

[54] **FLUID DRIVEN BELOW GROUND MOTOR FOR SINKING A CAISSON**

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[22] Filed: **Oct. 10, 1972**

[21] Appl. No.: **295,951**

[30] **Foreign Application Priority Data**

Oct. 30, 1971 Japan..... 46-86613

[52] U.S. Cl..... **175/94, 61/50, 175/171, 175/267**

[51] Int. Cl..... **E21b 3/12**

[58] Field of Search..... **175/94, 97-99, 175/171**

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Primary Examiner—Ernest R. Purser

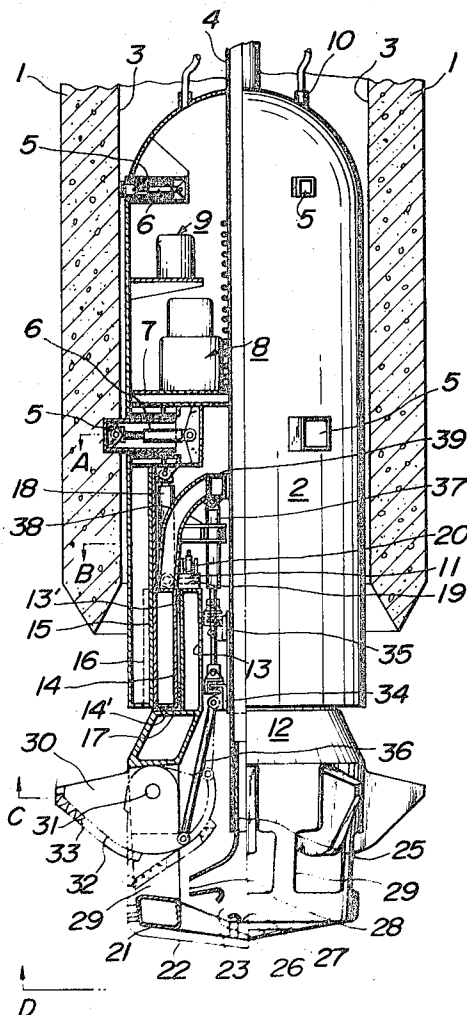
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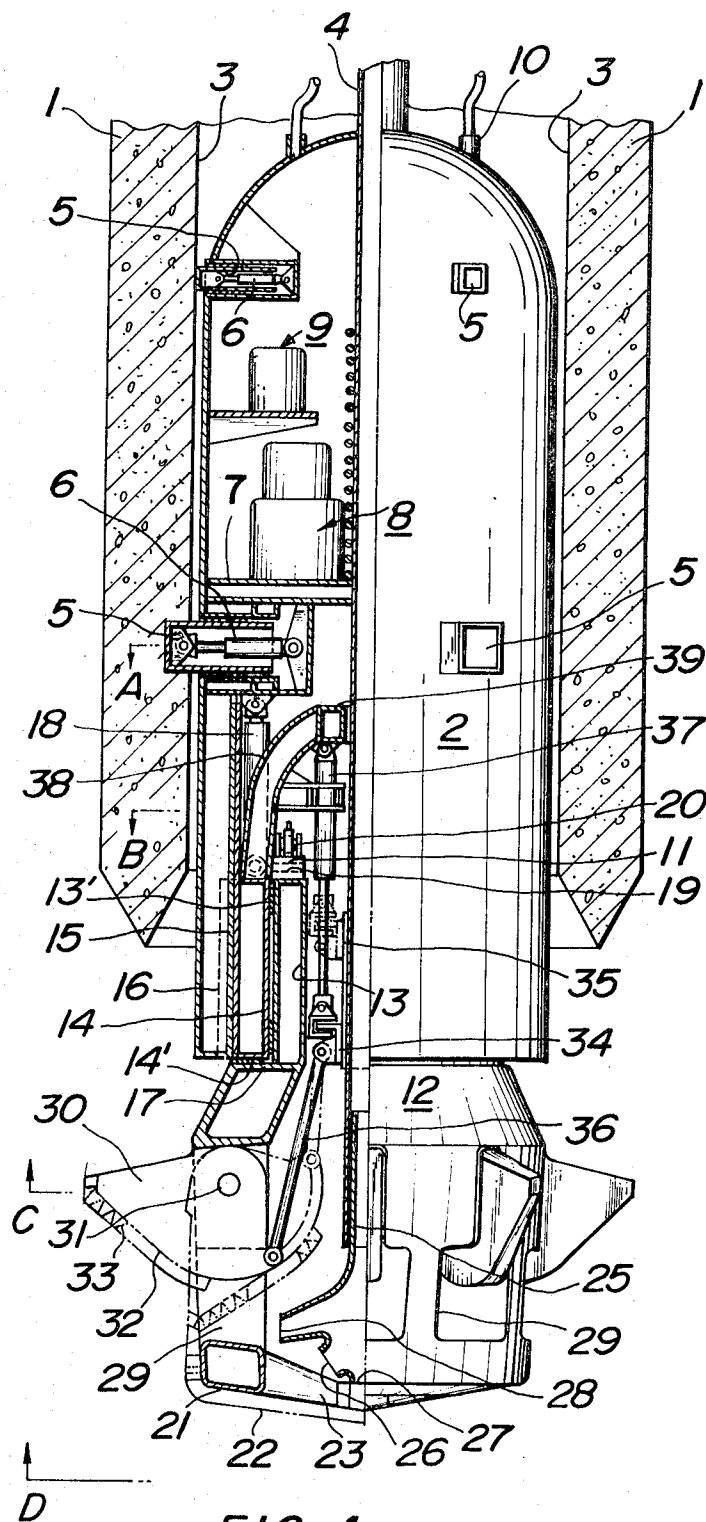
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ABSTRACT

An apparatus for sinking a caisson to the bottom of the water without utilizing a pneumatic caisson. A housing provided at its lower end with a cutter body is hung down with the aid of an air lift pipe extending through the housing into a vertical cavity formed in the caisson and locked therewith. Then, the cutter body is driven by groups of oil jacks so as to effect both boring and reaming operations of the cutter body whereby the bottom of the water is excavated to form a bored hole which is also enlarged to beneath the caisson. Subsequently, the caisson is released from the housing and sunk to the bottom of the water by its own weight or conventional forced sinking operation.

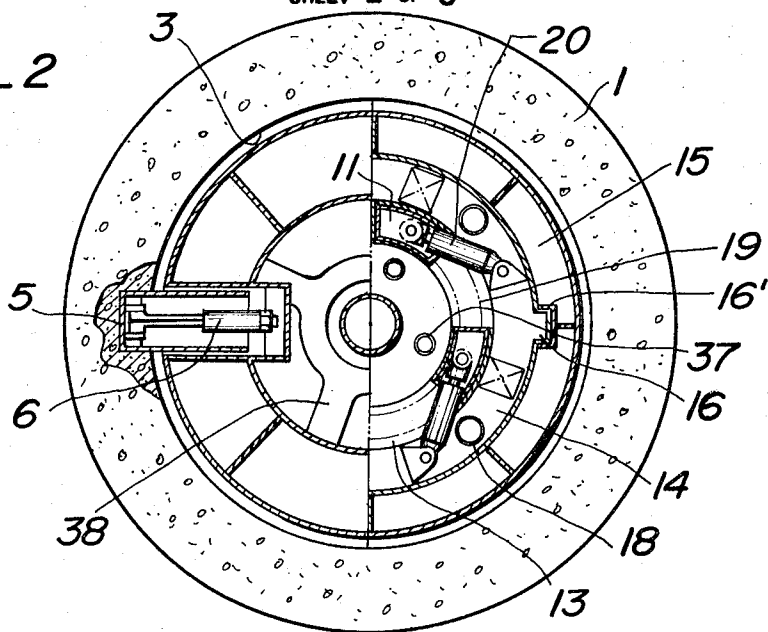
1 Claim, 5 Drawing Figures



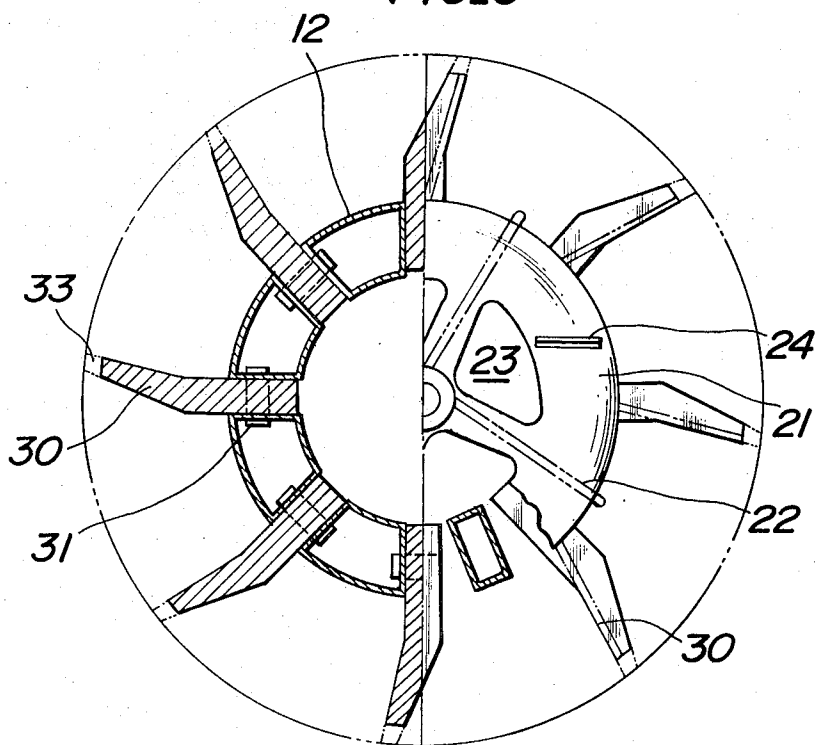


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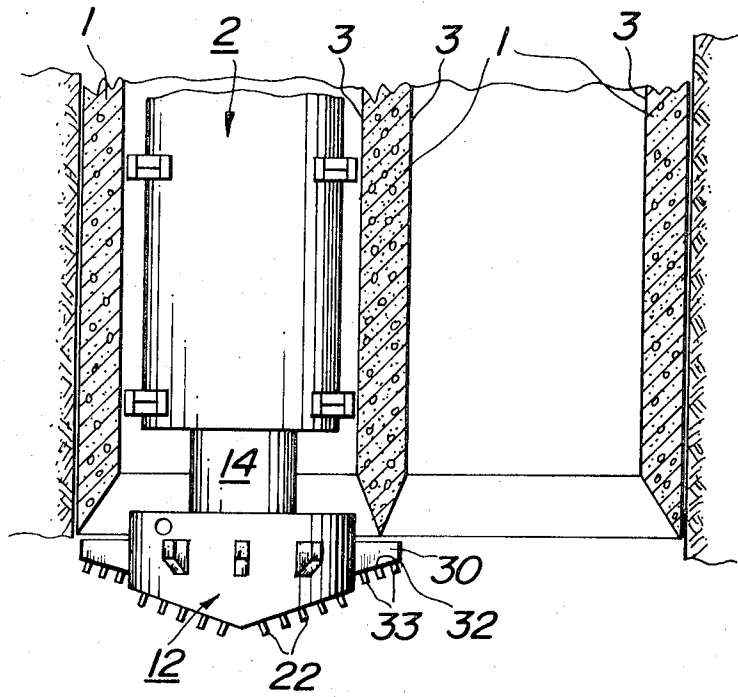
FIG_2



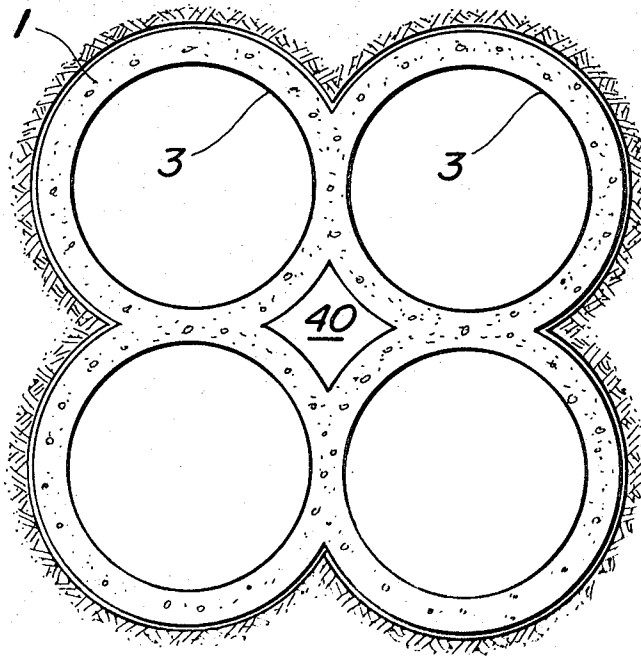
FIG_3



SHEET 3 OF 3
FIG_4



FIG_5



FLUID DRIVEN BELOW GROUND MOTOR FOR SINKING A CAISSON

This invention relates to a method of and apparatus for sinking a caisson to the bottom of the water.

In the conventional method of sinking a caisson and providing an integral part of the foundation of a bridge pier, etc., in general the bottom of the water is excavated by workmen in a working chamber provided at the bottom of caisson and filled with air under pressure and the removal of soil beneath the caisson forces the caisson downward until a firm stratum is reached. The use of such pneumatic caisson, however, is limited to depths not greater than substantially 3 Kg/cm². At depths greater than 3 Kg/cm², it becomes difficult to excavate the bottom of the water by workmen, and as a result, it is almost impossible to sink the caisson to the bottom of such deep water. On the other hand, it is necessary to excavate the total surface of the bottom of the water which corresponds to the sectional area of a caisson. If the bottom of the water is of a rock bed, that part of the rock bed which is located beneath the caisson could not sufficiently be excavated without remaining non-excavated portions which will prevent the caisson from being sunk to the bottom of the water.

The main object of the invention, therefore, is to provide a method of sinking a caisson to the bottom of the comparatively deep water which is capable of sinking the caisson to the bottom of the comparatively deep water at depths such as a depth greater than 30 m, excavating the bottom of the water to various configuration corresponding to various sizes and shapes of the sectional area of the caisson, and sinking the caisson to the depth of the water thus excavated.

Another object of the invention is to provide an apparatus for carrying out the method which is simple in construction and reliable in operation.

The above and other objects of the invention will become more apparent from the following description and accompanying drawings forming part of this application.

In the drawings:

FIG. 1 is a fragmentary longitudinal sectional view of an embodiment of an apparatus according to the invention;

FIG. 2 shows at its left half a cross-section on the line A of FIG. 1 viewed in the direction of the arrow and at its right half a cross-section on the line B of FIG. 1 also viewed in the direction of the arrow;

FIG. 3 shows at its left half a cross-section on the line C of FIG. 1 viewed in the direction of the arrow and at its right half a bottom plan of FIG. 1 viewed in the direction of the arrow D;

FIG. 4 is a fragmentary cross-sectional view showing the relation between a large bee-hive shaped caisson and the bottom of the water to be excavated; and

FIG. 5 is its bottom plan view.

Referring to FIG. 1, reference numeral 1 designates a hollow caisson, which is a thick-walled shell to be sunk to the bottom of the water. 2 is a dome-shaped cylindrical housing secured to an air lift pipe 4 to be described later and adapted to hang down the housing 2 into a vertical cavity 3 formed in the caisson 1. 5 shows a plurality of grippers mounted around the peripheral wall of housing 2 and equally spaced apart one from the other. These grippers 5 cooperate with a first group of oil jacks 6 in a manner such that extension of the

plunger of each oil jack 6 causes each gripper 5 to project out of the peripheral wall of housing 2 and bring it into engagement with the vertical cavity 3 whereby to align and lock the housing 2 with the caisson 1, and that contraction of the plunger of each oil jack 6 causes each gripper 5 to retract into the peripheral wall of housing 2 and release the housing 2 from the caisson 1. The housing 2 is hermetically divided by a bulkhead 7 into upper and lower chambers. The upper chamber serves as a control chamber and hence is provided with a pump unit 8 for operating groups of oil jacks including the first group of oil jacks 6, a control board 9 for controlling the above mentioned alignment of the housing 2 with the caisson 1 and effecting electric power distribution, and doors which permit the workmen to enter into and go out the housing 2, etc. To the dome of housing 2 is secured a conduit 10 for effecting ventilation of the control chamber and extending cables for the electrical devices therethrough. The air lift pipe 4 hermetically extends through the housing 2 and serves not only to hang down the housing 2 but also to remove the excavated soil from the bottom of the water therethrough. For this purpose, the air lift pipe 4 is connected at its top end to an air lift device 25 so as to maintain the air lift pipe 4 under reduced pressure.

12 designates a cutter body provided at its center with a rotary drum 13 formed integral with the cutter body 12 and projected upwards therefrom. The rotary drum 13 is rotatably journaled through a metal sleeve 13' in a ring 14 adapted to act as a bearing. The bearing ring 14 slidably engages with a peripheral frame 15 provided at the lower chamber of the housing 2. The bearing ring 14 is provided around its outer periphery with at least one projecting key 16 adapted to fit into corresponding groove 16' in the frame 15 thus forming a spline structure. The bearing ring 14 makes contact through a metal plate 14' with a shoulder 17 of the cutting body 12.

18 designates a second group of oil jacks pivoted to the upper end of the bearing ring 14 and the free end of each plunger of which is pivoted to a transverse frame of the housing 2. If the second group of oil jacks 18 extend in synchronism downwards, the bearing ring 14 is pushed downwards to push the cutter body 12 downwards. 19 shows a ratchet wheel secured coaxially to the upper end of the rotary drum 13. To the upper end of the bearing ring 14 is pivoted one end of a third group of oil jack 20 whose plungers are provided at their free ends with ratchets 11, respectively. The third group of oil jacks 20 are so arranged that all of the ratchets 11 come into engagement with the ratchet wheel 19, and that extension of their plungers causes the ratchet wheel 19 to rotate and contraction of their plungers causes each ratchet 11 to slidably move back along the ratchet wheel 19 to its original position. Thus, the extension and contraction of all the plungers of the third group of oil jacks 20 in synchronism are capable of intermittently rotating the ratchet wheel 19 or the extension and contraction of all the plungers of these oil jacks 20 in non-synchronism are capable of continuously rotating the ratchet wheel 19. These rotations of the ratchet wheel 19 are transmitted to the rotary drum 13, thereby rotating the cutter body 12.

To the lower end of the cutter body 12 is secured an end disc 21 which is provided with a plurality of equally spaced boring cutters 22 adapted to excavate a cylin-

drical hole and with a plurality of equally spaced scrapers 24 adapted to collect excavated soil and remove it through openings 23 formed between spokes of the end disc 21 into the cutter body 12. In the center of the cutter body 12 is arranged a suction pipe 25 whose upper part is slidably fitted in the lower end of the air lift pipe 4 and provided at its lower end with inlets 26 and 27 adapted to suck in the soil excavated by the boring cutters 22 together with water entered through the openings 23. The suction pipe 25 is provided at its side wall and above the inlets 26 and 27 with another inlet 28 adapted for sucking in the soil excavated by radially extending reaming cutters 33 to be described later.

The cutter body 12 is provided around its peripheral wall with a plurality of equally spaced inverted T-shaped windows 29. Each window 29 consists of an upper vertically extending narrow center part and a lower horizontally extending wide part. In each window 29 is pivotally mounted by a pin 31 a rotary segment 30. The rotary segment 30 is provided at its lower edge 32 with a plurality of equally spaced and radially extending reaming cutters 33. If the rotary segment 30 is rotated to project the reaming cutters 33 out of the window 29 through their upper vertically extending narrow center part, the reaming cutters 33 excavate the soil beneath and outside the caisson 1. If the rotary segment 30 is rotated to retract the reaming cutters 33 into the windows 29, the reaming cutters 33 force the excavated soil through the lower horizontally extending wide part of the windows 29 into the inlet 28.

To the lower part of the air lift pipe 4 is secured a plurality of equally spaced guide rails 35 along which are slidably mounted shoes 34. Each shoe 34 is connected through a connecting rod 36 to the rotary segment 30 such that the lowering movement of the shoe 34 causes the rotary segment 30 to project out of the window 29 through the upper vertically extending narrow center part thereof, and that the raising movement of the shoe 34 causes the rotary segment 30 to retract into the window 29. To each shoe 34 is pivoted the free end of a plunger of one of a fourth group of oil jacks 37 whose cylinders are pivoted at their upper ends to an annular frame 39 which is supported around the air lift pipe 4 by means of a plurality of equally spaced arms 38. The extension and contraction of each plunger of the fourth group of oil jacks 37 in synchronism cause each rotary segment 30 and reaming cutters 33 to project out of the window 29 and retract thereinto through each of shoes 34 and connecting rods 36. The fourth group of oil jacks 37 are adapted to connect the cutter body 12 through the connecting rods 36, rotary segments 30 and windows 29 to the housing 2 so as to abut the shoulder 17 of cutter body 12 through the metal sheet 14' against the lower end of bearing ring 14.

The above mentioned apparatus according to the invention will operate as follows. In the first place, the housing 2 is hung downward by means of the air lift pipe 4 such that the base surface of the cutter body 12 is positioned at a depth which is slightly higher than the lower end of the caisson 1. Then, the first group of oil jacks 6 are operated to urge the grippers 5 against the inner wall of vertical cavity 3 of the caisson 1 or indentations present therein. At this time, the other groups of oil jacks 18, 20 and 37 for driving the cutter body 12 are not in operation. Then, the second and third groups of oil jacks 18 and 20 are operated to rotate the

cutter body 12 while lowering it. Thus, the boring cutters 22 excavate soil beneath the cutter body 12 by means of the downward thrust and rotating torque thereof. This excavation proceeds as the second group of oil jacks 18 go deeper by one stroke. The excavated soil together with water are removed through the inlets 26 and 27 and air lift 4 by means of the sucking action applied to the top end of the air lift pipe 4. Subsequently, the fourth group of oil jacks 37 are operated. If the plunger of each oil jack 37 is extended, each rotary segment 30 is projected out of each window 29 to excavate soil beneath the lower end of caisson 1 so as to enlarge the hole bored by the boring cutters 22. If the plunger of each oil jack 37 is contracted, each rotary segment 30 is retracted into each window 29. If it is desired to excavate soil between adjacent rotary segments 30, at first the third group of oil jacks 20 are operated so as to slightly rotate the cutter body 12 and then the fourth group of oil jacks 37 are operated to extend and contract their plungers, and as a result, the soil between adjacent rotary segments 30 can be excavated. The rotary segments 30 retracting into the windows 29 serve to remove the excavated soil together with water through the inlet 28 of the suction pipe 25 and air lift pipe 4. After the hole bored by the boring cutters 22 has been enlarged by means of the reaming cutters 33, the first group of oil jacks 6 are operated to release the housing 2 from the caisson 1 and hang down it again with the aid of the air lift pipe 4. At this new depth, the first group of oil jacks 6 are operated to urge the grippers 5 against the inner wall of vertical cavity 3 of the caisson 1 and then the above mentioned boring and reaming operations are effected again. The above successive steps are repeated until the housing 2 arrives at a depth which is lower than the lower end of the caisson 1. Then, the first group of oil jacks 6 are operated to retract the grippers 5 into the housing 2 thus releasing the caisson 1 from the housing 2, and as a result, the caisson 1 can be sunk to the bottom of the water. The above mentioned steps are repeated to excavate to a firm stratum at great depths on which is sunk the caisson 1.

If the caisson 1 consists of a single well cylinder, a single housing 2 may be combined therewith and the boring and reaming cutters 22 and 33 provided on the cutter body 12 may effect the boring and reaming operations, respectively, thereby sinking the single well cylinder caisson 1 to the bottom of the water in a simple and reliable manner.

If it is desired to sink a large caisson 1 to the bottom of the water, the caisson 1 is formed into a bee-hive shape and provision is made of a plurality of vertical cavities 3 arranged like a bee-hive in the large caisson 1 as shown in FIGS. 4 and 5. Into each bore 3 is hung down the housing 2 and cutter body 12. All of these cutter bodies 12 are operated as mentioned above to effect the boring and reaming operations to enlarge the outer periphery of the excavated bottom to the outer periphery of the caisson 1 which is continuous as shown in FIG. 5. If a non-excavated portion 40 is eventually remained at the center of the four cutter bodies 12, the caisson 1 may be provided beforehand with a pipe through which is lowered down a boring rod. Then, a weak explosion of dynamite may cause the non-excavated portion 40 to be excavated in a simple manner. The housing 2 connected with the cutter body 12 which does not effect excavation is filled with air under

pressure and the weight of all of the caissons 1 is made in balance with buoyancy acting upon the caisson 1. Thus, after the bottom of the water has been excavated by one shift of the cutting body 12, the pressure in the housing 2 is adjusted to cause the caisson 1 to sink successively by one shift. In case of sinking the caisson 1 to the bottom of the water, the presence of excavated soil beneath the caisson 1 might prevent the caisson 1 from being sunk to the bottom of the water. In such a case, an air blow may be subjected to the outer surface of the caisson 1 so as to gradually decrease the resistance against the sinking of caisson 1.

As explained hereinbefore, the use of lowering thrust and rotating torque of the cutter body 12 against the reaction force of the caisson 1 for supporting the cutter body 12 ensures boring operation for the excavation of the bottom of the water and also the use of rotating torque of the cutter body 12 against the force of urging the cutting body 12 against the bottom of bored hole ensures reaming operation for the enlargement of the bored hole excavated by the boring operation and further provide the important advantage that the bored hole can be enlarged to the outer periphery of the caisson 1, and that the caisson 1 can easily and reliably be sunk to the bottom of the water with the aid of its own weight or the conventional forced sinking operation. In accordance with the invention, the housing 2 connected to the cutting body 12 is released from the caisson 1 after each excavating operation and hung down and then locked again with the caisson 1 to effect a new excavating operation and the above steps are repeated in the order mentioned. It is thus possible that the amount of soil excavated from the bottom of the water, that is, the amount of sinking the caisson 1, is increased, thereby significantly improving the efficiency of sinking the caisson 1 to the bottom of the water. The invention has the advantage that the excavation of the bottom of the water is automatically proceeded by the cutter body 12, and that workmen are not required to excavate in caissons filled with air under pressure. Thus, the invention provides the important advantage that the excavation of the bottom of the water can be effected in an easy and safe manner, and that the caissons can be sunk to a firm stratum located at great deep depths.

The embodiment of the invention shown in the drawings is for the purpose of describing the objects and features of the invention. It is to be understood, however, that modifications, changes and alternations may be made without departing from the scope and spirit of the invention.

What is claimed is:

1. An apparatus for sinking a caisson to the bottom of the water comprising a hollow caisson to be sunk to the bottom of the water, a housing provided at its peripheral wall with a plurality of equally spaced grippers and a first group of oil jacks for projecting said grippers out of said housing and retracting thereinto so as to lock said housing with said caisson and release said housing therefrom, said housing being further provided with an air lift pipe extending therethrough and for hanging down said housing and removing excavated soil together with water, a cutter body connected to the lower end of said housing and provided at its upper end with a rotary drum formed integral with said cutter body and a bearing ring coaxially surrounding said rotary drum and slidably engaged with the peripheral frame of said housing, at its end disc with a plurality of equally spaced boring cutters for boring the bottom of the water and openings for passing the excavated soil together with water therethrough, and around its peripheral wall with windows, a second group of oil jacks each of which is pivoted at its lower end to the upper end of said bearing ring and each plunger of which is pivoted at its free end to the transverse frame of said housing, a third group of oil jacks pivoted to said bearing ring and each plunger of which is provided at its free end with a ratchet engaged with a ratchet wheel secured to the upper end of said rotary drum, said cutter body being given downward thrust through said bearing ring by said second group of oil jacks and being given rotating torque through said rotary drum by said third group of oil jacks, a plurality of equally spaced and radially extending reaming cutters each pivoted to said cutter body and connected through connecting rods to shoes slidably engaged with guide rails secured to said air lift pipe, a fourth group of oil jacks pivoted to a plurality of equally spaced arms secured to said bearing ring and each plunger of which is pivoted at its free end to said shoe and adapted to rotate through said connecting rod said reaming cutters so as to project them out of said windows and retract thereinto, the projecting rotating torque of said reaming cutters acting to enlarge the hole excavated by said boring cutters, a suction pipe incorporated into said cutter body and slidably fitted in the lower end of said air lift pipe and provided at its lower parts with inlets for receiving soil excavated by said boring cutters together with water and with inlets for receiving soil excavated by said reaming cutters together with water, and a control chamber formed in said housing and for operating said first, second, third, and fourth groups of oil jacks.

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