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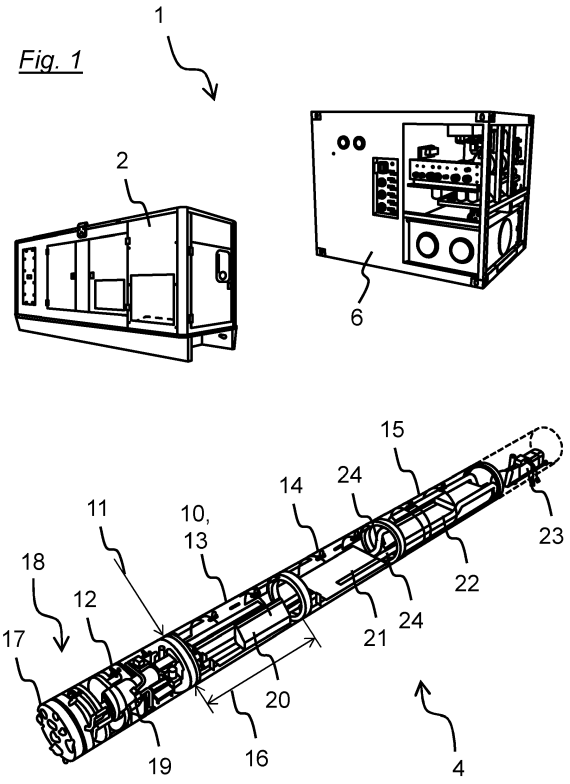
(54) MICROTUNNELING METHOD AND DEVICE

(57) The invention refers to a microtunneling method, comprising providing a boring machine (4) at a starting shaft, and jacking the boring machine (4) towards a target shaft, while electrically rotating about an axis of a tunnel a cutter head (17) at a front end (18) of the boring machine (4) and pumping a slurry that transports cuttings from the cutter head (17) out of the tunnel. The invention further refers to a microtunneling device (1) comprising a boring machine (4) with a cutter head (17) at a front end (18), and an electric motor (19) for rotating the cutter head (17), a jacking station, a power generator (2) providing electric energy, and a control container for controlling the device (1) at a surface above the tunnel.

To facilitate microtunneling in granular or argillaceous soil, the invention proposes that a synchronous reluctance motor (19) rotates the cutter head (17).

Fig. 1



EP 4 265 884 A1

Description

[0001] The invention relates to a microtunneling method, comprising providing a boring machine at a starting shaft, and jacking the boring machine towards a target shaft, while electrically rotating about an axis of a tunnel a cutter head at a front end of the boring machine and pumping a slurry that transports cuttings from the cutter head out of the tunnel. The invention further relates to a microtunneling device comprising a boring machine with a cylindrical housing, a cutter head at a front end of the can, and an electric motor for rotating the cutter head about an axis of the can, a jacking station for jacking the boring machine from a starting shaft towards a target shaft of the tunnel, a power generator providing electric energy, at least one pump for pumping a slurry that transports cuttings from the cutter head out of the tunnel, and a control container for controlling the device at a surface above the tunnel.

[0002] Microtunneling is commonly known for boring in ground soil utility tunnels for distributing service infrastructure (gas and air, water, steam and disposal pipelines, electric power and telecommunication cables, etc.) in urban and rural areas: The starting shaft (or entrance shaft) provides a concrete thrust block for the hydraulic jacking station vis-à-vis an entry eye of the tunnel. The boring machine (MTBM) is jacked through the entry eye with up to several hundred tons of force towards the target shaft (or reception shaft), while cutting into the soil at the head of the machine by rotating the cutter head, discharging the cuttings with a stream of slurry out of the tunnel. Due to small tunnel diameter, the jacking station and the boring machine are monitored and remotely operated from a control container outside the starting shaft on surface level.

[0003] A microtunneling method and device according to the above are commonly known with an induction motor rotating the cutter head, with near zero initial breakaway torque. After stopping in granular or argillaceous soil, pieces of rock are often found to settle in the cutter head and to hamper or even block re-starting the known device from the same position. For unblocking and re-starting the cutter head, the known device needs at least be withdrawn from contact with the soil, or even from the tunnel.

[0004] In further background of the invention, driving the cutter head with hydraulic motors is commonly known. General efficiency of such hydraulic systems is below 60 %.

Problem

[0005] The invention aims at facilitating microtunneling in granular soil.

Solution

[0006] Referring to the above-mentioned state of the art method, the invention proposes that a synchronous reluctance motor rotates the cutter head. Like asynchronous motors, synchronous reluctance motors have a wound stator, and even, but unequal numbers of stator and of rotor poles. Rotor speed is controlled by frequency of the operating electric power. Varying the rotor speed thus needs a frequency converter, in particular integrated into a variable-frequency drive (VFD). Maximum torque is available as breakaway torque and decreases with raising speed. The invention thus facilitates re-starting a cutter head that is blocked by settled rock from zero speed, without withdrawing from contact with the soil.

[0007] The invention is usable in granular soil, as well as in solid rock. General efficiency of the invention is above 90 %, power usage is dramatically reduced, resulting both in better CO_2-footprint and money saving.

[0008] The slurry can be a bentonite mix, and be recycled, i.e. separated from the cuttings outside the tunnel and fed back into a closed circuit. Bentonite can also be used for lubricating the outer surface of the boring machine and of the subsequent pipe segments outside, in the soil.

[0009] Preferably, in a method according to the invention the tunnel is a utility tunnel. Utility tunnels usually have 0.5 to 4 m diameter and 50 to 1,300 m length at down to 50 m below the surface.

[0010] Preferably, in a method according to the invention a voltage of the energy is stepped up at the starting shaft and stepped down for the motor. Higher voltage (and thus lower amperage) reduces both the cable width needed and reduces line loss in particular when boring long tunnels.

[0011] Preferably, in a method according to the invention cans of the boring machine and/or pipe segments are successively inserted into the tunnel following the cutter head at the starting shaft and jacked towards the target shaft together with the cutter head. For boring very long tunnels, additional intermediate jacking stations (called "interjacks") can then be inserted between segments for jacking groups of segments and thus reducing the force needed for the jacking.

[0012] Referring to the above-mentioned state of the art device, the invention proposes that the motor is a synchronous reluctance motor. The device according to the invention allows for executing and shares the above-mentioned advantages of the method according to the invention over the state of the art.

[0013] Preferably, a device according to the invention comprises at least one skid having at least one of the pumps, and optionally having a power transformer and/or a frequency converter for transforming the energy for the at least one of the pumps. Each such skid extends the available length of the slurry pipe and thus of the tunnel.

[0014] Preferably, in a device according to the invention the boring machine has units contained in separate cans. Splitting the boring machine into separate units allows for providing boring machines that exceed the range of the jacking station. Unit that can be provided in sepa-

rate cans are e.g. a power transformer for transforming the energy, a frequency converter for converting an electric frequency of the energy for the motor, and/or a cooling system.

Use case

[0015] The invention is explained in a use case. We show in

fig. 1 details of a device according to the invention,
fig. 2 a diagram of the device and
fig. 3 a detail of the device.

[0016] The device 1 according to the invention comprises a power generator 2, a control container 3, a jacking station, a boring machine 4, a slurry circuit and electric cables 5 providing electric energy from the generator 2 to each unit.

[0017] The Diesel generator 2 generates stationary 500 kVA of energy at three-phase current of 400 V and alternating at 50 Hz. The control container 3 comprises an operators stand and a buffer unit 6 having a 655 V 65 kWh LiFe-battery 7, AC/DC converters 8 and rectifiers 9. The buffer unit 6 receives from the generator 2 and provides to the control container 3, jacking station, boring machine 4 and slurry circuit excess energy up to 40 kVA. The hydraulic jacking station is not shown in the figures.

[0018] The boring machine 4 comprises a cylindrical housing 10 of 0.8 m diameter 11 that consists of four separate cans 12, 13, 14, 15 of approximately 2.5 m length 16 each, a cutter head 17 at the front end 18 of the first can 12 and an 80 kW synchronous reluctance motor 19 for rotating the cutter head 17 inside, a variable-frequency drive (VFD) 20 for the motor 19 in the second can 13, a cooling system 21 in the third can 14, and a 132 kVA power transformer 22 from 960 to 400 V in the fourth can 15. The electric components are liquid ingress protected according to at least IP65. A first trailing pump skid 23 carrying a 45 kW pump for the slurry is energized by the VFD 20.

[0019] The slurry circuit comprises a separation unit for separating the cuttings from the slurry, pipes 24 with four more pump skids 23 every 250 m behind the boring machine 4 and a stationary pump in the starting shaft connecting the circuit to the boring machine 4 as well as two converter skids 23 with 110 kVA transformer 22 from 960 to 400 V and VFD 20 each for energizing two of the pump skids 23. The stationary pump is energized by the buffer unit 6. The separation unit, the stationary pump and the converter skids are not shown in the figures.

[0020] For boring a utility tunnel of 1 m diameter and 1,300 m length at 2 m below the surface, the starting shaft and a target shaft each are prepared, and a concrete thrust block in the starting shaft. The tunnel and the shafts are not shown in the figures.

[0021] The jacking station is positioned in the starting shaft and the control container 3, the electric generator 2 and the separation unit on the surface with the operators stand in view of an entry eye of the tunnel. The boring machine 4 is positioned at the entry eye and connected to the pipes 24 and electric cables 5.

[0022] Along with the motor 19 and the jacking, the generator 2 starts automatically and constantly provides 500 kVA to the device 1. Excess energy not actually needed by the control container 3, jacking station, boring machine 4 and slurry circuit is stored into the buffer unit 6. During downtime of the cutter head 17, the generator 2 stops and the buffer unit 6 provides energy for releasing the jacking station, and for cleaning the slurry circuit. During night, weekend or holiday operation the buffer energizes the lighting and heating of the control container 3 and thrust pumps in the shafts. The generator 2 starts automatically if the battery 7 runs low.

[0023] In the figures are shown

1 microtunneling device
2 power generator
3 control container
4 boring machine
5 electric cables
6 buffer unit
7 battery
8 AC/DC converter
9 rectifier
10 housing
11 diameter
12 cutter head can
13 VFD can
14 cooling system can
15 transformer can
16 length
17 cutter head
18 front end
19 motor
20 VFD
21 cooling system
22 power transformer
23 pump skid
24 pipe

Claims

1. A microtunneling method, comprising

a) providing a boring machine (4) at a starting shaft, and
b) jacking the boring machine (4) towards a target shaft, while
c) electrically rotating about an axis of a tunnel a cutter head (17) at a front end (18) of the boring machine (4) and
d) pumping a slurry that transports cuttings from the cutter head (17) out of the tunnel,

characterized in that a synchronous reluctance motor (19) rotates the cutter head (17).

2. The method according to the preceding claim, ***characterized in that*** the tunnel is a utility tunnel.

3. The method according to any of the preceding claims, ***characterized in that*** a voltage of the energy is stepped up at the starting shaft and stepped down for the motor (19).

4. The method according to any of the preceding claims, ***characterized in that*** cans (12, 13, 14, 15) of the boring machine (4) and/or pipe segments are successively inserted into the tunnel following the cutter head (17) at the starting shaft and jacked towards the target shaft together with the cutter head (17).

5. A microtunneling device (1) comprising

a) a boring machine (4) with a cylindrical housing (10), a cutter head (17) at a front end (18) of the can, and an electric motor (19) for rotating the cutter head (17) about an axis of the can,
b) a jacking station for jacking the boring machine (4) from a starting shaft towards a target shaft of the tunnel,
c) a power generator (2) providing electric energy,
d) at least one pump for pumping a slurry that transports cuttings from the cutter head (17) out of the tunnel, and
e) a control container (3) for controlling the device (1) at a surface above the tunnel,

characterized in that *the* motor (19) is a synchronous reluctance motor (19).

6. The device (1) according to the preceding claim, ***characterized by*** at least one skid (23) having at least one of the pumps, and optionally a power transformer (22) and/or a frequency converter for transforming the energy for the at least one of the pumps.

7. The device (1) according to any of claims 7 and 8, ***characterized in that*** the boring machine (4) has units contained in separate cans (12, 13, 14, 15).

Fig. 1

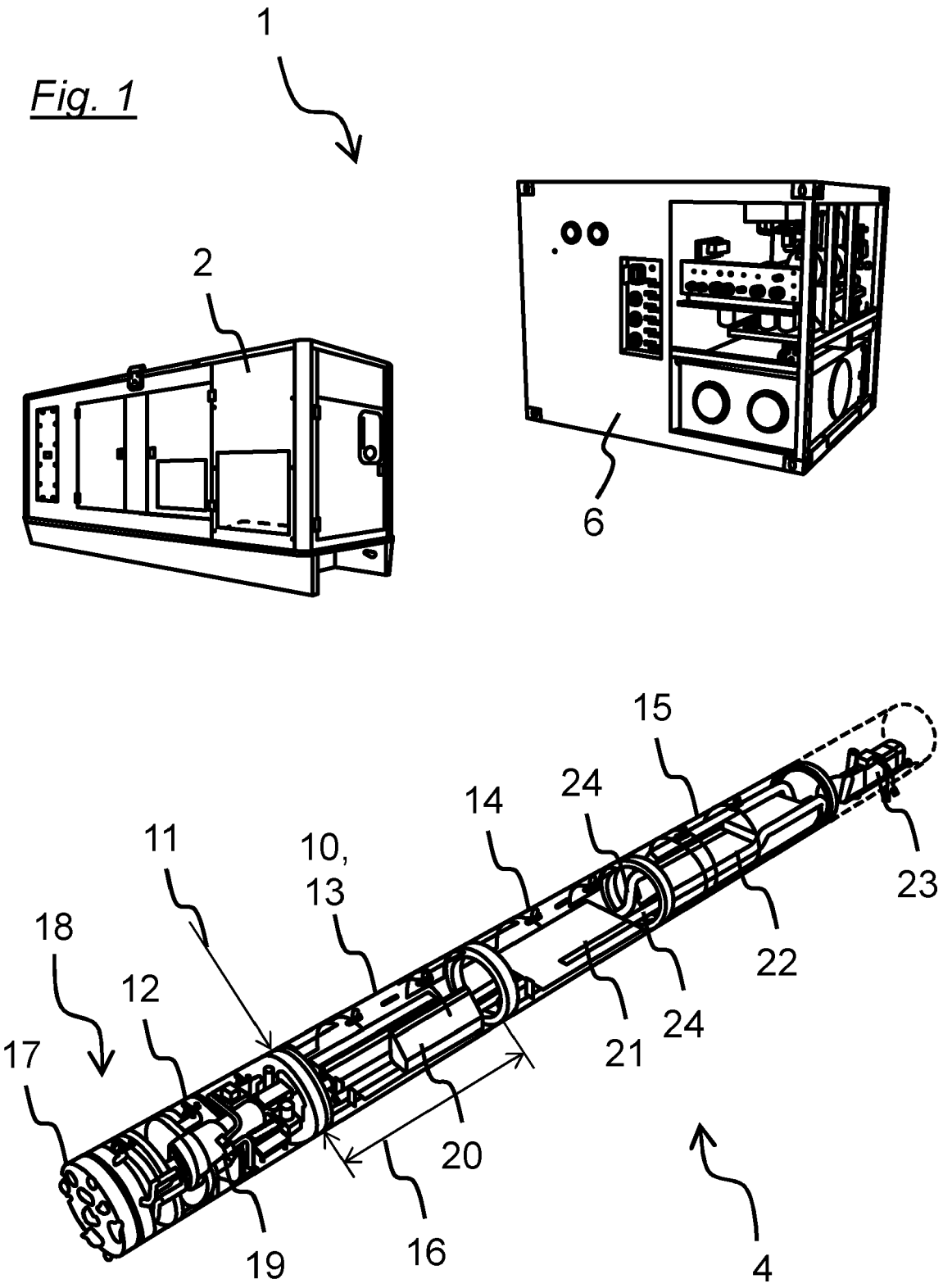


Fig. 2

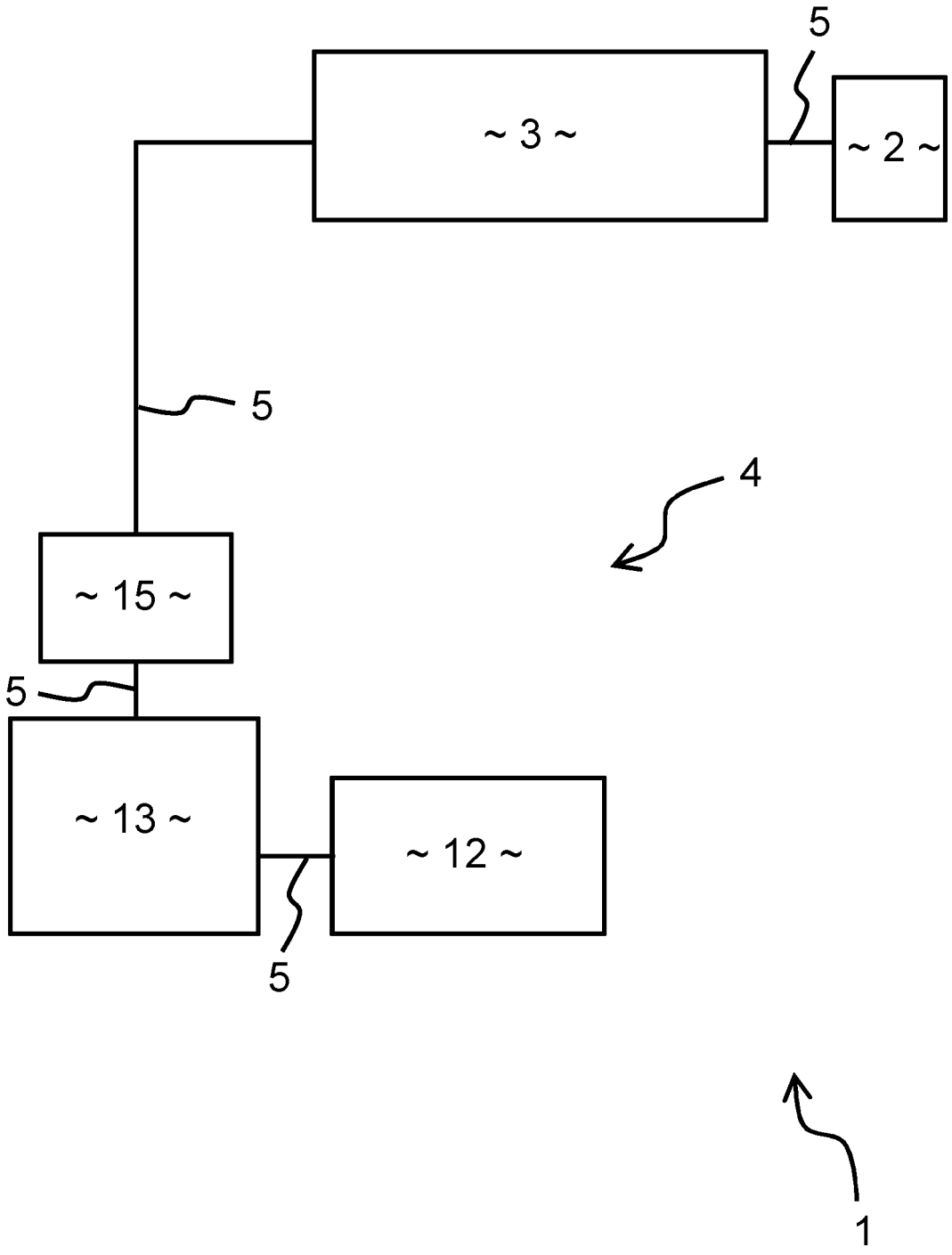
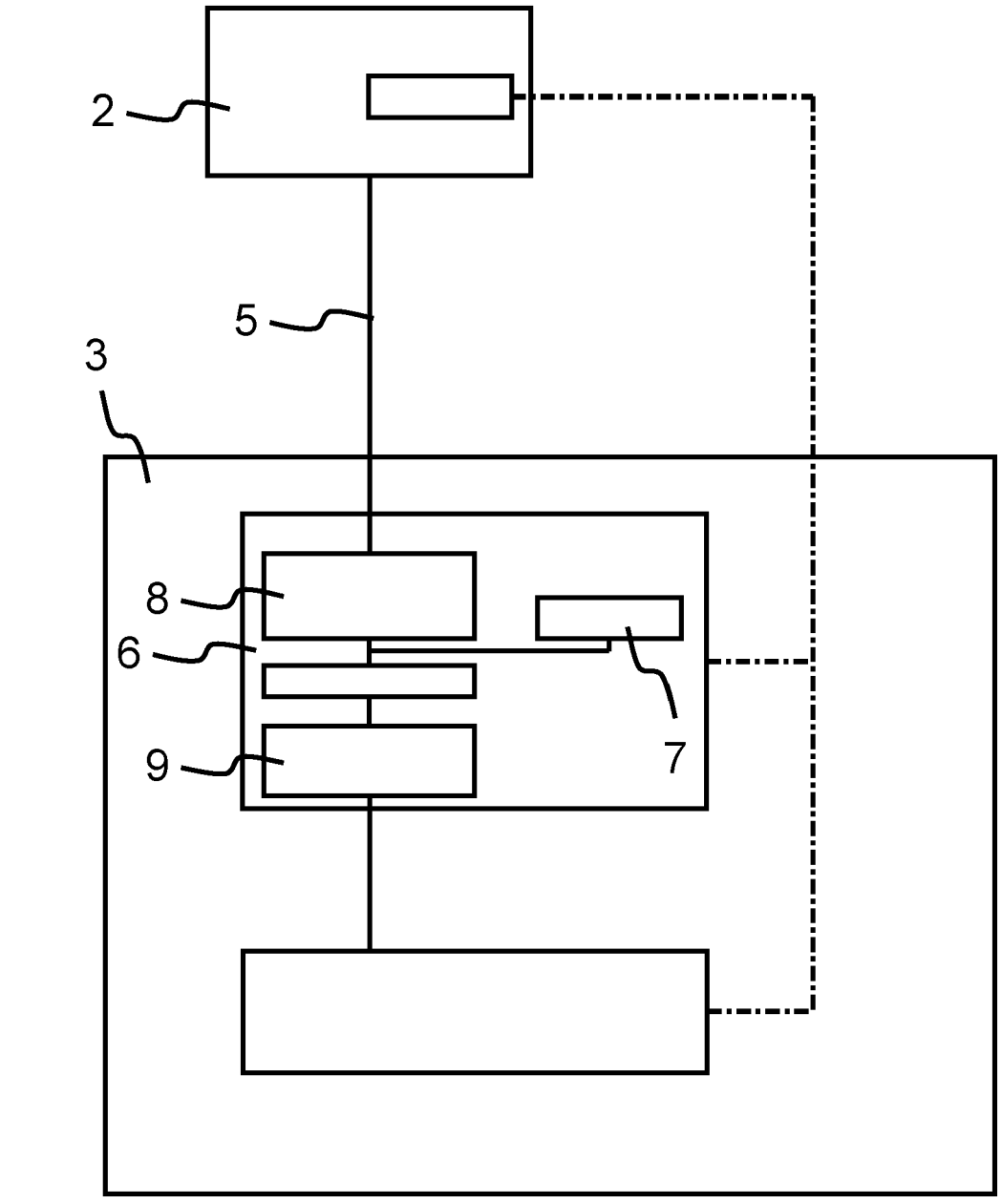


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 8698

DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	Vraetz Dr Tobias: "Technology transfer: How dredging and shipbuilding innovations are improving (micro)tunnelling operations", 37th international No-Dig conference , 1 October 2019 (2019-10-01), XP055962452, Retrieved from the Internet: URL:http://www.iatt.it/wp-content/uploads/2019/11/Tobias-Vraetz.pdf [retrieved on 2022-09-19] * page 10 - page 13 *	1-7	INV. E21D9/00 E21D9/10
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TECHNICAL FIELDS SEARCHED (IPC)
E21D
H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 September 2022	Jucker, Chava

CATEGORY OF CITED DOCUMENTS

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