(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 144 921 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.03.2023 Bulletin 2023/10

(21) Application number: **22191500.2**

(22) Date of filing: **22.08.2022**

(51) International Patent Classification (IPC):
E02D 5/72 *(2006.01)* ***E02D 5/52*** *(2006.01)*
E02D 5/30 *(2006.01)* ***E04H 17/22*** *(2006.01)*
E04H 12/22 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
E02D 5/72; E02D 5/30; E02D 5/526

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **02.09.2021 FI 20214092 U**

(71) Applicant: **R Konsultointi Oy**
15500 Lahti (FI)

(72) Inventor: **Rönnblad, Göran**
15500 Lahti (FI)

(74) Representative: **Papula Oy**
P.O. Box 981
00101 Helsinki (FI)

(54) **ROCK SHOE**

(57) A rock shoe (1) to be joined to an end of a pile (20) by gluing or by means of joint members (6), which rock shoe comprises a bottom plate (2), to a front surface of which a point part (5) has been attached. The rock shoe (1) comprises a box (7) attached to the bottom plate (2), into which box the end of the pile (20) is insertable, and a clamping ring (10) arranged around the box (7) for clamping the box (7) against sides of the pile (20).

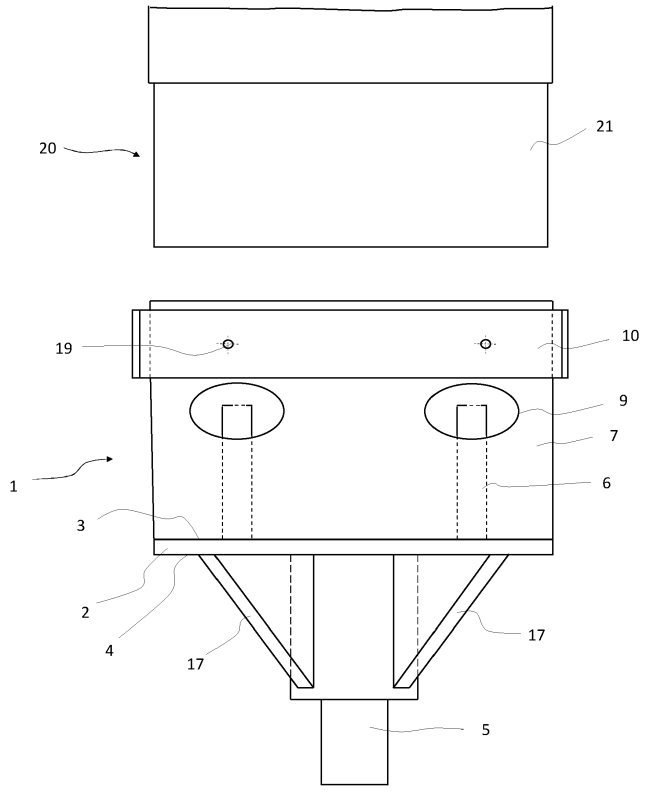

Fig. 1

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Description

[0001] This invention relates to a rock shoe according to the preamble of claim 1. The invention also relates to a pile according to the preamble of claim 8.

[0002] When a building is founded on loose soil, and it is not feasible to dig the soil out and replace it with a better base material, piling is a common type of foundation. A reinforced concrete pile is always provided with some type of tip protection in order that the concrete would not break from its corners when driven into the soil. The concrete piles are brought to a worksite by a lorry and are stored in proximity to the pile-driving site. A pile driver is a heavy tracked machine which is to be moved on the worksite as little as possible. The piles are generally fetched from a worksite store by hauling them with a long wire to the pile driver, whereby the driven end of the pile is trailed along the ground. The transport of the pile also requires protecting the tip of the pile.

[0003] Protection of the driven end of the pile is in its simplest form a bent thin plate. In Sweden, a sand shoe or so-called pile cap was standardized already in 1972. Protection of the driven end according to the standard has been disclosed in Finnish patent application FI20020402, Fig. 1. The application itself comprises a structural solution in which material use is more efficient.

[0004] In the Nordic countries (Finland, Sweden, Norway), the ice age shaped the soil producing a soil material called till. Boulders of various sizes have at that time been mixed into the soil material. The location and thickness of a till bed in the ground varies depending on how it was formed in the ice age. If such a bouldery layer must be penetrated with a driven pile, the sand shoe is no longer a sufficient protection means. When the bearing pile is driven to the bedrock, the underlying rock surface may be inclined. Thus, without a specially equipped driven end, the pile may slip sideways and break under bending stress. In Sweden, standard SIS 811196 was set for this purpose in 1972, which standard is still today applied in different forms. This so-called rock shoe is conical in shape in such a way that the side of the pile does not hit the inclined rock surface. The point part of the rock shoe is formed by a hardened dowel (standard SIS 811192) which has been fastened with a screw to a rigid sleeve welded with reinforcement plates to a bottom plate, a thickness of which is generally of the order of 20 mm.

[0005] Application FI20012026 discloses another way of reinforcing a bottom plate and attaching a point dowel to a shoe structure. This form of reinforcement displaces more of the packed till overlying the rock surface and is therefore easier to become damaged.

[0006] Looking at a pile-driving worksite after piling, piles of various lengths can often be seen rising from the ground. The pile is driven into the soil until at the final strokes it can be shown that it bears the loads according to plan. When the bearing layer is located at different depths, some length of a 12-16 m long standard pile always remains to be cut off. If the worksite is large, the driven piles can be cast in advance to a shorter length. In general, a precast concrete manufacturing plant has these shorter piles in store, because cast concrete requires approximately a month to achieve the final strength without chemical additives. The above-described rock shoe is cast onto the end of the standard pile. Thus, in order that the pile-driving worksite could be brought into action as promptly as possible, there must be a considerable number of different kinds of piles in store.

[0007] To reduce the pile store there are several solutions for retrofitting a rock shoe to the standard pile. However, a solution functioning in a desired manner is yet to be seen on worksites.

[0008] Swedish standard SIS 811197 from 1973 discloses a retrofittable rock shoe in which the standard point structure has been attached to a tall box which is wedged to a lower end of a standard pile. The rock shoe is exposed to considerable forces during installation of the pile both in a vertical and lateral direction, and these forces tend to break the end of the concrete pile.

[0009] Pile-driving guidelines PO2016 (RIL 254-2016) disclose the Finnish test requirements in part 2, chapter 3.9.4. The problem with a retrofittable rock shoe is the clearance remaining between the box of the rock shoe and the pile, which clearance is required in order that the box could be installed to the end of the pile. Concrete piles were manufactured for a long time outside in large battery moulds having side plates fastened to a bottom plate at regular intervals (Peter Alheid: Seminar paper: Betongpålar i Sverige, interior picture on page 7, pile seminar 2014). One had to be able to move on top of the mould e.g. by using planks, and the steel reinforcements and steel parts were installed between the side plates. The concrete mix exerted casting pressure on the side walls, and furthermore the finished product had to be removed from the mould. As a result, the moulds were no longer so accurate after extensive use. The allowed side dimension tolerance of a concrete pile has therefore been of the order of $\pm$ 10 mm, which must be taken into account in the clearance requirement. Thus, the wedging method as disclosed in the standard is in practice a much too unreliable way of fastening.

[0010] A rock shoe to be retrofitted to a ready-made pile is disclosed in publication WO 2007/080217, Fig. 6. A collar made from a thin plate engages the surface of a concrete pile by means of depressions made in the steel plate. When the end-bearing pile is driven to a hard base, a shock wave is reflected back from the tip of the pile as a tension wave which the joint between the rock shoe and the pile must be able to transmit. A required minimum value of resistance to the tensile force in the joint can be considered to be a yield force of 320 kN (corresponds to a mass of 32 tonnes) of the anchor rods of Swedish standard SIS 811196 (4 anchor rods d 16 material Ks40). It is clear that considering the manufacturing tolerances, the depressions as described in the application cannot transmit such tensile force.

[0011] Application FI 20185944 discloses a rock shoe fastened to a splice of a standard pile (Fig. 6). The application does not disclose a possible box of the rock shoe. The idea is to join a rock shoe to a regular splice, thus reducing storage need of the precast concrete manufacturing plant. The support wedges 203 of the rock shoe (support reinforcements under a bottom plate) are arranged in such a way that they support both of the structure of the rock shoe and the components of the joint system. The locking forces are transmitted via locking members, in the standard rock shoe the bottom plate is reinforced in a diagonal direction. In the solution, the reinforcement plate transmitting the driving forces from the point 202 to the pile 100 cannot be located at the lock housing 41. The soil material overlying the rock surface is generally packed till, and when piles are test driven into the soil and removed for testing, there is often a strong layer of till remaining between the reinforcements, which has bent the reinforcement plates. In the proposed solution the lock structure is located unprotected in a critical position exposed to considerable forces from the oblique rock surface and from the hard layer of soil overlying it. The locking structure is furthermore located outside the corrosion-protective concrete structure, so designing must be done with rust allowance (min. 2 mm / side) or with non-rusting lock parts, which would mean for standard piles, regardless of whether a point was joined to them or not, significant additional cost due to the material.

[0012] When safety factors against break are determined for the structures, it is an important consideration whether the functionality of the structure can be ensured afterwards. When a tens of meters long pile contacts an oblique rock surface, the final situation can generally not be verified. The current bearing capacity of the pile can only be estimated from the final driving forces. In Sweden, a method for ensuring that the rock shoe engages an oblique rock has been developed (Connie Olson & Göran Holm: Palgrundlaggning, 1993. Gö-terborgsmetoden, Fig. 4.21:6). A concrete pile is provided with a pipe enabling boring to the rock surface. The straightness of the pile can also be checked from the pipe. Artificial fills on coasts are another problem for driven piles because, in addition to boulders, the artificial fill may contain e.g. machine parts and other scrap. These problems can be solved by using bored piles, and when an obstacle is encountered it is cleared away.

[0013] The object of this invention is to provide an improved rock shoe and a pile equipped with the rock shoe.

[0014] The objective according to the invention is achieved with a rock shoe according to claim 1 and with a pile according to claim 8. The rock shoe according to the invention comprises a bottom plate, to a front surface of which a point part has been attached, and a box attached to the bottom plate, into which box the end of the pile is insertable. Further, the rock shoe comprises a clamping ring arranged around the box for clamping the box against sides of the pile.

[0015] The invention provides significant advantages. The rock shoe according to the invention is easily connectable to the end of a pile. Thereby the number of standard piles to be kept in store may be reduced. In case a need arises on the worksite to use a pile equipped with a rock shoe during piling, the rock shoe according to the invention may be brought to the worksite and joined to the end of the pile on the site.

[0016] The invention will be described below in more detail by way of examples, with reference to the accompanying drawings in which

Fig. 1 shows an end of a pile and a rock shoe according to one embodiment of the invention as a side view,

Fig. 2 shows the rock shoe of Fig. 1 as a top view,

Fig. 3 shows the rock shoe of Fig. 1 provided with a clamping ring according to another embodiment of the invention as a top view.

Fig. 4 shows a clamping part of the clamping ring of Fig. 3 as a side view, and

Fig. 5 shows the clamping part of Fig. 4 as a top view.

[0017] Fig. 1 and 2 show a rock shoe 1 according to one embodiment of the invention, which rock shoe is fixable to an end of a reinforced concrete pile 20 for example by gluing or by means of joint members. The pile may be square or rectangle shaped in cross-section. The end of the pile 20 may be equipped with a joint part 21 to which the rock shoe 1 is fixable. Alternatively, the rock shoe 1 may be fastened directly to the end of the pile 20 without the joint part 21, for example by gluing. The pile comprises reinforcement bars in a longitudinal direction of the pile, for example deformed bars, which are normally located in the concrete at corners of the pile.

[0018] The rock shoe 1 comprises a bottom plate 2, a back surface 3 of which is arranged against the end of the concrete pile to which the rock shoe 1 is to be fastened. The rock shoe 1 further comprises a point part 5 attached to a front surface 4 of the bottom plate 2. Support wedges 17 supporting the point part 5 have further been attached to the front surface 4 of the bottom plate 2. The rock shoe 1 is made from steel.

[0019] Joint members 6 have been fastened to the bottom plate 2 for fastening the rock shoe 1 to the joint part 21 of the end of the pile. The joint members 6 are located on an opposite side of the bottom plate 2 relative to the point part 5. There are at least two joint members 6. Typically there are four joint members, one at each corner of the bottom plate 2. In a rock shoe 1 intended for larger piles there may be eight joint members 6, one at each corner of the bottom plate 2 and one in the middle of each side of the bottom plate 2.

[0020] A first end of the joint member 6 has been joined to the bottom plate 2 for example by welding. A second

end of the joint member 6 is fixable to the joint part of the end of the pile, e.g. to a pile splice. The joint part 21 may comprise a locking member to which the second end of the joint member 6 is fitted and fastened.

[0021] The rock shoe 1 also comprises a collar-type box 7 extending away from the back surface 3 of the bottom plate 2. The box 7 is in cross-section of the same shape as the end of the pile, but is in internal diameter larger than the end of the pile. The box 7 encloses the joint members 6. The height of the box 7 may be greater than the length of the joint members 6. A first end of the box 7 has been fastened to the back surface or to the edges of the bottom plate 2. The box 7 is open at its second end, whereby the end of the pile may be inserted into the box 7. Also the first end of the box 7, i.e. the end to be fastened to the bottom plate, is open. The internal diameters of the box 7 are larger than the end of the pile, whereby the end of the pile is insertable in the box 7.

[0022] In conditions susceptible to corrosion, the empty spaces and/or weld holes of the box 7 may be filled with stiff material, for example petroleum jelly, preventing moisture from spreading inside the box 7.

[0023] On the sides of the box 7 there are openings 9 through which the position of the joint members 6 may be monitored and the joint members 6 guided in such a way that the joint members 6 fit the joint part 21 of the end of the pile when the pile is lowered onto the rock shoe 1. The openings 9 are located in alignment with the second ends of the joint members 6. The openings 9 may be located at corners of the box 7. In case the rock shoe 1 is glued to the end of the pile 20, excess glue may exit through the openings 9. When the pile has been fastened to the rock shoe 1, the empty spaces at the corners of the box 7 may be filled with a filling material, for example grouting mortar, epoxy glue etc. The filling material may be fed into the box 7 through the openings 9.

[0024] The corners of the box 7 may be partly open. The open corner portions 18 extend from the second end of the box 7 towards the first end. The open corner portions 18 make the box 7 more flexible, whereby the sides of the box 7 may be clamped against the sides of the pile. When the box 7 is not clamped, there is a clearance between the sides of the box 7 and the sides of the pile, the extent of which clearance is typically 2-5 mm.

[0025] The rock shoe 1 comprises a clamping ring 10 for clamping/pressing the box 7 against sides of the pile either directly or indirectly, for example by means of shims 11. The clamping ring 10 has been arranged around the box 7, typically at the second end of the box 7. The clamping ring 10 has been positioned at the open corner portions 18 of the box 7. The length of the open corner portions 18 of the box 7 is greater, typically 1-3 cm greater, than the height of the clamping ring 10.

[0026] In the embodiment of Fig. 1 and 2, the clamping ring 10 is placed around the box 7 at the second end of the box 7. The clamping ring 10 comprises screw holes 19, whereby the clamping ring 10 has been fastened to the box 7 by means of screws, for example self-drilling screws. Between the clamping ring 10 and the box 7 on each side there is a clearance, the extent of which is typically 2-3 mm. Shims 11 may be inserted in the clearances, which shims press the box 7 against the sides of the pile. There may be shims on only two sides of the box 7. In this case the shims 11 may be thicker and their handling easier. A lower edge of the shims 11 may also be made wedge-shaped for example by grinding. The shims 11 may be driven into the clearances with a hammer. Alternatively, the clamping ring 10 may be driven onto the wedge-shaped shims 11 for example with a small sledgehammer.

[0027] Alternatively the rock shoe 1 may be provided with a clamping ring 10 according to Fig. 3-5. The box 7 shown in Fig. 3 may be like that of the embodiment of Fig. 1 and 2. Likewise the bottom plate 2, the point part 5, the support wedges 17 and/or the joint members 6 of the rock shoe 1 of Fig. 3 may be like those of the embodiment of Fig. 1 and 2. The clamping ring 10 comprises four clamping parts 12. One clamping part 12 has been arranged against each side of the box 7. The clamping parts 12 have been attached to each other at each corner of the box 7.

[0028] In the middle of the clamping part 12 there is a middle part 12.1 arranged against the side of the box. The middle part 12.1 is straight. The middle part 12.1 is shorter than the side of the box 7 against which the middle part 12.1 is arranged.

[0029] At both ends of the clamping part 12 there are end parts 12.2 which are inclined relative to the middle part 12.1. The end parts 12.2 are directed away from the box 7. The end parts 12.2 are at an obtuse angle α, for example at an angle α of 120-160 degrees relative to the middle part 12.1. The clamping parts 12 on adjacent sides of the box 7 are attached to each other by the end parts 12.2. At the corners of the box 7, the ends of adjacent end parts 12.2 abut against each other. In the end parts 12.2 there are holes 13, for example elongated holes, for clamping screws 14.

[0030] A clamping screw 14 is inserted through the holes 13 of adjacent end parts 12.2. Nuts 15 are screwed onto both ends of the clamping screw 14. Between the nut 15 and the end part 12.2 there is a washer 16. When the nuts 15 are tightened, the end parts 12.2 abut against each other. The obliquity of the clamping screw 14 relative to the washers 16 may be adjusted by changing the length of the end parts 12.2, by placing an additional plate between ends of the end parts 12.2 and/or by using a washer 16 which is thicker or thinner from the side towards the end of the end part 12.2 than from the opposite side towards the middle part 12.1. The nuts 15 are first tightened in such a way that the clearances are removed. Thereby, at each corner of the box 7, there are openings of approximately the same size between the end parts 12.2. Finally, the nuts 15 are tightened to a desired tightening torque for example with a torque wrench.

[0031] Before installing the end of the pile 20 to the box 7, the inner surfaces of the box 7 and the end of the

pile 20 are cleaned. If necessary, dirt, for example dried laitance etc., is removed for example with a wire brush. A layer of mortar or glue may be arranged on the inner surfaces of the box 7. At a precast concrete manufacturing plant the rock shoe 1 is installed with a jack to the end of the pile in a horizontal position, while supporting the other end of the pile. On a worksite, the rock shoe 1 is installed in a vertical position. In this case the rock shoe 1 is supported for example with the installation box (bottom plate, side plates and support blocks) to the vertical position and the pile is dropped for example by a pile driver into the box 7 of the rock shoe.

[0032] When the end of the pile has been inserted into the box 7, the sides of the box 7 are clamped against the sides of the pile with the clamping ring 10 in the above-described manner. When the pile has been fastened to the rock shoe 1, the empty spaces at the corners of the box 7 may be filled with a filling material, for example grouting mortar, epoxy glue etc. The filling material is fed into the box 7 through the openings 9 on the sides.

Claims

1. A rock shoe (1) to be joined to an end of a pile (20) by gluing or by means of joint members (6), which rock shoe comprises a bottom plate (2), to a front surface (4) of which a point part (5) has been attached, **characterized in that** the rock shoe (1) comprises a box (7) attached to the bottom plate (2), into which box the end of the pile (20) is insertable, and a clamping ring (10) arranged around the box (7) for clamping the box (7) against sides of the pile (20).

2. The rock shoe (1) according to claim 1, **characterized in that** the clamping ring (10) comprises four clamping parts (12) arranged against sides of the box (7) and attached to each other at corners of the box (7).

3. The rock shoe (1) according to claim 2, **characterized in that** in the middle of the clamping part (12) there is a straight middle part (12.1) arranged against a side of the box (7), at both ends of the clamping part (12) there are end parts (12.2) which are inclined relative to the middle part (12.1), and the clamping parts (12) on adjacent sides of the box (7) have been attached to each other by the end parts (12.2).

4. The rock shoe (1) according to claim 1, **characterized in that** the clamping ring (10) has been fastened to the sides of the box (7) with screws, and between the clamping ring (10) and the sides of the box (7) there are gaps into which shims (11) have been inserted.

5. The rock shoe (1) according to any one of the preceding claims, **characterized in that** the corners of the box (7) are partly open, and the clamping ring (10) has been arranged at the open corner portions (18).

6. The rock shoe (1) according to any one of the preceding claims, **characterized in that** joint members (6) have been fastened to the bottom plate (2) for fastening the rock shoe (1) to a joint part (21) at the end of the pile (20).

7. The rock shoe (1) according to any one of the preceding claims, **characterized in that** on the side of the box (7) there are openings (9) for monitoring the position of the joint members (6) and/or for guiding the joint members (6) and/or for removing excess glue from the box (7) and/or for adding glue or mortar into the box (7).

8. A pile (20), an end of which is equipped with a joint part (21), **characterized in that** the rock shoe (1) according to any one of the preceding claims 1-7 has been fastened to the end of the pile (20), a clamping ring (10) having been arranged around the box (7) of the rock shoe (1) for clamping the box (7) against sides of the pile (20).

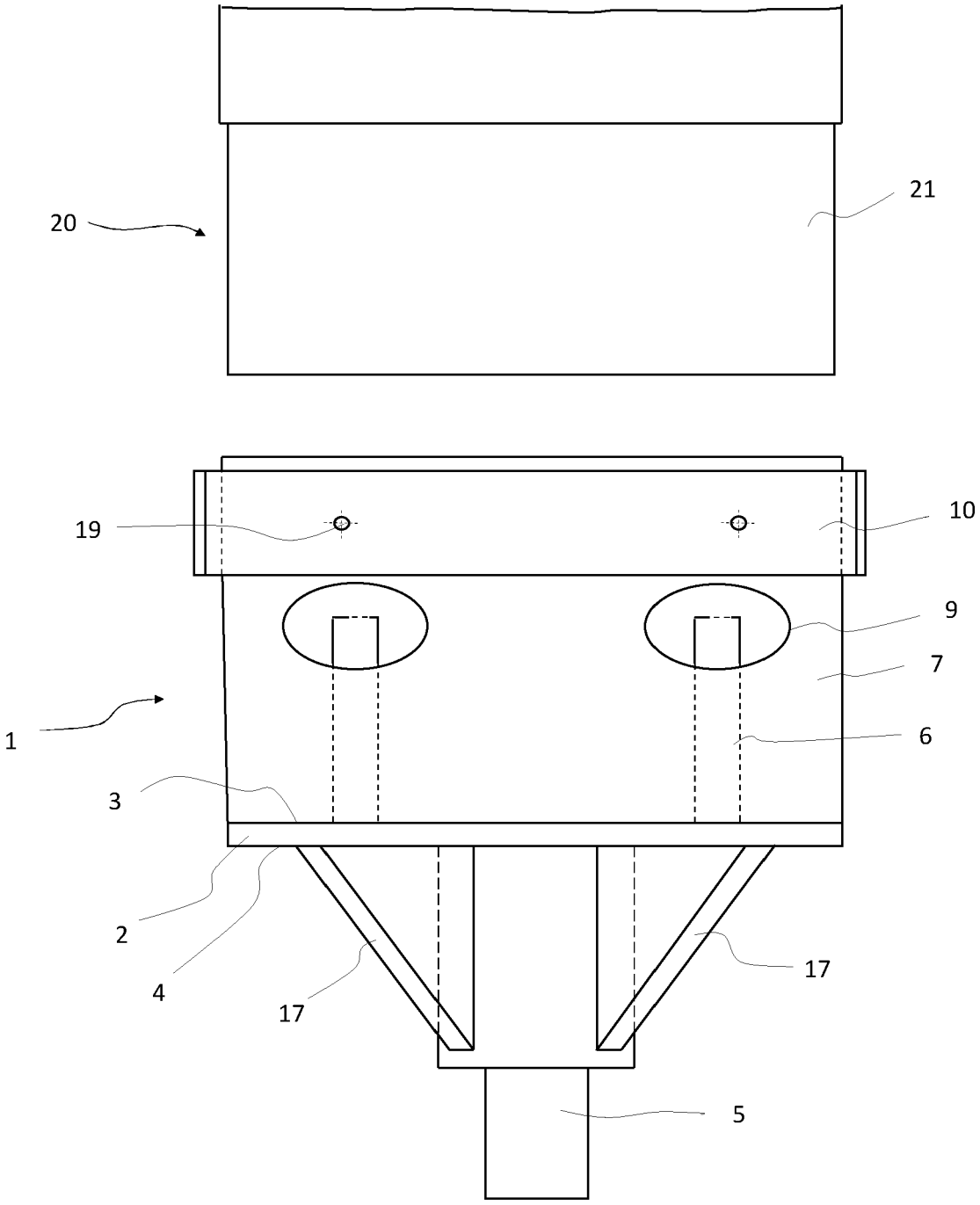

Fig. 1

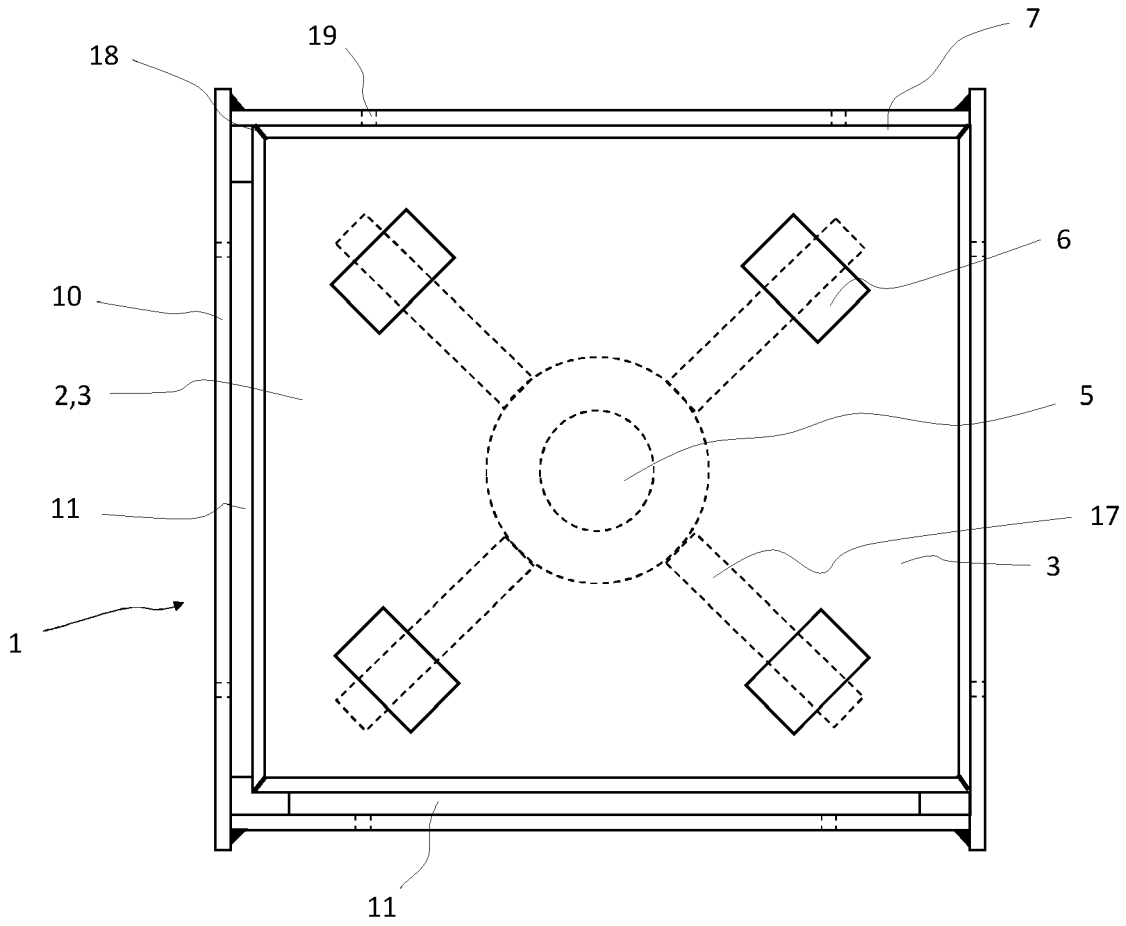

Fig. 2

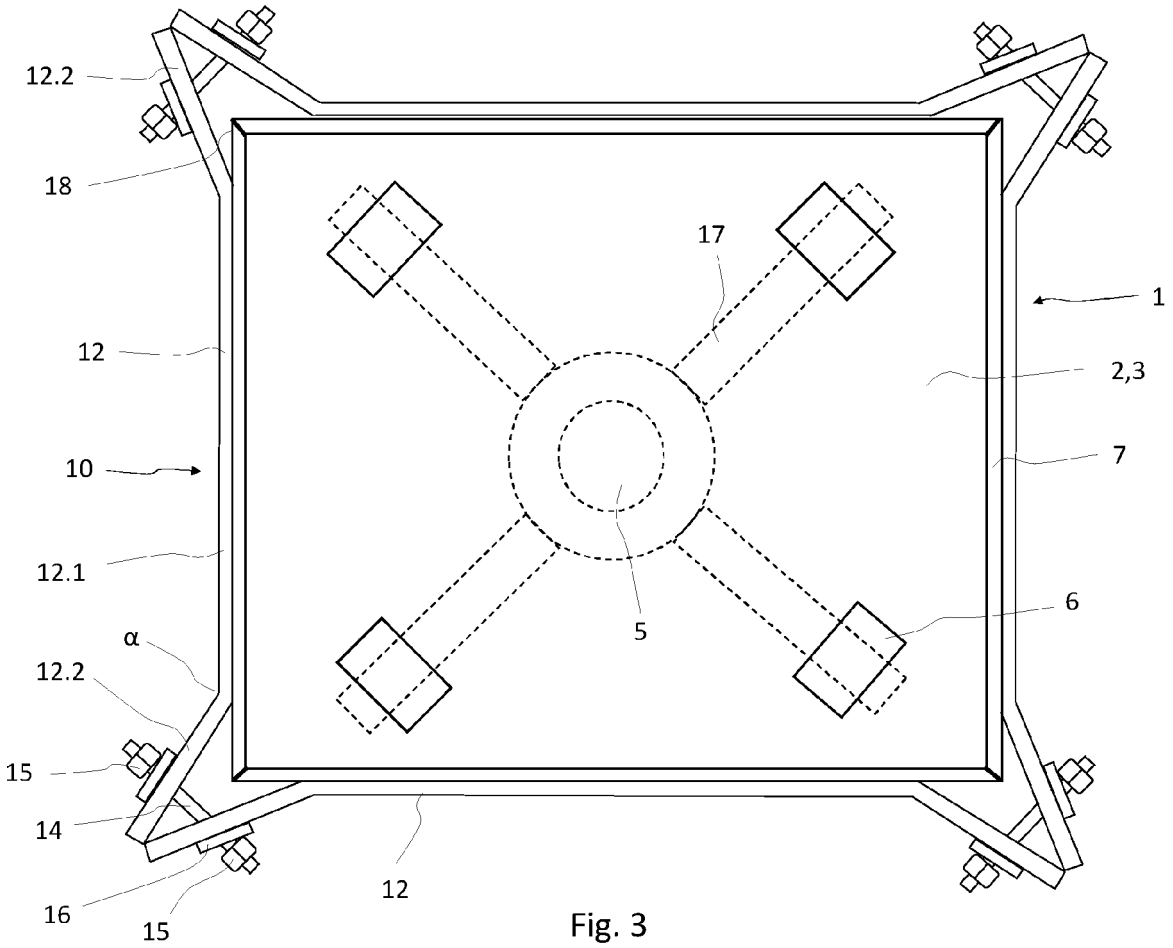

Fig. 3

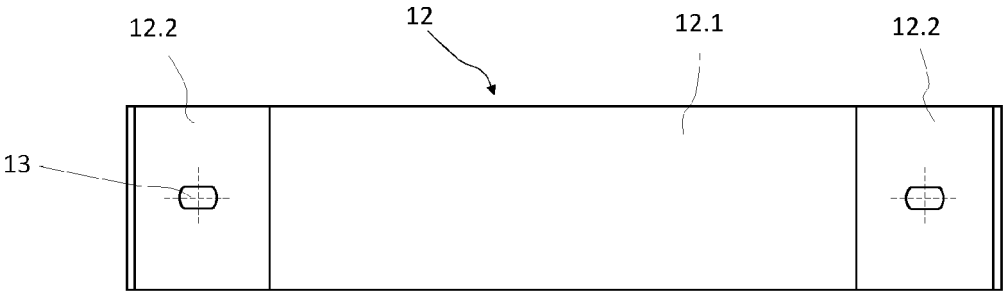

Fig. 4

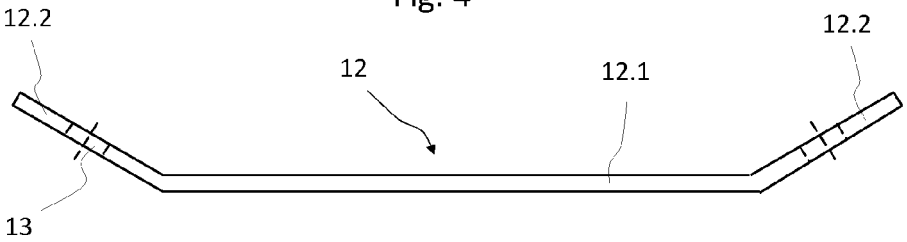

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 1500

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TECHNICAL FIELDS SEARCHED (IPC)

E02D
E04H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 January 2023	Koulo, Anicet

CATEGORY OF CITED DOCUMENTS

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