United States Patent

Koot

[15] **3,701,387**

[45] **Oct. 31, 1972**

[54] **CORE SAMPLING APPARATUS**

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[22] Filed: **Nov. 4, 1970**

[21] Appl. No.: **86,650**

[52] **U.S. Cl.** **175/6**, 175/20, 175/52, 175/60, 175/247

[51] **Int. Cl.**.....**F21b 7/12**

[58] **Field of Search**.....175/5, 6, 67, 246, 58, 59, 175/60, 236, 52, 215, 237, 239, 247, 248, 250, 309, 20

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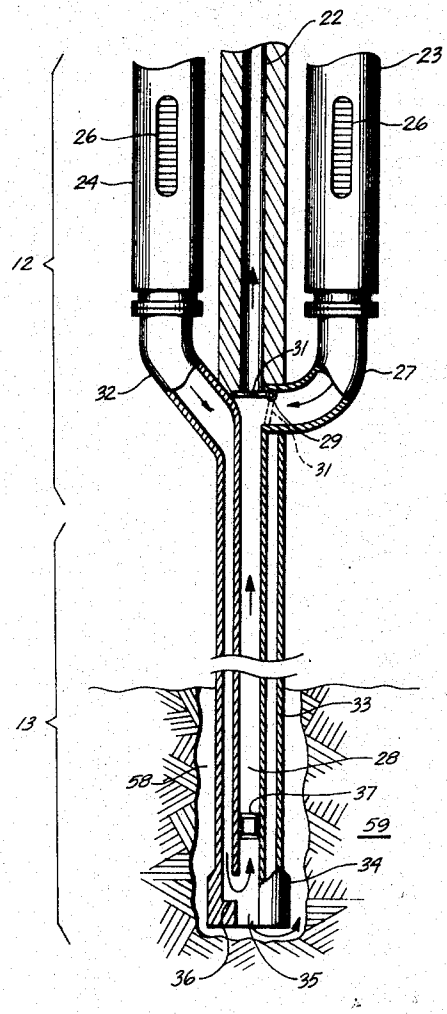
[57] **ABSTRACT**

Apparatus for taking a plurality of sequential punch core samples in underwater sediments is provided. Core sampling tubes are driven into the sediments by hydraulic pressure acting through a central guide tube. The core sampling tube is withdrawn by hydraulic pressure applied through an annular space between the guide tube and a surrounding pipe. The hydraulic pressures are applied by a pair of hydraulic pumps using sea water as the fluid. A plurality of core sampling tubes are contained in a magazine and are fed to the guide tube one at a time for taking samples. The filled core tubes are returned to the magazine where they are retained and stored. First and second sets of drive cams on the magazine are operated alternately by reverse operation of the hydraulic pumps so that the containers in the magazine controllably advance only one container width at a time.

15 Claims, 5 Drawing Figures

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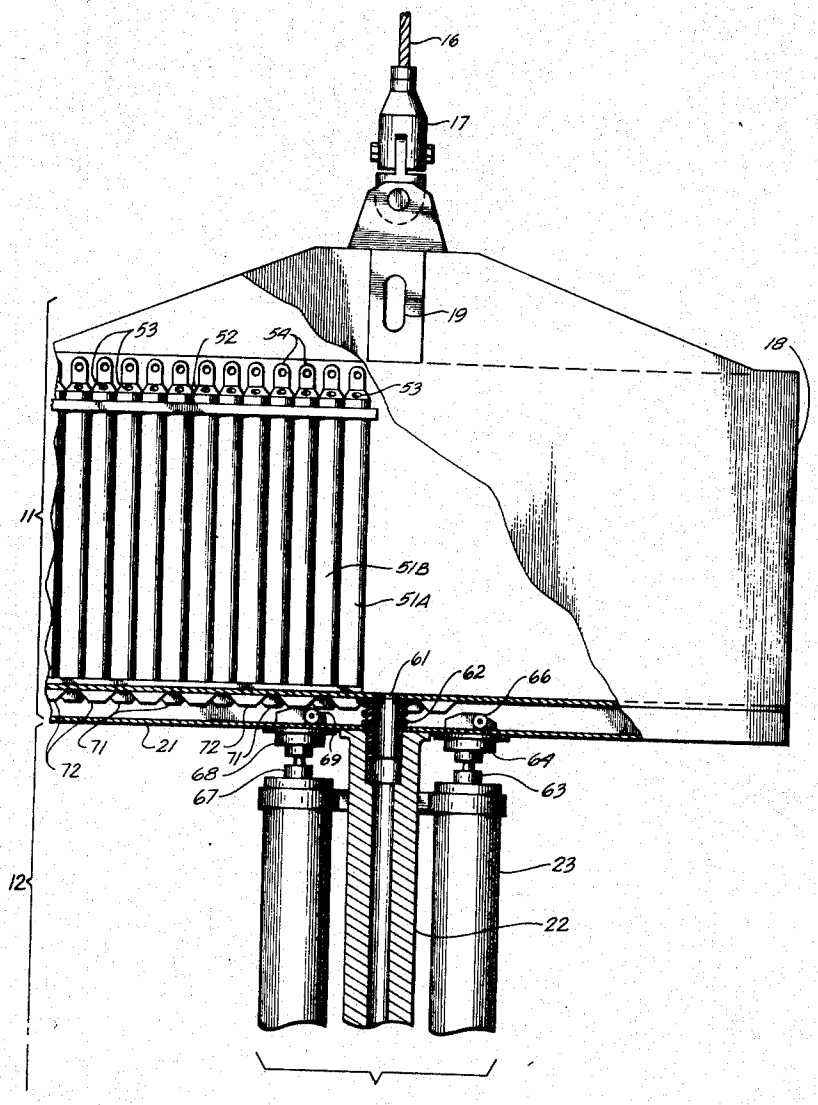
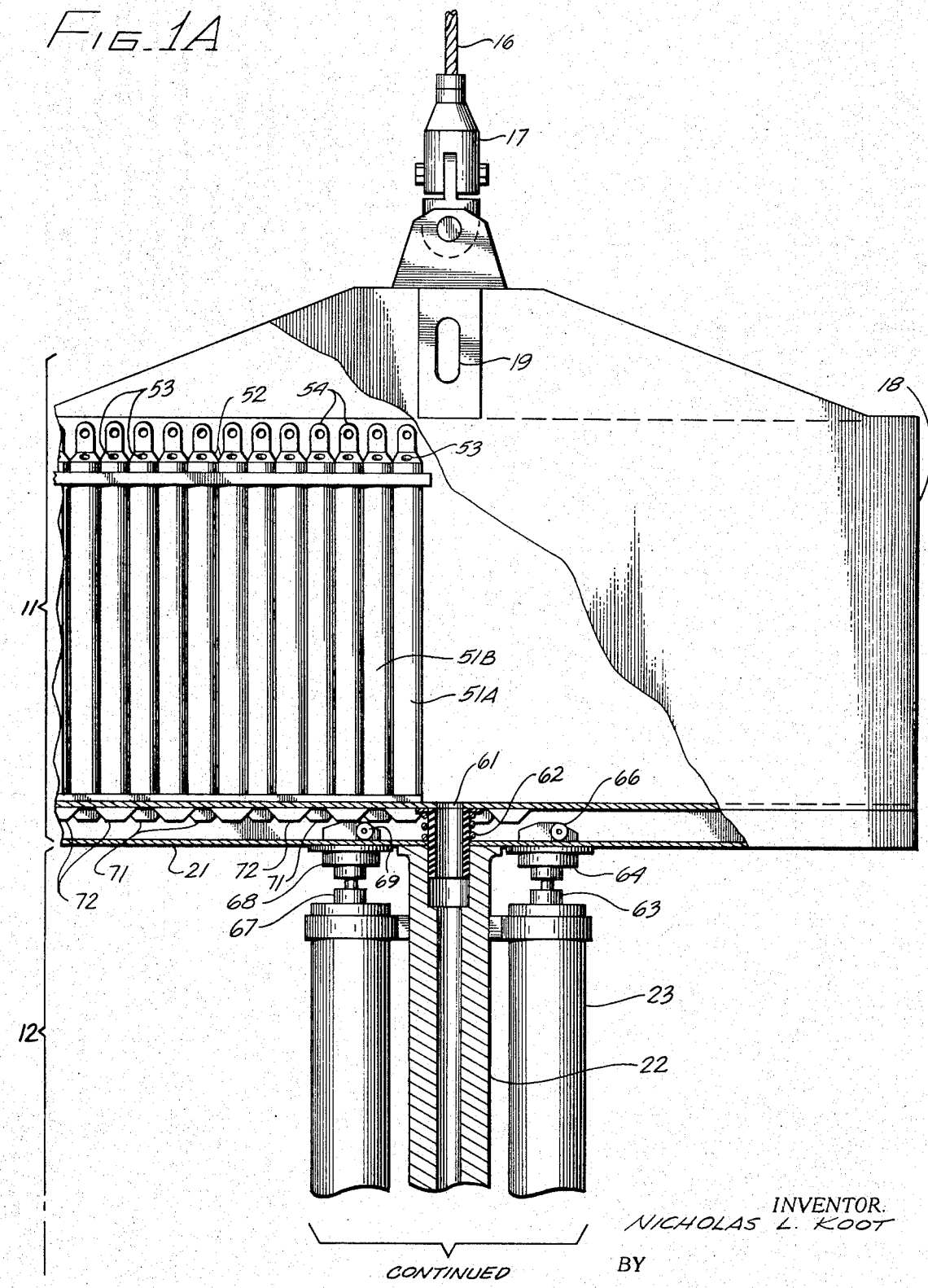


FIG. 1A



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FIG. 1B

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FIG. 1B

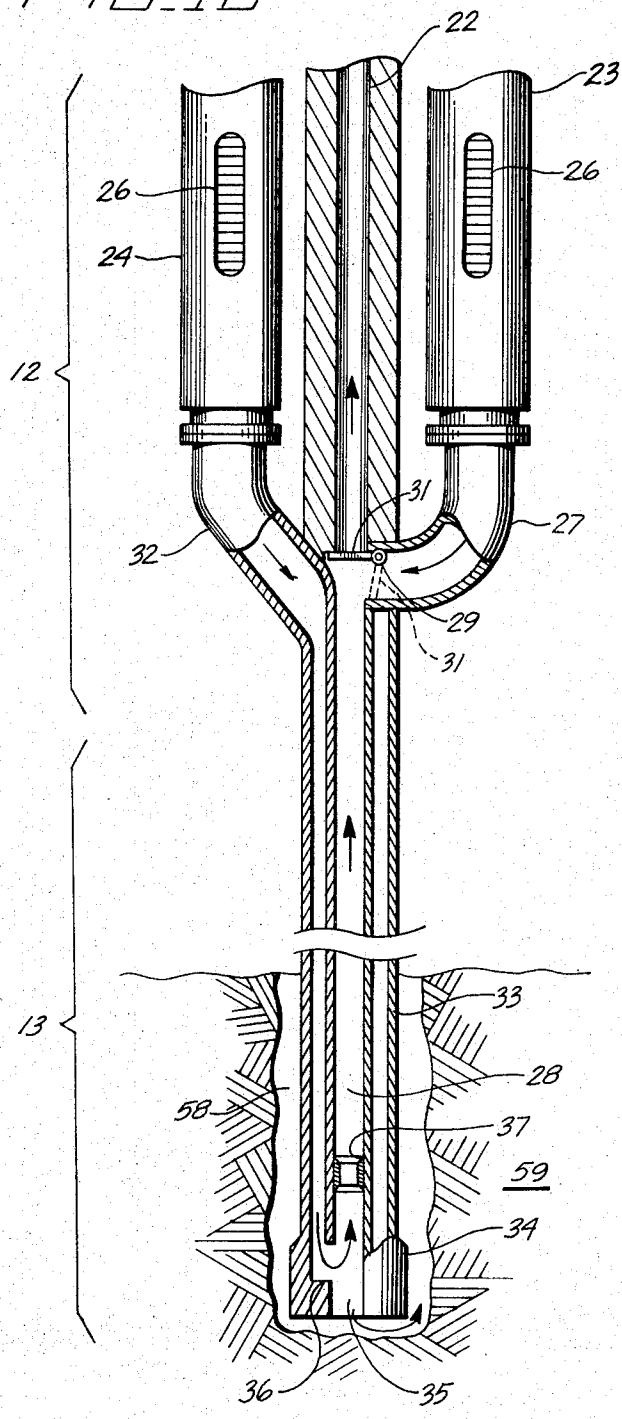
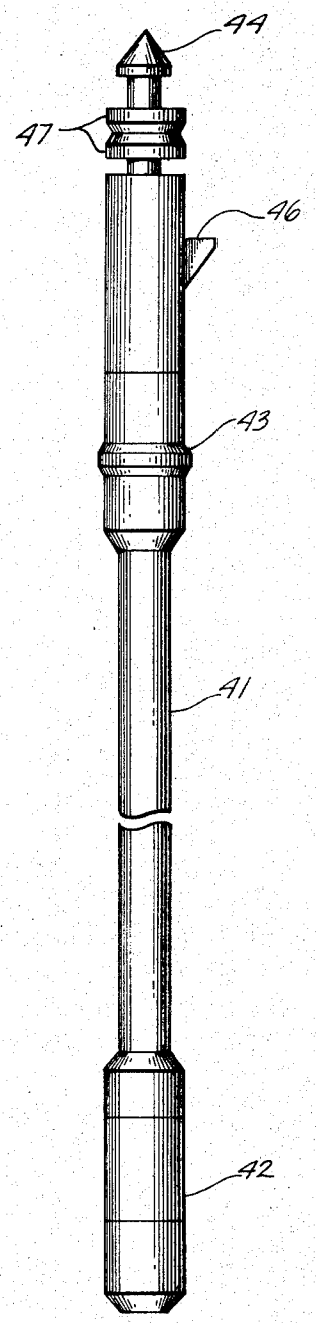


FIG 2



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FIG. 3

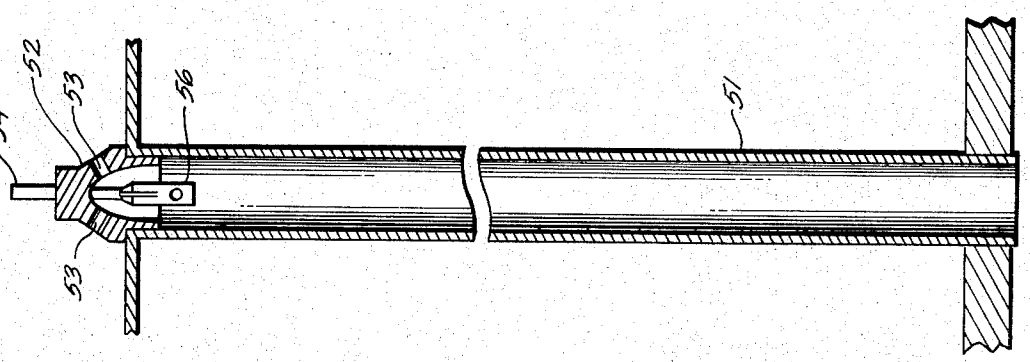
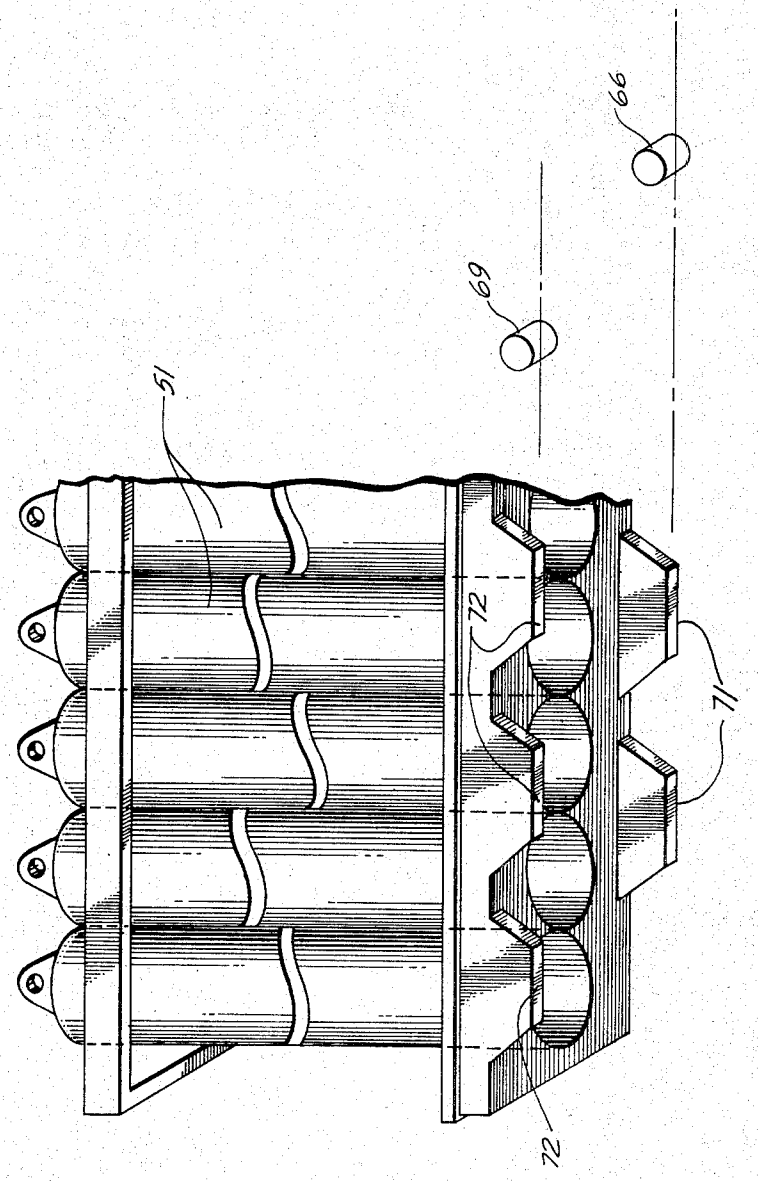


FIG. 4



CORE SAMPLING APPARATUS

BACKGROUND

There is considerable interest in obtaining core samples of undersea sediments for geologic exploration, either for scientific interest or for possible location of valuable minerals. It is preferred to obtain such samples by a relatively inexpensive punch coring where a hollow sample gathering tube is forced or pushed into the sediment rather than by relatively expensive core drilling. Punch coring has, however, been significantly limited by the buckling strength of core sampling tubes, and by operational considerations, to only a few feet of sediment thickness. If it is desired to obtain core samples from more than the first few feet of sediment thickness, either an expensive core drilling operation has been required or some means must be provided for re-entering a hole on the sea floor after one core sample has been removed. This latter is a difficult operation at best, and in deep water is virtually impossible without expensive equipment. It is, therefore, highly desirable to provide apparatus for obtaining relatively long punch core samples in underwater sediments without necessity of withdrawing the coring apparatus from the sea floor.

BRIEF SUMMARY OF THE INVENTION

Thus, in practice of this invention according to a preferred embodiment there is provided a multiple core sampling apparatus having means for forcing a core sampling tube into the material to be sampled; means for withdrawing the filled core sample tube from the sampled material; means for feeding a plurality of empty core sampling tubes one at a time to the means for forcing; and means for receiving and storing a plurality of filled core sampling tubes from the means for receiving for obtaining a plurality of core samples from along the length of a subsea hole.

DRAWINGS

These and other features and advantages of the invention will be appreciated as the same becomes better understood by reference to the following detailed description of a presently preferred embodiment when considered in connection with the accompanying drawings wherein:

FIGS. **1***a* and **1***b* illustrate in elevation and partial cross section a multiple core sampling apparatus constructed according to principles of this invention;

FIG. **2** illustrates a core sampling tube for use in the apparatus of FIG. **1**;

FIG. **3** illustrates a sampling tube container in the apparatus of FIG. **1**; and

FIG. **4** illustrates in perspective a fragment of a magazine of a plurality of containers in the apparatus of FIG. **1**.

Throughout the drawings like reference numerals refer to like parts.

DESCRIPTION

In order to obtain a long core sample in practice of this invention, a plurality of short core samples are taken sequentially along the length of the same hole. These punch core samples are taken without withdrawing the apparatus from the hole. FIG. **1** illustrates in

elevation and partial cross section a multiple core sampling apparatus constructed according to principles of this invention. As illustrated in this preferred embodiment the apparatus comprises three principle sub-sections, namely, a feed and storage magazine **11** for core sampling tubes, an operating sub-section **12** immediately below the feed magazine, and an elongated coring pipe string **13** below the operating section **12**. The apparatus is large, taking core samples about 10 feet long, and with a pipe string **13** in the order of 250 feet or more in length.

During operation the entire apparatus is suspended from a ship (not shown) by a hoisting line **16** connected to the apparatus by a clevis **17**. A sensing and control cable (not separately illustrated) is brought down along the hoisting line for monitoring performance of the core sampler and controlling the various functions thereof. The clevis **17** is connected to a rectangular case **18** forming the magazine housing. A pair of large open ports **19** are provided in the upper portion of the case **18** to serve as a water outlet during reverse circulation, as hereinafter pointed out. The bottom **21** of the case is preferably made of an open grill or with holes so that water and mud can freely pass therethrough.

A connecting tube **22** extends downwardly from the center of the rectangular case **18** and connects at its lower end to the pipe string **13**. The tube **22** provides mechanical support for a conventional electrically driven centrifugal pump and motor **23** employed for forcing a core tube into sub-sea sediments as hereinafter pointed out. The tube **22** also provides mechanical support for a second conventional electrically driven centrifugal pump and motor **24** opposite from the first pump **23**, and employed for withdrawing filled core sample tubes from the sediments as hereinafter described. The two pumps **23** and **24** operate with seawater drawn in through pump suction ports **26**.

The outlet **27** of the first pump **23** is connected to a guide tube **28**, the inside of which is effectively a continuation of the inside of the connecting tube **22** between the pipe string and the magazine. A spring loaded check valve **29** having a flapper plate **31** that is spring biased toward a closed position shown in phantom blocking the outlet **27** of the pump **23** for preventing flow back into the pump when it is not in operation. The flapper plate **31** is opened by operation of the pump **23** to a position shown in solid in FIG. **1** blocking the bore of the tube **22** for preventing water from passing up the tube as the pump **23** is operated.

The second pump **24** has an outlet **32** in fluid communication with an annular space between the guide tube **28** and a surrounding pipe **33** which collectively form the principal length of the pipe string **13**. At the lower end of the pipe **33** is a head **34** having a somewhat larger outside diameter than the outside diameter of the pipe **33**. The end of the guide tube **28** is also connected to the head **34** so that the lower end of the guide tube has a passage **35** through the head to the exterior of the apparatus. A fluid communication passage **36** is provided between the annular space inside the outer pipe **33** and the interior bore of the guide tube **28**. Within the bore of the guide tube **28**, near the bottom end of the pipe string, is a seat **37** having a smaller inside diameter than the inside diameter of the

guide tube. The ends of the seat **37** are tapered to prevent sample tubes from sticking as they pass this point.

A typical punch core sample tube is illustrated in FIG. **2**. The core sample tube comprises an elongated tubular barrel **41**, which in a typical embodiment may be about 10 feet long. At the lower end of the barrel **41** is a conventional cutter head assembly **42** such as commonly employed for punch coring. At the upper end of the core barrel **41** is an enlarged portion including a seat ring **43** which has an outside diameter smaller than the inside diameter of the guide tube and larger than the inside diameter of the seat **37** (FIG. **1**). Further up the core sampling tube is a conventional latching mechanism comprising a spearhead **44** connected to a side latch **46** in a conventional manner so that an axial force on the spearhead causes the latch **46** to protrude in the position shown in FIG. **2** for locking the entire sample tube assembly into some selected position. During operation of the sample tube for sampling, the latch **46** is retracted to permit ready sliding of the sampling tube assembly along the guide tube **29**. A pair of opposed rubber cups **47** adjacent the upper end of the sample tube are provided for engaging the walls of the connecting tube **22** and guide tube **29** so that hydraulic pressure can be applied to the core sampling tube assembly.

Referring again to FIG. **1**, within the rectangular magazine **18** is an assembly of several interconnected containers **51** shown in greater detail in FIGS. **3** and **4**. The containers **51** are connected together so as to be in a parallel array with the axes of the containers in a substantially vertical orientation parallel to the axis of the connecting tube **22**. In a typical embodiment, 20 such containers may be provided in the array, and the rectangular magazine **18** is sufficiently long that all twenty of the containers **51** can be arrayed on either side of the center.

As seen in greater detail in FIGS. **3** and **4**, each of the containers comprises a cylinder **50** open at the bottom end and closed at the top end by a cap assembly **52**. The cap assembly fits within the cylindrical container and includes a pair of circulation holes **53** to permit passage of seawater. A lifting eye **54** is also provided in the cap so that on shipboard or the like the cap **52** can be lifted along with any elements connected thereto. Connected inside the cap **52** is a conventional "overshot" latching mechanism **56** with which the spearhead **44** and latch **46** (FIG. **2**) on the core sample tube engage.

In order to operate the multiple core sampling apparatus, the entire assembly is lowered to the ocean floor on the hoisting line **16** until the head **34** engages the sea floor **59**. If it is desired to take a core sample of the sediment commencing at the sea floor, the sampling operation can commence at this time. Often, however, it is desired to obtain the core sample at a somewhat lower depth and, therefore, the pipe string is lowered into the sea floor a preselected distance.

In order to drive the pipe string into the sea floor, the pump **23** connected to the interior of the guide tube **28** is turned on so that a jet of seawater is forced out of the opening **35** at the lower end of the pipe string. The flow of water through the opening rapidly erodes the sediments adjacent the head **34** and the entire drill string can be lowered into a cylindrical hole **58** "jetted" into the sea floor **59**. Penetration of sediments and similar soil by such water-jetting action is well known. If desired, the second pump **24** can also be operated during the jetting operation for increased water flow. The first pump **23** is always operated during the jetting operation in order to open the check valve **29** and cause the flapper plate **31** to block the upper end of the guide tube **29**. After the drill string has been jetted into the sea floor by a selected distance such as, for example, 50 feet, the core sampling operation may proceed.

In order to take a core sample, a first container **51A** is moved laterally in the magazine **18**, by a mechanism hereinafter described in greater detail, so as to be aligned with the connecting tube **22**. Each of the containers **51** in the magazine has a punch core sampling tube such as illustrated in FIG. **2** contained loosely therein. Thus, when the container **51A** is aligned with the connecting tube **22**, the core sampling tube drops therefrom and falls through the connecting tube **22** into the guide tube **29**. (During this operation the pumps **23** and **24** are OFF so that the check valve **29** leaves the passage clear.)

After the core sample tube has entered the guide tube **29**, the first pump **23** is turned on so that the check valve **29** opens the pump outlet and the flapper plate **31** closes the entrance to the connecting tube **22**. This applies hydraulic pressure to the upper end of the core sample tube, which is sealed against the guide tube by the rubber cups **47**, and the flow of seawater from the pump pushes the core sample tube downwardly through the guide tube and punches it into the sediment beyond the head **34** until the seat ring **43** engages the seat **37** to stop the downward progress of the core sample tube. As the core sample tube penetrates the sediments, the cutter head **42** cuts into the sediment and assures a core of sediment being collected in the barrel **41**.

After the core barrel **41** is filled with sediment by punching into the sea floor, the first pump **23** is turned off, thereby permitting the flapper valve **29** to close and the flapper plate **31** to clear the passage between the connecting tube **22** and guide tube **29**. The second pump **24** is then turned on and seawater flows through the annular space between the pipe **33** and the guide tube **28**, and thence through the interconnecting passage **36** at the lower end of the pipe string. This applies a hydraulic force directed upwardly on the core sample tube, thereby withdrawing the tube from the sediments and propelling it upwardly through the guide tube and connecting tube back into the container **51A** where the spearhead **44** engages the overshot **56** for actuating the latch **46** and securing the core sample tube to the cap **52** of the container. A hard rubber sleeve **61** at the top of the connecting tube **22** is biased upwardly by a spring **62** to close any substantial gap between the connecting tube and the container so that the hydraulic force of the pump assures latching of the core sample tube in the container. Some seawater flows out of the opening **35** at the end of the pipe string, but the pressure still rises enough in the guide tube to force the sample tube upwardly.

After a first sample has been taken and the core sample tube returned and stored in container **51A**, the first pump **23** is again turned on for jetting the pipe string to

a lower elevation in the hole **58** corresponding to the length of core sample taken. When the pipe string has been so lowered, the magazine is again advanced until the second container **51B** is aligned with the connecting tube **22**, and a core sample tube therein is free to drop through the connecting tube into the guide tube **29** for a repeat of the operation just described. This operation is repeated as often as desired until the core sample tubes in the several containers **51** have each been used and the desired sample is stored therein. As illustrated in FIG. **1**, the containers **51** are at the left-hand side of the rectangular case **18** in a position where the contained core sampling tubes are loose therein. As these tubes are filled with samples, the assembly of containers proceeds to the right in FIG. **1**, and when all of the core sampling tubes are filled, the entire assembly is at the right side of this figure.

The mechanism for intermittently advancing the array of containers **51** into alignment over the connecting tube **22** employs the same motors used for driving the pumps **23** and **24**. The first pump **23** is connected with an override or cam clutch **63** which transmits no motion when the pump is operated in a forward direction and transfers motion when the pump motor is operated in reverse. The output of the overriding clutch **63** is connected to a right angle speed reducer **64** having a drive roller **66** as its output. Similarly, an overriding or cam clutch **67** is connected to the pump **24** so as to transmit no motion when the pump is operated in a forward direction and to transmit motion when the pump motor is operated in the reverse direction. The output of the overriding clutch **67** is connected to a right angle speed reducer **68** which has a roller **69** on its output. The two rollers **66** and **69** are thus driven only when the motor of the respective pump **23** or **24** is driven in reverse. The two rollers **66** and **67** are staggered, as illustrated schematically in FIG. **4**, for operating on different sets of drive cams.

A row of drive cams **71** is provided along one bottom edge of the assembly of containers, as seen in FIG. **4**. A second row of drive cams **72** is provided along the opposite bottom edge of the assembly of containers. One drive cam **71** is provided for every other container **51**, and one of the second drive cams **72** is provided for each alternate one of the containers **51** between those containers associated with a first cam **71**. Thus, in the illustrated embodiment, the second cams **72** are each staggered from the first cams **71**, with alternate ones of the cams **71** and **72** associated with successive containers.

The first driver roller **66** on the first pump **23** is aligned so as to engage the lowermost surface of the cams **71**. In a similar manner, the second roller **69** on the second pump **64** is aligned to engage the second set of cams **72**. Preferably the rollers **66** and **69** are arranged to be freewheeling when not being driven.

In operation, in order to advance the assembly of containers, one of the pumps, for example, the second pump **24**, is operated in reverse so that the roller **69** in engagement with a cam **72** drives the assembly to the right. This driving engagement of the roller **69** and camming surface **72** continues only along the length of one cam which corresponds to the advancement of the assembly by one container. The roller **69** then ceases to engage the camming surface **72** and advancement of the assembly stops even though the pump **24** may still be running in reverse. As the assembly advances, however, the leading edge of one of the camming surfaces **71** engages the presently freewheeling roller **66** connected to the other of the two pumps prior to disengagement of the roller **69** from the other camming surface **72**.

When it is desired to advance the assembly one additional container, the motor associated with the other pump **23** is operated in reverse so that the roller **66** in engagement with a cam **71** advances the entire assembly until that roller, in turn, loses engagement with the camming face **71**. Meanwhile the presently freewheeling roller **69** has engaged the next cam face **72**. In this manner, by operating the two pump motors alternately in reverse, the assembly of containers is advanced one unit at a time to bring the containers successively into alignment with the connecting tube **22**. With such a mechanical arrangement there is no requirement for position sensors or precisely controlled operating cycles on the pump motors. The motor need only be operated in reverse for a time longer than required to advance the assembly one container, and any excess of reverse operation is harmless. It should be apparent that in the illustrated embodiment, the two rows of cams **71** and **72** are staggered on the assembly of containers, and the two rollers **66** and **69**, although displaced from each other, are effectively aligned for purposes of operation. The same effect can be obtained with pairs of aligned cams and two staggered rollers. It will also be apparent in lieu of cams, and rollers; racks, gear sectors, and other driving engagements can be employed.

By employing a pair of hydraulic pumps the control required in the core sampler is simplified. One pump is used to force the core sampling tube down and the other to drive it back. These two functions could be obtained with a single pump and controlled valves. The single pump for such an embodiment would need to be large enough to effectively jet sediments for lowering the pipe string into the sea floor. In the illustrated embodiment, on the other hand, the two pumps can be smaller and they can be used together for jetting. The two pumps also provide the second function of advancing the container magazine incrementally without complex controls.

Although only one embodiment of multiple core sampling apparatus has been described and illustrated herein, many modifications and variations will be apparent to one skilled in the art. Thus, for example, in the illustrated arrangement, the array of containers for the core sampling tubes is linear. It will be apparent that the same result can be obtained with a cylindrical array of containers wherein the cylinder is rotated one container at a time for feeding core sample tubes in the apparatus. Many other modifications and variations will be apparent to one skilled in the art, and it is therefore to be understood that within the scope or the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A multiple core sampling apparatus comprising:

means for forcing a core sampling tube into a material to be sampled;

means for withdrawing the core sampling tube from the sampled material;

means for feeding a plurality of empty core sampling tubes one at a time to the means for forcing; and

means for receiving and storing a plurality of filled core sampling tubes from the means for withdrawing; and wherein

the means for forcing comprises means for applying hydraulic pressure in a forward direction on the core sampling tube; and

the means for withdrawing comprises means for applying hydraulic pressure in the rearward direction on the core sampling tube.

2. A core sampling apparatus as defined in claim 1 wherein the means for forcing further comprises a guide tube for the core sampling tube, and means for applying hydraulic pressure within the guide tube on a rearward portion of the core sampling tube; and

the means for withdrawing comprises:

a pipe surrounding the guide tube and in fluid communication with the guide tube at a forward end thereof; and

means for applying hydraulic pressure within the pipe for application to a core sampling tube within the guide tube.

3. A multiple core sampling apparatus as defined in claim 2 further comprising a seat within the guide tube at the forward end thereof for engagement with a seating member on a core sampling tube.

4. A core sampling apparatus as defined in claim 1 wherein the means for applying hydraulic pressure comprises a hydraulic pump and further comprising;

means interconnecting the hydraulic pump and means for feeding for actuating the means for feeding upon reverse driving of the hydraulic pump.

5. A multiple core sampling apparatus comprising:

means for forcing a core sampling tube into a material to be sampled;

means for withdrawing the core sampling tube from the sampled material;

means for feeding a plurality of empty core sampling tubes one at a time to the means for forcing; and

means for receiving and storing a plurality of filled core sampling tubes from the means for withdrawing; and wherein the means for feeding comprises:

a magazine with a plurality of containers for core sampling tubes; and

means for intermittently advancing the magazine an interval corresponding to one container; and

the means for receiving comprises means within each container for securing a filled core sampling tube therein.

6. A core sampling apparatus as defined in claim 5 further comprising a motor, and wherein forward operation of the motor actuates the means for forcing and reverse operation of the motor actuates the means for feeding.

7. A core sampling apparatus as defined in claim 5 further comprising second means for intermittently advancing the magazine a distance corresponding to one container and wherein the first and second means for intermittently advancing are operable only alternately, operation of the first means for advancing, enabling operation of the second means for advancing, and operation of the second means for advancing, enabling the first means for advancing.

8. A core sampling apparatus as defined in claim 7 wherein the first means for advancing the magazine comprises a plurality of first drive cams for every other container; and first means for driving the first drive cams; and wherein

the second means for advancing the magazine comprises a plurality of second drive cams for alternate containers in the magazine from the first drive cams, and second means for driving the second drive cams.

9. A subsea punch coring apparatus for obtaining a plurality of punch core samples in a plurality of punch core sample tubes comprising:

an elongated guide tube;

a pipe surrounding the guide tube for providing an annular conduit therebetween;

means for pumping seawater into the guide tube for forcing a punch core sample tube within the guide tube into subsea soil;

means for pumping seawater into the annular conduit between the guide tube and pipe for withdrawing a core sample tube from the subsea soil; and

means for feeding an empty punch core sampling tube into the guide tube comprising:

a magazine including a plurality of core sampling tube receiving stations;

first means for intermittently advancing the magazine one station; and

second means for intermittently advancing the magazine one station, the first and second means for advancing being operable only alternately, operation of the first means enabling operation of the second means and operation of the second means enabling operation of the first means.

10. A magazine as defined in claim 9 wherein the first means for advancing comprises a plurality of first drive cams for every other station, and means for driving the first drive cams; and wherein

the second means for advancing comprises a plurality of second drive cams for alternate containers from the first drive cams, and second means for driving the second drive cams.

11. An underwater punch core sampling apparatus for obtaining a plurality of punch core samples in a plurality of punch core sample tubes comprising:

an elongated guide tube;

a pipe surrounding the guide tube for providing an annular conduit therebetween;

means for pumping seawater into the guide tube for forcing a punch core sample tube within the guide tube into subsea soil;

means for pumping seawater into the annular conduit between the guide tube and pipe for withdrawing a core sample tube from the subsea soil; and

means for feeding an empty punch core sampling tube into the guide tube; and wherein the means for pumping seawater into the guide tube comprises:

a first pump;

a conduit connecting the first pump and the guide tube;

a two-position valve having a first position closing the conduit and a second position closing the guide tube; and

means for biasing the valve toward the first position.

12. An underwater punch core sampling apparatus as defined in claim 11 wherein the means for pumping water into the annular conduit comprises a second pump and a conduit interconnecting the second pump and the annular conduit, said first and second pumps being operable alternately and simultaneously.

13. An underwater punch core sampling apparatus as defined in claim 11 wherein the means for feeding comprises:

a magazine with a plurality of container means for loosely accommodating an empty punch core sample tube in each container;

means associated with each container for securing a filled punch core sampling tube within each container means; and

means for intermittently advancing the magazine an interval corresponding to one container means;

said apparatus further comprising a passage interconnecting the guide tube and a container means and wherein the means for pumping seawater for withdrawing is further for passing a filled puch core sample tube through the guide tube and connecting passage to a container means.

14. An underwater punch core sampling apparatus as defined in claim 13 wherein the means for intermittently advancing comprises:

means connected to one of the means for pumping for advancing the magazine upon reverse operation of the means for pumping. punch

15. An underwater punch core sampling apparatus as defined in claim 13 wherein the means for feeding comprises:

a plurality of first drive means for every other container means;

a plurality of second drive means for every other container means in the magazine alternately with the first drive means;

first means for engaging the first drive means for advancing the magazine a distance equivalent to one container means;

means interconnecting the means for engaging and the first means for pumping only upon reverse operation of the first means for pumping;

second means for engaging the second drive means for advancing the magazine a distance equivalent to one container means; and

means interconnecting the means for engaging and means for pumping for operation only upon reverse operation of the means for pumping.

* * * * *