



(51) International Patent Classification:

B01F 7/02 (2006.01) **B01F 15/02** (2006.01)
B01F 7/00 (2006.01) **B22C 5/04** (2006.01)
B01F 7/16 (2006.01)

(21) International Application Number:

PCT/IB2015/055719

(22) International Filing Date:

29 July 2015 (29.07.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **DISA INDUSTRIES A/S** [DK/DK]; Højager
 8, DK-2630 Taastrup (DK).

(72) Inventor: **HANSEN, Claus Ejvind**; Morbærvej 10, DK-
 4690 Haslev (DK).

(74) Agent: **BUDDE SCHOU A/S**; Hausergade 3, DK-1128
 Copenhagen K (DK).

(81) Designated States (unless otherwise indicated, for every
 kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
 BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
 DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
 HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
 KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
 MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
 PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
 SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
 TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
 kind of regional protection available): ARIPO (BW, GH,
 GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
 TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
 TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
 DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
 LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
 SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
 GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SAND MIXING DEVICE AND METHOD OF MIXING SAND

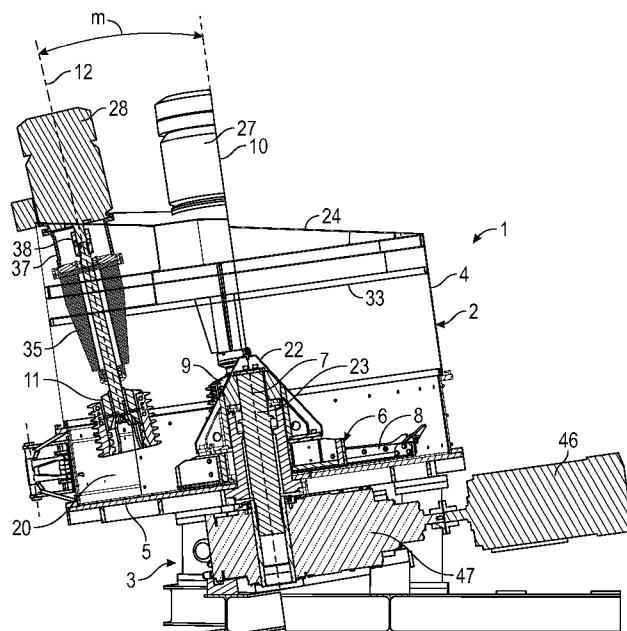


FIG. 2

(57) Abstract: The sand mixing device (1) has a mixing bowl (2) arranged stationarily on a support frame (3) and including a peripheral side wall (4) and a bottom wall (5). A central mixing tool (6) is arranged rotatably about a central mixer axis (7) of the mixing bowl and has a number of blades (8) extending along the bottom wall to the peripheral side wall. The mixing bowl is arranged in an inclined position on the support frame so that the central mixer axis is inclined at an angle to the vertical. A first cross-sectional plane extending through the mixing bowl and including both the central mixer axis and a horizontal line extending in a plane defining the bottom wall divides the mixing bowl into a lower part and a higher part. At least one peripheral mixing tool (9, 11) is arranged in the lower part of the mixing bowl.

Sand mixing device and method of mixing sand

The present invention relates to a sand mixing device having a mixing bowl which is arranged stationarily on a support frame and includes a peripheral side wall and a bottom wall, a central mixing tool being arranged rotatably about a central mixer axis of the mixing bowl and having a number of blades extending along the bottom wall to the peripheral side wall, and at least one peripheral mixing tool being arranged rotatably about a peripheral mixer axis.

- 10 A sand mixing device of the above-mentioned type is available under the trade name DISA TM Mixer.

DE 39 01 774 discloses a weighing mixer particularly suitable for bulk material, such as synthetic granulate. The mixer has a cylindrical vessel with a steeply inclined lower base part which facilitates easy emptying of the vessel through an outlet inserted without dead space. A mixing tool is arranged rotatably about an axis displaced in relation to the cylinder axis of the cylindrical vessel. This kind of mixer is less suitable for sand mixing in a foundry.

- 20 FR 1.271.334 discloses another mixer having a steeply inclined mixing vessel and a helical mixing tool arranged non-centrally and close to a cylindrical wall of the mixing vessel.

EP 0 125 389 discloses an apparatus for treating materials which are capable of flow, comprising a mixing container which rotates about its central axis which is inclined with respect to the vertical, with a wall and/or bottom scraper plate which is arranged substantially stationarily with respect to the cylindrical inside wall of the mixing container, a discharge opening disposed in the bottom of the mixing container and one or two non-centrally arranged rotating tools which engage into the material. To reduce the amount of power consumed, while giving good treatment effects, and to enhance the output of the machine, with respect to the available volume in the machine, it is proposed that the mixing container is driven at a sub-critical speed of rotation, the rotating tool is arranged exclusively at the downstream side of the apex, that the space on the upstream side is free of fittings therein and that the scraper plate is disposed in the vicinity of the apex of the mixing container. However, in this type of apparatus, because of

the rotating mixing container, an outer stationary shield is necessary which may complicate the filling and emptying operations and sample takings.

5 The object of the present invention is to provide a sand mixing device of the type mentioned by way of introduction, whereby process cycle time and energy consumption may be reduced.

10 In view of this object, the mixing bowl is arranged in an inclined position on the support frame so that the central mixer axis of the mixing bowl is inclined at an angle to the vertical, a first cross-sectional plane extending through the mixing bowl and including both the central mixer axis and a horizontal line extending in a plane defining the bottom wall divides the mixing bowl into a lower part positioned relatively lower and a higher part positioned relatively higher, and at least one peripheral mixing tool is arranged in the lower part of the mixing bowl.

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The combination of the inclined mixing bowl and the positioning of at least one peripheral mixing tool in the lower part of the mixing bowl has proven to provide both more efficient mixing and lower energy consumption so that mixing time and energy consumption may be reduced at the same time. A further beneficial effect of the inclined mixing bowl is that emptying of the mixing vessel may be performed faster. The total effect is therefore that a substantially reduced process cycle time and a substantially reduced energy consumption may be achieved. Surprisingly, test results have revealed that the inclined mixing bowl in itself, although providing reduced energy consumption, does not provide an improved mixing result without also positioning at least one peripheral mixing tool in the lower part of the mixing bowl. Furthermore, test results have revealed that the reduced energy consumption obtained by the inclined mixing bowl may be boosted by positioning at least one peripheral mixing tool in the lower part of the mixing bowl. Therefore, it may be concluded that according to the present invention, a surprising synergistic effect may be achieved.

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In an embodiment, the central mixer axis of the mixing bowl is inclined at an angle of between 5 and 30 degrees, preferably of between 7 and 25 degrees, more preferred of between 8 and 20 degrees, and most preferred of between 9 and 15 degrees to the vertical. Thereby, the synergistic effect according to the invention of the inclined mixing bowl and the positioning of the peripheral mixing tools in the lower part of the mixing bowl may be optimized.

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In an embodiment, the blades of the central mixing tool are distributed evenly about the central mixer axis of the mixing bowl, neighbouring blades thereby forming a certain mutual angle, and the at least one peripheral mixing tool is arranged so that the mutual angle between any pair of peripheral mixing tools is different from an integer multiple of the certain mutual angle of the neighbouring blades of the central mixing tool. Surprisingly, tests have proven that if two blades of the central mixing tool during rotation simultaneously pass a respective one of the peripheral mixing tools, an undesirable counter-phase effect may cause increased energy consumption. The tests have further proven that by means of said arrangement of the at least one peripheral mixing tool in combination with the inclined mixing bowl, such undesirable counter-phase effect may be reduced or avoided in such a way that the energy consumption may be reduced without influencing the mixing efficiency negatively, so that mixing time is not increased. On the other hand, the tests have proven that said arrangement of the at least one peripheral mixing tool without an inclined mixing bowl may reduce energy consumption, but at the same time reduce mixing efficiency, so that the mixing time would have to be prolonged. In fact, the total effect of this would be longer mixing time and higher energy consumption. It may therefore be concluded that a synergistic effect may be achieved by the combined effect of said arrangement of the at least one peripheral mixing tool and an inclined mixing bowl.

In an embodiment, the at least one peripheral mixing tool is arranged so that the mutual angle between any pair of peripheral mixing tools differs more than 3 per cent, preferably more than 5 per cent, and most preferred more than 7 per cent, from an integer multiple of the certain mutual angle of the neighbouring blades of the central mixing tool. Thereby, the above-mentioned undesirable counter-phase effect may be reduced or avoided even more efficiently in such a way that the energy consumption may be reduced even more efficiently without prolonging the necessary mixing time.

In an embodiment, the sand mixing device includes a first peripheral mixing tool being arranged rotatably about a first peripheral mixer axis at a first angular mixer position about the central mixer axis of the mixing bowl and a second peripheral mixing tool being arranged rotatably about a second peripheral mixer axis at a second angular mixer position about the central mixer axis of the mixing bowl, and the first and the second peripheral mixing tools are arranged in the lower part of the mixing bowl. This embodiment may be more efficient for relatively larger mixers.

In a structurally particularly advantageous embodiment, the central mixing tool includes four blades distributed evenly about the central mixer axis of the mixing bowl, neighbouring blades thereby forming a mutual angle of 90 degrees, and the first and the second peripheral mixing tools are arranged so that the first and second angular mixer positions differ by between 73 and 87 degrees, preferably by between 78 and 85 degrees, and most preferred by between 82 and 84 degrees. Thereby, the above-mentioned undesirable counter-phase effect may be reduced or avoided efficiently, and therefore, the energy consumption may be reduced efficiently. Furthermore, an even number of blades on the central mixing tool may be advantageous in that transverse forces in the central mixing tool may be avoided so that only moment is present.

In an embodiment, the central mixing tool is adapted to rotate sand in the mixing bowl in a main rotational direction, thereby defining an upstream and a downstream direction in the mixing bowl, the first peripheral mixing tool is located upstream in relation to the second peripheral mixing tool, and the first angular mixer position differs from an angular position of the first cross-sectional plane by between 10 and 55 degrees, preferably by between 20 and 45 degrees, and most preferred by between 30 and 35 degrees. Thereby, according to tests performed, at the same time, even more efficient mixing and even lower energy consumption may be achieved.

In an embodiment, the first peripheral mixing tool is arranged higher than the second peripheral mixing tool in relation to the bottom wall of the mixing bowl. Thereby, according to tests performed, at the same time, even more efficient mixing and even lower energy consumption may be achieved.

In a preferred embodiment, the central mixing tool is adapted to rotate in a main rotational direction, and the at least one peripheral mixing tool is adapted to rotate in a rotational direction opposite to the main rotational direction.

In a preferred embodiment, the central mixing tool is adapted to rotate in a main rotational direction, each blade of the central mixing tool extends from a central hub to a free end at the peripheral side wall of the mixing bowl, each blade curves from the central hub in a rotational direction opposite to the main rotational direction, and the free end of each blade is provided with a blade tip having an upper face slanting towards the bottom wall of the mixing bowl in the main rotational direction.

In an embodiment, the respective peripheral mixer axes, seen in respective radial cross-sectional views of the mixing bowl, form respective angles with the central mixer axis of at least 2 degrees, preferably at least 3 degrees, and most preferred at least 4
5 degrees, so that the lower ends of the peripheral mixing tools, respectively, are at least slightly pointed towards the central mixer axis. Thereby, according to tests performed, at the same time, even more efficient mixing and even lower energy consumption may be achieved.

10 In a preferred embodiment, the peripheral side wall is rotationally symmetric, such as composed by conical and/or cylindrical sections, about its central mixer axis, and wherein the central mixer axis is perpendicular to the bottom wall.

In a preferred embodiment, the peripheral side wall is a cylindrical wall, the bottom wall
15 is arranged at right angles to the cylindrical wall, and the central mixer axis of the peripheral side wall is a cylinder axis of the cylindrical wall.

In an embodiment, a second cross-sectional plane through the mixing bowl including the central mixer axis and extending at right angles to the first cross-sectional plane
20 defines a lowest point angular position in the lower part of the mixing bowl and a highest point angular position in the higher part of the mixing bowl, and an outlet port is arranged in the peripheral side wall, next to the bottom wall, at the lowest point angular position. Thereby, emptying of the mixing vessel may be performed even faster and consequently a reduced process cycle time may be achieved.

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In an embodiment, the sand mixing device is controlled to empty the mixing bowl by opening the outlet port, rotating the central mixing tool and at least substantially reducing the rotational speed of or stopping the first and second peripheral mixing tools. Thereby, according to tests, emptying of the mixing vessel may be optimized and consequently a reduced process cycle time may be achieved.
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In a structurally particularly advantageous embodiment, the central mixing tool is provided with a central conical top part covering the upper end of a central mixing shaft on which the central mixing tool is mounted. Thereby, the efficiency of the sand mixing
35 device may be improved in that circulation of sand in the mixing bowl may be facilitated so that sand moved downward at the central part of the mixing bowl may slide

down on the central conical top part and thereby be guided outwards to the blades of the central mixing tool at the bottom wall of the mixing bowl.

5 In an embodiment, the mixing bowl is provided with a horizontal top cover in which a sand feed hopper is arranged. Thereby, the sand feed hopper may be arranged in different angular orientations about a vertical axis according to requirements, without inclining the sand feed hopper in relation to the horizontal plane.

10 In a structurally particularly advantageous embodiment, a mounting opening in the horizontal top cover is adapted to the sand feed hopper so that the sand feed hopper may be arranged in at least four different angular orientations about a vertical axis. Thereby, the sand feed hopper may in an easy way be arranged in different angular orientations about a vertical axis according to requirements.

15 In a structurally particularly advantageous embodiment, each peripheral mixing tool is driven by a respective direct drive motor arranged on the horizontal top cover by means of a respective intermediate flange piece arranged on the horizontal top cover and having a respective motor connection flange adapted to the respective angle of the peripheral mixer axis.

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In a structurally particularly advantageous embodiment, the mixing bowl is provided with an oblique top cover arranged below the horizontal top cover, each peripheral mixing tool is driven by a respective direct drive motor arranged on the oblique top cover by means of a respective intermediate flange piece arranged on the oblique top cover and having a respective motor connection flange adapted to the respective angle of the respective peripheral mixer axis.

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The present invention further relates to a method of mixing sand in a mixing bowl which is maintained stationarily on a support frame and includes a peripheral side wall and a bottom wall, whereby a central mixing tool is rotated about a central mixer axis of the mixing bowl and has a number of blades extending to the peripheral side wall and swiping over the bottom wall, and whereby at least one peripheral mixing tool is rotated about a peripheral mixer axis.

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35 The method is characterised by that the mixing bowl is maintained in an inclined position on the support frame so that the central mixer axis of the mixing bowl is inclined at

an angle to the vertical, by that a first cross-sectional plane extending through the mixing bowl and including both the central mixer axis and a horizontal line extending in a plane defining the bottom wall divides the mixing bowl into a lower part positioned relatively lower and a higher part positioned relatively higher, and by that at least one peripheral mixing tool is rotated in the lower part of the mixing bowl. Thereby, the above described features may be obtained.

In an embodiment, the central mixer axis of the mixing bowl is inclined at an angle of between 5 and 30 degrees, preferably of between 7 and 25 degrees, more preferred of between 8 and 20 degrees, and most preferred of between 9 and 15 degrees to the vertical. Thereby, the above described features may be obtained.

In an embodiment, during rotation of the central mixing tool, two blades of the central mixing tool do not simultaneously pass two respective peripheral mixer axes of a pair of peripheral mixing tools. Thereby, the above described features may be obtained.

In an embodiment, during rotation of the central mixing tool, when one blade of the central mixing tool passes a peripheral mixer axis of a peripheral mixing tool, the angular position about the central mixer axis of any other blade of the central mixing tool is not nearer than 3 degrees, preferably not nearer than 4 degrees, more preferred not nearer than 5 degrees and most preferred not nearer than 6 degrees, to a peripheral mixer axis of another peripheral mixing tool. Thereby, the above described features may be obtained.

In an embodiment, a first peripheral mixing tool is rotated about a first peripheral mixer axis at a first angular mixer position about the central mixer axis of the mixing bowl and a second peripheral mixing tool is rotated about a second peripheral mixer axis at a second angular mixer position about the central mixer axis of the mixing bowl, and the first and the second peripheral mixing tools are rotated in the lower part of the mixing bowl. Thereby, the above described features may be obtained.

In an embodiment, the central mixing tool rotates sand in the mixing bowl in a main rotational direction, thereby defining an upstream and a downstream direction in the mixing bowl, the first peripheral mixing tool meets sand upstream in relation to the second peripheral mixing tool, and the first angular mixer position differs from an angular position of the first cross-sectional plane by between 10 and 55 degrees, preferably

by between 20 and 45 degrees, and most preferred by between 30 and 35 degrees. Thereby, the above described features may be obtained.

5 In an embodiment, the first peripheral mixing tool is arranged higher than the second peripheral mixing tool in relation to the bottom wall of the mixing bowl. Thereby, the above described features may be obtained.

10 In an embodiment, the central mixing tool rotates in a main rotational direction, and the at least one peripheral mixing tool rotate in a rotational direction opposite to the main rotational direction. Thereby, the above described features may be obtained.

15 In an embodiment, the central mixing tool rotates in a main rotational direction, each blade of the central mixing tool extends from a central hub to a free end at the peripheral side wall of the mixing bowl, each blade curves from the central hub in a rotational direction opposite to the main rotational direction, and the free end of each blade is provided with a blade tip lifting sand in upward direction in relation to the bottom wall of the mixing bowl. Thereby, the above described features may be obtained.

20 In an embodiment, the respective peripheral mixer axes, seen in respective radial cross-sectional views of the mixing bowl, form respective angles with the central mixer axis of at least 2 degrees, preferably at least 3 degrees, and most preferred at least 4 degrees, so that the lower ends of the peripheral mixing tools, respectively, are at least slightly pointed towards the central mixer axis. Thereby, the above described features may be obtained.

25 In an embodiment, the peripheral side wall is rotationally symmetric, such as composed by conical and/or cylindrical sections, about its central mixer axis, and wherein the central mixer axis is perpendicular to the bottom wall. Thereby, the above described features may be obtained.

30 In an embodiment, the peripheral side wall is a cylindrical wall, the bottom wall is arranged at right angles to the cylindrical wall, and the central mixer axis of the peripheral side wall is a cylinder axis of the cylindrical wall. Thereby, the above described features may be obtained.

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In an embodiment, a second cross-sectional plane through the mixing bowl including the central mixer axis and extending at right angles to the first cross-sectional plane defines a lowest point angular position in the lower part of the mixing bowl and a highest point angular position in the higher part of the mixing bowl, and, subsequent to sand mixing, the mixing bowl is emptied of sand through an outlet port arranged in the peripheral side wall, next to the bottom wall, at the lowest point angular position. Thereby, the above described features may be obtained.

In an embodiment, subsequent to sand mixing, the mixing bowl is emptied by opening the outlet port, rotating the central mixing tool and at least substantially reducing the rotational speed of or stopping the first and second peripheral mixing tools. Thereby, the above described features may be obtained.

In an embodiment, the central mixing tool is provided with a central conical top part covering the upper end of a central mixing shaft on which the central mixing tool is mounted, and sand moves downward at the central part of the mixing bowl and slides down on the central conical top part and thereby is guided outwards to the blades of the central mixing tool at the bottom wall of the mixing bowl. Thereby, the above described features may be obtained.

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In an embodiment, the mixing bowl is provided with a horizontal top cover in which a sand feed hopper is arranged. Thereby, the above described features may be obtained.

In an embodiment, a mounting opening in the horizontal top cover is adapted to the sand feed hopper so that the sand feed hopper may be arranged in at least four different angular orientations about a vertical axis. Thereby, the above described features may be obtained.

In an embodiment, each peripheral mixing tool is driven by a respective direct drive motors arranged on the horizontal top cover by means of a respective intermediate flange piece arranged on the horizontal top cover and having a respective motor connection flange adapted to the respective angle of the peripheral mixer axis. Thereby, the above described features may be obtained.

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In an embodiment, the mixing bowl is provided with an oblique top cover arranged below the horizontal top cover, each peripheral mixing tool is driven by a respective direct drive motor arranged on the oblique top cover by means of a respective intermediate flange piece arranged on the oblique top cover and having a respective motor connection flange adapted to the respective angle of the respective peripheral mixer axis. Thereby, the above described features may be obtained.

The invention will now be explained in more detail below by means of examples of embodiments with reference to the very schematic drawing, in which

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Fig. 1 is a top view of a sand mixing device according to the present invention, seen obliquely from above in the direction of a central mixer axis, whereby the sand feed hopper has been removed;

15 Fig. 2 is a cross-section through a part of the sand mixing device along the line II-II in Fig. 1;

Fig. 3 is a radial cross-section through a part of the sand mixing device along the line III-III in Fig. 1;

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Fig. 4 is a side view of another embodiment of the sand mixing device in Fig. 1;

Fig. 5 is a perspective view of another embodiment of the sand mixing device in Fig. 1;

25 Fig. 6 is a partly cross-sectional side view of an embodiment of the sand mixing device; illustrating a sand feed hopper arranged in a first position;

Fig. 7 is a top view of the sand mixing device in Fig. 6 illustrating a sand feed hopper arranged in a first position;

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Fig. 8 is a partly cross-sectional side view of an embodiment of the sand mixing device; illustrating a sand feed hopper arranged in a second position;

35 Fig. 9 is a top view of the sand mixing device in Fig. 8 illustrating a sand feed hopper arranged in a second position;

Fig. 10 is a top view of the central mixing tool of the sand mixing device in Figs. 1 to 3;

Fig. 11 is a partly cross-sectional side view of the central mixing tool in Fig. 10;

- 5 Fig. 12 is a graphical representation of the power consumption for a prior art sand mixing device; and

Fig. 13 is a graphical representation of the power consumption for a sand mixing device according to the present invention.

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Throughout the following description of different embodiments of the invention, similar elements have generally been denoted by identical reference numerals.

- The present invention relates to sand mixing devices suitable for mixing sand and water preferably for the use in sand moulding machines. Fig. 2 illustrates a sand mixing
15 device 1 having a mixing bowl 2 which is arranged stationarily on a support frame 3 and includes a peripheral side wall 4 and a bottom wall 5. A central mixing tool 6 is arranged rotatably about a central mixer axis 7 of the mixing bowl 2 and has four blades 8 extending along the bottom wall 5 to the peripheral side wall 4. As seen in
20 Fig. 1, a first peripheral mixing tool 9 is arranged rotatably about a first peripheral mixer axis 10 at a first angular mixer position P_1 about the central mixer axis 7 of the mixing bowl 2. The first angular mixer position is located in the cross-section illustrated in Fig. 3. A second peripheral mixing tool 11 is arranged rotatably about a second peripheral mixer axis 12 at a second angular mixer position P_2 about the central mixer
25 axis 7 of the mixing bowl 2. The second angular mixer position is located in the cross-section illustrated in Fig. 2.

- As seen in Figs. 2 and 3, the mixing bowl 2 is arranged in an inclined position on the support frame 3 so that the central mixer axis 7 of the mixing bowl is inclined at an
30 angle M to the vertical. In the illustrated embodiment, the angle M is approximately 8 degrees. However, the angle M may according to the invention be between 5 and 30 degrees, preferably between 7 and 25 degrees, more preferred between 8 and 20 degrees, and most preferred between 9 and 15 degrees. The support frame 3 is provided with not shown feet or the like adapted to position the support frame 3 on a horizontal-
35 ly extending floor so that the mixing bowl 2 is inclined at said angle M to the vertical. During operation of the sand mixing device 1, the peripheral side wall 4 and the bottom

wall 5 are contacted directly by the sand material being mixed in the sand mixing device 1.

Fig. 1 is a top view of the sand mixing device 1 according to the present invention, seen obliquely from above in the direction of the central mixer axis 7. Fig. 1 illustrates a first cross-sectional plane 13 extending through the mixing bowl 2 and including both the central mixer axis 7 and a not shown horizontal line extending in a plane defining the bottom wall 5. The first cross-sectional plane 13 divides the mixing bowl 2 into a lower part 14 positioned relatively lower and a higher part 15 positioned relatively higher. The first and the second peripheral mixing tools 9, 11 are arranged in the lower part 14 of the mixing bowl 2. Generally, according to the present invention, at least one peripheral mixing tool is arranged in the mixing bowl 2, and at least one of these peripheral mixing tools is arranged in the lower part 14 of the mixing bowl 2.

In the embodiment illustrated in the figures, the central mixing tool 6 includes four blades 8 distributed evenly about the central mixer axis 7 of the mixing bowl 2. Neighbouring blades 8 thereby form a mutual angle of 90 degrees. The first and second peripheral mixing tools 9, 11 are arranged so that the first and second angular mixer positions differ by an angle P_{12} of approximately 83 degrees. However, according to the invention, the first and the second peripheral mixing tools 9, 11 may be arranged so that the first and second angular mixer positions differ by an angle P_{12} of between 73 and 87 degrees, preferably by between 78 and 85 degrees, and most preferred by between 82 and 84 degrees.

Tests have proven that if two blades 8 of the central mixing tool 6 during rotation simultaneously or almost simultaneously pass a respective one of the peripheral mixing tools 9, 11, an undesirable counter-phase effect may cause increased energy consumption. By the immediately above mentioned arrangement of the first and the second peripheral mixing tools 9, 11 in combination with the inclined mixing bowl 2, such undesirable counter-phase effect may be reduced or avoided in such a way that the energy consumption may be reduced without influencing the mixing efficiency negatively, so that mixing time is not increased.

In other embodiments, the central mixing tool 6 may include other numbers of blades 8 distributed evenly about the central mixer axis 7 so that neighbouring blades form a certain mutual angle. In this case, generally, according to the invention, the first and

the second peripheral mixing tools 9, 11 are arranged so that the first and second angular mixer positions P_1 , P_2 differ by an angle P_{12} that is different from an integer multiple of the certain mutual angle of the neighbouring blades 8 of the central mixing tool 6. In the case that a greater number of peripheral mixing tools is arranged, such as three, four or even more peripheral mixing tools, these are arranged so that the mutual angle between any pair of peripheral mixing tools is different from an integer multiple of the certain mutual angle of the neighbouring blades of the central mixing tool. Thereby, the above-mentioned undesirable counter-phase effect may be reduced.

- 10 Preferably, the peripheral mixing tools are arranged so that the mutual angle between any pair of peripheral mixing tools differs more than 3 per cent, preferably more than 5 per cent, and most preferred more than 7 per cent, from an integer multiple of the certain mutual angle of the neighbouring blades of the central mixing tool. Thereby, the above-mentioned undesirable counter-phase effect may be substantially reduced or
15 avoided.

In the embodiments illustrated in the figures, the central mixing tool 6 is adapted to rotate sand in the mixing bowl 2 in a main rotational direction R , thereby defining an upstream and a downstream direction in the mixing bowl 2. As seen in Fig. 1, the first
20 peripheral mixing tool 9 is located upstream in relation to the second peripheral mixing tool 12. When the angular position of the first cross-sectional plane 13 in the top half of Fig. 1 is set to zero degrees, it is preferred that the first angular mixer position P_1 is between 10 and 55 degrees, preferably between 20 and 45 degrees, and most preferred between 30 and 35 degrees. In the embodiment illustrated in Fig. 1, the first
25 angular mixer position P_1 is 32 degrees, and the second angular mixer position P_2 is 115 degrees.

Preferably, the first peripheral mixing tool 9 is arranged higher than the second peripheral mixing tool 11 in relation to the bottom wall 5 of the mixing bowl 2.

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Preferably, the central mixing tool 6 is adapted to rotate in the main rotational direction R , and the first and second peripheral mixing tools 9, 11 are adapted to rotate in a rotational direction r opposite to the main rotational direction R . In Fig. 1, the main rotational direction R is counter clockwise.

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The central mixing tool 6 is adapted to rotate in the main rotational direction R, and as illustrated in Fig. 10, each blade 8 of the central mixing tool 6 extends from a central hub 16 to a free end 17 at the peripheral side wall 4 of the mixing bowl 2 so that each blade 8 curves from the central hub 16 in a rotational direction opposite to the main rotational direction R. Thereby, two opposed blades 8 together makes an S-formed configuration. The free end 17 of each blade 8 is provided with a blade tip 18 having an upper face 49 slanting towards the bottom wall 5 of the mixing bowl 2 in the main rotational direction R. During mixing of sand, the blade tips may lift sand in upward direction in relation to the bottom wall 5 of the mixing bowl 2.

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The first and second peripheral mixer axes 10, 11, as seen in Figs. 3 and 2 in the respective radial cross-sectional views of the mixing bowl 2, form respective angles m with the central mixer axis, so that the lower ends of the first and second peripheral mixing tools 10, 11, respectively, are at least slightly pointed towards the central mixer axis 7. In the embodiment illustrated, the respective angles m equal 5 degrees; however, generally, according to the present invention, the angles may be at least 2 degrees, preferably at least 3 degrees, and most preferred at least 4 degrees.

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In the illustrated embodiment, the peripheral side wall 4 of the mixing bowl 2 is a cylindrical wall, the bottom wall is arranged at right angles to the cylindrical wall, and the central mixer axis 7 of the peripheral side wall 4 and of the mixing bowl 2 is a cylinder axis of the cylindrical wall. However, generally, according to the present invention, the peripheral side wall 4 is rotationally symmetric, such as composed by conical and/or cylindrical sections, about its central mixer axis 7. The central mixer axis 7 is preferably perpendicular to the bottom wall 5.

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Fig. 1 further illustrates a second cross-sectional plane 19 extending through the mixing bowl 2, including the central mixer axis 7 and extending at right angles to the first cross-sectional plane 13. The second cross-sectional plane 19 defines a lowest point angular position L_P of the bottom wall 5 in the lower part 14 of the mixing bowl 2 and a highest point angular position H_P of the bottom wall 5 in the higher part 15 of the mixing bowl 2. An outlet port 20 is arranged in the peripheral side wall 4, next to the bottom wall 5, at the lowest point angular position L_P .

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By means of a computer 21, the sand mixing device 1 is controlled to, subsequent to sand mixing, empty the mixing bowl 2 by opening the outlet port 20, rotating the cen-

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tral mixing tool 6 and at least substantially reducing the rotational speed of or stopping the first and second peripheral mixing tools 9, 11. Rotation of the central mixing tool 6 may facilitate the emptying operation, whereas rotation of the first and/or the second peripheral mixing tool 9, 11 in some circumstances may slow down the emptying operation.

As illustrated in Figs. 2, 3 and 11, the central mixing tool 6 is provided with a central conical top part 22 covering the upper end of a central mixing shaft 23 on which the central mixing tool 6 is mounted. During mixing of sand, sand moves downward at the central part of the mixing bowl 2 and slides down on the central conical top part 22 and is thereby guided outwards to the blades 8 of the central mixing tool 6 at the bottom wall 5 of the mixing bowl 2. The central mixing tool 6 is driven by means of a drive motor 46 via an angular gearbox 47.

As illustrated in Figs. 6 to 9, the mixing bowl 2 is provided with a horizontal top cover 24 in which a sand feed hopper 25 also denoted a batch hopper is arranged. It is noted that in Figs. 6 and 8, the central mixing tool 6 has not been mounted. In the horizontal top cover 24, a mounting opening 26 is adapted to fit a substantially rectangular bottom part of the sand feed hopper 25 so that the sand feed hopper 25 may be arranged in at least four different angular orientations about a vertical axis. Thereby, the orientation of the sand feed hopper 25 may conveniently be adapted to the position of a sand conveyor adapted to fill sand into the sand feed hopper 25. In the configuration illustrated in Figs. 8 and 9, the sand feed hopper 25 has been rotated 90 degrees about said vertical axis in relation to the configuration illustrated in Figs. 6 and 7. Of course, the mounting opening 26 may have different forms in order to fit the sand feed hopper 25 so that the sand feed hopper 25 may be rotated to be mounted in different positions. In the illustrated embodiment, the mounting opening 26 is at least substantially square-formed. In an alternative configuration, the bottom part of the sand feed hopper 25 is circular, and the corresponding mounting opening 26 is circular.

The sand feed hopper 25 is in a well-known way provided with three not shown weighing cells. When the required weight of sand has been achieved in the sand feed hopper 25, this is detected by the weighing cells, and a bottom door of the sand feed hopper 25 is opened by means of a pneumatic cylinder so that the sand is fed into the sand mixing device 1. The sand mixing device 1 is furthermore provided with a not shown water supply including a water tank large enough to contain the amount re-

quired for at least one batch operation of the sand mixing device, for instance 100 litres. The water tank is also provided with a number of weighing cells so that the weight of water present in the water tank may be weighed continuously as the water is supplied from the tank to the mixing bowl 2. Firstly, a relatively large amount of water, such as 90 kilogrammes, estimated to be almost enough for the required humidity of the sand, is filled into the mixing bowl via a relatively large control valve. This is preferably done simultaneously with the sand filling operation. This relatively large amount of water may for instance be supplied to the mixing bowl within 15 seconds. The relatively large control valve may provide fast water filling. Subsequently, after that the sand mixing operation has been performed for a certain time, the sand humidity in the mixing bowl 2 is measured and a required additional sand weight is calculated. Then, a relatively small amount of water, such as 4 kilogrammes, estimated to be enough for the required humidity of the sand, is filled into the mixing bowl via a relatively small control valve. The relatively small control valve may provide precision.

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In the embodiments illustrated in Figs. 4 and 5, each peripheral mixing tool 9, 11 is driven by a respective direct drive motor 27, 28 arranged on the horizontal top cover 24 by means of a respective intermediate flange piece 29, 30 arranged on the horizontal top cover 24 and having a respective motor connection flange 31, 32 adapted to the respective angle of the respective peripheral mixer axis 10, 12. As the direct drive motors 27, 28 are relatively compact compared to prior art belt drives, this arrangement facilitates the above-mentioned design of the sand feed hopper 25 whereby the sand feed hopper 25 may be arranged in different angular orientations about a vertical axis. Furthermore, the direct drive motors provide for easier maintenance than belt drives.

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In the embodiments illustrated in Figs. 2, 3, and 6 to 9, the mixing bowl 2 is provided with an oblique top cover 33 arranged below the horizontal top cover 24. Each peripheral mixing tool 9, 11 is driven by a respective direct drive motor 27, 28 arranged on the oblique top cover 33 by means of a respective intermediate flange piece 34, 35 arranged on the oblique top cover 33 and having a respective motor connection flange 36, 37 adapted to the respective angle of the respective peripheral mixer axis 10, 12. Each peripheral mixing tool 9, 11 is connected to the respective drive motor 27, 28 by means of a respective flexible coupling 38.

35 Figs. 12 and 13 illustrate simulated comparative test results regarding power consumption for sand mixing devices having a mixing capacity of approximately 3000 kil-

ogrammes per batch. Fig. 13 is a graphical representation of the power consumption for the sand mixing device 1 according to the present invention as illustrated in Figs. 1 to 3. Fig. 12 is a corresponding graphical representation of the power consumption for a prior art sand mixing device corresponding in size and sand mixing capacity to the sand mixing device 1 illustrated in Figs. 1 to 3 and having a corresponding central mixing tool, but having a mixing bowl arranged vertically so that the central mixer axis is vertical, and having two peripheral mixing tools arranged diametrically opposed in relation to the central mixer axis. The central mixing tool of both tested sand mixing devices rotated at approximately 26 rpm. The peripheral mixing tools of the prior art device rotated at approximately 1200 rpm, and the peripheral mixing tools of the sand mixing device 1 according to the present invention rotated at approximately 1000 rpm. As mentioned above, for the sand mixing device 1 according to the present invention as illustrated in Figs. 1 to 3, the first angular mixer position P_1 is 32 degrees, the first and second angular mixer positions differ by an angle P_{12} of approximately 83 degrees, the mixing bowl is inclined at an angle M of approximately 8 degrees to the vertical, and the first and second peripheral mixer axes 10, 11 form respective angles m of approximately 5 degrees with the central mixer axis 7. The peripheral mixer axes of the peripheral mixing tools of the prior art device form respective angles of approximately 2 degrees with the central mixer axis.

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Fig. 12 illustrates the power consumption of the central mixing tool by means of the curve 39 and the average thereof by means of the line 40. Furthermore, Fig. 12 illustrates the power consumption of one of the peripheral mixing tools by means of the curve 41 and the average thereof by means of the line 42.

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In Fig. 12 it is seen that in the prior art sand mixing device, the central mixing tool consumes an average of approximately 140 kilowatt, and the two peripheral mixing tools consume a total average of approximately 115 kilowatt (each peripheral mixing tool consumes slightly less than 60 kilowatt). This makes a total average power consumption for the prior art sand mixing device of approximately 255 kilowatt.

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Fig. 13 illustrates the power consumption of the central mixing tool 6 by means of the curve 43. Furthermore, Fig. 13 illustrates the power consumption of the first peripheral mixing tool 9 by means of the curve 44 and the power consumption of the second peripheral mixing tool 11 by means of the curve 45.

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In Fig. 13 it is seen that in the sand mixing device 1 according to the present invention, the central mixing tool 6 consumes an average of approximately 130 kilowatt, and the two peripheral mixing tools 9, 11 consume a total average of approximately 100 kilowatt (each peripheral mixing tool consumes approximately 50 kilowatt). This makes a total average power consumption for the sand mixing device 1 according to the present invention of approximately 230 kilowatt.

Therefore, a result of the simulated comparative test is that the sand mixing device 1 according to the present invention consumes 10 per cent less power than the prior art sand mixing device.

However, according to the simulated test result, the mixing time required to achieve a satisfactory mixing result was also reduced from the prior art sand mixing device to the sand mixing device 1 according to the present invention. Whereas the prior art sand mixing device requires 120 seconds of mixing to obtain a satisfactory result, the sand mixing device 1 according to the present invention only requires 110 seconds.

On the basis of the above, a further result of the simulated comparative test is that the total energy consumption required to mix a batch of sand to a satisfactory mixing result is reduced by almost 20 per cent.

Furthermore, it should be noted that according to tests, the sand mixing device 1 according to the present invention may perform the sand and water filling operation in approximately 10 seconds which is generally faster than standard prior art procedures which depend on tap pressure in that water is simply supplied from a tap.

Additionally, it should be noted that according to tests, the sand mixing device 1 according to the present invention may perform the emptying operation in approximately 20 seconds compared to approximately 30 seconds for the prior art sand mixing device.

Summing up the above, it is estimated that the total batch processing time for the sand mixing device 1 according to the present invention may be reduced by at least 10 to 15 per cent compared to the prior art sand mixing device.

It should be mentioned that throughout this description, whenever sand is referred to, it should be understood that any suitable particulate material may be applied. The sand or particulate material may typically be so-called green sand (also called clay bound sand), i.e. moulding material based on quartz sand, clay, coal dust and water. However, other particulate materials and binder systems may be applied.

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List of reference numbers

	H _P	highest point angular position
	L _P	lowest point angular position
5	M	angle to the vertical of central mixer axis
	m	angle formed between peripheral mixer axis and central mixer axis
	R	main rotational direction of central mixing tool
	r	rotational direction of peripheral mixing tools
	P ₁	first angular mixer position about central mixer axis
10	P ₂	second angular mixer position about central mixer axis
	P ₁₂	difference between first and second angular mixer positions
	1	sand mixing device
	2	mixing bowl
	3	support frame
15	4	peripheral side wall
	5	bottom wall
	6	central mixing tool
	7	central mixer axis
	8	blade of central mixing tool
20	9	first peripheral mixing tool
	10	first peripheral mixer axis
	11	second peripheral mixing tool
	12	second peripheral mixer axis
	13	first cross-sectional plane
25	14	lower part of mixing bowl
	15	higher part of mixing bowl
	16	central hub
	17	free end of blade
	18	blade tip
30	19	second cross-sectional plane
	20	outlet port
	21	computer
	22	central conical top part
	23	central mixing shaft
35	24	horizontal top cover
	25	sand feed hopper

- 26 mounting opening
- 27 first direct drive motor
- 28 second direct drive motor
- 29 first intermediate flange piece
- 5 30 second intermediate flange piece
- 31 first motor connection flange
- 32 second motor connection flange
- 33 oblique top cover
- 34 first intermediate flange piece
- 10 35 second intermediate flange piece
- 36 first motor connection flange
- 37 second motor connection flange
- 38 flexible coupling
- 39 power consumption of central mixing tool (prior art mixing device)
- 15 40 average of power consumption of central mixing tool (prior art mixing device)
- 41 power consumption of peripheral mixing tool (prior art mixing device)
- 42 average of power consumption of peripheral mixing tool (prior art mixing device)
- 43 power consumption of central mixing tool (embodiment of invention)
- 44 power consumption of first peripheral mixing tool (embodiment of invention)
- 20 45 power consumption of second peripheral mixing tool (embodiment of invention)
- 46 drive motor of central mixing tool
- 47 angular gearbox
- 49 upper face of blade tip

Claims

1. A sand mixing device (1) having a mixing bowl (2) which is arranged stationarily on a support frame (3) and includes a peripheral side wall (4) and a bottom wall (5), a
5 central mixing tool (6) being arranged rotatably about a central mixer axis (7) of the mixing bowl (2) and having a number of blades (8) extending along the bottom wall (5) to the peripheral side wall (4), and at least one peripheral mixing tool (9, 11) being arranged rotatably about a peripheral mixer axis (10, 12), **characterised in that** the mixing bowl (2) is arranged in an inclined position on the support frame (3) so that the
10 central mixer axis (7) of the mixing bowl (2) is inclined at an angle to the vertical, in that a first cross-sectional plane (13) extending through the mixing bowl (2) and including both the central mixer axis (7) and a horizontal line extending in a plane defining the bottom wall (5) divides the mixing bowl (2) into a lower part (14) positioned relatively lower and a higher part (15) positioned relatively higher, and in that at least one
15 peripheral mixing tool (9, 11) is arranged in the lower part (14) of the mixing bowl (2).
2. A sand mixing device according to claim 1, wherein the central mixer axis (7) of the mixing bowl (2) is inclined at an angle (M) of between 5 and 30 degrees, preferably of between 7 and 25 degrees, more preferred of between 8 and 20 degrees, and most
20 preferred of between 9 and 15 degrees to the vertical.
3. A sand mixing device according to claim 1 or 2, wherein the blades (8) of the central mixing tool (6) are distributed evenly about the central mixer axis (7) of the mixing bowl (2), neighbouring blades (8) thereby forming a certain mutual angle, and
25 wherein the at least one peripheral mixing tool (9, 11) is arranged so that the mutual angle between any pair of peripheral mixing tools (9, 11) is different from an integer multiple of the certain mutual angle of the neighbouring blades (8) of the central mixing tool (6).
- 30 4. A sand mixing device according to claim 3, wherein the at least one peripheral mixing tool (9, 11) is arranged so that the mutual angle between any pair of peripheral mixing tools differs more than 3 per cent, preferably more than 5 per cent, and most preferred more than 7 per cent, from an integer multiple of the certain mutual angle of the neighbouring blades of the central mixing tool (6).

5. A sand mixing device according to any one of the preceding claims, wherein the sand mixing device (1) includes a first peripheral mixing tool (9) being arranged rotatably about a first peripheral mixer axis (10) at a first angular mixer position (P_1) about the central mixer axis (7) of the mixing bowl (2) and a second peripheral mixing tool (11) being arranged rotatably about a second peripheral mixer axis (12) at a second angular mixer position (P_2) about the central mixer axis (7) of the mixing bowl (2), and wherein the first and the second peripheral mixing tools (9, 11) are arranged in the lower part (14) of the mixing bowl (2).

6. A sand mixing device according to claim 5, wherein the central mixing tool (6) includes four blades (8) distributed evenly about the central mixer axis (7) of the mixing bowl (2), neighbouring blades (8) thereby forming a mutual angle of 90 degrees, and wherein the first and the second peripheral mixing tools (9, 11) are arranged so that the first and second angular mixer positions (P_1 , P_2) differ by between 73 and 87 degrees, preferably by between 78 and 85 degrees, and most preferred by between 82 and 84 degrees.

7. A sand mixing device according to claim 5 or 6, wherein the central mixing tool (6) is adapted to rotate sand in the mixing bowl (2) in a main rotational direction (R), thereby defining an upstream and a downstream direction in the mixing bowl (2), wherein the first peripheral mixing tool (9) is located upstream in relation to the second peripheral mixing tool (11), and wherein the first angular mixer position (P_1) differs from an angular position of the first cross-sectional plane (13) by between 10 and 55 degrees, preferably by between 20 and 45 degrees, and most preferred by between 30 and 35 degrees.

8. A sand mixing device according to claim 7, wherein the first peripheral mixing tool (9) is arranged higher than the second peripheral mixing tool (11) in relation to the bottom wall (5) of the mixing bowl (2).

9. A sand mixing device according to any one of the preceding claims, wherein the central mixing tool (6) is adapted to rotate in a main rotational direction (R), and wherein the at least one peripheral mixing tool (9, 11) is adapted to rotate in a rotational direction (r) opposite to the main rotational direction (R).

10. A sand mixing device according to any one of the preceding claims, wherein the central mixing tool (6) is adapted to rotate in a main rotational direction (R), wherein each blade (8) of the central mixing tool (6) extends from a central hub (16) to a free end (17) at the peripheral side wall (4) of the mixing bowl (2), wherein each blade (8) curves from the central hub (16) in a rotational direction opposite to the main rotational direction (R), and wherein the free end (17) of each blade (8) is provided with a blade tip (18) having an upper face (49) slanting towards the bottom wall (5) of the mixing bowl (2) in the main rotational direction (R).
11. A sand mixing device according to any one of the preceding claims, wherein the respective peripheral mixer axes (10, 12), seen in respective radial cross-sectional views of the mixing bowl (2), form respective angles with the central mixer axis (7) of at least 2 degrees, preferably at least 3 degrees, and most preferred at least 4 degrees, so that the lower ends of the peripheral mixing tools (9, 11), respectively, are at least slightly pointed towards the central mixer axis (7).
12. A sand mixing device according to any one of the preceding claims, wherein the peripheral side wall (4) is rotationally symmetric, such as composed by conical and/or cylindrical sections, about its central mixer axis (7), and wherein the central mixer axis (7) is perpendicular to the bottom wall (5).
13. A sand mixing device according to any one of the preceding claims, wherein the peripheral side wall (4) is a cylindrical wall, the bottom wall (5) is arranged at right angles to the cylindrical wall, and the central mixer axis (7) of the peripheral side wall (4) is a cylinder axis of the cylindrical wall.
14. A sand mixing device according to any one of the preceding claims, wherein a second cross-sectional plane (19) through the mixing bowl (2) including the central mixer axis (7) and extending at right angles to the first cross-sectional plane (13) defines a lowest point angular position (L_P) in the lower part (14) of the mixing bowl (2) and a highest point angular position (H_P) in the higher part (15) of the mixing bowl (2), and wherein an outlet port (20) is arranged in the peripheral side wall (4), next to the bottom wall (5), at the lowest point angular position (L_P).
15. A sand mixing device according to claim 14, wherein the sand mixing device (1) is controlled to empty the mixing bowl (2) by opening the outlet port (20), rotating the

central mixing tool (6) and at least substantially reducing the rotational speed of or stopping the first and second peripheral mixing tools (9, 11).

16. A sand mixing device according to any one of the preceding claims, wherein the
5 central mixing tool (6) is provided with a central conical top part (22) covering the upper end of a central mixing shaft (23) on which the central mixing tool (6) is mounted.

17. A sand mixing device according to any one of the preceding claims, wherein the
10 mixing bowl (2) is provided with a horizontal top cover (24) in which a sand feed hopper (25) is arranged.

18. A sand mixing device according to claim 17, wherein a mounting opening (26) in
15 the horizontal top cover (24) is adapted to the sand feed hopper (25) so that the sand feed hopper may be arranged in at least four different angular orientations about a vertical axis.

19. A sand mixing device according to claim 17 or 18, wherein each peripheral mixing
20 tool (9, 11) is driven by a respective direct drive motor (27, 28) arranged on the horizontal top cover (24) by means of a respective intermediate flange piece (29, 30) arranged on the horizontal top cover (24) and having a respective motor connection flange (31, 32) adapted to the respective angle of the respective peripheral mixer axis (10, 12).

20. A sand mixing device according to claim 17 or 18, wherein the mixing bowl (2) is
25 provided with an oblique top cover (33) arranged below the horizontal top cover (24), wherein each peripheral mixing tool (9, 11) is driven by a respective direct drive motor (27, 28) arranged on the oblique top cover (33) by means of a respective intermediate flange piece (34, 35) arranged on the oblique top cover and having a respective motor connection flange (36, 37) adapted to the respective angle of the respective peripheral
30 mixer axis (10, 12).

21. A method of mixing sand in a mixing bowl (2) which is maintained stationarily on
a support frame (3) and includes a peripheral side wall (4) and a bottom wall (5), whereby a central mixing tool (6) is rotated about a central mixer axis (7) of the mixing
35 bowl and has a number of blades (8) extending to the peripheral side wall (4) and swiping over the bottom wall (5), and whereby at least one peripheral mixing tool (9,

11) is rotated about a peripheral mixer axis (10, 12), **characterised by that** the mixing bowl (2) is maintained in an inclined position on the support frame (3) so that the central mixer axis (7) of the mixing bowl (2) is inclined at an angle to the vertical, by that a first cross-sectional plane (13) extending through the mixing bowl (2) and including
5 both the central mixer axis (7) and a horizontal line extending in a plane defining the bottom wall (5) divides the mixing bowl (2) into a lower part (14) positioned relatively lower and a higher part (15) positioned relatively higher, and by that at least one peripheral mixing tool (9, 11) is rotated in the lower part (14) of the mixing bowl (2).

10 22. A method of mixing sand according to claim 21, whereby the central mixer axis (7) of the mixing bowl (2) is inclined at an angle (M) of between 5 and 30 degrees, preferably of between 7 and 25 degrees, more preferred of between 8 and 20 degrees, and most preferred of between 9 and 15 degrees to the vertical.

15 23. A method of mixing sand according to claim 21 or 22, whereby, during rotation of the central mixing tool (6), two blades (8) of the central mixing tool do not simultaneously pass two respective peripheral mixer axes (10, 12) of a pair of peripheral mixing tools (9, 11).

20 24. A method of mixing sand according to any one of the claims 21 to 23, whereby, during rotation of the central mixing tool (6), when one blade (8) of the central mixing tool (6) passes a peripheral mixer axis (10, 12) of a peripheral mixing tool (9, 11), the angular position about the central mixer axis (7) of any other blade (8) of the central mixing tool (6) is not nearer than 3 degrees, preferably not nearer than 4 degrees,
25 more preferred not nearer than 5 degrees and most preferred not nearer than 6 degrees, to a peripheral mixer axis (10, 12) of another peripheral mixing tool (9, 11).

25. A method of mixing sand according to any one of the claims 21 to 24, whereby a first peripheral mixing tool (9) is rotated about a first peripheral mixer axis (10) at a first
30 angular mixer position (P_1) about the central mixer axis (7) of the mixing bowl (2) and a second peripheral mixing tool (11) is rotated about a second peripheral mixer axis (12) at a second angular mixer position (P_2) about the central mixer axis (7) of the mixing bowl (2), and whereby the first and the second peripheral mixing tools (9, 11) are rotated in the lower part (14) of the mixing bowl (2).

26. A method of mixing sand according to claim 25, whereby the central mixing tool (6) rotates sand in the mixing bowl (2) in a main rotational direction (R), thereby defining an upstream and a downstream direction in the mixing bowl (2), whereby the first peripheral mixing tool (9) meets sand upstream in relation to the second peripheral mixing tool (11), and whereby the first angular mixer position (P_1) differs from an angular position of the first cross-sectional plane (13) by between 10 and 55 degrees, preferably by between 20 and 45 degrees, and most preferred by between 30 and 35 degrees.

27. A method of mixing sand according to claim 25 or 26, whereby the first peripheral mixing tool (9) is arranged higher than the second peripheral mixing tool (11) in relation to the bottom wall (5) of the mixing bowl (2).

28. A method of mixing sand according to any one of the claims 21 to 27, whereby the central mixing tool (6) rotates in a main rotational direction (R), and wherein the at least one peripheral mixing tool (9, 11) rotates in a rotational direction (r) opposite to the main rotational direction (R).

29. A method of mixing sand according to any one of the claims 21 to 28, whereby the central mixing tool (6) rotates in a main rotational direction (R), whereby each blade (8) of the central mixing tool (6) extends from a central hub (16) to a free end (17) at the peripheral side wall (4) of the mixing bowl (2), whereby each blade (8) curves from the central hub (16) in a rotational direction opposite to the main rotational direction (R), and whereby the free end (17) of each blade (8) is provided with a blade tip (18) lifting sand in upward direction in relation to the bottom wall (5) of the mixing bowl (2).

30. A method of mixing sand according to any one of the claims 21 to 29, whereby the respective peripheral mixer axes (10, 12), seen in respective radial cross-sectional views of the mixing bowl (2), form respective angles with the central mixer axis (7) of at least 2 degrees, preferably at least 3 degrees, and most preferred at least 4 degrees, so that the lower ends of the peripheral mixing tools (9, 11), respectively, are at least slightly pointed towards the central mixer axis (7).

31. A method of mixing sand according to any one of the claims 21 to 30, whereby the peripheral side wall (4) is rotationally symmetric, such as composed by conical

and/or cylindrical sections, about its central mixer axis (7), and wherein the central mixer axis (7) is perpendicular to the bottom wall (5).

32. A method of mixing sand according to any one of the claims 21 to 31, whereby
5 the peripheral side wall (4) is a cylindrical wall, the bottom wall (5) is arranged at right angles to the cylindrical wall, and the central mixer axis (7) of the peripheral side wall (4) is a cylinder axis of the cylindrical wall.

33. A method of mixing sand according to any one of the claims 21 to 32, whereby a
10 second cross-sectional plane (19) through the mixing bowl (2) including the central mixer axis (7) and extending at right angles to the first cross-sectional plane (13) defines a lowest point angular position (L_P) in the lower part (14) of the mixing bowl (2) and a highest point angular position (H_P) in the higher part (15) of the mixing bowl (2), and whereby, subsequent to sand mixing, the mixing bowl (2) is emptied of sand
15 through an outlet port (20) arranged in the peripheral side wall (4), next to the bottom wall (5), at the lowest point angular position (L_P).

34. A method of mixing sand according to claim 33, whereby, subsequent to sand mixing, the mixing bowl (2) is emptied by opening the outlet port (20), rotating the cen-
20 tral mixing tool (6) and at least substantially reducing the rotational speed of or stopping the first and second peripheral mixing tools (9, 11).

35. A method of mixing sand according to any one of the claims 21 to 34, whereby the central mixing tool (6) is provided with a central conical top part (22) covering the
25 upper end of a central mixing shaft (23) on which the central mixing tool (6) is mounted, and whereby sand moves downward at the central part of the mixing bowl (2) and slides down on the central conical top (22) part and thereby is guided outwards to the blades (8) of the central mixing tool (6) at the bottom wall (5) of the mixing bowl (2).

30 36. A method of mixing sand according to any one of the claims 21 to 35, whereby the mixing bowl (2) is provided with a horizontal top cover (24) in which a sand feed hopper (25) is arranged.

37. A method of mixing sand according to any one of the claims 21 to 36, whereby a
35 mounting opening (26) in the horizontal top cover (24) is adapted to the sand feed

hopper (25) so that the sand feed hopper may be arranged in at least four different angular orientations about a vertical axis.

38. A method of mixing sand according to any one of the claims 21 to 37, whereby
5 each peripheral mixing tool (9, 11) is driven by a respective direct drive motors (27, 28) arranged on the horizontal top cover (24) by means of a respective intermediate flange piece (29, 30) arranged on the horizontal top cover (24) and having a respective motor connection flange (31, 32) adapted to the respective angle of the peripheral mixer axis (10, 12).

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39. A method of mixing sand according to any one of the claims 21 to 37, whereby
the mixing bowl (2) is provided with an oblique top cover (33) arranged below the horizontal top cover (24), whereby each peripheral mixing tool (9, 11) is driven by a respective direct drive motor (27, 28) arranged on the oblique top cover (33) by means
15 of a respective intermediate flange piece (29, 30) arranged on the oblique top cover (33) and having a respective motor connection flange (31, 32) adapted to the respective angle of the respective peripheral mixer axis (10, 12).

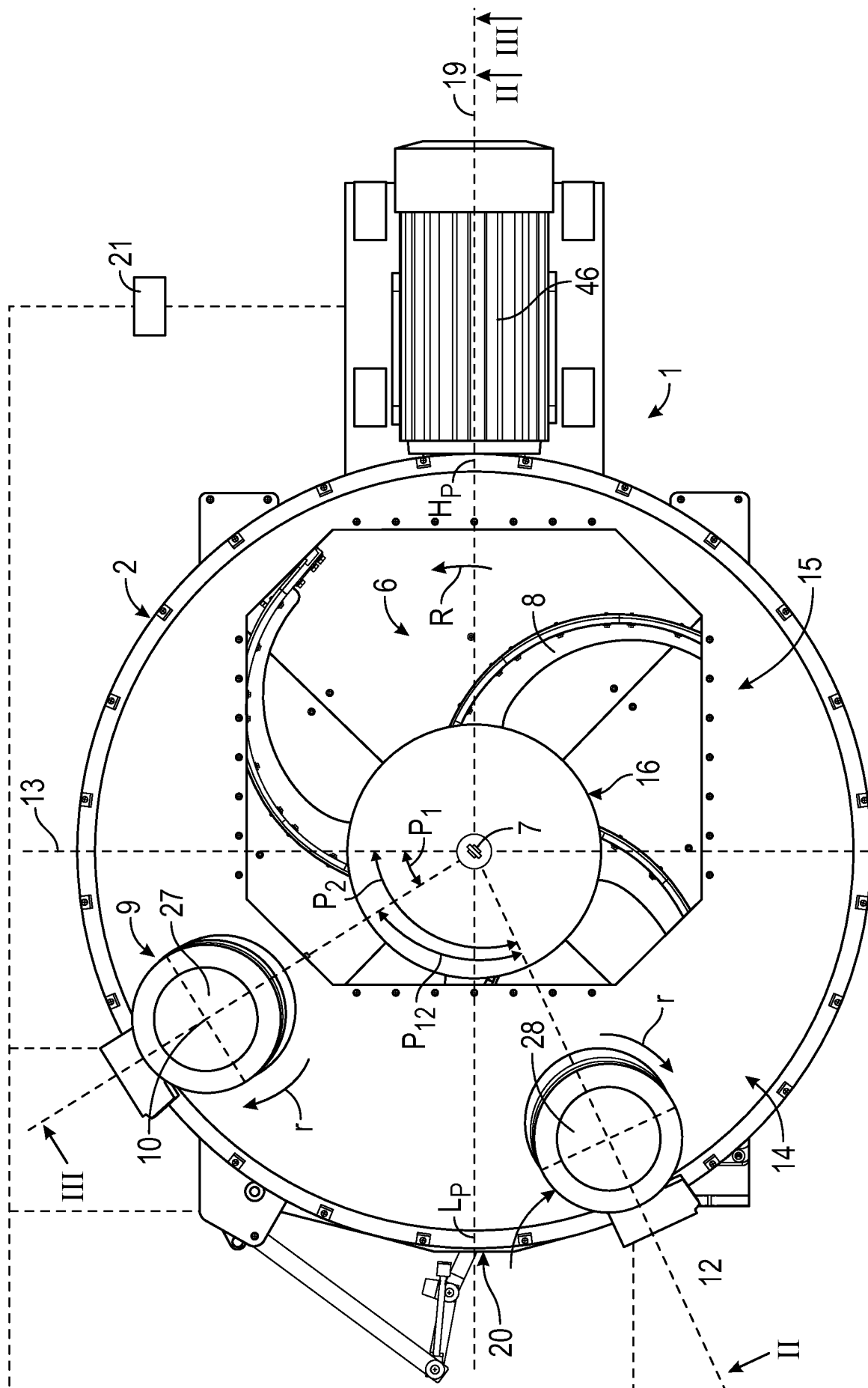


FIG. 1

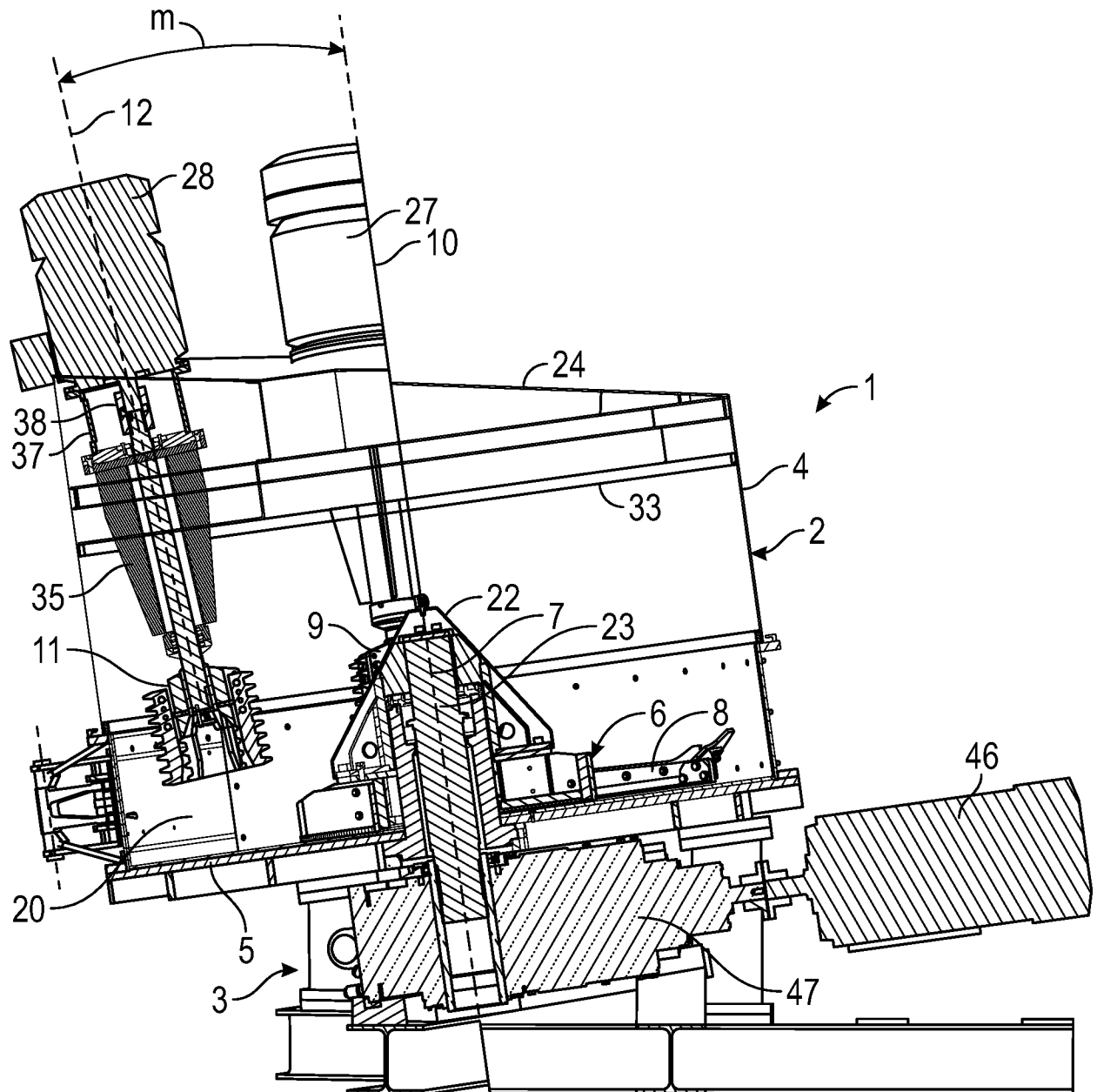


FIG. 2

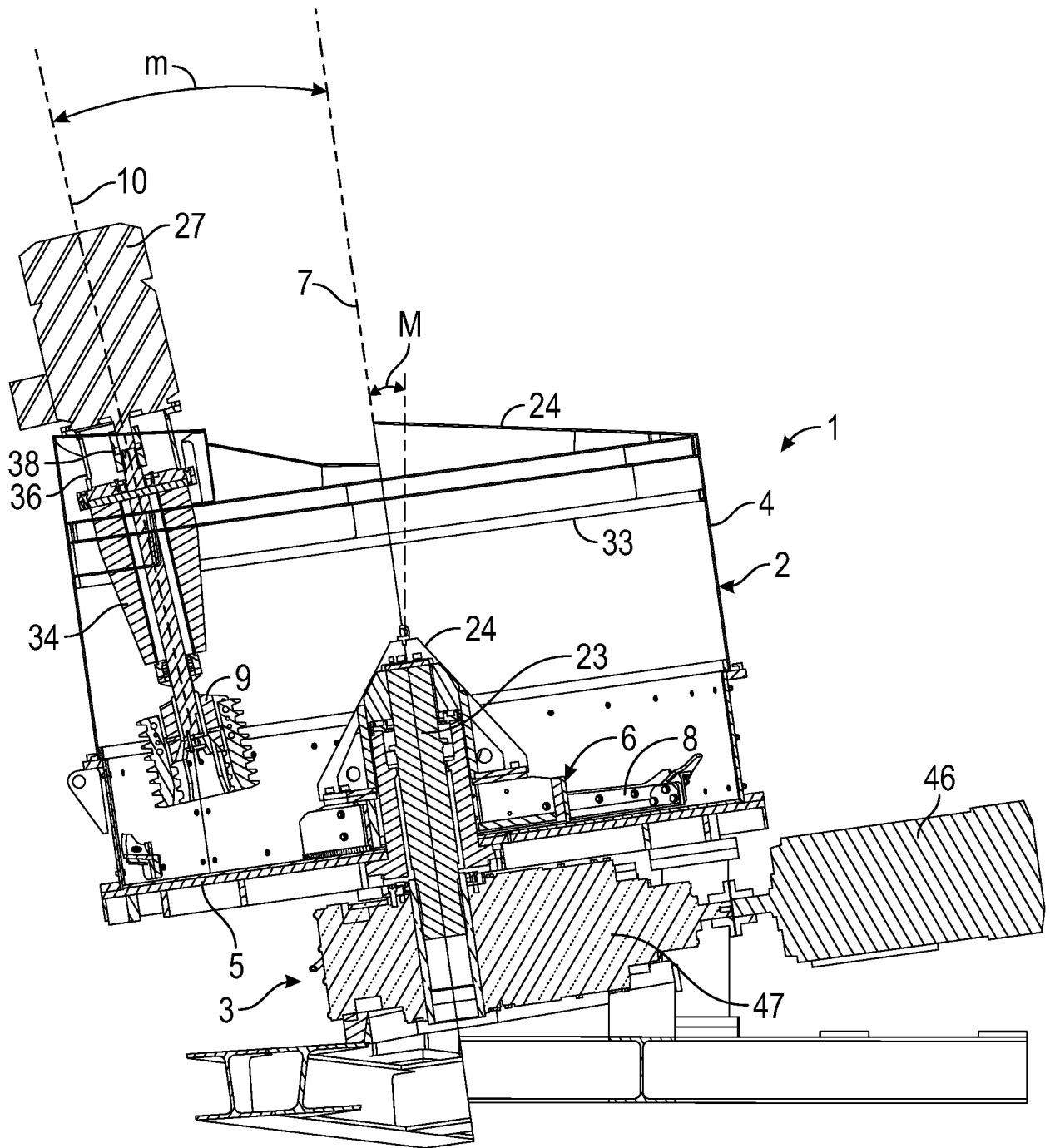


FIG. 3

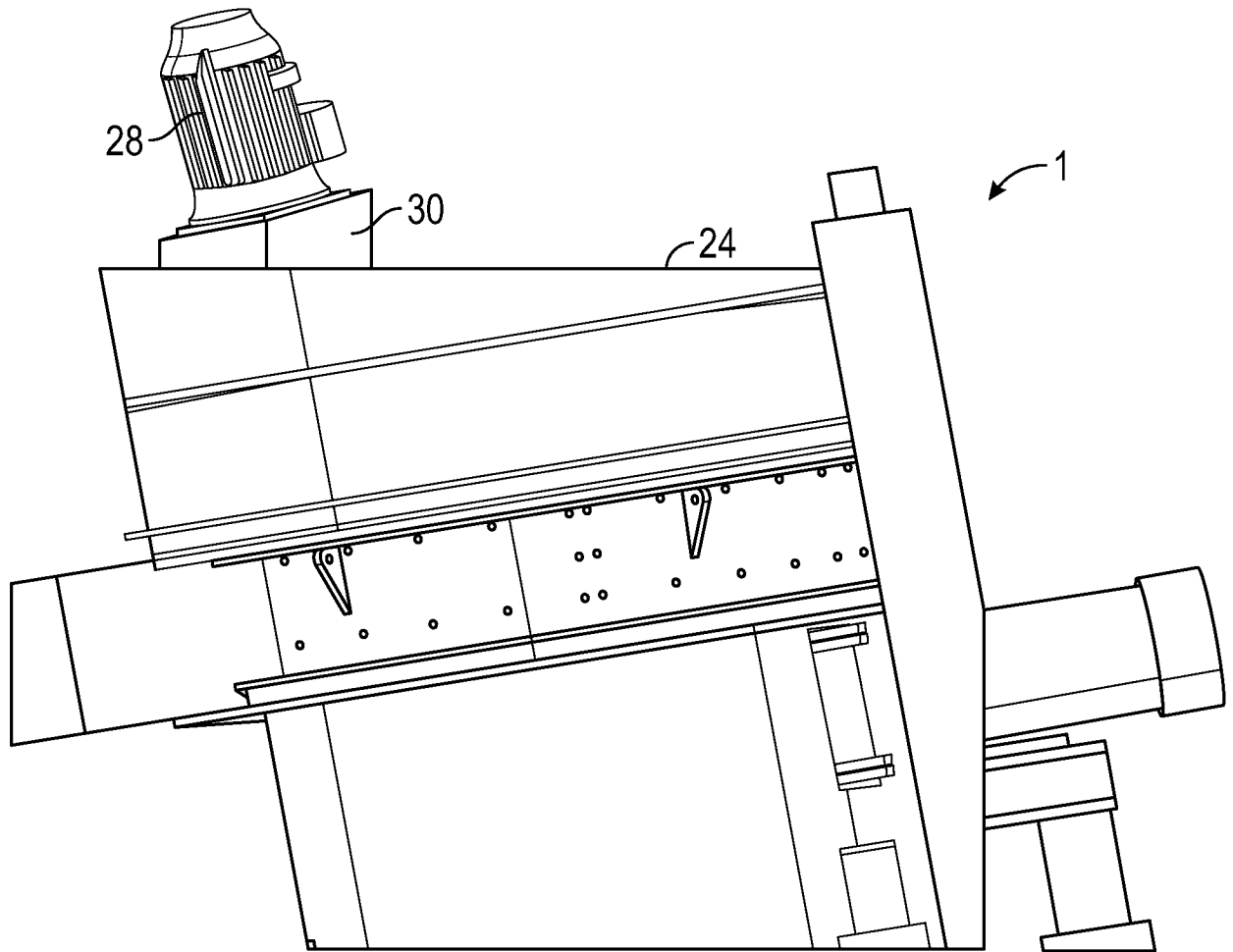


FIG. 4

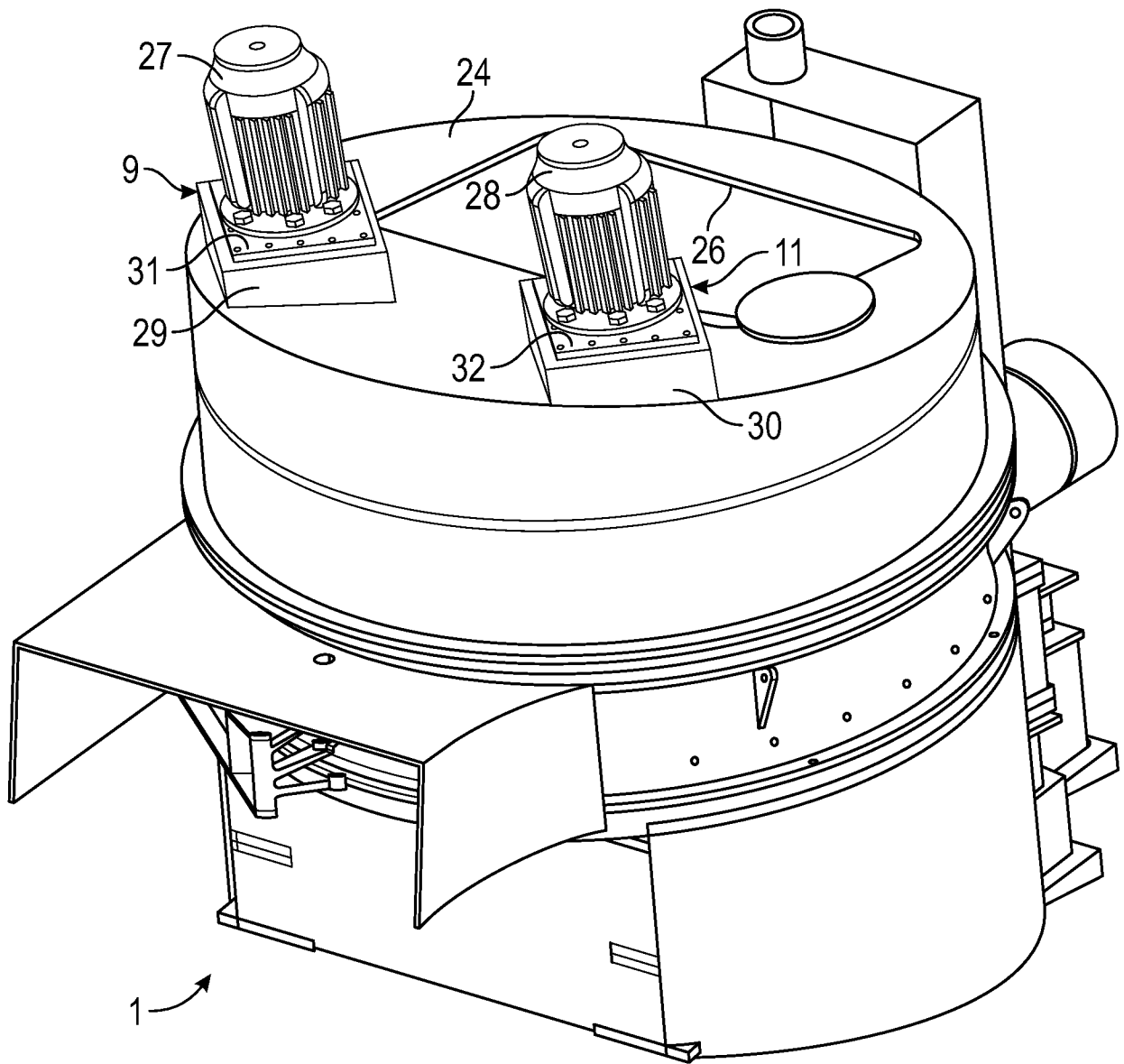


FIG. 5

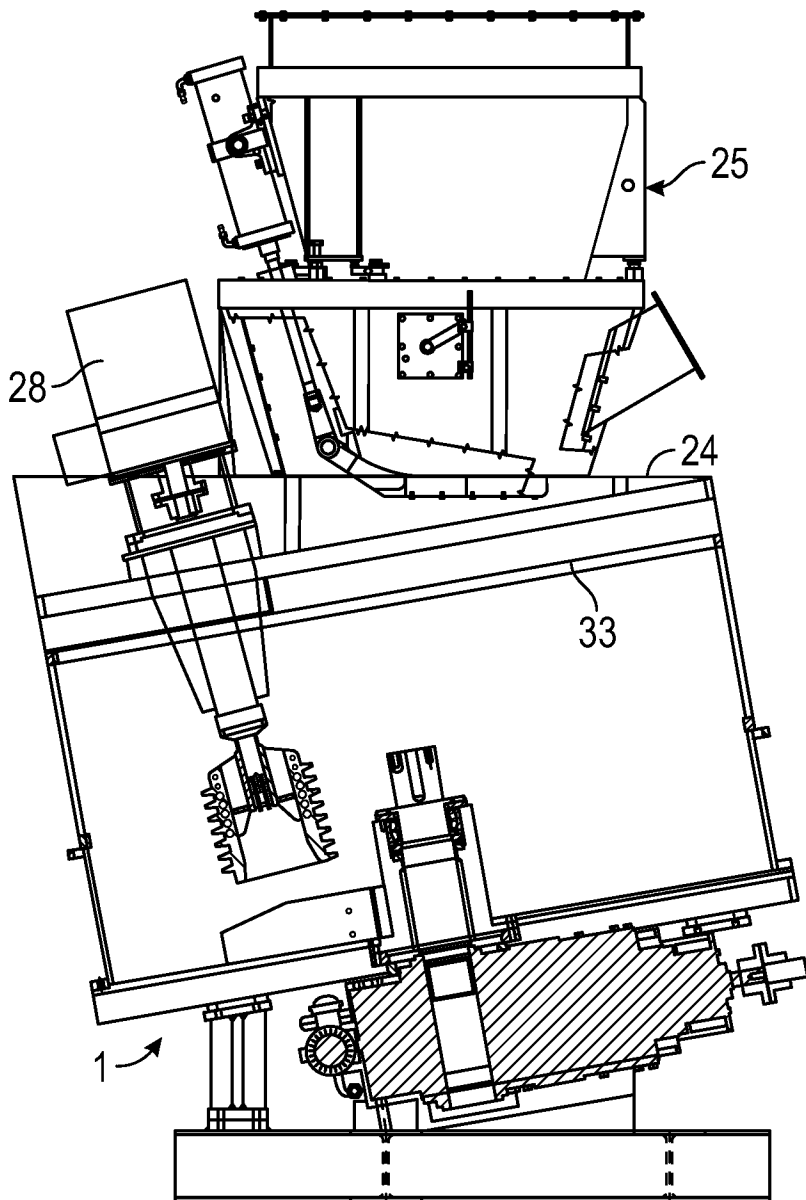


FIG. 6

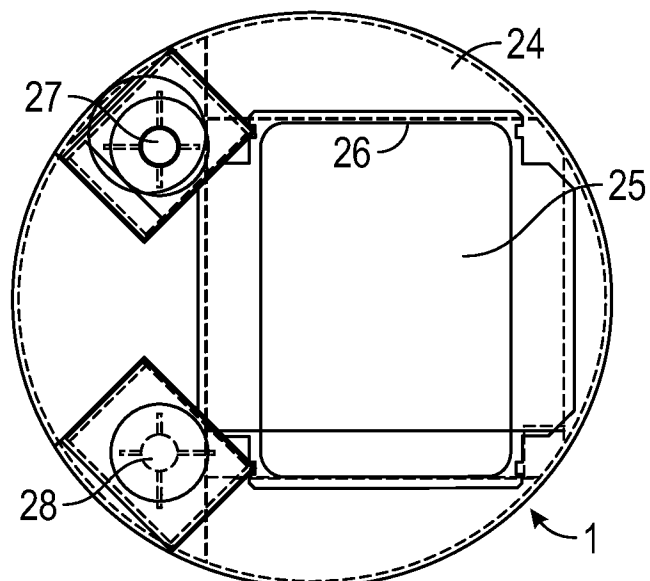


FIG. 7

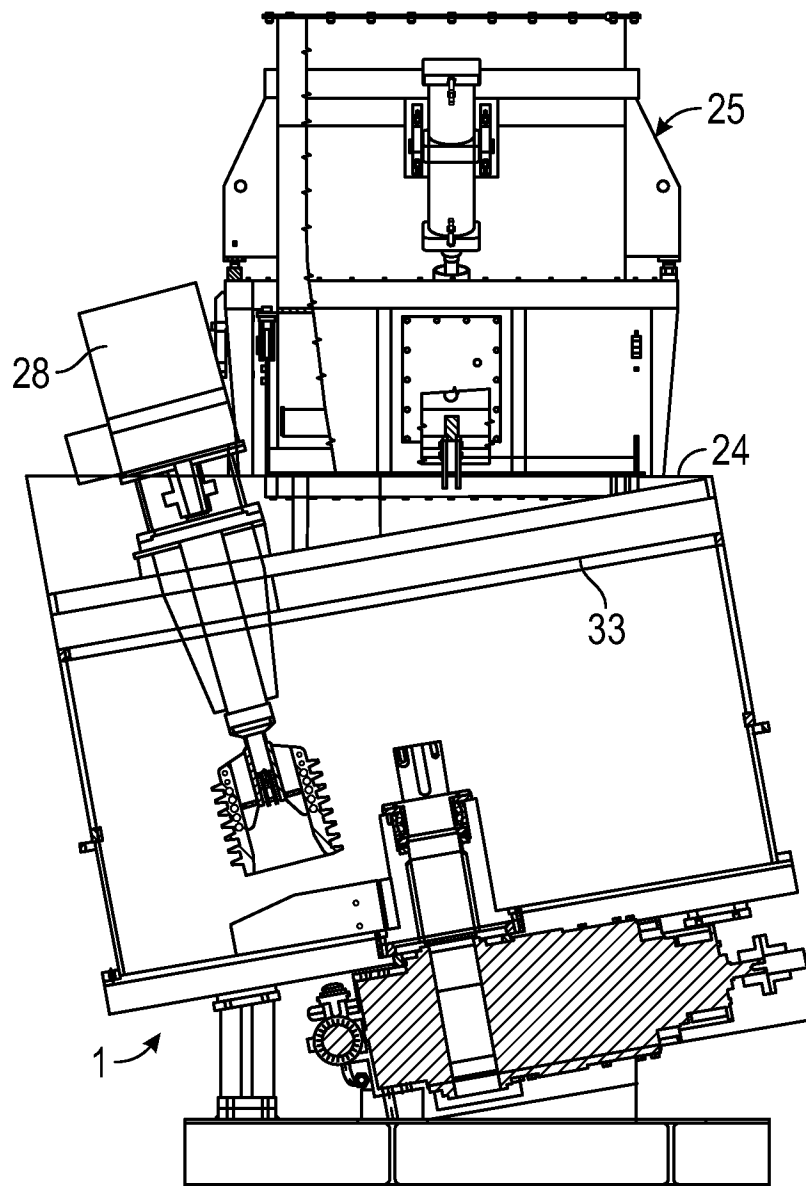


FIG. 8

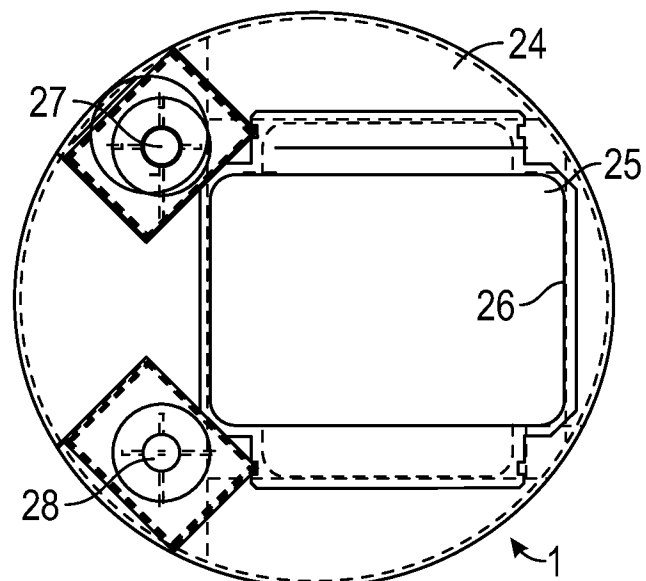


FIG. 9

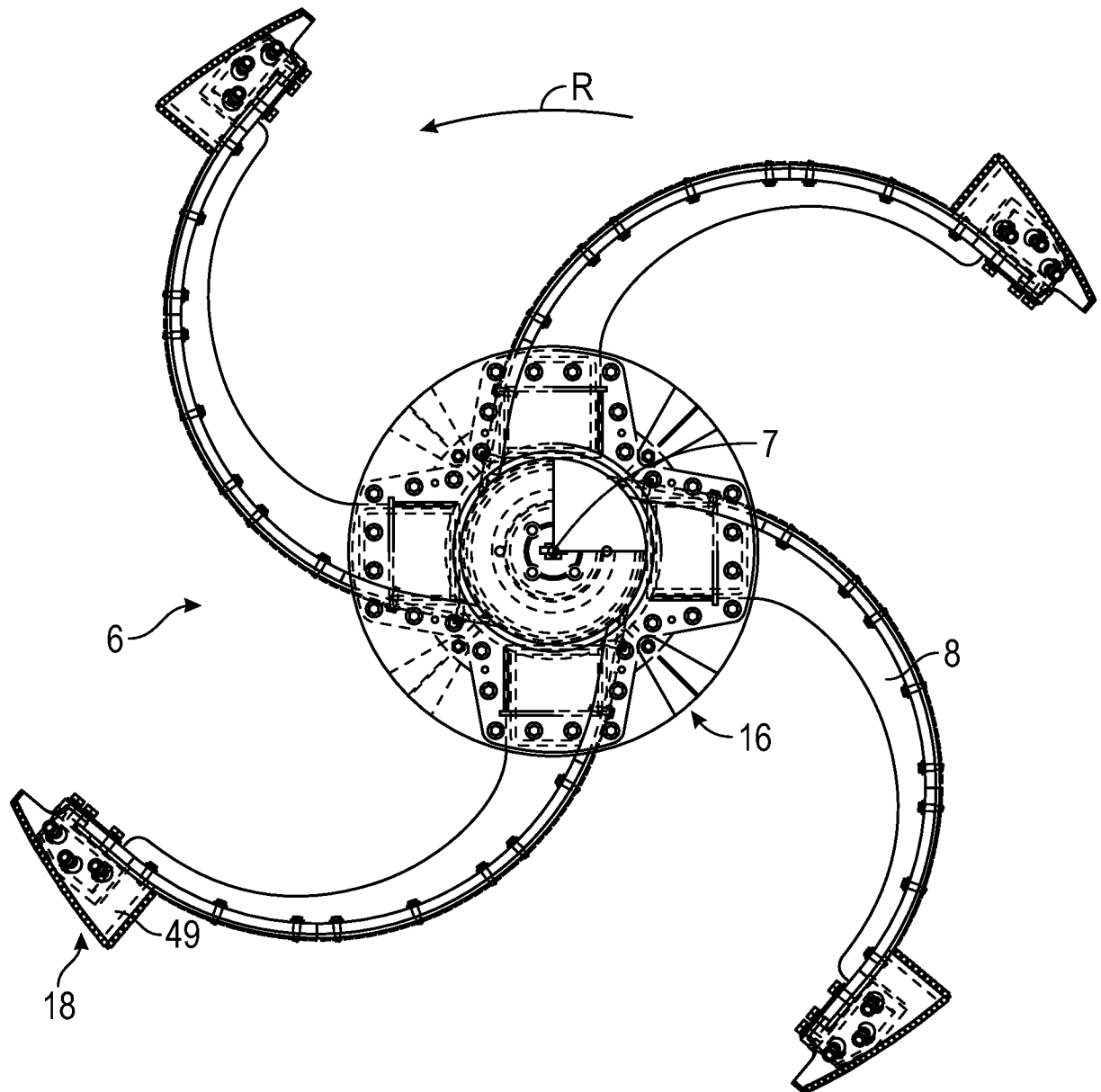


FIG. 10

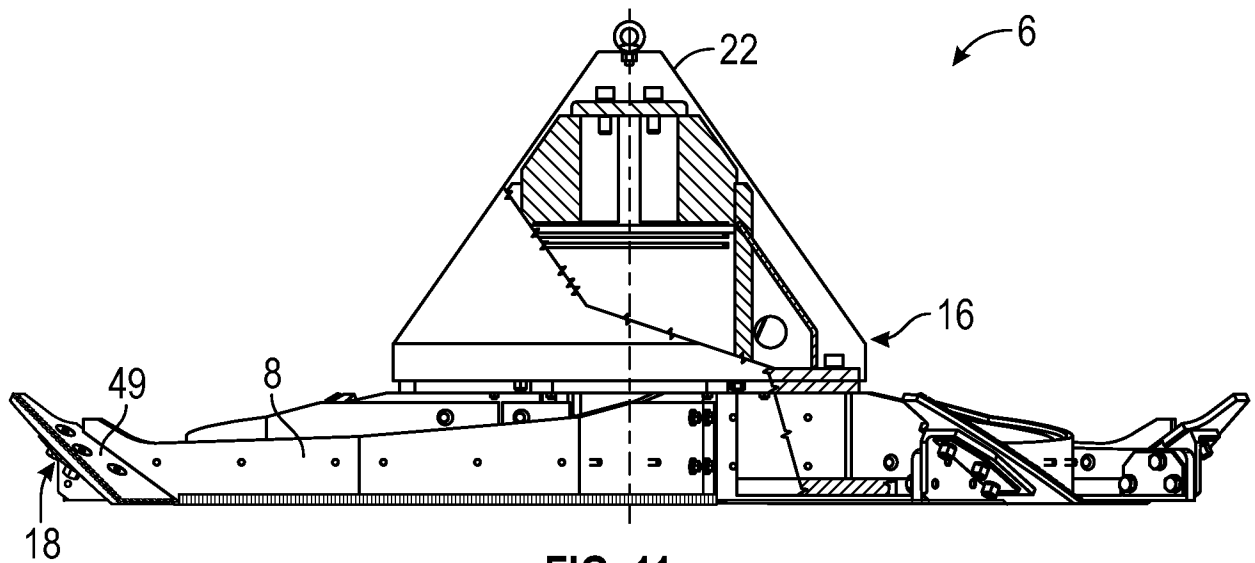


FIG. 11

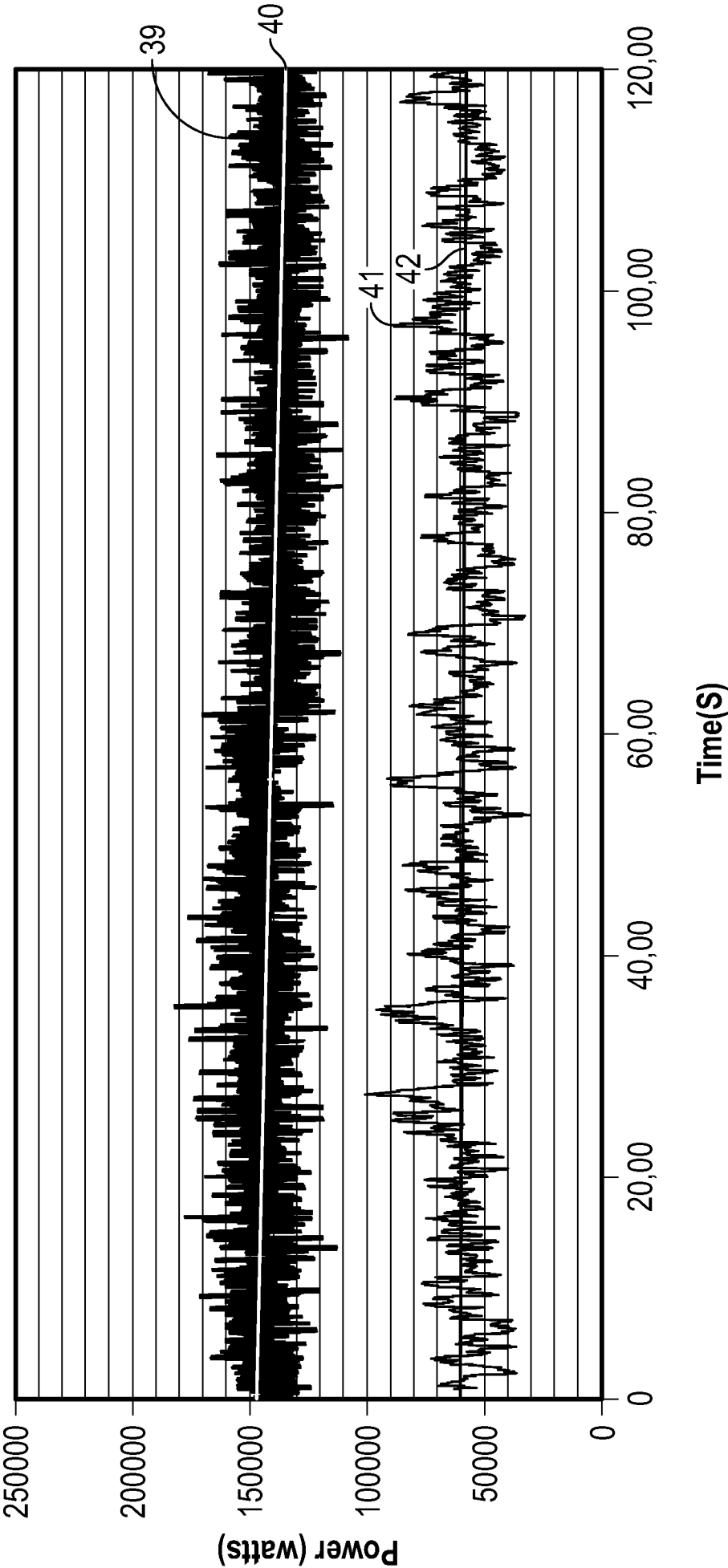


FIG. 12

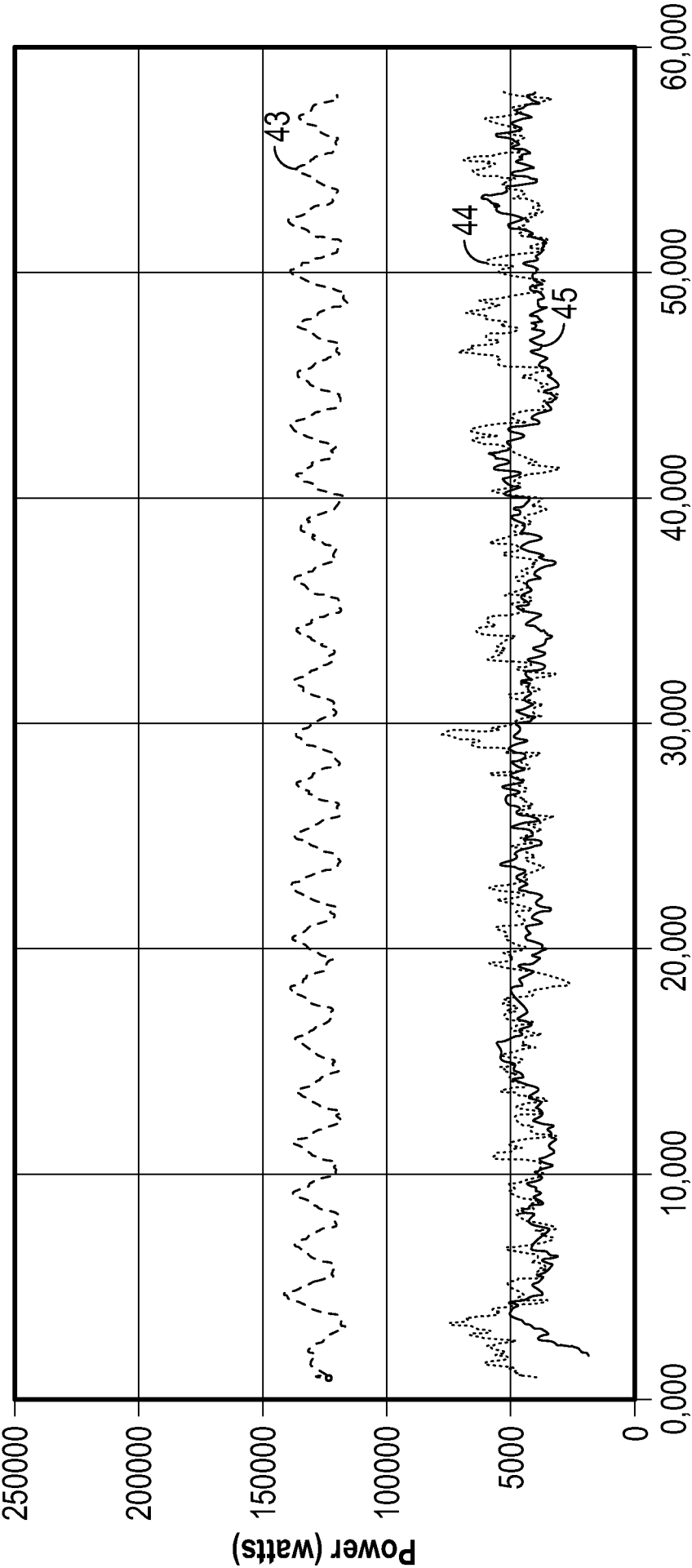


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/055719

A. CLASSIFICATION OF SUBJECT MATTER INV. B01F7/02 B01F7/00 B01F7/16 B01F15/02 B22C5/04 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B01F B22C B28C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 23 18 692 B1 (BADISCHE MASCHINENFABRIK GMBH) 8 August 1974 (1974-08-08) column 1, line 39 - line 41 column 4, line 7 - line 19 figures	1-39
A	----- WO 02/074468 A1 (ENGINEERING GMBH NV [CH]; NEUMANN HERBERT [CH]) 26 September 2002 (2002-09-26) page 1, line 4 - line 19 page 9, line 1 - page 10, line 10 page 12, line 24 - page 14, line 12 figures ----- -/--	1-39
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search	Date of mailing of the international search report	
12 April 2016	26/04/2016	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Real Cabrera, Rafael	

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2015/055719

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	DE 38 15 053 A1 (GISAG VEB [DD]) 23 February 1989 (1989-02-23) column 1, line 46 - line 49 column 3, line 6 - line 32 figures -----	1-39
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