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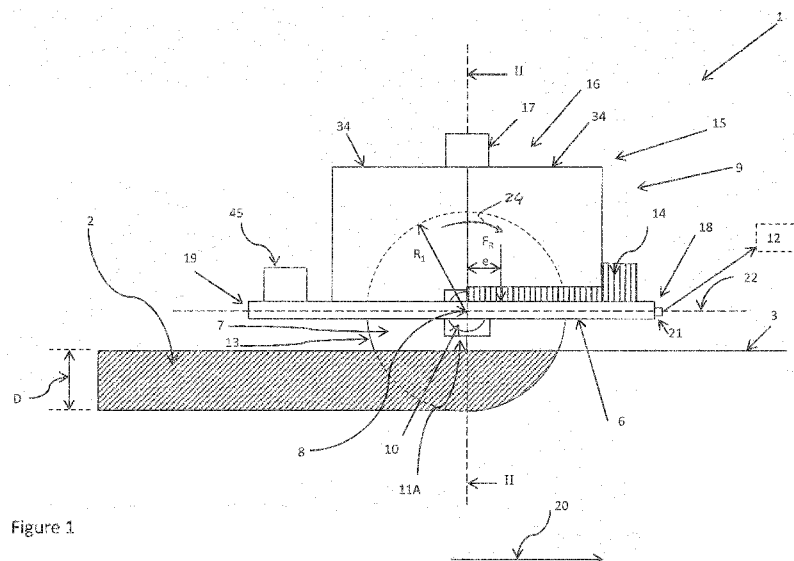


Figure 1

(57) Abstract: A trenching device (1) for forming a trench (2) in a seabed (3) to receive an elongate object, such as a pipeline, said trenching device (1) comprising a base frame (6), and a trenching wheel (7) which is connected to the base frame (6) and rotatable about a trenching wheel axis (8) to form the trench (2), wherein the trenching device (1) is configured to push the trenching wheel (7) into the seabed (3) when the trenching wheel (7) is positioned on the seabed (3).

Title: Trenching device

5 The invention relates to the forming of a trench in a seabed to receive an elongate object, such as a pipeline.

 Shallow Arctic waters are characterized by the occurrence of ice ridges which may hit the seabed in typical water depths between 10 and 60 meters and form deep gouges into the soil. Pipelines crossing such ice ridge zones must be buried deeply below the seabed to
10 avoid damage as a result of ice ridge loading. Typical burial depths against ice ridges are 4 to 6 meters.

 In other Arctic waters, icebergs may occur. Icebergs are heavier than ice ridges and may have a draft of 200 to 300 meters. Icebergs may touch the seabed in water depths as deep as 200 to 300 meters and form even deeper gouges than ice ridges. Typical pipeline
15 burial depths against ice bergs may be as deep as 5 to 8 meters.

 For protection against ice ridge or iceberg loading, the trench must be backfilled after the pipeline has been laid in it.

 The seabed in Arctic offshore regions frequently contain hard glacial over-consolidated soils with frequent occurrence of boulders. Occasionally, lenses of permafrost
20 may occur. The hard soils may be covered by a few meters of soft Holocene soils. The surface of the seabed is very uneven as a result of gouges and berms formed in the past. Gouges may be as deep as 2 to 4 meters below the average seabed and berms as high as 2 meters above it. The gouges may be filled with loose sands and silts.

 An additional requirement is, that the offshore installation season in the Arctic may
25 be extremely short, i.e. as short as 1 and 2 months per year. In that limited time typical pipeline lengths of 100 to 200 kilometres must be laid, buried and backfilled before the sea freezes up again and new ice ridges are formed. It will be clear that the same situations arise in the Antarctic waters.

 Existing trenching technologies are ploughing, excavating, jetting and suction cutting.
30 Each of these technologies has one or more drawbacks, such as that it is not suitable for deep trenches as required in Arctic soil condition, does not comply with requirements for environmental conditions (for example due to the forming of dust clouds in the water or removal of too much soil), or has difficulties with hard objects such as big stones, boulders, or frozen soil.

35 It is an object to provide an improved, or at least alternative, solution for the forming of a trench in a seabed to bury an elongate pipe, such as a pipeline.

This object is achieved with a trenching device for forming a trench in a seabed to receive an elongate object, such as a pipeline, said trenching device comprising a base frame, and a trenching wheel which is connected to the base frame and rotatable about a trenching wheel axis to form the trench, wherein the trenching device is configured to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed. This allows the forming of a trench without the need of ploughing, excavating, jetting or suction cutting.

In an embodiment of the trenching device, the trenching device is configured to push the soil of the seabed away with the trenching wheel to form the trench, without conveying excavated soil of the seabed out of the trench

In an embodiment of the trenching device, the trenching device is configured to form the trench by only pushing the soil of the seabed away with the rotating trenching wheel when the trenching device is moved along the seabed.

In an embodiment of the trenching device, the trenching wheel rotates in the direction of movement of the trenching device.

In an embodiment of the trenching device, a ballast is provided to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed.

In an embodiment of the trenching device, the trenching wheel is configured and arranged to push the soil of the seabed to the side when the trenching device is moved along the seabed while the trenching wheel is pushed into the seabed.

In an embodiment of the trenching device, the trenching wheel comprises an outer circumference.

In an embodiment of the trenching device, the trenching wheel comprises a first side surface and an opposite second side surface, the trenching wheel is arranged such that the outer circumference is pushed into the seabed and the first side surface and second side surface push the soil of the seabed to the side when the trenching device is moved along the seabed.

In an embodiment of the trenching device, the trenching wheel comprises a radius $R1$ which is larger than a depth D of the trench that is formed.

In an embodiment of the trenching device, the radius $R1$ is between 5 and 15 m.

In an embodiment of the trenching device, the radius $R1$ is between 10 and 12 m.

In an embodiment of the trenching device, the trenching device is configured to form a trench with a depth D between 1 and 8 m.

In an embodiment of the trenching device, the trenching device is configured to form a trench with a depth D of around 5 m.

In an embodiment of the trenching device, the trenching wheel axis in use extends parallel, or substantially parallel, to the seabed.

In an embodiment of the trenching device, the trenching wheel extends perpendicular from the base frame.

In an embodiment of the trenching device, the trenching wheel in use extends upwardly from the seabed.

5 In an embodiment of the trenching device, the outer circumference of the trenching wheel is rounded.

In an embodiment of the trenching device, the outer circumference of the trenching wheel is roughened to enhance friction between said outer circumference and the seabed.

10 In an embodiment of the trenching device, the trenching wheel, in the direction of the trenching wheel axis, comprises a thickness and the thickness decreases in the direction from the trenching wheel axis to the outer circumference of the trenching wheel.

In an embodiment of the trenching device, the trenching wheel comprises a thickness t1 near the trenching wheel axis and a thickness t2 near the outer circumference of the trenching wheel, and the thickness decreases in the direction from the trenching wheel axis
15 to the outer circumference of the trenching wheel.

In an embodiment of the trenching device, the trenching wheel comprises a thickness t1 near the trenching wheel axis and a thickness t2 near the outer circumference of the trenching wheel, and the thickness decreases in the direction from the trenching wheel axis to the outer circumference of the trenching wheel in a linear manner from t1 to t2.

20 In an embodiment of the trenching device, t1 is between 1,5 and 4 m and t2 is between 1 and 2 m.

In an embodiment of the trenching device, the ballast is formed, or partly formed, by a fixed ballast member connected to the base frame in a fixed position.

25 In an embodiment of the trenching device, the ballast is formed, or partly formed, by a ballast system.

In an embodiment of the trenching device, the ballast system is configured to adjust the magnitude of the force working on the base frame.

In an embodiment of the trenching device, the ballast system is configured to adjust the position of the force working on the base frame.

30 In an embodiment of the trenching device, the ballast system comprises a ballast tank configured to hold a fluid.

In an embodiment of the trenching device, the ballast tank comprises multiple ballast compartments.

35 In an embodiment of the trenching device, the ballast system comprises a pump system to pump water and gas in the ballast tank.

In an embodiment of the trenching device, the pump system is configured to pump water and gas in multiple ballast compartments independently from each other.

In an embodiment of the trenching device, the ballast is formed, or partly formed, by the mass of the trenching wheel.

In an embodiment of the trenching device, wherein the trenching wheel at the inside thereof is filled with a material to enhance the mass of the trenching wheel.

5 In an embodiment of the trenching device, the majority of the ballast is located above the trenching wheel axis.

In an embodiment of the trenching device, the trenching device comprises a front side and a rear side, the trenching device is configured to be moved in the direction from the rear side to the front side, the resultant force of the ballast acting on the base frame is
10 located at a distance e beyond the trenching wheel axis when seen in the direction from the rear side to the front side.

In an embodiment of the trenching device, the trenching device comprises a propulsion system formed by at least one propulsion unit which is connected to the base frame to move the trenching device along the seabed.

15 In an embodiment of the trenching device, at least one propulsion unit comprises a wheel drive to rotate the trenching wheel around the trenching wheel axis in order to move the trenching device along the seabed.

In an embodiment of the trenching device, the base frame comprises a connector to connect the base frame to an external propulsion system for moving the trenching device
20 along the seabed.

In an embodiment of the trenching device, the base frame comprises a length direction, and at least one propulsion unit is connected to the base frame at a distance from the trenching wheel in said length direction.

In an embodiment of the trenching device, at least one propulsion unit comprises an
25 assisting wheel connected to the base frame and rotatable about an assisting wheel axis, and a further wheel drive to rotate the assisting wheel around the assisting wheel axis in order to move the trenching device along the seabed.

In an embodiment of the trenching device, the trenching wheel axis and the assisting wheel axis extend in one plane.

30 In an embodiment of the trenching device, at least one propulsion unit comprises a driven caterpillar track.

In an embodiment of the trenching device, the trenching wheel axis and the assisting wheel axis extend parallel, or substantially parallel, to each other.

In an embodiment of the trenching device, the assisting wheel axis in use extends
35 parallel, or substantially parallel, to the seabed.

In an embodiment of the trenching device, the assisting wheel comprises an outer circumference.

In an embodiment of the trenching device, the outer circumference of the assisting wheel is rounded.

In an embodiment of the trenching device, the outer circumference of the assisting wheel is roughened to enhance friction between said outer circumference and the seabed.

5 In an embodiment of the trenching device, the assisting wheel in the direction of the assisting wheel axis comprises a thickness t_3 and the thickness t_3 remains constant in the direction from the assisting wheel axis to the outer circumference of the assisting wheel.

In an embodiment of the trenching device, the thickness t_3 equals t_2 .

10 In an embodiment of the trenching device, the thickness t_3 is larger than t_2 and smaller than t_1 .

In an embodiment of the trenching device, the thickness t_3 is larger than t_2 and smaller than $t_2 + 0,5(t_1 - t_2)$.

In an embodiment of the trenching device, the assisting wheel comprises a radius R_2 which equals R_1 .

15 In an embodiment of the trenching device, the base frame comprises a first frame part and a second frame part which are connected to each other via a pivot connection, the trenching wheel is connected to the first frame part, and at least one propulsion unit is connected to the second frame part.

20 In an embodiment of the trenching device, the second frame part is pivotable about a frame pivot axis relative to the first frame part, and the frame pivot axis extends perpendicular, or substantially perpendicular, to the trenching wheel axis.

In an embodiment of the trenching device, the trenching device comprises a steering system configured to pivot the second frame part relative to the first frame part.

25 In an embodiment of the trenching device, the base frame comprises a first frame side and an opposite second frame side and supports are connected to the first frame side and second frame side to hold the trenching wheel in an upwardly extending position.

In an embodiment of the trenching device, the supports are constructed to be positioned in contact with the seabed.

30 In an embodiment of the trenching device, at least one of the supports is provided with at least one propulsion unit.

In an embodiment of the trenching device, the height of the supports is adjustable to follow unevenness of the seabed.

35 In an embodiment of the trenching device, the trenching device comprises a further trenching wheel which is connected to the base frame and rotatable about a further trenching wheel axis to form the trench, and the trenching device is configured to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed.

In an embodiment of the trenching device, the trenching device comprises a further ballast to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed.

In an embodiment of the trenching device, the further trenching wheel comprises
5 corresponding features of the trenching wheel as defined in any of the claims 3-12.

In an embodiment of the trenching device, the further ballast comprises corresponding features of the ballast as defined in any of the claims 13-23.

In an embodiment of the trenching device, the trenching device is configured to push the trenching wheel over a first distance D1 into the seabed and to push the further
10 trenching wheel over a second distance D2 into the seabed.

In an embodiment of the trenching device, the distance D2 is larger than the distance D1.

The invention further relates to a method of forming a trench in a seabed to receive an elongate object, such as a pipeline, with a trenching device comprising a base frame, a
15 trenching wheel which is connected to the base frame and rotatable about a trenching wheel axis to form the trench, wherein the trenching device is configured to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed and said method comprises positioning the trenching wheel on the seabed, pushing the trenching wheel into the seabed, and moving the trenching device along the seabed to form the
20 trench.

In an embodiment of the method, the method comprises pushing the soil of the seabed away with the trenching wheel to form the trench, without conveying excavated soil out of the trench.

In an embodiment of the method, the method comprises forming the trench by only
25 pushing the soil of the seabed away with the rotating trenching wheel when the trenching device is moved along the seabed.

In an embodiment of the method, the method comprises rotating the trenching wheel in the direction of movement of the trenching device.

In an embodiment of the method, the trenching device comprises a ballast and the
30 method comprises pushing the trenching wheel into the seabed by the weight of the ballast.

In an embodiment of the method, the method comprises pushing the soil of the seabed to the side by moving the trenching device along the seabed while the trenching wheel is pushed into the seabed.

In an embodiment of the method, the trenching wheel comprises an outer
35 circumference, a first side surface and an opposite second side surface, the method comprises pushing the outer circumference into the seabed and pushing the soil of the

seabed to the side with the first side surface and the second side surface by moving the trenching device is along the seabed.

In an embodiment of the method, the trenching device comprises a front side and a rear side and the method comprises moving the trenching device in the direction from the rear side to the front side.

In an embodiment of the method, the ballast is formed, or partly formed, by a ballast system configured to adjust the magnitude and/or the position of the force of the ballast working on the base frame, and the method comprises adjusting the magnitude and/or the position of the force of the ballast working on the base frame to push the trenching wheel into the seabed.

In an embodiment of the method, the ballast system comprises a ballast tank configured to hold a fluid and the method comprises filling the ballast tank with water to increase the magnitude of the force of the ballast working on the base frame. This means that the ballast tank can be partly filled or completely filled with water. The ballast tank can be filled between 0 and 100% with water, depending on the required force of the ballast.

In an embodiment of the method, wherein the method comprises filling the ballast tank with air to decrease the magnitude of the force of the ballast working on the base frame and/or to create buoyancy such that the trenching device is neutrally buoyant or floats up in the water. This means that the ballast tank can be partly filled or completely filled with gas. The ballast tank can be filled between 0 and 100% with gas.

In an embodiment of the method, the trenching device comprises a propulsion system formed by at least one propulsion unit connected to the base frame and the method comprise moving the trenching device along the seabed with the propulsion system.

In an embodiment of the method, at least one propulsion unit comprises a wheel drive to rotate the trenching wheel around the trenching wheel axis and the method comprises rotating the trenching wheel to move the trenching device along the seabed.

In an embodiment of the method, the base frame comprises a length direction, and at least one propulsion unit is connected to the base frame at a distance from the trenching wheel in said length direction and the method comprises moving the trenching device along seabed with the propulsion unit.

In an embodiment of the method, at least one propulsion unit comprises an assisting wheel connected to the base frame and rotatable about an assisting wheel axis and a further wheel drive to rotate the assisting wheel around the assisting wheel axis and the method comprise rotating the assisting wheel around the assisting wheel axis to move the trenching device along the seabed.

In an embodiment of the method, the base frame comprises a first frame part and a second frame part which are connected to each other via a pivot connection, the trenching

wheel is connected to the first frame part, at least one propulsion unit is connected to the second frame part, the trenching device comprises a steering system configured to pivot the second frame part relative to the first frame part and the method comprises pivoting the second frame part relative to the first frame part to adjust the direction in which the trenching device is moved along the seabed.

In an embodiment of the method, the trenching device comprises a further trenching wheel which is connected to the base frame and rotatable about a further trenching wheel axis to form the trench, and the trenching device is configured to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed and the method comprises pushing the trenching wheel over a first distance D1 into the seabed and pushing the further trenching wheel over a second distance D2 into the seabed, while the trenching device is moved along the seabed.

In an embodiment of the method, the distance D2 is larger than the distance D1.

The invention further relates to a method of forming a trench in a seabed to receive an elongate object, such as a pipeline, with the trenching device according to the invention, wherein said method comprises positioning the trenching wheel on the seabed, pushing the trenching wheel into the seabed, and moving the trenching device along the seabed to form the trench. In an embodiment, said method comprises the method steps defined in any of the claims 45-59.

The invention further relates to a use of the trenching device according to the invention to form a trench in a seabed.

Embodiments of the trenching device and the method will be described by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

Figure 1 schematically shows a side view of a first embodiment of the trenching device and method,

Figure 2 schematically shows a view in cross section along line II-II of the trenching device of fig. 1,

Figure 3 schematically shows a side view of the trenching wheel of fig. 1,

Figure 4 schematically shows a side view a second embodiment of the trenching device and method,

Figure 5 schematically shows a view in cross section along line V-V of the trenching device of fig. 4,

Figure 6 schematically shows a side view of the trenching wheel of fig. 4,

Figure 7 schematically shows a side view of a third embodiment of the trenching device and method,

Figure 8 schematically shows a side view of a fourth embodiment of the trenching device and method,

Figure 9 schematically shows a side view of a fifth embodiment of the trenching device and method,

5 Figure 10 schematically shows a side view of a sixth embodiment of the trenching device and method,

Figure 11 and 12 schematically show a top view of a seventh embodiment of the trenching device and method,

10 Figure 13 schematically shows a side view of a eighth embodiment of the trenching device and method,

Figure 14 schematically shows a view in cross section along line X-X of the trenching device of fig. 13, and

Figure 15 schematically shows a side view of a ninth embodiment of the trenching device and method.

15 The figure 1 shows a side view of a first embodiment of the trenching device and method. The trenching device 1 is forming a trench 2 in a seabed 3 to receive an elongate object, such as a pipeline. The trenching device 1 comprises a base frame 6, and a trenching wheel 7 which is connected to the base frame 6 and rotatable about a trenching wheel axis 8 to form the trench 2. The trenching device 1 is configured to push the trenching
20 wheel 7 into the seabed 3 when the trenching wheel 7 is positioned on the seabed 3. This means that the trench is formed without ploughing, excavating, jetting or suction cutting.

The trenching device 1 is configured to push the soil of the seabed 3 away with the trenching wheel 7 to form the trench 2, without conveying excavated soil of the seabed 3 out of the trench 2.

25 The trenching device 1 is configured to form the trench 2 by only pushing the soil of the seabed 3 away with the rotating trenching wheel 7 when the trenching device 1 is moved along the seabed 3. When the trenching device 1 is moved along the seabed 3, the trenching wheel 7 is rotated in the direction of movement of the trenching device 1. The rotation of the trenching wheel 7 is indicated by arrow 24.

30 A ballast 9 is provided to push the trenching wheel 7 into the seabed 3 when the trenching wheel 7 is positioned on the seabed 3. The trenching wheel 7 is configured and arranged to push the soil of the seabed 3 to the side when the trenching device 1 is moved along the seabed 3 while the trenching wheel 7 is pushed into the seabed 3 by the ballast 9. The trenching wheel 7 comprises an outer circumference 13. The trenching wheel 7
35 comprises a first side surface 4 and an opposite second side surface 5, the trenching wheel 7 is arranged such that the ballast 9 pushes the outer circumference 13 into the seabed 3 and the first side surface 4 and second side surface 5 push the soil of the seabed 3 to the

side when the trenching device 1 is moved along the seabed 3. The trenching device 1 comprises a front side 18 and a rear side 19. The trenching device 1 is moved in the direction from the rear side 19 to the front side 18, as indicated by arrow 20.

5 The trenching wheel 7 comprises a radius R1 which is larger than a depth D of the trench 2 that is formed. The radius R1 is around 10 m. In other examples of the trenching device 1, the radius R1 is between 5 and 15 m. The depth D of the trench 2 is around 5 m. In other examples the trenching device 1 is configured to form a trench with a depth D between 1 and 8 m.

10 The trenching wheel axis 8 extends parallel, or substantially parallel, to the seabed 3. The trenching wheel 7 extends perpendicular from the base frame 6. The trenching wheel 7 extends upwardly from the seabed 3.

The ballast 9 is formed by a fixed ballast member 14 connected to the base frame 6 in a fixed position and by a ballast system 15. The ballast system 15 is configured to adjust the magnitude and the position of the force working on the base frame 6. This means that
15 the amount of Newton the ballast system 15 subjects to the base frame 6 can be controlled. Also the position where the force of the ballast system 15 is subjected on base frame 6 can be controlled. In other examples of the trenching device 1, only the magnitude or the position of the force of the ballast system 15 working on the base frame 6 can be adjusted.

The ballast system 15 comprises a ballast tank 16 configured to hold a fluid. The
20 ballast tank 16 can hold liquid and gas. The ballast tank 16 comprises multiple ballast compartments 34. The ballast system 15 comprises a pump system 17 to pump either water and gas in the ballast tank 16. The pump system 17 is configured to pump water and gas in the multiple ballast compartments 34 independently from each other. Each ballast compartment 34 can be filled between 0 and 100% with water, independently from each
25 other. Each ballast compartment 34 can be filled between 0 and 100% with gas, independently from each other. The ballast compartments 34 are positioned next to each other along the base frame 6. By controlling the amount of water held by the ballast tank 16, the magnitude of the force of the ballast system 15 can be adjusted. By controlling the amount of water in the different ballast compartments 34, the position where the force of the
30 ballast system 15 works on the base frame 6 can be adjusted.

In the situation shown, the majority of the ballast 9 is located beyond the trenching wheel axis 8 when seen in the direction from the rear side 19 to the front side 18. The resultant force F_r of the ballast 9 acting on the base frame 6 is located beyond the trenching wheel axis 8 when seen in the direction from the rear side 19 to the front side 18. The
35 resultant force F_r of the ballast 9 acting on the base frame 6 is located at a distance e beyond the trenching wheel axis 8 when seen in the direction from the rear side 19 to the

front side 18. By adding water or gas in the different ballast compartments 34, the ballast system 15 can adjust the distance e.

The ballast 9 is located above the trenching wheel axis 8. In other examples of the trenching device 1, the majority of the ballast 9 is located above the trenching wheel axis 8.

5 In other examples of the trenching device 1, the ballast 9 is formed, or partly formed, by the mass of the trenching wheel 7. In said situation, the trenching wheel 7 is constructed to have a large mass. The inside of the trenching wheel 7 can for example be filled with a material, such a concrete, to enhance the mass of the trenching wheel 7.

The trenching device 1 comprises a propulsion system formed by a propulsion unit
10 11 which is connected to the base frame 6 to move the trenching device 1 along the seabed 3. The propulsion unit 11 comprises a wheel drive 10 to rotate the trenching wheel 7 around the trenching wheel axis 8 in order to move the trenching device 1 along the seabed 3. The base frame 6 comprises a connector 21 to connect the base frame 6 to an external propulsion system 12, such as a vessel, for moving the trenching device 1 along the seabed
15 3. In other examples of the trenching device 1, only a connector 21 and no propulsion system is provided. In other examples of the trenching device 1, the propulsion system comprises multiple propulsion units.

The operations of the propulsion system (formed by the propulsion unit 11) and ballast system 15 (comprising the pump system 17) are controlled by a control system 45
20 provided on the base frame 6.

Figure 2 shows a view in cross section along line II-II of the trenching device 1. The trenching wheel 7 comprises an outer circumference 13. The outer circumference 13 forms a transition from the first side surface 4 and the second side surface 5. The outer circumference 13 of the trenching wheel 7 is rounded. The outer circumference 13 is
25 rounded in the direction from the first side surface 4 to the second side surface 5. The rounded outer circumference 13 increases the surface area of the outer circumference 13 and therefore enhances the friction between the outer circumference 13 and the soil of the seabed 3 when the trenching wheel 7 is driven around the trenching wheel axis 8. The outer circumference 13 of the trenching wheel 7 is roughened to enhance the friction between
30 said outer circumference 13 and the seabed 3.

In the direction of the trenching wheel axis 8, the trenching wheel 7 comprises a thickness and the thickness decreases in the direction from the trenching wheel axis 8 to the outer circumference 13 of the trenching wheel 7. Said form of the trenching wheel 7 facilitates the forming of the trench. The trenching wheel 7 comprises a thickness t_1 near the
35 trenching wheel axis 8 and a thickness t_2 near the outer circumference 13 of the trenching wheel 7. The thickness decreases in the direction from the trenching wheel axis 8 to the outer circumference 13 of the trenching wheel 7. The thickness decreases in a linear

manner from t_1 to t_2 . The thickness t_1 is around 3 m and t_2 is around 1,5 m. In other examples of the trenching device 1, the thickness decreases in a non-linear manner from t_1 to t_2 . In other examples of the trenching device 1, the thickness t_1 is between 1,5 and 4 m and t_2 is between 1 and 2 m. The bottom of the trench 2 has a width of at least 1 m.

5 The method of forming the trench 2 in the seabed 3 to receive an elongate object, such as a pipeline, with the trenching device 1 comprises positioning the trenching wheel 7 on the seabed 3, pushing the trenching wheel 7 into the seabed 3 by the weight of the ballast 9, moving the trenching device 1 along the seabed 3 to form the trench. The soil of the seabed 3 is pushed to the side by moving the trenching device 1 along the seabed 3
10 while the trenching wheel 7 is pushed into the seabed 3 by the ballast 9. The outer circumference 13 of the trenching wheel 7 is pushed into the seabed 3 by the ballast 9 and the soil of the seabed 3 is pushed to the side with the first side surface 4 and the second side surface 5 by moving the trenching device 1 along the seabed 3. The trenching device 1 is moved in the direction from the rear side 19 to the front side 18. The trenching device 1
15 is moved along the seabed 3 with the propulsion system. The trenching wheel 7 is rotated to move the trenching device 1 along the seabed 3.

The magnitude and the position of the force of the ballast 9 working on the base frame 6 to push the trenching wheel 7 into the seabed 3 can be adjusted. The ballast tank 16 can be filled with water to increase the magnitude of the force of the ballast 9 working on the
20 base frame 6. The ballast tank 16 can be filled between 0 and 100% with water, depending on the required force of the ballast 9. The ballast tank 16 can be filled with air to decrease the magnitude of the force of the ballast 9 working on the base frame 6. This way, the magnitude of the force can be adjusted to the hardness of the soil in which the trench 2 is formed. Harder soils require a large force, whereas softer soil require a smaller force. The
25 ballast tank 16 can be filled with air to create buoyancy such that the trenching device 1 is neutrally buoyant or floats up in the water. The ballast system 15 is configured position the trenching device 1 in a horizontal, or substantially horizontal, position when floating at the water surface or under the water surface. The ballast tank 16 can be filled between 0 and 100% with gas.

30 Figure 3 shows a side view of the trenching wheel 7 of fig. 1 being moved in the direction 20 along the seabed 3 while being pushed into the seabed 3 by the ballast 9. Due to the form of the trenching wheel 7, only a relatively small part first side surface 4 and second side surface 5 of the trenching wheel 7 will be in contact with the soil of the seabed 3. Only the indicated friction area 37 of the trenching wheel 7 will be in contact with the soil
35 of the seabed 3. This tends to have a positive effect on the friction of the soil of the seabed 3 which the trenching device 1 experiences when forming the trench.

Figure 4 shows a side view a second embodiment of the trenching device 1 and method. The trenching device 1 of fig. 4 differs from the one in fig. 1 in that it does not comprises a connector 21 and in that an additional propulsion unit 11B formed by an assisting wheel 23 is provided. In other examples of the trenching device 1, a connector 21
5 can be provided in combination with the assisting wheel 23 or a different type of additional propulsion unit 11B. In other examples of the trenching device 1, the propulsion system only comprises the driven assisting wheel 23.

The base frame 6 comprises a length direction 22, and the additional propulsion unit 11B is connected to the base frame 6 at a distance from the trenching wheel 7 in said length
10 direction 22. The additional propulsion unit 11 comprises an assisting wheel 23 connected to the base frame 6 and rotatable about an assisting wheel axis 33, and a further wheel drive 10B to rotate the assisting wheel 23 around the assisting wheel axis 33 in order to move the trenching device 1 along the seabed 3. When the trenching device 1 is moved along the seabed 3, the trenching wheel 7 and the assisting wheel 23 rotate in the direction of the
15 arrows 24A and 24B, respectively.

The trenching wheel axis 8 and the assisting wheel axis 33 extend in one plane. The trenching wheel axis 8 and the assisting wheel axis 33 extend parallel to each other. The assisting wheel axis 33 extends parallel, or substantially parallel, to the seabed 3. The assisting wheel 23 extends perpendicular from the base frame 6. The assisting wheel 23 in
20 use extends upwardly from the seabed 3.

The operations of the propulsion system (formed by the propulsion units 11A, 11B) and ballast system 15 (comprising the pump system 17) are controlled by a control system 45 provided on the base frame 6.

Figure 5 shows a view in cross section along line V-V of the trenching device 1 of fig.
25 4. The assisting wheel 23 comprises an outer circumference 35, a first side surface 39 and a second side surface 40. The outer circumference 35 of the assisting wheel 23 is rounded. The outer circumference 35 of the assisting wheel 23 is rounded in a similar manner as the outer circumference 13 of the trenching wheel 7 is rounded. The outer circumference 35 of the assisting wheel 23 is roughened to enhance friction between said outer circumference
30 35 and the soil of the seabed 3. In the direction of the assisting wheel axis 33, the assisting wheel 23 comprises a thickness t_3 and the thickness t_3 remains constant in the direction from the assisting wheel axis 33 to the outer circumference 35 of the assisting wheel 23. The thickness t_3 is around 1,5 In other examples of the trenching device 1, the thickness t_3 is larger than t_2 and smaller than $t_2 + 0,5(t_1 - t_2)$. The assisting wheel 23 comprises a radius
35 R_2 which equals R_1 . In other examples of the trenching device 1, the assisting wheel 23 comprises a radius R_2 which differs from R_1 .

Figure 6 shows a side view of the trenching wheel 7 of fig. 4 being moved through the trench. Due to the form of the assisting wheel 23, only a relatively small part of the first side surface 39 and second side surface 40 of the assisting wheel 23 will be in contact with the soil of the seabed 3. Only the indicated friction area 38 of the assisting wheel 23 will be in contact with the soil of the seabed 3. This tends to have a positive effect on the friction of the soil of the seabed 3 which the trenching device 1 experiences when forming the trench. The trenching device 1 is configured to form a trench with a length of around 10 km a day.

The method of forming the trench 2 in the seabed 3 comprises rotating the assisting wheel 23 around the assisting wheel axis 33 to move the trenching device 1 along the seabed 3.

Figure 7 shows a side view of a third embodiment of the trenching device and method. The trenching device 1 differs from the one shown in fig. 4, in that a further ballast 9B is provided at the assisting wheel 23. The further ballast 9B comprises two fixed further ballast members 14B and a further ballast system 15B. The further ballast system 15B has the same or corresponding design as the ballast system 15A. The further ballast 9B allows to enhance the grip that the assisting wheel 23 has on the soil of the seabed 3. The operations of the further ballast system 15B is also controlled by the control system 45.

Figure 8 shows a side view of a fourth embodiment of the trenching device and method. The trenching device 1 comprises a further trenching wheel 7B which is connected to the base frame 6 and rotatable about a further trenching wheel axis 8B to form the trench 2, and the trenching device 1 is configured to push the further trenching wheel 7B into the seabed 3 when the further trenching wheel 7B is positioned on the seabed 3.

The trenching device 1 comprises a further ballast 9B to push the further trenching wheel 7B into the seabed 3 when the further trenching wheel 7B is positioned on the seabed 3. The further trenching wheel 7B has the same or corresponding design as the trenching wheel 7A. The further ballast system 15B has the same or corresponding design as the ballast system 15A. The trenching device 1 is configured to push the trenching wheel 7A over a first distance D1 into the seabed and to push the further trenching wheel 7B over a second distance D2 into the seabed. The distance D2 is larger than the distance D1.

The method of forming a trench comprises pushing the trenching wheel 7A over a first distance D1 into the seabed and pushing the further trenching wheel 7B over a second distance D2 into the seabed, while the trenching device 1 is moved along the seabed 3.

In other examples, the trenching device 1 comprises multiple trenching wheels 7 in combination with one or more assisting wheels 23.

Figure 9 shows a side view of a fifth embodiment of the trenching device and method. The trenching device 1 differs from the one shown in fig. 8, in that trenching wheel axis 8A is positioned higher in the vertical direction relative to the further trenching wheel

axis 8B. The trenching device is configured to adjust the position of the trenching wheel axis 8A in the vertical direction relative to the base frame 6. In other examples, the position of the further trenching wheel axis 8B is in the vertical direction also adjustable relative to the base frame 6. In other examples, only the position of the further trenching wheel axis 8B is in the vertical direction adjustable relative to the base frame 6.

Figure 10 shows a side view of a sixth embodiment of the trenching device and method. The trenching device 1 differs from the one shown in fig. 8, in that the radius R1A of the trenching wheel 7A is smaller than the radius R1B of the further trenching wheel 7B.

Figure 11 and 12 show a top view of a third embodiment of the trenching device 1 and method. The ballast 9 is not shown in order to obtain a clear view. The trenching device 1 can be provided with the ballast 9 shown in fig. 1.

The base frame 6 comprises a first frame part 25 and a second frame part 26 which are connected to each other via a pivot connection 27, the trenching wheel 7 is connected to the first frame part 25, and a propulsion unit 11B is connected to the second frame part 26. The second frame part 26 is pivotable about a frame pivot axis 28 relative to the first frame part 25, and the frame axis extends perpendicular to the trenching wheel axis 8. The trenching device 1 comprises a steering system 29 configured to pivot the second frame part 26 relative to the first frame part 25. The steering system 29 is formed by two steering actuator 44 positioned at opposite sides of the pivot connection 27. Each steering actuator 44 is connected with one end to the first frame part 25 and with the other end to the second frame part 26. The length of the steering actuators can be increased or decreased. In fig. 7, the first frame part 25 and second frame part 26 are positioned in line with each other. As a result of this, as straight trench 2 is formed when the trenching device 1 is moved along the seabed 3. When the length of one of the steering actuators (for example the first steering actuator 41) is decreased and the length of the other steering actuator (in said situation the second steering actuator 42) is increased, the first and second frame part 26 will pivot relative to each other as shown in fig. 8. As result of this, a curved trench 2 is formed when the trenching device 1 is moved along the seabed 3.

The operations of the propulsion system (formed by the propulsion units 11A, 11B), ballast system (not shown), and steering system 29 (formed by the steering actuators 41, 42) are controlled by the control system 45 provided on the base frame 6.

The method of forming the trench 2 in the seabed 3 comprises pivoting the second frame part 26 relative to the first frame part 25 to adjust the direction in which the trenching device 1 is moved along the seabed 3.

Figure 13 shows a side view of a fourth embodiment of the trenching device 1 and method. Figure 14 shows a view in cross section along line X-X of the trenching device 1 of fig. 9. The base frame 6 comprises a first frame side 30 and an opposite second frame side

31 and supports 32 are connected to the first frame side 30 and second frame side 31 to hold the trenching wheel 7 in an upwardly extending position. The trenching device 1 has in total four supports 32. The supports 32 are constructed to be positioned in contact with the seabed 3. Each least support is provided with at least one propulsion unit 11C-F. Each of
5 said propulsion units 11C-F comprise a driven a caterpillar track. The supports 32 comprise support actuators 44. The supports actuators 44 are constructed to adjust the height H1, H2 of the supports 32. This way the supports 32 can follow unevenness of the seabed 3. The trenching device 1 is configured to cope with gouges of around 2 m in the seabed 3 and berms of around 2 m on the seabed 3. The operations of the propulsion system (formed by
10 the propulsion units 11A, 11B and 11C-F), ballast system 15 (comprising the pump system 17) and support actuators 32 are controlled by the control system 45 provided on the base frame 6.

Figure 15 schematically shows a side view of a fifth embodiment of the trenching device 1 and method. The trenching device 1 differs from the one shown in fig. 9 and 10 in
15 that the propulsion unit 11B formed by the assisting wheel 23 is removed and replaced by a propulsion unit 11B comprising a driven caterpillar track 43 connected to the base frame 6. The operations of the propulsion system (formed by the propulsion units 11A, 11B and 11C-F), ballast system 15 (comprising the pump system 17) and support actuators 32 are controlled by the control system 45 provided on the base frame 6.

20 It will be apparent to those skilled in the art that various modifications can be made to the device and method without departing from the scope as defined in the claims.

CLAIMS

1. Trenching device for forming a trench in a seabed to receive an elongate object, such as a pipeline, said trenching device comprising;
5 - a base frame, and
- a trenching wheel which is connected to the base frame and rotatable about a trenching wheel axis to form the trench, wherein the trenching device is configured to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed.
10
2. Trenching device according to claim 1, wherein the trenching device is configured to push the soil of the seabed away with the trenching wheel to form the trench, without conveying excavated soil of the seabed out of the trench.
- 15 3. Trenching device according to claim 1 or 2, wherein the trenching device is configured to form the trench by only pushing the soil of the seabed away with the rotating trenching wheel when the trenching device is moved along the seabed.
4. Trenching device according to any of the preceding claims, wherein the trenching
20 device comprises a ballast to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed.
5. Trenching device according to any of the preceding claims, wherein the trenching wheel is configured and arranged to push the soil of the seabed to the side when the
25 trenching device is moved along the seabed while the trenching wheel is pushed into the seabed.
6. Trenching device according to any of the preceding claims, wherein the trenching wheel comprises an outer circumference.
30
7. Trenching device according to claim 6, wherein the trenching wheel comprises a first side surface and an opposite second side surface, the trenching wheel is arranged such that the outer circumference is pushed into the seabed and the first side surface and second side surface push the soil of the seabed to the side when the trenching device is
35 moved along the seabed.

8. Trenching device according to any of the preceding claims, wherein the trenching wheel comprises a radius $R1$ which is larger than a depth D of the trench that is formed.

9. Trenching device according to claim 8, wherein the radius $R1$ is between 5 and 15 m.

5

10. Trenching device according to any of the preceding claims, wherein the trenching device is configured to form a trench with a depth D between 1 and 8 m.

11. Trenching device according to any of the claims 6-10, wherein the outer

10 circumference of the trenching wheel is rounded.

12. Trenching device according to any of the claims 6-11, wherein the outer circumference of the trenching wheel is roughened to enhance friction between said outer circumference and the seabed.

15

13. Trenching device according to any of the claims 6-12, wherein the trenching wheel, in the direction of the trenching wheel axis, comprises a thickness and the thickness decreases in the direction from the trenching wheel axis to the outer circumference of the trenching wheel.

20

14. Trenching device according to any of the claims 6-13, wherein the trenching wheel comprises a thickness $t1$ near the trenching wheel axis and a thickness $t2$ near the outer circumference of the trenching wheel, and the thickness decreases in the direction from the trenching wheel axis to the outer circumference of the trenching wheel.

25

15. Trenching device according to any of the preceding claims, and in combination with claim 4, wherein the ballast is formed, or partly formed, by a fixed ballast member connected to the base frame in a fixed position.

30 16. Trenching device according to any of the preceding claims, and in combination with claim 4, wherein the ballast is formed, or partly formed, by a ballast system.

17. Trenching device according to claim 16, wherein the ballast system is configured to adjust the magnitude of the force working on the base frame.

35

18. Trenching device according to claim 16 or 17, wherein the ballast system is configured to adjust the position of the force working on the base frame.
19. Trenching device according to any of the claims 16-18, wherein the ballast system
5 comprises a ballast tank configured to hold a fluid.
20. Trenching device according to any of the claims 16-19, wherein the ballast system comprises a pump system to pump water in the ballast tank.
- 10 21. Trenching device according to claim 20, wherein the pump system is configured to pump gas in the ballast tank.
22. Trenching device according to any of the claims 19-21, wherein the ballast tank comprises multiple ballast compartments.
15
23. Trenching device according to claim 22, wherein the pump system is configured to pump water in multiple ballast compartments independently from each other.
24. Trenching device according to claim 22 or 23, wherein the pump system is configured
20 to pump gas in multiple ballast compartments independently from each other.
25. Trenching device according to any of the preceding claims, and in combination with claim 4, wherein the trenching device comprises a front side and a rear side, the trenching device is configured to be moved in the direction from the rear side to the front
25 side, the resultant force of the ballast acting on the base frame is located at a distance e beyond the trenching wheel axis when seen in the direction from the rear side to the front side.
26. Trenching device according to any of the preceding claims, wherein the trenching
30 device comprises a propulsion system formed by at least one propulsion unit which is connected to the base frame to move the trenching device along the seabed.
27. Trenching device according to claim 26, wherein at least one propulsion unit
35 comprises a wheel drive to rotate the trenching wheel around the trenching wheel axis in order to move the trenching device along the seabed.

28. Trenching device according to claim 26 or 27, wherein the base frame comprises a length direction, and at least one propulsion unit is connected to the base frame at a distance from the trenching wheel in said length direction.

5 29. Trenching device according to any of the claims 26-28, wherein at least one propulsion unit comprises an assisting wheel connected to the base frame and rotatable about an assisting wheel axis, and a further wheel drive to rotate the assisting wheel around the assisting wheel axis in order to move the trenching device along the seabed.

10 30. Trenching device according to any of the claims 26-29, wherein at least one propulsion unit comprises a driven caterpillar track.

31. Trenching device according to any of the preceding claims, and in combination with claim 29, wherein the assisting wheel in the direction of the assisting wheel axis
15 comprises a thickness t_3 and the thickness t_3 remains constant in the direction from the assisting wheel axis to the outer circumference of the assisting wheel.

32. Trenching device according to claim 31, wherein the thickness t_3 is larger than t_2 and smaller than t_1 .

20

33. Trenching device according to claim 31, wherein the thickness t_3 is larger than t_2 and smaller than $t_2 + 0,5(t_1 - t_2)$.

34. Trenching device according to any of the preceding claims, and in combination with
25 claim 29, wherein the assisting wheel comprises a radius R_2 which equals R_1 .

35. Trenching device according to any of the claims 26-34, wherein the base frame comprises a first frame part and a second frame part which are connected to each other via a pivot connection, the trenching wheel is connected to the first frame part, and at
30 least one propulsion unit is connected to the second frame part.

36. Trenching device according to claim 35, wherein the second frame part is pivotable about a frame pivot axis relative to the first frame part, and the frame pivot axis extends perpendicular, or substantially perpendicular, to the trenching wheel axis.

35

37. Trenching device according to claim 34 or 35, wherein the trenching device comprises a steering system configured to pivot the second frame part relative to the first

frame part.

38. Trenching device according to any of the preceding claims, wherein the base frame comprises a first frame side and an opposite second frame side and supports are
5 connected to the first frame side and second frame side to hold the trenching wheel in an upwardly extending position.

39. Trenching device according to claim 38, and in combination with claim 26, wherein at least one of the supports is provided with at least one propulsion unit.

10

40. Trenching device according to claim 38 or 39, wherein the height of the supports is adjustable to follow unevenness of the seabed.

15

41. Trenching device according to any of the preceding claims, wherein the trenching device comprises a further trenching wheel which is connected to the base frame and rotatable about a further trenching wheel axis to form the trench, and the trenching device is configured to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed.

20

42. Trenching device according to claim 41, wherein the trenching device comprises a further ballast to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed.

25

43. Trenching device according to claim 41 or 42, wherein the further trenching wheel comprises corresponding features of the trenching wheel as defined in any of the claims 5-14.

30

44. Trenching device according to claim 42 or 43, wherein the further ballast comprises corresponding features of the ballast as defined in any of the claims 15-25.

45. Trenching device according to any of the claims 41-44, wherein the trenching device is configured to push the trenching wheel over a first distance D1 into the seabed and to push the further trenching wheel over a second distance D2 into the seabed.

35

46. Trenching device according to claim 45, wherein the distance D2 is larger than the distance D1.

47. Method of forming a trench in a seabed to receive an elongate object, such as a pipeline, with a trenching device comprising a base frame, a trenching wheel which is connected to the base frame and rotatable about a trenching wheel axis to form the trench, wherein the trenching device is configured to push the trenching wheel into the seabed when the trenching wheel is positioned on the seabed and said method comprises;

- positioning the trenching wheel on the seabed,
- pushing the trenching wheel into the seabed,
- moving the trenching device along the seabed to form the trench.

48. Method according to claim 47, wherein the method comprises pushing the soil of the seabed away with the trenching wheel to form the trench, without conveying excavated soil of the seabed out of the trench.

49. Method according to claim 47 or 48, wherein the method comprises forming the trench by only pushing the soil of the seabed away with the rotating trenching wheel when the trenching device is moved along the seabed.

50. Method according to claim 47-49, wherein the trenching device comprises a ballast and the method comprises pushing the trenching wheel into the seabed by the weight of the ballast.

51. Method according to claim 47-50, wherein the method comprises pushing the soil of the seabed to the side by moving the trenching device along the seabed while the trenching wheel is pushed into the seabed.

52. Method according to any of the claims 47-51, wherein the trenching wheel comprises an outer circumference, a first side surface and an opposite second side surface, the method comprises pushing the outer circumference into the seabed and pushing the soil of the seabed to the side with the first side surface and the second side surface by moving the trenching device along the seabed.

53. Method according to any of the claims 47-52, and in combination with claim 50, wherein the ballast is formed, or partly formed, by a ballast system configured to adjust the magnitude of the force of the ballast working on the base frame, and the method comprises adjusting the magnitude of the force of the ballast working on the base frame

to push the trenching wheel into the seabed.

54. Method according to claim 53, wherein the ballast system is configured to adjust the position of the force of the ballast working on the base frame, and the method comprises
5 adjusting the position of the force of the ballast working on the base frame to push to trenching wheel into the seabed.

55. Method according to claim 53 or 54, wherein the ballast system comprises a ballast tank configured to hold a fluid and the method comprises filling the ballast tank with
10 water to increase the magnitude of the force of the ballast working on the base frame.

56. Method according to claim 55, wherein the method comprises filling the ballast tank with air to decrease the magnitude of the force of the ballast working on the base frame and/or to create buoyancy such that the trenching device is neutrally buoyant or floats up
15 in the water.

57. Method according to any of the claims 47-56, wherein the trenching device comprises a propulsion system formed by at least one propulsion unit connected to the base frame and the method comprise moving the trenching device along the seabed with the
20 propulsion system.

58. Method according to claim 57, wherein at least one propulsion unit comprises a wheel drive to rotate the trenching wheel around the trenching wheel axis and the method comprises rotating the trenching wheel to move the trenching device along the
25 seabed.

59. Method according to claim 57 or 58, wherein the base frame comprises a length direction, and at least one propulsion unit is connected to the base frame at a distance from the trenching wheel in said length direction and the method comprises moving the
30 trenching device along seabed with the propulsion unit.

60. Method according to any of the claims 57-59, wherein at least one propulsion unit comprises an assisting wheel connected to the base frame and rotatable about an assisting wheel axis and a further wheel drive to rotate the assisting wheel around the
35 assisting wheel axis and the method comprise rotating the assisting wheel around the assisting wheel axis to move the trenching device along the seabed.

61. Method according to any of the claims 57-60, wherein the base frame comprises a first frame part and a second frame part which are connected to each other via a pivot connection, the trenching wheel is connected to the first frame part, at least one propulsion unit is connected to the second frame part, the trenching device comprises a steering system configured to pivot the second frame part relative to the first frame part and the method comprises pivoting the second frame part relative to the first frame part to adjust the direction in which the trenching device is moved along the seabed.

62. Method according to any of the claims 47-61, wherein the trenching device comprises a further trenching wheel which is connected to the base frame and rotatable about a further trenching wheel axis to form the trench, and the trenching device is configured to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed and the method comprises pushing the trenching wheel over a first distance D1 into the seabed and pushing the further trenching wheel over a second distance D2 into the seabed, while the trenching device is moved along the seabed.

63. Method according to claim 62, wherein the distance D2 is larger than the distance D1.

64. Method of forming a trench in a seabed to receive an elongate object, such as a pipeline, with a trenching device according to any of the claims 1-46, wherein said method comprises;

- positioning the trenching wheel on the seabed,
- pushing the trenching wheel into the seabed,
- moving the trenching device along the seabed to form the trench.

65. Method according to claim 64, comprising the method steps defined in any of the claims 47-63.

66. Use of a trenching device according to any of the claims 1-46 to form a trench in a seabed.

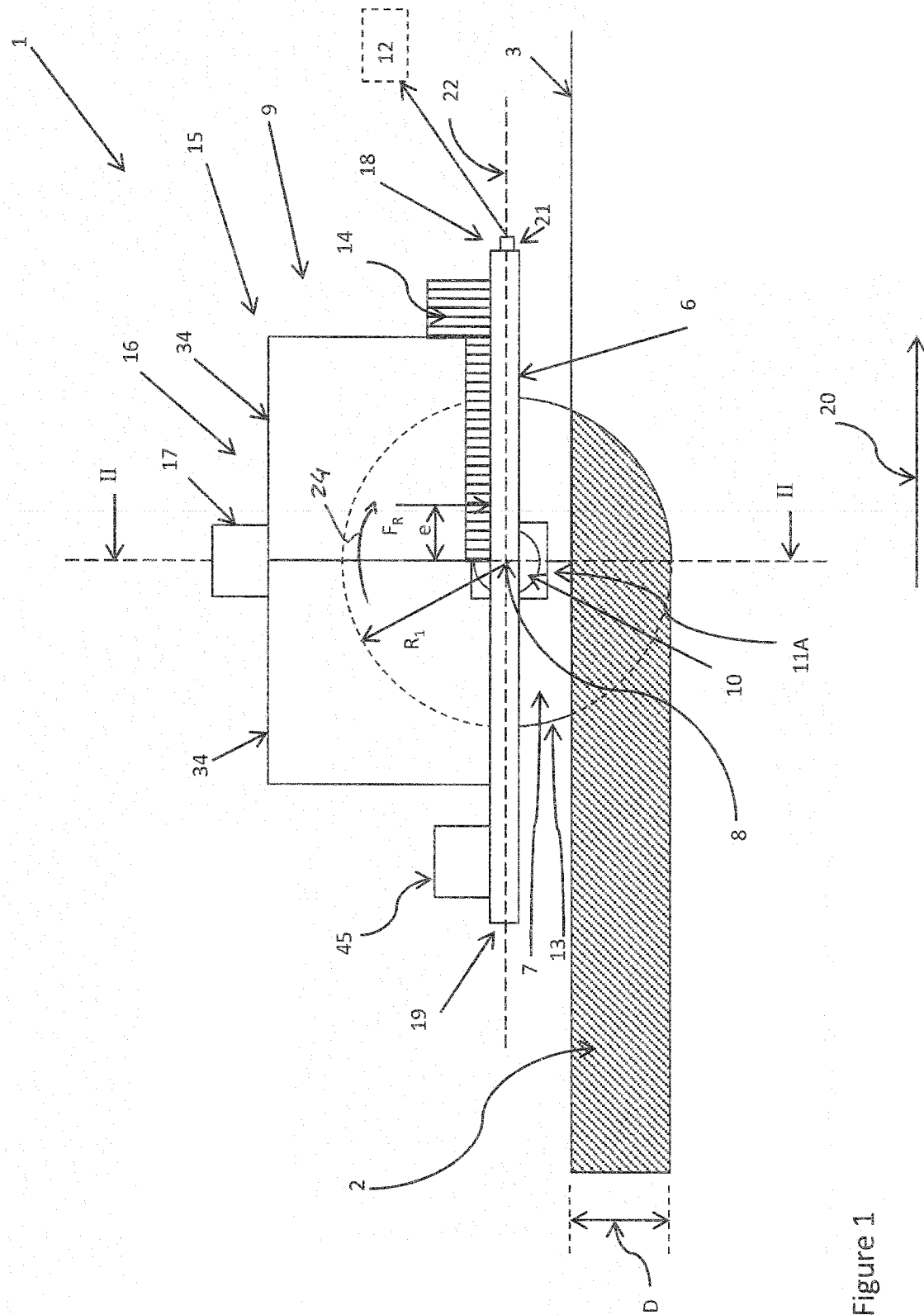


Figure 1

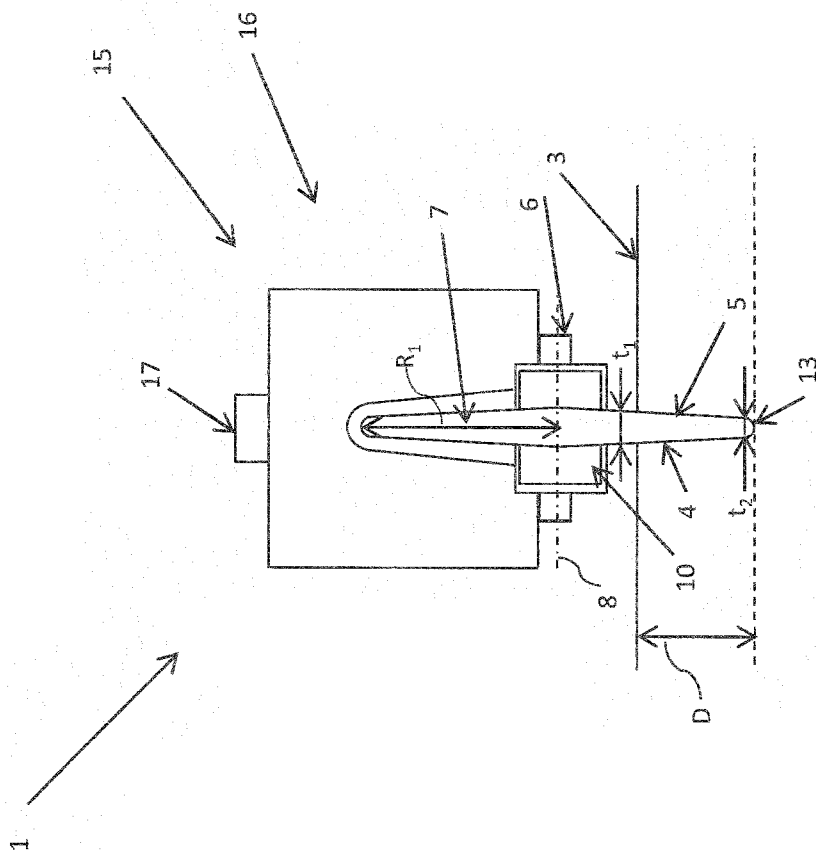


Figure 2

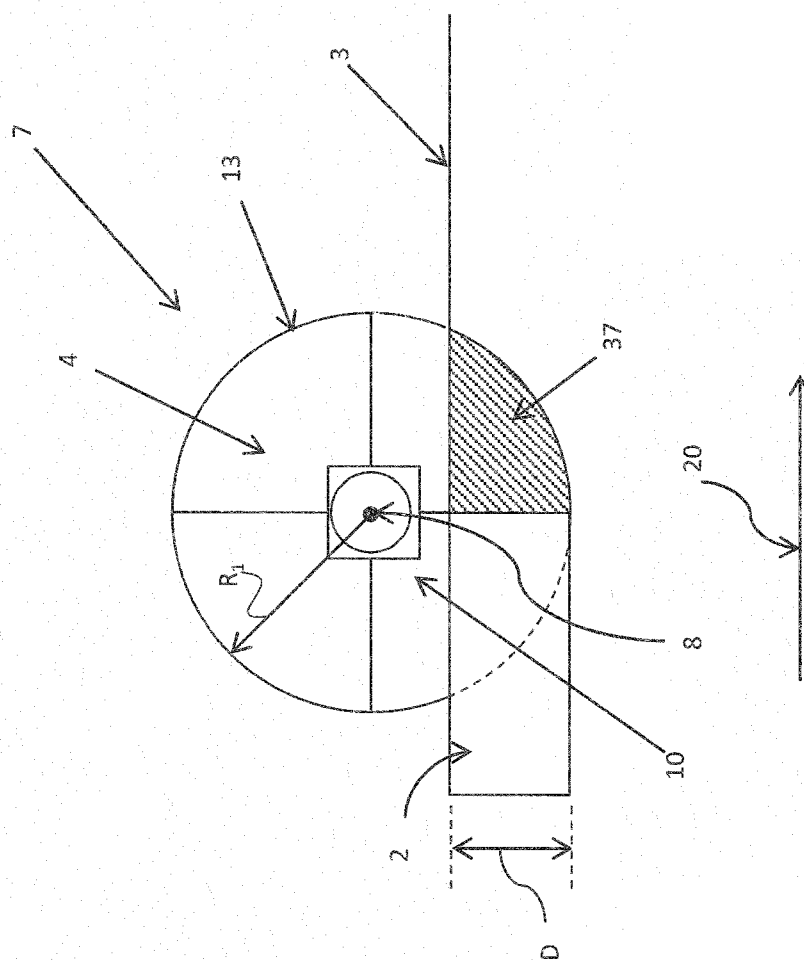


Figure 3

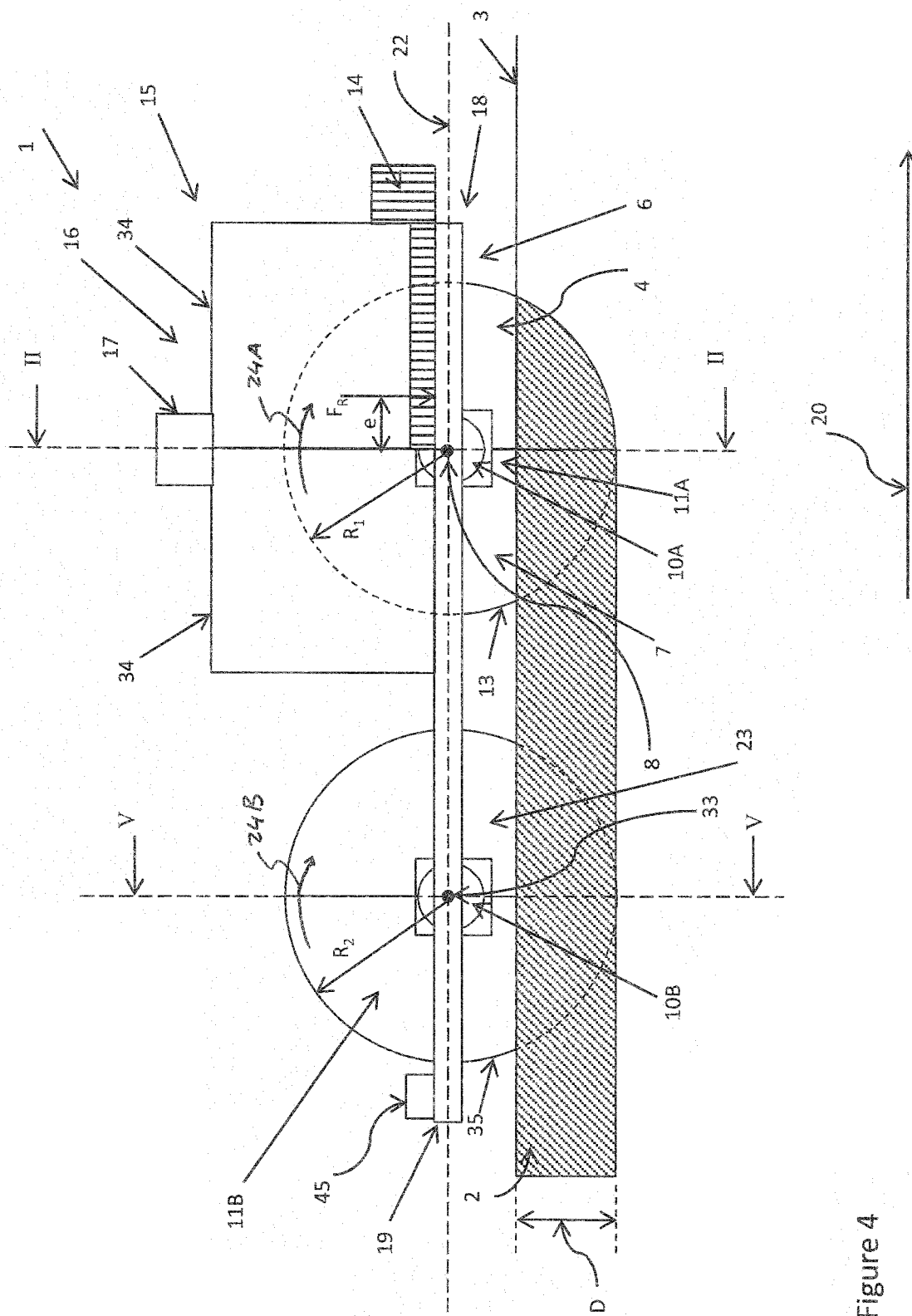


Figure 4

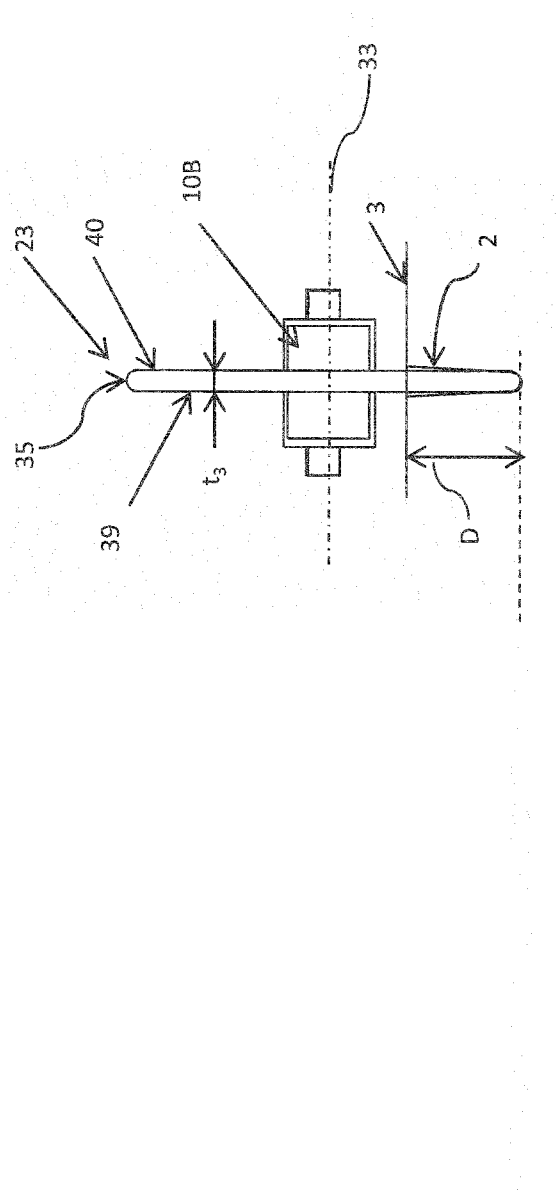


Figure 5

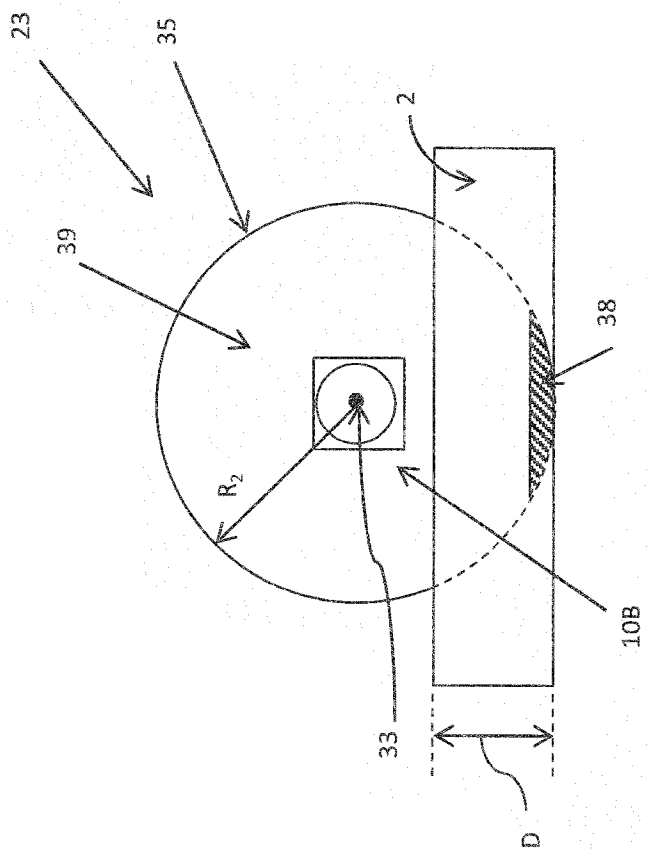


Figure 6

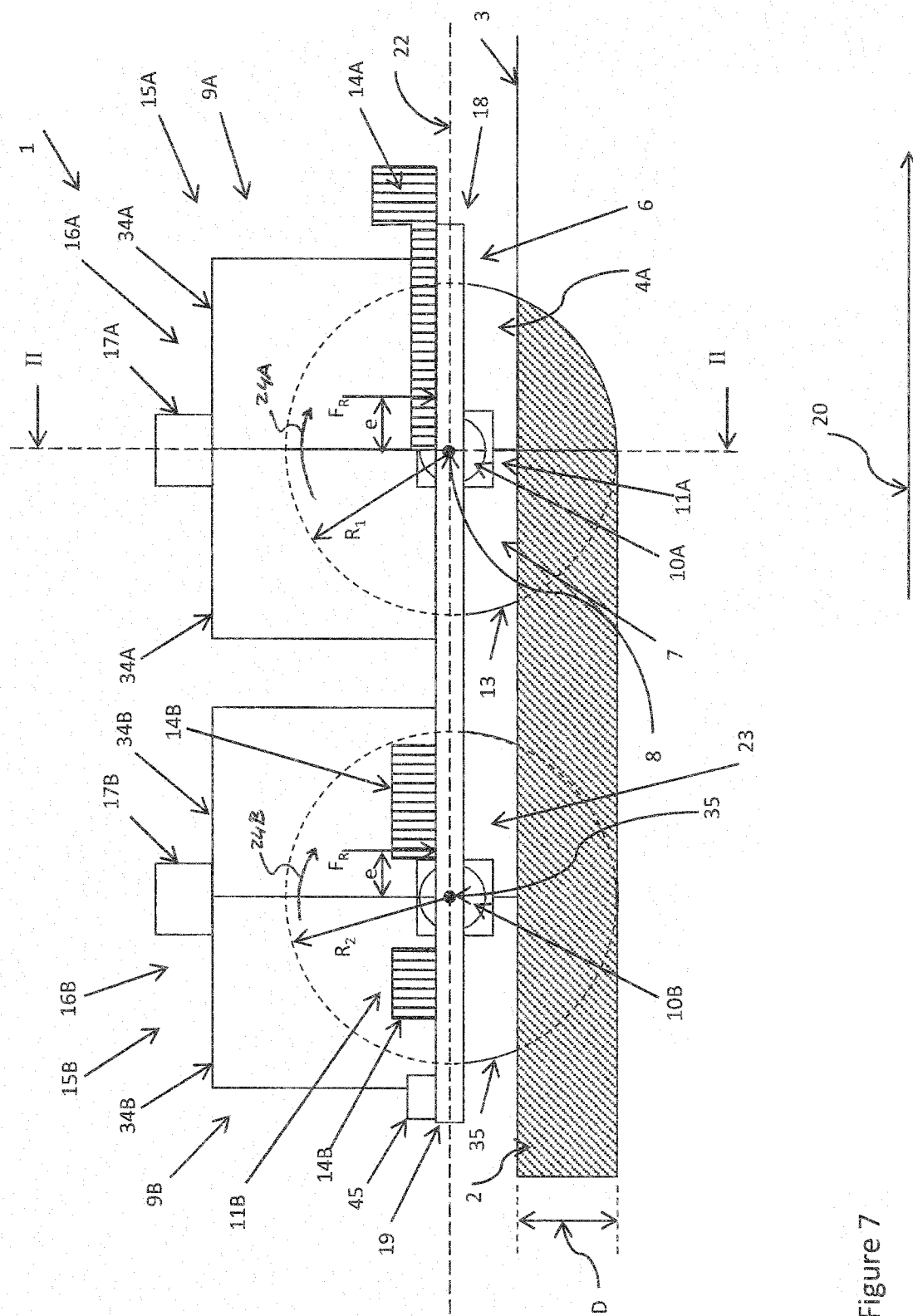


Figure 7

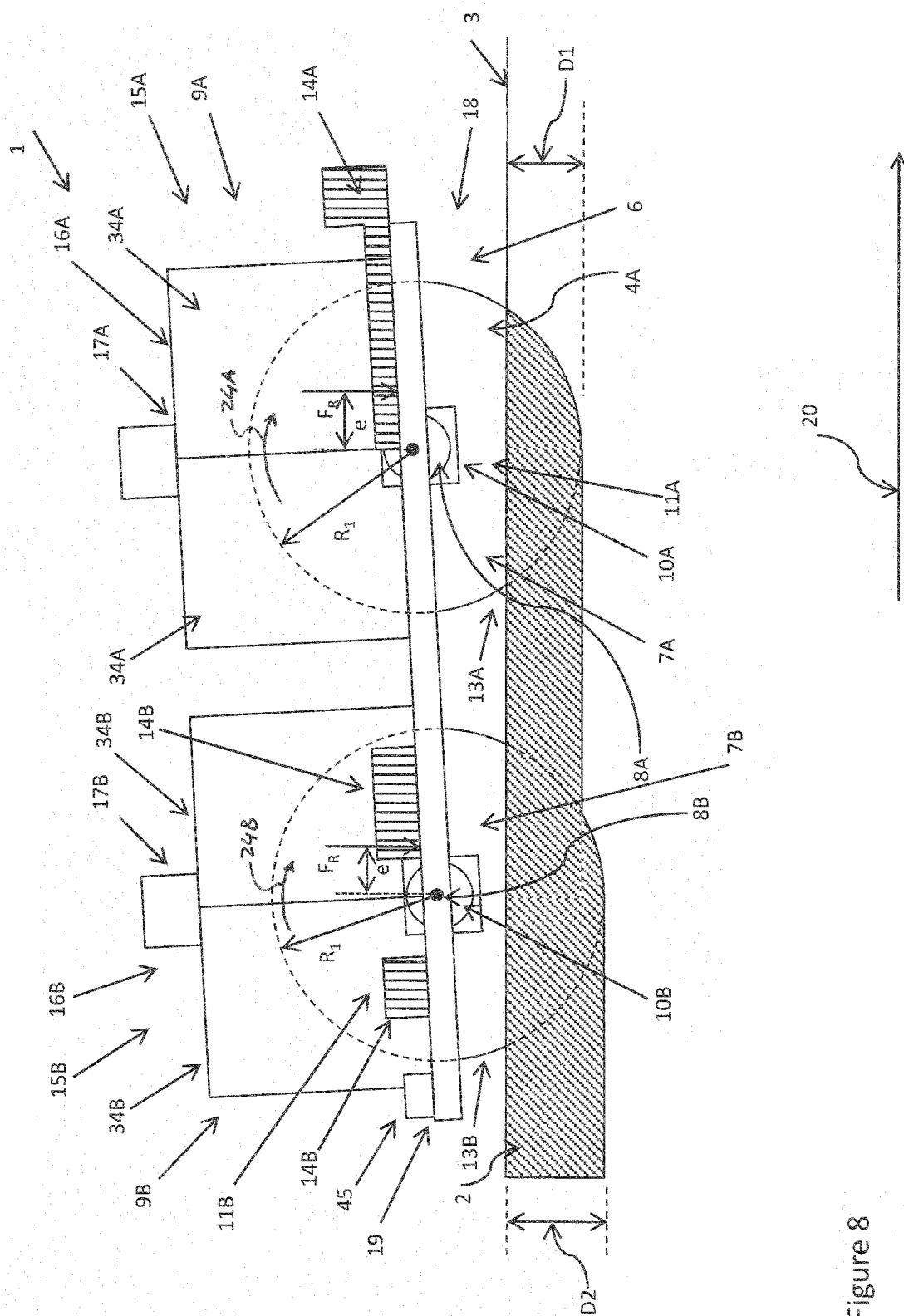


Figure 8

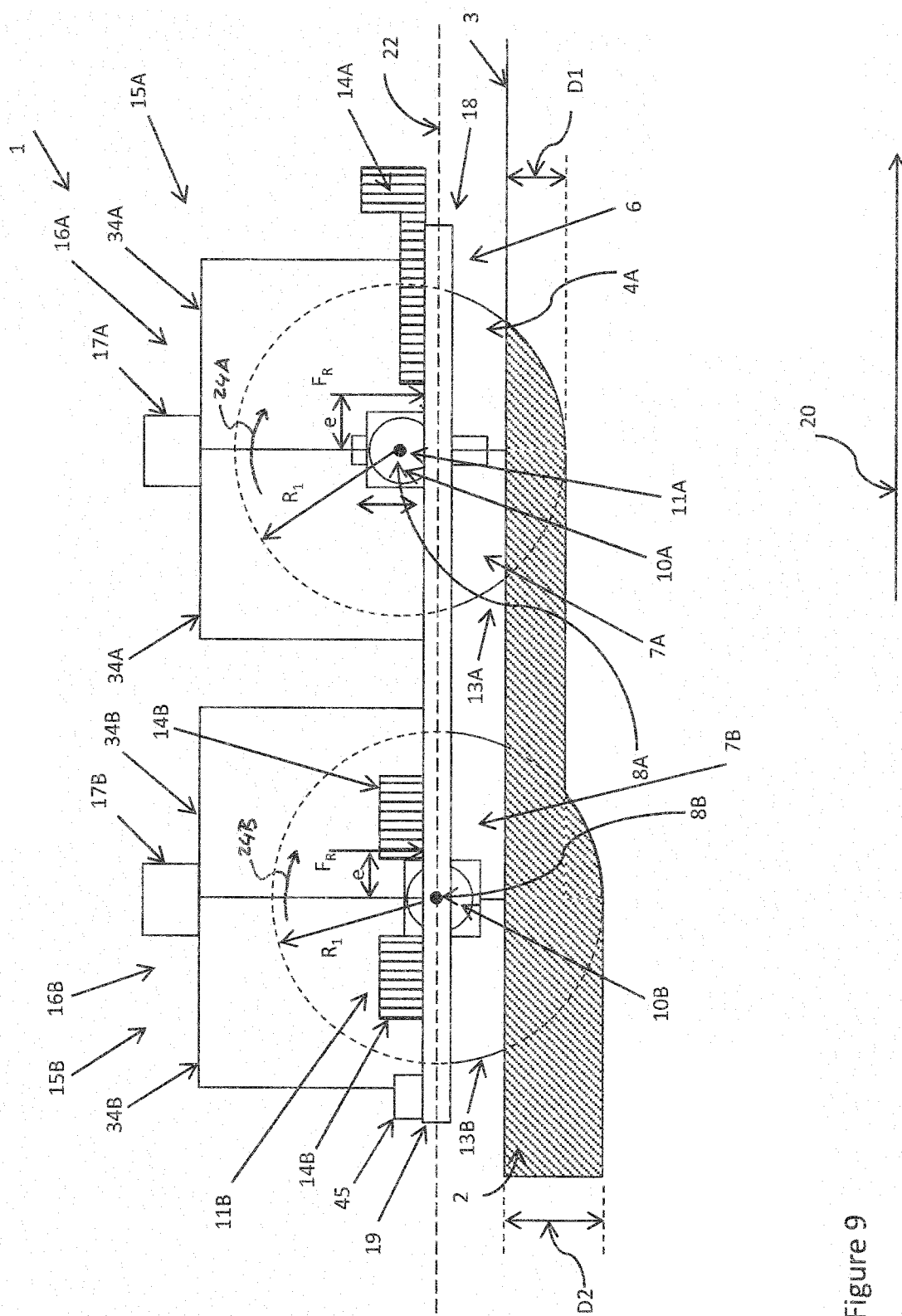


Figure 9

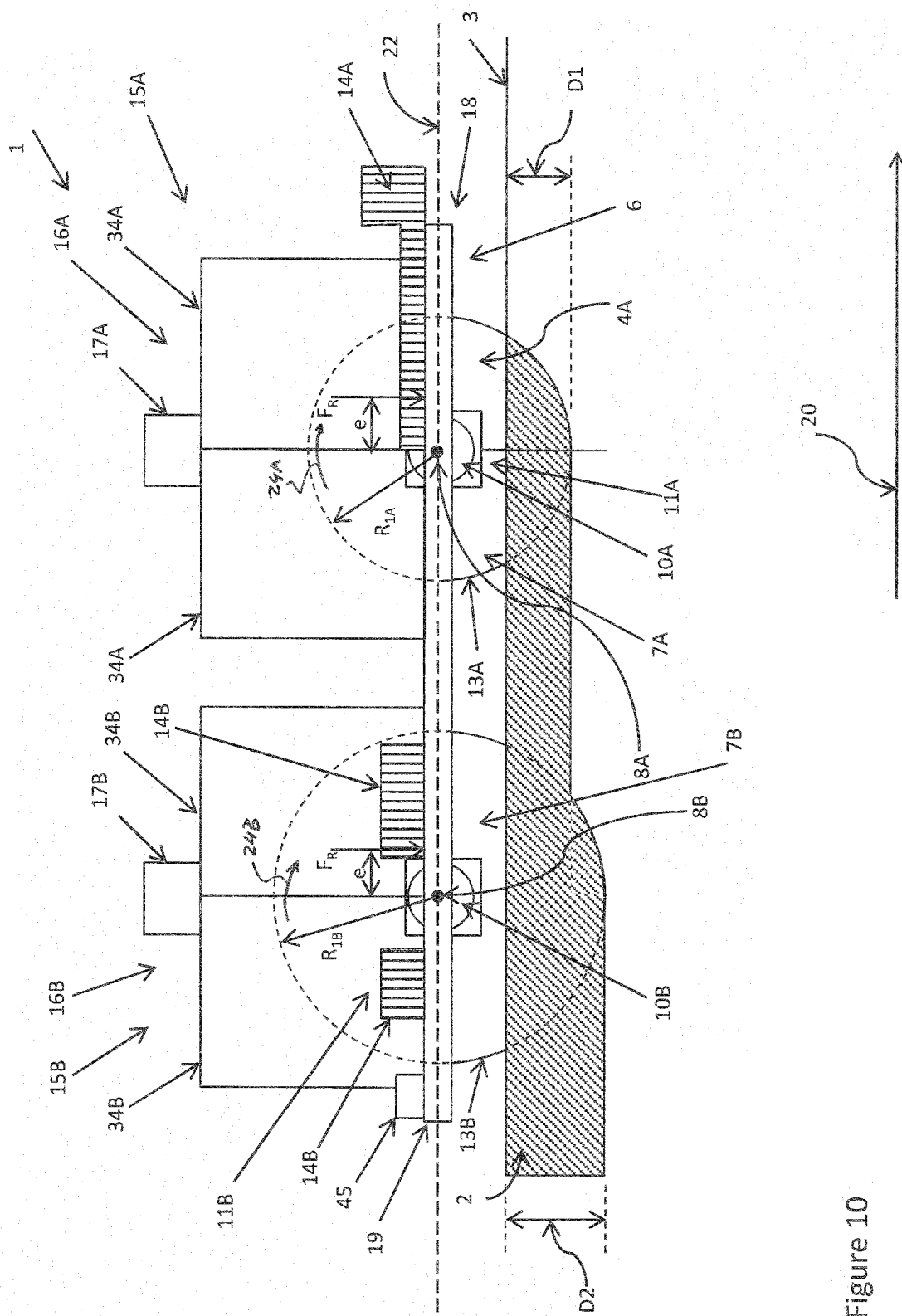


Figure 10

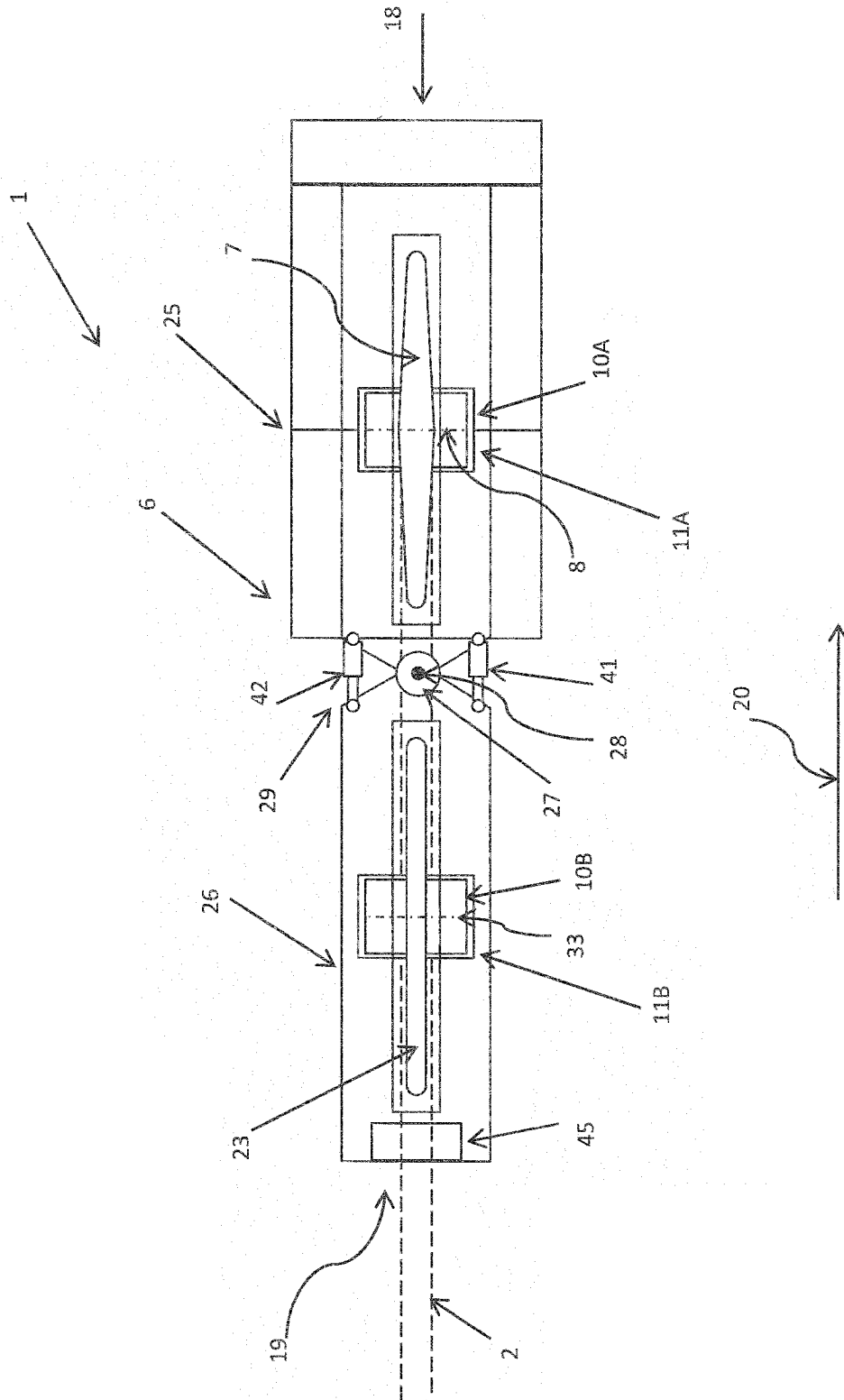


Figure 11

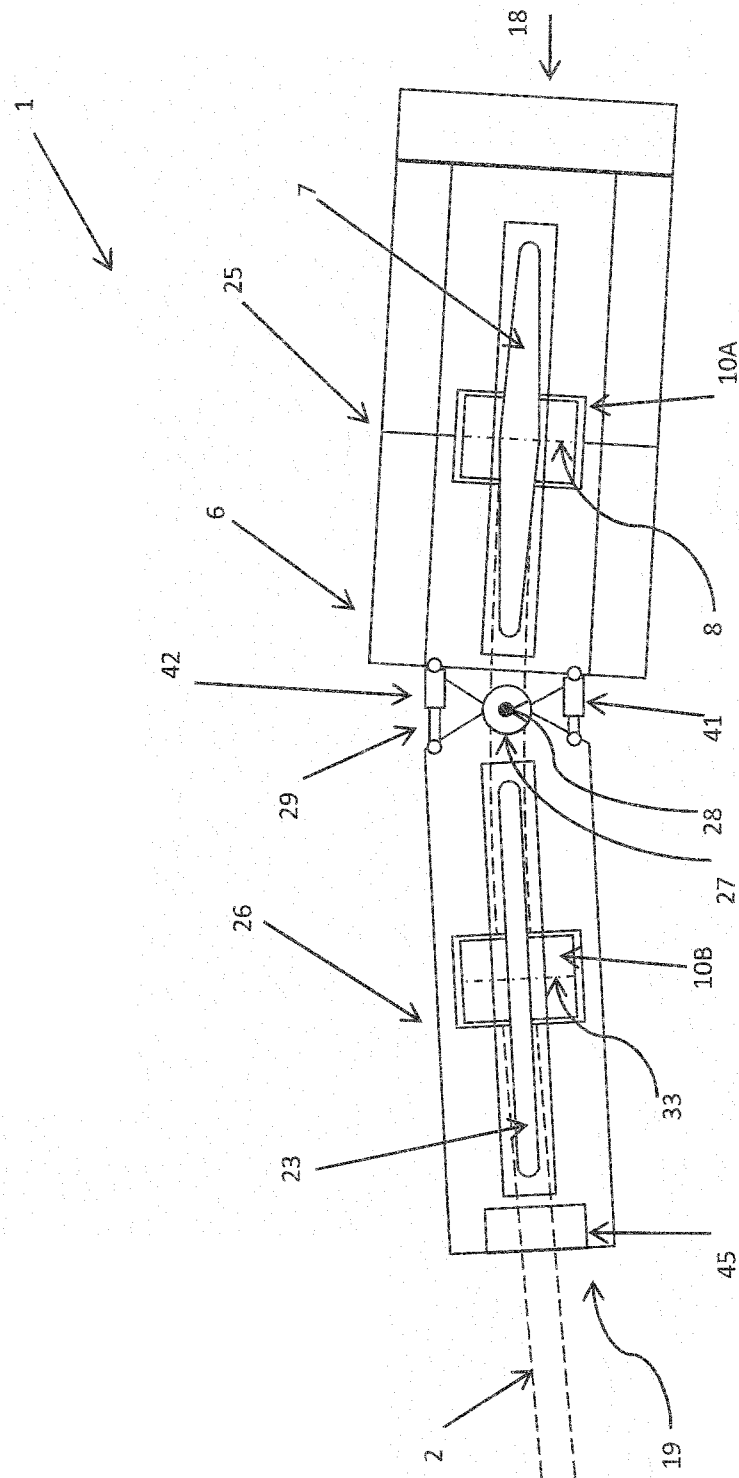


Figure 12

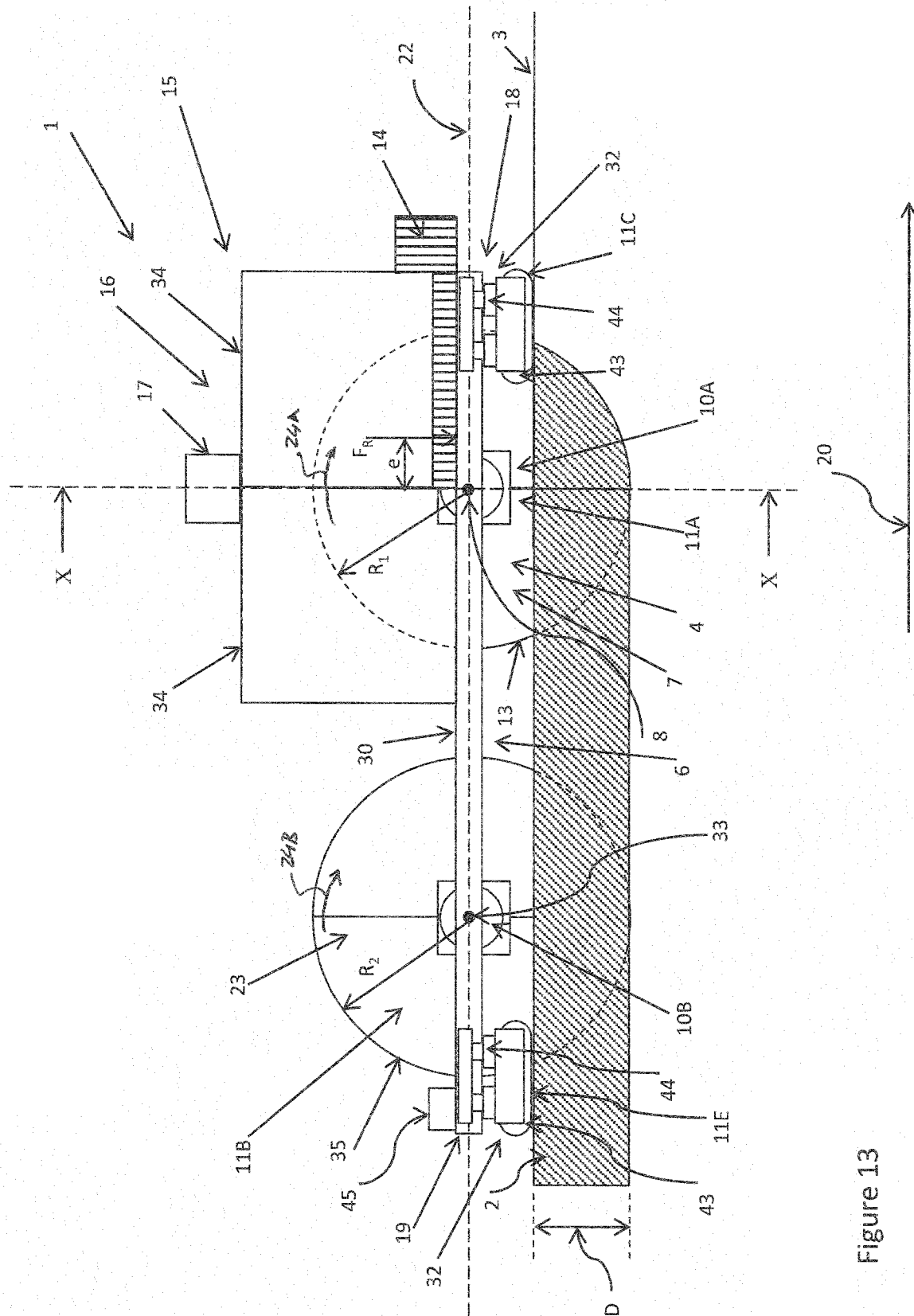


Figure 13

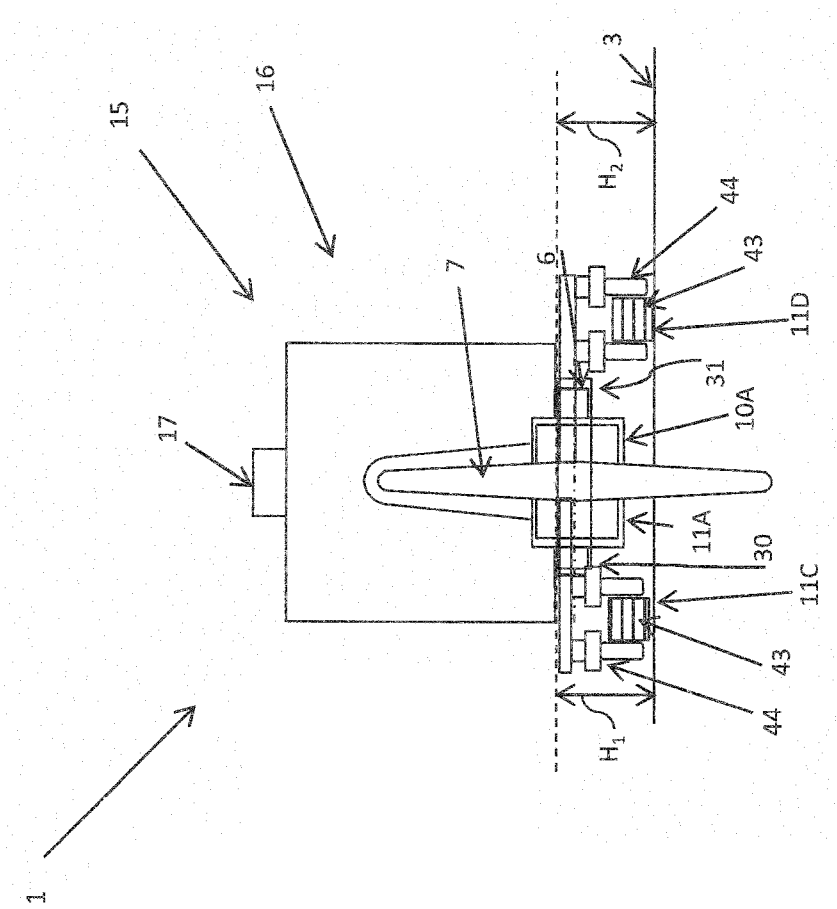


Figure 14

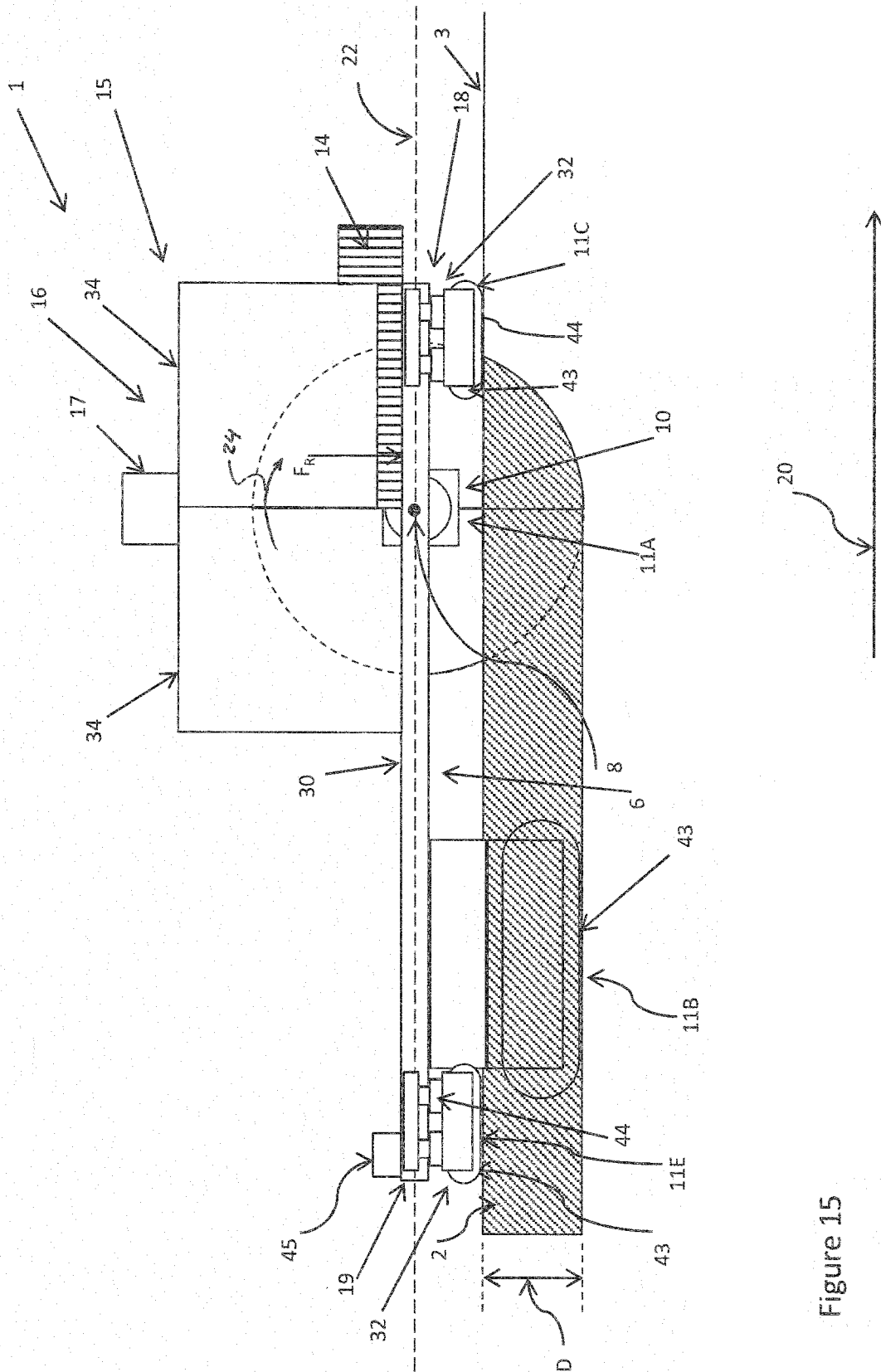


Figure 15

INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2013/050594

A. CLASSIFICATION OF SUBJECT MATTER

INV. E02F5/10 E02F5/12
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)

E02F A01B E02B

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.
X	GB 2 036 129 A (LAND & MARINE ENG LTD) 25 June 1980 (1980-06-25) the whole document	1,4-7, 47, 50-52,66
X	DE 26 09 457 A1 (WIENANDS HERMANN) 15 September 1977 (1977-09-15) the whole document	1,4-7, 12-14, 47, 50-52,66
X	GB 2 428 437 A (SMITH DAWN VIOLET [GB]; SMITH MICHAEL JOHN [GB]) 31 January 2007 (2007-01-31) the whole document	1-7,11, 13,14, 47-52,66
X	US 7 219 452 B1 (RAGUSE STEVEN F [US]) 22 May 2007 (2007-05-22) the whole document	1-7,11, 12



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

14 October 2013

Date of mailing of the international search report

17/12/2013

Name and mailing address of the ISA/

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Authorized officer

Laurer, Michael

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NL2013/050594

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-7, 47-52(completely); 11-14, 66(partially)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7, 47-52(completely); 11-14, 66(partially)

are directed to the known trencher of claims 1, 2, 3 and/or 4 or the related methods wherein as potential special technical features the trenching wheel is configured and arranged to push the soil of the seabed to the side when the trenching device is moved along the seabed while the trenching wheel is pushed into the seabed (claim 5) or the trenching wheel comprises an outer circumference (claim 6). The resulting technical effects are: Excavated material is conveyed out of the trench. The objective technical problem to solve may be formulated as: Improve clearing of the trench behind such a trenching device.

2. claims: 8-10(completely); 11-14(partially)

are directed to the known trencher of claims 1 to 4 and the related methods wherein as potential special technical features the trenching wheel comprises a radius which is larger than the depth of the formed trench (claim 8) or the trenching device is configured to form a trench with a depth between 1 and 8m (claim 10). The resulting technical effects are: The size of the trenching wheel is adapted to the desired trenching depth of the trench. The objective technical problem to solve may be formulated as: Select an appropriately sized tool for such a trenching device.

3. claims: 15-25, 53-56

are directed to the known trencher of claims 1 to 4 and the related methods wherein as potential special technical features the ballast is formed, or partly formed, by a fixed ballast member connected to the base frame in a fixed position (claim 15), or the ballast is formed by a ballast system (claim 16), or the position of the ballast with respect to the base frame is selected frontward of the trenching wheel axis in the motion direction (claim 25). The resulting technical effects are: The ballast system is adapted to the desired trench. The objective technical problem to solve may be formulated as: Select an appropriate ballast for such a trenching device.

4. claims: 26-37, 57-61

are directed to the known trencher of claims 1 to 4 and the related methods wherein as potential special technical features the trenching device comprises a propulsion system formed by at least one propulsion unit which is connected to the base frame to move the trenching device along the

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

seabed. The resulting technical effects are: The trenching device may be moved along the seabed. The objective technical problem to solve may be formulated as: Provide an appropriate propulsion system for such a trenching device.

5. claims: 38-40

are directed to the known trencher of claims 1 to 4 wherein as potential special technical features the trenching device comprises a first frame side and an opposite second frame side and supports are connected to said sides to hold the trenching wheel in an upwardly extending position. The resulting technical effects are: The trenching device may keep a selected posture with respect to the seabed even over rough terrain. The objective technical problem to solve may be formulated as: Provide an appropriate posture of such a trenching device with respect to the seabed even over rough and uneven grounds.

6. claims: 41-46, 62, 63

are directed to the known trencher of claims 1 to 4 and the related methods wherein as potential special technical features the trenching device comprises a further trenching wheel which is connected to the base frame and rotatable about a further trenching wheel axis to form the trench, and the trenching device is configured to push the further trenching wheel into the seabed when the further trenching wheel is positioned on the seabed. The resulting technical effects are: A higher trenching efficiency and/or the possibility of different trench forms is achieved. The objective technical problem to solve may be formulated as: Improve trenching efficiency in such a trenching device.

7. claims: 64, 65

are directed to methods utilising the known trencher of claims 1 to 4 wherein as potential special technical features the trenching device is suitable for laying a pipeline into the seabed. The resulting technical effects are: Pipelines may be laid into the seabed. The objective technical problem to solve may be formulated as: Enable laying of a pipeline with such a trenching device.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/NL2013/050594

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2036129	A	25-06-1980	NONE	

DE 2609457	A1	15-09-1977	NONE	

GB 2428437	A	31-01-2007	NONE	

US 7219452	B1	22-05-2007	NONE	
