Jan. 27, 1970 J. DELACOUR ET AL 3,491,842

APPARATUS FOR UNDERWATER DRILLING AND CORING LOOSE SEDIMENTS

Filed May 6, 1968 4 Sheets-Sheet 1

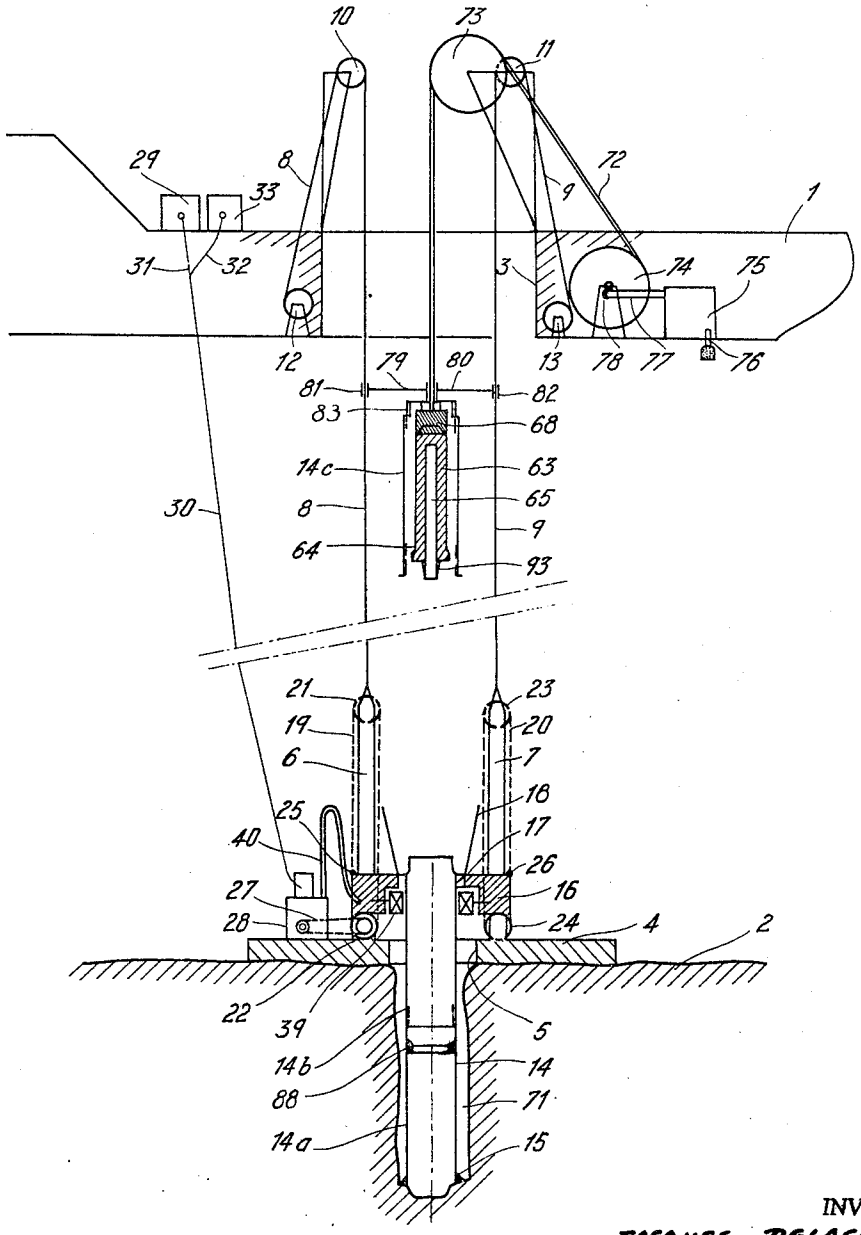

Fig. 1

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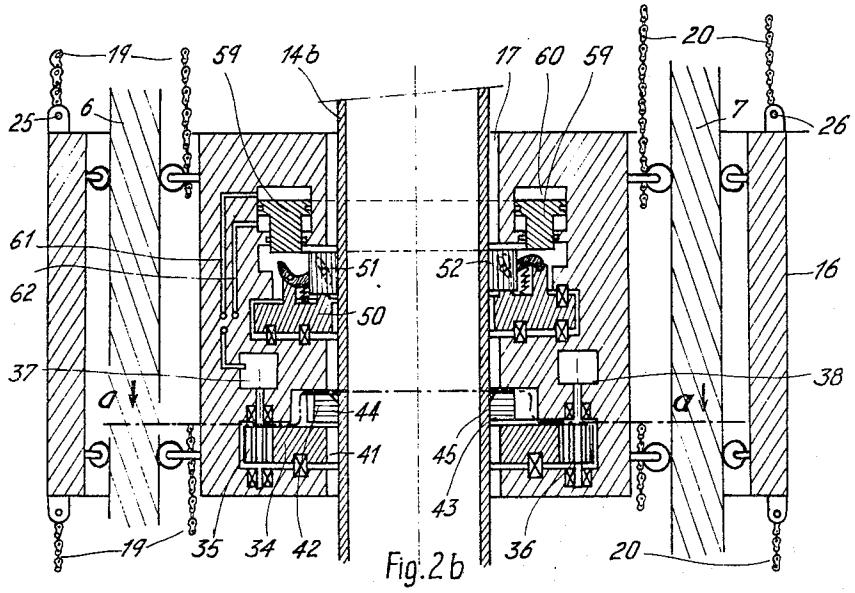

Fig. 2b

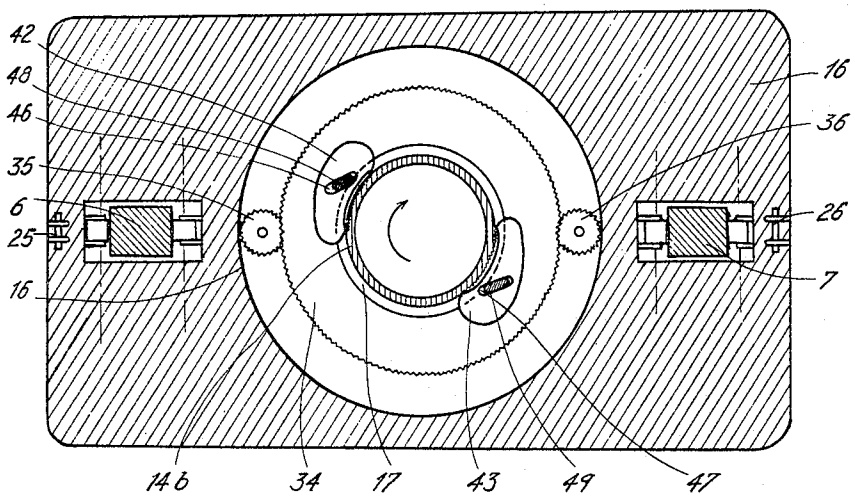

Fig. 2a

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APPARATUS FOR UNDERWATER DRILLING AND CORING LOOSE SEDIMENTS

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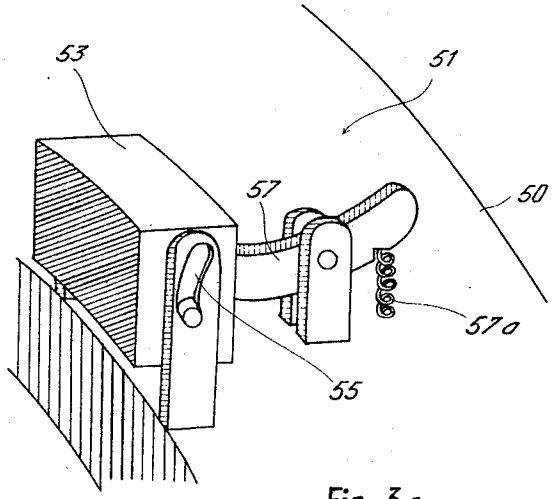

Fig. 3a

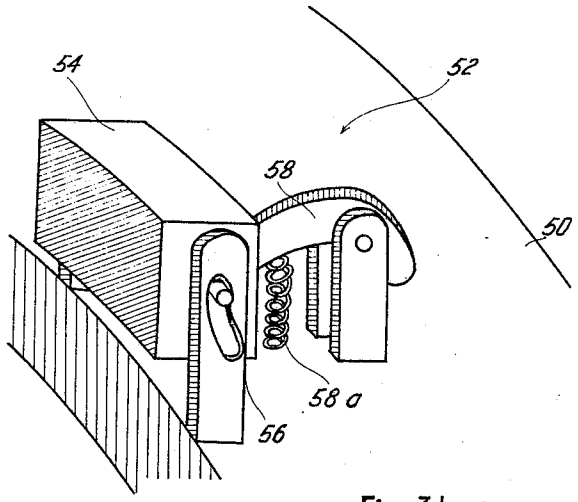

Fig. 3b

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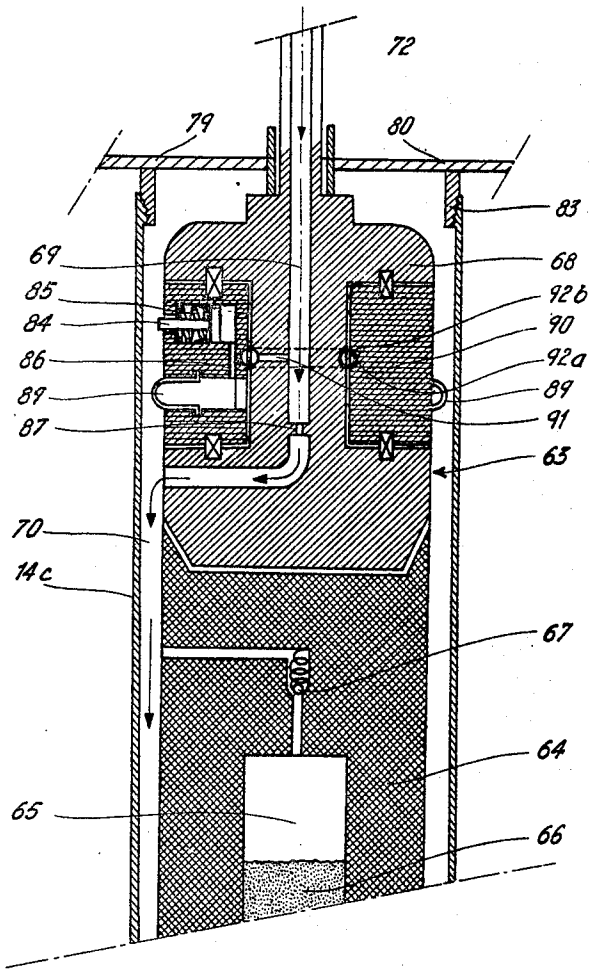

Fig. 4

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United States Patent Office 3,491,842
Patented Jan. 27, 1970

3,491,842

APPARATUS FOR UNDERWATER DRILLING AND CORING LOOSE SEDIMENTS

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Int. Cl. E21b 7/12
U.S. Cl. 175—6 4 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for drilling cores at an underwater bottom with the core drill being inside a casing which prevents crumbling of the walls of the bore hole. Sections of the casing are connected or disconnected by rotary driven gripping means at the under bottom. The rotary driven gripping means can be driven up or down by an underwater drive means to insert or retract the casing. The core drill in the casing can be connected to the casing or disconnected therefrom.

The present invention relates to an apparatus for driving into the underwater floor an elongated member, particularly for underwater drilling and coring operations performed from a floating support or surface installation adapted for such offshore drilling operations.

These operations may for example consist in coring samples or cores of the sediments, which are generally loose, covering the rocky underwater sub-strata and which may reach a thickness of several tens meters, such samples or cores being collected for the purpose of geological studies or for studying the mechanical properties of the underwater ground layers.

The apparatus according to the invention also permits to core the first metres of the underlying rocky sub-strata and to perform in situ measuring operations using such measuring instruments as cohesimeters, penetrometers, pressure measuring devices etc. at any depth within the sediments, whereby these measurements may follow the above-indicated coring operations or be performed in turns with them.

One of the most difficult problems arising during such coring or measuring operations performed in underwater loose sediments is to prevent the bottom of the hole or well drilled in these sediments of being filled with earth crumbling from the walls of this well, such crumbling making very difficult the interpretation of the performed measuring operations.

This crumbling occurs, in particular, when the measuring or coring operations are performed after drilling runs, the coring or measuring apparatus being then lowered into the drilled well after having removed the drill bit.

Another possible application of the apparatus according to the invention is to drive into the underwater loose sediments tubings or casings having lengths of several tens meters with simultaneous removing of the sediments located within this casing so as to allow the subsequent introduction into this casing of reinforcements and of various cement slurries so as to constitute underwater anchoring means the anchoring strength of which is very high, for instance up to several hundred tons.

An important object of the invention is to permit the driving of an elongated member into the underwater grounds from a floating surface installation, without requiring any permanent connection between this rigid elongated member so as to not subject this member to high stresses resulting from the movements of the floating installation, the complete suppression of these movements being impossible, even with means for precise anchoring or positioning of the floating installation, the cost of such means for precise anchoring being moreover very high.

According to the invention, these different problems can be simultaneously solved with an apparatus operable from a surface installation for driving into the underwater floor an elongated member constituted of a plurality of elements adapted to be connected end to end, particularly for offshore drilling and coring operations, including a base member which can be seated on the underwater floor and is provided with a central well for the passage of said elongated member and with rigid guide columns extending in a direction parallel to the axis of said central well, substantially parallel guide cables connecting said surface installation to the respective tops of said guide columns, a drill head slidable along said guide columns and provided with a bore for the passage of said elements of the elongated member and with means inside said bore for gripping said elements, said drill head incorporating at least a submersible motor for driving said elongated member into the underwater floor, at least a power line and a line for remote control connecting said submersible motor and said gripping means to said surface installation, said apparatus including a connecting element provided with guide means arranged to ride down said guide cable and to be seated onto the top of said guide elements, said connecting element being adapted for detachable connection with the top of the upper element of said elongated member and being suspended by a flexible line from said floating installation for successively lowering the elements constituting said elongated member, in combination with remotely controlled means supported by said base plate for upwardly driving said drill head along said guide column.

A non-limitative embodiment of the invention, applied to coring the underwater ground layers, will be described hereinafter, with reference to the attached drawings wherein:

FIGURE 1 diagrammatically illustrates a coring apparatus according to the invention operated from a ship,

FIGURES 2*a* and 2*b* are sectional views, on a larger scale, of the drill head of the apparatus, FIGURE 2*a* corresponding to the section *a*—*a* indicated in FIGURE 2*b* and this last figure to a section of FIGURE 2*a*,

FIGURES 3*a* and 3*b* illustrate devices for gripping the casing,

FIGURE 4 is a sectional view of the upper part of the coring tool.

In the embodiment of the invention, illustrated by way of example by FIGURE 1, the coring apparatus is operated from the ship **1** which is maintained in a substantially fixed position by any suitable means (not shown), such as by conventional anchoring or dynamic positioning, over the selected location of the water bottom **3** where the coring operation is to be performed.

Through the hull of the ship is provided a well **2** for the passage of the apparatus according to the invention (the proportions between the ship and the coring apparatus have not been respected in the drawing, so as to more clearly show the apparatus).

The coring apparatus includes a broad base plate **4** adapted to rest on the water floor **2** and provided with a central aperture or well **5**. Two guide columns **6** and **7** parallel to the axis of the well **5** are integral with this base plate.

The tops of these columns are connected with the ship **1** by means of guide cables **8** and **9** passing over return sheaves **10**, **11** carried by the ship and are wound on

winches **12** and **13** of conventional type adapted to keep the cables **8** and **9** under tension.

The guide cables **8** and **9** are used for handling the base plate **4** from the ship, i.e. for lowering and raising this base plate, as well as for guiding the successive casing elements which are lowered from the ship in the manner to be indicated in the following.

The casing used for lining the drilled well during the coring operation, i.e. for holding up the walls of this well, is formed of tubular elements such as **14***a*, **14***b*, **14***c* which can be connected end to end such as by screwing or by any other suitable means and the unit-length of which is at least equal to the greatest height of the successive coring runs.

The lower element **14***a* of this casing is provided at its bottom with a drill crown **15** which is provided with teeth or cutting elements.

The apparatus according to the invention includes a driving drill head **16** constituted of a frame displaceable along the guide columns over a length thereof at least equal to that of a casing element and which is traversed by a bore **17** providing a passage for this casing.

A guide funnel-shaped element facilitates the introduction of the casing elements into the bore **17**.

The upright displacements in either direction of the drill head **16** along the guide columns **6** and **7** are produced, in the considered embodiment, by means of two endless chains **19** and **20** passing over toothed wheels **21** to **24**, located at both ends of each guide column. The drill head **16** is secured to one line of each chain at locations such as **25** and **26**.

In the illustrated embodiment the chains **19** and **20** are driven by a reversible hydraulic motor, through the chain belt **27**.

This hydraulic motor is actuated by a hydraulic unit secured to the base plate **4**.

The electric motor driving the pump of this hydraulic unit is supplied with electric current from the electric generator **29** located on the ship, through the line **30**.

This line is constituted of a cable in which are embedded electric power conductors **31** as well as electric conductors for remote control, the latter permitting to control the different operations performed on the water bottom from a telecontrol station **33**, in particular the actuation, in either of its directions of rotation, of the hydraulic motor driving the chains **19** and **20**.

These conductors for remote control are connected with electrically operated valves of a conventional type adapted to the hydraulic circuit of the unit **28**.

The construction of this circuit will be obvious to those skilled in the art and is therefore not described here.

The drill head includes devices for clamping, holding and driving in rotation the casing, the whole of these devices being designated by the general reference **39** in FIG. 1.

These devices will be described in the following more in detail with reference to FIGURES 2*a* and 2*b* showing sectional views on a larger scale of the drill head **16**.

This drill head includes a rotor **34** for driving the casing in rotation, constituted for a peripherally toothed crown in mesh with driving pinions.

Two of these pinions are rotated by the reversible hydraulic motors **37** and **38** which are supplied with hydraulic fluid by the hydraulic unit **28** through a flexible hydraulic hose **40** (FIG. 1). This flexible hose can follow the displacements of the drill head **16** along the guide columns and includes at least a pipe supplying fluid under pressure and a pipe for conveying the low pressure fluid back to the hydraulic unit **28**.

The rotor crown **34** has an internal bore **41** of a diameter sufficient to provide for a very easy passage to the different elements of the casing.

On this rotor are located devices **42**, **43** for automatically clamping or gripping the casing, providing for the rotation thereof (the number of these clamping elements is not limited to two).

In the illustrated embodiment, these elements have an internal wall including a cylindrical part **44**, **45** having a shape adapted to fit the outer wall of the casing with a high friction factor.

In these clamping elements are provided along a direction substantially parallel to the axis of the rotor **34** stud-holes **46** and **47** respectively, each of which having a cross-section which is elongated along a direction deviating from the axis of the rotor **34** in the direction opposed to the direction of rotation of the latter.

In the stud-holes of the self-clamping elements are inserted studs **48** and **49** integral with the rotor **34** and the cross section of which has a shape complementary to that of the stud-holes **46** and **47**, permitting to bring the self-clamping elements more or less near the axis of the rotor **34**, and which is adatped to prevent the rotation of these clamping elements about the studs towards the axis of the rotor **34**. This rotation might otherwise happen when no casing element is inserted in the drill head **15**, which would then make difficult, if not impossible, and subsequent passage of a casing element through this drill head.

The location of the studs **48** and **49** on the rotor **34** permits an easy passage of the casing elements when the self-clamping elements **42** and **43** have been moved aside from the axis of the rotor **34** and a clamping action on these casing elements which is sufficient to make them fast in rotation with the rotor **34**, when these clamping elements are simultaneously brought nearer the rotor axis.

The shape of the elements **42** and **43** as well as their respective locations on the rotor **34** are so selected that all the clamping elements are in abutment and automatically grip or clamp the casing, when the rotor is rotated in its normal direction of rotation (indicated by the arrow on FIG. 2*a*) which corresponds to the coring operation, whereby this clamping action is automatically suppressed by simply reversing the directon of rotation of the rotor **34** which allows to clear the drill head **16** from the casing element traversing this drill head.

Inside the drill head **16** is also located a rotary crown **50** coaxial with the bore **17** and provided with devices **51**, **52** for axially holding the casing, these devices being hingedly secured to the crown **50** in the illustrated embodiment.

These devices which are illustrated on a larger scale on FIGURES 3*a* and 3*b* are devices for self-clamping the casing, adapted to withstand longitudinal forces exerted on the casing either downwardly (device of FIG. 3*b*) or upwardly.

They may be in any number, being regularly distributed at the periphery of the crown **50**.

In the illustrated embodiment, each of these elements includes a gripping shoe (**53**, **54**) integral with a horizontal stud which is guided by a groove or stud-hole (**55**, **56**) integral with the rotary crown **50**. These gripping shoes are secured to the end of a lever arm (**57**, **58**) hingedly mounted on the crown **50**.

The grooves **55** and **56** having the shape of arcs of circles are so located as to bring the gripping shoe towards the rotation axis of the crown **50**, either when the gripping shoe is lowered (device of FIG. 3*a*) or when the gripping shoe is raised (device of FIG. 3*b*). There is thus provided by self-gripping action the axial blocking in both directions of the casing traversing the drill head **16**.

The springs **57***a* and **58***a* when expanding push the lever arms **57** and **58** back to their clamping position in which the casing is gripped by the shoes **53** and **54**.

The releasing of the casing by moving apart the clamping shoes is performed in the illustrated embodiment by means of an annular pisto **59** which is slidably mounted in the annular cylinder **60** (FIG. 2*b*) and which, by pressing the lever arms **57** and **58**, causes the gripping shoes to move away from each other.

The control of the displacements of the piston **59** is performed from the station **33** at the water surface, by remotely controlling the inlet of hydraulic fluid under pressure into any of the two compartments of the cylinder **60** through the flexible hydraulic coupling **40** and one or the other of the pipes **61** and **62**.

This apparatus according to the invention also includes a coring tool **63** (FIG. 1 and 4) the lower part of which is constituted of a core barrel **64** provided with an internal bore for housing the core **66**.

The bore **65** is at its upper part provided with a gauged valve **67** to allow water to escape from above the core **66**.

The head **68** of the coring tool is in the following referred to by the expression "handling head" since this head is used as a seat or abutment for the successive casing elements during the lowering and the raising thereof as hereinafter described.

This handling head is traversed by one or several channels **69** for delivering flushing fluid to the annular space **70** between the coring tool and the casing which constitutes a lining of the walls of the well **71** drilled through the sediments.

The supply with flushing fluid is performed through a flexible pipe **72** at the lower end of which the coring tool is suspended.

This pipe passing over the guide pulley **73** supported by the ship is reeled on a winch **74**.

The upper end of the pipe **72** secured to the rim of the winch **74** is supplied in a known manner with water under pressure which constitutes the flushing fluid, by means of the pump **75** drawing up water from the sea through the pipe **76** and delivering this water into the pipe **72** through the pipe **77** and through a rotary coupling or swivel **78** of a conventional type.

Guilding elements permit to lover and raise the successive casing elements by sliding along the guide cables **8** and **9**.

These guiding elements include (FIG. 1 and 4) radial arms **79**, **80** integral with sliding sleeves **81** and **82** through which the guide cablen pass and which are adapted to fit the upper part of the guide columns **6** and **7** (these sleeves being however stopped above the upper pinions **21**, **23** of these columns).

A tubular coupling or connectig element **83** which is externally threaded at its lower part and is integral with the radial arms **79** and **80** allow to hang on to the guiding element (**79** to **82**) each casing element such as **14***c*(FIG. 1) during the lowering and the raising of this element.

The flexible pipe **72** permits to perform these operations of lowering and raising a casing element screwed to the connecting element **83** integral with the arms **79** and **80** which then come in abutment against the top of the handling head **58** (FIG. 4).

This handling head includes (FIG. 4) retracting anchoring fingers or pawls such as the finger **84** integral with a piston **85** which can silde in the cylinder **86** against the action of a return spring. The cylinder **86** communicates with the channel **69** delivering flushing fluid upflow from a throttling (nozzle **87**) of this channel.

With such a arrangement, the fluid under pressure supplied by the flexible pipe **72** causes automatically the movement of the fingers **84** away from one another, since the pressure of the flushing fluid in the channel **69** upflow from the throttling **87** is higher than its pressure downflow from this throttling.

By interrupting the supply of the pipe **72** with fluid under pressure the finger **84** is automatically retracted by the action of the return spring.

The lower element **14***a* of the casing is internally provided with an annular shoulder **88** (FIG. 1) under which the anchoring fingers **84** come into abutment when they are spaced away from one another under the action of the flushing fluid, this annular shoulder preventing the core barrel **63** to be displaced upwardly in the casing element **14***a*, when the latter is driven into the sediments.

In the illustrated embodiment (FIG. 1) the core barrel **64** is downwardly extended by a cutting tubular element **93** (of small wall thickness) the length of which is so selected that this tubular element is downwardly protruding from the coring crown **15** over a few centimeters when the core barrel occupies its position within the lower element **14***a* of the casing.

The handling head **68** is further provided with an annular sealing packing **89** constituted of an annular recess which is outwardly limited by a flexible wall, this recess communicating with the channel **69** delivering flushing fluid under pressure, upflow from the throttling **87**.

The water under pressure supplied from the flexible pipe **72** causes the inflation of the sealing packing which is pressed against the internal wall of the casing which surrounds the coring tool, so that the flushing fluid can only flow towards the bottom of the drilled well **71**.

In the embodiment illustrated by FIG. 3, the cylinder **86** and the annular sealing packing **89** are adapted to an annular element **90** rotatably mounted with a small clearance around the body of the handling head **68** by means of bearings.

In that way the coring tool which includes the core barrel **64** is not driven in rotation together with the casing when the fingers **84** and the annular sealing packing are pressed against the internal wall of this casing. The rotation of the core barrel **64** is prevented by the resistance of the flexible pipe **72** to torsional stresses.

The flushing fluid reaches the cylinder **86** and the annular recess limited by the packing **89**, by following the channel **91** and entering the annular cavity limited by the two annular grooves **92***a* and **92***b* facing each other respectively provided in the annular element **90** and in the non-rotatable part of the handling head **68**.

The operation of the coring apparatus according to the invention is performed in the manner described hereinunder.

The ship **1** is positioned and maintained over the location selected for coring.

The base plate **4** provided with the drill head is then suspended to the two guide cables **8** and **9** and lowered to the water bottom where it is laid. The guide cables are kept under tension.

A length of casing constituted for example of the lower element **14***a* and of the adjacent element **14***b* located just above is lowered, hanging at the lower end of the flexible pipe **72** in the manner which has been illustrated by FIG. 1 for the lowering of the element **15***c*, i.e. the element **14***b* of the casing is screwed at its lower part to the connecting element **83** integral with the element for guiding along the guide cables **5** and **6** and the whole is lowered by unwinding the pipe **72**.

The drill head **16** is raised up to the top of the guide columns **6** and **7** by remotely controlling the hydraulic unit **28** and the gripping shoes **51**, **52** are moved away from the axis of the bore **17** of the drill head, also by remote control causing the downward displacement of the annular piston **59** (FIG. 2*b*).

The casing may then be easily inserted into the bore **17** through the guiding funnel-shaped element **18**.

The gripping shoes **51** and **52** are then pressed against the external wall of the casing by remotely controlling the raising of the annular piston **59** in the cylinder **60**.

It is no longer necessary to support the upper element **14***b* by the flexible pipe **72** and, by continuing to unwind this pipe, the coring tool **63** can be lowered into the lower casing element **14***a*.

When the coring tool has reached its proper level in this casing element **14***a*, the flexible pipe **72** is supplied with water under pressure, thereby expanding the fingers **84** holding the coring tool under the annular shoulder **88** and simultaneously providing for sealing at the level of the packing **89**.

By remotely controlling the actuation of the hydraulic motor driving the chains **19** and **20** and of the hydraulic

motors such as 37 and 38 (FIG. 2*b*), the casing is rotated, which results in the unscrewing of the upper part of this casing from the connecting element 83 (FIG. 4), since the two sleeves 81 and 82 of the guide element 80 (FIG. 1) are then secured to the tops of the guide columns 6 and 7, which prevents the rotation of the connecting element 83. The well 71 is then bored (FIG. 1) by the toothed crown or bit 15, a core being formed in the housing 65 of the core barrel 64, the drill head being moved downwardly by the chains 19 and 20 thereby drilling the well 71.

When the drill head 16 reaches its lowermost position shown by FIG. 1, the first coring run is finished and it is then necessary to add a new casing element 14*c*. Since the connecting element 83 is no longer screwed at the top of the casing element 14*b*, the coring tool 63 surmounted by the guide element 79, 80 can be easily raised by winding up the flexible pipe 72 on the winch 74.

The shoes gripping the casing element 14*b* are moved away from this casing by remote control from the water surface and then the drill head is raised up to the top of the guide column 6 and 7.

An additional casing element 14*c* is lowered in the manner illustrated by FIG. 1 and is introduced into the bore 17 of the drill head 16 through the funnel shaped guide element 18, the lower part of this new casing element coming into abutment against the upper part of the preceding casing element 14*b*.

It will generally be necessary that additional guide elements, which have not been illustrated in FIG. 1 so as to not complicate the drawing, for example hydraulically actuated jaws supported by the base plate 4, can grip the casing element 14*b* before the raising of the drill head 16 so as to keep the axis of the bore 17 of the drill head.

In that way the additional casing element 14*c* is located exactly in the extension of the preceding one 14*b*.

The operation of remotely controlling the gripping of the casing element 14*c* by the gripping shoes 51 and 52 is then followed by telecontrolling the actuation of the motor driving the chains 19 and 20 and of the motors driving the rotor 34.

This causes successively the screwing end to end of the casing element 14*b* and of the casing element 14*c*, the unscrewing of the upper part of the element 14*c* from the connecting element 83 (FIG. 3), then the rotation of the whole casing for a new coring run at the end of which a new length of casing will be added in the manner which has already been described.

During the coring runs it will be necessary, in this embodiment, to unwind a sufficient length of the flexible pipe 72 so as to prevent the device from being subjected to vertical movements which the ship is subjected to at the surface, since these movements would be transmitted to the device by a pipe which is too much stretched.

At the end of the coring operations, the raising of the successive elements is performed after interrupting the supply of the flexible pipe 72 with fluid under pressure. The fingers 84 (FIG. 3) and the annular sealing packing 89 are then retracted and the coring tool 63 can then be easily raised by winding up the flexible pipe 72 on the winch 74.

The tubing can in turn be raised, for example by lowering at the lower end of the pipe 72, also by following the guide cables 8 and 9 a fishing tool of a type conventionally used during offshore drilling operations and adapted to be connected with the top of the casing, this tool remaining connected with the ship by a fishing cable suspended at the top of a mast or of a lifting derrick.

By suppling the interior of the casing with water under pressure through the flexible pipe to top of the casing being obturated by the fishing tool a swabbing effect is created which is favourable to the extraction of the tubing, this extraction being performed by means of the fishing tool.

When the casing has been raised into the well 3 of the ship it will be gripped at this level by conventional (not illustrated) means, then unscrewed element after element, so as to be stored on the ship deck.

If the casing cannot be extracted from the water floor, the loss will be limited to a few casing lengths, only the lower element 14*a* (FIG. 1) of which is of a special type.

The operation will be achieved by raising the base plate by means of the guide cables 8 and 9. Although the present invention has been described with reference to a particular embodiment thereof illustrated by the attached drawings, it must be understood that numerous changes may be made in this embodiment which was indicated by way of illustration, without departnig from the spirit and scope of the present invention. For example the driving of the drill head 16 by means of chains may be replaced by constituting the guide columns 6 and 7 as endless worms rotated around their upright axes by means of at least one hydraulic motor actuating two pinions each of which is integral with one of these guide columns, each of the latter traversing a non rotatable threaded nut integral with the drill head 16.

It is also possible to constitute each of the guide elements as an upright toothed rack in mesh with a toothed pinion having an horizontal axis and rotated by an hydraulic motor carried by the drill head 16.

The core barrel 63 may be of any known type suitable for collecting cores of loose sediments with as little alteration as possible occurring within the sample, the present invention being by no way limited to the use of any particular core barrel.

This core barrel may be simple, provided or not with obturating devices and with devices for withholding the core, and may protrude from the lower part of the casing by a tubular element having a thin cutting wall.

This core barrel may also be double (formed of two concentrical tubes) and optionally be provided with a flexible sleeve continuously covering the core as the latter is being formed.

What is claimed is:

1. Apparatus operable from a surface installation for driving into the underwater floor an elongated member constituted of a plurality of elements adapted to be connected end to end, particularly for offshore drilling and coring operations, including a base member which can be seated on the underwater floor and is provided with a central well for the passage of said elongated member and with rigid guide columns extending in a direction parallel to the axis of said central well, substantially parallel guide cables connecting said surface installation to the respective tops of said guide columns, a drill head slidable along said guide columns and provided with a bore for the passage of said elements of the elongated member and with means inside said bore for gripping said elements, said drill head incorporating at least a submersible motor for driving said elongated member into the underwater floor, at least a power line and a line for remote control connecting said submersible motor and said gripping means to said surface installation, said apparatus including a connecting element provided with guide means arranged to ride down said guide cable and to be seated onto the top of said guide elements, said connecting element being adapted for detachable connection with the top of the upper element of said elongated member and being suspended by a flexible line from said floating installation for successively lowering the elements constituting said elongated member, in combination with remotely controlled means supported by said base plate for upwardly driving said drill head along said guide column.

2. Apparatus according to claim **1**, wherein the elements constituting said elongated member are rotatably connected with one another, said submersible motor being adapted for rotation of said elongated member and said connecting element being detachable from the upper ele-

ment of said elongated member through said rotation, when said guide means are seated at the top of said guide columns.

3. Apparatus according to claim 1, wherein said elongated member is a tubular casing terminated at its lower end by a drill bit, and wherein said flexible line is a flexible pipe for supplying said drill bit with flushing fluid.

4. Apparatus according to claim 3, for underwater coring in loose sediments, wherein said flexible pipe is terminated at its lower end by a core barrel the top of which constitutes a seat for said connecting element during the lowering of the successive elements of said tubular casing, said apparatus including releasable means for anchoring said core barrel within the lower element of said tubular casing.

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