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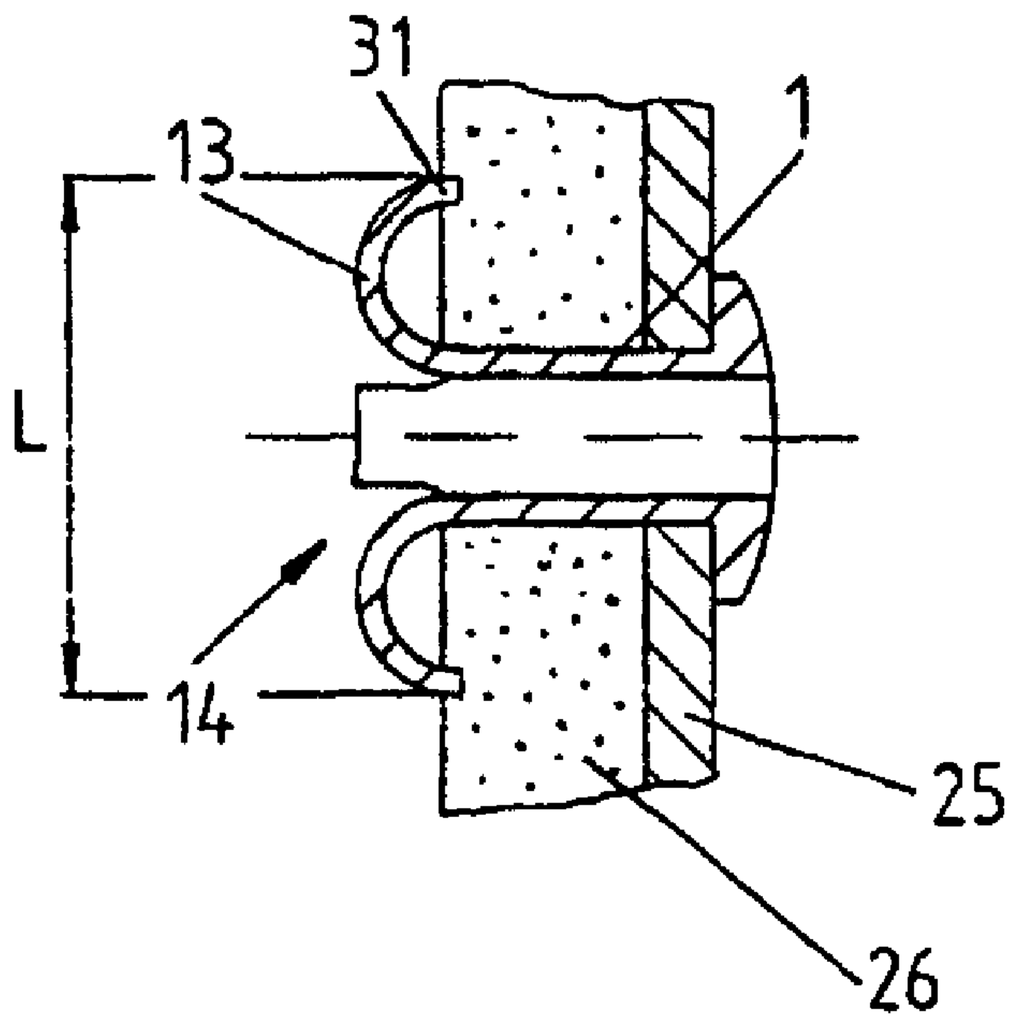
(54) **RIVET AVEUGLE CHIRURGICAL DOTE D'UN ELEMENT DE FERMETURE**

(54) **SURGICAL BLIND RIVETS WITH CLOSING ELEMENTS**



(57) L'invention concerne un dispositif de fixation d'implants chirurgicaux, de fils ou de tissus dans ou sur l'os. Le dispositif comprend un rivet aveugle (1) et un élément de fermeture (2). L'élément de fermeture (2) présente une section polygonale sur au moins une partie (7) de sa longueur, située dans le prolongement de son extrémité postérieure (12) et, sur cette partie (7), la section (5) s'élargit le long de l'axe longitudinal (3) vers l'extrémité postérieure (12). Lors de la fermeture du rivet aveugle (1), ce dernier peut être divisé en languettes d'ancrage séparées (13) et les languettes d'ancrage (13) peuvent être évasées par rapport à l'axe longitudinal (3) à l'aide de l'élément de fermeture et constituer la tête de fermeture (14) du rivet aveugle (1). Le passage (4) pratiqué dans le rivet aveugle (1) présente sur la partie de fermeture (9) une section polygonale.

(57) The invention relates to a device for fixing surgical implants, threads or tissues in or on bone, comprising a blind rivet (1) and a closing element (2). Said closing element (2) has a polygonal cross section (5) at least on a part (7) of its length adjoining the rear end (12). The cross section (5) also becomes wider on this part (7) in the direction of the rear end (12), along the longitudinal axis (3). When the blind rivet (1) is closed it can be split into separate anchoring tongues (13). Said anchoring tongues (13) can be expanded in relation to the longitudinal axis (3) by means of the closing element (2) and form the closing head (14) of the blind rivet (1). The through opening (4) in the blind rivet (1) has a polygonal cross-section on the closing part (9).

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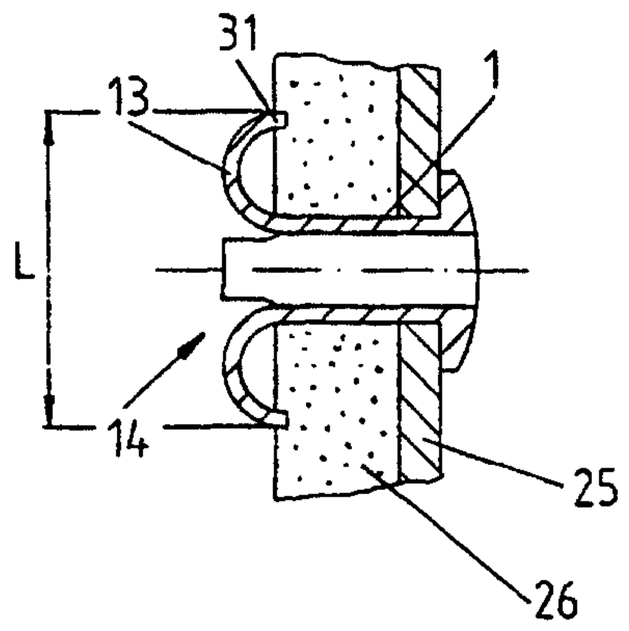


(57) Abstract

The invention relates to a device for fixing surgical implants, threads or tissues in or on bone, comprising a blind rivet (1) and a closing element (2). Said closing element (2) has a polygonal cross section (5) at least on a part (7) of its length adjoining the rear end (12). The cross section (5) also becomes wider on this part (7) in the direction of the rear end (12), along the longitudinal axis (3). When the blind rivet (1) is closed it can be split into separate anchoring tongues (13). Said anchoring tongues (13) can be expanded in relation to the longitudinal axis (3) by means of the closing element (2) and form the closing head (14) of the blind rivet (1). The through opening (4) in the blind rivet (1) has a polygonal cross-section on the closing part (9).

*(Siehe PCT Gazette Nr. 12/2000, "Section II")

English translation of the International Patent Application PCT/CH99/00194 "Blind rivet with fastener" in the name of Synthes AG Chur

BLIND RIVET WITH FASTENER

The invention relates to a device affixing surgical implants, surgical threads, i.e. sutures, or tissues in or at the bone in the manner defined in the preamble of claim 1.

Blind rivets already are known in the extra-medical fields of which the closing heads consist of separate and comparatively widely spread legs. Such blind rivets are known for instance from the US Wright patent 4,696,610 and the US Francis patent 4,580,936. These known blind rivets comprise longitudinal slits or cuts making possible to form the closing heads consisting of separate legs when the blind rivet is being closed. The closing heads so formed rest on a large area. These known blind rivets incur the drawback that the closing heads are formed by bending the longitudinal legs and consequently the leg ends are not sharp tines and cannot be pressed as such into the material at the closing-head side, which, if it were the case, might prevent the blind rivet from rotating in the boreholes of the materials to be connected.

A further non-medical blind rivet is known from the British patent 2,054,082 (Tucker Fasteners), which however comprises a circular passage precluding irrotationality.

The objective of the invention is palliation. Its purpose is to create a fastener insertable through a small borehole and comprising, following affixation, a broad resting surface on the inner bone surface thanks to the spread-out anchoring legs which can dig into the inner bone surface and thereby prevent the blind rivet from rotating.

In the medical field, the fastener of the invention is applicable almost universally in the treatment of bone fractures where presently bone screws are used, in particular:

- for porotic bones partly comprising only a very thin cortex, the fastener of the invention can replace screws in fastening plates,

- in the spongiosa the fastener of the invention can serve as an anchor for plates, sutures or to affix again tendons and ligaments; the claws formed when spreading the closing head will anchor outstandingly well into the trabecular structure of the spongiosa; and
- in joint heads such as the femur head or the humerus head, the fastener of the invention can be used as the anchor of a side plate or of an intramedullar support; heretofore large screws have been used to anchor the longitudinal supports, however these screws anchor less than optimally in the joint heads' porotic bones.

Similar systems consist of screws, marrow pins or hip screws, fitted with unlatching claws, for instance the Seidel marrow pin for the humerus. This marrow pin is fitted with slits at the tip and the slits are spread apart by a central pin with a ballhead. In this manner the legs are bent outward like wings. However these legs are bent only slightly away from the nail.

These known fasteners incur the drawback that so far they have not solved the problem of anchoring implants in porotic bones. Often an implant can be affixed into the bone only by injecting bone cement into the bone. This procedure is quite problematical because damaging the bone on account of the heat dissipated as the cement hardens. Moreover the cement no longer can be removed as would be required in case of infection.

Another drawback of these known fasteners is that the anchoring strength for instance of a screw is determined by its diameter. If there is axial overload. a cylinder of bone equal to the screw diameter will be torn out. In healthy bone the anchoring strength of bone screws will be sufficient. But in the case of osteoporosis, in joint zones or as regards thin, shell-like bones, screw affixation often will be inadequate. Larger screws cannot be used because of lack of space, or else they destroy the remaining bone even more.

The objective of the invention is palliation. The invention intends to create a fastener insertable through a small borehole and which following affixation shall widely rest on the inner bone surface thanks to the spread-apart anchoring legs.

The invention solves this problem by a device affixing surgical implants, sutures or tissues on or into the bone and defined by the features of claim 1.
The passage in the blind rivet at its closing part is cross-sectionally polygonal, preferably being square though optionally also triangular, pentagonal, hexagonal or higher.

In a preferred embodiment, the fastener of the invention for surgical implants, sutures or tissues in or at the bone consists of a blind rivet comprising a longitudinal axis and a coaxial passage aperture, further of a closing element insertable into the passage. At least over part of its length adjoining its rear end, the closing element comprises a polygonal cross-section, the closing element's cross-section flaring along the longitudinal axis at this part of the closing element. The closing element is inserted in such manner into the blind rivet that the smaller cross-section of the conical part of the closing element is first inserted into the blind rivet until the element rests on account of the flaring cross-section at the passage aperture. Upon closing the blind rivet by further pressing the closing element into the blind rivet's passage, this rivet is severed at its closing part by the flaring polygonal part of the closing element into separate anchoring legs which subsequently are spread apart in half-circular manner by said flaring part and form a closing head anchored on a large area and consisting of a number of anchoring legs. The number of anchoring legs corresponds to the number of edges of the polygonal cross-section of the closing element.

Further advantageous embodiments are defined in the dependent claims.

Another embodiment of the fastener of the invention differs from the one above in that the closing element is cross-sectionally square at least over a segment of its length starting at its rear end. The advantage of a cross-section of few polygonal edges is that the edges are more sharply defined and severing the rivet shank into separate anchoring legs and widening these legs when closing the blind rivet is thus enhanced.

Another embodiment of the fastener of the invention differs from the above ones in that the cross-section of the closing element flares conically toward its rear end over

at least a segment of its length, along the longitudinal direction, starting at that rear end, the conical angle being selected in such manner that both severing of the rivet shank into separate anchoring legs and widening of the anchoring legs when closing the blind rivet will be enhanced.

Another embodiment of the fastener of the invention differs from the above ones in that the passage in the blind rivet is cross-sectionally square at the closing part and in that design rupture sites are provided in the rivet shank at the corners to enhance the severing the rivet shank into separate anchoring legs when the blind rivet is being closed. Advantageously the rupturing sites' wall thickness shall be between 1 and 10 %, preferably between 5 and 9 % of the outside diameter D of the blind rivet.

Another embodiment of the fastener of the invention differs from the above ones only in that the closing element is detachably connected to a closing pin.

Another embodiment of the fastener of the invention differs from the above ones only in that at least one closing element is part of a marrow spindle.

Another embodiment of the fastener of the invention differs for the above ones in that the blind rivet comprises a detachable rivet head. For that purpose the detachable rivet head may be fitted with an inside thread which can be screwed onto a matching outside thread of the blind rivet. If the blind rivet is used as an anchor, for instance as a fastener in the femur head, together with a side plate or a marrow spindle or a suture anchor, an embodiment of the blind rivet without a rivet head will be appropriate. The design of a headless blind rivet offers the advantage of deeper bone penetration during spreading. This "post-slippage" prevents cutting the spongiosa when the blind rivet is being spread apart.

Yet another embodiment of the fastener of the invention differs form the above ones by mounting a gimlet at the rear end of the closing element to eliminate pre-boring the bone.

Yet another embodiment of the fastener of the invention differs from the above ones in that the passage in the blind rivet is fitted with an inside thread over part of its

length opposite the part to be closed to illustratively allow screwing another implant or implant part into the affixed blind rivet.

Yet another embodiment of the fastener of the invention differs from the above ones in that the closing pin of the closing element will bend elastically. In this manner it is possible to mount the blind rivet for instance in to the femur head, allowing thereby to pull the closing pin through all the femur bone.

Yet another embodiment of the fastener of the invention is characterized in that the wall thickness "s" at the closing part of the blind rivet is between 1 and 20 % of the outside diameter D of the blind rivet. This design allows spreading the rivet shank in simple manner into the separate anchoring elements by means of the polygonal cone at the closing element.

Yet another embodiment of the fastener of the invention is characterized in that the anchoring legs can be spread by the closing elements into a semi-circular shape relative to the longitudinal axis and shall form the blind rivet's closing head. This feature provides a broad rest for instance on the inside bone surface and, because the semi-circular shape of the anchoring leg ends rest almost perpendicularly on the bone surface, this design offers jaw-like anchoring the closing head.

Yet another embodiment of the fastener of the invention is characterized over the above embodiment in that the blind rivet is made of a plastically deforming material such as pure titanium, a titanium alloy or implant-steel, enhancing the formation of the above cited semi-circular anchoring legs.

Yet another embodiment of the fastener of the invention is characterized over the above described embodiments in that two mutually opposite ends of two mutually opposite anchoring legs of the closing element subtend a distance L which is twice to triple the blind rivet's diameter D. Again this considerable widening of the anchoring legs provides a broad rest on the inside bone surface.

The advantages offered by the invention foremost are that the fastener of the invention requires only a small borehole in the bone and that the blind rivet of the invention following installation broadly rests on the inner bone surface. Moreover

and illustratively in a manner different from the case relating to a hip screw, the semi-circular anchor-like design of the anchoring legs and their anchoring in the bone preclude rotation by the fastener head. Moreover as regards porotic bones, the spongiosa in joint heads -- if still present at all -- will not be mechanically stressed. In other words, the hip screw is situated in a cavity, and this feature entails a dislocation of the hip head relative to the hip screw. The hip screw only can become functional after it makes contact with the inner bone surface. In such cases however the interface between screw and bone often is inadequate, the bone may penetrate the hip joint. In the invention on the other hand, the inner head surface is used as the interface between implant and bone when using the blind rivet of the invention with the semi-circular anchoring legs. In this manner the surface of contact with the bone is larger and matches optimally on account of the anatomically matching anchoring legs. If the blind rivet of the invention is used to anchor a marrow spindle into the femur head, the size of the borehole receiving the blind rivet of the invention will only be about 8 mm. This feature offers the advantage that in comparison with conventional systems of marrow-spindles/hip-screws, the diameter of the marrow spindle can be substantially reduced in the application of the invention.

The invention and further embodiments are elucidated below in relation to partly schematic Figures of several illustrative embodiments.

Fig. 1 shows a longitudinal section of an embodiment of the blind rivet of the invention and an embodiment of a closing element of the invention,

Fig. 2 shows a longitudinal section of an embodiment of the blind rivet of the invention and another embodiment of a closing element of the invention,

Fig. 3 is a cross-section of the embodiment of the closing element of the invention of Fig. 2,

Fig. 4 is a longitudinal section of an embodiment of a closed blind rivet of the invention with a bone plate and a bone segment,

Fig. 5 is an elevation of the embodiment of a closed blind rivet shown in Fig. 4.

Fig. 6 is a longitudinal section of a further embodiment of the blind rivet of the invention,

Fig. 7 is a front view of the embodiment of the blind rivet shown in Fig. 6,

Fig. 8 is a longitudinal section of another embodiment of the blind rivet of the invention,

Fig. 9 is a longitudinal section of another embodiment of the blind rivet of the invention and a further embodiment of the closing element of the invention,

Fig. 10 is a front view of the embodiment of the blind rivet of the invention of Fig.9 with the closing element of the invention of Fig. 9, and

Fig. 11 is a longitudinal section of a femur bone with an blind rivet of the invention, a marrow spindle and an assembly sleeve.

Fig. 1 shows a blind rivet 1 and a closing element 2 of one embodiment of the fastener of the invention. The blind rivet 1 comprises a longitudinal axis 3 and consists of a cylindrical rivet shank 8 which runs parallel to the longitudinal axis 3 but which is not necessarily circular-cylindrical, further a rivet head 19 rigidly joined to the rivet shank 8 and a cylindrical passage 4 coaxially passing through the blind rivet 1. The rivet shank 8 is of diameter D and as a result the wall thickness defined by the width of the cylindrical passage 4 and the outside diameter D is such that when closing the blind rivet 1 by means of the closing element 2 this blind rivet 1 can be severed at the closing part 9 into anchoring legs 13 (Figs. 4, 5), the number of anchoring legs 13 corresponding to the number of edges of the polygonal cross-section 5 of the closing element 2 (Fig. 3). In this particular embodiment of the blind rivet 1, the wall thickness "s" of the rivet shank 8 amounts to 14% of the outside diameter D. In the embodiment of the fastener of the invention shown in Fig. 1, the closing element 2 is a component of a closing pin 16. At its length segment adjoining its rear end 12, the closing element 2 is of polygonal cross-section 5 (Fig. 3) flaring toward said rear end 3. The blind rivet 1 will be closed following insertion of the

closing element 2 which, by tension applied to the closing pin 16, is pressed into the closing part 9 of the blind rivet 1. When the flaring segment 7 is pressed inward, the wall of the rivet shank 8 is widened by this segment 7 of the closing element 2 and is severed by the edges of the polygonal cross-section 5 (Fig. 3) into the anchoring legs 13 (Figs. 4, 5). The closing pin 16 can be connected by a design rupture site to the closing element 2 to allow separating this pin from this closing element after closing the blind rivet 1, for instance by applying twisting forces.

The embodiment of the fastener of the invention shown in Fig. 2 differs from the embodiment of Fig. 1 only in that the closing element 2 is fitted with an inside thread 24 coaxial with the longitudinal axis 3 and in that the closing pin 17 is fitted with a matching outside thread 23 to allow detachably screwing the closing pin 17 -- which is a separate part -- into the closing element 2. Following closure of the blind rivet 1, the closing pin 17 can be screwed out of the closing element 2 and thereby be removed from the closed blind rivet 1.

Fig. 3 is a section perpendicular to the longitudinal axis of the closing element 2. In this embodiment the polygonal cross-section 5 is a square 6 forming four anchoring legs 13 when closing the blind rivet 1. Fig. 3 also shows the inside thread 24 of the closing element 2 of the fastener of the invention embodiment of Fig. 2.

Fig. 4 shows a longitudinal section of a closed blind rivet 1 of one embodiment of the invention. The blind rivet 1 connects a bone plate 25 to a bone 26. The closing head 14 comprises four anchoring legs 13 of which the ends 31 subtend the distance L. This Figure also shows that the distance L subtended by the ends 31 of the anchoring legs 13 is approximately triple the diameter D of the rivet shank 8. Fig. 5 shows an elevation of the closed blind rivet 1 of Fig. 4 with four anchoring legs 13.

The blind rivet 1 shown in Figs. 6 and 7 of another embodiment of the fastener of the invention only differs from the embodiment of Fig. 1 in that the cylindrical passage 4 at the closing part 9 of the blind rivet 1 away from the rivet head 19 is square. The corners 15 of the cylindrical passage 4 form design rupture sites between this passage and the outside diameter D of the rivet shank 8 to split up this shank 8 into the anchoring legs 13 (Figs. 4, 5) when the blind rivet 1 is being closed. At the

segment of the blind rivet 1 adjoining the rivet head 19, the cylindrical passage 4 is fitted with an inside thread 22 coaxial with the longitudinal axis 3 in this particular embodiment of the fastener of the invention.

The blind rivet 1 of a further embodiment of the invention shown in Fig. 8 only differs from the embodiments of Figs. 1 through 7 in that the rivet head 1 is detachably connected to the rivet shank 8 of the blind rivet 1. This detachable connection of rivet head 20 and river shank 8 is implemented by threads. For that purpose the river shank 8 is fitted with an outside thread 27 coaxial with the longitudinal axis 3 and the rivet head 20 is fitted with a matching inside thread 28.

Figs. 9 and 10 show a further embodiment of the fastener of the invention. In this case the blind rivet 1 also is cylindrical but lacks a rivet head and consists of a cylindrical rivet shank 8 having a longitudinal axis 3 and a cylindrical passage 4 also coaxial with the axis 3. The closing element 2 differs from that of Fig. 1 only in that the rear end 12 of the closing element 2 is fitted with an awl 21. The diameter d of the awl 21 corresponds to the outside diameter D of the blind rivet 1 and thereby pre-drilling the bone 26 (Fig. 4) is not needed when assembling the blind rivet 1. Instead of the awl 21 shown in Figs. 9 and 10, a gimlet of course may also be used.

Fig. 11 shows an application of the blind rivet 1 as defined in one of the embodiments of the fastener of the invention to lock a marrow spindle 18 for instance in a femur bone 29. The marrow spindle 18 is secured axially in the proximal direction by inserting the blind rivet 1. The closing element 2 is mounted as a component of the marrow spindle 18 at its distal end 32. To assemble the blind rivet 1, it is clamped between the closing element 2 and a case 30 and is inserted together with the marrow spindle 18 into the femur bone 29. By tensioning the marrow spindle 18 in the proximal direction and applying an opposite retention force to the case 30, the closing head 14 is shaped at the blind rivet 1 which thereby is locked.

English Translation of the Amendments under Article 19 of the International Patent Application No. PCT/CH99/00194 "Surgical blind rivet with closing element" in the name of Synthes AG Chur

CLAIMS

1. A fastener to affix surgical implants, sutures or tissues in or at the bone, where
A) the fastener comprises a blind rivet (1) having a longitudinal axis (3) and a coaxial passage (4), further a closing element (2) having a rear end (12) and a front end (32),
B) the closing element (2) is of polygonal cross-section (5) at least on a segment (7) adjoining its rear end (12), the cross-section (5) flaring along the longitudinal axis (3) toward the rear end (12) at this segment (7),
C) the blind rivet (1) when being closed being severable into separate anchoring legs (13) by the closing element (2) being pressed into the part (9) to be closed of the blind rivet (1),
D) the anchoring legs (13) can be spread by the closing element (2) relative to the longitudinal axis (3) and form the closing head (14) of the blind rivet (1); and
E) the cross-section of the passage (4) at the closing part (9) of the blind rivet (1) is polygonal,
characterized in that
F) design rupture sites are present in or on the rivet shank (8) at the corners (15) of the polygonal cross-section.

2. Fastener as claimed in claim 1, characterized in that the closing element (2) is of polygonal cross-section (6) at least on a segment (7) of its length adjoining the rear end (12).

3. Fastener as claimed in claim 1 or 2, characterized in that the cross-section (5) of the closing element (2) flares conically along the longitudinal axis (3) toward the rear end (12) of the closing element (2) at least on one segment of its length adjoining the rear end (12).

4. Fastener as claimed in one of claims 1 through 3, characterized in that the closing element (2) is a component of a closing pin (16).

5. Fastener as claimed in one of claims 1 through 3, characterized in that the closing element (2) is detachably connected to the closing pin (17).

6. Fastener as claimed in one of claims 1 through 3, characterized in that at least one closing element (2) is part of a marrow spindle (18).

7. Fastener as claimed in one of claims 1 through 6, characterized in that the blind rivet (1) comprises an integral rivet head (19)

8. Fastener as claimed in one of claims 1 through 6, characterized in that the blind rivet (1) comprises a detachable rivet head (20).

9. Fastener as claimed in claim 8, characterized in that the detachable rivet head (20) comprises an inside thread (28) and in that the blind rivet (1) comprises a matching outside thread (27).

10. Fastener as claimed in one of claims 1 through 9, characterized in that an awl (21) is mounted at the rear end (12) of the closing element (2).

11. Fastener as claimed in one of claims 1 through 10, characterized in that the passage (4) in the blind rivet (1) is fitted with an inside thread (22) on a segment of its length opposite the part (9) of the rivet to be closed.

12. Fastener as claimed in one of claims 1 through 11, characterized in that the closing pin (16; 17) of the closing element (2) can be bent in deforming manner.

13. Fastener as claimed in one of claims 1 through 11, characterized in that the closing pin (16; 17) of the closing element (2) is elastically bending.

14. Fastener as claimed in one of claims 1 through 13, characterized in that the wall thickness "s" at the closing part (9) of the blind rivet (1) is between 1 and 20 % of the outside diameter D of the blind rivet (1).

15. Fastener as claimed in one of claims 1 through 14, characterized in that the anchoring legs (13) can be widened in semi-circular manner relative to the longitudinal axis (3) by the closing element (2) and in that they form the closing head (14) of the blind rivet (1).

16. Fastener as claimed in one of claims 1 through 15, characterized in that the design rupture sites (15) are of a wall thickness between 1 and 10 % the diameter D of the blind rivet (1).

17. Fastener as claimed in one of claims 1 through 15, characterized in that the design rupture sites (15) are of a wall thickness between 5 and 9 % the diameter D of the blind rivet (1).

18. Fastener as claimed in one of claims 1 through 17, characterized in that two mutually opposite ends (31) of the closing head (14) subtend a distance L twice to three times the diameter D of the blind rivet (1).

19. Fastener as claimed in one of claims 1 through 17, characterized in that the wall thickness "s" becomes thicker in the direction of the rivet head (19; 20) at the part (9) of the blind rivet (1) to be closed.

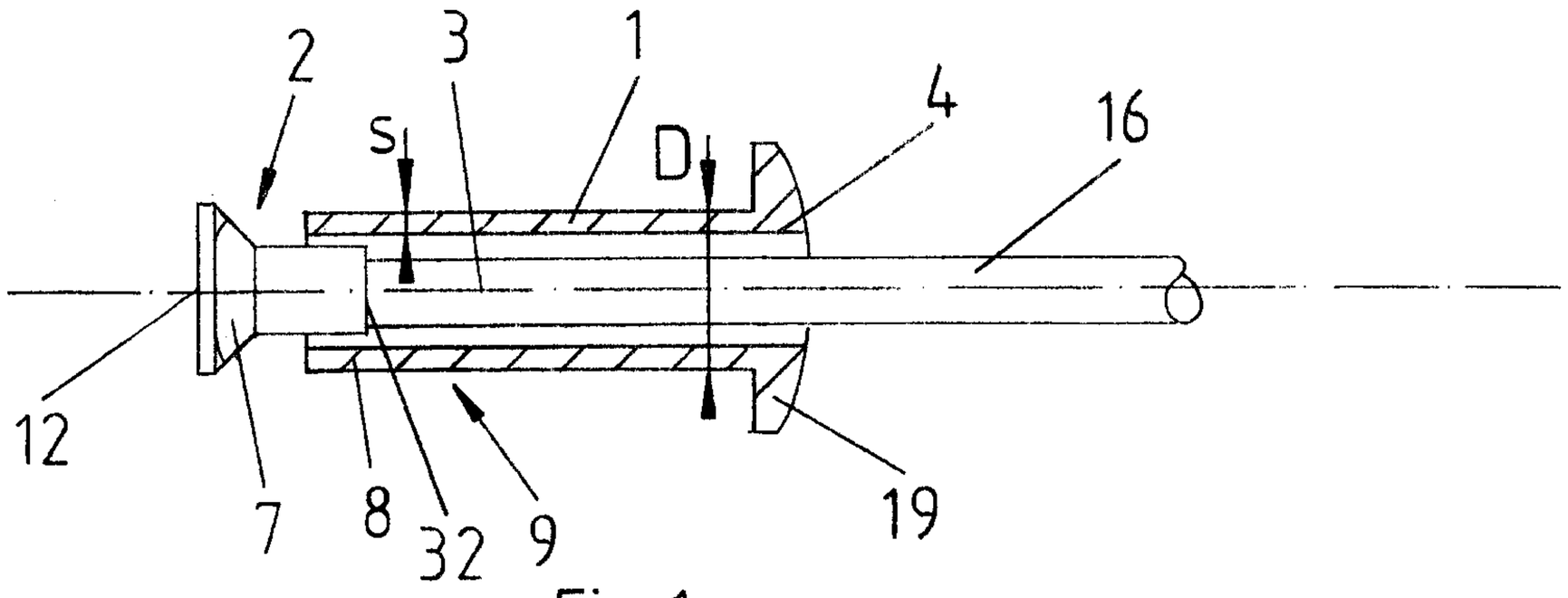


Fig. 1

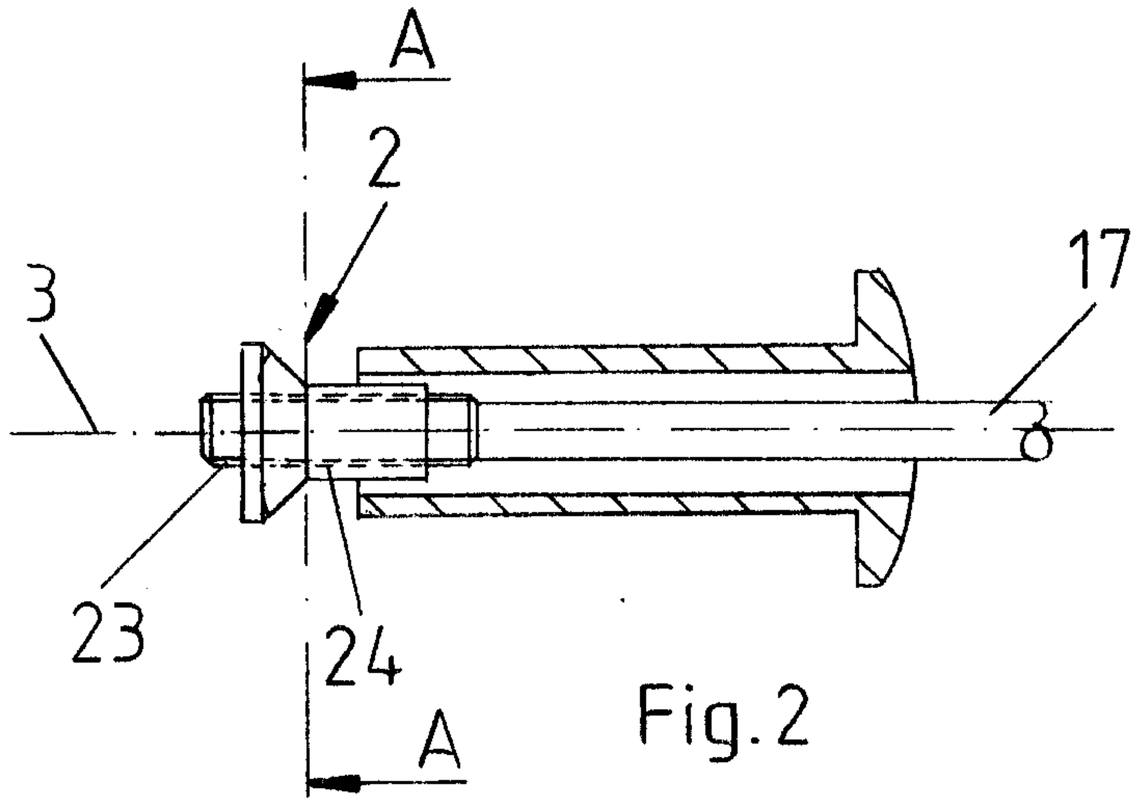


Fig. 2

Schnitt A-A

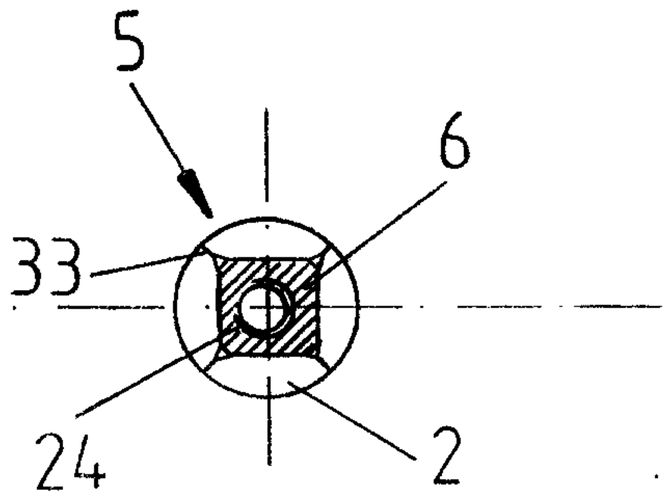


Fig. 3

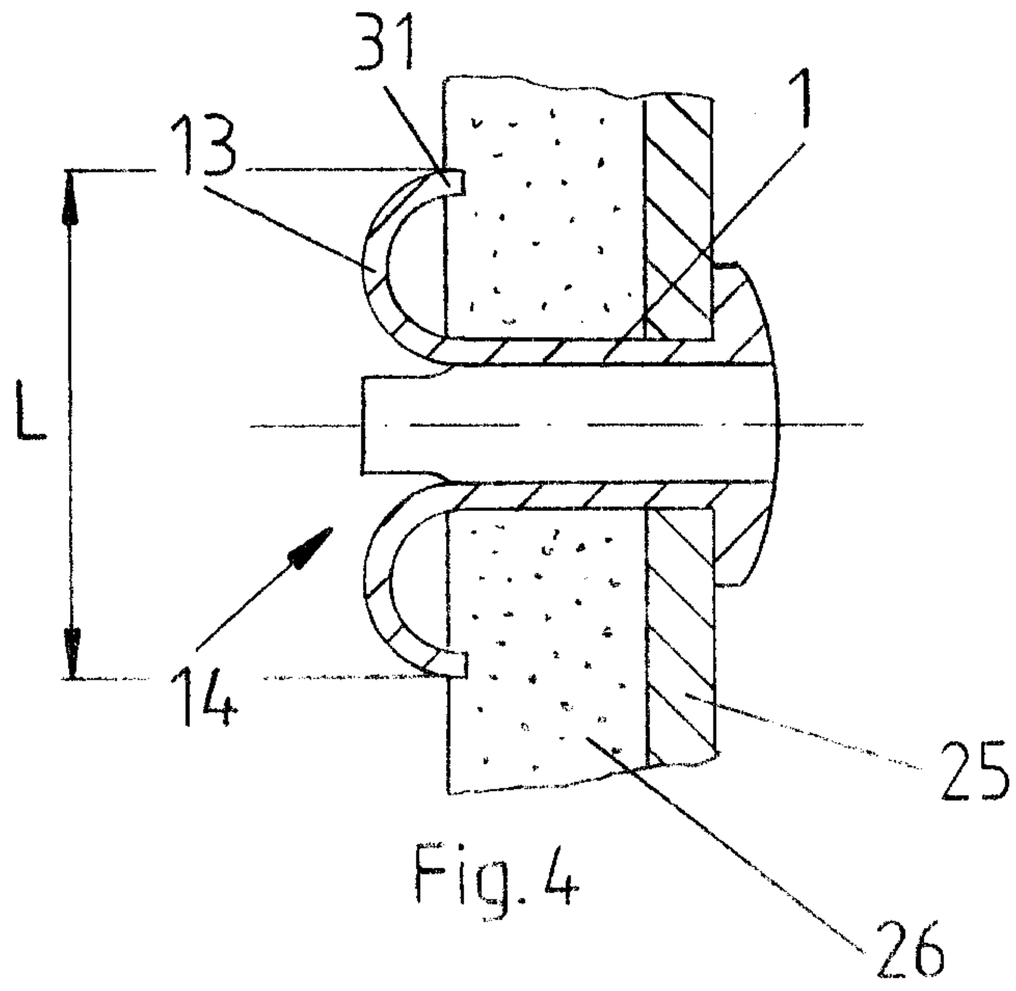


Fig. 4

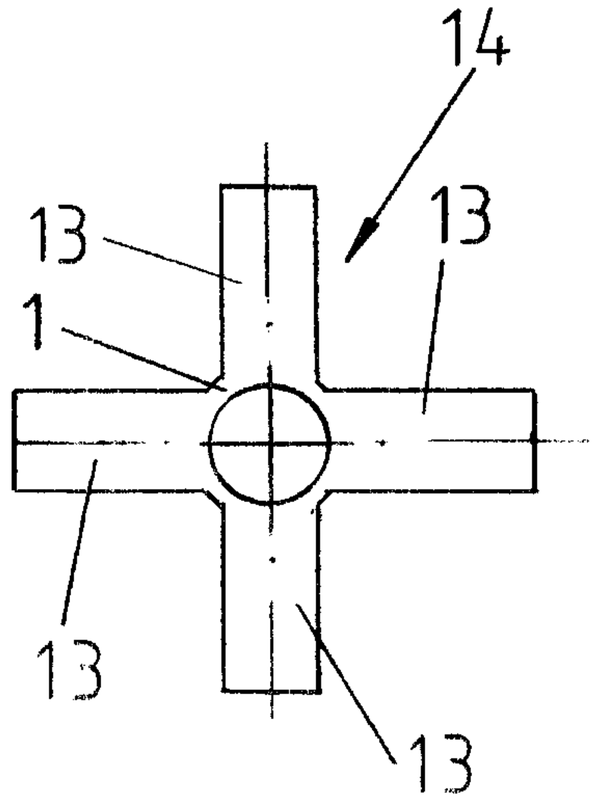


Fig. 5

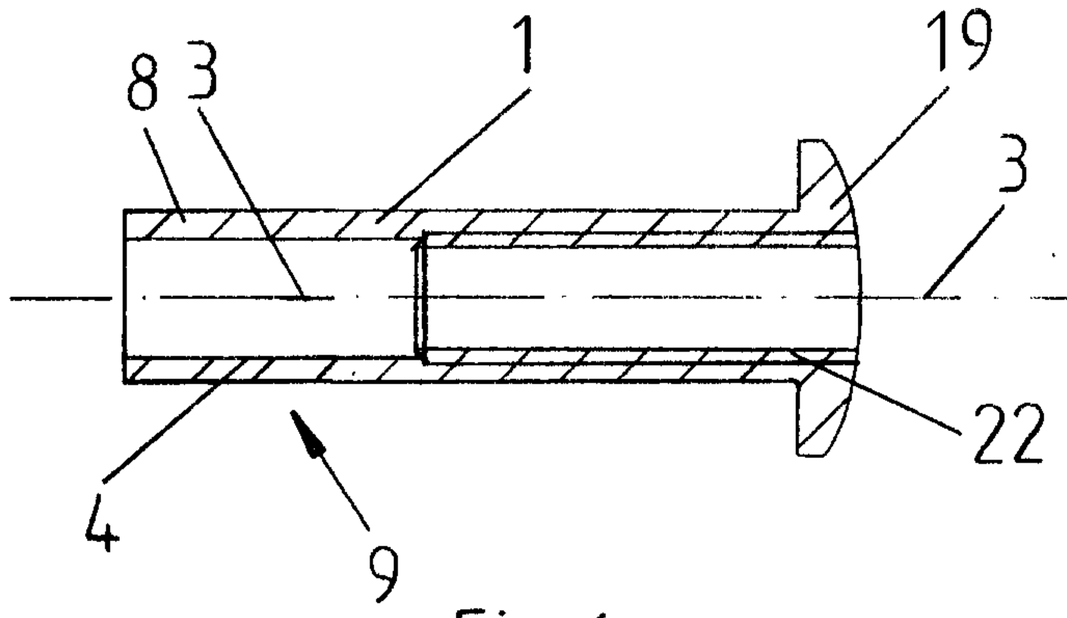


Fig.6

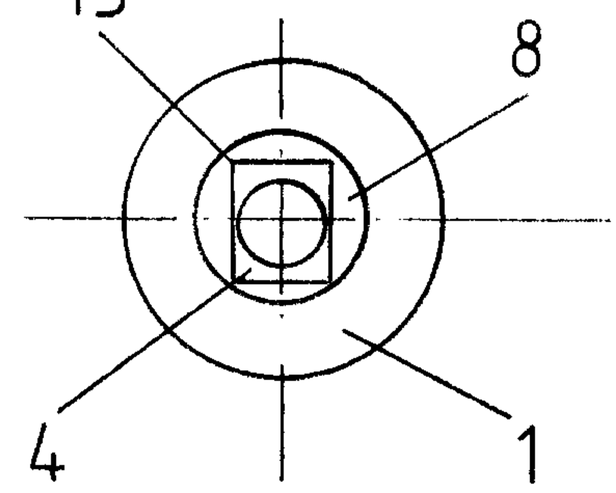


Fig.7

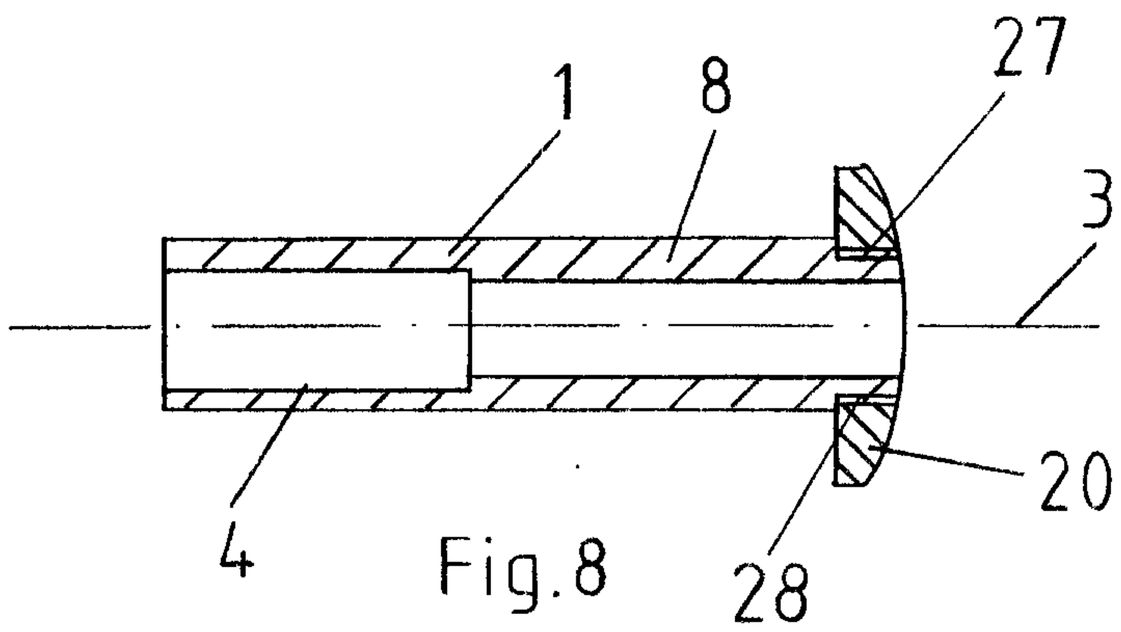


Fig.8

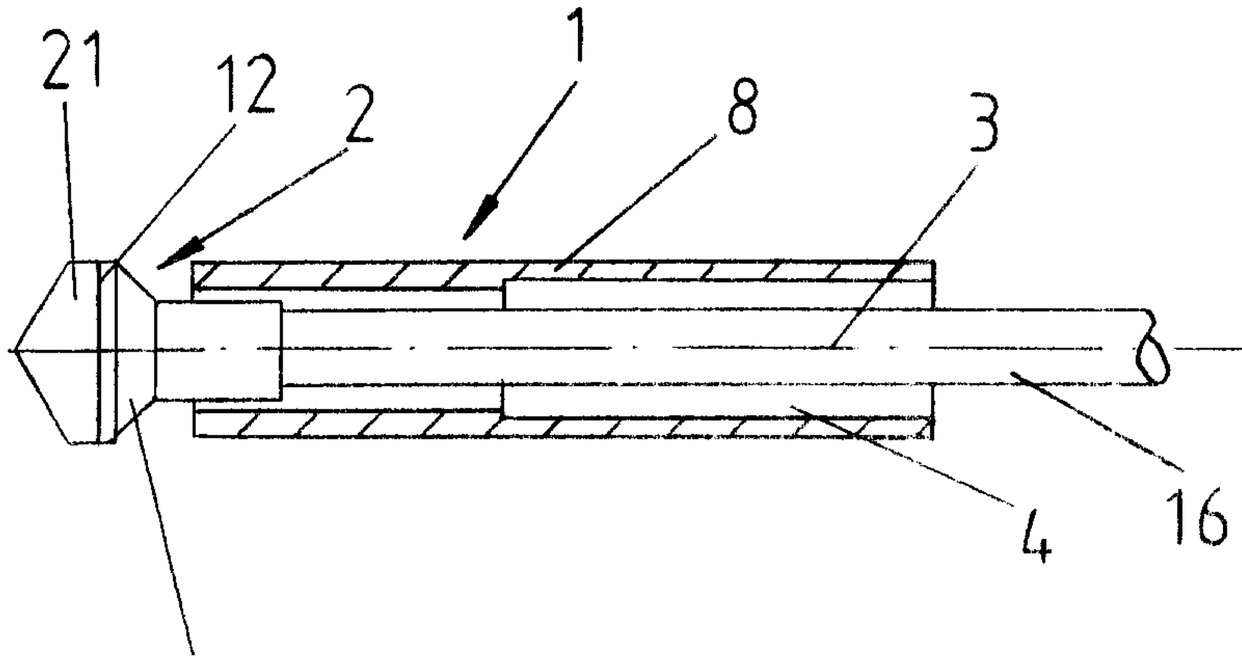


Fig.9

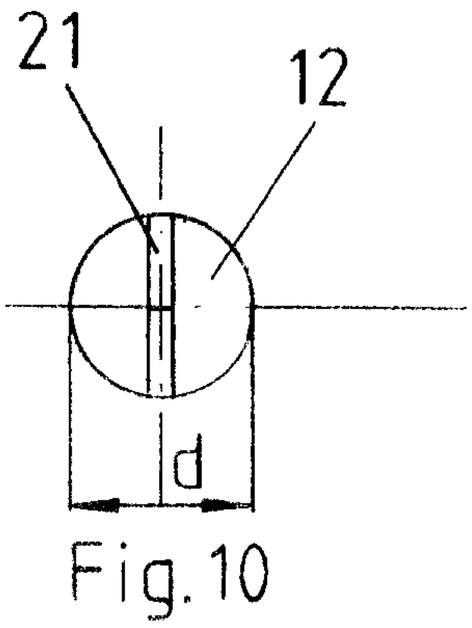


Fig.10

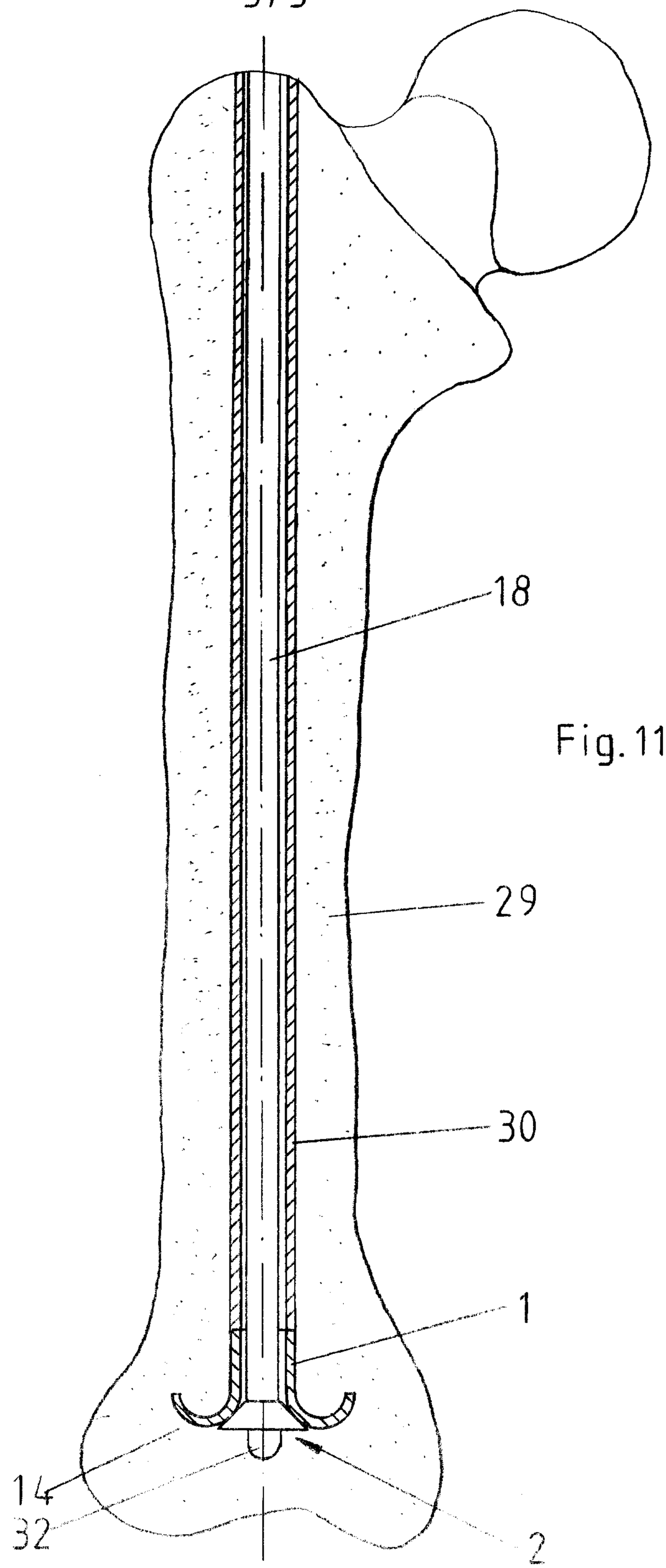
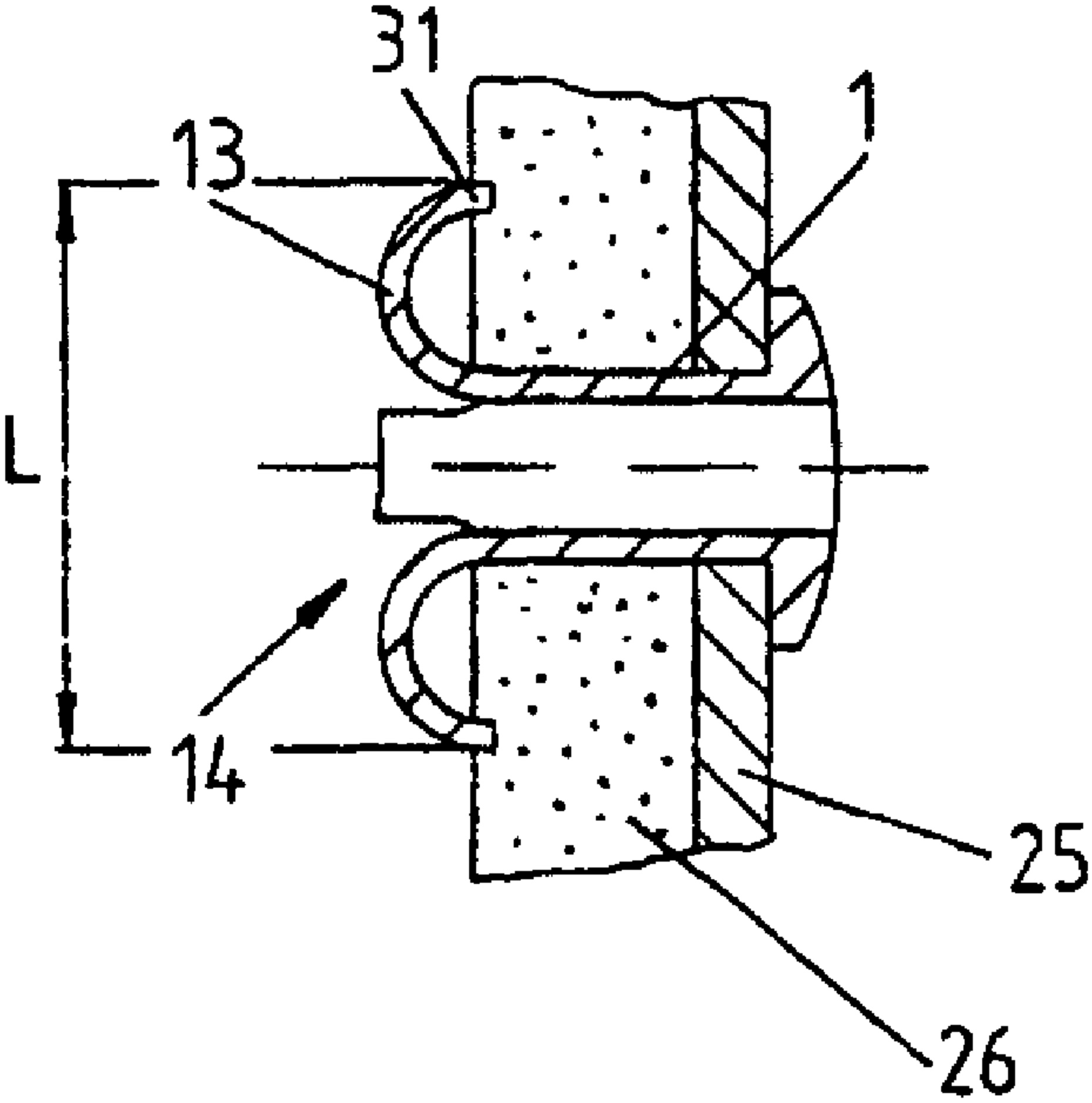


Fig. 11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