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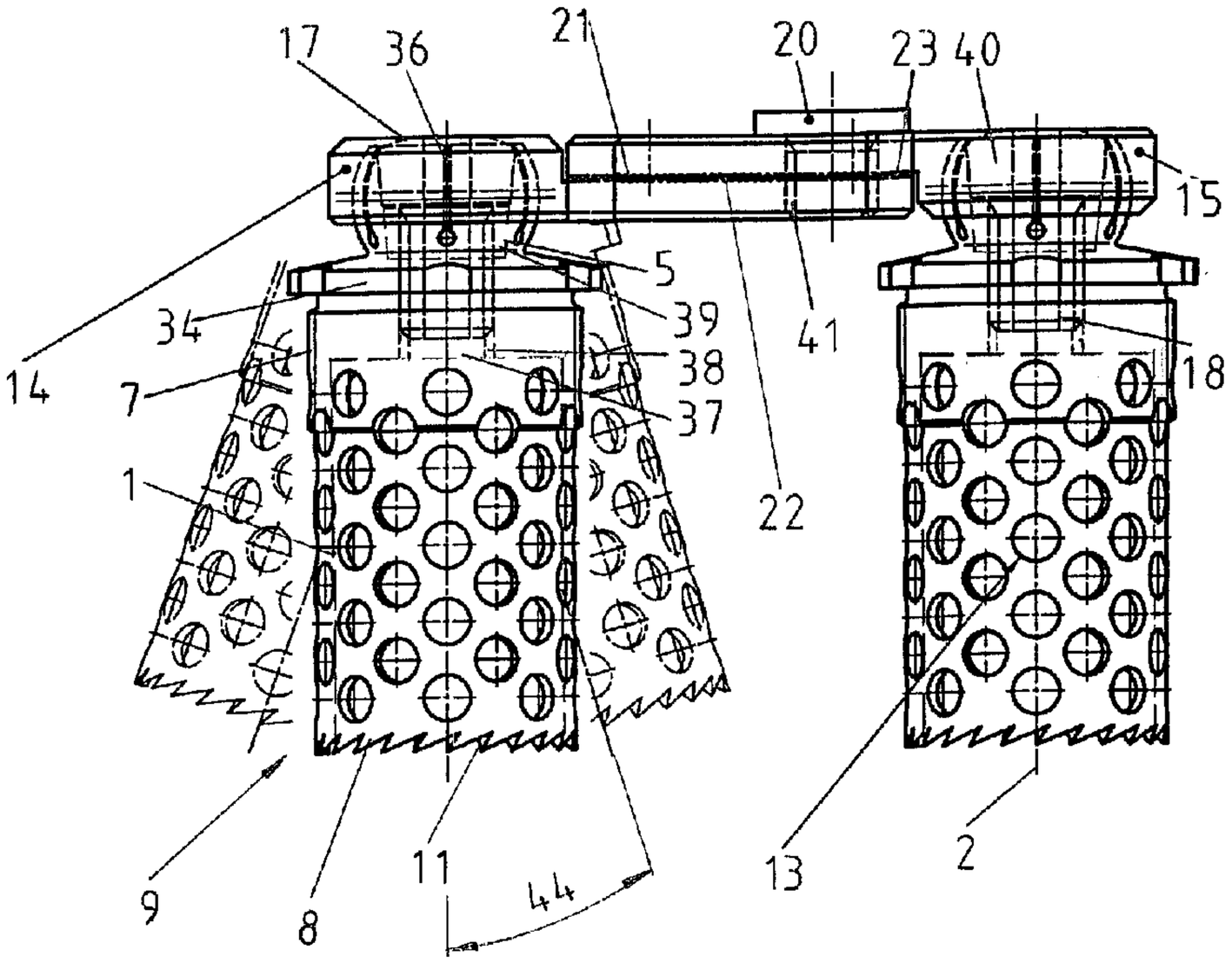

(57) Abrégé/Abstract:
A bone-anchoring assembly (9) to affix bone parts to another implant, comprising (a) a longitudinal, circular-cylindrical anchoring part (1) having a longitudinal axis (2), an upper end (3) and a lower end (4) ; and (b) a connecting element (5) mounted at the upper end (3) to couple to another implantable element; where (c) an external thread (7) is present on the outside surface (6) of the anchoring part (1); (d) the anchoring part (1) is of height H in the direction of the longitudinal axis (2) and is fitted with a borehole (10) concentric to the longitudinal axis (2) and of a depth T starting at the lower end (4); and (e) the anchoring part (1) at the lower end (4) is self-cutting. Apparatus for bone fixation comprising (a) two bone-anchoring assemblies (9); (b) at least one plate (14; 15) having a central axis (16), where this at least one plate (14; 15) is fitted with means (17) seating the connecting elements (5) of the two bone-anchoring assemblies (9); and (c) means (18) to affix the bone-anchoring assemblies (9) in the plates (14; 15); where (d) the two bone-anchoring assemblies (9) are displaceable in the direction of the central axis (16).

ABSTRACT

A bone-anchoring assembly (9) to affix bone parts to another implant, comprising (a) a longitudinal, circular-cylindrical anchoring part (1) having a longitudinal axis (2), an upper end (3) and a lower end (4) ; and (b) a connecting element (5) mounted at the upper end (3) to couple to another implantable element; where (c) an external thread (7) is present on the outside surface (6) of the anchoring part (1); (d) the anchoring part (1) is of height H in the direction of the longitudinal axis (2) and is fitted with a borehole (10) concentric to the longitudinal axis (2) and of a depth T starting at the lower end (4); and (e) the anchoring part (1) at the lower end (4) is self-cutting.

Apparatus for bone fixation comprising (a) two bone-anchoring assemblies (9); (b) at least one plate (14; 15) having a central axis (16), where this at least one plate (14; 15) is fitted with means (17) seating the connecting elements (5) of the two bone-anchoring assemblies (9); and (c) means (18) to affix the bone-anchoring assemblies (9) in the plates (14; 15); where (d) the two bone-anchoring assemblies (9) are displaceable in the direction of the central axis (16).

SELF-CUTTING HOLLOW CYLINDRICAL BONE ANCHORING ELEMENT

The invention relates to a bone-anchoring assembly.

Pedicle screws or other bone-anchoring assemblies are affixed to internal plates or bars in the fixation of bone segments or in particular in the fixation of vertebras.

An implant for the relative affixation of bone parts or also vertebral fixation is disclosed in the German document 297 10 979 AESCULAP. The implant comprises anchoring elements insertable into each bone segment, connecting elements to which the anchoring elements can be mounted using a detachable ball clamp, and longitudinal supports also clamped to the connecting elements and by means of which several anchoring elements inserted into various bone segments or also vertebras can be rigidly connected. The anchoring elements are in the form of hollow-cylindrical bone screws and are externally threaded and also fitted with radial boreholes between the threads. A seating duct must be drilled or milled in the bone before these hollow-cylindrical anchoring elements can be inserted.

Another implant comprising a hollow-cylindrical bone screw is disclosed in the US patent 5,015,247 (Michelson). This bone screw, like the above mentioned anchoring element, is designed foremost for insertion in the intervertebral space, and consists of a hollow cylinder with an external thread and radial passages between the threads. This implant is either screwed into a drilled or milled bone duct as above or into a bone borehole. In the latter case the cavity in the bone screw will be filled bone chips from the patient's body, enhancing in this manner the fusion between adjacent vertebras and between vertebras and the implant.

Both above implants incur the drawback that a duct or borehole must be milled or drilled in the bone before the hollow-cylindrical bone screw or the anchoring element can be screwed into this bone.

The objective of the invention is palliation. Its purpose is to create a self-cutting anchoring element. This self-cutting feature of the bone-anchoring assembly results in a substantially shortened time of implantation.

The invention solves this problem by a bone-anchoring assembly of the features described herein.

In a preferred embodiment of the bone-anchoring assembly of the invention, it consists of a circular-cylindrical anchoring part fitted at one end with tangentially arranged cutting teeth. The anchoring element is hollow-cylindrical and comprises a self-creating thread on its outer surface. By means of the cutting or sawing teeth, the anchoring element can be inserted into the bone without prior drilling or milling a bone duct. The bone chips are removed into the borehole of the hollow cylinder.

The number of cutting teeth is between 10 and 40, preferably between 25 and 35, where the rake is understood being the angle between the longitudinal axis of the hollow-cylindrical anchoring element and the cutting surface of a cutting tooth. Appropriately the clearance angle is between 5 and 40°, preferably between 18 and 28°.

The cutting edge also subtends an angle with the perpendicular to the longitudinal axis of 30 to 60°, preferably between 40 and 50°, the cutting corner being at the outside surface of the anchoring element.

A fixation screw having a through hole, a circular cylindrical anchoring section, connecting element at the upper end and a self-cutting external thread on the outside surface of the anchoring section is known from US 4,537,185 STEDNITZ. This known fixation screw is axially bored through and is provided

with cutting teeth at the front end.

Another orthopedic fixation screw being bored through and having a circular- cylindrical anchoring section and a self-cutting external thread on the outside surface of the anchoring section is known from US 5,129,901 DECOSTE. This known fixation screw is axially bored through and provided with cutting teeth at the front end as well.

Both above fixation screws are provided with external threads reaching to or close to the tip of the screw and are therefore screwed into or also into the spongy region of the bone. This has the drawback that in case of osteoporosis, where the cortical region remains almost normal but the spongy region is receded an anchorage through a thread adapted to the spongy part is not practicable. Furthermore, in case of both of the above mentioned fixation screws the self-cutting quality of the external thread is established by means of axial grooves, such that the fixation screws are not provided with an outside surface having a smooth surface at the front.

Here, the objective of the invention is palliation. Its purpose is to create an anchoring element, which is anchored within the cortical region of the bone through one single, particular cortical thread and which allows a better recovery of the blood circulation as well as a better incorporation of the implant by means of a smooth surface in the spongy region. An elongation of such a cortical thread until into the spongy region is disadvantageous because in case of micro-motions shear and notch effects arise that might harm the spongy region.

At its other end, the anchoring element is fitted with a connecting element for coupling to another implantable element, for instance a connection plate, an adjustment plate or to longitudinal supports. In the simplest embodiment, this connecting element is a cylinder insertable into a corresponding borehole in the plate. Advantageously however the connecting element is designed to allow affixing in pivoting manner the anchoring element to the plate throughout an angular range. This swiveling action can be implemented for instance by the connecting element being a ball seated in matching recesses in the plate.

In another embodiment, the outside surface of the anchoring element can be smooth, starting from the lower end fitted with cutting teeth, over part of the length. This embodiment is advantageous because the side wall of the hollow-cylindrical anchoring part may be fitted over this part-length with radial borehole passages allowing fusion of the bone outside the anchoring element with the core of the bone inside the anchoring element. Moreover the passage boreholes save material and thereby may substantially lower the weight of the implant. The part-length L appropriately is between 60 and 85 %, preferably between 70 and 80 % of the height H of the anchoring element.

A preferred embodiment of the apparatus of the invention comprises at least two bone-anchoring assemblies, at least one plate with a central axis, this at least one plate being fitted with means to receive the connecting elements of the two bone-anchoring assemblies. The connection-means receiving- means essentially consist of boreholes of appropriate longitudinal cross-sections in the plate allowing the connection means mounted on the anchoring elements to be supported therein and to be detachably affixed by bone-anchoring assembly fasteners in the plate(s). In preferred embodiments of the apparatus of the invention, the bone-anchoring

assembly fasteners are screws or nuts which can be screwed into or on the connecting elements. The means receiving the connection means, for instance elongated slots arrayed along the central axis of the plate, are designed in such manner that the two bone-anchoring assemblies are relatively displaceable over a distance Z which may be 10 to 80 mm, preferably 20 to 60 mm.

In another embodiment of the apparatus of the invention, this apparatus is fitted with two plates displaceable in the direction of the central axis, each plate comprising means to seat a connecting element and a fastener to mutually affix the two plates. This fastener is a screw in the various embodiments and passes through a borehole in one of the plates and is screwed into the other plate.

By suitably configuring the connecting elements, for instance as ball connecting elements, an angle between 60 and 120°, preferably between 70 and 110° can be set between the central axis of the at least one plate and each of the longitudinal axes of the anchoring parts.

In another embodiment of the apparatus of the invention, the two plates are serrated at the surfaces in mutual contact. Accordingly the apparatus is secured against relative slippage of the two plates and made more stable. Moreover the two plates are made irrotational by lateral lugs or guide jaws.

In another embodiment of the apparatus of the invention, two annular disks are used instead of a second plate, one disk being mounted underneath the plate and seating the connection means of the anchoring element, the other disk together with a screw insertable in it being used to clamp in place the first anchoring element relative to the plate. The second anchoring element is affixed in the plate. To implement the variable spacing between the two anchoring elements, at least one of the boreholes receiving the connecting elements is an elongated slot. The disk

underneath the plate and the plate itself too may be fitted with a grating on the two contact surface.

The spherical connecting element can be replaced by a unilaterally convex dish resting on the plate and with a matching concave upper end of the anchoring element to allow swiveling the anchoring element.

Essentially the advantages of the invention are that thanks to the bone-anchoring assembly of the invention drilling or milling need NOT being carried out at the bone before inserting the implant.

The invention and further embodiments of this invention are elucidated below in relation to the partly schematic Figures of an illustrative embodiment.

Fig. 1 is a schematic perspective of an embodiment of the bone-anchoring assembly of the invention,

Fig. 2 is a detail of a cutting tooth in one embodiment of the device of the invention,

Fig. 3 is a front view of an embodiment of the apparatus of the invention, and

Fig. 4 is topview of the embodiment of the apparatus of the invention shown in topview in Fig. 3.

Fig. 1 schematically shows an embodiment of the bone-anchoring assembly 9 of the invention. This assembly comprises a circular-cylindrical anchoring element 1 of height H fitted with a connecting element 5 coaxial to the longitudinal axis 2 of the element 1 and in this embodiment shown being a simple cylindrical journal. Instead of the cylindrical journal, the connecting element 5 also may be spherical. The connecting element connects directly, in the direction of the longitudinal axis 2, to the upper end 3 of the anchoring element 1. A borehole 10 of a depth T less than the height H enters concentrically the lower end 4 of the anchoring element 1. As a result the cross-section

of the anchoring element 1 is hollow cylindrical over a length corresponding to the depth T. Cutting or sawing teeth 8 are tangentially configured at the lower end 4 on the hollow cylinder. In this embodiment, the cutting edges 11 of the cutting teeth 8 configured tangentially run radially. The outside surface 6 of the anchoring element 1 is smooth over a partial length L also less than the height H and beginning at the lower end 4, whereas the remainder of the height H is fitted with an external thread 7. The bone-anchoring assembly 9 may be fitted at the end face of the connection part 5 with a hexagonal socket to simplify, using a matching tool, insertion of the bone-anchoring assembly 9 into the bone. The hexagonal socket furthermore may be replaced by a hexagonal head at the connecting part 5 or at the portion of the anchoring element 1 which adjoins the upper end 3.

Fig. 2 shows a detail of a cutting tooth 8. The Figure also shows a 3-D coordinate system with a z-axis parallel to the longitudinal axis 24, a radial x-axis 25 and a y-axis 26 tangential to the outside surface 6 and orthogonal to this radius. The nose 27 is situated on the outside surface 6 of the anchoring part 1. The angle of nose 27 subtended by the z-axis 24 and the cutting-tooth surface 32 on which runs the chip, is 30°. The clearance angle 29 of the cutting tooth edge 33 at the outside surface 6 and the plane 31 determined by the x-axis 25 and y-axis 26 is 22.5°.

The angle 30 between the radial cutting edge 11 and the plane 31 determined by the x-axis 25 and the y-axis 26 is 45°, as a result of which the noses 27 of the cutting teeth 8 constitute the lower end 4 (Fig. 1) of the anchoring part 1 and are situated on the outer circumference.

Figs. 3 and 4 show an embodiment of the apparatus of the invention with two bone-anchoring assemblies 9. The two bone-anchoring assemblies 9 are fitted at their hollow-cylindrical parts with radial borehole passages 13. The two bone-anchoring

assemblies 9 are connected by two plates 14; 15 of a common central axis. The two plates 14; 15 overlap at mutually contacting surfaces 21; 22 running along the central axis 16. These two mutually contacting surfaces 21; 22 are fitted with serrations 23 to prevent the two plates 14; 15 from relatively slipping under load. Furthermore the two plates 14; 15 are fitted at their mutually opposite ends with lateral lugs 43 and extending beyond the thickness of the particular other plate 14; 15. These lugs prevent the plates 14; 15 from rotating relative to each other, as a result of which they would become misaligned relative to the central axis 16. The means 17 receiving the connecting elements 9 are spherical boreholes. The connecting elements 5 are spherical shells and of a diameter corresponding to that of the spherical boreholes. The spherical-shell connecting elements 5 are fitted with boreholes 37 comprising an inside thread 38 and a conically lathed geometry 39 tapering away from the upper end 3. The lathed geometries (39) receive the conical screw heads 40 of the screws 18 used to affix the bone-anchoring assemblies 9 to the plates 14; 15. When the screws are tightened, the connecting elements 5 fitted with slits 36 and with a lathed geometry 39 are clamped against the wall of the spherical boreholes serving as means 17 to seat the connecting elements 5 by the screw heads 40. In this respect the cone angle of the screw head 40 need not be identical with the conical lathed geometry 39. In this manner the bone-anchoring assembly 9 can be affixed with respect to the perpendicular to the plates 14; 15 at an angle 44 from 16° on the inside to 19° on the outside in the plate 14; 15. The clamping means 20 affixing the plates 14, 15 relative to each other is a screw which is rotated in the lower plate 14 into a threaded borehole 41 and passes through an elongated slot 42 in the upper plate 15. To allow displacing the two plates relative to each other, thereby changing the distance between the two bone-anchoring assemblies 9 along the central axis 16, the elongated slot 42 in the plate 15 is used as the borehole

passage for the said screw. The anchoring part 1 comprises a larger diameter at its upper end 3 than the flange 34 comprising the anchoring part 1. This flange 34 comprises six semi-circular notches 35 subtending an angle of 60° between adjoining notches. By means of these notches 35 and a matching tool, the bone-anchoring assembly 9 can be rotated into the bone. Instead of the notches 35, the flange 34 also might be fitted with an external hexagonal head. Moreover the flange 34 acts as a stop to prevent the bone-anchoring assembly 9 from being turned excessively deep into the bone or vertebra.

Insertion of the above described implant does not require fashioning beforehand a receiving duct into the bone. Before the bone-anchoring assembly is inserted into the bone, first a Kirschner wire is concentrically inserted into the bone. Thereupon the bone-anchoring assembly is directly rotated, by a wrench snapping into the ballhead of the connection part and externally engaging the six notches, into the bone or also vertebra. The wrench comprises a borehole and in this manner is guided by the previously inserted Kirschner wire. The duct to receive the hollow-cylindrical anchoring part 1 is milled out of the bone by the cutting teeth 8. The bone chips so created are removed into the inside of the hollow-cylindrical anchoring part 1. After the bone-anchoring assembly 9 has been screwed-in, the Kirschner wire may be removed. The second bone-anchoring assembly 9 is inserted into the bone in the same manner. After the bone-anchoring assemblies 9 have been inserted into the bone parts or the vertebras, the plates 14; 15 are snapped onto the connection parts 5. The implant as a whole can be locked in a desired position by screwing-in and tightening the screws with the conical screwheads 40 and by means of the affixation screw 20.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A bone anchoring element comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device;

at least one tooth extending from the lower end of the body for cutting into bony tissue; and

threading on an exterior surface of the body for anchoring the body into surrounding bony tissue,

wherein the threading is near the upper end of the body and the lower end of the body is smooth, and the connecting element pivotably couples to the fixation device.

2. The bone anchoring element of claim 1, further comprising a plurality of radial boreholes extending through the hollow cylindrical body between the upper and lower ends.

3. The bone anchoring element of claim 1, wherein the at least one tooth extends tangentially from the lower end of the body.

4. The bone anchoring element of claim 3, wherein the at least one tooth has radial cutting edges that form an angle between 30° and 60° from a plane determined by a radial axis of the body and an associated tangential axis.

5. The bone anchoring element of claim 4, wherein the at least one tooth has edges that extend along a back of each tooth from the radial cutting edge to the lower end of the body and each of the edges forms an angle between 15° and 30° from the plane determined by the radial axis of the body and the associated tangential axis.

6. The bone anchoring element of claim 4, wherein the at least one tooth has a rake between 25° and 35°.

7. A bone anchoring element configured to be inserted to an insertion depth, comprising:

a hollow cylindrical body with an upper end and a lower end;

a flange located at the upper end of the body for limiting the insertion depth of the bone anchoring element;

a connecting element located above the flange at the upper end of the body for coupling to a fixation device; and

at least one tooth extending from the lower end of the body for cutting into bony tissue.

8. The bone anchoring element of claim 7, wherein the flange has a plurality of notches for receiving an insertion tool.

9. The bone anchoring element of claim 7, wherein the flange is hexagonal.

10. The bone anchoring element of claim 1, wherein the connecting element is circular-cylindrical or hexagonal-cylindrical.

11. The bone anchoring element of claim 1, wherein the connecting element concentrically houses a borehole configured and dimensioned to receive a fastener.

12. A bone anchoring assembly comprising:

a first fixation plate having a first end, a second end, and a central axis; and

a first bone anchoring element having a hollow cylindrical body with an upper end and a lower end, a connecting element at the upper end for coupling to the first fixation plate, and at least one tooth extending from the lower end for cutting into bony tissue;

wherein the first fixation plate further comprises an elongated slot located along the central axis at the first end and a borehole configured and dimensioned

to pivotably receive the connecting element of the first bone anchoring element and located at the second end.

13. The bone anchoring assembly of claim 12, further comprising:

a second bone anchoring element,

wherein the elongated slot is configured and dimensioned to pivotably receive the connecting element of the first bone anchoring element thereby allowing relative displacement between the first bone anchoring element when pivotably coupled to the elongated slot and the second bone anchoring element when pivotably coupled to the borehole.

14. The bone anchoring assembly of claim 12, further comprising:

a second fixation plate having an elongated slot; and

a second bone anchoring element having a hollow cylindrical body with an upper end and a lower end, and having a connecting element at the upper end for coupling to the second fixation plate;

wherein the elongated slots of the first and second fixation plates are configured and dimensioned to receive a fastener thereby allowing the fixation plates to be coupled together at varying separation distances along the central axis; and the connecting elements of the bone anchoring elements have boreholes configured and dimensioned to receive fasteners allowing the bone anchoring elements to be pivotably coupled to the fixation plates.

15. The bone anchoring assembly of claim 14, wherein the separation distance between the bone anchoring elements is configured to be varied between 20 mm and 60 mm.

16. The bone anchoring assembly of claim 14, wherein the first end of each fixation plate is textured.

17. The bone anchoring assembly of claim 14, wherein the fixation plates have lateral extensions at the first end of each fixation plate for limiting the rotation of the fixation plates with respect to the central axis.

18. A bone anchoring assembly comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device;

at least one tooth extending from the lower end of the body for cutting into bony tissue; and

the fixation device having a first end, a second end, and an axis extending along the longitudinal length of the device;

wherein at least one borehole configured and dimensioned to pivotably receive the connecting element is located along the axis between the first and second ends of the fixation device.

19. A bone anchoring element comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device; and

at least one tooth extending from the lower end of the body for cutting into bony tissue,

wherein the at least one tooth extends tangentially from the lower end of the body and has radial cutting edges that form an angle between 30° and 60° from a plane determined by a radial axis and an associated tangential axis.

20. The bone anchoring element of claim 19, further comprising a threading on an exterior surface of the body for anchoring the body into surrounding bony tissue.

21. The bone anchoring element of claim 20, wherein the threading is self-tapping.

22. The bone anchoring element of claim 20, wherein the threading is near the upper end of the body and the lower end of the body is smooth.

23. The bone anchoring element of claim 19, wherein the body has at least two teeth and the teeth have edges that extend along a back of each tooth from the radial cutting edge to the lower end of the body and each of the edges forms an angle between 15° and 30° from a plane determined by the radial axis of the body and the associated tangential axis.

24. The bone anchoring element of claim 23, wherein the teeth have a rake between 25° and 35°.

25. The bone anchoring element of claim 19, further comprising a plurality of radial boreholes extending through the hollow cylindrical body between the upper and lower ends.

26. The bone anchoring element of claim 25, further comprising a threading on an exterior surface of the body for anchoring the body into bony tissue, wherein the threading is near the upper end of the body and the lower end of the body is smooth.

27. A bone anchoring element configured to be inserted to an insertion depth, comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device;

a flange located at the upper end of the body for limiting the insertion depth of the bone anchoring element; and

at least one tooth extending from the lower end of the body for cutting into bony tissue;

wherein the flange has a plurality of notches for receiving an insertion tool.

28. The bone anchoring element of claim 1, further comprising a flange located at the upper end of the body for limiting the insertion depth of the bone anchoring element.

29. The bone anchoring element of claim 28, wherein the flange has a plurality of notches for receiving an insertion tool.

30. The bone anchoring element of claim 28, wherein the flange is hexagonal.

31. A bone anchoring element comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device;

at least one tooth extending from the lower end of the body for cutting into bony tissue;

a plurality of radial boreholes in an exterior surface of the body; and

threading on the exterior surface of the body for anchoring the body into surrounding bony tissue,

wherein the threading is near the upper end of the body and the lower end of the body is smooth.

32. A bone anchoring element configured to be inserted to an insertion depth, comprising:

a hollow cylindrical body with an upper end and a lower end;

a connecting element at the upper end of the body for coupling to a fixation device;

at least one tooth extending from the lower end of the body for cutting into bony tissue; and

a flange located at the upper end of the body for limiting the insertion depth of the bone anchoring element,

wherein the flange has a plurality of notches for receiving an insertion tool.

33. The bone anchoring element of claim 27, wherein the connecting element concentrically houses a borehole configured and dimensioned to receive a fastener.

34. The bone anchoring element of claim 7, wherein the connecting element pivotably couples to the fixation device.

35. The bone anchoring element of claim 7, further comprising a plurality of radial boreholes in an exterior surface of the hollow cylindrical body.

36. A bone anchoring element comprising:

a hollow cylindrical body with an upper end and a lower end;

a flange disposed proximate the upper end;

a connecting element disposed proximate the upper end for coupling to a fixation device; and

at least one tooth extending from the lower end of the body for cutting into bony tissue.

37. The bone anchoring element of claim 36, wherein the fixation device is a plate.

38. A bone anchoring element comprising:

a hollow cylindrical body with an upper end and a lower end;

a flange disposed proximate the upper end and comprising a plurality of notches for receiving an insertion tool;

a connecting element disposed proximate the upper end for coupling to a fixation device; and

at least one tooth extending from the lower end of the body for cutting into bony tissue.

39. The bone anchoring element of claim 38, wherein the fixation device is a plate.

40. A bone anchoring element comprising:

a hollow cylindrical body with a threaded upper end, a smooth lower end, and a plurality of boreholes extending into the body between the upper and lower ends;

a connecting element disposed proximate the upper end for coupling to a fixation device; and

at least one tooth extending from the lower end for cutting into bony tissue.

41. The bone anchoring element of claim 40, wherein the fixation device is a plate.

42. A bone anchoring assembly comprising:

a first cylindrical body pivotably connected to a first plate;

a second cylindrical body pivotably connected to a second plate; and

teeth disposed on a free end of each of the first and second cylindrical bodies;

wherein the first and second plates are configured and dimensioned to be coupled together to permit the distance between the cylindrical bodies to be adjusted.

43. The bone anchoring assembly of claim 42, wherein the first cylindrical body further comprises threading.

44. The bone anchoring assembly of claim 43, wherein the second cylindrical body further comprises threading.

45. The bone anchoring assembly of claim 42, further comprising:

a flange disposed proximate the upper end of the body.

46. The bone anchoring assembly of claim 42, wherein the first plate comprises a slot, and the plates are coupled together by a fastener extending through the slot.

47. The bone anchoring assembly of claim 42, wherein the first and second plates each comprise a textured surface, and the textured surfaces contact each other.

48. The bone anchoring assembly of claim 42, wherein the first cylindrical body is pivotably connected to the first plate with an expandable connector.

49. The bone anchoring assembly of claim 42, wherein the expandable connector comprises a connector body with an arcuate outer surface and a borehole.

50. The bone anchoring assembly of claim 49, further comprising a screw threadably received in the borehole of the connector body.

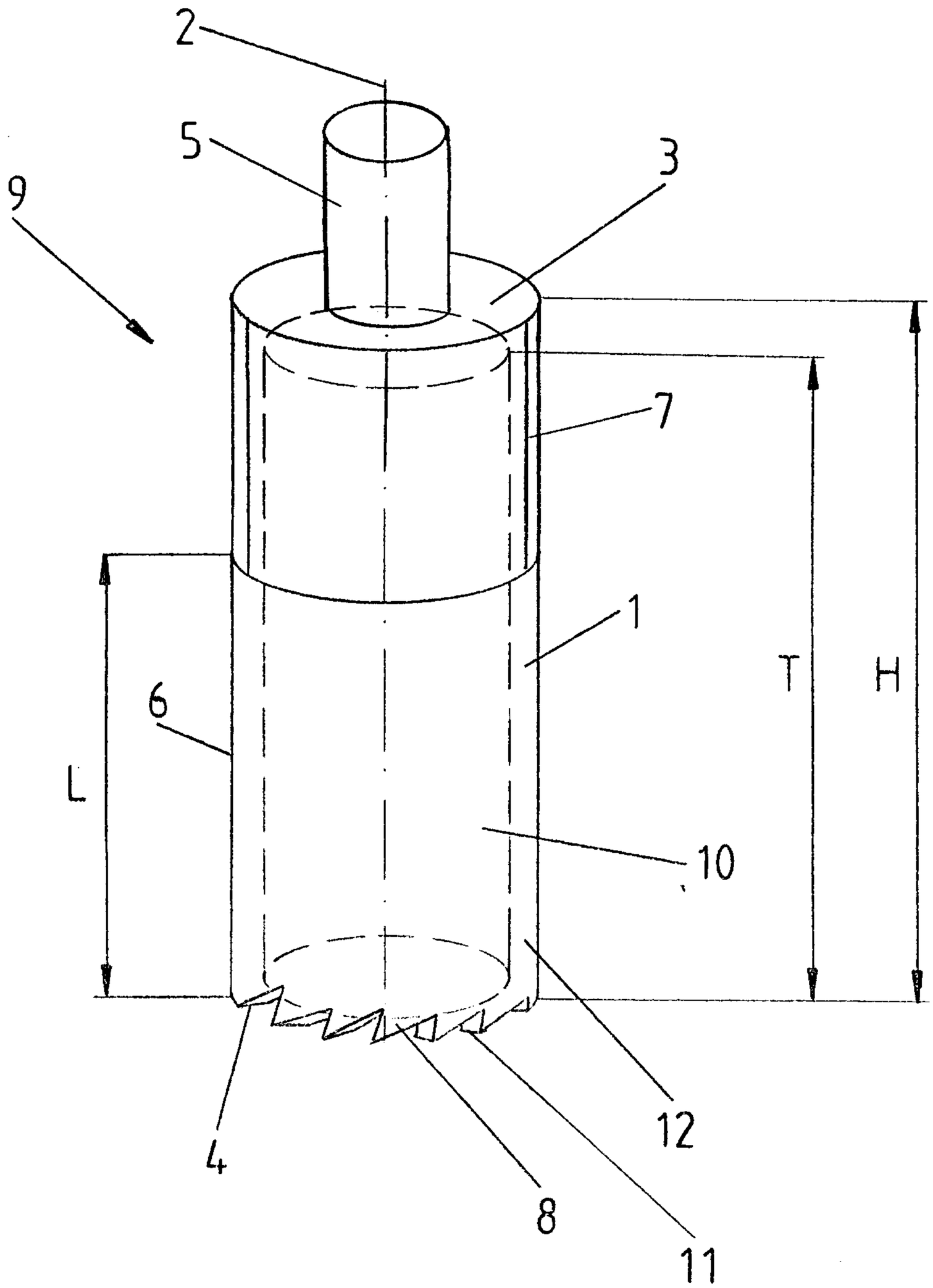

Fig. 1

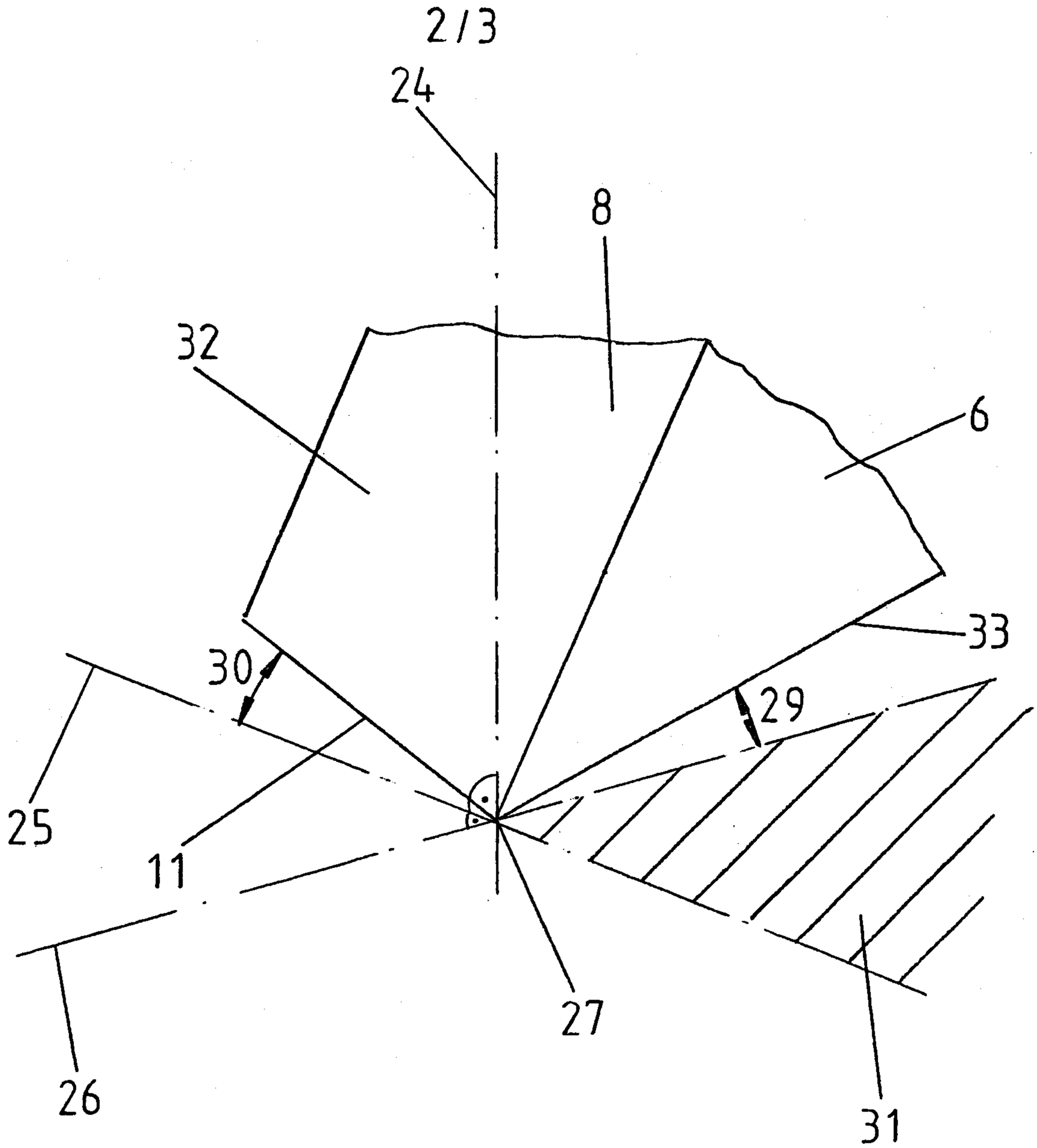

Fig. 2

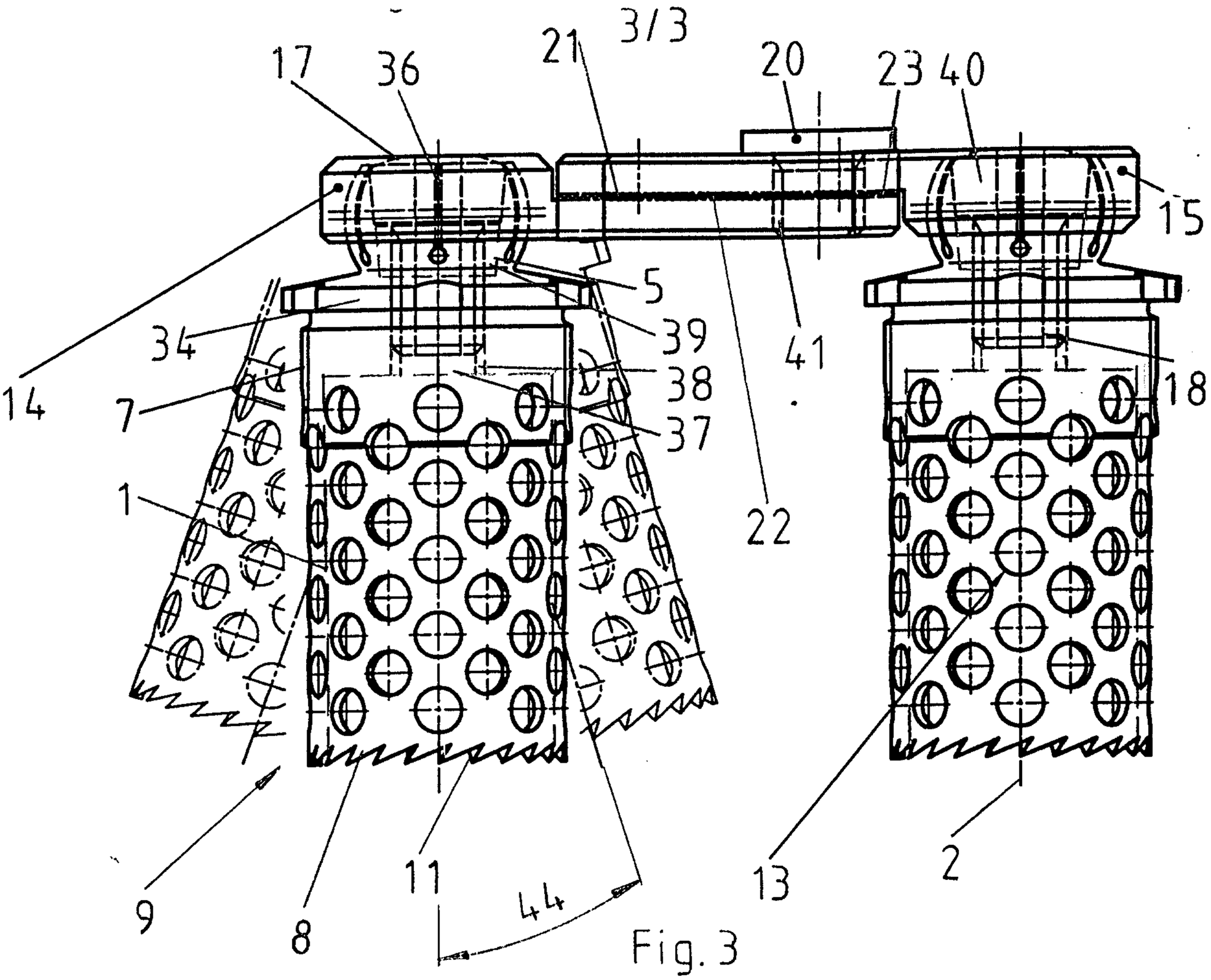
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Fig. 3

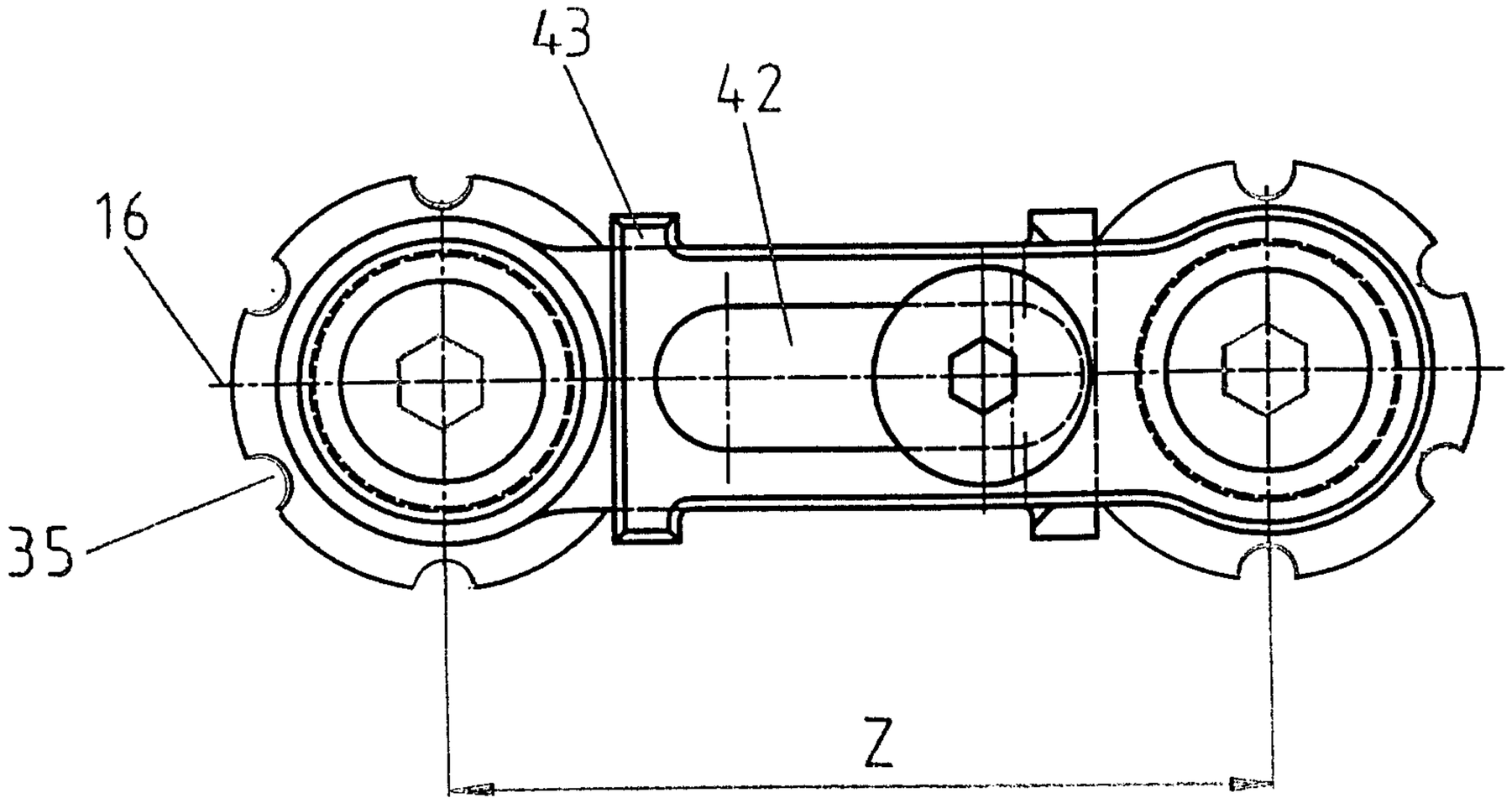
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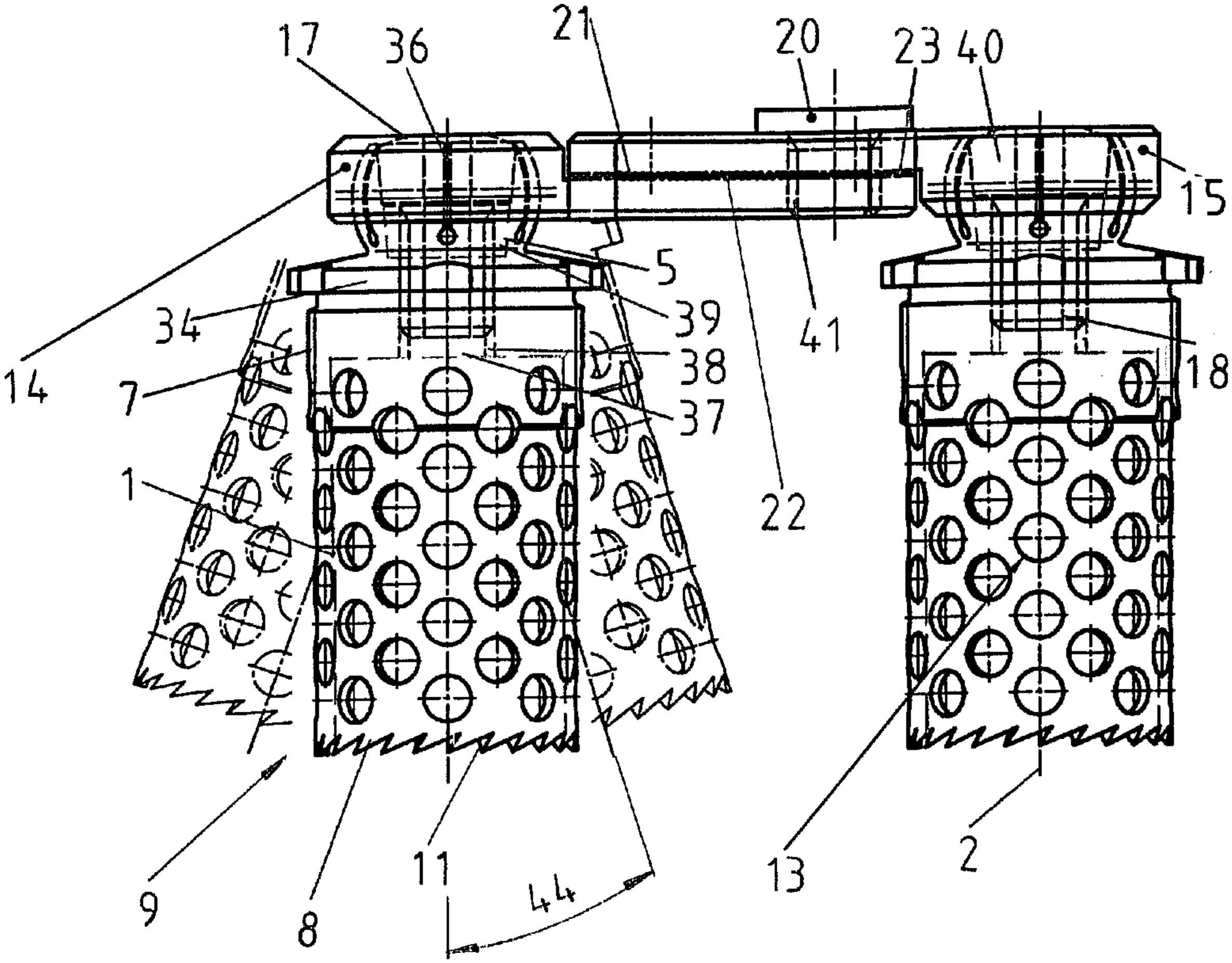
Fig. 4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