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Declarations under Rule 4.17:

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Published:

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(54) Title: A SEAFLOOR NODULE CONCENTRATING SYSTEM AND METHOD

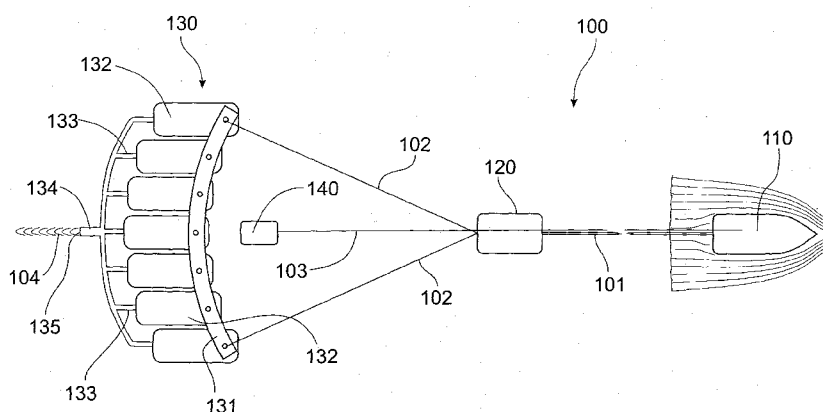


FIG. 1

(57) Abstract: A seafloor nodule concentrating system is disclosed. The seafloor nodule concentrating system has a surface vessel and an undersea steering vehicle secured to the surface vessel. The undersea steering vehicle is adapted to be towed by the surface vessel. The seafloor nodule concentrating system also has a nodule collecting apparatus connected to the undersea steering vehicle. The nodule collecting apparatus is located on the seafloor. The seafloor nodule concentrating system also has a position determination device adapted to determine the position of the nodule collecting apparatus and communicate position information of the nodule collecting apparatus to the undersea steering vehicle and surface vessel.



TITLE**A SEAFLOOR NODULE CONCENTRATING SYSTEM AND METHOD**FIELD OF THE INVENTION

The invention relates to a seafloor nodule concentrating system. The invention relates in particular, although not exclusively, to a system and method of mining mineral nodules located on the floor of the deep sea.

BACKGROUND OF THE INVENTION

In various locations in the ocean, and in particular in a large area in the central Pacific Ocean to the South of the Hawaiian Islands, polymetallic nodules exist in a muddy surface layer on the bottom of the deep sea. The size of the nodules varies from pebble size to fist size and generally lie in water depths of around 5000 metres.

Since the late 1970's, there have been various attempts to engineer a commercially viable solution to mine the nodules from the deep ocean seafloor.

One prior art solution is described in US Patent 4,042,279. This solution comprises a seafloor nodule recovery vehicle and an ore hoisting system to transport ore from the seafloor nodule recovery vehicle to a surface vessel.

The seafloor nodule recovery vehicle described in 4,042,279 is of a category of vehicles referred to as benthic sleds. Benthic sleds are typically unable to move under their own power nor do the sleds have the ability to steer. In the system described, the seafloor nodule recovery vehicle and associated ore hoisting system is towed along by the surface vessel and collects nodules from the seafloor adjacent an underside of the recovery vehicle. The nodules, in a slurry, are then pumped from the recovery vehicle to

the ore hoisting system, in this case a riser pipe.

The solution described in US Patent 4,042,279 has various disadvantages. Whilst the seafloor nodule recovery vehicle is effective enough in collecting the nodules from the seafloor and communicating the collected
5 nodules to the ore hoisting system, the seafloor nodule recovery vehicle is unable to steer to follow a predetermined path and tends to "snake" as it travels due mostly to drag on, and vortex shedding off, the riser pipe. This effect worsens with increased speed through the water.

In circumstances where the seafloor nodule recovery vessel is operating
10 in depths of around 5000 metres, this inability to maintain a desired path greatly reduces the recovery rate of nodules from the seafloor.

A further disadvantage of the system described in US Patent 4,042,279 is the cost associated with the surface vessel and the ore delivery system. The surface vessel needs to be large enough to have a riser system extending
15 towards the seafloor of a length sufficient to deliver the ore to the surface vessel.

The weight associated with a riser system of this scope is significant and thus the surface vessel needs to be of a size to carry that weight. This leads to very high operating costs in circumstances where the seafloor nodule recovery
20 vessel is only able to recover a relatively small amount of nodules in any given time period.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as

an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

OBJECT OF THE INVENTION

5 It is an object of the invention to overcome or at least alleviate one or more of the above problems and/or provide the consumer with a useful or commercial choice.

Other preferred objects of the present invention will become apparent from the following description.

SUMMARY OF THE INVENTION

10 In one form, although it need not be the only or indeed the broadest form, the invention resides in a seafloor nodule concentrating system comprising:

a surface vessel;

15 an undersea steering vehicle secured to the surface vessel, the undersea steering vehicle adapted to be towed by the surface vessel;

a nodule collecting apparatus connected to the undersea steering vehicle, the nodule collecting apparatus located on the seafloor; and

20 a position determination device adapted to determine the position of the nodule collecting apparatus and communicate position information of the nodule collecting apparatus to the undersea steering vehicle and surface vessel.

Suitably, the undersea steering vehicle is adapted to alter the direction of the nodule mining apparatus. Suitably, the undersea steering vehicle is

adapted to alter the direction of the nodule collecting apparatus in response to receiving position information of the nodule collecting apparatus from the position determination device.

In another form, the invention resides in a nodule collecting apparatus
5 comprising:

a support member;

two or more nodule collection devices, each nodule collection device
being secured to the support member and being adapted to collect ore nodules
from the seafloor adjacent an underside thereof and communicate those
10 nodules to an outlet pipe; and

a combined outlet pipe adapted to receive the collected ore nodules
from the outlet pipe of each nodule collection device and re-deposit the
collected nodules on the seafloor in the form of a windrow.

In still a further form, the invention resides in a seafloor mining method
15 including the steps of:

towing a nodule collecting apparatus behind a surface vessel along the
seafloor;

determining when the nodule collecting apparatus deviates from a
predetermined path;

20 altering the direction of the nodule collecting apparatus to return the
nodule collecting apparatus to the predetermined path.

Preferably, an undersea steering vehicle is disposed between the
surface vessel and the nodule collecting apparatus and is adapted to alter the
direction of the nodule mining apparatus.

Further features of the invention will become apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

To assist in understanding the invention and to enable a person skilled in the art to put the invention into practical effect, preferred embodiments of the invention will be described by way of example only with reference to the accompanying drawings, wherein:

FIG 1 shows a plan view of a schematic of a seafloor nodule concentrating system according to an embodiment of the invention;

FIG 2 shows a perspective view of a schematic of a seafloor nodule concentrating system according to an embodiment of the invention;

FIG 3A shows a plan view of a support member forming part of a seafloor recovery apparatus of the seafloor nodule concentrating system shown in FIG 1;

FIG 3B shows a plan view of an alternative support member forming part of a seafloor recovery apparatus of the seafloor nodule concentrating system shown in FIG 1;

FIG 3C shows a plan view of an alternative support member forming part of a seafloor recovery apparatus of the seafloor nodule concentrating system shown in FIG 1;

FIG 3D shows a plan view of an alternative support member forming part of a seafloor recovery apparatus of the seafloor nodule concentrating system shown in FIG 1; and

FIG 3E shows a plan view of an alternative support member forming part

of a seafloor recovery apparatus of the seafloor nodule concentrating system shown in FIG 1.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG 1 shows a plan view of a schematic of a seafloor nodule concentrating system 100 according to an embodiment of the invention and FIG 2 shows a perspective view of a schematic of the seafloor nodule concentrating system 100.

Seafloor nodule concentrating system 100 has a surface vessel 110, an undersea steering vehicle 120 secured to the surface vessel by way of line 101 and a nodule collecting apparatus 130 secured to the undersea steering vessel 120 by way of lines 102. Seafloor nodule concentrating system 100 further comprises a position determination device 140 secured to surface vessel 110 by way of line 103.

Surface vessel 110 is in the form of a boat, tug or ship. As mentioned previously, undersea steering vehicle 120 is connected to surface vessel 110 by way of line 101 in the form of a heavy duty tow cable or the like.

Undersea steering vehicle 120 is preferably in the form of a Remotely Operated Vehicle (ROV) as is known in the art. ROV's are used extensively in deep sea oil projects and are essentially submarines that are adapted to be operated remotely and/or are programmed to follow a predetermined course.

Undersea steering vehicle 120 is towed by surface vessel 110.

Nodule collecting apparatus 130 is connected to undersea steering vehicle 120 by way of lines 102. Undersea steering vehicle 120 is located proximal nodule collecting apparatus 130 and distal surface vessel 110. By

way of example, in circumstances where nodule collecting apparatus 130 is operating in 5000 metres of water, the distance between the surface vessel 110 and the nodule collecting apparatus 130 may be 8000 metres. On that distance, the undersea steering vehicle 120 is preferably positioned about 20 to
5 100 metres from the nodule collecting apparatus 130.

In the embodiment shown two static cables connect undersea steering vehicle 120 to nodule collecting apparatus 130. Alternative forms may include more cables or even a bridle of cables some of which may feature trim controls via hydraulics or mechanical levers mounted on undersea steering vehicle 120.

10 In the embodiment shown undersea steering vehicle 120 is suspended in the water several meters to tens of meters above the seabed. Alternative forms may connect the undersea steering vehicle 120 to the seabed via guiding wheels or skids.

In the embodiment shown, nodule collecting apparatus 130 comprises a
15 support member 131 having a plurality of nodule collection devices 132 secured thereto. In a preferred form, each nodule collection device is a benthic sled and functions as described in US Patent 4,042,279.

Each of lines 102 are attached to support member 131 at opposing ends thereof. In the embodiment, support member 131 is arcuate in shape having a
20 concave edge on a leading side thereof and a convex edge on a trailing edge as shown. The support member 131 is preferably in the form of a rigid beam. In a preferred form each nodule collection device 132 is secured to the support member 131 by way of a hinge or spring or the like.

Each nodule collection device 132 has an outlet pipe or hydraulic

conveyor 133 attached to an end thereof. Each outlet pipe or hydraulic conveyor 133 is adapted to receive nodules collected adjacent an underside of a respective nodule collection device and communicate those nodules to combined outlet pipe or hydraulic conveyor 134. In preferred form outlet pipe or hydraulic conveyor 133 is attached with a flexible linkage to nodule collection device 132 and outlet pipe or hydraulic conveyor 134 is attached with a flexible linkage to outlet pipe or hydraulic conveyor 133.

In another form outlet pipe or hydraulic conveyor 134 may be integrated or adjoined with support member 131.

Combined outlet pipe or hydraulic conveyor 134 is configured to output the nodules collected by each of the nodule collection devices 132 to the seafloor.

In preferred form water pressure to communicate the nodules along combined outlet pipe or hydraulic conveyor 134 is provided by forward motion of the seafloor concentration system through the water.

Position determination device 140 is connected to surface vessel 110 by way of tow line 103. In the embodiment, position determination device 140 is in the form of a surface towed transponder adapted to communicate with beacons (not shown) located on nodule collecting apparatus 130 to together form an Ultra Short Base Line acoustic position system as is known in the art. In this way, position determination device 140 is adapted to determine the position of nodule collecting apparatus 130 and communicate that position in order to assist in controlling the direction of undersea steering vehicle 120 as will be discussed in greater detail below.

In an alternative embodiment, position determination device 140 may be located on the undersea steering vehicle 120 or indeed on the nodule collecting apparatus 130 and may be in the form of an accelerometer, GNSS system or other similar position determination technology. In such an arrangement,
5 position determination device 140 functions to determine the position of nodule collecting apparatus 130 and communicate that position to undersea steering vehicle 120.

In use, surface vessel 110 tows all of underwater steering vessel 120, nodule collecting apparatus 130 and position determination device 140 along a
10 predetermined path to thereby mine nodules from the seafloor.

As nodule collecting apparatus 130 is towed along, drag on line 101 may cause it to snake as mentioned previously. Position detection device 140 is adapted to detect the position of nodule collecting apparatus 130 as previously discussed. As nodule collecting apparatus 130 moves off the predetermined
15 path, position detection device 140 communicates this event and also the details of that movement to underwater steering vessel 120. Underwater steering vessel 120 consequently adjusts course in order to move nodule collecting apparatus 130 back on to the predetermined path.

Consequently, the seafloor nodule concentrating system 100 of the
20 invention is able to provide for a deep water nodule recovery system that is able to effectively and efficiently recover nodules present on the seafloor by ensuring that recovery may be carried out following predetermined paths. In this way, acceptable amounts of nodules are not left on the seafloor and/or the seafloor mining apparatus is not being towed over seafloor that has already

been partly exploited.

As nodule collecting apparatus 130 is towed by the surface vessel 110 along the predetermined path on the seafloor, each of the nodule collection devices 131 collect nodules from the seafloor adjacent to the underside of each
5 nodule collection device and communicate the collected nodules to a respective outlet pipe 133 thereof.

As previously mentioned and in a preferred form, this collection occurs as described in US Patent 4,042,279 which is hereby incorporated by cross reference. In an alternative form, each nodule collection device may be in the
10 form of other types of benthic sleds.

Each of the outlet pipes 133 communicate the collected nodules to combined outlet pipe 134 which then deposits the collected nodules 104 on the seafloor.

As the seafloor mining apparatus tracks across the predetermined
15 pathway on the seafloor, it leaves behind it a windrow of collected nodules in a relatively narrow track as it travels. This then enables another vessel, equipped with an ore hoisting system connected by a tail line to a seafloor recovery apparatus, to lift and transport the collected nodules from seafloor to surface.

20 This process represents commercial benefits over the known methods of collecting as the large operating costs associated with employing a large vessel having an ore hoisting system attached thereto are used to collect a relatively larger volume of nodules per pass of the surface vessel at a more manageable speed.

FIGS 3A to 3E show plan views of alternative support members forming part of the nodule collecting apparatus 130.

Support member 231 shown in FIG 3A is formed from first support member 231A and second support member 2331B arranged at an angle to first support member 231A. In a preferred form that angle is around 90 degrees and support member 231A and 231B form a convex edge on a trailing edge of support member 231.

Support member 331 shown in FIG 3B is arcuate in shape and has a convex edge on a leading side thereof and a concave edge on a trailing edge.

Support member 431 shown in FIG 3C is formed from a linear member as shown.

Support member 131 shown in FIG 3D is as previously described.

Support member 531 shown in FIG 3A is formed from first support member 531A and second support member 5331B arranged at an angle to first support member 531A. In a preferred form that angle is around 90 degrees and support member 531A and 531B form a convex edge on a leading edge of support member 531.

Whilst the nodule collecting apparatus 130 is shown with a plurality of nodule collection devices 132, the system and method of seafloor mining 100 may employ a seafloor recovery apparatus that has a single nodule collection device 132, two collection devices 132 or more than two nodule collection devices 132.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a

stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

OBJECT OF THE INVENTION

1. A seafloor nodule concentrating system comprising:

a surface vessel;

an undersea steering vehicle secured to the surface vessel, the

5 undersea steering vehicle adapted to be towed by the surface vessel;

a nodule collecting apparatus connected to the undersea steering vehicle, the nodule collecting apparatus located on the seafloor; and

a position determination device adapted to determine the position of the nodule collecting apparatus and communicate position information of the nodule collecting apparatus to the undersea steering vehicle and surface vessel.

2. The seafloor nodule concentrating system of claim 1, wherein the undersea steering vehicle is adapted to alter the direction of the nodule collecting apparatus in response to receiving position information of the nodule collecting apparatus from the position determination device.

3. The seafloor nodule concentrating system of claim 1, wherein the undersea steering vehicle is located proximal the nodule collecting apparatus.

4. The seafloor nodule concentrating system of claim 1, wherein the undersea steering vehicle is in the form a remotely operated vehicle.

5. A nodule collecting apparatus comprising:

a support member;

two or more nodule collection devices, each nodule collection device being secured to the support member and being adapted to collect ore nodules from the seafloor adjacent an underside thereof and communicate those
5 nodules to an outlet pipe; and

a combined outlet pipe adapted to receive the collected ore nodules from the outlet pipe of each nodule collection device and re-deposit the collected nodules on the seafloor in a windrow.

10 6. The nodule collecting apparatus of claim 5, wherein the support member has a concave shape on a leading side thereof.

7. The nodule collecting apparatus of claim 6, wherein the support member has a convex shape on a trailing edge thereof.

15 8. The nodule collecting apparatus of claim 5, wherein the support member is arcuate in shape.

9. The nodule collecting apparatus of claim 5, wherein the support member is
20 in the form of a rigid beam.

10. The nodule collecting apparatus of claim 5, wherein the combined outlet pipe is in the form of a hydraulic conveyor.

11. The nodule collecting apparatus of claim 5, wherein the ore nodules are communicated along the outlet pipe of each nodule collection device, to the combined outlet pipe and redeposited in a windrow on the seafloor by the force
5 of water pressure created by forward motion of the nodule collecting apparatus.

12. A seafloor mining method including the steps of:

towing a nodule collecting apparatus behind a surface vessel along the seafloor;

10 determining when the nodule collecting apparatus deviates from a predetermined path;

altering the direction of the nodule collecting apparatus to return the nodule collecting apparatus to the predetermined path.

15 13. The seafloor mining method of claim 12, wherein an undersea steering vessel is disposed between the surface vessel and the nodule collecting apparatus and is adapted to alter the direction of the nodule mining apparatus.

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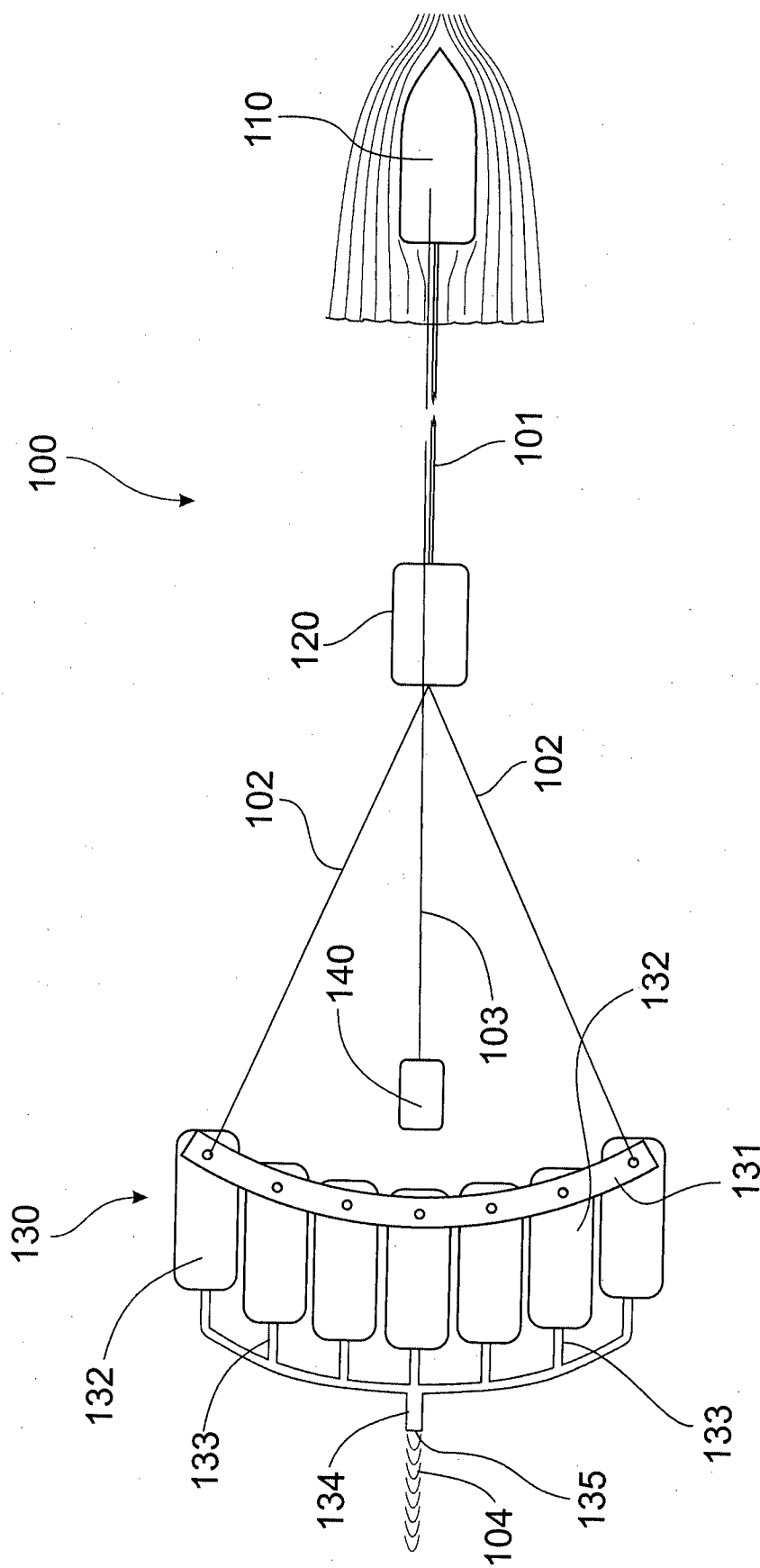
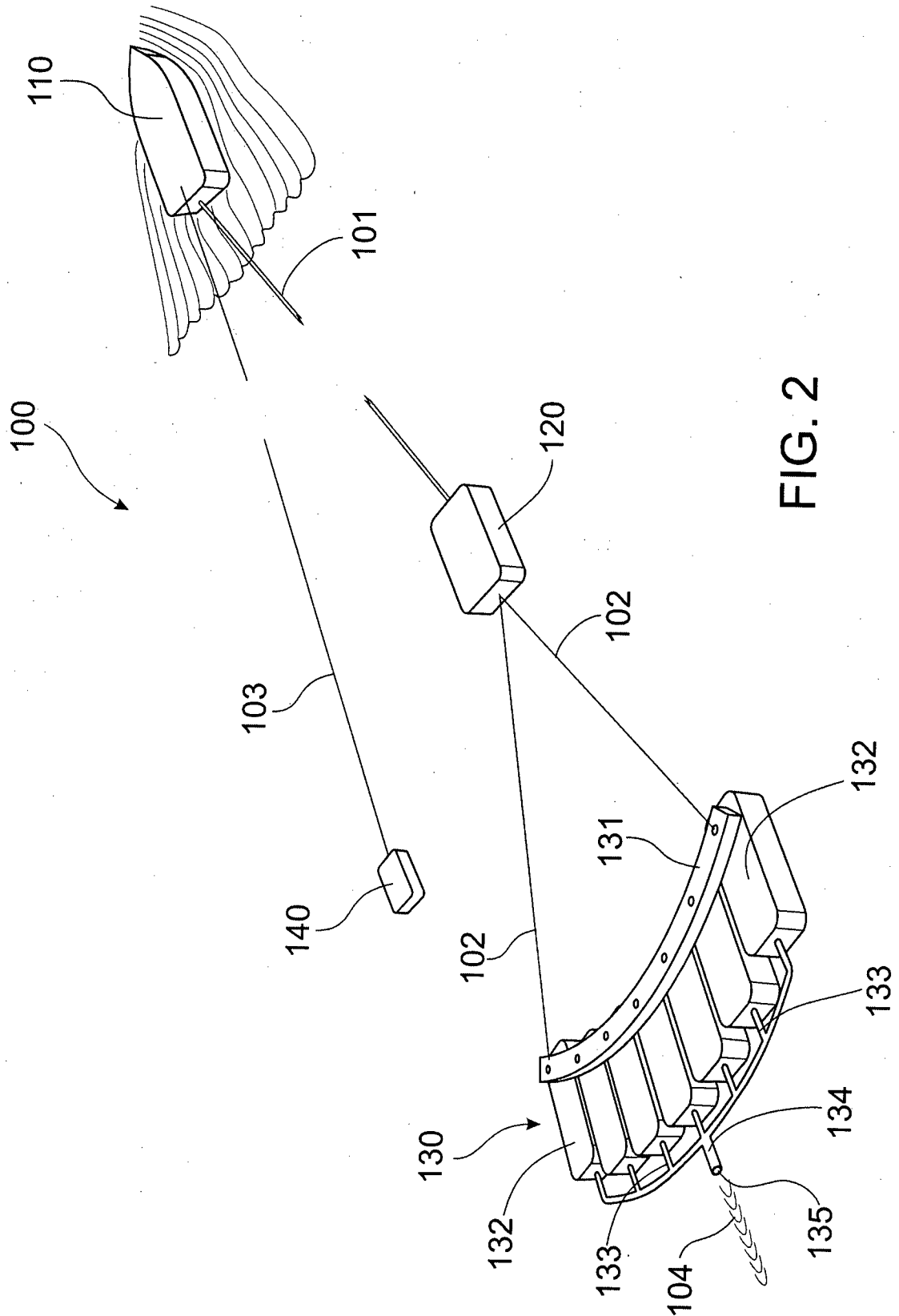


FIG. 1

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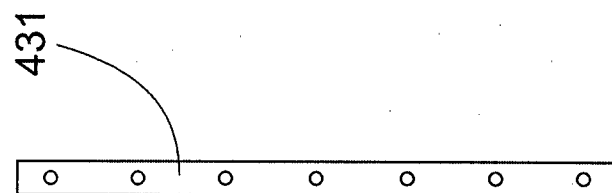


FIG. 3C

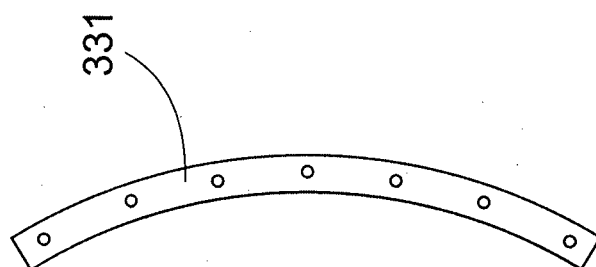


FIG. 3B

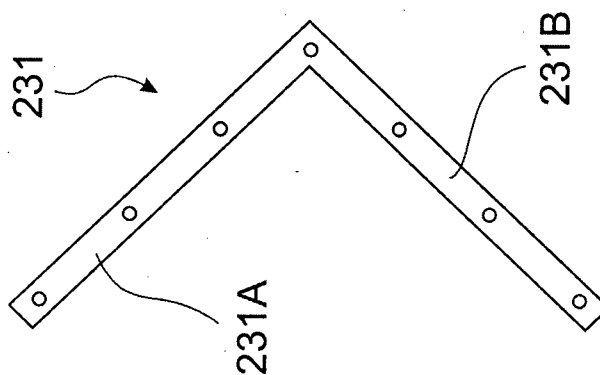


FIG. 3A

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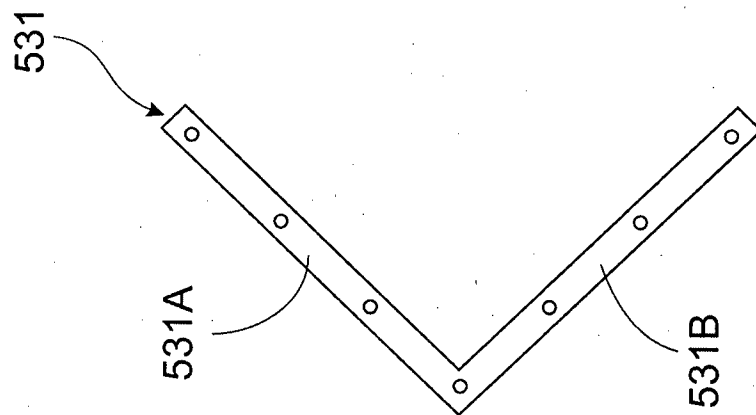


FIG. 3E

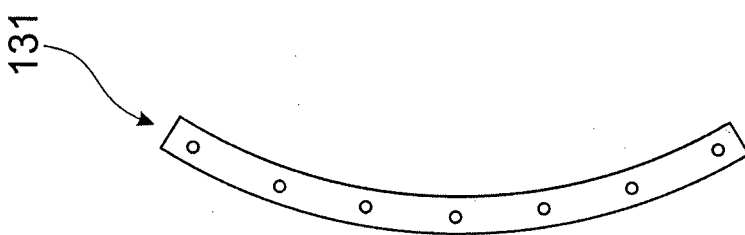


FIG. 3D

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/SG2014/000054

A. CLASSIFICATION OF SUBJECT MATTER

E02F 1/00 (2006.01) **E02F 3/04 (2006.01)** **E02F 3/88 (2006.01)** **E02F 5/00 (2006.01)** **E02F 7/00 (2006.01)**
E02F 9/00 (2006.01) **E21C 45/00 (2006.01)** **E21C 50/00 (2006.01)** **B63C 11/52 (2006.01)**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Database used: EPODOC, WPI, GOOGLE PATENTS and ESPACENET PATENT SEARCH

IPC and CPC Marks used: E02F1/00, E02F3/-, E02F5/-, E02F7/-, E02F9/-, E21C45/-, E21C50/- AND B63C11/52

Keywords used: ocean, seafloor, seabed, position, guidance, steer, windrow, redeposit, nodule, mining and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 1 May 2014	Date of mailing of the international search report 01 May 2014
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au Facsimile No.: +61 2 6283 7999	Authorised officer Adnan Ahmed AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832557

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/SG2014/000054
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4685742 A (MOREAU) 11 August 1987 Fig.1; column 3, lines 5-10, 21-26, 45-54; column 4, lines 36-40	12-13
Y	Fig.1; column 3, lines 5-10, 21-33, 45-59	1-4
X	US 4052800 A (FUHRBOTER et al.) 11 October 1977 Figs.1-5, claim 1	5-11
X	US 4232903 A (WELLING et al.) 11 November 1980 Abstract, Figs.1, 31-32	12
Y	Abstract; column 21, lines 37-39; Fig.33	1-4
A	US 4042279 A (ASAKAWA) 16 August 1977	

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-4 are directed to a seafloor nodule concentrating system. The features of a surface vessel, an undersea steering vehicle secured to and towed by the vessel and a position determination device, are specific to claims 1-4.
- Claims 5-11 are directed to a nodule collecting apparatus. The features of a support member, two or more nodule collection devices, each nodule collection device being secured to the support member and being adapted to collect ore nodules and communicate those nodules to an outlet pipe and a combined outlet pipe adapted to receive those collected nodules from the outlet pipe of each nodule collection device and re-deposit the nodules on the seafloor in a windrow, are specific to claims 5-11.
- Claims 12-13 are directed to a seafloor mining method. The features of the steps of a towing a nodule collecting apparatus behind a surface vessel, determining when the nodule collecting apparatus deviates from a predetermined path and altering the direction of the nodule collecting apparatus to return the nodule collecting apparatus to the predetermined path, are specific to claims 12-13.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is 'a nodule collecting apparatus'.

However this feature does not make a contribution over the prior art because it is disclosed in:

US 4042279 A (ASAKAWA) 16 August 1977.

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/SG2014/000054	
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