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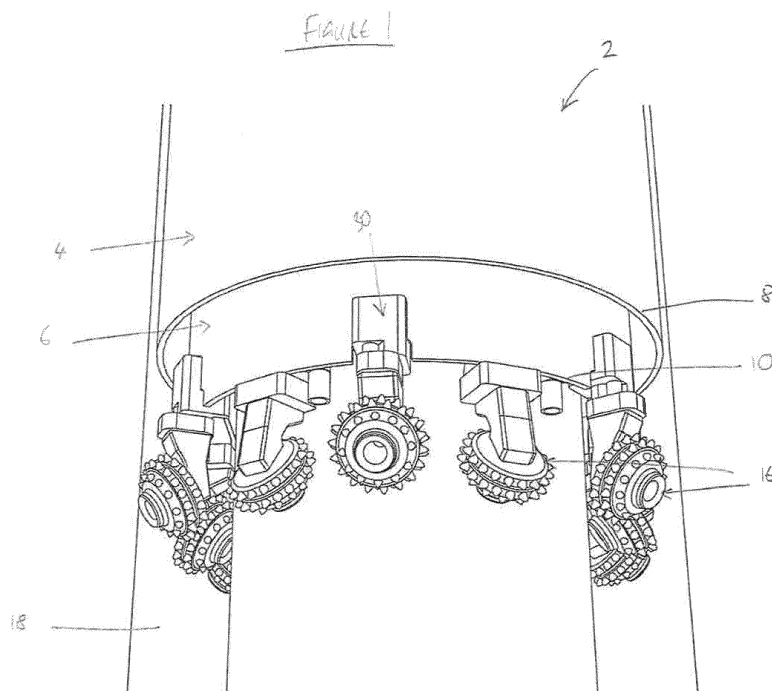
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(54) **APPARATUS AND METHOD FOR DRILLING ANNULAR CAVITIES**

(57) A drilling assembly (2) for forming an annular cavity in a substrate is disclosed. The drilling assembly comprises an annular inner pile (6) including a first annular part (10), an annular outer pile (4) including a second annular part (8) and cutters (16) mounted to an end of the inner pile. The first annular part is located inside the second annular part, and the cutters are moveable

relative to the inner pile between a first condition, in which rotation in a first direction of the inner pile causes the cutters to form an annular cavity in the substrate, and a second condition, in which the inner pile and the cutters can be removed from the cavity while leaving the outer pile in the cavity.



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Description

[0001] The present invention relates to an apparatus and a method for drilling annular cavities and relates particularly, but not exclusively, to an apparatus and method for drilling annular cavities for the location of piles and construction of retaining walls.

[0002] It is known to provide anchor devices in the form of cylindrical piles which are driven into the ground by means of hammering or augering, and to anchor a structure to the ground by means of bonding of the external surfaces of the piles with the ground. This arrangement suffers from the drawback that excessive amounts of energy are consumed in removing a large volume of material when forming a cylindrical cavity for receiving the pile.

[0003] EP2813623A1 discloses an anchor device adapted to form an annular cavity and locate an anchor device therein. While a body member of the anchor device may be separated from the device and recovered after a drilling operation, the cutting members cannot be recovered and are consequently left behind in the annular cavity after the drilling process has been completed. Separate cutting members are therefore needed for each annular cavity formed, which leads to excessive costs.

[0004] Preferred embodiments of the present invention seek to overcome one or more of the disadvantages of the prior art.

[0005] According to a first aspect of the present invention, there is provided a drilling assembly for forming an annular cavity in a substrate, the drilling assembly comprising: a first body member including a first substantially annular part; a second body member including a second substantially annular part; and a plurality of cutting members mounted adjacent an end of said first body member; wherein at least part of one of said first and second substantially annular parts is adapted to be located inside the other of said first and second substantially annular parts such that one of said first and second annular parts defines a first radially outer surface, and the other of said first and second substantially annular parts defines a first radially inner surface, and wherein a plurality of said cutting members are moveable relative to said first body member between a first condition, in which rotation in a first direction of the first body member causes the cutting members to form an annular cavity in the substrate, the annular cavity defining a second radially outer surface spaced from said first radially outer surface and a second radially inner surface spaced from said first radially inner surface, and a second condition, in which said first body member, with said cutting members mounted thereto, can be removed from said cavity while leaving said second body member in said cavity.

[0006] By providing a drilling assembly having a plurality of said cutting members moveable relative to said first body member between a first condition, in which rotation in a first direction of the first body member causes the cutting members to form an annular cavity defining a second radially outer surface spaced from said first

radially outer surface and a second radially inner surface spaced from said first radially inner surface, and a second condition, in which said first body member, with said cutting members mounted thereto, can be removed from said cavity while leaving said second body member in said cavity, the advantage is provided that the first body member and cutting members mounted to it may be retrieved after each drilling operation, thereby allowing the first body member and cutting portions to be reused and therefore reducing installation costs.

[0007] At least one said cutting member may be adapted to pivot between said first condition and said second condition in response to rotation of said first body member in a second direction opposite said first direction.

[0008] This provides the advantage of a simple mechanism for transferring the cutting member from the first condition to the second condition, thereby making the drilling assembly simpler to operate.

[0009] The drilling assembly may further comprise at least one abutment member adapted to abut at least one cutting member in at least one of said first and second conditions.

[0010] This provides the advantage of maintaining at least one cutting member in a desired condition by means of a simple construction.

[0011] The drilling assembly may further comprise at least one connecting device mounted adjacent an outer surface of said second body member, said at least one connecting device being adapted to connect said second body member to at least one sheet pile.

[0012] This provides the advantage of allowing sheet piles to be connected to the second member, thereby facilitating the construction of barrier walls and cofferdam-type structures with retaining properties.

[0013] At least one said connection device may comprise at least one male or female connector extending on said outer surface, wherein at least one said male or female connector is adapted to engage a respective female or male connector of a sheet pile.

[0014] This provides the advantage of allowing the sheet pile to be more easily mounted to the second body member in a desired location.

[0015] The drilling assembly may further comprise at least one fluid delivery channel mounted to at least one of said first and second body members, wherein said at least one fluid delivery channel is adapted to transport bonding material into said annular cavity.

[0016] This provides the advantage that bonding material, such as grout, may be transported into the annular cavity to form a more stable anchor.

[0017] According to a second aspect of the present invention, there is provided a method of forming an annular cavity, the method comprising: forming an annular cavity by means of a drilling assembly as defined above; and removing said first body member, with said cutting members mounted thereto, from said cavity while leaving said second body member in said cavity.

[0018] The method may further comprise the steps of:

(i) forming two additional annular cavities; (ii) locating at least one sheet pile between at least one pair of said second body members left in said cavities; (iii) transporting bonding material into two of said cavities; (iv) repeating steps (i) to (iii) a desired number of times; and (v) transporting bonding material into a final cavity not containing any bonding material.

[0019] This provides the advantage that sheet piles may be located in sequence while avoiding difficulty associated with hardened bonding material interfering with placement.

[0020] The method may further comprise using a template to position said drilling assembly during formation of said cavities.

[0021] This provides the advantage of ensuring the correct placement of at least one second body member.

[0022] The method may further comprise the step of rotating at least one second body member remaining in a cavity into an orientation for engaging at least one sheet pile.

[0023] This provides the advantage of increasing the ease with which a sheet pile may be located in a desired location.

[0024] Preferred embodiments of the invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective bottom view of a drilling assembly of a first embodiment of the present invention in a first condition;

Figure 2 is a bottom view of the drilling assembly of Figure 1;

Figure 3 is a perspective bottom view of the drilling assembly of Figure 1 in a second condition;

Figure 4 is a bottom view of the drilling assembly of Figure 3;

Figure 5 is a partially cutaway perspective view of a drilling assembly of a second embodiment of the present invention;

Figure 6 is a perspective bottom view of the drilling assembly of Figure 5 in a first condition;

Figure 7 is a bottom view of the drilling assembly of Figure 6;

Figure 8 is a perspective bottom view of the drilling assembly of Figure 5 in a second condition;

Figure 9 is a partially cut-away bottom view of the drilling assembly of Figure 8;

Figure 10 is a schematic top view of a retaining wall

constructed by means of a method embodying the present invention; and

Figure 11 is a top view of part of the retaining wall of Figure 10.

[0025] Referring to Figures 1 to 4, a drilling assembly 2 is shown having a first body member in the form of an annular inner pile 6 and a second body member in the form of an annular outer pile 4, the body members having respective first substantially annular part 10 and second substantially annular part 8. The annular outer pile 4 has greater inner and outer radii than the annular inner pile 6. The outer pile 4 defines a first outer surface 12 of the drilling assembly 2 and the inner pile 6 defines a first inner surface 14 of the drilling assembly 2. A plurality of cutting members in the form of rotary cone-shaped cutters 16 are shown mounted to an end of the inner pile 6.

[0026] Figures 1 and 2 show the cutters 16 deployed in a first condition, in which the drilling assembly 2 forms an annular cavity 18 by driving the inner pile 6 and the cutters 16 to rotate in a first direction. The drilling assembly may also drive the cutters 16 to rotate about their respective axes to cut the annular cavity 18. The annular cavity 18 is defined by a second outer surface 20 and a second inner surface 22. In the first condition, the cutters 16 are alternately arranged such that six of the twelve cutters 16 are oriented to extend beyond the first outer surface 12 of the outer pile to the second outer surface 20 of the annular cavity 18, and the other six cutters are oriented to extend beneath the first inner surface 14 of the inner pile 6 to the second inner surface 22 of the annular cavity 18. In doing so, a sufficient distance is provided between both the first and second inner surfaces 14, 22 and the first and second outer surfaces 12, 20 for the outer pile 4 and the inner pile 6 to proceed unimpeded into the cavity 18.

[0027] Figure 2 shows a bottom view of the cutters 16 in the first condition. In this figure, the annular cavity defined by the second outer and inner surfaces 20, 22, and the first outer and inner surfaces 12, 14, is shown. Two connecting devices 24 are shown mounted on the outer pile 4, located on opposite sides of the outer pile 4, though it is possible to mount more than two such devices. In this embodiment, the connecting devices 24 are shown as hook-shaped devices for connecting to similar respective devices (see Figure 11) mounted on one or more sheet piles. Channels in the form of grouting tubes 26 are shown mounted on the inner pile 6.

[0028] Referring to Figures 3 and 4, the drilling assembly 2 is shown in a second condition, in which all twelve of the cutters 16 are oriented to extend to the second inner surface 22 of the annular cavity 18. In the second condition, none of the cutters 16 are oriented to extend to the second outer surface 20 of the cavity 18, nor do any of the cutters 16 extend outwardly as far as an inner surface 28 of the outer pile 4. Abutment members 30 are shown abutting a number of cutters 16 in the second

condition. The abutment members 30 are also shown in Figure 1, abutting a number of cutters 16 in the first condition.

[0029] The drilling assembly 2 is used to cut an annular cavity 18 in the ground, locate the outer pile 4, and have the inner pile 6 and cutters 16 removed after drilling for reuse. The cutters 16 are oriented in the first condition (Figures 1 and 2), and the inner pile 6 is driven by external means (not shown) in the first direction to cut the annular cavity 18. The cutters 16 may also be driven to rotate about each of their axes for cutting the cavity 18. In the first condition, the cutters 16 are oriented to cut the annular cavity which is defined by the second outer surface 20 and second inner surface 22, where the second outer surface 20 has a larger radius than the first outer surface 12 of the outer pile 4 and where the second inner surface 20 has a smaller radius than the first inner surface 14 of the inner pile 6. This allows both the outer pile 4 and inner pile 6 to proceed unimpeded into the cavity 18 as the cavity is being formed by the cutters 16. Six of the cutters 16 are pivotable between the first condition and the second condition. In both conditions, each of the six pivotable cutters abuts a respective abutment member 30 adjacent thereto. The abutment members 30 thereby prevent pivoting of the pivotable cutters beyond angles of orientation defining the first and second conditions.

[0030] Once a desired cavity depth has been achieved, the inner pile 6 is rotated in a second direction, opposite to the first direction. Contact between the cutters 16 and the base of the annular cavity causes the pivotable cutters 16 to pivot from the first condition, their cutting orientation, into the second condition (Figures 3 and 4), in which the pivotable cutters 16 have an orientation matching the cutting orientation of the fixed cutters. The pivoting of the pivotable cutters is stopped by the abutment members 30, located adjacent the pivotable cutters, to maintain them in the second condition.

[0031] As a result of the pivotable cutters being in the second condition, in which none of the cutters extend outwardly as far as the inner surface 28 of the outer pile 4, the outer pile 4 can be detached from the drilling apparatus 2, and the inner pile 6, together with the cutters 16 mounted to it, can consequently be retracted and removed from the cavity 18 for reuse.

[0032] After removal of the inner pile 6, the outer pile 4 can be rotated about its longitudinal axis in order to orient the connecting devices 24 as required for subsequent attachment of one or more sheet piles. In this way, a number of piles 4 may be located in proximity to one another, in a corresponding number of annular cavities 18, and have sheet piles located between them to form a retaining wall or cofferdam-type structure.

[0033] The grouting tubes 26 transport a bonding material into the cavity 18 before the inner pile 6, together with the cutters 16, has been removed. Alternatively, the grouting tubes 26 may be mounted on the outer pile 4, and may transport the bonding material into the cavity 18 after the inner pile 6, together with the cutters 16, has

been removed.

[0034] Referring to Figures 5 to 9, a drilling assembly 200 is shown having a first body member in the form of an annular outer pile 400 and a second body member in the form of an annular inner pile 600, the body members having respective first and second substantially annular parts 800, 1000. The annular outer pile 400 has greater inner and outer radii than the annular inner pile 600. The outer pile 400 defines a first outer surface 1200 of the drilling assembly 200 and the inner pile 600 defines a first inner surface 1400 of the drilling assembly 200. A plurality of cutting members in the form of rotary cone-shaped cutters 1600 are shown mounted to an end of the outer pile 400.

[0035] Figure 6 shows the cutters 1600 deployed in a first condition, in which the drilling assembly 200 forms an annular cavity 1800 by driving the outer pile 400 and the cutters 1600 to rotate in a first direction. The annular cavity 1800 is defined by a second outer surface 2000 and a second inner surface 2200. In the first condition, the cutters 1600 are alternately arranged such that four of the eight cutters 1600 are oriented to extend beyond the first outer surface 1200 of the outer pile to the second outer surface 2000 of the annular cavity 1800, and the other four cutters are oriented to extend beneath the first inner surface 1400 of the inner pile 600 to the second inner surface 2200 of the annular cavity 1800. In doing so, a sufficient distance is provided between both the first and second inner surfaces 1400, 2200 and the first and second outer surfaces 1200, 2000 for the outer pile 400 and the inner pile 600 to proceed unimpeded into the cavity 1800.

[0036] Figure 7 shows a bottom view of the cutters 1600 in the first condition. In this figure, the annular cavity defined by the second outer and inner surfaces 2000, 2200, and the first outer and inner surfaces 1200, 1400, is shown. Two connecting devices 2800 are shown mounted on the inner pile 600, located on opposite sides of the inner pile 600, though it is possible to mount more than two such devices. In this embodiment, the connecting devices 2800 are shown as one male device 2400 and one female device 2600 for connecting to respective female and male connecting devices (not shown) mounted on one or more sheet piles. A channel in the form of a grouting tube 3000 is shown mounted on the inner pile 600.

[0037] Referring to Figures 8 and 9, the drilling assembly 200 is shown in a second condition, in which all eight of the cutters 1600 are oriented to extend to the second outer surface 2000 of the annular cavity 1800. In the second condition, none of the cutters 1600 are oriented to extend to the second inner surface 2200 of the cavity 1800, nor do any of the cutters 1600 extend inwardly beyond a circumference having a radius defined by the outermost point of either the grouting tube 3000 or at least one of the two connecting devices 2800. Abutment members 3200 are shown abutting a number of cutters 1600 in the second condition. The abutment members

3200 are also shown in Figure 6, abutting a number of cutters in the first condition.

[0038] The drilling assembly 200 is used to cut an annular cavity 1800 in the ground, locate the inner pile 600, and have the outer pile 400 and cutters 1600 removed after drilling for reuse. The cutters 1600 are oriented in the first condition (Figures 6 and 7), and the outer pile 400 is driven by external means (not shown) in the first direction to cut the annular cavity 1800. The cutters 1600 may also be driven to rotate about each of their axes for cutting the cavity 1800. In the first condition, the cutters 1600 are oriented to cut the annular cavity which is defined by the second outer surface 2000 and second inner surface 2200, where the second outer surface 2000 has a larger radius than the first outer surface 1200 of the outer pile 400 and where the second inner surface 2000 has a smaller radius than the first inner surface 1400 of the inner pile 600. This allows both the outer pile 400 and inner pile 600 to proceed unimpeded into the cavity 1800 as the cavity is being formed by the cutters 1600. Four of the cutters 1600 are pivotable between the first condition and the second condition. In both conditions, each of the four pivotable cutters abuts a respective abutment member 3200 adjacent thereto. The abutment members 3200 thereby prevent pivoting of the pivotable cutters beyond angles of orientation defining the first and second conditions.

[0039] Once a desired cavity depth has been achieved, the outer pile 400 is rotated in a second direction, opposite to the first direction. This causes the pivotable cutters to pivot from the first condition, their cutting orientation, into the second condition (Figures 8 and 9) in which the pivotable cutters have an orientation matching the cutting orientation of the fixed cutters. The pivoting of the pivotable cutters is stopped by the abutment members 3200, located adjacent the pivotable cutters, to maintain them in the second condition.

[0040] As a result of the pivotable cutters being in the second condition, in which none of the cutters extend inwardly beyond the radius defined by the outermost point of either the grouting tube 3000 or either of connecting devices 2800, the inner pile 600 can be detached from the drilling apparatus 200, and the outer pile 400, together with the cutters 1600 mounted to it, can consequently be retracted and removed from the cavity 1800 for reuse.

[0041] After removal of the outer pile 400, the inner pile 600 can be rotated about its longitudinal axis in order to orient the connecting devices 2800 as required for subsequent attachment of one or more sheet piles. In this way, a number of piles 600 may be located in proximity to one another, in a corresponding number of annular cavities 1800, and have sheet piles located between them to form a retaining wall or cofferdam-type structure.

[0042] The grouting tube 3000 transports a bonding material into the cavity 1800 after the outer pile 400, together with the cutters 1600, has been removed. Alternatively, the grouting tube 3000 may be mounted on the

outer pile 400, and may transport the bonding material into the cavity 1800 before the outer pile 400, together with the cutters 1600, has been removed.

[0043] Referring to Figures 10 and 11, in order to construct a retaining wall structure, the following steps are followed:

1a) three annular cavities (C1, C2, and C3) are formed having piles (P1, P2, and P3) located within them respectively;

1b) a sheet pile (S12) is located between the first two piles (P1 and P2);

1c) bonding material is transported into the first cavity (C1) ;

1d) a sheet pile (S23) is located between the second pile (P2) and the third pile (P3);

1e) bonding material is transported into the second cavity (C2)

2a) two additional annular cavities (C4 and C5) are formed having additional piles (P4 and P5) located within them respectively;

2b) a sheet pile (S34) is located between the first pile in the sequence in an ungrouted cavity (P3, C3) and the subsequent pile (P4);

2c) bonding material is transported into the first ungrouted cavity (C3);

2d) a sheet pile (S45) is located between the two piles of step 2a (P4 and P5);

2e) bonding material is transported into the first cavity of step 2a (C4) ;

2f) steps 2a to 2e are repeated as required;

3a) a final annular cavity (CN) is formed having a final pile (PN) located within it;

3b) a final sheet pile (SN) is located between the final pile (PN) and the previous pile (P5); and

3c) bonding material is transported into the previous cavity (C5) and the final cavity.

[0044] In between any two of the above steps, any piles (P1 - PN) located in ungrouted cavities may be rotated to align connecting devices mounted to those piles as required for the attachment of sheet piles to those piles.

[0045] A template may be used to position the drilling assembly during formation of a cavity. In a preferred embodiment, the template is used to position the drilling as-

sembly relative to an existing cavity. The distance between the two cavities can therefore be chosen to correspond to a desired width of sheet pile to be located between the two piles located in those cavities.

[0046] Figure 11 shows the arrangement of piles P1, P2 and sheet pile S12 upon completion of step 1b, described above.

[0047] It will be appreciated by persons skilled in the art that the above embodiments have been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the claims. For example, that either of the inner and outer piles may or may not rotate during the drilling procedure according to the configuration of external driving apparatus.

Claims

1. A drilling assembly for forming an annular cavity in a substrate, the drilling assembly comprising:-
a first body member including a first substantially annular part;
a second body member including a second substantially annular part; and
a plurality of cutting members mounted adjacent an end of said first body member;
wherein at least part of one of said first and second substantially annular parts is adapted to be located inside the other of said first and second substantially annular parts such that one of said first and second annular parts defines a first radially outer surface, and the other of said first and second substantially annular parts defines a first radially inner surface, and
wherein a plurality of said cutting members are moveable relative to said first body member between a first condition, in which rotation in a first direction of the first body member causes the cutting members to form an annular cavity in the substrate, the annular cavity defining a second radially outer surface spaced from said first radially outer surface and a second radially inner surface spaced from said first radially inner surface, and a second condition, in which said first body member, with said cutting members mounted thereto, can be removed from said cavity while leaving said second body member in said cavity.
2. A drilling assembly according to claim 1, wherein at least one said cutting member is adapted to pivot between said first condition and said second condition in response to rotation of said first body member in a second direction opposite said first direction.
3. A drilling assembly according to any one of the preceding claims, further comprising at least one abut-

ment member adapted to abut at least one cutting member in at least one of said first and second conditions.

4. A drilling assembly according to any one of the preceding claims, further comprising at least one connecting device mounted adjacent an outer surface of said second body member, said at least one connecting device being adapted to connect said second body member to at least one sheet pile.
5. A drilling assembly according to claim 4, wherein at least one said connection device comprises at least one male or female connector extending on said outer surface, wherein at least one said male or female connector is adapted to engage a respective female or male connector of a sheet pile.
6. A drilling assembly according to any one of the preceding claims, further comprising at least one fluid delivery channel mounted to at least one of said first and second body members, wherein said at least one fluid delivery channel is adapted to transport bonding material into said annular cavity.
7. A method of forming an annular cavity, the method comprising:-
forming an annular cavity by means of a drilling assembly according to any one of the preceding claims;
and
removing said first body member, with said cutting members mounted thereto, from said cavity while leaving said second body member in said cavity.
8. A method according to claim 7, further comprising the steps of:
 - (i) forming two additional annular cavities;
 - (ii) locating at least one sheet pile between at least one pair of said second body members left in said cavities;
 - (iii) transporting bonding material into two of said cavities;
 - (iv) repeating steps (i) to (iii) a desired number of times; and
 - (v) transporting bonding material into a final cavity not containing any bonding material.
9. A method according to claim 7 or 8, further comprising using a template to position said drilling assembly during formation of said cavities.
10. A method according to any one of claims 7 to 9, further comprising the step of rotating at least one second body member remaining in a cavity into an orientation for engaging at least one sheet pile.

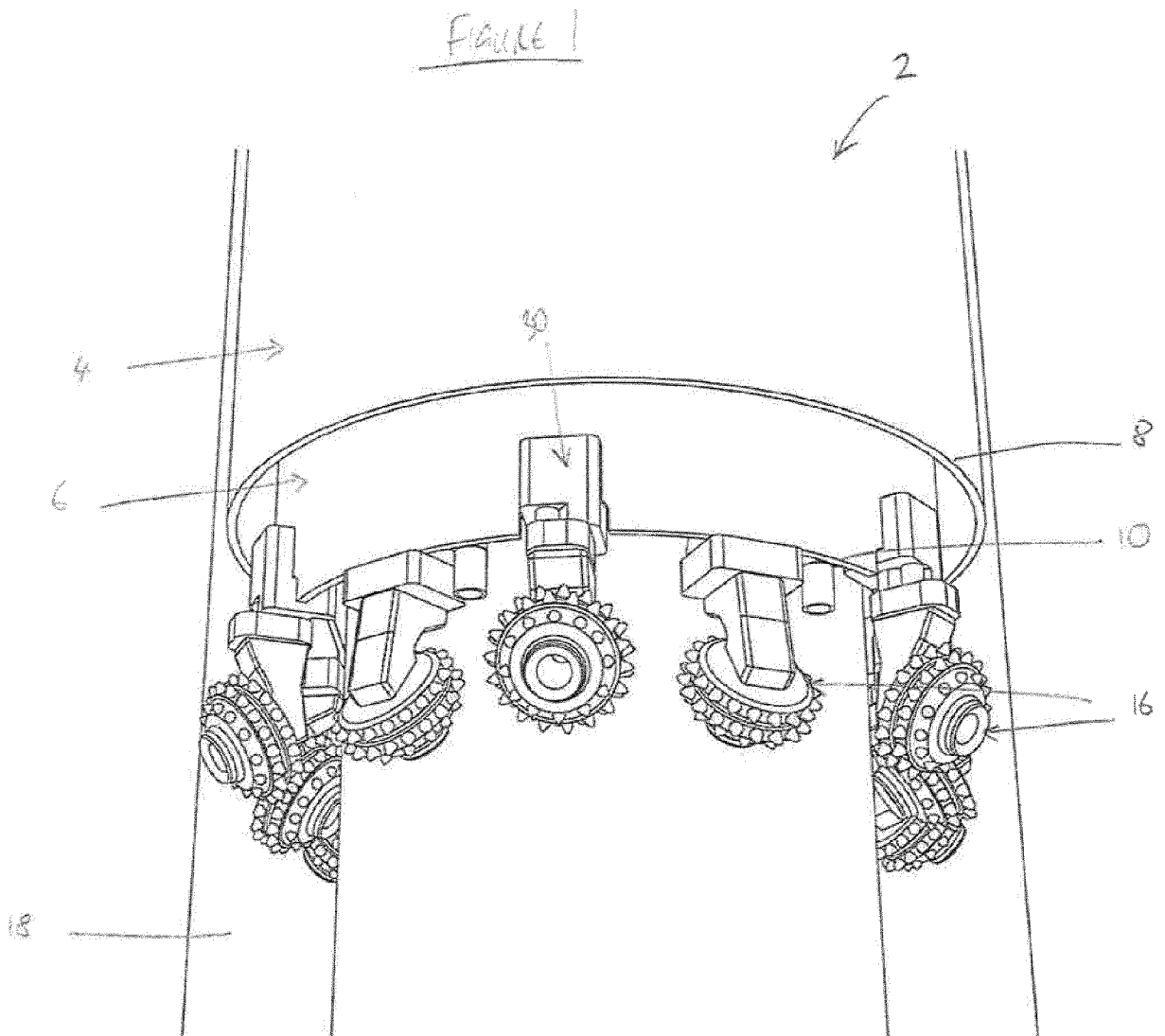


FIGURE 2

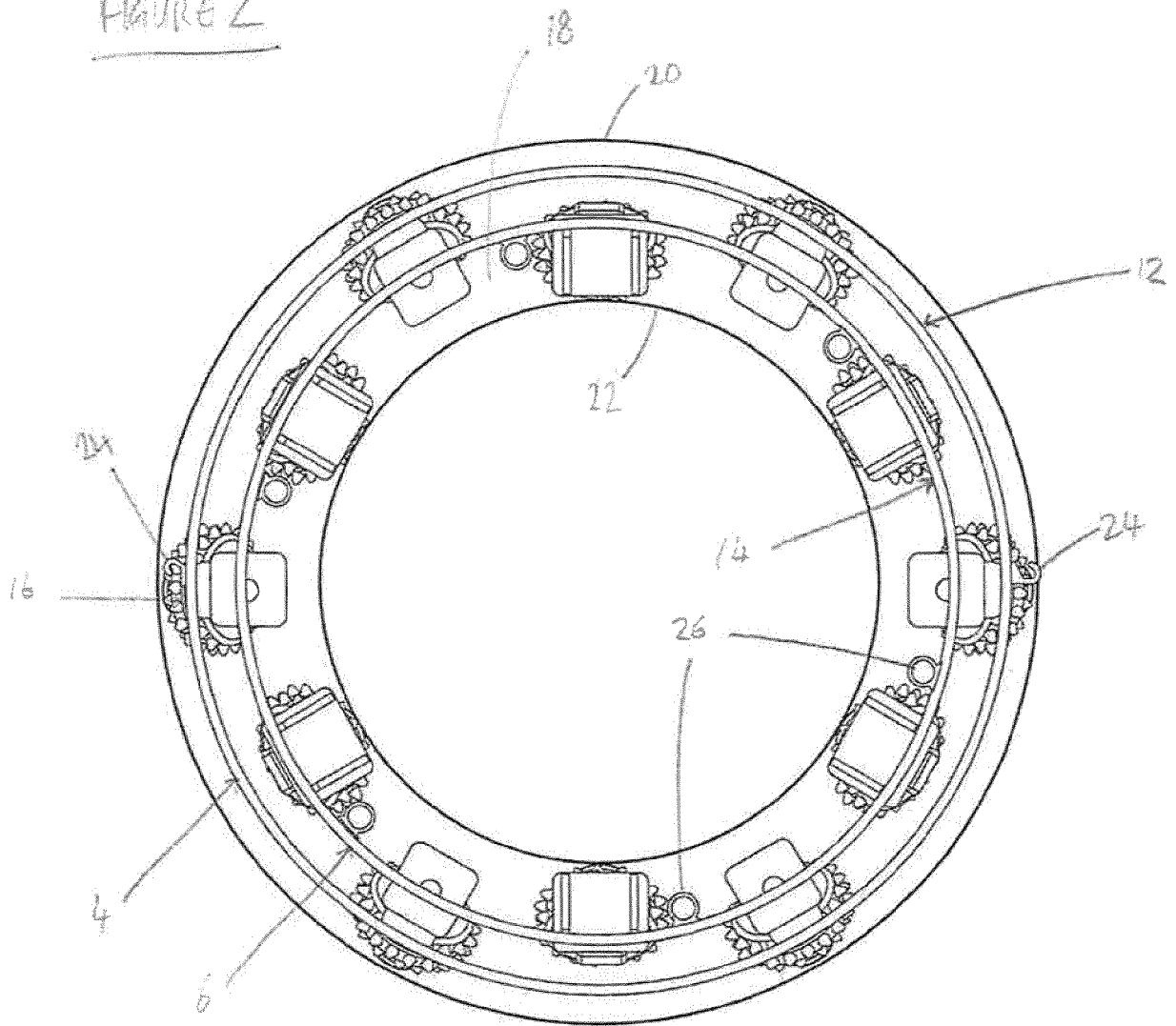
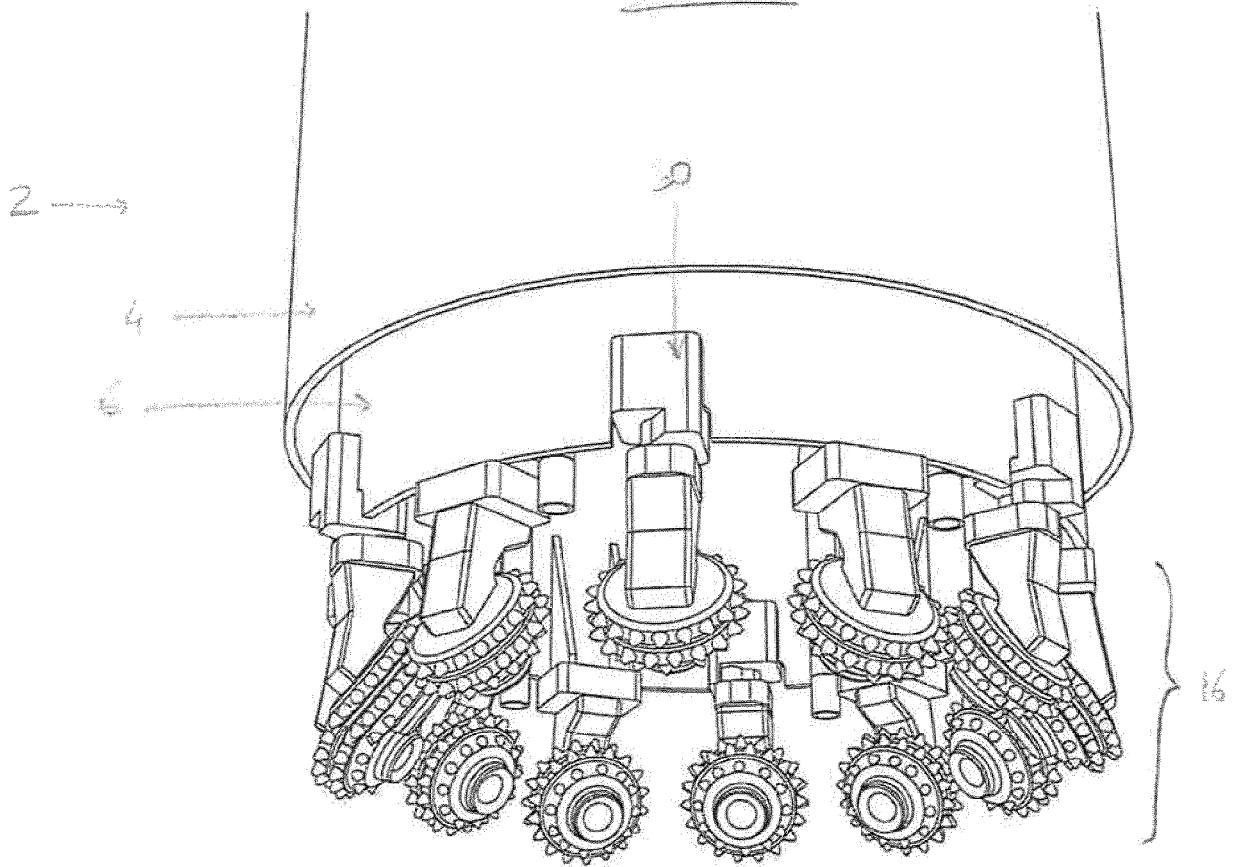


FIGURE 3



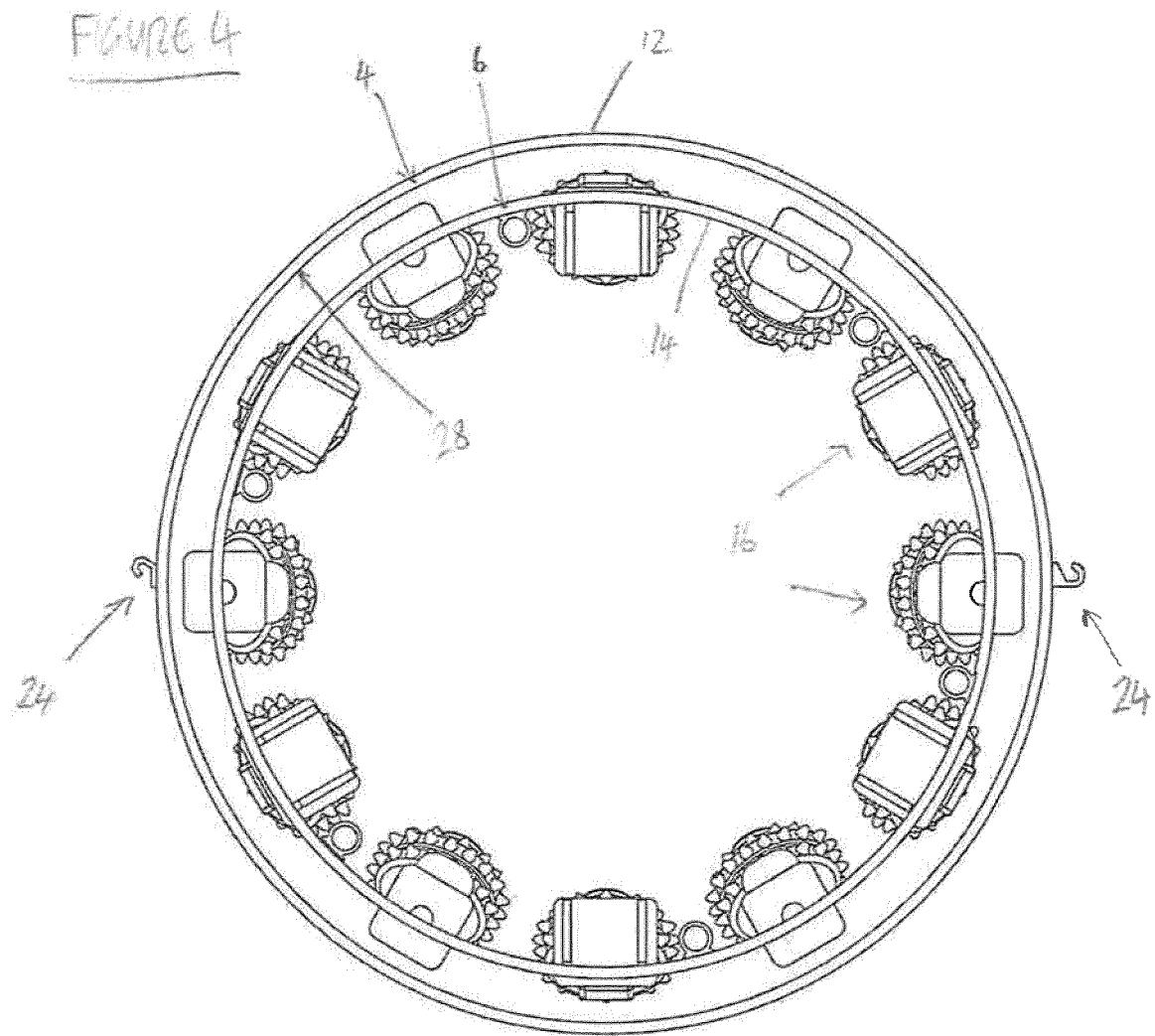


FIGURE 5

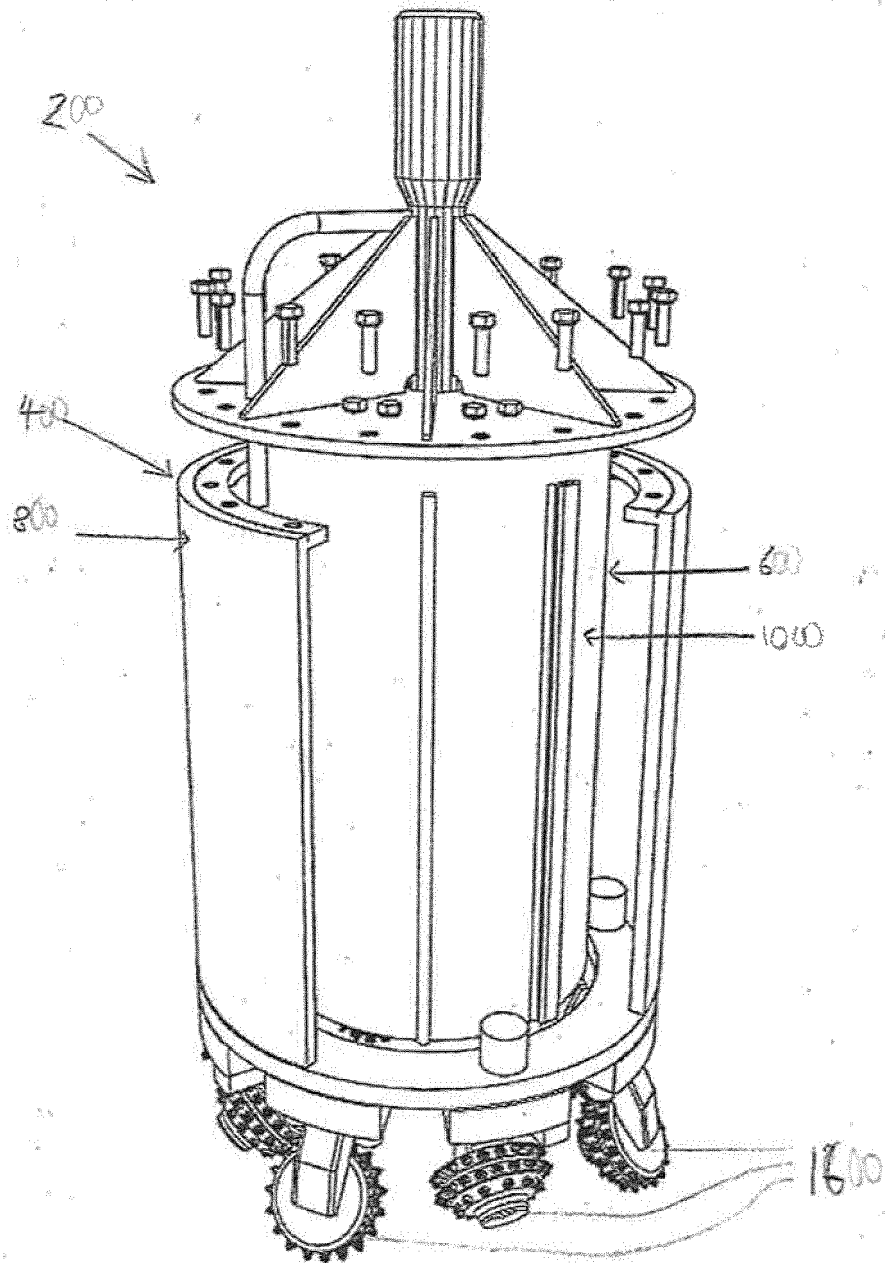


FIGURE 6

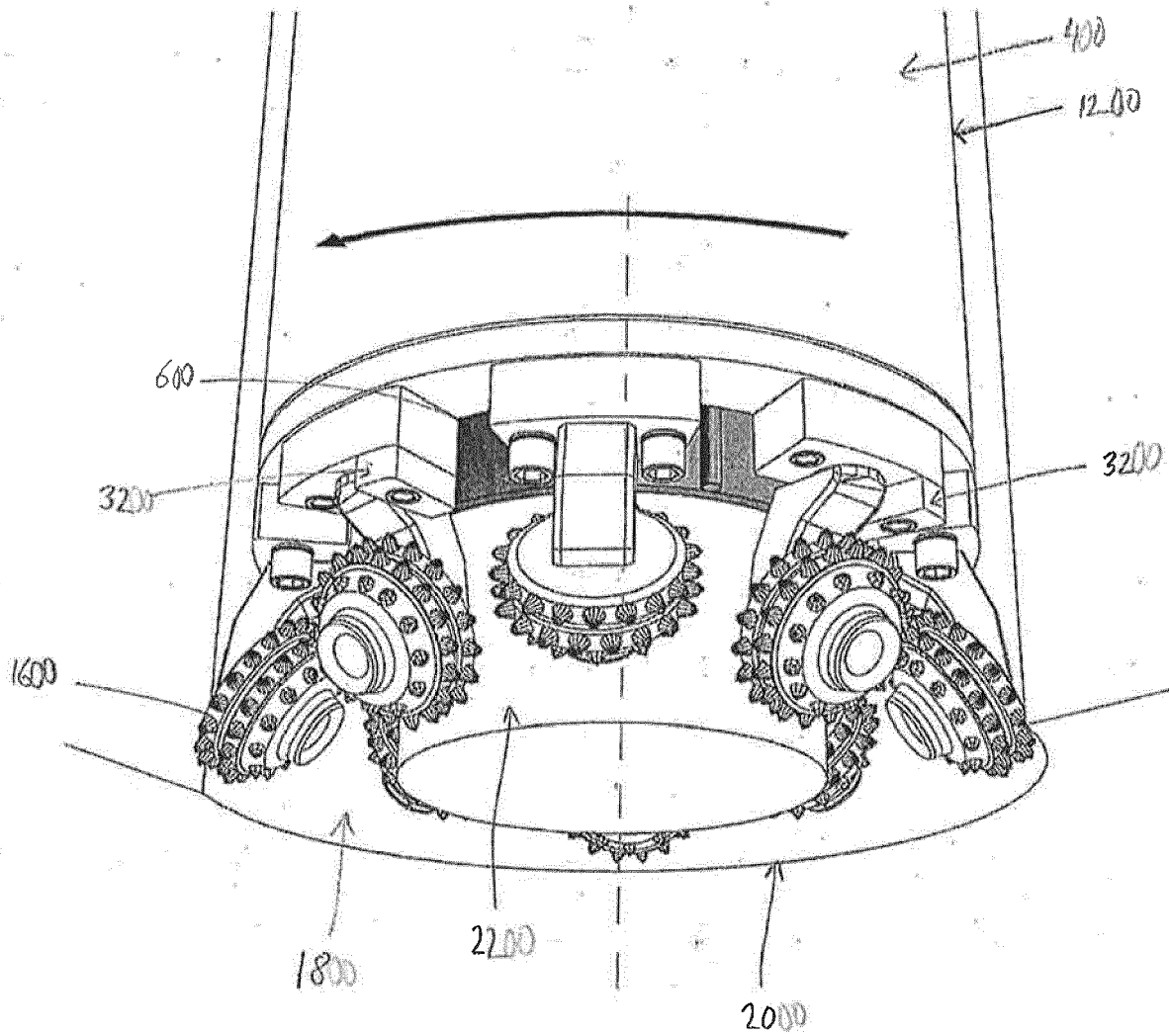


FIGURE 7

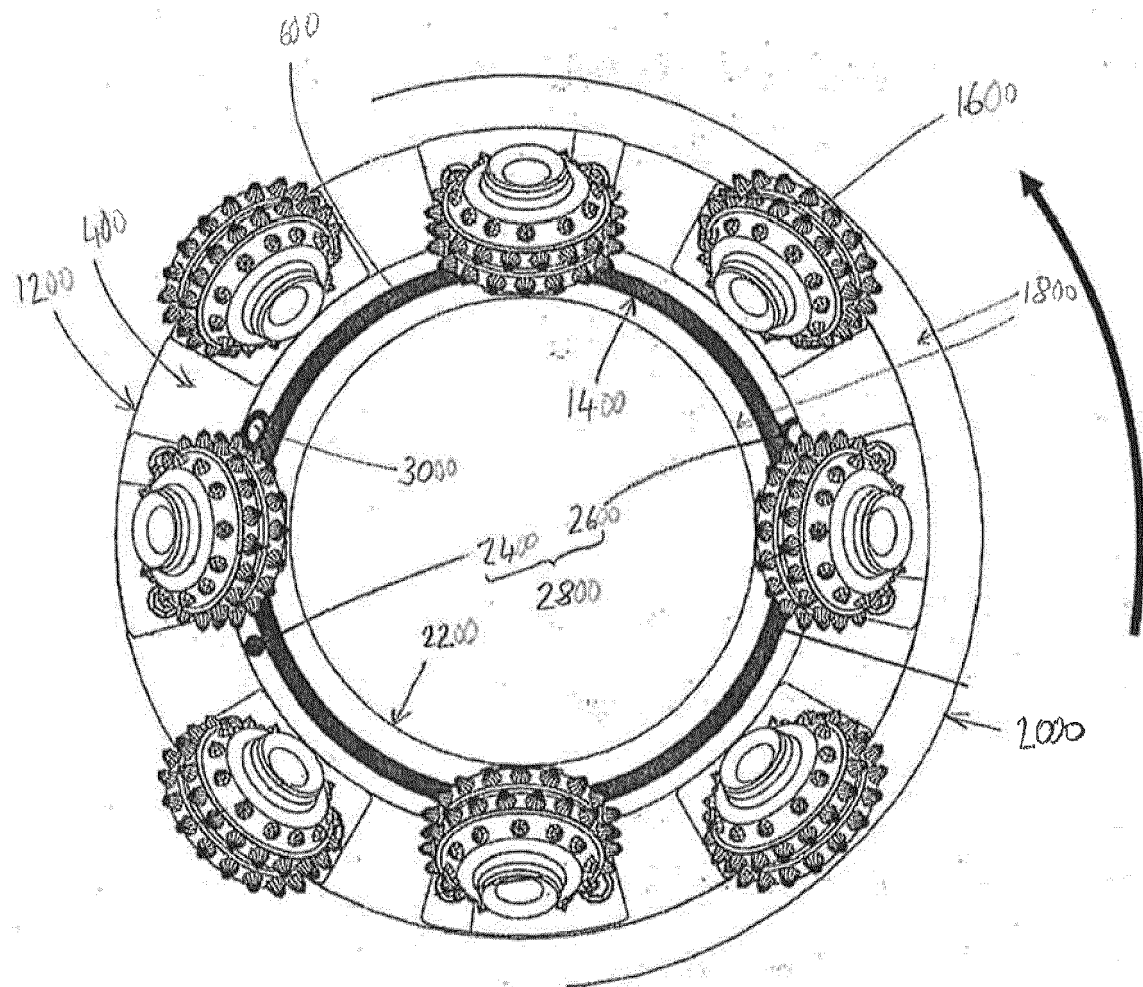


FIGURE 8

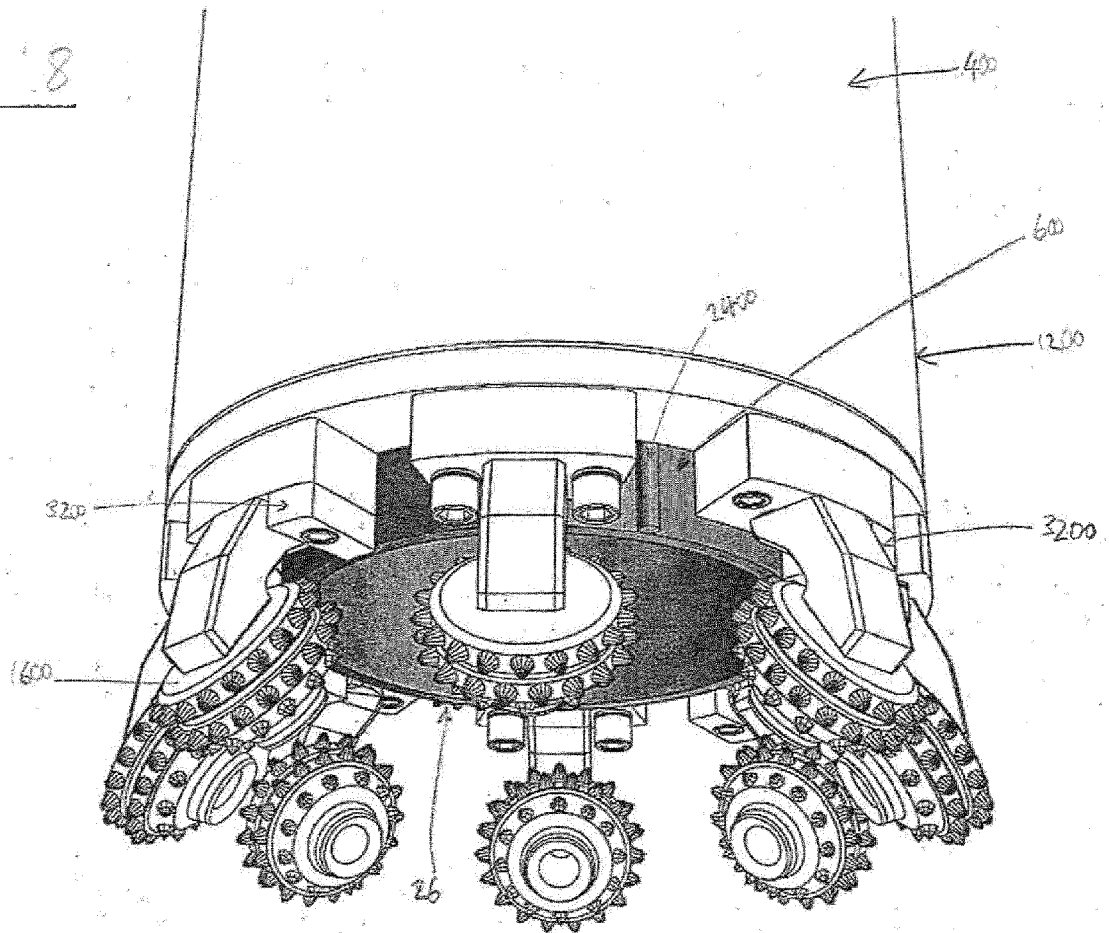


FIGURE 9

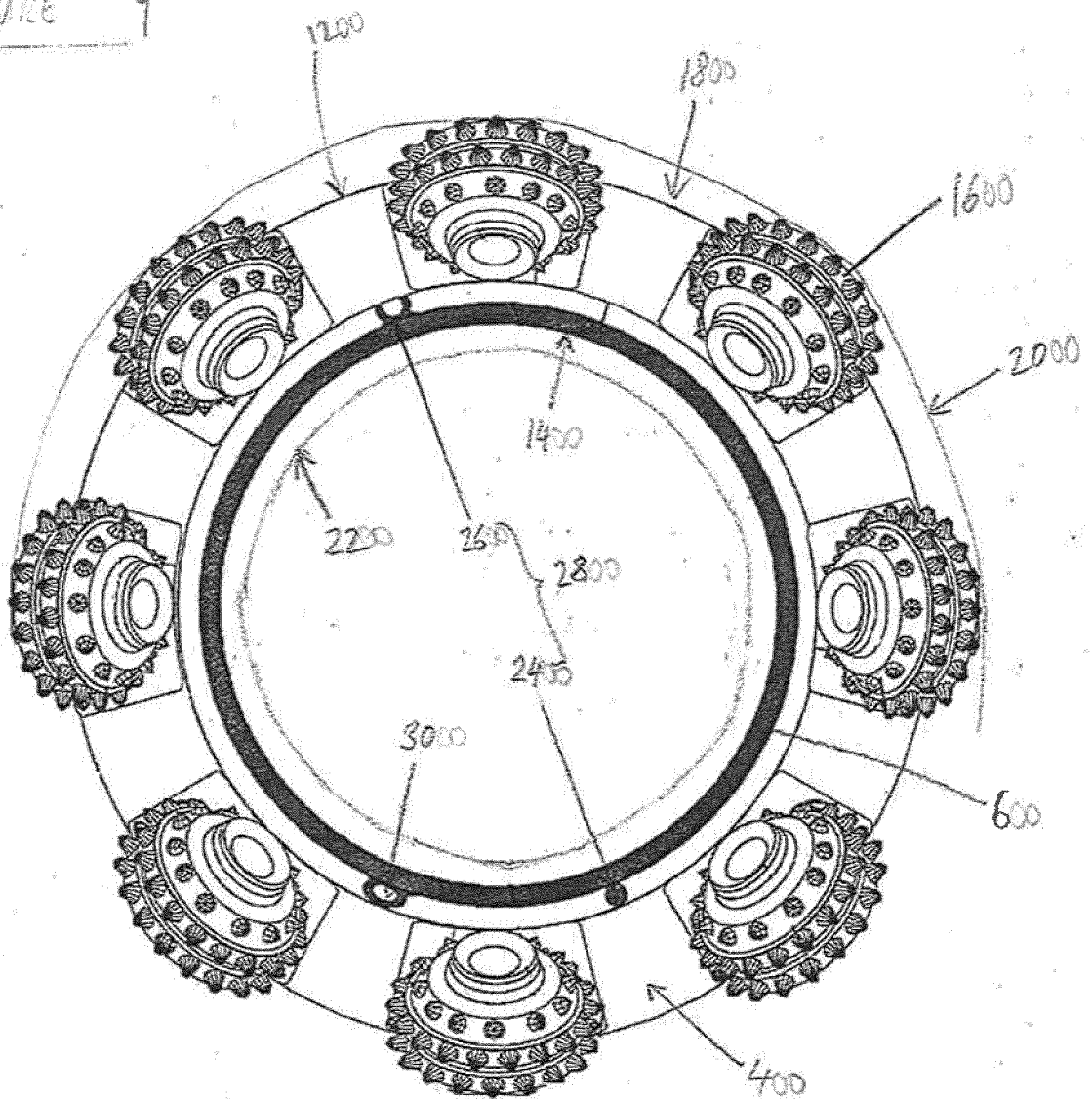
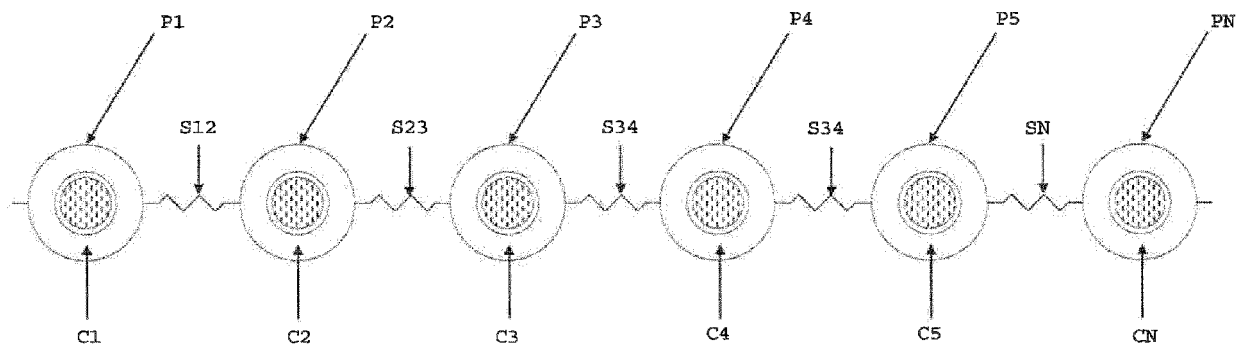
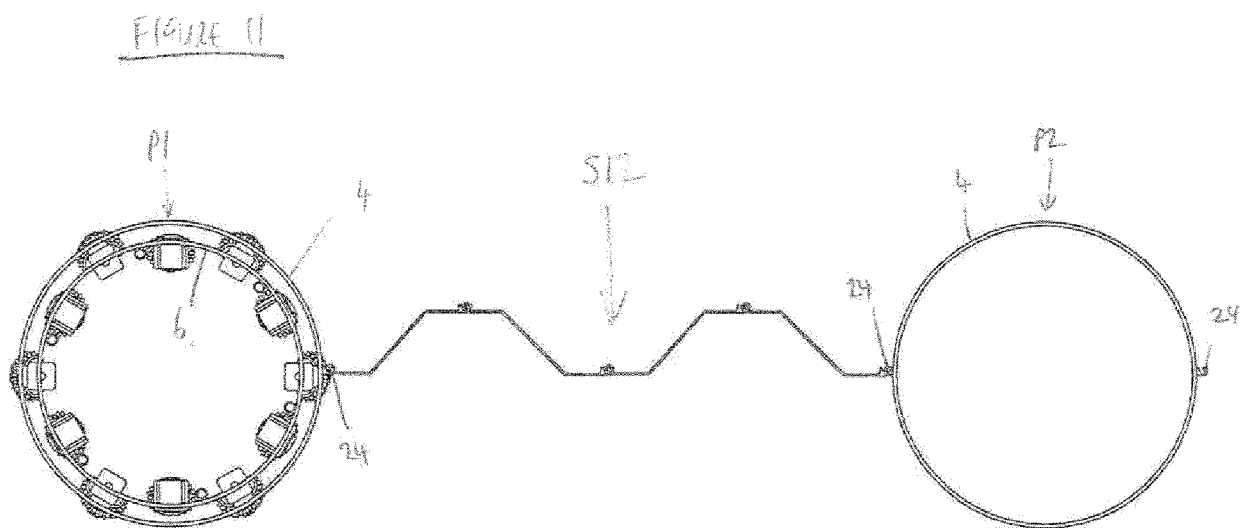


Figure 10







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Application Number
EP 16 15 3711

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 July 2016	Examiner Friedrich, Albert
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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