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(54) **APPARATUS FOR DREDGING DETRITAL MATERIAL FROM A TUBULAR FOUNDATION**

(57) Apparatus for dredging detrital material from a tubular foundation planted in a seabed, comprising a support frame (2), a plurality of crushing heads (3), mounted on the support frame (2) in peripheral position and each comprising a first hydraulic motor (31), supplied by a pressurized fluid, and at least one excavator tool (32), movable by the first hydraulic motor (31) in order to remove detrital material from the tubular foundation (100).

The apparatus for dredging also comprises at least one suction pump (4), fixed to the support frame (2) and placed in a central portion of the latter, interposed between the crushing heads (3) and comprising a second hydraulic motor (41), supplied by a pressurized fluid, and a pump body (42), provided with a suction opening (42'), arranged for suctioning the detrital material from the tubular foundation (100), and a discharge opening (42"), arranged for expelling the detrital material outside the tubular foundation (100) or for transferring said detrital material to a deposition zone.

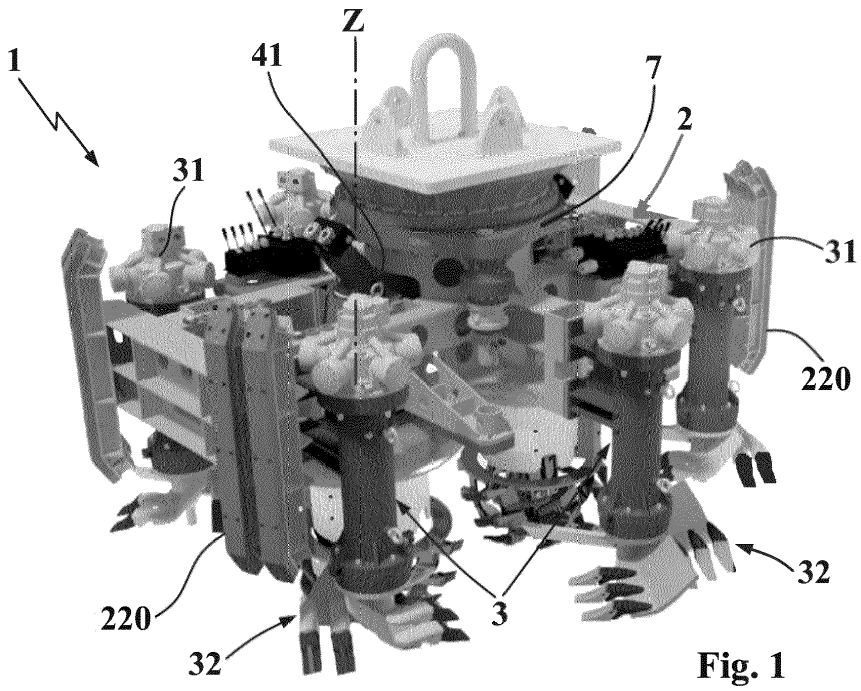

Fig. 1

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Description

Field of application

[0001] The present invention regards an apparatus for dredging detrital material from a tubular foundation, which is planted on a seabed, e.g. a marine or ocean seabed, according to the preamble of the independent claim 1.

[0002] The present apparatus for dredging is therefore inserted in the field of production of apparatuses for dredging detrital material, which are in particular configured for operating on tubular foundations planted on seabeds, even at considerable depth.

[0003] The present apparatus for dredging is intended to be advantageously used for operations on seabeds of bodies of water, for dredging works and excavation works within tubular foundations planted on seabeds, e.g. for wind turbines.

State of the art

[0004] In the industrial field of operating machines for dredging, apparatuses for removing detrital material from tubular foundations planted on seabeds have been known for some time.

[0005] The apparatuses for dredging detrital material from tubular foundations of known type are susceptible of being inserted within a tubular foundation, which is planted on a seabed and is arranged for housing the base of a wind turbine or a similar off-shore structure. Normally such apparatuses remove material of various type, as a function of the different site in which they are used, in order to remove such detrital material from within the foundation planted on the seabed, in order to allow the "clearing" of the tubular foundation and allow the installation of the base of the off-shore structure. For example, such operating machines can remove sandy, clay, stone or bituminous material from the seabed.

[0006] The operation of removing detritus from the tubular foundations provides for a first step of abrasion of the seabed, attained inside the foundation, and a second step of removal, by means of pumping of the detrital material, in which the abraded detritus are removed and transported outside the tubular foundation, in order to "clear" the interior of the foundation of the removed detrital material.

[0007] One example of an apparatus of known type, for dredging detrital material from a tubular foundation, is described in the patent application WO 2019/013646 and comprises a support structure, arranged for being fixed to the free end of a tubular foundation, and a dredging device, slidably housed within the support structure and arranged for sliding within the tubular foundation to be dredged.

[0008] More in detail, the support structure has substantially box-like form and is provided with a lower mouth, through which the dredging device is lowered by means of a hoist fixed on the upper part to the support structure.

[0009] The apparatus for dredging of known type described in the aforesaid patent comprises a crushing head provided with a shaft, on which a disc-shaped foot is mounted. The foot of the crushing head of known type is provided with a plurality of movable nozzles on a lower face thereof directed towards the seabed, which are oriented along rows placed radially and are arranged for dispensing water at high pressure (greater than 100 bar) towards the seabed and removing, by means of the hydraulic action, the detrital material from the seabed. For such purpose, the apparatus of known type comprises a hydraulic pump, in order to supply with pressurized water the plurality of movable nozzles placed on the crushing head of the apparatus.

[0010] The crushing head of the apparatus also comprises, on the lower part, a suction opening, placed centrally on the foot and hydraulically connected to a suction duct and to a suction pump, in order to remove the detritus removed by the movable nozzles, in order to transport it outside the tubular foundation to be dredged. The aforesaid suction pump is a volumetric pump.

[0011] The apparatus of known type provides that the dispensing nozzles are movable, and in particular that they are movable in rotation, in order to carry out a more uniform removal of the sediments. The aforesaid movement of the nozzles can be of independent type, in which each nozzle is moved independently of the others, or coordinated, in particular by means of the rotation of the foot of the crushing head of the dredging device. More in detail, in this case, the shaft of the crushing head is moved by means of a motor, hydraulic or electric, in order to rotate the foot of the crushing head. In such case, in order to allow the relative rotation of the two elements, the foot is hydraulically connected to the discharge duct by means of a rotary hydraulic joint.

[0012] The apparatus also comprises a plurality of teeth, which are placed on the lower face of the crushing head and are extended along radially-placed rows, which are alternated with the rows of nozzles. The aforesaid plurality of teeth allows executing an action of mechanical dredging parallel to the action of hydraulic dredging operated by the movable nozzles. Also in this case, therefore, in order to attain the mechanical dredging it is necessary to rotate the crushing head of the apparatus by means of the aforesaid electric or hydraulic motor.

[0013] However, the apparatus for dredging of known type, described briefly up to now, has in practice demonstrated that it does not lack drawbacks.

[0014] A first drawback lies in the fact that the dredging operation of the apparatus described in the patent application WO 2019/013646 is not suitable for operating on particularly hard seabeds. Indeed, the dredging action of the aforesaid apparatus is mainly ascribable to the hydraulic dredging attained by the movable nozzles, which however are unsuitable for operating on particularly resistant seabeds. For example, in case of rocky seabeds,

the movable nozzles described in the aforesaid patent are not very effective, and this involves a greater duration of the dredging operation, with consequent increased costs. A further drawback lies in the fact that the apparatus of known type has shown to be complex in the assembly thereof and in the operation thereof. Indeed, in order to execute a mechanical dredging to support the aforesaid hydraulic dredging, it is necessary to operate a rotation of the entire crushing head in order to rotate the teeth of the crushing head.

[0015] Such combination is in particular necessary in the case of rocky terrain, in which hydraulic dredging on its own is insufficient. Nevertheless, the rotation of the crushing head requires a hydraulic or electric motor, which must be suitable for underwater operation, and a connection with rotary hydraulic joint between the crushing head and the removal duct (and possibly with the hydraulic pumps connected to the crushing head), which in reality makes the apparatus of known type complex in the assembly thereof and in the operation thereof, also having to operate at high pressures (greater than 100 bar).

[0016] A further drawback of the apparatus of known type lies in the fact that the mechanical dredging has proven incompatible with the hydraulic dredging. Indeed, the teeth described in the aforesaid patent application and their placement have proven unsuitable for "collaborating" with the movable nozzles.

[0017] More in detail, the teeth, the movable nozzles and the removal opening are placed on the lower face of the crushing head, and this requires placing the same lower face of the crushing head substantially in abutment against the seabed so as to allow the teeth to operate on the seabed itself. However, such positioning involves the substantial abutment also of the movable nozzles on the seabed to be dredged, which in the case of clay seabeds could cause the obstruction of the nozzles, and in the case of rocky seabeds could damage the nozzles themselves, in some cases causing malfunctions of the entire operating machine. In addition, the aforesaid positioning involves the substantial abutment of the suction opening, which is therefore obstructed and not free in the operation thereof, preventing a correct removal of the detrital material from the seabed. In addition, the pump arranged for supplying the movable nozzles is not actuatable during the mechanical dredging operation, when the crushing head is placed in contact with the seabed, in order to avoid that the high pressure (greater than 100 bar) necessary for the mechanical dredging brings the crushing head away from the seabed itself, preventing the mechanical action of the teeth.

[0018] Further apparatuses for dredging detrital material are described in the documents EP 2481490 A1 and CN 111764454 A and substantially comprise a suction pump formed by a hydraulic motor connected to a pump body, which is provided with a central suction opening in order to suction the detrital material and with a discharge opening in order to expel the detrital material outside. Also the latter solutions of known type have not proven suitable for overcoming the abovementioned problems.

Presentation of the invention

[0019] The essential object of the present invention is therefore that of eliminating the drawbacks of the abovementioned prior art, by providing an apparatus for dredging detrital material from a tubular foundation which is capable of operating on all types of seabeds (rocky, clay and others), ensuring high effectiveness.

[0020] A further object of the present invention is to provide an apparatus for dredging detrital material which can be produced in a quick and inexpensive manner manner, avoiding complex assembly operations.

[0021] A further object of the present invention is to provide an apparatus for dredging detrital material which is capable of operating in an optimal manner in association with tubular foundations.

[0022] A further object of the present invention is to provide an apparatus for dredging detrital material which is structurally strong and entirely reliable in operation.

Brief description of the drawings

[0023] The technical characteristics of the invention, according to the aforesaid objects, are clearly seen in the contents of the below-reported claims and the advantages thereof will be more evident from the following detailed description, made with reference to the enclosed drawings, which represent several merely exemplifying and non-limiting embodiments of the invention, in which:

- figure 1 shows a bottom perspective view of an apparatus for dredging, object of the present invention;
- figure 2 shows a top plan view of the apparatus of figure 1;
- figure 3 shows a bottom plan view of the apparatus of figure 1;
- figure 4 shows a bottom plan view of a support frame of the apparatus of figure 1;
- figure 5 shows a top perspective view of the apparatus of figure 1 housed within the tubular foundation, the latter illustrated in section;
- figure 6 shows a bottom plan view of the apparatus of figure 5;
- figure 7 shows a bottom perspective view of a pump body of a suction pump of the apparatus for dredging;
- figure 8 shows a third excavator tool of the suction pump and a support casing of the apparatus for dredging;
- figures 9a and 9b respectively show a first and a second crushing head of the apparatus of figure 1;
- figures 10a and 10b show a detail of figures 9a and 9b, respectively relative to a first and a second excavator tool of the crushing heads of the apparatus for dredging;
- figure 11 shows a sectional view of the suction pump

of the apparatus for dredging.

Detailed description of a preferred embodiment

[0024] With reference to the enclosed drawings, reference number 1 overall indicates the apparatus for dredging, object of the present invention.

[0025] The apparatus for dredging 1, object of the present invention, is employable for dredging detrital material from a tubular foundation 100 planted in a seabed. More in detail, with detrital material it must be intended the ground, composed of loam, clay, sand, gravel or even rock, which remains in the tubular foundation 100 planted on the seabed and which must be removed for a certain depth in order to allow housing an off-shore structure, such as for example the pole of a wind turbine.

[0026] More in detail, the tubular foundations comprise, in a per se known manner, a tubular body which can be made for example of steel and which is planted on a seabed and is extended between a free end, placed above the seabed, and a buried end, placed below the seabed. The tubular foundations are arranged for housing off-shore structure bases, such as for example poles for wind turbines, in order to constrain the aforesaid off-shore structures to the seabed.

[0027] The apparatus 1 is advantageously employable for operating both on tubular foundations completely immersed in water, in which the free end is placed below the water surface, and for operating on foundations that are partially immersed in water, in which the free end is placed above the water surface.

[0028] The apparatus 1 is arranged for being connected to a crane placed on a watercraft (or similar movement systems), in order to be moved closer to the tubular foundation 100 to be dredged.

[0029] More in detail, in the case of tubular foundations completely immersed in water, the crane lowers the apparatus 1 within the water in order to place it above, in proximity to the free end of the tubular foundation 100. Otherwise, in the case of tubular foundations partially immersed in water, the crane lifts and brings the apparatus 1 close in order to place it above, in proximity to the free end of the tubular foundation 100.

[0030] In accordance with the idea underlying the present invention, the apparatus 1 for dredging detrital material comprises a support frame 2, mechanically connectable to a watercraft, to a crane or to another structure suitable for supporting the apparatus 1 in order to lower it within a tubular pipe. For such purpose, the apparatus 1 preferably comprises a support cable (not represented), for example a metallic ring chain.

[0031] The apparatus 1 is susceptible of being hydraulically connected, in a per se known manner, to pressurized fluid generation means, in order to supply the hydraulic motors of the apparatus 1. The aforesaid pressurized fluid generation means can be placed directly on the watercraft, from which the apparatus 1 is lowered, or they can be immersed together with the apparatus 1 itself, so as to limit the distance of the pressurized fluid supply ducts.

[0032] The apparatus 1 also comprises a plurality of crushing heads 3, mounted on the support frame 2, preferably on a central portion 21 of the support frame 2, in peripheral position, and each comprising a first hydraulic motor 31 supplied by a pressurized fluid and at least one excavator tool 32, movable by the corresponding first hydraulic motor 31 in order to remove detrital material from the tubular foundation 100.

[0033] Advantageously, each first hydraulic motor 31 is of radial piston type, comprising a series of pistons, placed to intercept the pressurized fluid and mechanically connected to a connecting rod connected to a first rotor shaft, in order to rotate aforesaid rotor shaft along a first rotation axis Z, which is substantially vertical when the apparatus 1 is lowered within the tubular foundation 100.

[0034] Otherwise, it is possible to provide that the first hydraulic motor 31 is a vane motor, comprising a series of vanes placed to intercept the pressurized fluid in order to be actuated in rotation, and a first rotor shaft, fixed to the first series of vanes and arranged for rotating along a first rotation axis Z, substantially vertical when the apparatus 1 is fit within the tubular foundation 100.

[0035] The apparatus 1 also comprises at least one suction pump 4, described more in detail hereinbelow, which is fixed to the support frame 2, interposed between the crushing heads 3 and placed in a central portion of the latter.

[0036] The suction pump 4 comprises a second hydraulic motor 41, supplied by a pressurized fluid, and a pump body 42, provided with a suction opening 42', arranged for suctioning the detrital material from the tubular foundation 100, and a discharge opening 42", arranged for transferring the aforesaid detrital material outside the tubular foundation 100 or for transferring the detrital material to a deposition zone, advantageously placed on a watercraft.

[0037] In accordance with a first embodiment of the support frame 2 of the apparatus 1, illustrated in the enclosed figures, the support frame 2 comprises a fixed central portion 21, on which the two crushing heads 3 are mounted, and two lateral guide portions 22. Advantageously, the lateral guide portions 22 are movable with respect to the central portion 21. Preferably, the central portion 21 is provided with telescopic guides 23 within which corresponding telescopic portions 24 of the lateral guide portions 22 are slidably inserted.

[0038] Of course, without departing from the protective scope of the present invention, it is possible to equip the lateral guide portions 22 with telescopic guides 23 and the central portion 21 with corresponding telescopic portions 24 slidably housed in the telescopic guides 23.

[0039] Otherwise, it is also possible to provide for an external guide fixed to one of the two portions 21, 22 of the support frame 2, within which a corresponding guide element is susceptible of sliding, made on the other portion of the support frame 2. Advantageously, the appa-

ratus 1 comprises actuator means (not represented), preferably at least one hydraulic piston, in order to move the lateral guide portions 22 with respect to the fixed central portion 21 in a horizontal adjustment direction orthogonal to a vertical axis Y, in order to place the lateral guide portions 22 at the internal surface of the tubular foundation 100.

[0040] More in detail, the lateral guide portions 22 of the support frame 2 each comprise at least one sliding block 220 susceptible of facing the internal surface of the tubular foundation 100 (as illustrated in figure 5) in order to guide the apparatus 1 along the cavity of the tubular foundation 100.

[0041] In operation, the lateral guide portions 22 are movable between a retracted configuration, in which they are gathered close to the central portion 21 and spaced from the internal surface of the tubular foundation 100, and an extended position, in which the lateral guide portions 22 are spaced from the central portion 21 and the sliding blocks 220 are placed at the internal surface of the tubular foundation 100, in order to guide the apparatus 1 and prevent oscillations thereof during dredging.

[0042] In accordance with the preferred embodiment, the plurality of crushing heads 3 comprises at least one first crushing head 5, comprising a first excavator tool 51, and at least one second crushing head 6 comprising a second excavator tool 61. Preferably, the second excavator tool 61 of the second crushing head 6 is provided with a first radial extension R1 greater than a second radial extension R2 of the first excavator tool 51 of the first crushing head 5. More in detail, with the expression "radial extension" hereinbelow it will be intended the maximum extension along a plane orthogonal to the first rotation axis Z of the first hydraulic motors 31.

[0043] Advantageously, each excavator tool 51, 61 comprises a hub, fixed to the corresponding hydraulic motor 31 and at least one blade provided with a plurality of teeth, and such blade is fixed to the hub and radially protrudes from the hub itself. Preferably, each blade lies on a plane substantially orthogonal to the first rotation axis Z of the first hydraulic motors 31.

[0044] In accordance with the preferred embodiment, illustrated in figure 10A, the first excavator tool 51 is provided with three first blades 510, each carrying two first teeth 520 mounted thereon, and the second excavator tool 61 is provided with three second blades 610, each carrying three second teeth 620 mounted thereon.

[0045] Of course, without departing from the protective scope of the present invention, it is also possible to provide for a different combination of blades and of teeth for each excavator tool 51, 61, and it is also possible to equip the first and the second excavator tool 51, 61 with the same number of blades and teeth.

[0046] In accordance with the preferred embodiment, illustrated in the enclosed figure 3, the apparatus 1 comprises six crushing heads 3 and two suction pumps 4. Advantageously, the crushing heads 3 are circumferentially mounted on the support frame 2 and comprise four first crushing heads 5 and two second crushing heads 6, while the suction pumps 4 are mounted in a central portion of the support frame 2, inside the crushing heads 3.

[0047] More particularly, the apparatus 1 comprises two pairs of first crushing heads 5, placed two-by-two aligned along two respective parallel and spaced first axes X, and in which the first crushing heads 5 of each pair are movable counter-rotating with respect to each other.

[0048] The apparatus 1 advantageously comprises a pair of second crushing heads 6 aligned along a second axis X' which is parallel to the first axes X and interposed therebetween, and in which the second crushing heads 6 of the pair of second crushing heads 6 are movable counter-rotating with respect to each other. Advantageously, the two suction pumps 4 are placed aligned along a third axis W, orthogonal to the first axes X and to the second axis X' of the pairs of first and second crushing heads 5, 6.

[0049] Advantageously, the suction pumps 4 are respectively interposed between one of the two first axes X and the second axis X', so as to be offset with respect to each pair of crushing heads 5, 6.

[0050] In accordance with the preferred embodiment, the second crushing heads 6 of the pair of second crushing heads 6 are placed at a first mutual distance D greater than the second mutual distance d between the two first crushing heads 5 of each pair of first crushing heads 5, such that the set of the crushing heads 3 is placed substantially along a circumference.

[0051] Advantageously, the apparatus 1 comprises movement means, mounted on a load-bearing structure and connected to the support frame 2, in order to move the apparatus 1 along a vertical axis Y within the tubular foundation 100. Advantageously, the movement means are also arranged for rotating the apparatus 1 on a rotation plane substantially orthogonal to the vertical axis Y.

[0052] Advantageously, the movement means comprise a hoist (not illustrated in the enclosed figures), on which the support cable is connected in order to be wound and unwound so to lift and lower the apparatus 1.

[0053] In operation, the apparatus 1 is movable between a rest configuration, in which it is at least partially housed within a load-bearing structure, and an operative configuration, in which the apparatus 1 is lowered along the tubular foundation 100 in order to intercept the seabed and dredge it.

[0054] Advantageously, during the dredging operations, the apparatus 1 slides along the tubular foundation 100 due only to the force of gravity after the progressive crushing of the seabed below it. Preferably, in the rest configuration, the apparatus 1 is entirely contained within the load-bearing structure, in order to be protected during the initial movement approaching the tubular foundation 100.

[0055] Advantageously, the support frame 2 of the apparatus 1 comprises a slewing bearing 7, in order to allow the rotation of the apparatus 1 during the dredging operations.

[0056] In accordance with the preferred embodiment, on the slewing bearing 7, a fixing plate 70 is fixed which is mechanically connected to the movement means. For such purpose, the fixing plate 70 comprises at least one eyebolt 700, and the support cable is connectable, at a first upper end thereof, to a first lifting hook fixed to the movement means, and comprises, at a lower end thereof, a second connection hook, connectable to the eyebolt 700 of the fixing plate 70 in order to connect the apparatus 1 and the movement means.

[0057] In accordance with the aforesaid embodiment, illustrated in the enclosed figure 5, the fixing plate 70 comprises a central eyebolt 700 and four spaced fixing rings 701 that are susceptible of being connected to the second connection hook, in a manner per se known to the man skilled in the art and therefore not discussed in detail hereinbelow. As mentioned above, the apparatus 1 comprises at least one suction pump 4, which comprises a second hydraulic motor 41 and a pump body 42.

[0058] Advantageously, each second hydraulic motor 41 is of rotary type and preferably comprises a second rotor shaft, arranged for rotating along a second rotation axis Z', parallel to the first rotation axis Z of the first hydraulic motors 31 and substantially parallel to the vertical axis Y, when the apparatus 1 is lowered within the tubular foundation 100.

[0059] The suction pump 4 also comprises an impeller 420, preferably of centrifugal type, placed within the pump body 42 and fixed to the second rotor shaft of the second hydraulic motor 41, preferably by means of fitting.

[0060] In operation, the detrital material enters within the pump body 42 through the suction opening 42', where it is energized by the rotating impeller 420, and subsequently the detrital material is expelled under pressure by the pump body 42 by means of the discharge opening 42".

[0061] Advantageously, the pump body 42 comprises a stirrer element 421, for example a dynamic mixer, fixed to the impeller 420 of the pump body 42 in order to be rotated and it is placed to intercept the suctioned detrital material towards the suction opening 42', in order to mix and make uniform the entering flow of detrital material. Otherwise, it is also possible to provide for a static mixer, fixed to a fixed element of the suction pump 42.

[0062] Advantageously, the stirrer element 421 comprises a screw placed coaxially with the second rotation axis Z' which is arranged for imparting a helical motion to a fluid of detrital material.

[0063] The discharge opening 42" is advantageously hydraulically connected to a discharge duct 42", which is extended between a first end connected to the discharge opening 42", and a second end placed spaced from the tubular foundation 100 and in fluid communication with the outside environment, so as to convey the suctioned detritus outside the tubular foundation 100.

[0064] Advantageously, the suction pump 4 comprises a filtering element 45 arranged upstream of the suction opening 42', in order to block bodies of detrital material transported by the flow of detrital material and having dimensions such to be able to obstruct the pump body 42 and the impeller 420.

[0065] More in detail, the filtering element 45 is provided with multiple filtering holes 46, through which first bodies of the detrital material smaller than such filtering holes 46 are susceptible of passing. The filtering element 45 is adapted to intercept second bodies of the detrital material larger than the filtering holes 46, blocking such second bodies in order to prevent them from reaching the pump body 42, obstructing it.

[0066] For example, the filtering holes 46 of the filtering element 45 have substantially circular shape, with diameter of about 60 mm.

[0067] In accordance with the preferred embodiment, illustrated in figure 11, at least one of the suction pumps 4 comprises a third hydraulic motor 440 and a third excavator tool 44, movable by the third hydraulic motor 440 in order to remove the detrital material from the tubular foundation 100. More in detail, the third hydraulic motor 440 is placed below the suction mouth 42' of the pump body 42, along the second rotation axis Z'. The third excavator tool 44 is fixed to the third hydraulic motor 440 and advantageously defines a lower end of the suction pump 4, so as to primarily intercept the seabed. Preferably, the third excavator tool 44 comprises a hub, fixed to the third hydraulic motor 440 and at least one third blade 441, provided with a plurality of third teeth 442, and fixed to the hub. Preferably, the third excavator tool 44 comprises six third blades 441, each carrying three third teeth 442 mounted thereon. In accordance with the aforesaid embodiment, the third blades 441 are placed around the second rotation axis Z' and are separated from each other by a corresponding lateral slit. More particularly, the third blades 441 of the third excavator tool 44 are bent backwards towards the filtering element 45 and delimit a space within which the third hydraulic motor 440 of the third excavator tool 44 is at least partially housed, in order to protect the third hydraulic motor 440 during dredging.

[0068] The apparatus 1 for dredging, object of the present invention, therefore attains the foreseen objects.

Claims

1. Apparatus for dredging detrital material from a tubular foundation planted in a seabed, said apparatus for dredging (1) comprising:

    - a support frame (2);
    - a plurality of crushing heads (3), mounted on said support frame (2) in peripheral position, each comprising:

        - a first hydraulic motor (31), supplied by a pressurized fluid, and
        - at least one excavator tool (32), movable

by said first hydraulic motor (31) in order to remove detrital material from the tubular foundation (100);

- at least one suction pump (4), fixed to said support frame (2) and placed in a central portion of the latter, interposed between said crushing heads (3) and comprising:

  - a second hydraulic motor (41), supplied by a pressurized fluid, and
  - a pump body (42), provided with a suction opening (42'), arranged to suction said detrital material from the tubular foundation 100, and a discharge opening (42"), arranged to expel said detrital material outside the tubular foundation (100) or to transfer said detrital material to a deposition zone.

2. Apparatus for dredging according to claim 1, wherein the support frame (2) of said apparatus for dredging (1) comprises a fixed central portion (21), on which said crushing heads (3) are mounted, and two lateral guide portions (22), said apparatus for dredging (1) comprising actuator means for moving said lateral guide portions (22) with respect to said fixed central portion (21) in a horizontal adjustment direction that is orthogonal to a vertical axis (Y), in order to place said lateral guide portions (22) at the internal surface of said tubular foundation (100).

3. Apparatus for dredging according to claim 2, wherein the lateral guide portions (22) of said support frame (2) each comprise at least one sliding block (220) susceptible of facing the internal surface of said tubular foundation (100) in order to guide said apparatus for dredging (1) along the cavity of said tubular foundation (100).

4. Apparatus for dredging according to any one of the preceding claims, wherein said plurality of crushing heads (3) comprises at least one first crushing head (5) comprising a first cutting tool (51), and at least one second crushing head (6) comprising a second cutting tool (61), said second crushing head (6) being provided with a first radial extension (R1) greater than a second radial extension (R2) of said first crushing head (5).

5. Apparatus for dredging according to claim 4, comprising:

  - six crushing heads (3), circumferentially mounted on said support frame (2) and comprising four said first crushing heads (5) and two said second crushing heads (6);
  - two suction pumps (4), mounted in a central portion, inside said crushing heads (3).

6. Apparatus for dredging according to claim 5, comprising:

  - two pairs of first crushing heads (5), placed two-by-two aligned along two respective parallel and spaced first axes (X), the first crushing heads (5) of each pair being movable counter-rotating with respect to each other;
  - a pair of second crushing heads (6) aligned along a second axis (X') interposed between said first axes (X) and parallel thereto, the second crushing heads (6) of said pair of second crushing heads (6) being movable counter-rotating with respect to each other;

said two suction pumps (4) being placed aligned along a third axis (W) orthogonal to said first and second axis (X, X') of said pairs of first and second crushing heads (5, 6).

7. Apparatus for dredging according to any one of the preceding claims, comprising movement means, mounted on a load-bearing structure and connected to the support frame (2) in order to move said apparatus for dredging (1) along said vertical axis (Y) within said tubular foundation (100);
the support frame (2) of said apparatus for dredging (1) comprising a slewing bearing (7) on which a fixing plate (70) is fixed which is mechanically connected to said movement means.

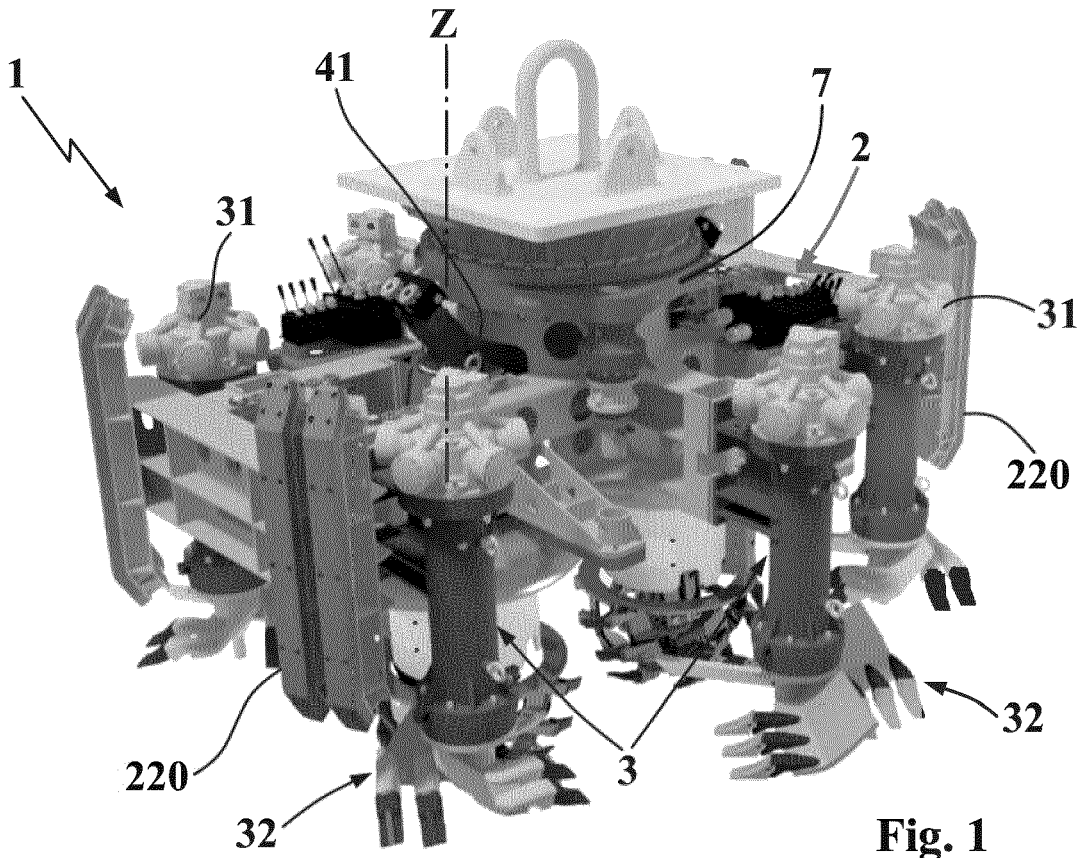


Fig. 1

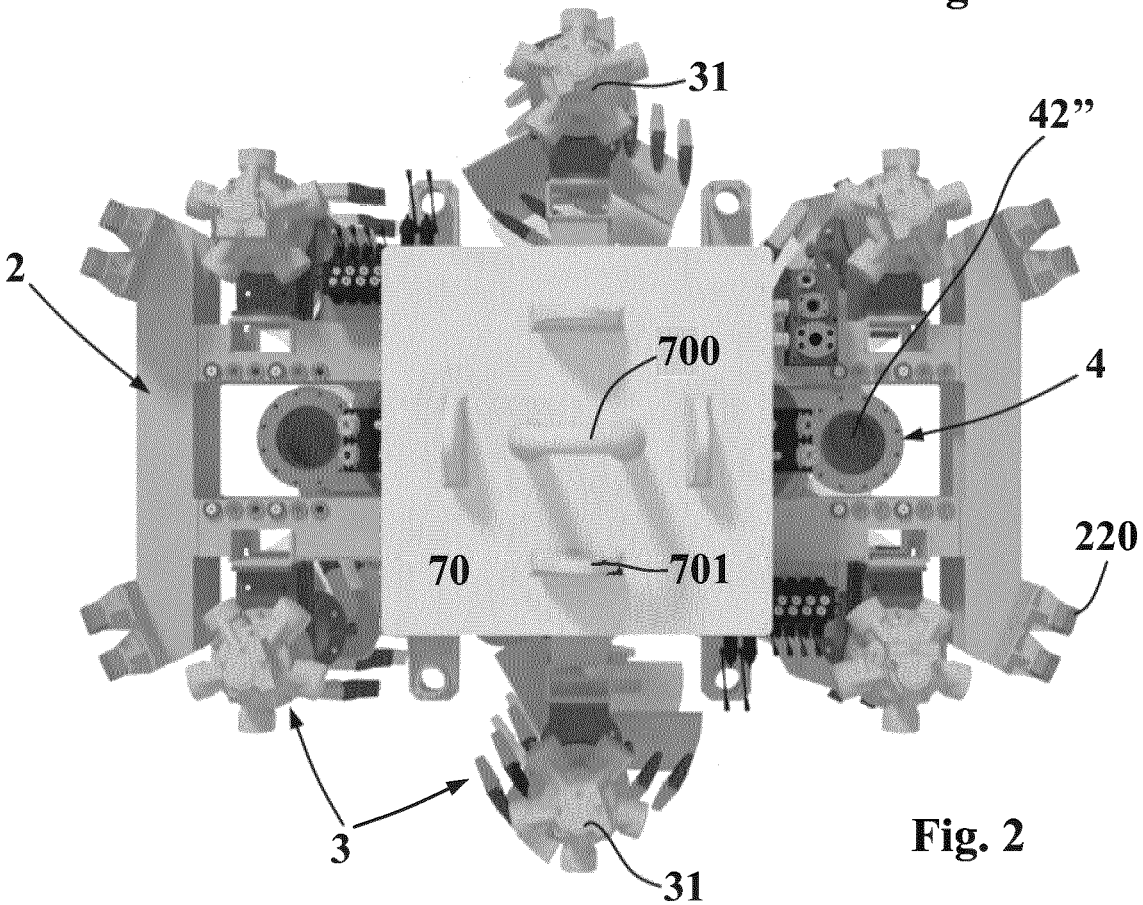


Fig. 2

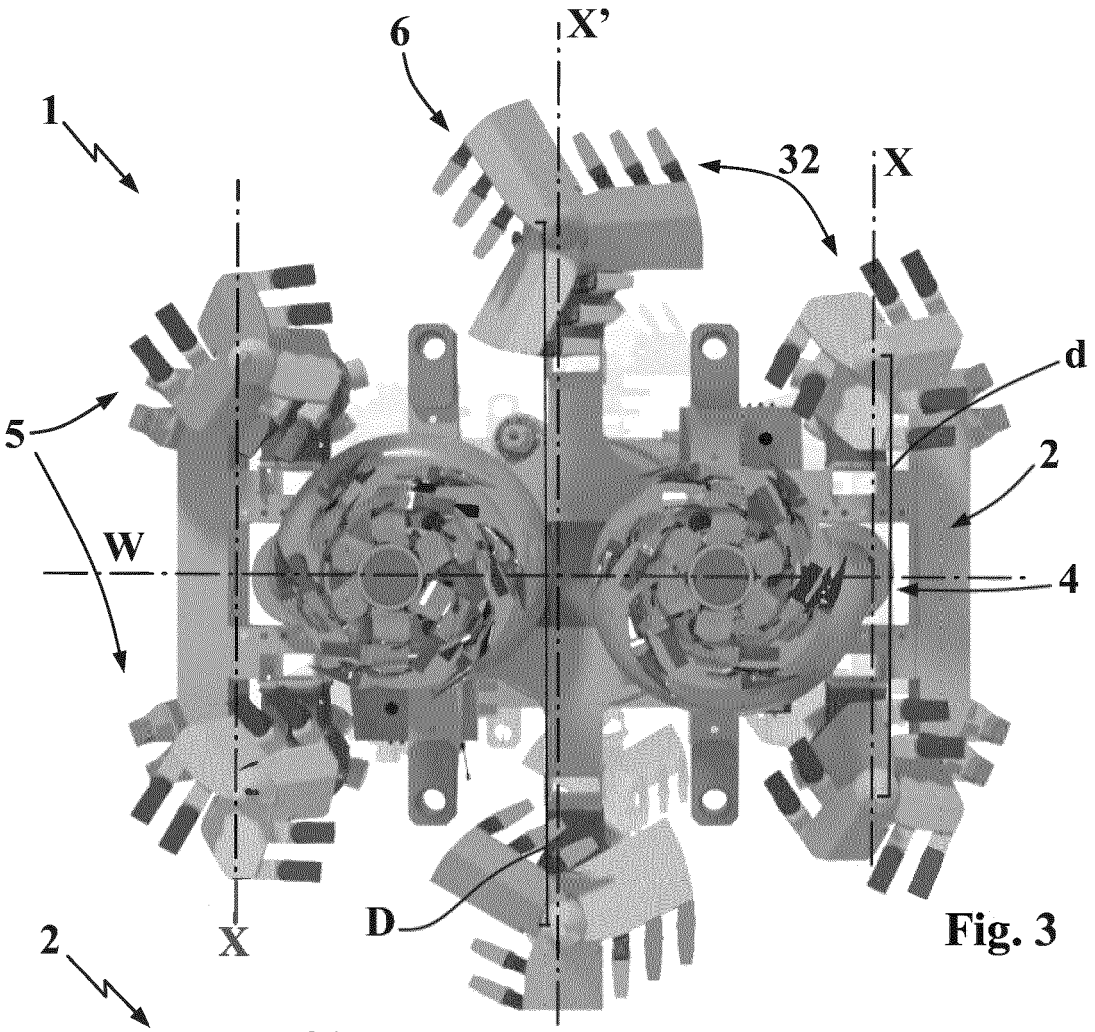


Fig. 3

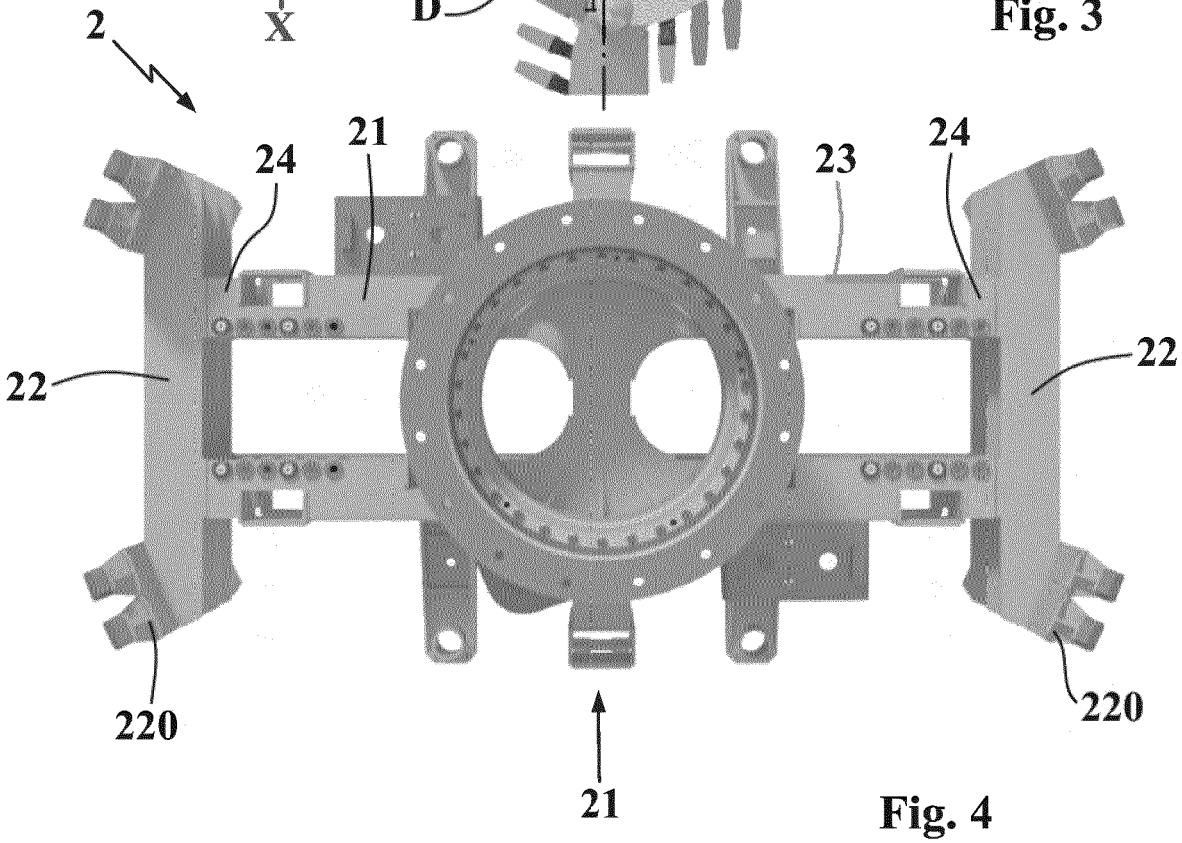


Fig. 4

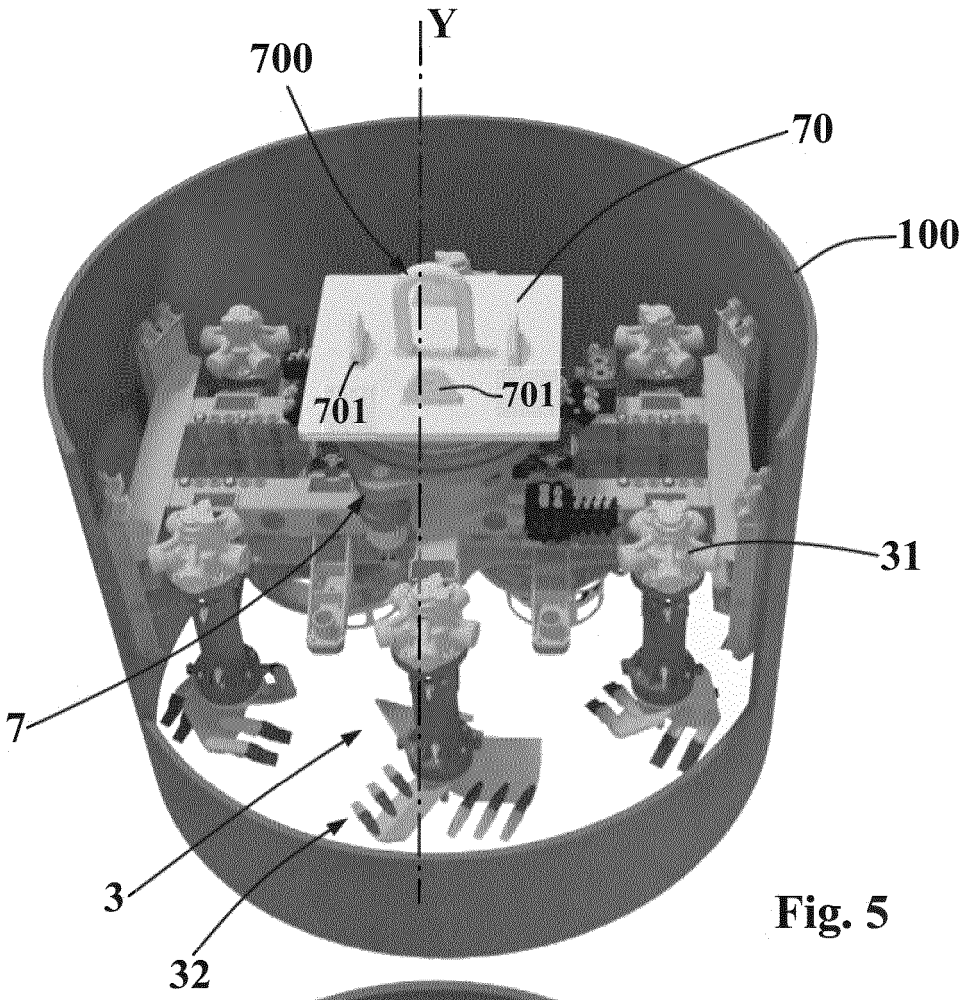


Fig. 5

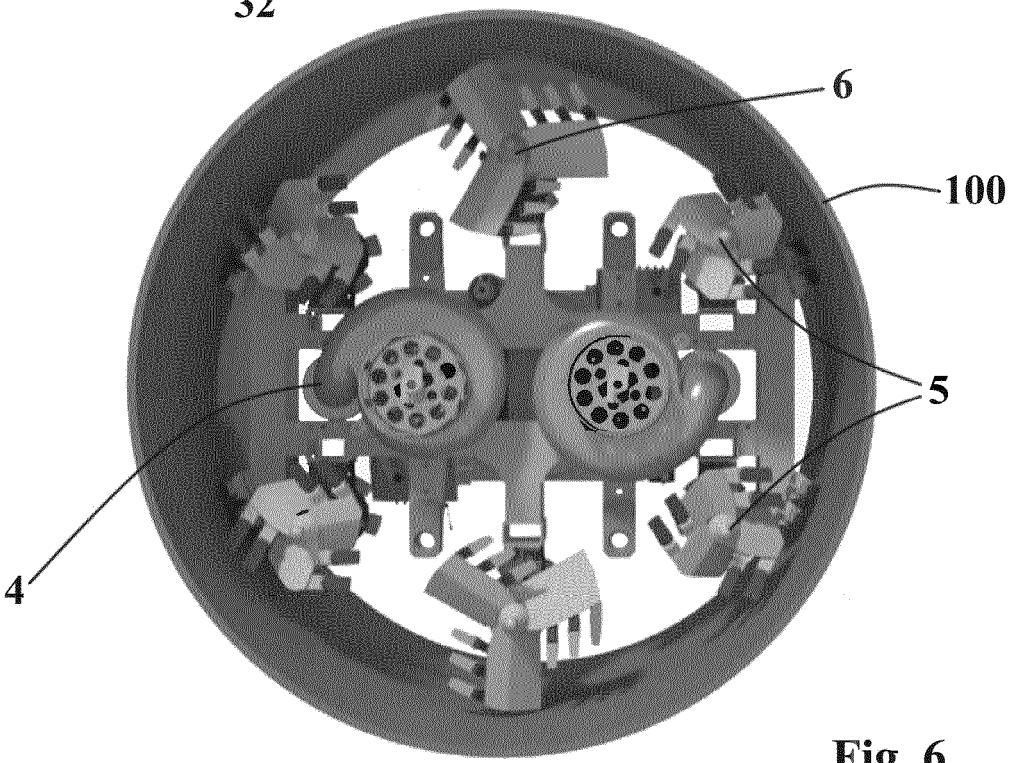
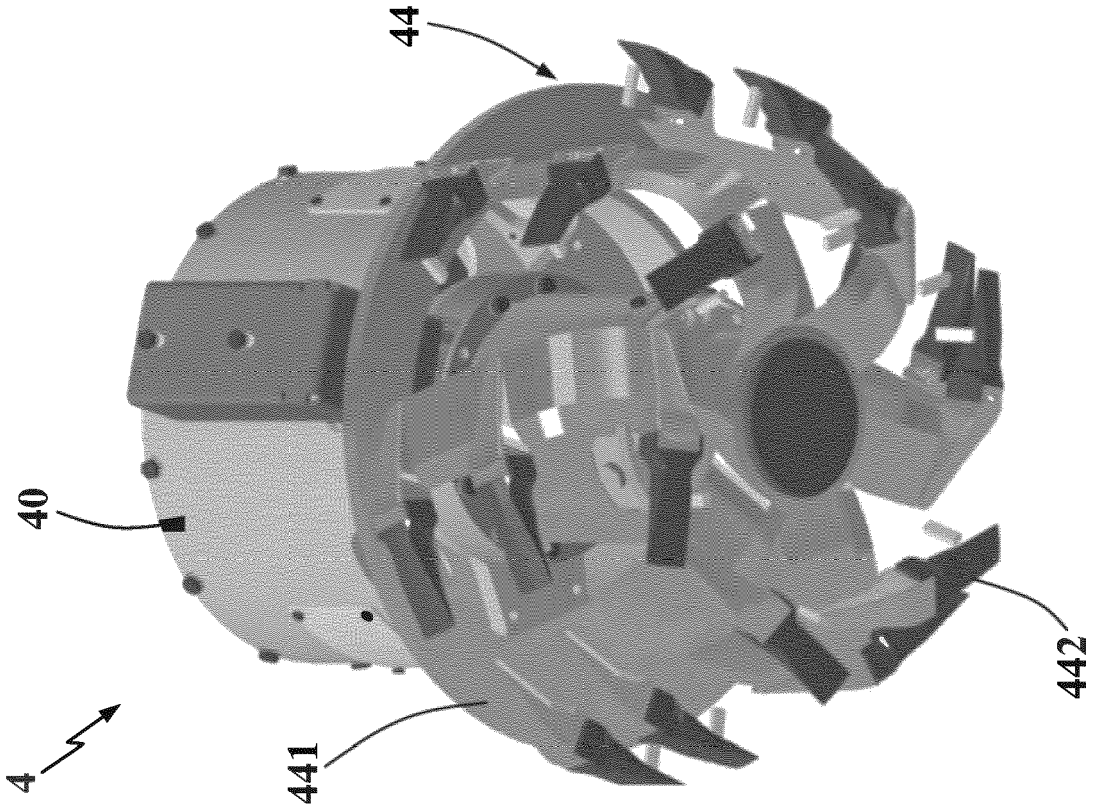


Fig. 6



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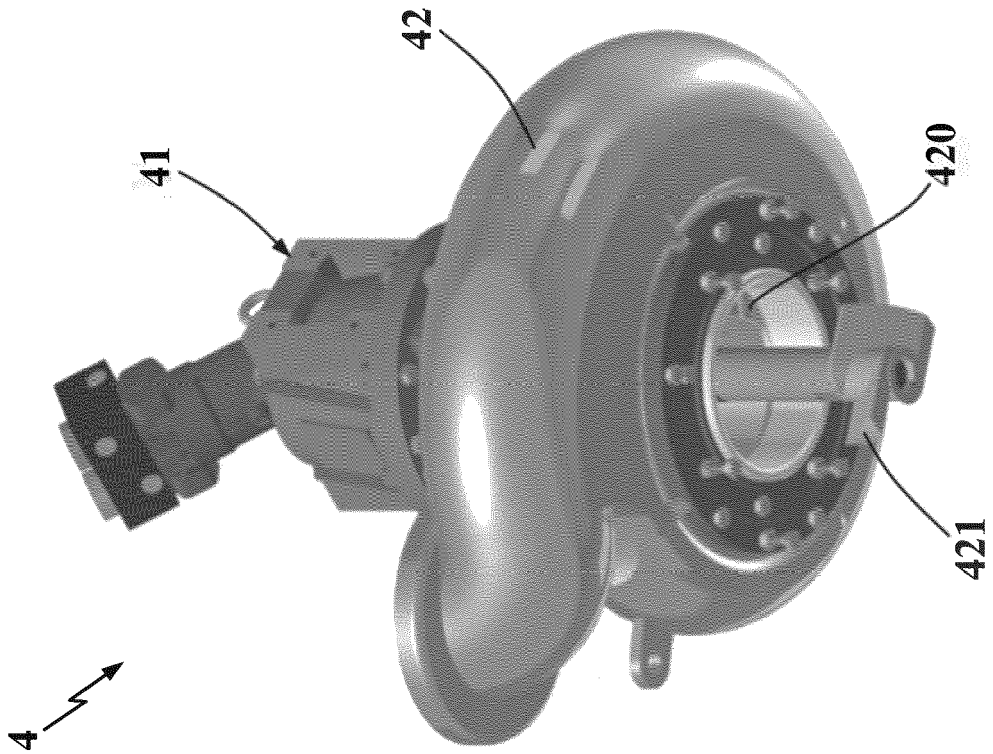

Fig. 7

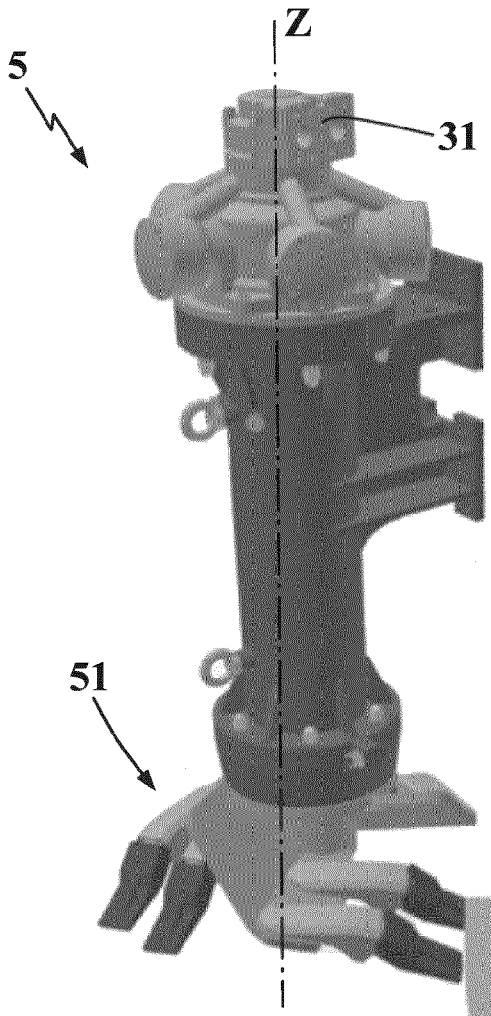

Fig. 9A

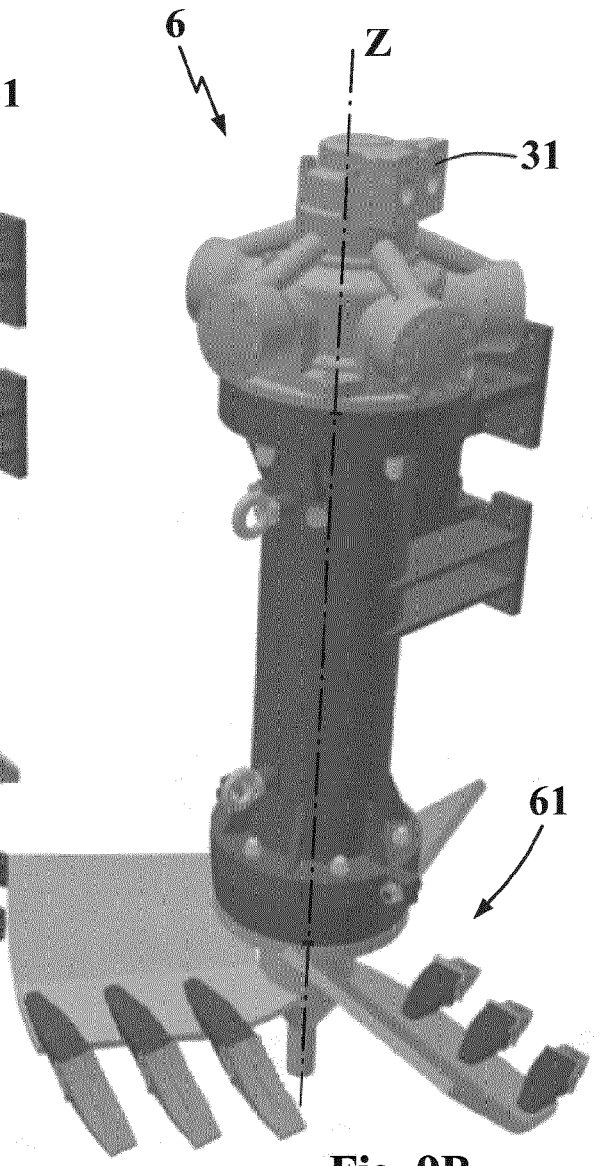

Fig. 9B

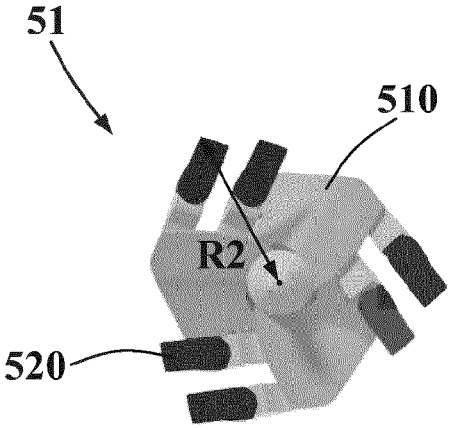

Fig. 10A

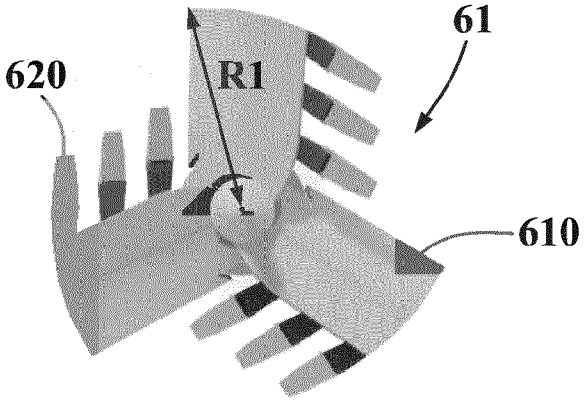

Fig. 10B

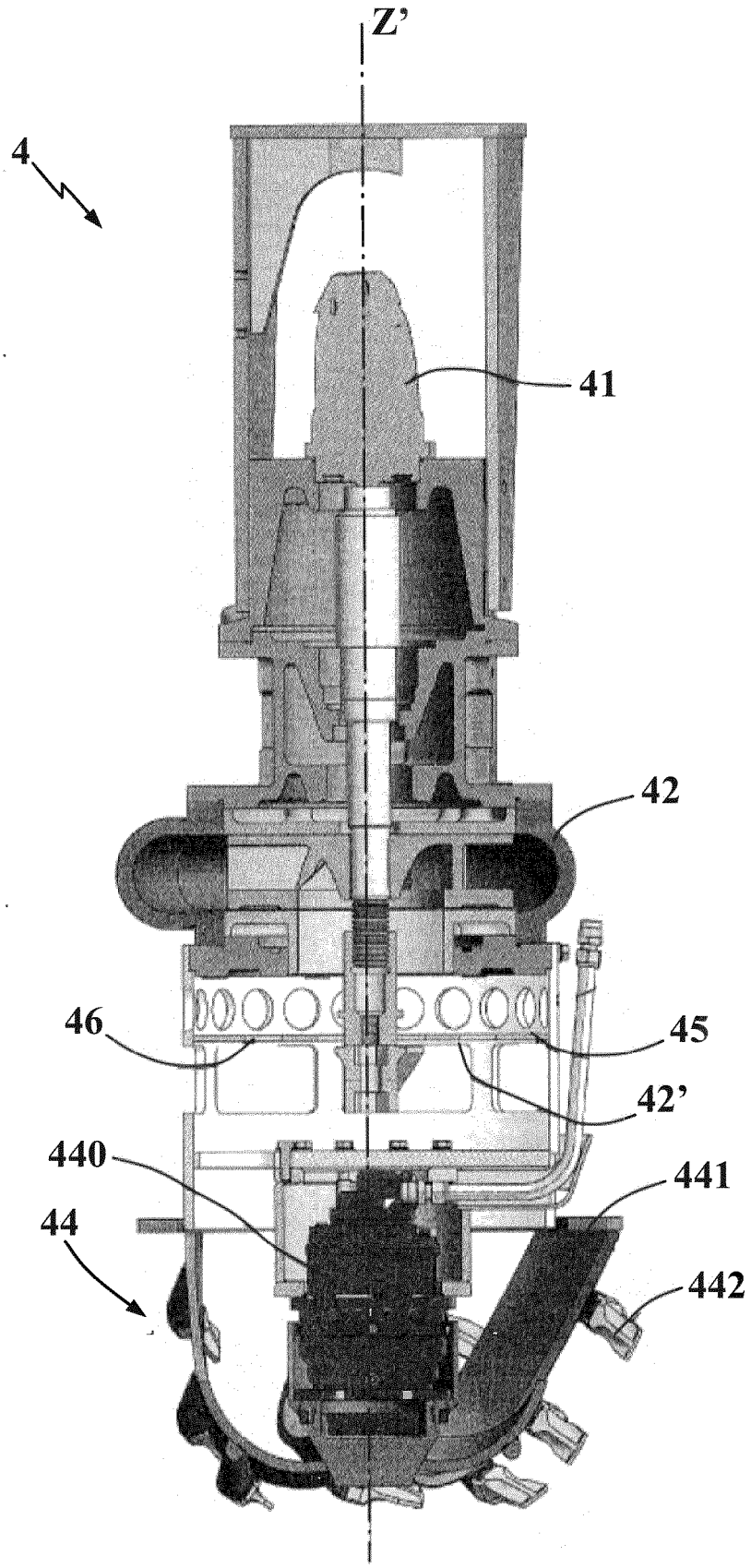

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 5446

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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E02F
E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 June 2022	Clarke, Alister

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