299/8

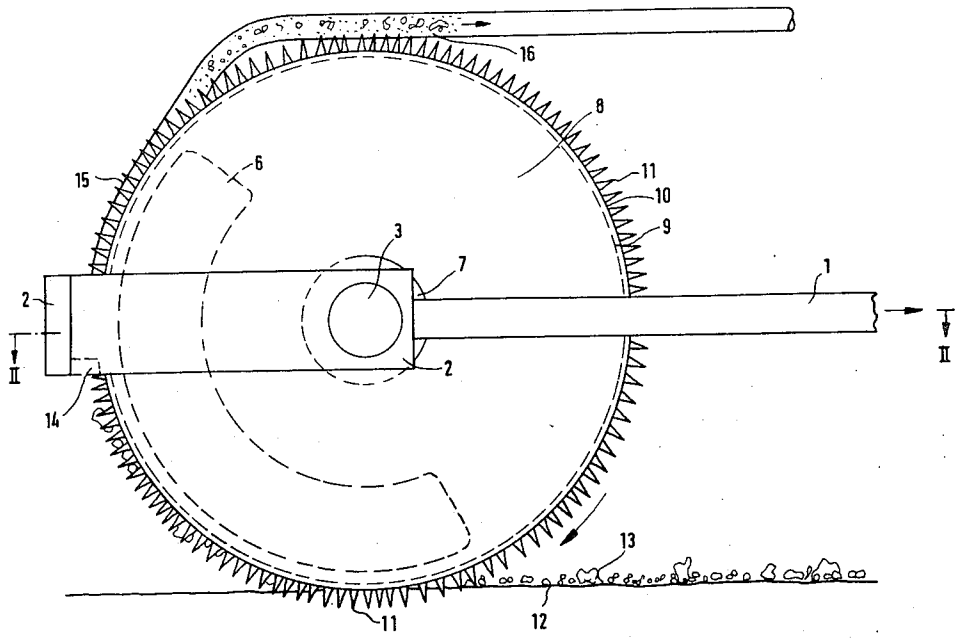
Primary Examiner—Ernest R. Purser
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[57] **ABSTRACT**

Apparatus for collecting manganese or other magnetizable material from the bottom of the sea and conveying it to the sea surface comprising a rotating drum having teeth on the surface thereof to lift said material from said sea bottom, a plurality of magnets mounted inside the drum extending along the axis of the drum through an arc of between 90° and 180°, and a suction means mounted at the surface of the drum near the terminal ends of the magnets to carry the material from the drum to the surface. The magnets do not rotate with the drum surface but remain disposed at the trailing edge of the rotating drum to hold the material on the surface until it reaches the suction conveyor.

In a preferred form of the invention the arcuate magnets are arranged side by side with the North and South poles alternating with each other in the axial direction of the drum.

15 Claims, 9 Drawing Figures



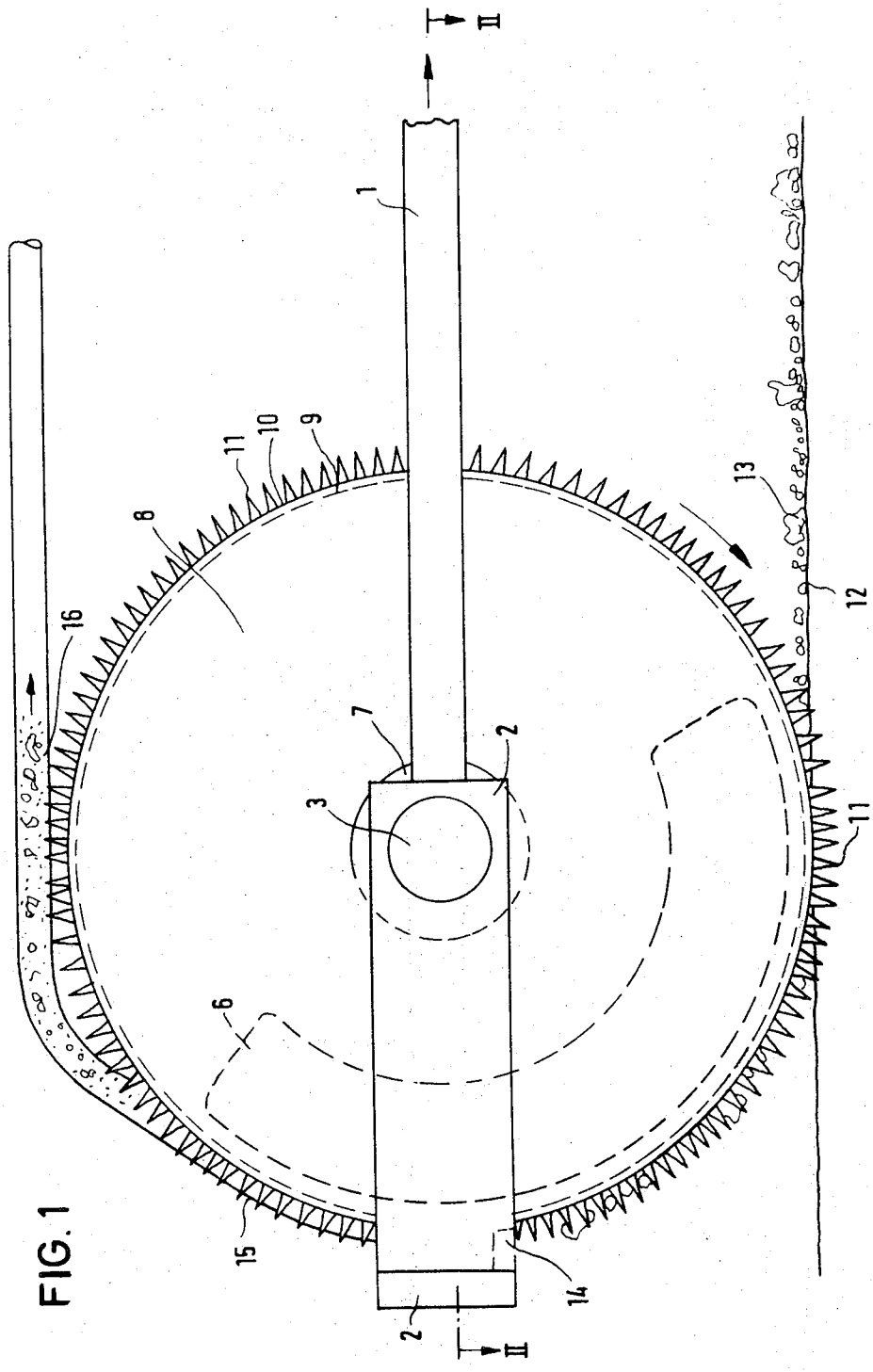


FIG. 1

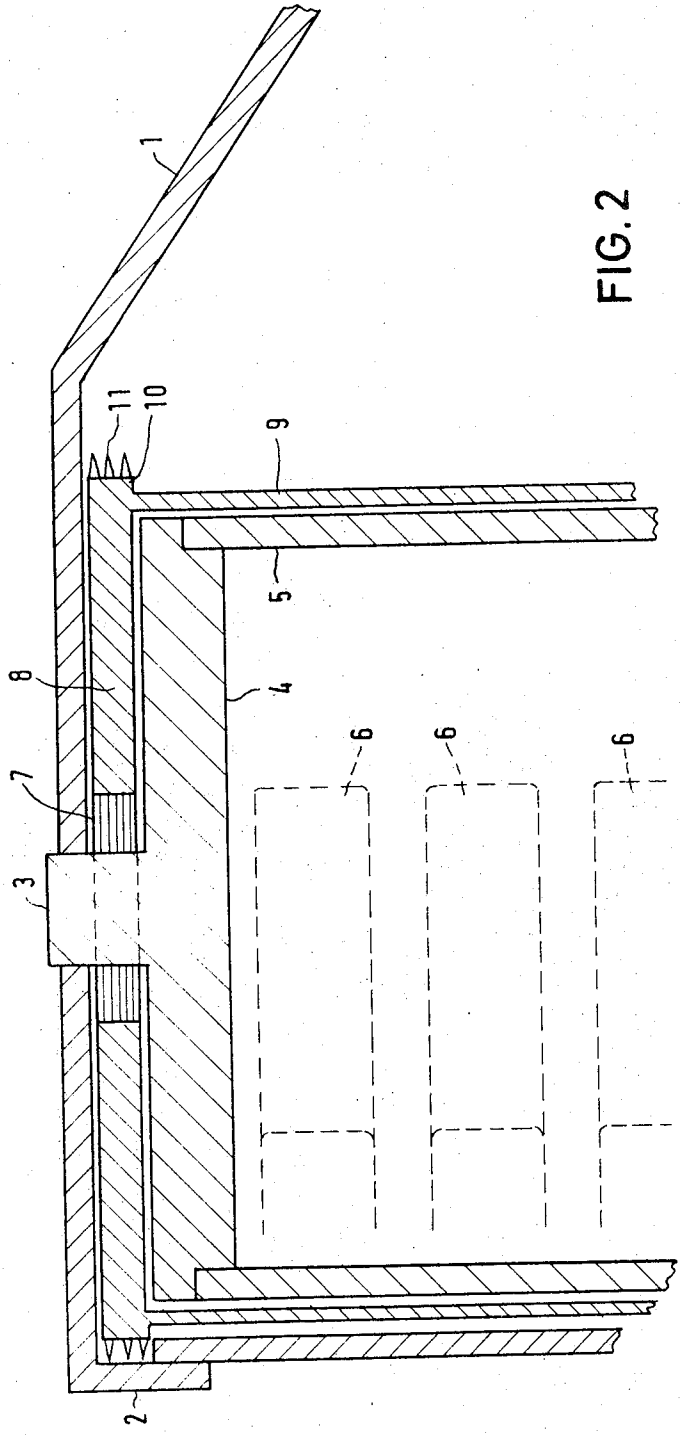


FIG. 2

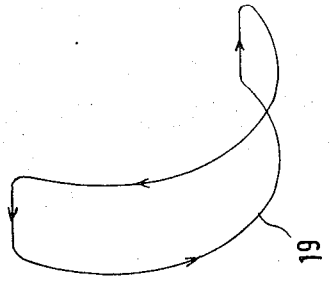
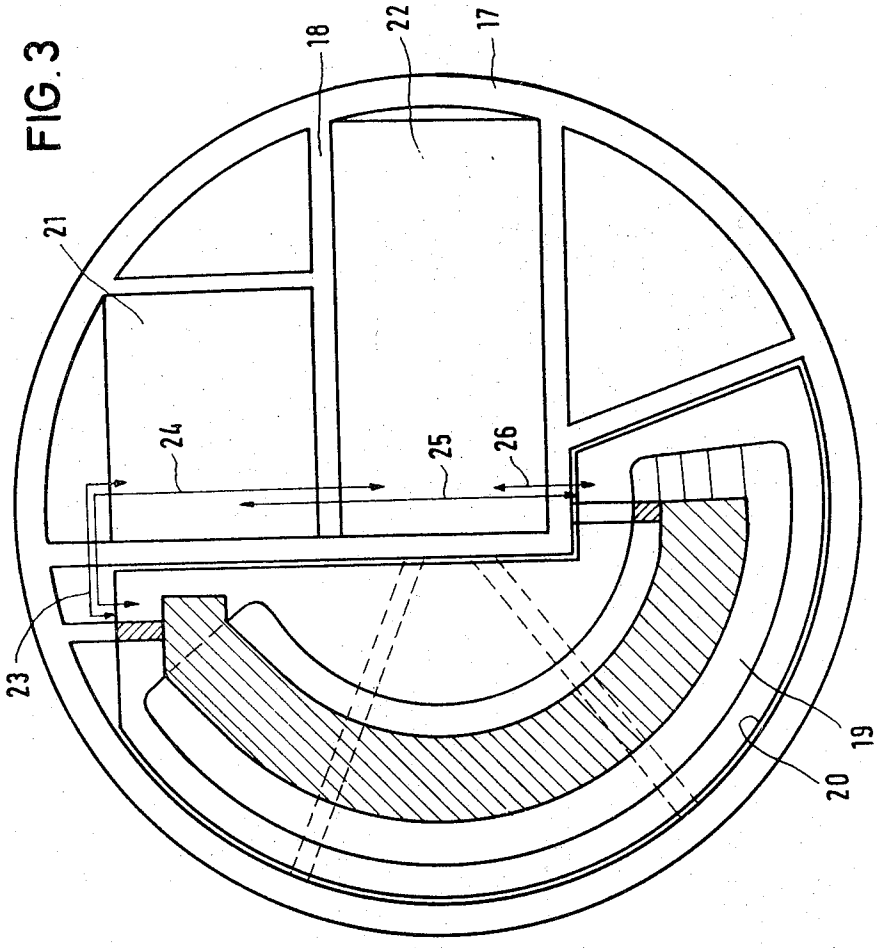


FIG. 4

FIG. 3



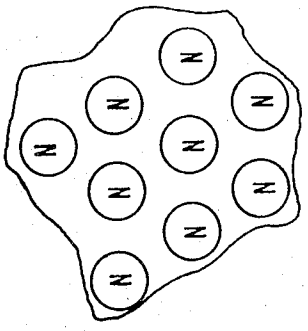


FIG.6

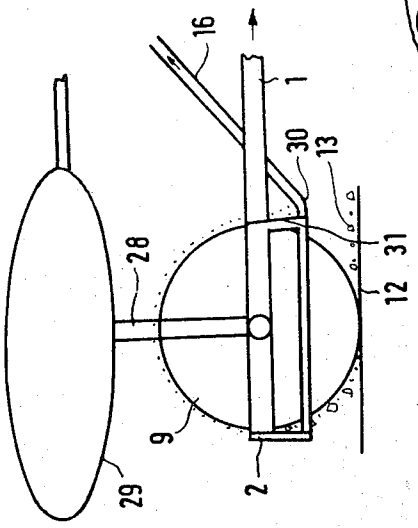


FIG.7

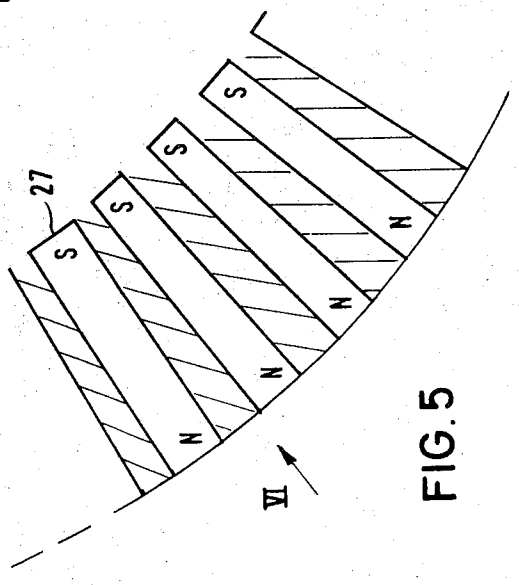


FIG.5

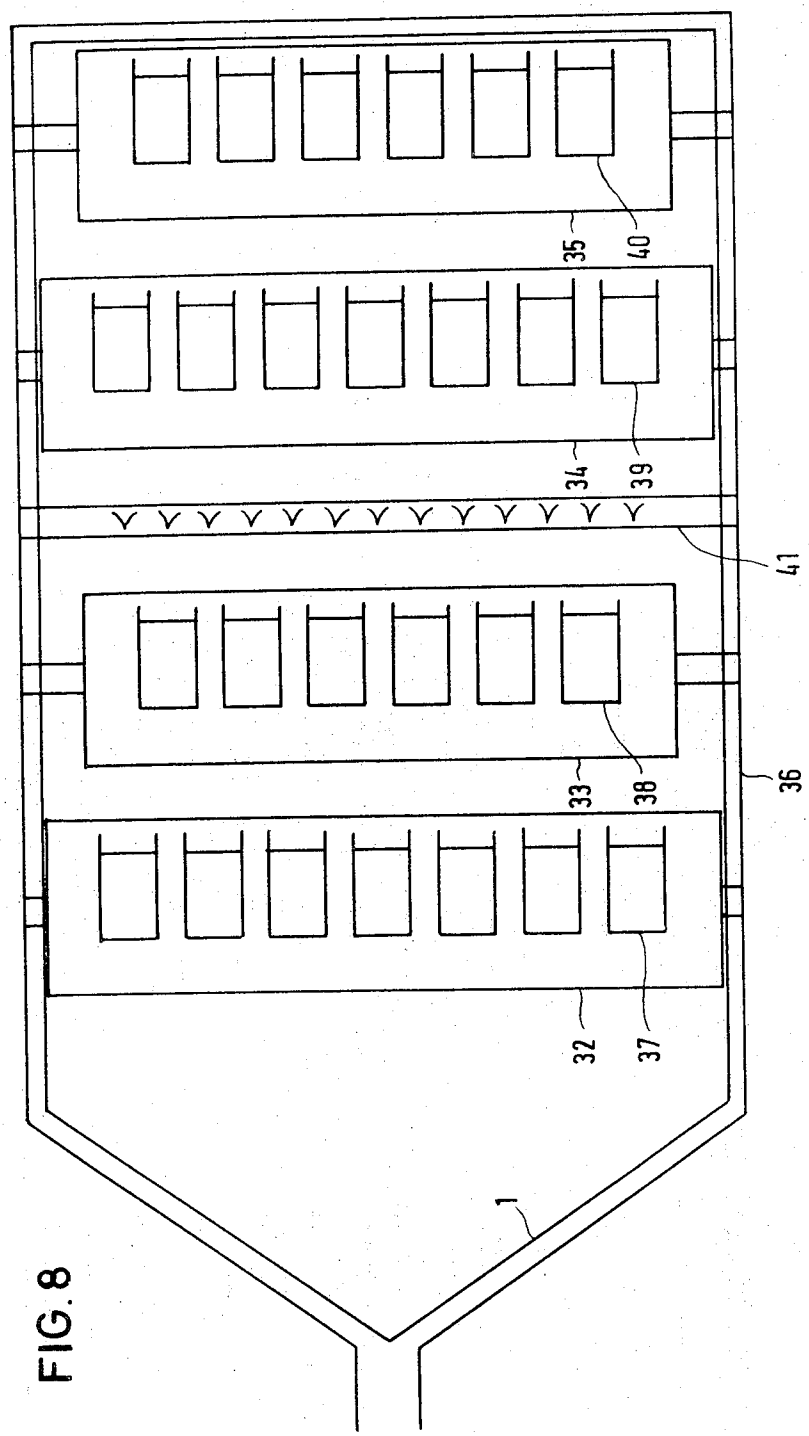


FIG. 8

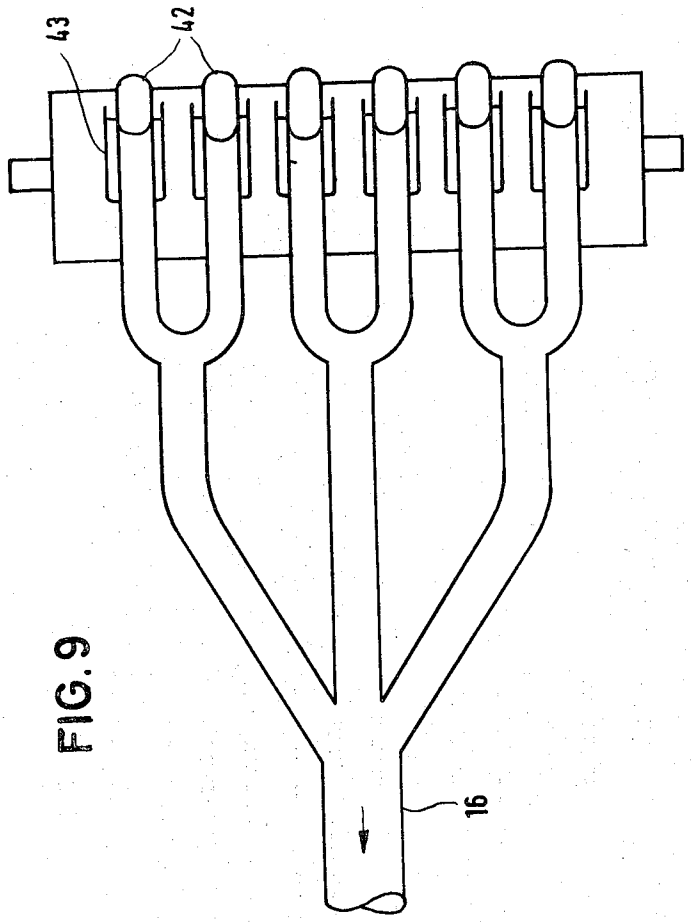


FIG. 9

APPARATUS FOR RECOVERY OF MAGNETIZABLE MATERIALS FROM THE SEA BOTTOM

The invention concerns a system for the recovery of magnetisable raw materials, in particular of lumps of manganese, from the deep sea with a lifting machine for lifting the magnetisable raw material from the ocean bed and with a conveyor system for conveying the raw material which has been lifted from the lifting machine to the surface of the sea.

It is known that accumulations of lumps of manganese occur variously on the beds of the oceans. In order to recover such lumps of manganese it is known (U.S. Pat. No. 3,305,950) how to move a rake type device over the sea bed which picks up the lumps of manganese from the sea bed. With this process a separation according to size is effected simultaneously so that particles having a size characteristic for lumps of manganese are conveyed to the attached conveyor system. The main disadvantage of this known lifting system consists in the fact that only particles of a certain size are conveyed, a major part of the deposit consisting, e.g., of relatively fine grains being frequently lost to the recovery operation. A further disadvantage consists in the probability that barren minerals of the appropriate granular size are also conveyed and cause, owing to their hardness which is in general much greater than that of lumps of manganese, damage to the pumps.

Although a large variety of processing systems are known, their application on the sea bed constitutes a considerable expense. In addition, many processing systems cannot be applied on the sea bed since they operate under dry conditions or at least presuppose a possibility of the individual particles falling freely.

It is the object of the invention to create a system which avoids the disadvantages of the known systems and at the same time separates mineral raw materials from non-mineral raw materials, so that barren minerals need not be conveyed to the surface of the sea.

The problem underlying the invention is solved in that the system for raising the magnetisable raw material from the sea bed consists of a magnetically non-conductive drum which is rotatably mounted about a horizontal spigot and rolls over the sea bed, and in which there is a magnet that extends from the lowest zone of the drum in the direction of rotation over part of the drum circumference upwards and is located closely adjacent to the inner wall of the drum, and in that the conveyor system picks up the magnetisable raw material particles carried along on the surface of the drum, where the magnet ends.

The solution according to the invention hence exploits the fact that, e.g., lumps of manganese can be magnetised, with a view to lifting only the latter from the sea bed and passing them to the conveyor system which conveys them to the surface of the sea. Particles which cannot be magnetised are not picked up and remain on the sea bed so that they do not burden the conveyor system. The magnetic forces of attraction also enable magnetisable particles which are not directly at the surface to be likewise attracted, whereby it may be, in addition, be advisable to stir up the sea bed to some extent. With a lifting system in accordance with the invention, stirring up may be effected directly by the latter, and if several lifting systems are used in front of subsequent lifting systems, whereby it is possible for the depth to which stirring up takes place to be made greater if several lifting systems are used so that the sea bed is mined to a greater depth than would be possible if only a single lifting system were used.

A further development of the invention consists in the fact that the drum with its outer surface is guided at a distance from the sea bed, e.g., by radially projecting rims fitted laterally to the drum. In order to aid picking up these rims may be provided with roughening means, e.g., in the form of teeth.

In order to avoid excessively deep penetration of the sea bed or excessively firm positioning of the drum on the sea bed, as a result of which the lumps of manganese may be rolled into the ground thus making it impossible to raise them magnetically, it is advisable to compensate the weight of the drum and the machinery associated with it, at least in part, by means of a buoy. In this way one also avoids damage to the drum if it rolls over major rocks.

To produce the magnetic forces permanent magnets or electric magnets may be used. If electric magnets are used it is advisable to provide a supra-conductive winding so that the energy losses are small and the magnetic forces generated large. The units for cooling the winding of the electric magnet may be advantageously installed direct within the drum. The poles of the magnet or magnets extend in the peripheral direction of the drum. Hence, the windings have a longitudinal extending shape in the direction of the periphery.

It is, however, also advisable to provide several permanent magnets with high coercive power at a distance from one another and next to one another within the drum so that equal poles face the outer wall of the drum. In this way particularly great magnetic forces are produced. In this connection it is advisable for the permanent magnets to be attached direct to the inner wall of the drum and to rotate with the latter and further to provide a scraper in front of the suction intake of the conveyor tube.

In order to promote picking up of the magnetisable particles carried along by the outer surface of the rotating drum and attracted by the magnets, it is advisable to provide a scraper plate, i.e., preferably direct within the suction intake of the conveyor system. The suction intake of the conveyor system is preferably so designed that a powerful current is produced within the range of the drum surface so that the particles are pulled along.

If several magnets or electric magnets, respectively, are provided next to one another in the axial direction it is advisable to arrange a separate suction intake above each individual magnet thus concentrating the main current share on those regions in which the magnetic attraction is greatest.

In order to avoid the picked up particles to be flushed away before they are seized by the suction intake, it is advisable for the suction intake to originate already within the range in which the magnetic forces of attraction are still effective and for it to continue to the range in which the magnetic forces of attraction have become small or disappeared.

It is also possible to provide a crusher between the lifting system and the conveyor system for disintegrating large lumps of manganese.

The invention is explained in detail with reference to specimen embodiments and to the drawing.

FIG. 1 shows an embodiment in accordance with the invention presented diagrammatically in the axial direction of the drum.

FIG. 2 shows a section II—II through FIG. 1.

FIG. 3 shows a view of an embodiment similar to the one shown in FIG. 1 but in radial section through the drum which is provided with electric magnets with supra-conductive windings.

FIG. 4 ishows in perspective view the form of windings used for the electric magnets according to FIG. 3.

FIG. 5 shows diagrammatically an arrangement of permanent magnets with high coercive power for use within the drum.

FIG. 6 shows a partial view of the direction of an arrow VI in FIG. 5.

FIG. 7 corresponds substantially to the embodiment in accordance with FIG. 1 and shows the use of a buoy.

FIG. 8 shows the arrangement of several lifting systems in accordance with the invention together with a stirring up system provided between them.

FIG. 9 shows an embodiment in which several suction intakes are each arranged above the individual electric magnets.

Below reference is made simultaneously to FIGS. 1 and 2 of the drawing.

A draw-bar 1 which is only partly shown and is drawn by a traction device not illustrated here comprises a frame 2 which firmly retains a spigot 3 within a disk 4, the edges of which are firmly welded to a pipe 5. The pipe 5 and the opposite disks 4 constitute a cylindrical inner space in which there are magnets 6 indicated by broken lines.

Between the frame 2 and the disk 4 a space is provided axially, in which a bearing 7 is rotatably mounted on the spigot 3. The bearing 7 is located within an end disk 8 of a drum 9 which is thus rotatably located about the spigot 3. In the radial direction the end disk 8 projects beyond the outer surface of the drum 9 by a projection 10 which is fitted with teeth 11.

The drum 9 moves with its projections 10 over a sea bed 12 on which there are lumps of manganese 13. Appropriate picking up is effected by the teeth 11 which dig into the sea bed. As soon as the lumps of manganese 13 come within the range of attraction of magnets 6, they are raised from the sea bed 12 and adhere to the surface of drum 9. Distance between the surface of drum 9 and the sea bed 12, which is determined by the height of the projection 10 and the extent to which they have penetrated the sea bed 12, is so designed as to make the distance over which the force of attraction acts as small as possible while at the same time any risk of the lumps of manganese 13 being pressed into the sea bed 12 by the surface of drum 9 is largely eliminated, such pressing entailing a risk of the power of magnet 6 no longer being sufficient to extract the lumps of manganese 13 which have been pressed in again from the sea bed 12.

The lumps of manganese 13 drawn by the magnets 6 against the surface of drum 9 are taken along by the surface of drum 9 which moves upward. Lumps of manganese which are too large are wiped off by a scraper 14 so that they cannot damage the subsequent conveyor pumps. The lumps of manganese 13 which have been taken along finally get within range of a suction intake 15 of a conveyor tube 16. Within the range of the suction intake 15 which extends to a point close above the surface of drum 9 a powerful current is generated along the surface of drum 9 in the direction in which the surface moves, the said current pulling along the lumps of manganese and removing them from the surface of drum 9. This takes place no later than within a range following the end of magnets 6 in which the force of attraction is small or has disappeared. For this reason the suection intake 15 extends beyond the magnets 6. Since the suction intake 15 is at a sufficient height above the sea bed 12 there is no danger of barren particles being drawn in as the result of suction and passed through the conveyor system. In order entirely to prevent a suction current in front of the suction intake, which emanages from the sea bed 12, baffles may be provided.

The magnets 6 of the embodiment in accordance with FIG. 1 and 2 may be permanent magnets or electric magnets. If electric magnets are employed it is however advisable to make use of supra-conductivity. FIG. 3 shows such an example of the use of an electric magnet with supra-conductivity.

In FIG. 3 a pressure cylinder 17 is provided which substantially matches the cylinder formed of disk 4 and pipe 5 in FIG. 1 and 2 but is so massively constructed that it can withstand the powerful pressure exerted by the sea at great depths. To reinforce this cylinder struts 18 are also provided. The electric magnet consists of a winding 19 contained within a chamber 20, which is filled with helium. A nitrogen liquefier 21 cools the heat reduction screen which is not illustrated, and a refrigerator 22 serves to cool the helium bath in the chamber 20. The connecting lines between the chamber 20, the nitrogenliquefier 21 and the refrigerator 22 are indicated by diagrammatically drawn lines 23 to 26.

FIG. 4 shows in a more diagrammatic way and in perspective view the form of winding 19.

FIG. 5 shows an arrangement of permanent magnets 27 which can be used instead of the magnet 6 in FIG. 1 and 2. The bar type permanent magnets 27 arerranged next to one another in a roughly radial direction of the drum, in such a way that equal poles point in the same radial direction. In this way a magnetic field is generated which is capable of particularly great forces of attraction. Owing to the fact that equal poles are close to one another great forces of repulsion are of course generated and it is therefore necessary for the permanent magnets 27 to be mounted in an appropriately stable manner. This somewhat increased mechanical effort is counterbalanced by the advantage that no pressure vessel is required, it being possible for the arrangement comprising the permanent magnets 27 to be exposed to the water drag. As a result the pole faces of the permanent magnets 27 may be closely adjacent on the inner wall of drum 9 which results in small distances between the permanent magnets 27 and the lumps of manganese 13 which are to be attracted and in correspondingly large forces of attraction. The permanent magnets 27 exert a coercive force which is preferably larger than 50 kg. They may, e.g., be cylindrical with a diameter of 2 cm and a length of 15 cm.

FIG. 6 shows a view VI in direction of the arrow in FIG. 5. It will be seen that the North poles are equally distributed.

FIG. 7 shows an embodiment which substantially corresponds to the one in FIG. 1 and 2, and corresponding parts are therefore marked with the same numbers of reference. With this embodiment however an arm 28 is provided on frame 2, the said arm being connected

with a buoy above drum 9. The buoy is so dimensioned that the contact pressure of drum 9 or of its projections 10, respectively, on the sea bed 12 is just sufficient for rotating the drum. A further difference between the embodiment in FIG. 7 and the embodiment in FIG. 1 consists in the fact that a suction intake 30 is provided on the descending side of drum 9. In this zone the lumps of manganese drop downward, preferably also as the result of being scraped from the surface of drum 9 by a scraper 31, on the descending side of drum 9 and downward into the suction intake 30.

FIG. 8 shows an embodiment comprising several drums 32, 33, 34 and 35 arranged within a frame so as to be in tandem order in the direction in which the machine travels. The magnets 37 to 40 in the various drums are each offset in relation to the adjacent magnets of other drums so that the sea bed is covered over its entire surface. Between the drums 33 and 34 there is a stirring up device 41 in the form of a rake, the prongs of which penetrate the sea bed and thus cause lumps of manganese located at a deeper level, which could not yet be raised by the drums 32 and 33 which are located in front from the point of view of the direction in which the machine travels, to be raised to the surface these being picked up by the subsequent drums 34 and 35.

FIG. 9 shows an efficient arrangement of suction intakes 42 directly within the axial range of magnets 43. In this way one ensures that the maximum suction of the suction intakes 42 is produced within the range of magnets 43.

We claim:

1. An apparatus for the recovery of magnetizable raw materials, in particular, lumps of manganese, from the deep sea which comprises, in combination, a lifting system for raising the magnetizable raw material from the sea bed and a conveyor system for conveying the raised raw material from the lifting system to the surface of the sea, said lifting system further characterized as comprising a horizontal spigot, a magnetically non-conductive drum to roll over the sea bed rotatably mounted about said spigot, a magnet contained within said drum extending from the lowest zone of the drum in the direction of rotation over a part of the drum circumference in an upward direction and closely adjacent to the inner wall of the drum, said magnets adapted to collect magnetizable raw material along the surface of the drum in the range where the magnet ends or thereafter, and wherein said conveyor system is adapted to pick up the magnetizable raw material particles collected on the surface of drum by the action of the magnets.

2. An apparatus in accordance with claim 1 characterized in that the magnet has a North pole and a South pole wherein the poles extend longitudinally in the direction in which the drum travels.

3. An apparatus in accordance with claim 1 which includes a plurality of magnets with North and South poles positioned next to one another within the drum wherein the North and South poles alternate with one another in the axial direction of drum.

4. An apparatus in accordance with claim 1 wherein several drums with parallel axes are positioned behind one another in respect of the direction of travel and which includes a stir-up device positioned between at least two consecutive drums for stirring up the sea bed.

5. An apparatus in accordance with claim 1 characterized in that a crusher is positioned between the lifting system and the conveyor system.

6. An apparatus in accordance with claim 1 characterized in that the drum includes means for guiding the drum at a distance above the sea bed.

7. An apparatus in accordance with claim 6 characterized in that said guide means comprise lateral projections positioned on the drum surface to keep the drum at a distance above the sea bed, the diameter of said projections being greater than the diameter of the drum.

8. An apparatus in accordance with claim 7 characterized in that the projections include teeth for driving the projections and for rotating the drum.

9. An apparatus in accordance with claim 1 characterized in that the conveyor system includes a conveyor tube having a suction intake, the suction intake positioned within the range of the end of magnet or thereafter.

10. An apparatus in accordance with claim 9 characterized in that a scaper is provided in front of the suction intake of the conveyor tube.

11. An apparatus in accordance with claim 10 characterized in that several magnets are arranged next to one another along the axis of the drum and the suction intake of the conveyor tube is provided above each magnet.

12. An apparatus in accordance with claim 1 characterized in that the magnet is an electric magnet with a cooled supraconductive winding.

13. An apparatus in accordance with claim 12 which includes means for cooling the winding of the electric magnet positioned within the drum.

14. An apparatus in accordance with claim 1 characterized in that the magnet comprises several individual permanent magnets with high coercive power, wherein equal poles are arranged at small distances from one another and face the outer wall of drum.

15. An apparatus in accordance with claim 14 characterized in that the permanent magnets are fitted directly to the inner wall of the drum and rotate with the latter and which includes a scraper positioned in front of the suction intake of conveyor tube.

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