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(54) Drilling device

(57) Drilling device for in situ mixing of soil with a binder to form a pile in the ground, comprising

- a drivable shaft with a bottom end (2),
- means mounted (3,9) at the bottom end of the shaft for loosening the soil;
- injection means for injecting the binder into the loosened soil;

wherein a bore-crown (4) is further mounted on the shaft, which bore-crown is provided on at least a part of its periphery with cutting means (6) for overcutting a pile adjacent to the pile for forming.

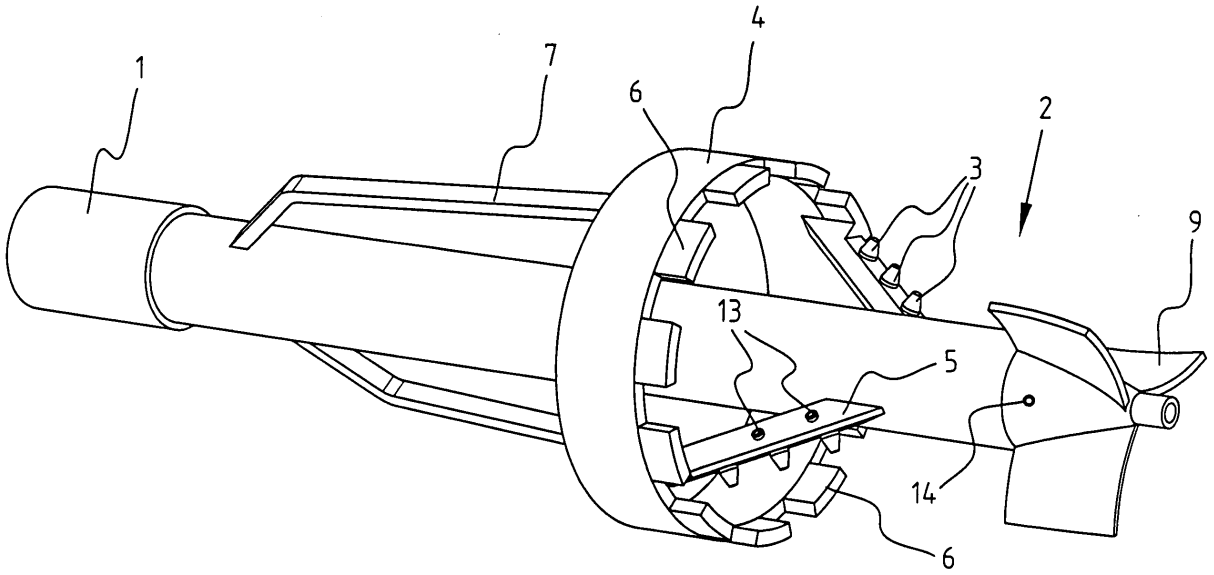

FIG. 1

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Description

[0001] The present invention relates to a drilling device for in situ mixing of soil with a binder to form in each case a pile in the ground, comprising a drivable shaft with a bottom end, means mounted at the bottom end of the shaft for loosening the soil and injection means for injecting the binder into the loosened soil.

[0002] Such drilling devices are generally known and are typically used in ground improvement and the construction of earth-retaining walls, such as a sheet piling for a pit excavation. An example of such a drilling device is described in, among others, US 5,368,415. The known devices generally have the drawback that they display problems when adjacent, possibly already partly hardened piles must be partly overcut in order to form a closed wall. In addition, many helical mixing blades are usually required to achieve a good mixing of the soil with the binder, particularly when working in clay soils.

[0003] The invention has for its object to provide a drilling device of the type stated in the preamble, with a simple structure, with which piles can be formed by in situ mixing, and adjacent piles can be overcut without problem.

[0004] For this purpose the drilling device according to the invention is distinguished in that a bore-crown is mounted on the shaft, which is provided on at least a part of its periphery with cutting means for overcutting a pile adjacent to the pile for forming. By providing a bore-crown adjacent piles can be overcut, while a pile is simultaneously formed by in situ mixing.

[0005] According to a preferred embodiment, the cutting means comprise a number of cutting teeth distributed regularly along the periphery of the bore-crown such that sufficiently neat outer contours are obtained for the pile.

[0006] The bore-crown is preferably mounted on the shaft by means of a bracket. This bracket provides for a strengthening of the drilling device and ensures a further mixing of the material situated above the bore-crown as seen in axial direction.

[0007] The means for loosening the soil preferably comprise an array of first teeth which are arranged at a distance from the shaft and which are located substantially under the bore-crown. These teeth have substantially the function of a rake with which the soil is loosened. These teeth must be oriented such that optimum loosening of the soil is obtained, and will for instance be oriented substantially perpendicularly of the at least one arm.

[0008] According to a possible embodiment, the first teeth are arranged on at least one arm which extends substantially between the shaft and the bore-crown and which is preferably oriented obliquely downward from the bore-crown. In this manner the teeth can readily be placed at different distances from the shaft.

[0009] The means for loosening the soil can also comprise a number of second teeth, which are arranged around the shaft close to the bottom end thereof. These second teeth serve for the first central cutting into the soil for loosening.

[0010] According to a further developed embodiment, there are provided spray nozzles for enhancing loosening and mixing of the soil. In order to also achieve a good mixing of the material above the bore-crown, and to avoid the drilling device getting stuck when used in clay soils, it is recommended to provide first spray nozzles which are oriented substantially upward from the plane of the bore-crown. These spray nozzles can for instance be arranged along the periphery of the bore-crown.

[0011] Second spray nozzles can further be provided in the vicinity of the means for loosening the soil. A first number thereof can thus be arranged for instance close to the first teeth and a second number thereof close to the second teeth. These second spray nozzles likewise contribute toward a good mixing of the soil with the binder.

[0012] According to yet another variant, mixing means for mixing the loosened soil can be provided above the bore-crown as seen in axial direction. These mixing means can for instance comprise mixing arms or helical mixing blades.

[0013] Drive means are preferably provided for driving the shaft at a speed of 50 to 180 revolutions per minute. This is a speed which is higher than the usual speed for normal drilling installations and which ensures that a good mixing is achieved.

[0014] The invention further relates to a multi-shaft drilling installation comprising at least two drilling devices according to the invention, wherein the two drilling devices are mounted such that partially overlapping piles can be formed.

[0015] According to a preferred embodiment, the shafts of the at least two drilling devices are accommodated in a fixed support structure. This support structure provides for additional stabilization of the drilling devices, particularly when drilling takes place in difficult soils.

[0016] According to a possible embodiment, the bore-crown of a first drilling device, as seen in the plane of the shafts, is mounted higher than the bore-crown of a second adjacent drilling device, wherein the bore-crowns partly overlap each other as seen in a perpendicular projection onto a plane lying perpendicularly of the shafts.

[0017] In a first drilling device with a bracket this bracket preferably has axial dimensions which are considerably greater than those of the bracket of an adjacent second drilling device. In this manner overlapping piles can be formed without the brackets of two adjacent drilling devices impeding each other.

[0018] According to a further developed embodiment of this variant, the second drilling device with the bracket with smaller axial dimensions is provided above the bracket with mixing arms mounted on its shaft. These mixing arms compensate the loss of mixing capacity resulting from the smaller bracket.

[0019] The first drilling device is further preferably axially displaceable relative to the second drilling device, wherein this axial displacement can be controlled as a function of the diameter of the piles for forming.

[0020] Finally, it is advantageous in some cases when the bottom end of the shaft of the first drilling device with larger bracket is located lower than the bottom end of the adjacent second drilling device, although this will of course depend on the dimensions of the two drilling devices. With this measure a better guiding of the drilling installation is after all achieved since the first drilling device engages in the as yet unloosened soil.

[0021] The invention will now be further elucidated on the basis of the following figure description of a number of exemplary embodiments, which have in no way a limiting character, and which are illustrated in the accompanying figures, in which:

figure 1 is a perspective view of a first embodiment of a drilling device according to the invention;
figure 2 is a perspective view of a second embodiment of a drilling device according to the invention;
figure 3 is a schematic front view of a third embodiment of a drilling device according to the invention;
figure 4 is a schematic bottom view of the third embodiment of figure 3;
figure 5 is a perspective view of a first embodiment of a two-shaft drilling installation according to the invention; figure 6 is a schematic front view of a second embodiment of a two-shaft drilling installation according to the invention; figure 7 is a schematic front view of an embodiment of a three-shaft drilling installation according to the invention.

[0022] Figure 1 shows a drilling device for in situ mixing of soil with a binder for the purpose of forming a pile in the ground. In the figure can be seen a rotatingly drivable shaft 1 with a bottom end 2. Mounted on the side of bottom end 2 of shaft 1 are means for loosening the soil, which here consist of:

- an array of first teeth 3 which are arranged at a distance from the shaft and which are arranged on two arms 5;
- a number of mixing blades 9 which are arranged around shaft 1, close to the bottom end thereof.

[0023] Further mounted on the shaft is a bore-crown 4 which is provided on its periphery with cutting teeth 6 for overcutting a pile adjacent to the pile for forming. The cutting teeth can for instance take the form of a number of cutting blocks oriented substantially axially downward, but can also be for instance obliquely oriented teeth. This overcutting will be better understood with reference to figures 8a and 8b, which show how a series of mutually adjacent piles can be obtained using a drilling device according to the invention. The bore-crown is mounted on shaft 1 by means of a bracket 7. This bracket brings about strengthening of the whole and during drilling also contributes toward a further mixing of the binder with the soil above bore-crown 4.

[0024] In the embodiments shown in figures 1, 2 and 3 the bracket has a longer form in axial direction than is usual in order to enhance this mixing. This bracket can however also be given a shorter form, in which case it is recommended to provide additional mixing means. As shown in the schematic view of a two-shaft drilling installation of figure 6, in the case of second drilling device B mixing arms 10a-c are provided as seen in axial direction above bracket 7', which arms partly fulfill the function of the larger bracket 7 of first drilling device A.

[0025] The binder is injected through hollow shaft 1 into the loosened soil (at 16 in figure 3) at the bottom of this hollow shaft. This is a known principle for drilling devices for in situ mixing, and will therefore not be described here in detail.

[0026] In order to further enhance loosening of the soil and/or mixing of the soil with the binder, binder can be injected at different positions in the vicinity of the drilling device. In the variants shown in figures 1-4 this takes place using a number of spray nozzles:

- first spray nozzles 12 (shown in broken lines in figure 3), each with an outlet and oriented substantially upward relative to the bore-crown. In the shown embodiments these are arranged on the inside of bore-crown 4, but these spray nozzles can also be arranged in other manner, wherein all that is important is that they spray in the direction of the matter located above bore-crown 4;
- second spray nozzles 13, 14 in the vicinity of means 5, 8, 9 for loosening the soil, of which a number of second spray nozzles 13 are arranged between and/or behind the first teeth, and another number of second spray nozzles 14 are provided close to mixing blades 9 (figure 1) or close to the second teeth 8 (figures 2-4).

[0027] Figures 5 and 6 illustrate embodiments of a two-shaft drilling device according to the invention. This comprises a first drilling device A, which has already been explained with reference to figures 2-4, and a second drilling device B. The second drilling device B differs from the first drilling device A in that its bracket 7', as seen in axial direction, is shorter than bracket 7 of the first drilling device. In this manner brackets 7 and 7' do not touch each other during the rotation of shafts 1, 1'. These two drilling devices are mounted such that two partially overlapping piles can be formed.

[0028] The method for forming two such piles is illustrated in figures 8a and 8b, which show how a series of adjacent piles can be arranged to form for instance a sheet piling for a pit excavation. The figure shows the step in which two piles 20a and 20b are formed simultaneously by the two-shaft drilling installation. A pile 20c, which has been formed together with pile 20d during a previous step, is herein partly overcut in grey coloured area 21 of pile 20c. This overcutting takes place without problem owing to the presence of bore-crown 4' of the second drilling device B.

[0029] The drivable shafts 1, 1' of drilling devices A, B of figures 5 and 6 are accommodated in a fixed support structure 15 which imparts extra stability to the whole. As seen in axial direction, bore-crown 4 of the first drilling device A is in a higher position than bore-crown 4' of the second adjacent drilling device B and, as seen in a perpendicular projection onto a plane perpendicularly of the shafts, bore-crowns 4, 4' overlap each other partly to form two partially overlapping piles 20a, 20b. Additional mixing blades 10a-c are further provided in the second drilling device B, above bracket 7', so as to further enhance the mixing.

[0030] Figure 7 finally shows a three-shaft drilling installation comprising three drilling devices A, B, C. The skilled person will understand that, depending on the desired applications and the available drive means, one-, two-, three- or multi-shaft installations can be provided, and that the invention is not limited to the above exemplary embodiments.

Claims

1. Drilling device for in situ mixing of soil with a binder to form a pile in the ground, comprising

   - a drivable shaft with a bottom end,
   - means mounted at the bottom end of the shaft for loosening the soil;
   - injection means for injecting the binder into the loosened soil;

   characterized in that a bore-crown is further mounted on the shaft, which bore-crown is provided on at least a part of its periphery with cutting means.

2. Drilling device as claimed in claim 1, **characterized in that** the cutting means comprise cutting teeth distributed regularly along the periphery of the bore-crown.

3. Drilling device as claimed in claim 1 or 2, **characterized in that** the bore-crown is mounted on the shaft by means of a bracket.

4. Drilling device as claimed in any of the claims 1-3, **characterized in that** the means for loosening the soil comprise an array of first teeth arranged at a distance from the shaft.

5. Drilling device as claimed in claim 4, **characterized in that** the first teeth are arranged on at least one arm which extends substantially between the shaft and the bore-crown.

6. Drilling device as claimed in claim 5, **characterized in that** the first teeth are oriented substantially perpendicularly of the at least one arm.

7. Drilling device as claimed in claim 6, **characterized in that** the means for loosening the soil comprise a number of second teeth, which are arranged around the shaft close to the bottom end thereof.

8. Drilling device as claimed in any of the foregoing claims, **characterized in that** spray nozzles are provided for the purpose of enhancing loosening and mixing of the soil.

9. Drilling device as claimed in claim 8, **characterized in that** first spray nozzles are provided which are oriented substantially upward from the plane of the bore-crown.

10. Drilling device as claimed in claim 9, **characterized in that** the first spray nozzles are arranged along the periphery of the bore-crown.

11. Drilling device as claimed in any of the claims 8-10, **characterized in that** second spray nozzles are provided in the vicinity of the means for loosening the soil.

12. Drilling device as claimed in claim 11 and any of the claims 4-6, **characterized in that** a number of second spray nozzles are provided on the at least one arm on which the first teeth are arranged.

13. Drilling device as claimed in claims 7 and 11 or 12, **characterized in that** a number of second spray nozzles are provided close to the second teeth.

14. Drilling device as claimed in any of the foregoing claims, **characterized in that** mixing means for mixing the loosened soil are provided above the bore-crown.

15. Drilling device as claimed in claim 14, **characterized in that** the mixing means comprise mixing arms mounted on the shaft.

16. Drilling device as claimed in any of the foregoing claims, **characterized in that** drive means are provided for driving the shaft at a speed of 50 to 180 revolutions per minute.

17. Multi-shaft drilling installation, comprising at least two drilling devices as claimed in any of the foregoing claims, wherein the two drilling devices are mounted such that partially overlapping piles can be formed.

18. Multi-shaft drilling installation as claimed in claim 17, **characterized in that** the shafts of the at least two drilling devices are accommodated in a fixed support structure.

19. Multi-shaft drilling installation as claimed in claim 17

or 18, **characterized in that** the bore-crown of a first drilling device, as seen in the plane of the shafts, is mounted higher than the bore-crown of a second adjacent drilling device of the at least two drilling devices, wherein the bore-crowns partly overlap each other as seen in a perpendicular projection onto a plane lying perpendicularly of the shafts.

20. Multi-shaft drilling installation as claimed in any of the claims 17-19, **characterized in that** the bracket of a first drilling device of the at least two drilling devices has axial dimensions which are considerably greater than those of an adjacent second drilling device.

21. Multi-shaft drilling installation as claimed in claim 20, **characterized in that** the second drilling device with the bracket of smaller axial dimensions is provided above the bracket with mixing blades mounted on its shaft.

22. Multi-shaft drilling installation as claimed in any of the claims 17-21, **characterized in that** the bottom end of the shaft of a first drilling device of the at least two drilling devices is located further downward relative to the bottom end of an adjacent second drilling device.

23. Multi-shaft drilling installation as claimed in any of the claims 17-22, **characterized in that** a first drilling device of the at least two drilling devices is axially displaceable relative to an adjacent second drilling device.

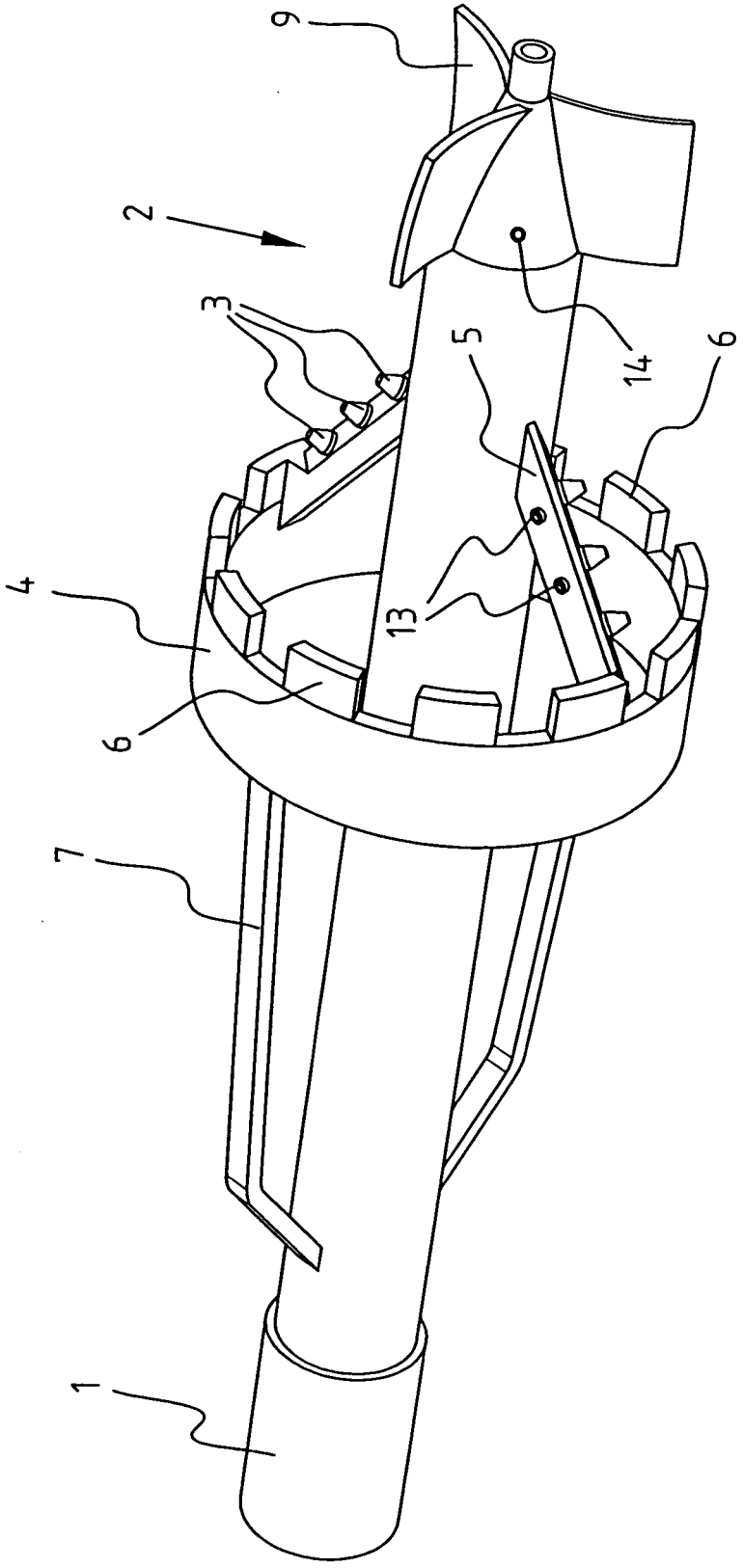

FIG. 1

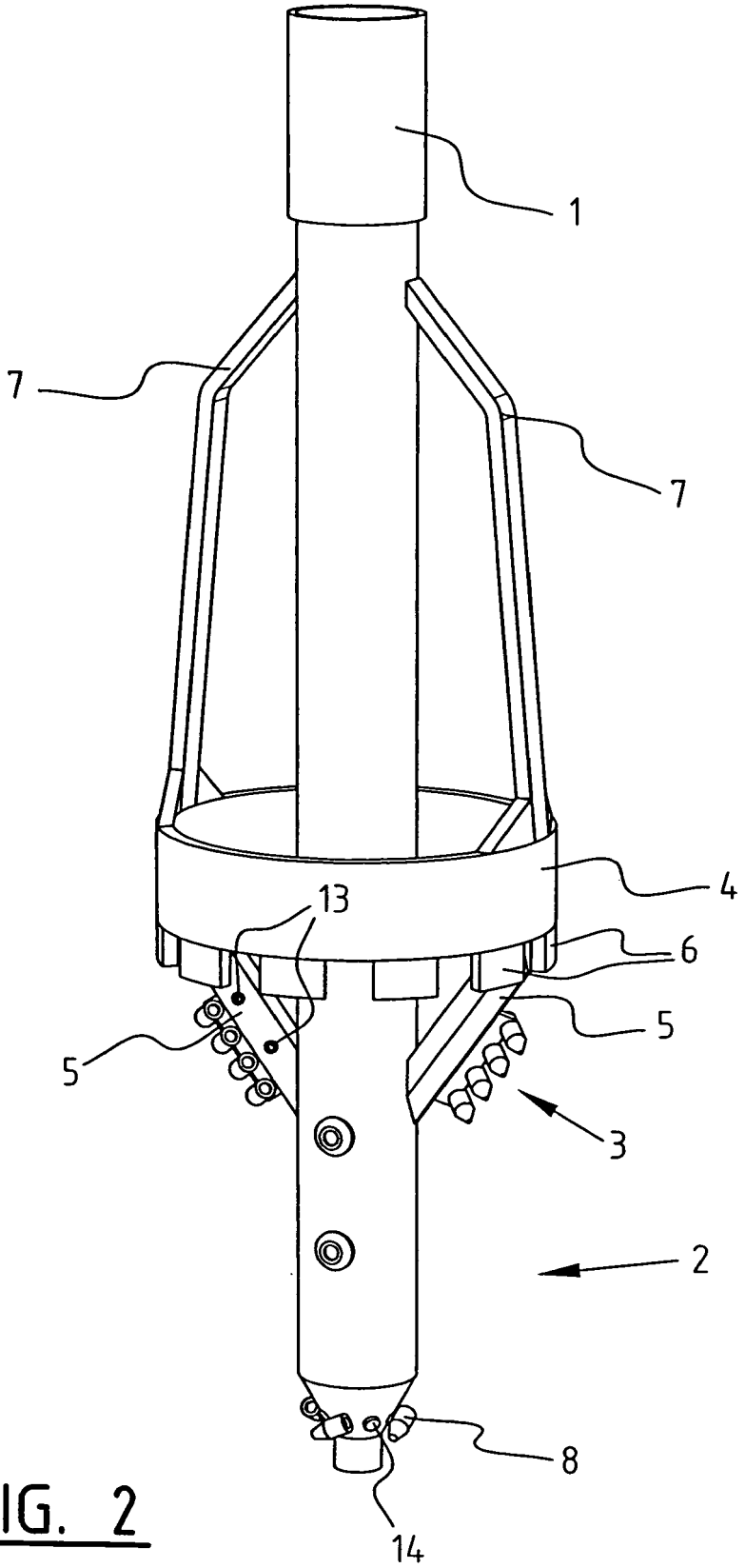

FIG. 2

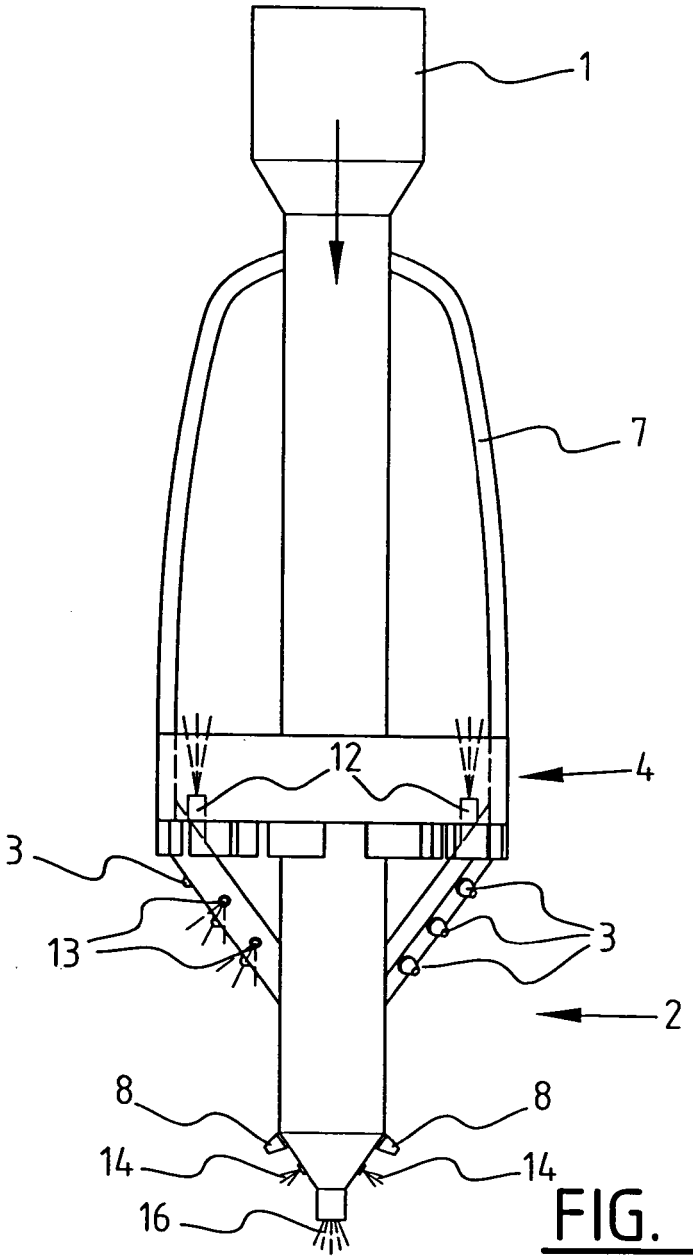

FIG. 3

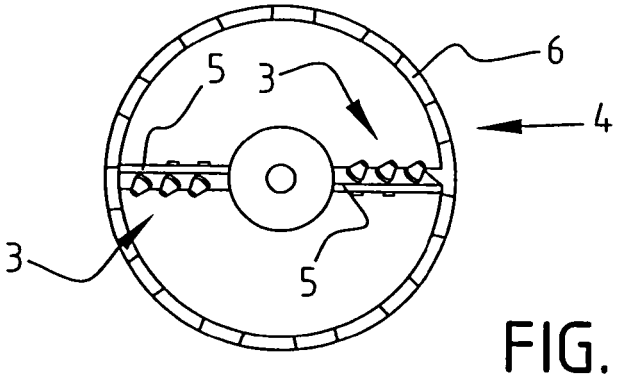

FIG. 4

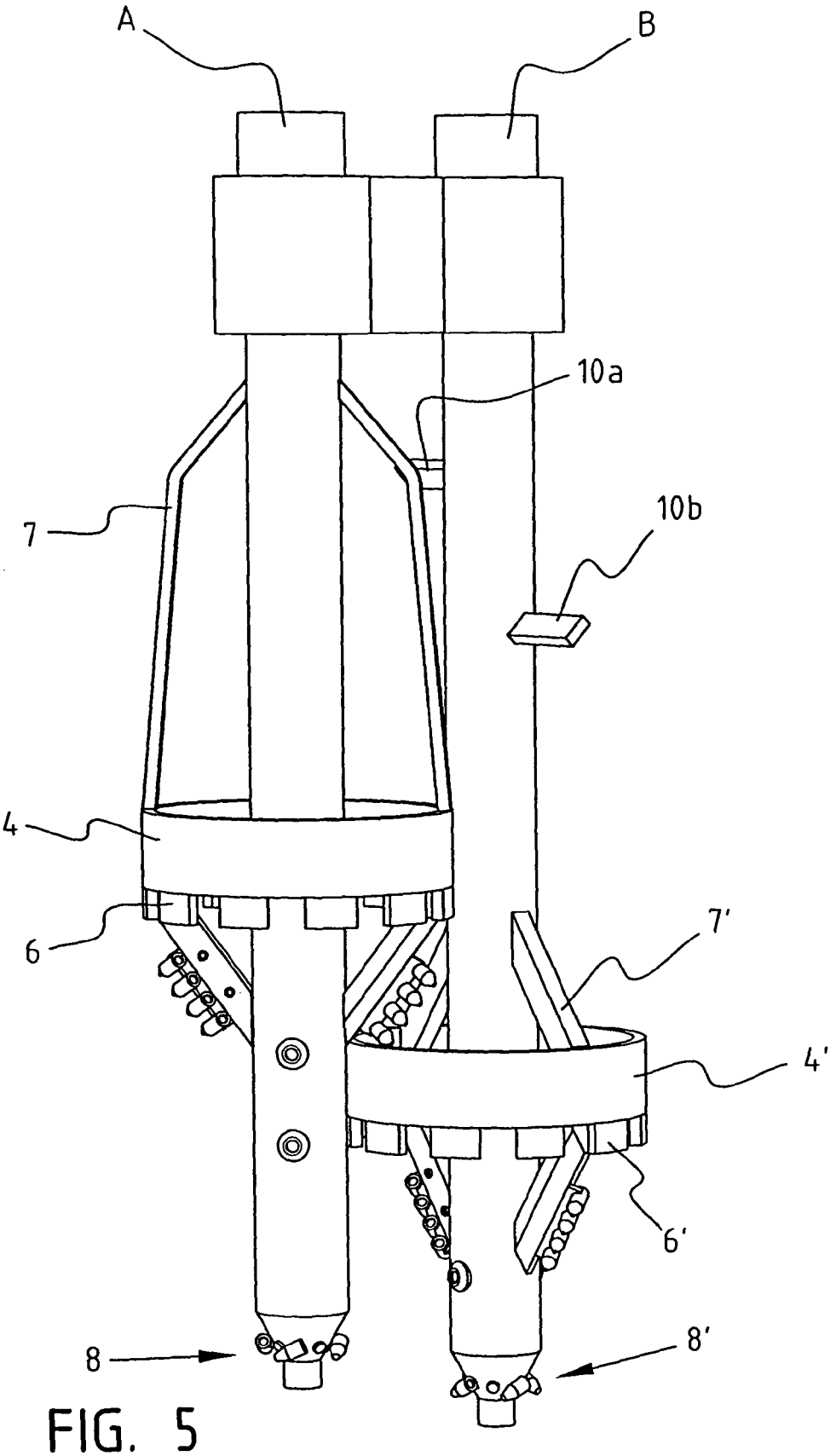

FIG. 5

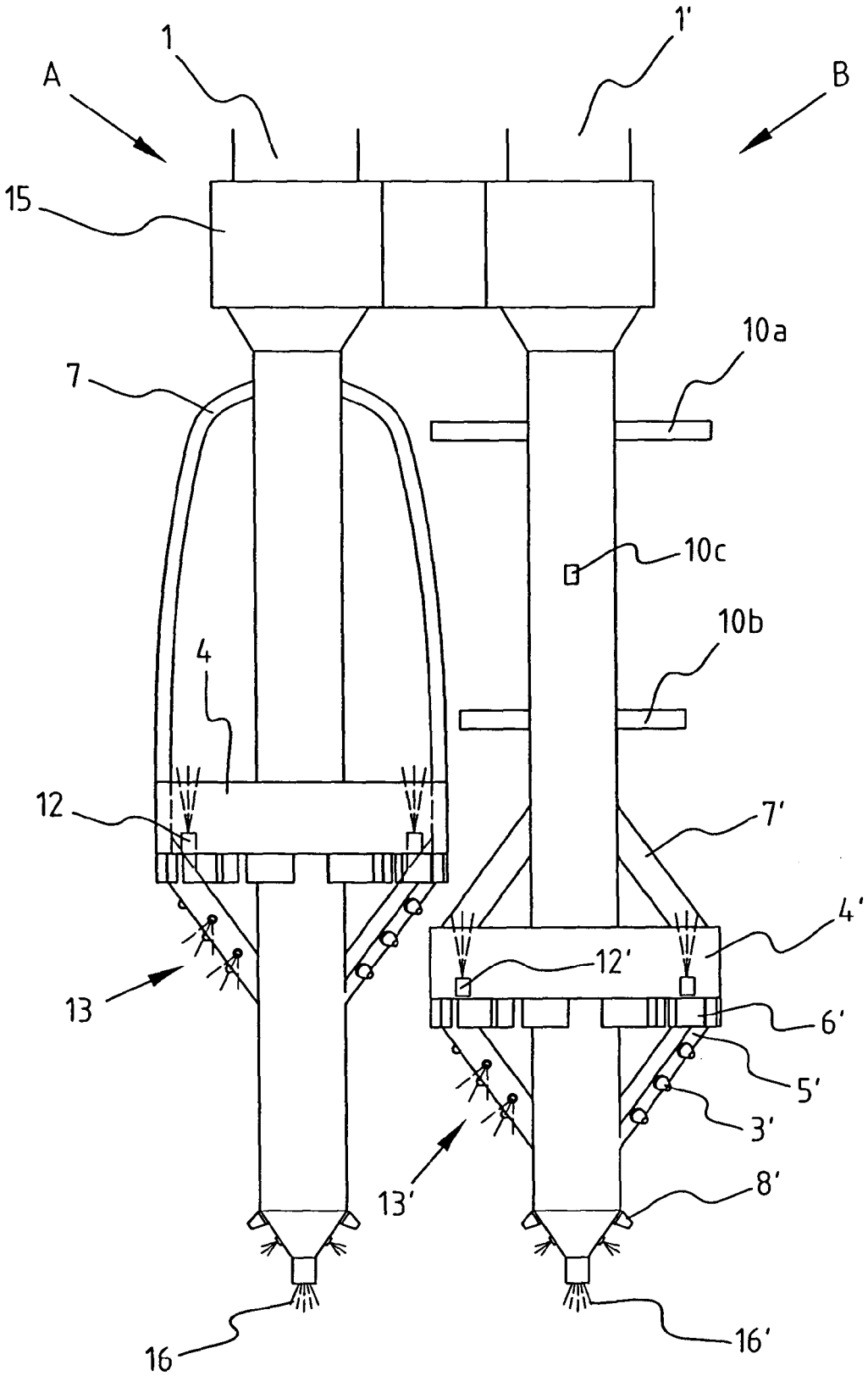

FIG. 6

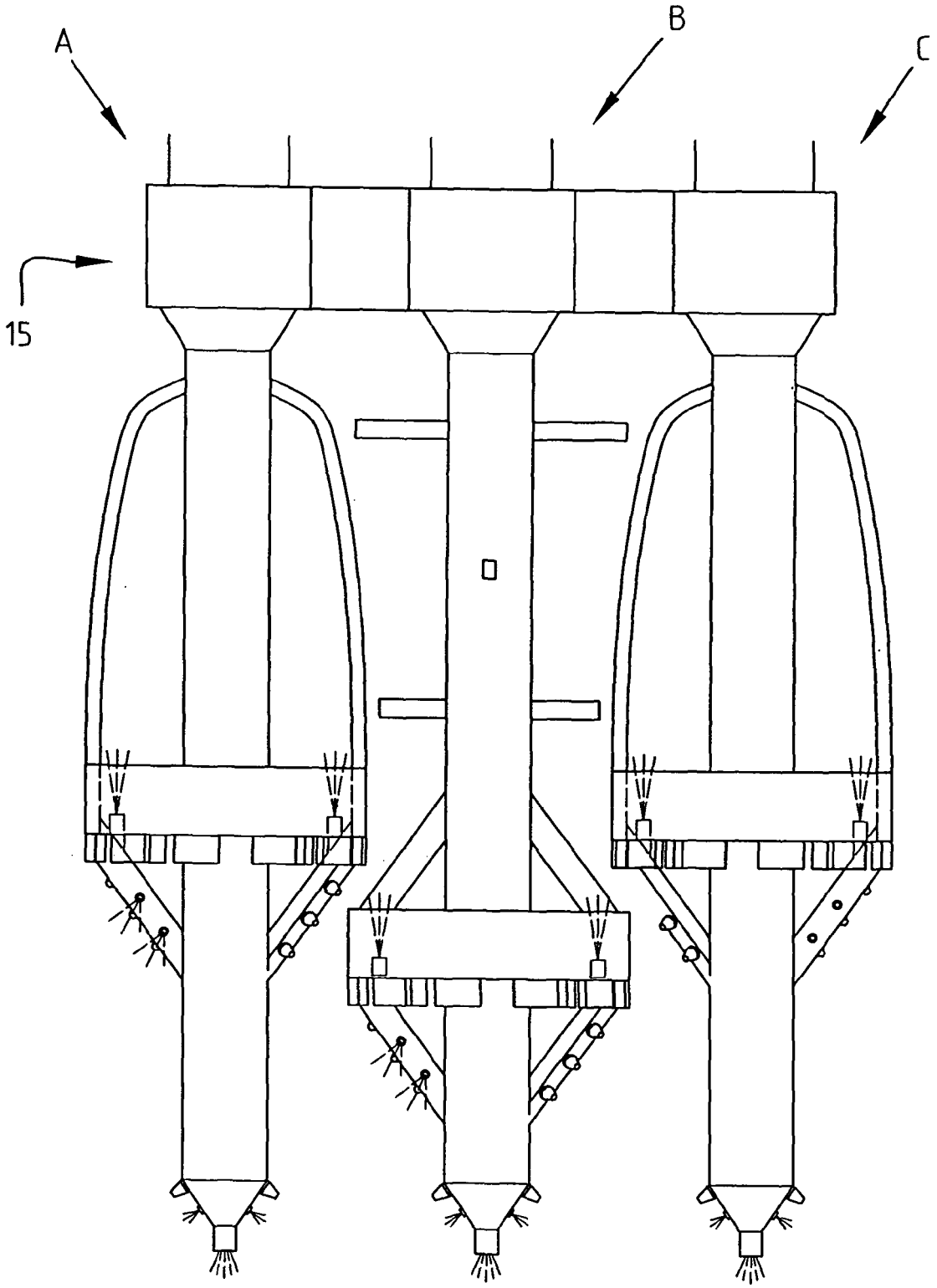

FIG. 7

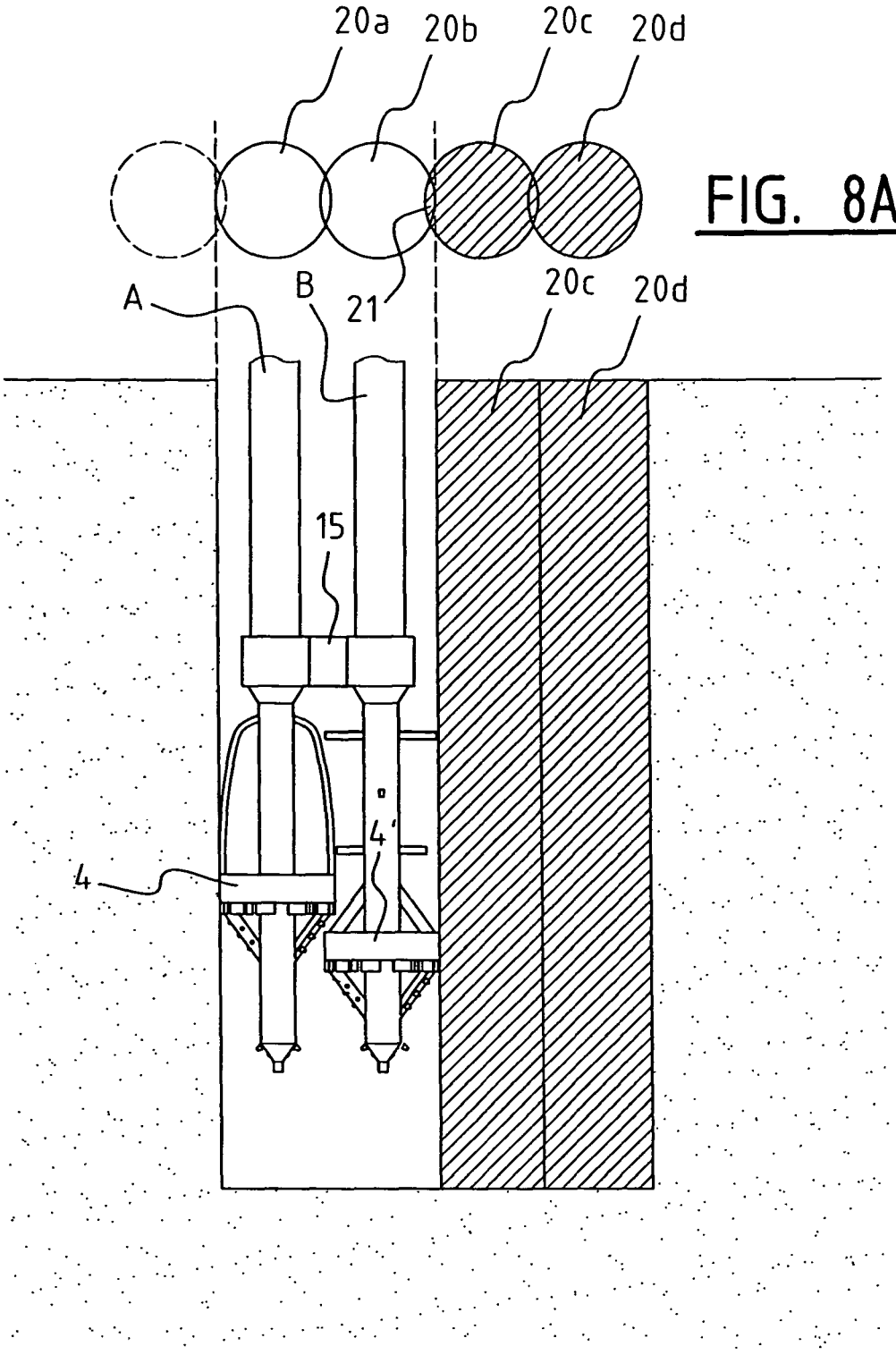

FIG. 8A

FIG. 8B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 07 7778

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 April 2006	Leroux, C

CATEGORY OF CITED DOCUMENTS

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