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(71) Applicant(s)
Nexus Capital Ltd

(72) Inventor(s)
Zinn, Michael Trevor;Woods, Quinton Encombe;Buys, Petrus Hendrik

(74) Agent / Attorney
Shelston IP Pty Ltd., Level 21, 60 Margaret Street, Sydney, NSW, 2000

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(71) Applicant: **SMART APPLICATIONS LIMITED** [CN/CN]; 12th Floor, Lockhart Road, Wanchai, Hong Kong 00852 (CN).

(71) Applicant *(for VC only)*: **DE BEER, Deon** [ZA/ZA]; 495 Summit Road, Monrningside, 2128 Johannesburg (ZA).

(72) Inventors: **ZINN, Michael Trevor**; 22 The Ring str, Lynnwood, 0081 Pretoria (ZA). **WOODS, Quinton Encombe**; 53 Kyalami Crest, Whisken ave, Crowthorne, 1682 Johannesburg (ZA). **BUYS, Petrus Hendrik**; 39 Lorraine Street, 1034 Witbank (ZA).

(74) Agent: **DE BEER, Deon**; Dessington de Beer Attorneys, PO Box 1238 Rivonia, 2128 Johannesburg (ZA).

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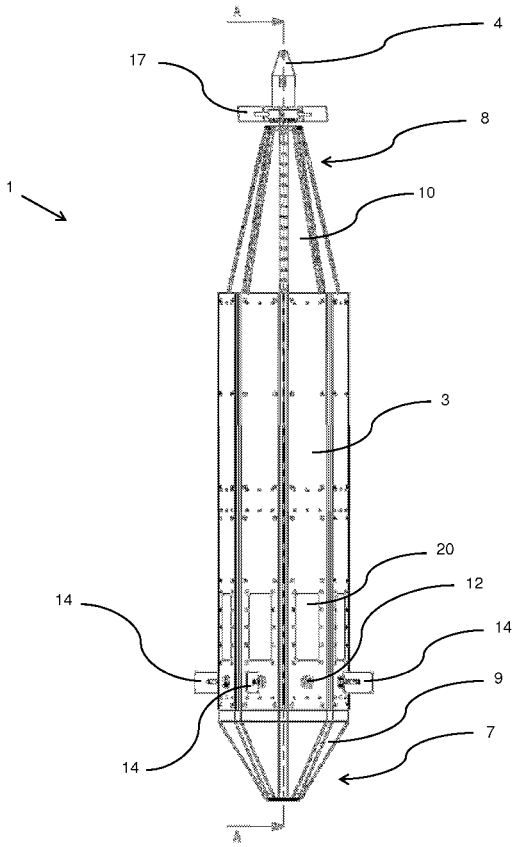

FIGURE 1

(57) Abstract: The invention relates to an inspection and repair module for an internal side wall of a vertically erected structure, with the module including a carrier for supporting at least one data recording mechanism and being securable to a hoist, and for an inspection and repair module for an internal wall of a conduit with the module including propulsion means comprising a set of driven tracked wheels controllable by a controller carried by the carrier and configured to provide, within a conduit, longitudinal forward and reverse motion.

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INSPECTION AND REPAIR MODULE

Field of the Invention

This invention relates to an inspection and repair module for industrial applications.

Background of the Invention

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

Many industrial processes operate at conditions that are harmful to humans. Such processes include infrastructure that require constant monitoring to ensure optimal performance and prevent dangerous conditions from developing.

Such infrastructure includes, for example, smoke stacks, pipes, ducting, shafts, ladles (for molten metal and the like), and raw mineral ore silos.

Apart from the dangerous operating conditions the physical size of the infrastructure also poses challenges to its inspection and repair. Typically when such infrastructure is inspected a partial or full shutdown of the associated equipment and processes is required. For example, when a power plant smoke stack is conventionally inspected there cannot be any smoke passing through the smoke stack. For its inspection people have to access the inside of the smoke stack to manually inspect the brick work of the smoke stack and detect any problem areas. Any repairs are then done at the same time.

Such an inspection and repair process requires a shutdown of the smoke stack, which puts it out of service for at least one or two days. Even if no problems are found during the inspection which may require repair, the smoke stack is still out of service for a relatively long time.

At a time when energy demand is continuously increasing and the cost of building new plants is extensive and in some instances prohibitive, any unnecessary loss of availability of a smoke stack is a significant problem.

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In respect of other industries downtime of processes and equipment due to routine inspection and repair also has a significant impact on the availability of such equipment.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative. It is an object of as especially preferred form of the invention to provide an inspection and repair module which at least partly overcomes the abovementioned problem/s.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

Although the invention will be described with reference to specific examples it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

Summary of the Invention

According to a first aspect of the present invention there is provided an inspection module for inspecting an internal side wall of a vertical structure, comprising any one of smoke stack, cooling tower or chimney; the module including a carrier for supporting a controller with an associated power source, a cover that is abrasion resistant and insulated against heat transfer that substantially surrounds and seals the carrier against the environment within the structure it is inspecting, and rotational stabilising means comprising a plurality of pivotally adjustable rudders extending from the module, a sensing gyroscope configured to measure rotation of the module around its longitudinal axis and which is connected to the controller to relay rotational movement measurements to the controller, and a steering gyroscope configured to effect rotation of the module around its longitudinal axis and which is connected to the controller for control of the steering gyroscope in response to measurements from the sensing gyroscope, and with the controller further configured to control the operation of at least one data recording mechanism which includes at least one laser range finder configured to determine the distance from the module to an internal side wall of the vertical structure in which the module is deployed to inspect and to relay distance

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measurements to the controller, with the module including communication means in the form of a radio transceiver that is configured for communication with a radio transceiver operated remotely by an operator and which forms part of a remote controller for controlling the inspection module, wherein the inspection module is configured to receive input from the data recording mechanism and transmit the input using the communication means to the remote controller, and the module is securable to a hoist.

According to a second aspect of the present invention there is provided an inspection system for inspecting an internal side wall of a vertical structure comprising a module as defined according to the first aspect of the present invention, a remote controller with an associated power source remotely located from the module configured to communicate through the communication means with the module controller to control the operation of the data recording mechanism, and a hoist with a cable secured to the hook of the module and a hoist controller to controllably lower and raise the module within the structure, for inspection thereof through operation of the data recording mechanism, and preferably a movable support securable over a rim of a side wall of a vertical structure in which the module is deployed for inspecting it, the support including drive means to controllably move the support around the rim.

According to a third aspect of the present invention there is provided an inspection module for inspecting an internal wall of a conduit, the module including a carrier for supporting a controller with an associated power source, with the controller to control the operation of at least one data recording mechanism which includes at least one laser range finder configured to determine the distance from the module to an internal side wall of a conduit in which the module is deployed to inspect and to relay distance measurements to the controller, and propulsion means comprising a set of driven tracked wheels controllable by a controller carried by the carrier and configured to provide, within a conduit, longitudinal forward and reverse motion, the data recording mechanism including at least one laser range finder which is configured to determine the distance from the module to an internal side wall of an internal side wall of a conduit in which the module is deployed to inspect and to relay distance measurements to the controller, with the module further including communication means in the form of a radio transceiver that is configured for communication with a radio transceiver operated remotely by an operator and which forms part of a remote

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controller for controlling the inspection module, wherein the inspection module is configured to receive input from the data recording mechanism and transmit the input using the communication means to the remote controller.

According to a fourth aspect of the present invention there is provided an inspection system for inspecting an internal wall of a conduit comprising an inspection module as defined according to the third aspect of the present invention, a remote controller with an associated power source remotely located from the module configured to communicate through communication means, which preferably comprises an electrical or wireless communication link between the remote controller and the module controller, to control the operation of the data recording mechanism and motion of the module within the conduit.

According to a fifth aspect of the present invention there is provided a method of internally inspecting a side wall of a vertical structure comprising securing suspension means on a rim of the structure, suspending an inspection module as defined according to the first aspect of the present invention from the suspension means, lowering the module into the structure and recording images of the side wall of the structure using a data recording mechanism carried by the module, and directing the module out of the structure, preferably the method including one or both of:

a. receiving at a remote control unit connected to and in communication with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control instructions to the module; and
b. directing the module to a part of the internal side wall thereof to be repaired, and operating repair apparatus to repair the designated repair site.

According to a sixth aspect of the present invention there is provided a method of internally inspecting an internal wall of a conduit comprising directing an inspection module as defined according to the third aspect of the present invention into the conduit, and recording images of the wall of the conduit using a data recording mechanism carried by the module, and directing the module out of the structure, preferably the method including one or both of:

a. receiving at a remote control unit connected to and in communication

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with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control instructions to the module; and

b. directing the module to a part of the internal side wall thereof to be repaired, and operating the repair apparatus to repair the designated repair site.

In accordance with this invention there is provided an inspection module for inspecting an internal side wall of a vertically erected structure, the module including a carrier for supporting at least one data recording mechanism and being securable to a hoist.

There is further provided for the module to be securable to the hoist by means of a hook for a cable at an operatively upper end of the module.

There is further provided for the module to include a controller with an associated power source, with the power source preferably carried by the frame, alternatively remotely located from the module and electrically connected to the module, with the controller configured to control the operation of the data recording mechanism.

There is also provided for the data recording mechanism to include at least one recording device comprising a camera, preferably a plurality of cameras, configured to record images, preferably video, of the surroundings of the module, operatively recording images of the internal side wall of a vertically erected structure in which the module is deployed to inspect.

There is further provided for the data recording mechanism to include one or more or a combination of high definition, thermal imaging, infra-red cameras, and multi quantifying cameras, operatively for use in optical surface inspection and making use of defect detection technology associated with the module.

There is further provided for the data recording mechanism to be carried by a collar rotatably secured to the carrier, preferably including at least one light associated with the data recording mechanism, more preferably a high lux light providing light in excess of 1 100 lux.

There is still further provided for the data recording mechanism to include one or more of a sonar and ultra-sound wall thickness probe, and preferably for the wall thickness probes to also include associated lights.

There is further provided for the module to include communication means comprising at least a data signal transmitter, more preferably a data signal transmitter and receiver, alternatively data input and output ports accessible by means of cables having complimentary plugs, the cable preferably being heat and chemically shielded which is connected to the controller.

There is also provided for the module to include data storage means, carried by the carrier for storage of data recorded by the data recording mechanism.

There is still further provided for the data recording mechanism to include remote distance determination equipment, preferably in the form of a plurality of laser range finders, and further preferably for each of these range finders to be secured proximate a camera alternatively integrated with a camera, and configured to determine, preferably continuously, the distance from the module to an internal side wall of a vertically erected structure in which the module is deployed to inspect, and to relay such distance measurements to the controller.

There is further provided for the module to comprise an elongate body with a circular cylindrical shape having a longitudinal axis extending from its operative top to its operative bottom, and for the module to include at least four range finders, equidistantly spaced around the circumference of the module and directed radially away from its longitudinal axis, and further preferably also a range finder located in the front end of the module aligned with the longitudinal axis and directed to the front end of the module, and which is configured to determine the distance to a base of a vertically erected structure in which the module is deployed for inspection and to relay distance measurements to the controller.

There is further provided for the body to include a cover substantially surrounding the entire carrier, preferably comprised of a set of panels removably securable around the carrier, and further preferably for the cover panels to be sealed over the module.

There is further provided for the module to include a pressurised gas source associated with it, preferably an inert gas, and a pressure sensor connected to the controller to determine the

gas pressure within the module and to control the gas source to release gas to maintain a predetermined gas pressure within the module.

There is further provided for the cover to include observation apertures covered with heat and abrasion resistant and heat transfer insulated transparent shields over the data recording mechanism devices and range finders.

The invention further provides for the module to include lighting means for its surroundings, preferably associated with the data recording mechanism devices; and further preferably for a light to be located proximate each camera and directed through the transparent shield proximate each data recording mechanism devices.

According to an alternative feature of the invention the module is provided with a series of equidistantly spaced apart stationary circumferential lights, preferably high lux lights each providing light in excess of 1100 lux, and more preferably for the lights to be arranged in a collar located adjacent to the data recording mechanism, and most preferably for a light collar to be located above and below the data recording mechanism.

The invention further provides for the module to include rotational stabilising means, preferably including a plurality of pivotally adjustable rudders extending from the module, the rudders being equidistantly spaced apart around the circumference of the module, and further preferably for the module to include four rudders.

There is further provided for the rotational stabilising means to include a set of two gyroscopes, a first of which comprises a steering gyroscope and a second of which comprises a sensing gyroscope.

There is further provided for the steering gyroscope to be configured to effect rotation of the module around its longitudinal axis, and for the sensing gyroscope to be configured to measure rotation of the module around its longitudinal axis and relay this measurement to the controller, and for the controller to be configured to control the operation of the steering gyroscope in response to measurements from the sensing gyroscope.

There is further provided for the stabiliser to comprise a magnetic stabiliser.

According to a further feature of the invention there is provided for the power source to comprise a battery, preferably a lithium ion battery pack, carried by the frame.

There is further provided for the module to be provided with a set of rotatable blades secured to a shaft for rotational stability of the module, which preferably extends from the operative top end of the module, and further preferably for the shaft to be connected to a generator, operatively connected to the battery operatively to charge the battery upon rotation of the shaft by the blades as a result gas flow over the blades.

According to a still further feature of the invention there is provided for the module to include attachment means for repair apparatus comprising a turret from which a nozzle rotatably and pivotally extends, the nozzle being in fluid communication with a pressurised supply of fluidic repair material, and further for the repair apparatus operatively to be connectable to the controller for control thereby.

There is further provided for the module to include a closable port configured to receive a feed pipe secured to the supply of fluidic repair material, and for the port to be removably connectable to the nozzle of the repair module, preferably by means of a fluid conduit contained within the module.

There is further provided for the fluidic repair material to comprise one or more of gunite, shotcrete, sprayable concrete, water, blasting grit and compressed air, and still further for the repair apparatus to include a rotatable and pivotable welding torch.

The invention also provides for the cover of the module to be at least partly removable to expose attachment means for the repair apparatus, including a mounting bracket and a fluid conduit connector, and preferably for the repair apparatus to include a cover complementary to the remainder of the cover of the module with the removable portion removed.

According to a yet further feature of the invention there is provided for the module to include propulsion means, including one or more of a hoist control and a set of driven tracked wheels, controllable by the controller and configured to provide propulsion of the module within a structure, and preferably, within a conduit, longitudinal forward and reverse motion by means of traction provided by the tracked wheels, and within a substantially vertical structure up and down hoisting.

There is further provided for each set of tracked wheels to be secured to an extension from the carrier, and for the tracked wheels to be arranged longitudinally in line with the central axis of the module, for a plurality of sets of tracked wheels to be equidistantly spaced around the module, and preferably for the module to include four sets of tracked wheels.

There is further provided for each wheel set to be extendable between retracted and extended positions, and for the extension to be controlled by the controller.

There is further provided for the wheel sets to be provided with pressure and extension sensors, measuring the extent and pressure with which each wheel set is extended towards and against a surface, and for these pressure and extension measurements to be relayed to the controller to control the extent and pressure to which with each wheel set is extended to ensure sufficient traction between the tracked wheels on each wheel set and the surface against which it is extended and to control the alignment of the module within a conduit the module is deployed to inspect, and further preferably for this module to also be configured to receive a repair module as defined above.

In accordance with a further feature of the invention there is provided an inspection and repair system comprising an inspection and repair module as defined above, a remote controller, and a hoist with a cable securable to the cable attachment means of the module.

There is further provided for the system to include a carriage securable to a rim of circular structure to be inspected, for the carriage to include drive means to controllably move the carriage around the rim and a hoist controller to controllably lower and raise the module within the structure.

According to a still further feature of the invention there is provided a method of internally inspecting a side wall of a vertically erected structure comprising securing suspension means on a rim of the structure, suspending an inspection module as defined above from the suspension means, lowering the module into the structure and recording images of the side wall of the structure using a data recording mechanism carried by the module, and directing the module out of the structure.

There is further provided for the method to include receiving at a remote control unit connected to and in communication with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control

instructions to the module, and preferably for the suspension means to comprise a hoist with a hoist control operable by the remote controller.

The invention further provides a method of internally inspecting an internal wall of a conduit comprising directing an inspection module having tracked wheels as defined above into the conduit, and recording images of the wall of the conduit using a data recording mechanism carried by the module, and directing the module out of the structure.

There is further provided for the method to include receiving at a remote control unit connected to and in communication with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control instructions to the module.

There is still further provided for the method to include directing the tracked-wheel module to a part of the internal wall of a conduit to be repaired, and operating the repair apparatus to repair the designated repair site.

There is further provided for the structure to comprise a smoke stack, cooling tower, chimney, or pipe.

These and other features of the invention are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention is described by way of example only and with reference to the accompanying drawings in which:

Figure 1	is a side elevation of a first embodiment of an inspection module according to the invention;
Figure 2	is rear perspective view of the module of Figure 1;
Figure 3	is a sectional view of the module of Figure 1;
Figure 4	shows detail C from Figure 3;
Figure 5	shows detail A from Figure 2;
Figure 6	shows detail D from Figure 3;
Figure 7	shows detail E from Figure 3;

Figure 8 shows detail F from Figure 3;
Figure 9 shows detail G from Figure 3; and
Figure 10 shows detail H from Figure 3.

DETAILED DESCRIPTION OF THE INVENTION

An inspection module (1) according to the invention for use in inspecting a power plant smoke stack is shown in its most basic form in the drawings. The module (1) is designed to be lowered into a smoke stack of a power plant from an overhead hoist. The module (1) may be lowered in close proximity to the side wall of the smoke stack to inspect the inner surface thereof. The hoist (not shown) is secured to a support carriage that is movable around the circumference of the smoke stack rim (not shown), thus allowing the entire smoke stack inner surface to be inspected.

The module (1) comprises a carrier (2) carrying a cover (3) and cable attachment pulley (4), with an internal power supply in the form of a lithium ion battery (5) that is connected to a controller (6) secured to the carrier (2) of the module (1).

The module (1) has a right circular cylindrical shape and has two tapered ends, namely a bottom end (7) and a top end (8). The ends (7, 8) form part of the cover (2) and includes two separate removable covers (9, 10), secured to the carrier (2) of the module (1). The pulley (4) is secured to a cable (not shown) that extends through the top cover (10) from attachment points on the carrier (2).

The shape of the module (1) makes it streamlined, the purpose of which will be discussed further on.

The module (1) also includes communication means in the form of a radio transceiver that is in communication with a radio transceiver (not shown) operated remotely by an operator (not shown), and which forms part of a remote controller (not shown).

The controller (6) is also connected to a data recording mechanism (11) and the communication means. The controller (6) is configured to receive input from data recording mechanism (11) and transmit the input by means of the communication means to the remote transceiver. The controller (6) includes data storage means (not shown) which allows for data received by the data recording mechanism (11) to also be stored on-board the module (1),

which is useful as backup in the event that the radio communication is unreliable (which is possible in certain types of structures depending on the materials they are made from).

The data recording mechanism (11) in this basic embodiment it includes a set of cameras (12) and infra-red distance gauges (not shown). The cameras (12) include high definition, thermal imaging cameras, infra-red cameras and multi quantifying cameras. The bottom end (7) of the module is also provided with an infra-red distance gauge (not shown) which determines the distance of the module (1) above the base of a structure that is inspected by it. This allows for accurately controlled lowering of the module (1) within a smoke stack to prevent it from hitting the ground. It also allows for very accurate height determinations to be done of areas within the smoke stack, i.e. on the smoke walls, that are observed to be in need of repair. With known axial orientation and height above the ground, the module can be removed and returned to the exact same spot if required.

The cameras (12) and infra-red distance gauges are mounted on a platform (13) which is secured to the carrier (2). The cameras are also provided with integral LED lights (not shown), and together with the cameras (12), these are equidistantly spaced apart around the module (1). Each high intensity light has an intensity of above 1100 lux.

The cameras (12), infra-red distance gauges and lights are located behind transparent heat resistant shields (20) in the cover (3), which protects them against heat, dust and abrasion and still allows them to capture high definition images and video of the inside of a smoke stack.

The module (1) also includes stabilisers in the form of a set of rudders (14), which is located just behind its front end (7) (which is also the lower end whilst in operation and which faces any gas flow in a smoke stack). Each of the rudders (14) in the set is electrically operable to rotate around a shaft to which it is mounted. These rudders (14) may in use be rotated to a specific orientation with respect to the module (1) to control unwanted rotational movement of the module (1) around its central axis, which may result from gas blowing over the module (1) through a smoke stack. The rudders (14) are used to counter a substantially constant force typically resulting from uneven gas flow in a smoke stack.

The stabilisers further include a set of two gyroscopes (15, 16), a first of which comprises a steering gyroscope (15) and a second of which comprises a sensing gyroscope (16).

The steering gyroscope (15) is configured to effect rotation of the module (1) around its longitudinal axis, and the sensing gyroscope (16) configured to measure rotation of the module around its longitudinal axis and relay this measurement to the controller (6). The controller (6) then uses this data to control the operation of the steering gyroscope (15) to achieve rotational movement of the module (1) around its longitudinal axis or to maintain it in a certain position whilst under force of for example flow of gas over it. The gyroscopes (15, 16) are useful in countering fluctuating forces resulting from sudden changes in gas flow and also for deliberate steering of the module (1).

The module (1) further includes a set of propeller blades (17) at its operative top end (8), which is rotatably secured to a shaft (18) which extends into the module (1). The shaft (18) is connected to a generator (19), which is configured to generate electricity to charge the battery (5). When the module is used in a smoke stack that is still in operation there will be gas flow over it, which will drive the propellers (17) to rotate the shaft (18). This thus generates electricity which is useful to keep the batteries (5) charged, enabling the module (1) to be operated for longer missions.

In use, as discussed above in part already, the module (1) is suspended from a hoist which is secured to a support carriage on the rim of a smoke stack. The module (1) is then lowered into the smoke stack for inspection thereof. The lowering of the module (1) up and down the smoke stack and the movement around its rim are remotely controlled by the operator.

The module controller receives input representing the images captured by the various cameras (12) and distance measurements from the infra-red distance gauges, and transmits this back to the remote controller by means of radio transmission. The radio transmission is received by the remote controller and the images displayed to the operator on a display screen associated with the remote controller. The data stream is processed and analysed and the results presented to the operator. The data relating to the images may also be processed and analysed to provide more information to the operator than what is possible by the visuals alone.

When it becomes necessary for repairs to be performed the module (1) is moved to the top of the stack and swung into an accessible position. The bottom cover (9) is removed and repair apparatus (not shown) is secured to attachment points on the carrier of the module (1). The repair module includes a rotatable and pivotable turret. The turret includes a nozzle that extends from it.

A feed pipe is connected to the module (1) in its top cover (10), into a closable port (not shown). The port (not shown) is connected through the module (1) with the nozzle (not shown). The pipe (not shown) is connected at its other end to a pressurised fluidic repair material supply. This repair material varies depending on the type of repair that is required, and can include any one or more of gunite, shotcrete, sprayable concrete, water, and compressed air.

As mentioned the turret (not shown) is rotatable and pivotable with respect to the central axis of the module (1). The movement of the turret (not shown) is controlled by the stabilisers, which include the gyroscopes (15, 16) and rudders (14) module controller, which in turn is controlled by means of radio frequency by the remote controller. The gyroscopes (15, 16) are also used to counter forces resulting from the operation of the repair apparatus.

This enables the operator to remotely control the nozzle (not shown), allowing him to remotely apply any of the various fluidic repair materials. For example, if an area inside the smoke stack is worn it may be cleaned with water, dried with compressed air, and rebuilt with gunite, shotcrete or sprayable concrete.

When the repair work in one area is done the module (1) may be moved to another area for similar or different repairs.

The above repairs are done when the smoke stack is out of operation.

However, it is possible and desirable to conduct the same whilst the smoke stack is fully operational. This is done by stabilising the module against influence of gas flow through the smoke stack, and insulating and chemically shielding the module and its components against the damaging effects of the gasses, which is done by pressuring the interior of the module with inert gas.

By making use of the module according to the invention it is possible to provide an inspection and repair service of a smoke stack, whilst it is operational. The module is intrinsically safe. It has no flammable liquids or gasses on board and is grounded by means of the supporting cable against static electricity. In addition, the pressurised interior of the module prevents the ingress into the module of gasses that may be present in a structure that is serviced. This

protects the module and also isolates the electrical components of the module against such gasses.

It will be appreciated that the embodiments described above are given by way of example only and are not intended to limit the scope of the invention.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An inspection module for inspecting an internal side wall of a vertical structure, comprising any one of smoke stack, cooling tower or chimney; the module including a carrier for supporting a controller with an associated power source, a cover that is abrasion resistant and insulated against heat transfer that substantially surrounds and seals the carrier against the environment within the structure it is inspecting, and rotational stabilising means comprising a plurality of pivotally adjustable rudders extending from the module, a sensing gyroscope configured to measure rotation of the module around its longitudinal axis and which is connected to the controller to relay rotational movement measurements to the controller, and a steering gyroscope configured to effect rotation of the module around its longitudinal axis and which is connected to the controller for control of the steering gyroscope in response to measurements from the sensing gyroscope, and with the controller further configured to control the operation of at least one data recording mechanism which includes at least one laser range finder configured to determine the distance from the module to an internal side wall of the vertical structure in which the module is deployed to inspect and to relay distance measurements to the controller, with the module including communication means in the form of a radio transceiver that is configured for communication with a radio transceiver operated remotely by an operator and which forms part of a remote controller for controlling the inspection module, wherein the inspection module is configured to receive input from the data recording mechanism and transmit the input using the communication means to the remote controller, and the module is securable to a hoist.

2. A module according to claim 1, in which the stabilising means includes one or more of:
    a. a magnetic stabiliser; and
    b. a set of rotatable blades secured to a shaft that extends from the operative top end of the module.

3. A module according to claim 1 or claim 2, in which the shaft is connected to a generator connected to the battery operatively to charge the battery upon rotation of the shaft by the blades as a result of gas flowing over the blades.

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4. A module according to any one of the preceding claims, which includes a plurality of equidistantly spaced apart range finders, in which preferably the, or each, range finder is secured proximate a camera, alternatively integrated with a camera, and/or in which the, or each, range finder continuously relays distance measurements to the controller and/or in which the power source comprises a battery, preferably a lithium ion battery pack, carried by the carrier.

5. A module according to any one of the preceding claims, which has an elongate body with a circular cylindrical cross section and having a longitudinal axis extending from its operative top to its operative bottom and which includes a laser range finder in the operatively bottom end of the module aligned with the longitudinal axis and directed away from the operatively bottom end of the module and which is configured to determine the distance to a base of a vertical structure in which the module is deployed for inspection and to relay distance measurements to the controller.

6. A module according to any one of the preceding claims, in which the data recording mechanism includes at least one recording device comprising a camera, preferably a plurality of cameras, configured to record images of the surroundings of the module, operatively recording images, preferably video images, of the internal side wall of a vertical structure in which the module is deployed to inspect, and wherein more preferably:.
    a. the or each camera comprises one or more or a combination of high definition, thermal imaging, infra-red cameras, and multi quantifying cameras, operatively for use in optical surface inspection and making use of defect definition technology associated with the module; and/or
    b. In which the data recording mechanism includes any one or more of sonar, ultrasound, electromagnetic and depth detection devices.

7. A module according to any one of the preceding claims, including one or more of the following:
    a. the data recording mechanism being carried by a collar rotatably secured to the carrier;
    b. at least one light associated with the data recording mechanism;

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c. a plurality of lights arranged in collars located, preferably above and below, the data recording mechanism;
d. the data recording mechanism devices being directed radially away from the longitudinal axis of the module towards the internal side wall of the vertical structure in which the module is deployed to inspect; and
e. data storage means carried by the carrier for storage of data recorded by the recording mechanism.

8. A module according to any one of the preceding claims, wherein the radio transceiver comprises a data signal transmitter and receiver, and/or data input and output ports accessible by means of cables having complimentary plugs, wherein the cable which is connected to the controller is preferably heat and chemically shielded.

9. A module according to any one of the preceding claims, which includes a pressurised gas source associated with it, preferably an inert gas source, and a pressure sensor connected to the controller to determine gas pressure within the module and to control the gas source to release gas to maintain a predetermined gas pressure within the module.

10. A module according to any one of the preceding claims, in which the cover includes observation apertures covered with transparent shields over the data recording mechanism devices.

11. A module according to claim 1, in which the rudders are located proximate the operative bottom end of the module, and preferably the module includes four rudders.

12. A module according to any one of the preceding claims, which includes attachment means for repair apparatus comprising a turret from which a nozzle rotatably and pivotally extends, the nozzle being in fluid communication with a pressurised supply of fluidic repair material, and the repair apparatus is operatively connected to the controller for control thereby.

13. A module according to claim 12, which includes one or more of the following:

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a. a closable port configured to receive a feed pipe secured to the supply of fluidic repair material, and the port is removably connectable to the nozzle, and/or the port is connectable to the nozzle by means of a fluid conduit contained within the module;

b. the fluidic repair material comprising one or more of gunite, shotcrete, sprayable concrete, water, blasting grit and compressed air; and

c. at least part of the cover of the module is removable to expose attachment means for the repair apparatus, including a mounting bracket and of a fluid conduit connector, and/or a rotatable and pivotable welding torch.

14. An inspection system for inspecting an internal side wall of a vertical structure comprising a module as defined according to any one of the preceding claims, a remote controller with an associated power source remotely located from the module configured to communicate through the communication means with the module controller to control the operation of the data recording mechanism, and a hoist with a cable secured to the hook of the module and a hoist controller to controllably lower and raise the module within the structure, for inspection thereof through operation of the data recording mechanism, and preferably a movable support securable over a rim of a side wall of a vertical structure in which the module is deployed for inspecting it, the support including drive means to controllably move the support around the rim.

15. An inspection module for inspecting an internal wall of a conduit, the module including a carrier for supporting a controller with an associated power source, with the controller to control the operation of at least one data recording mechanism which includes at least one laser range finder configured to determine the distance from the module to an internal side wall of a conduit in which the module is deployed to inspect and to relay distance measurements to the controller, and propulsion means comprising a set of driven tracked wheels controllable by a controller carried by the carrier and configured to provide, within a conduit, longitudinal forward and reverse motion, the data recording mechanism including at least one laser range finder which is configured to determine the distance from the module to an internal side wall of an internal side wall of a conduit in which the module is deployed to inspect and to relay distance

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measurements to the controller, with the module further including communication means in the form of a radio transceiver that is configured for communication with a radio transceiver operated remotely by an operator and which forms part of a remote controller for controlling the inspection module, wherein the inspection module is configured to receive input from the data recording mechanism and transmit the input using the communication means to the remote controller.

16. A module according to claim 15, which includes a plurality of equidistantly spaced apart range finders, in which preferably the, or each, range finder is secured proximate a camera, alternatively integrated with a camera, and/or in which the, or each, range finder continuously relays distance measurements to the controller and/or in which the power source comprises a battery, preferably a lithium ion battery pack, carried by the carrier.

17. A module according to claim 15 or claim 16, which includes a plurality of sets of tracked wheels, preferably four sets, secured to an extension from the carrier and equidistantly spaced around the module, each set of tracked wheels arranged longitudinally in line with a longitudinal axis of the module.

18. A module according to claim 17, in which each wheel set is provided with pressure and extension sensors, configured to measure the extent and pressure with which each wheel set is extended towards and against a surface within a conduit the module is deployed to inspect, and the pressure and extension measurements are relayed to the controller to control the extent and pressure to which each wheel set is extended from the carrier to ensure sufficient traction between the tracked wheels on each wheel set and the surface against which it is extended for controlled forward and backwards motion and to control the alignment of the module within the conduit.

19. A module according to any one of claims 15 to 18, in which the data recording mechanism includes at least one recording device comprising a camera, preferably a plurality of cameras, configured to record images, preferably video images, of the surroundings of the module, operatively recording images of an internal side wall of a conduit in which the module is deployed to inspect, and wherein more preferably:

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a. the or each camera comprises one or more or a combination of high definition, thermal imaging, infra-red cameras, and multi quantifying cameras, operatively for use in optical surface inspection and making use of defect definition technology associated with the module; and/or

b. In which the data recording mechanism includes any one or more of sonar, ultrasound, electromagnetic and depth detection devices.

20. A module according to any one of claims 15 to 19, including one or more of the following:

a. the data recording mechanism being carried by a collar rotatably secured to the carrier;

b. at least one light associated with the data recording mechanism;

c. a plurality of lights arranged in collars located, preferably above and below, the data recording mechanism;

d. the data recording mechanism devices being directed radially away from the longitudinal axis of the module towards the internal side wall of the vertical structure in which the module is deployed to inspect; and

e. data storage means carried by the carrier for storage of data recorded by the recording mechanism.

21. A module according to any one of claims 15 to 20, wherein the radio transceiver comprises a data signal transmitter and receiver, and/or data input and output ports accessible by means of cables having complimentary plugs, wherein the cable which is connected to the controller is preferably heat and chemically shielded.

22. A module according to any one of claims 15 to 21, which has an elongate body with a circular cylindrical cross section and having a longitudinal axis extending from its operative front to its operative rear, and in which the data recording mechanism devices are directed radially away from the longitudinal axis of the module towards the internal side wall of a conduit in which the module is deployed to inspect.

23. A module according to any one of claims 15 to 22, which includes a cover that is insulated against heat transfer that substantially surrounds and seals the carrier

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against the environment within the conduit it is inspecting.

24. A module according to any one of claims 15 to 23, in which the module includes a pressurised gas source associated with it, preferably an inert gas source, and a pressure sensor connected to the controller to determine gas pressure within the module and to control the gas source to release gas to maintain a predetermined gas pressure within the module.

25. A module according to claim 23 or claim 24, in which the cover includes observation apertures covered with transparent shields over the data recording mechanism devices.

26. A module according to any one of claims 15 to 25, which includes attachment means for repair apparatus comprising a turret from which a nozzle rotatably and pivotally extends, the nozzle being in fluid communication with a pressurised supply of fluidic repair material, and the repair module is connectable to the controller for control thereby.

27. A module according to claim 26, which includes one or more of the following:
    a. a closable port configured to receive a feed pipe secured to the supply of fluidic repair material, and the port is removably connectable to the nozzle, and/or the port is connectable to the nozzle by means of a fluid conduit contained within the module;
    b. the fluidic repair material comprising one or more of gunite, shotcrete, sprayable concrete, water, blasting grit and compressed air; and
    c. at least part of the cover of the module is removable to expose attachment means for the repair apparatus, including a mounting bracket and of a fluid conduit connector, and/or a rotatable and pivotable welding torch.

28. An inspection system for inspecting an internal wall of a conduit comprising an inspection module as defined according to any one of claims 15 to 27, a remote controller with an associated power source remotely located from the module configured to communicate through communication means, which preferably comprises an electrical or wireless communication link between the remote

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controller and the module controller, to control the operation of the data recording mechanism and motion of the module within the conduit.

29. A method of internally inspecting a side wall of a vertical structure comprising securing suspension means on a rim of the structure, suspending an inspection module as defined according to any one of claims 1 to 13 from the suspension means, lowering the module into the structure and recording images of the side wall of the structure using a data recording mechanism carried by the module, and directing the module out of the structure, preferably the method including one or both of:
    a. receiving at a remote control unit connected to and in communication with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control instructions to the module; and
    b. directing the module to a part of the internal side wall thereof to be repaired, and operating repair apparatus to repair the designated repair site.

30. A method of internally inspecting an internal wall of a conduit comprising directing an inspection module as defined according to any one of claims 15 to 27 into the conduit, and recording images of the wall of the conduit using a data recording mechanism carried by the module, and directing the module out of the structure, preferably the method including one or both of:
    a. receiving at a remote control unit connected to and in communication with the module data feedback from the recording mechanism relating to the structure, and providing directional and rotational stability control instructions to the module; and
    b. directing the module to a part of the internal side wall thereof to be repaired, and operating the repair apparatus to repair the designated repair site.

Dated this 2nd day of December 2016

Shelston IP

Attorneys for: Nexis Capital Inc.

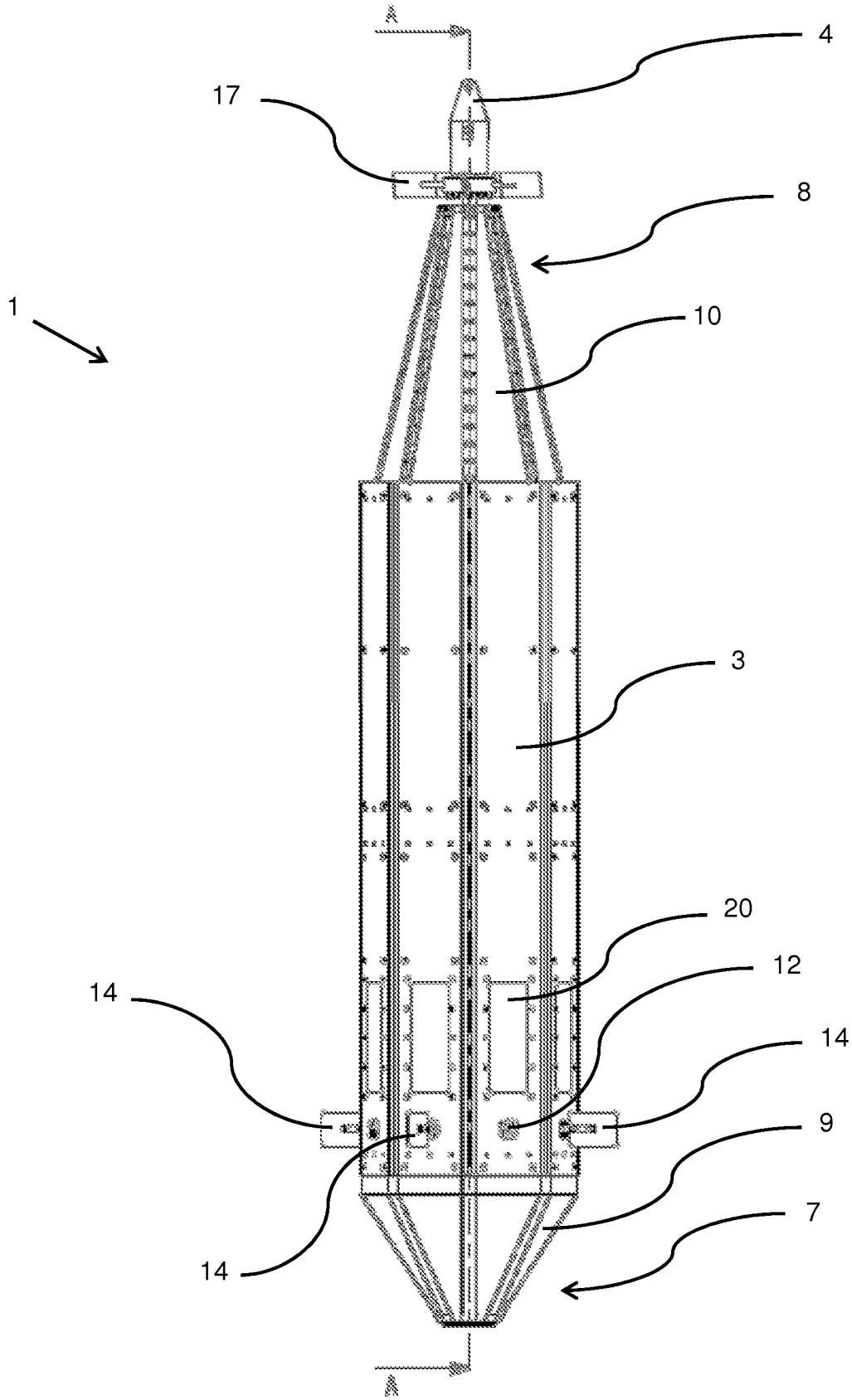


FIGURE 1

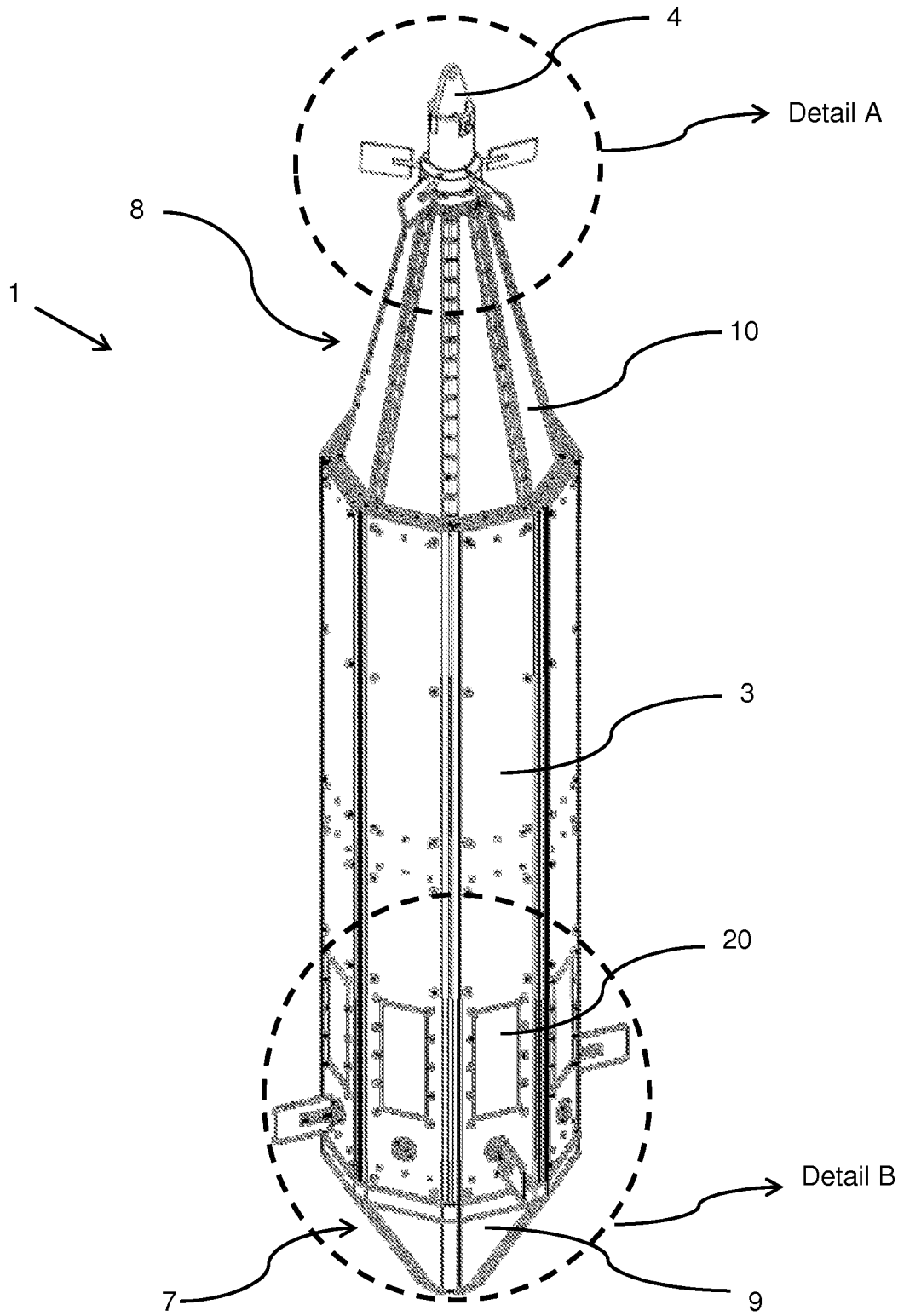
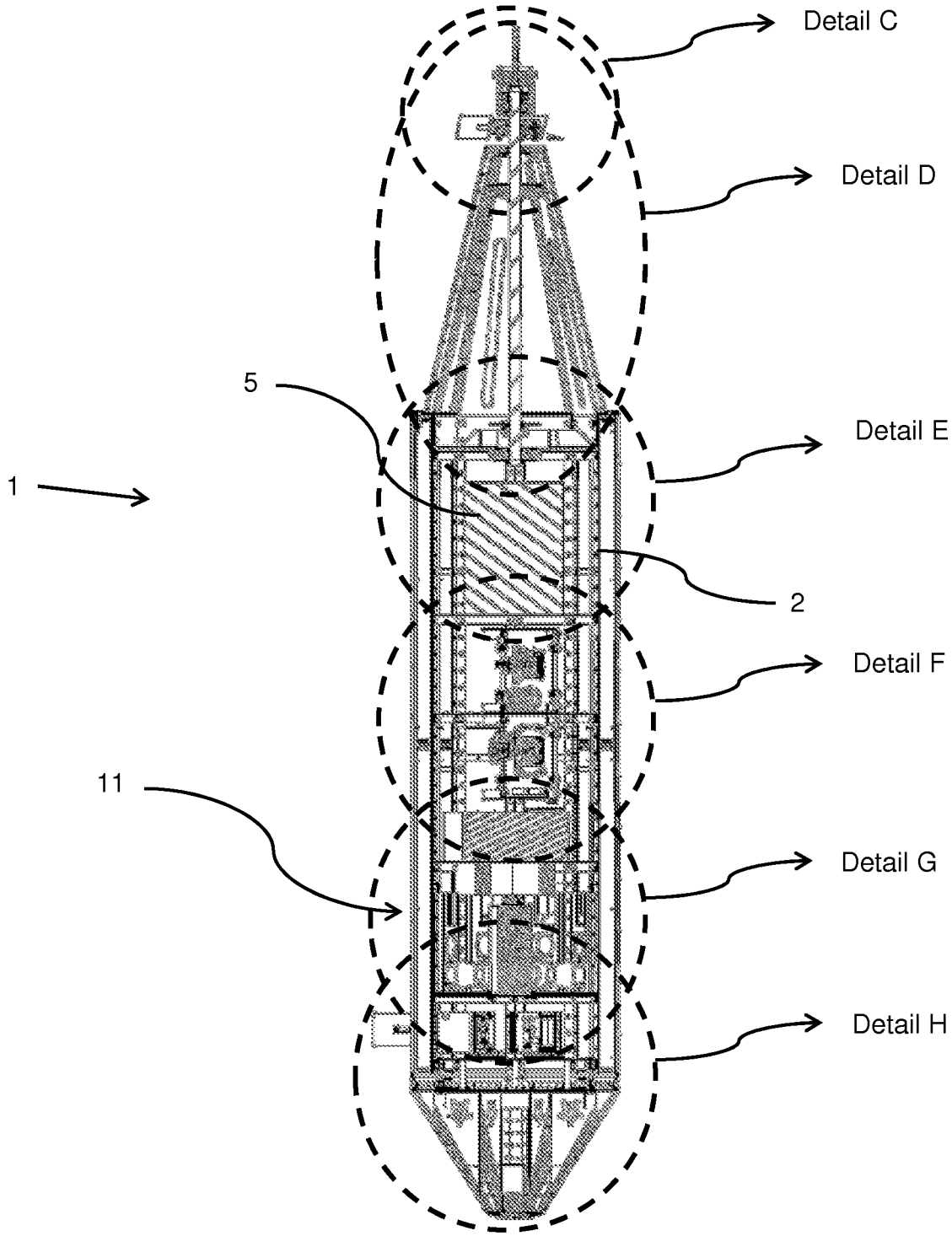


FIGURE 2



SECTION A-A

FIGURE 3

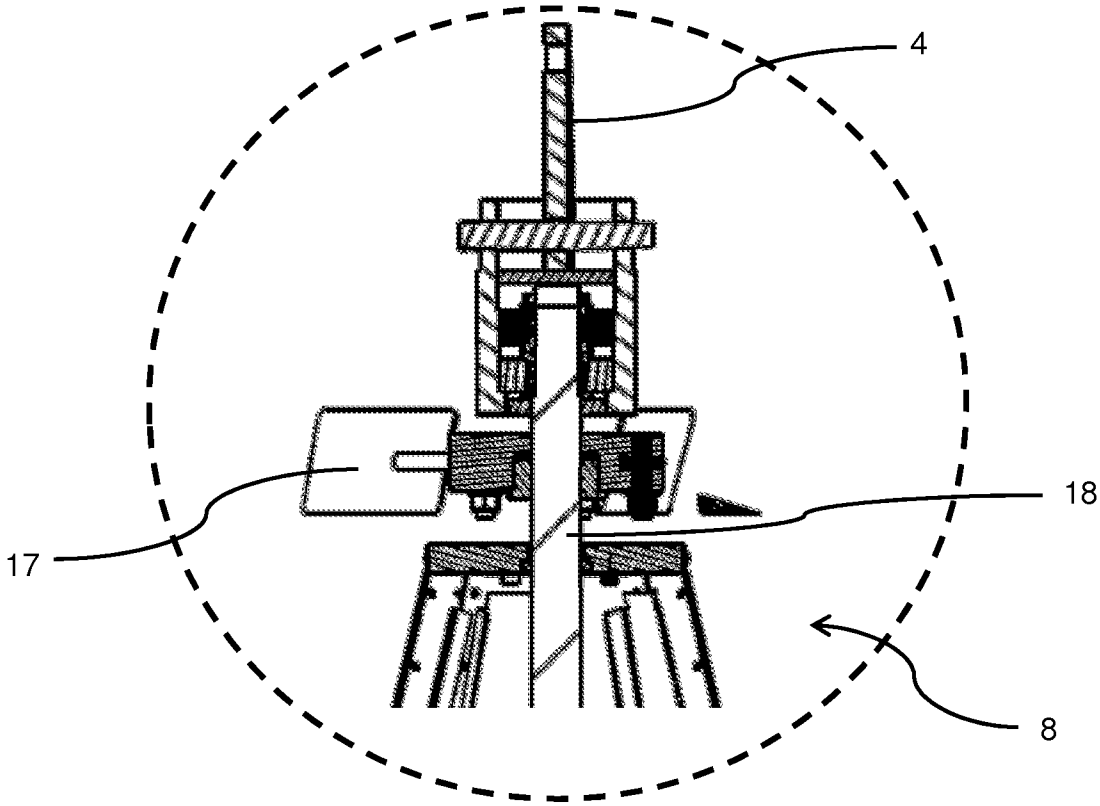


FIGURE 4

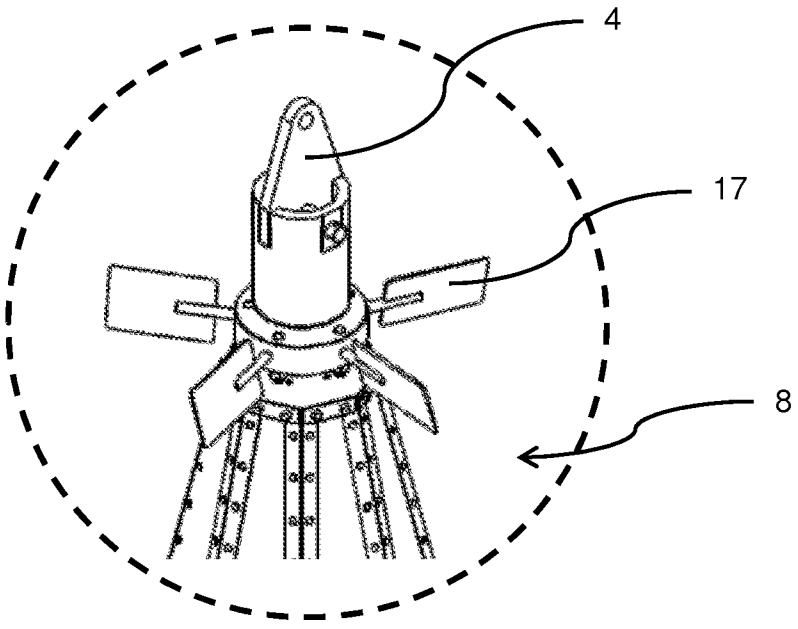


FIGURE 5

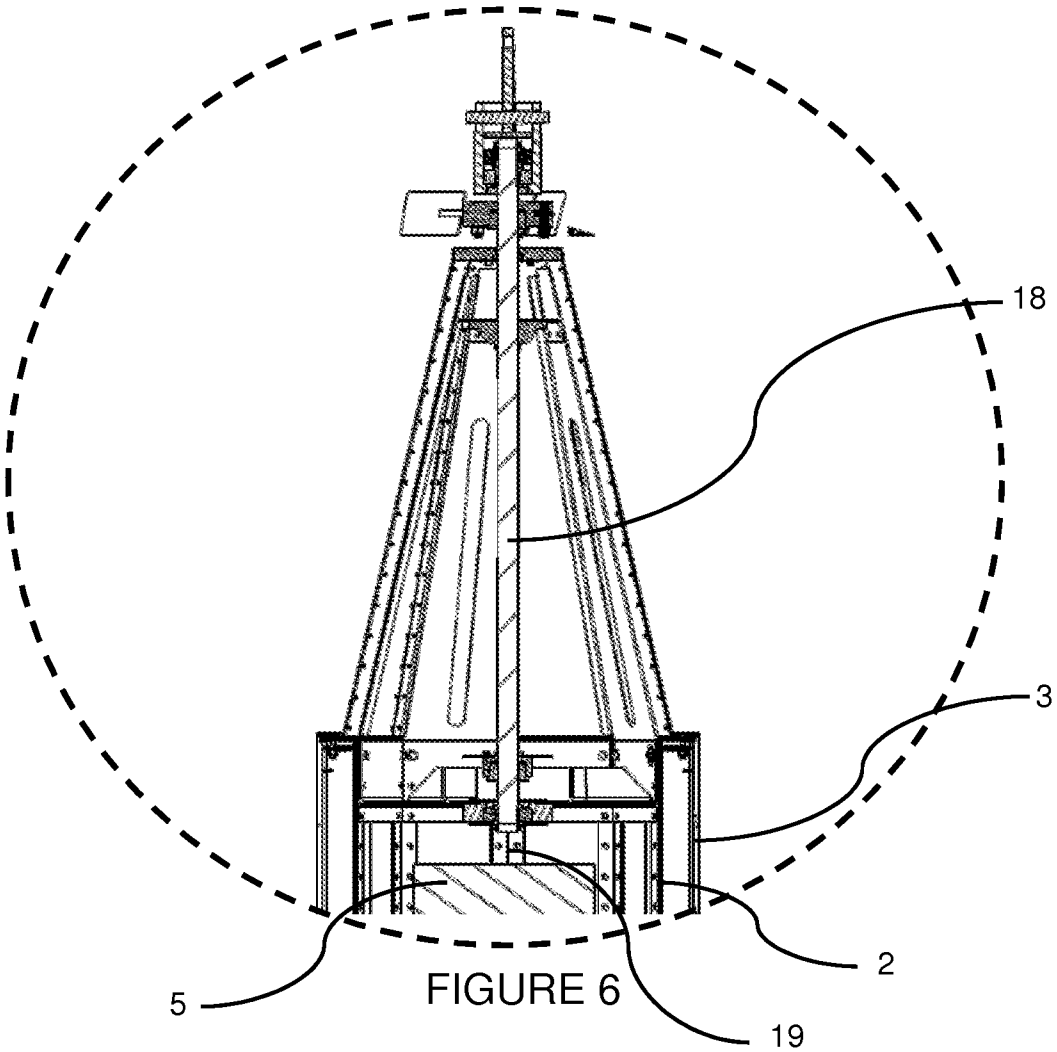


FIGURE 6

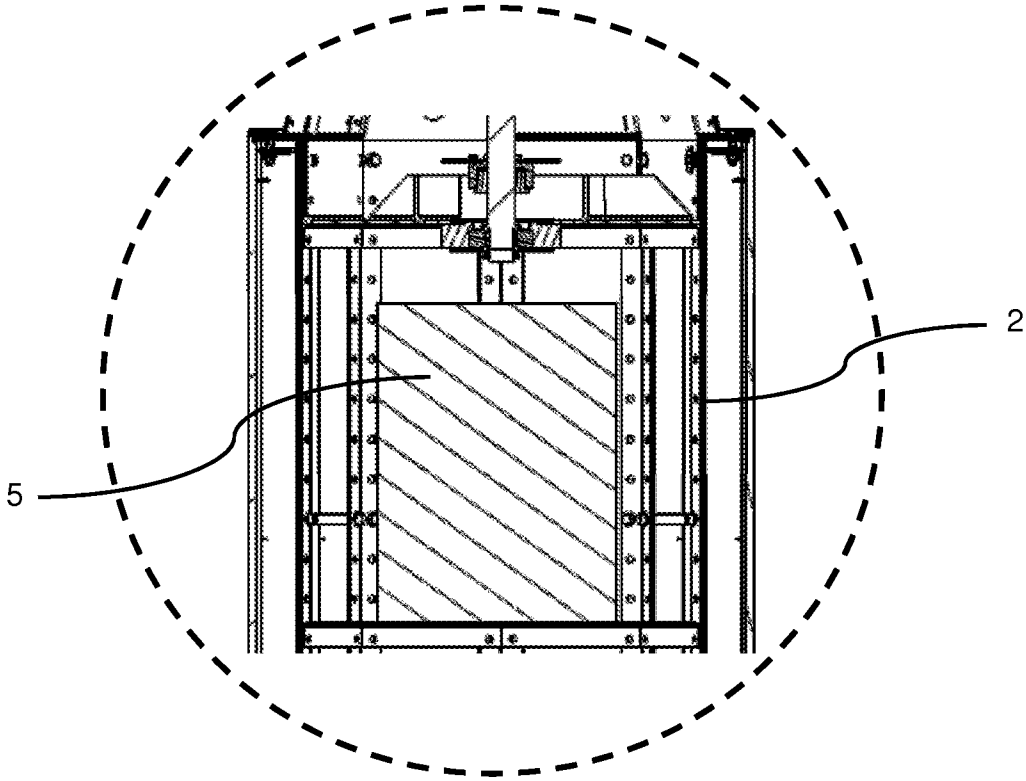


FIGURE 7

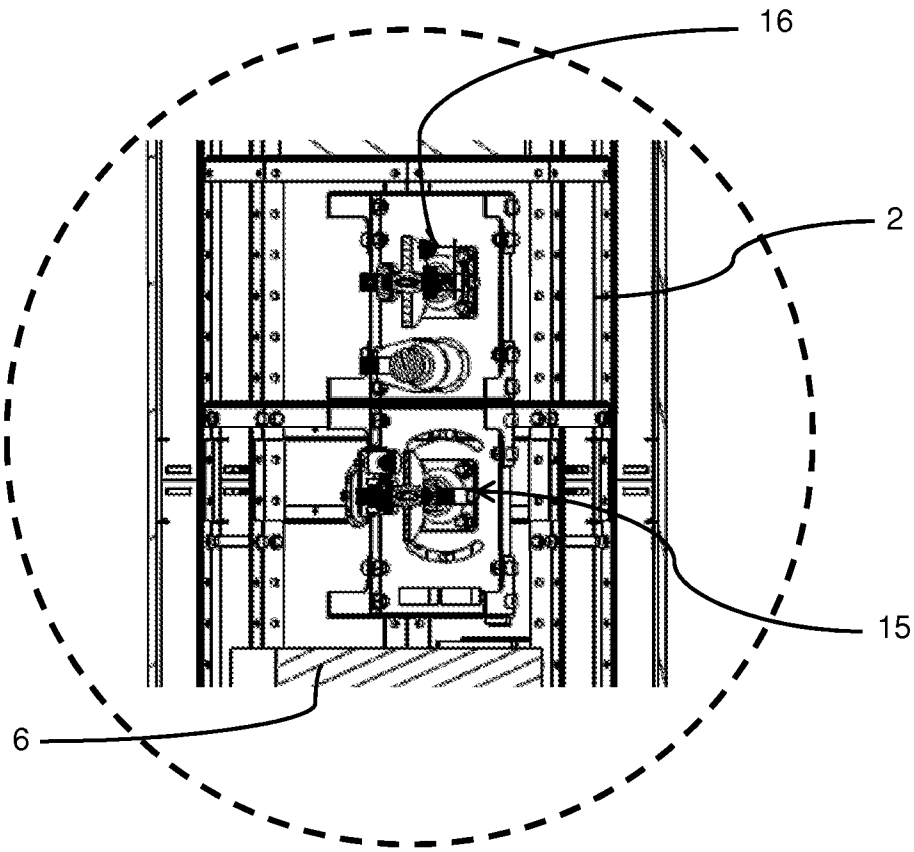


FIGURE 8

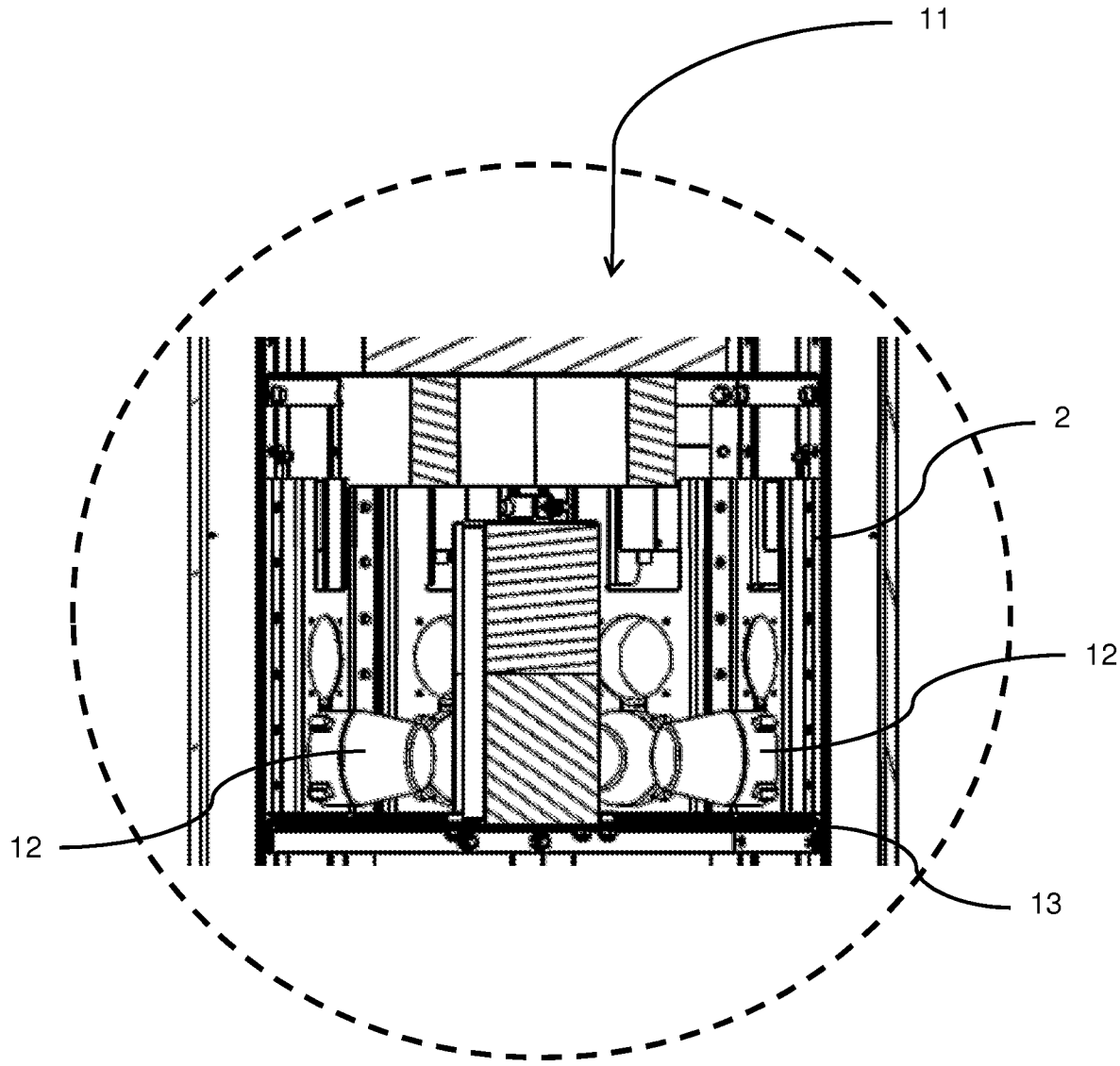


FIGURE 9

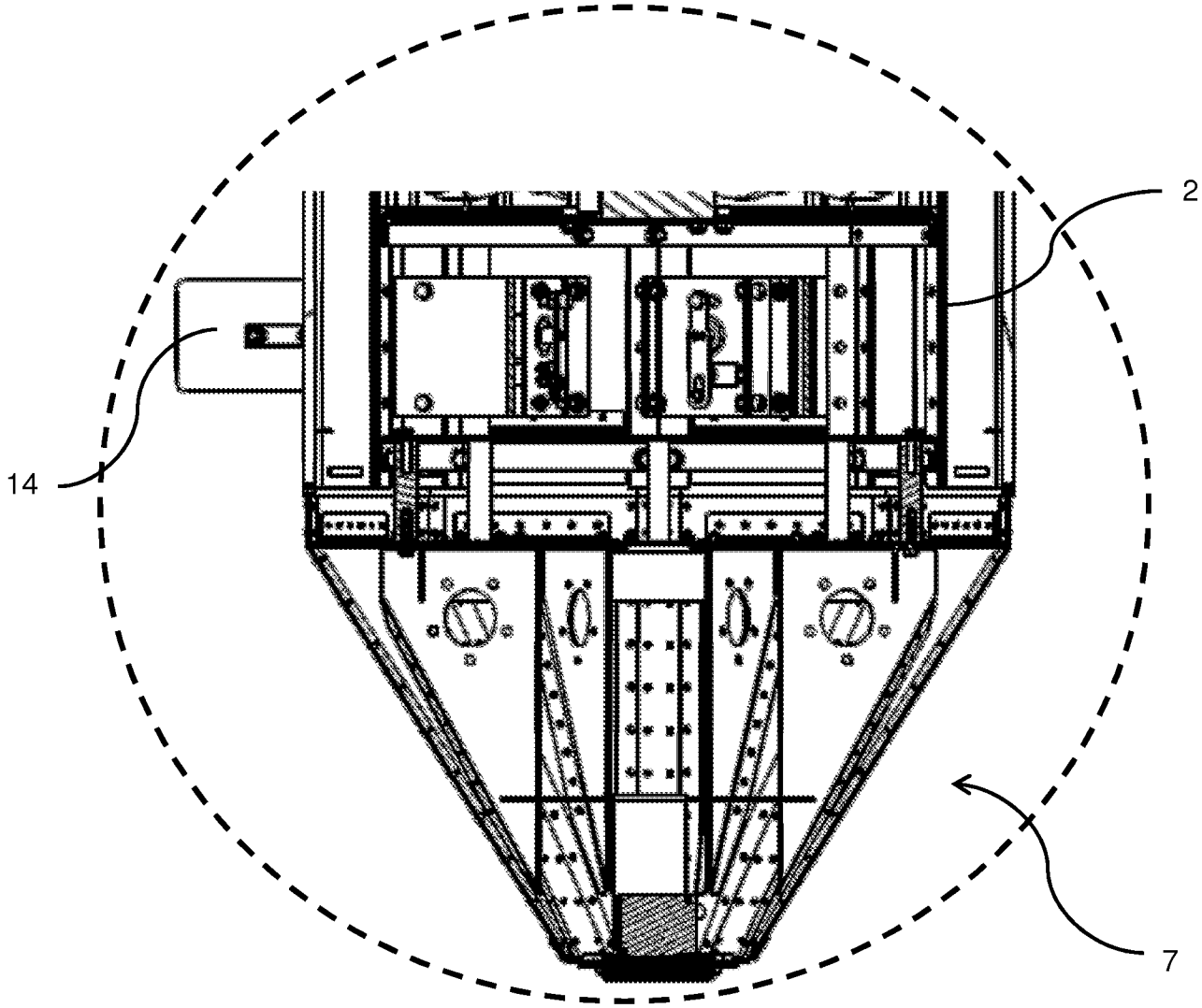


FIGURE 10

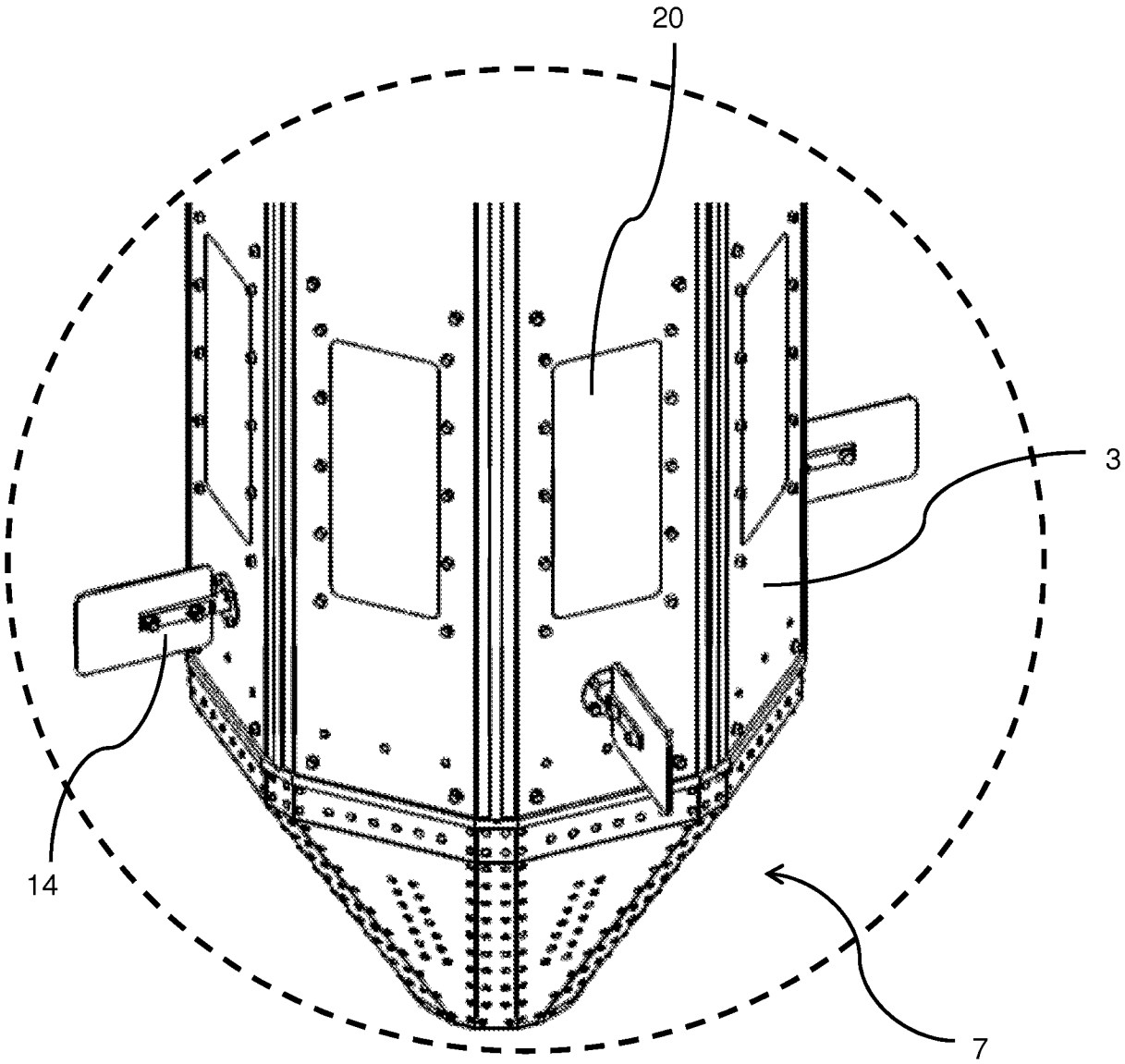


FIGURE 11