

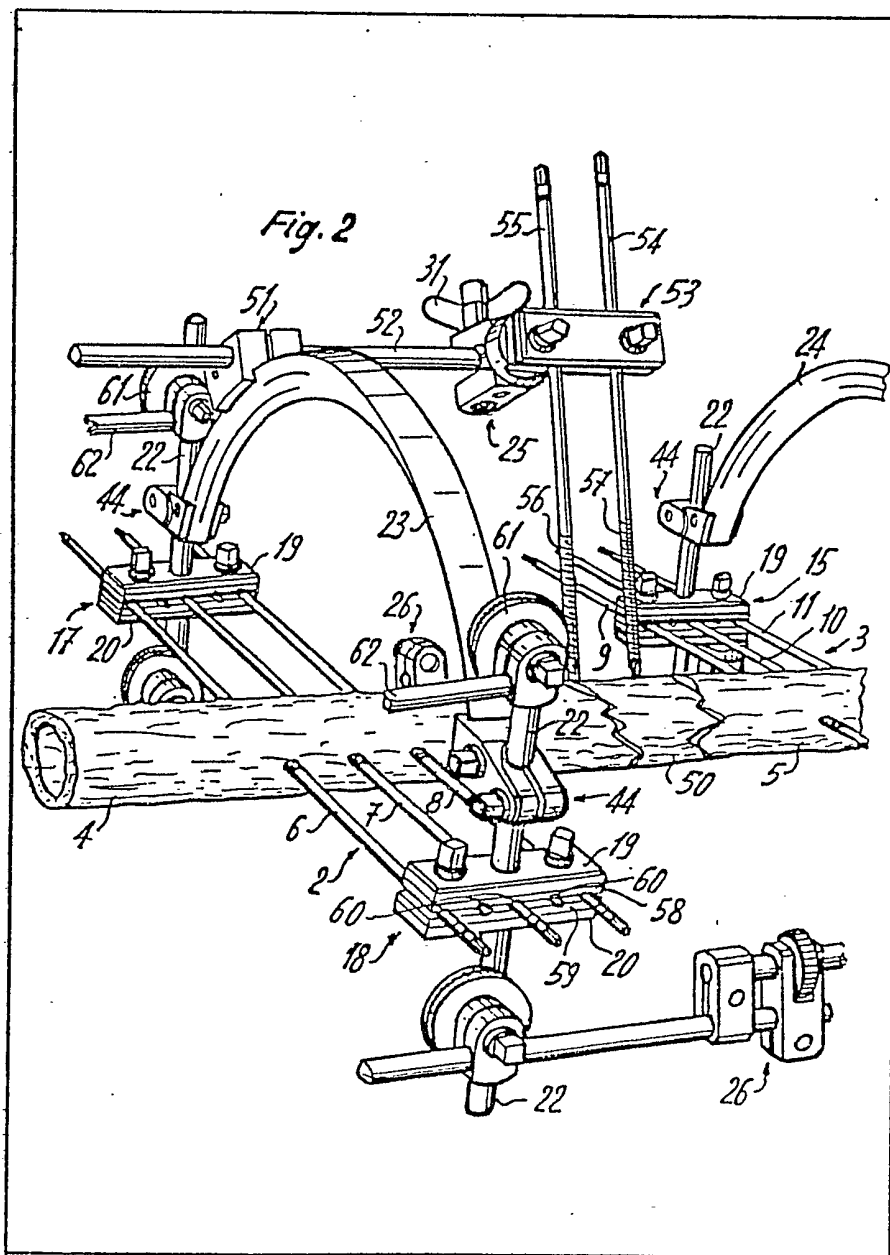
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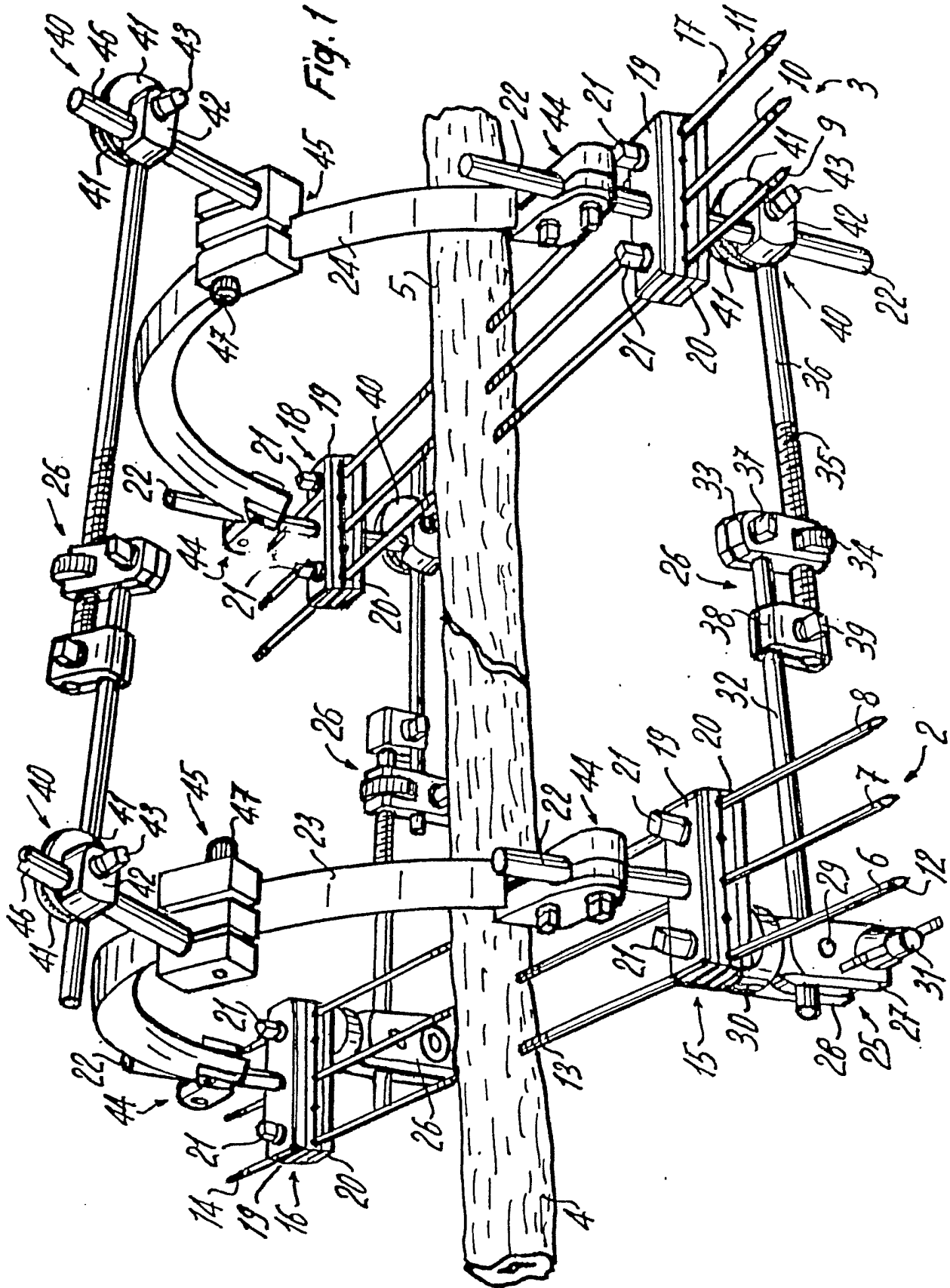
(54) External bone-pin splint

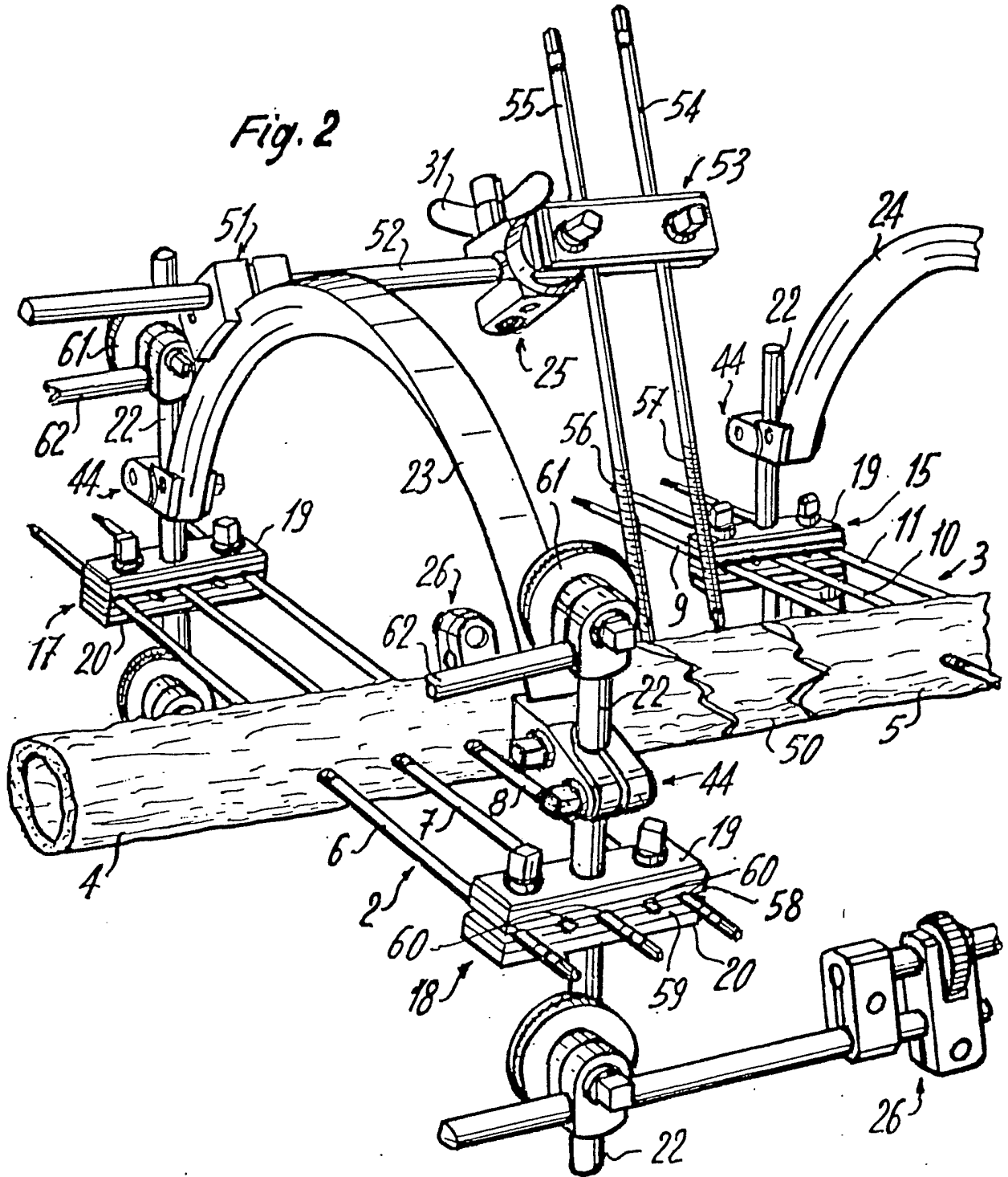
(57) An external bone anchoring means comprises two groups of pins, each comprises of at least one pin or wire for retaining a bone portion, at least one assembly rod connected to each of the two groups, for

interconnecting them, at least one arcuate member of polygonal cross-section connected to the assembly rod adjacent one of the groups of pins, and at least one support piece for supporting the said one group of pins on the arcuate member anywhere along its length.



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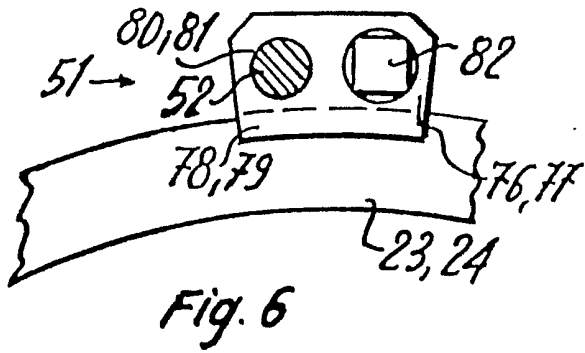


Fig. 6

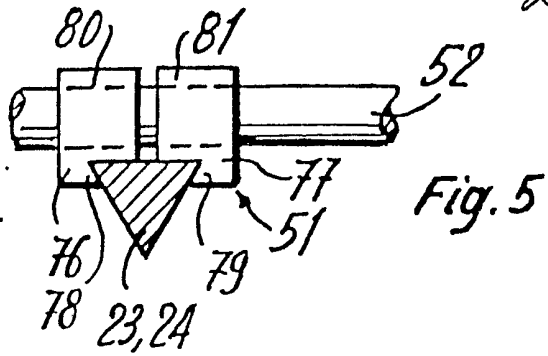


Fig. 5

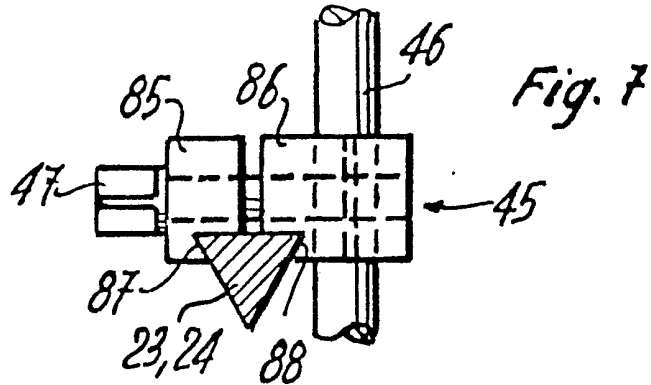


Fig. 7

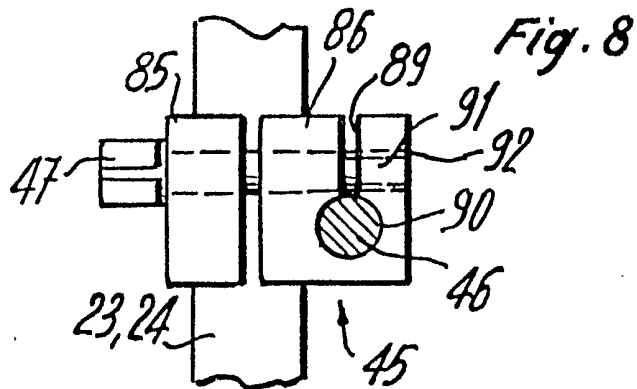


Fig. 8

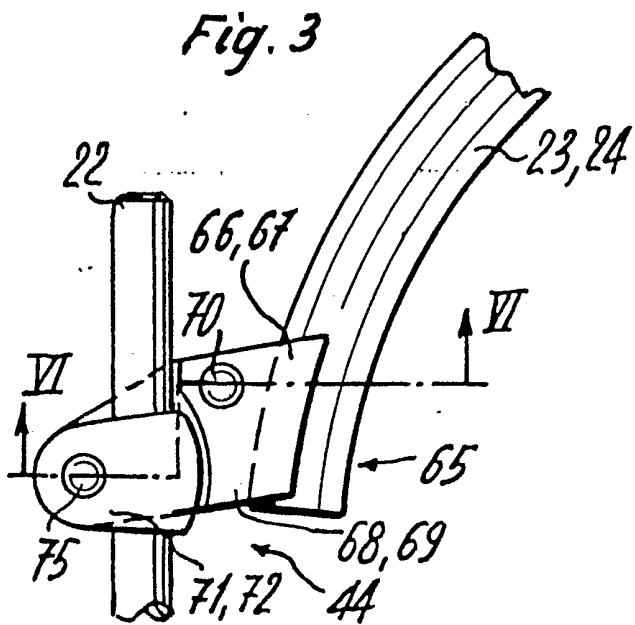


Fig. 3

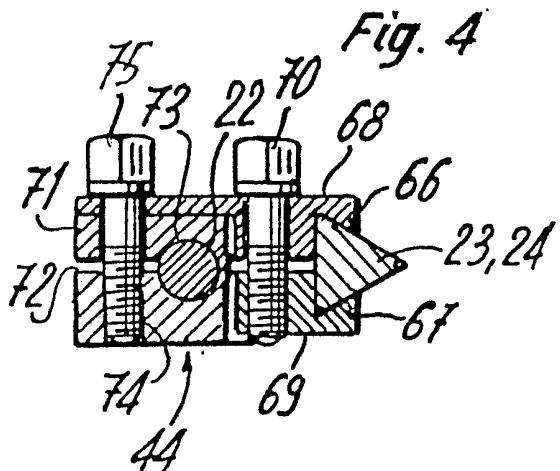
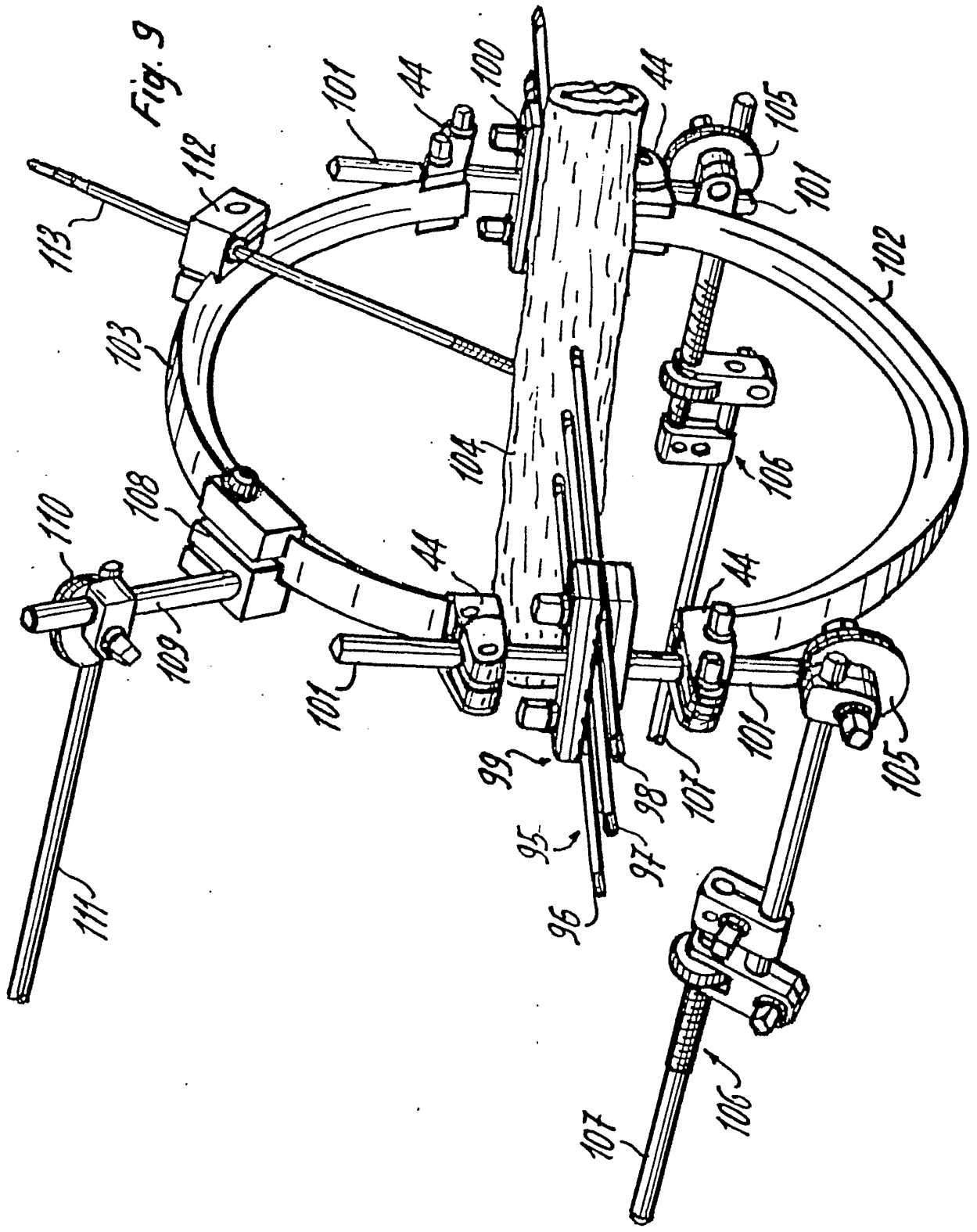
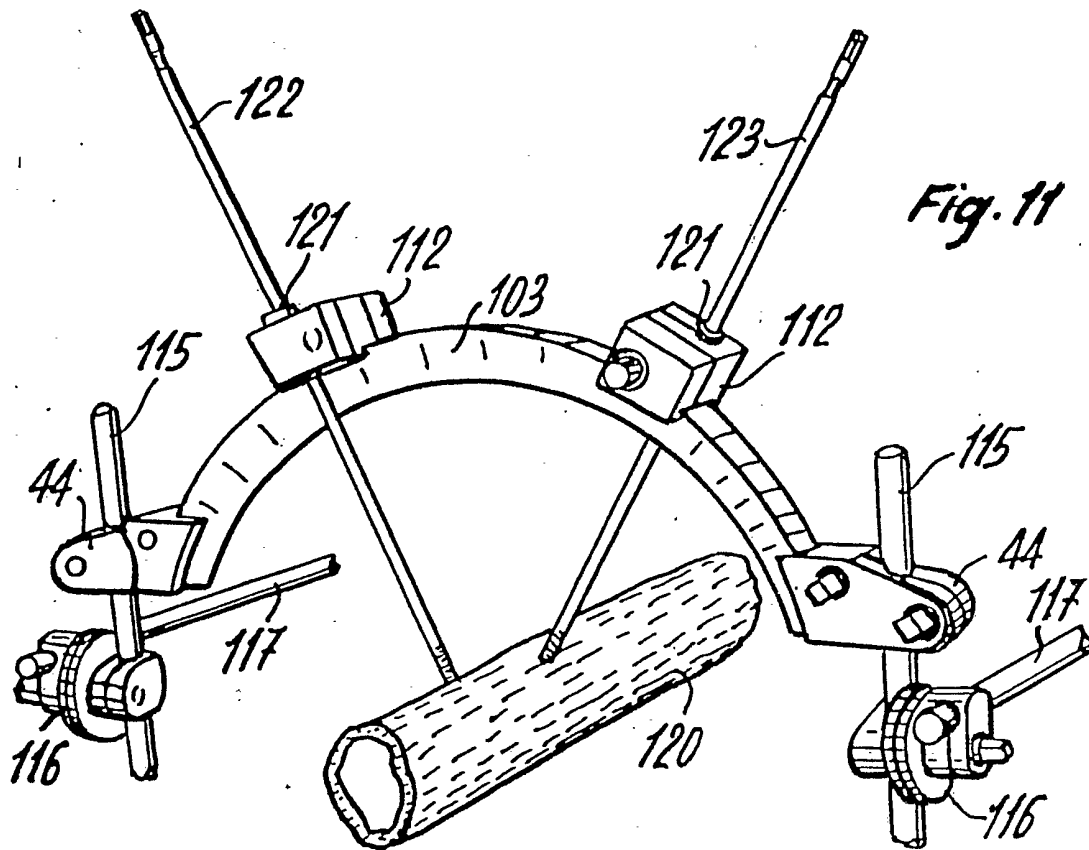
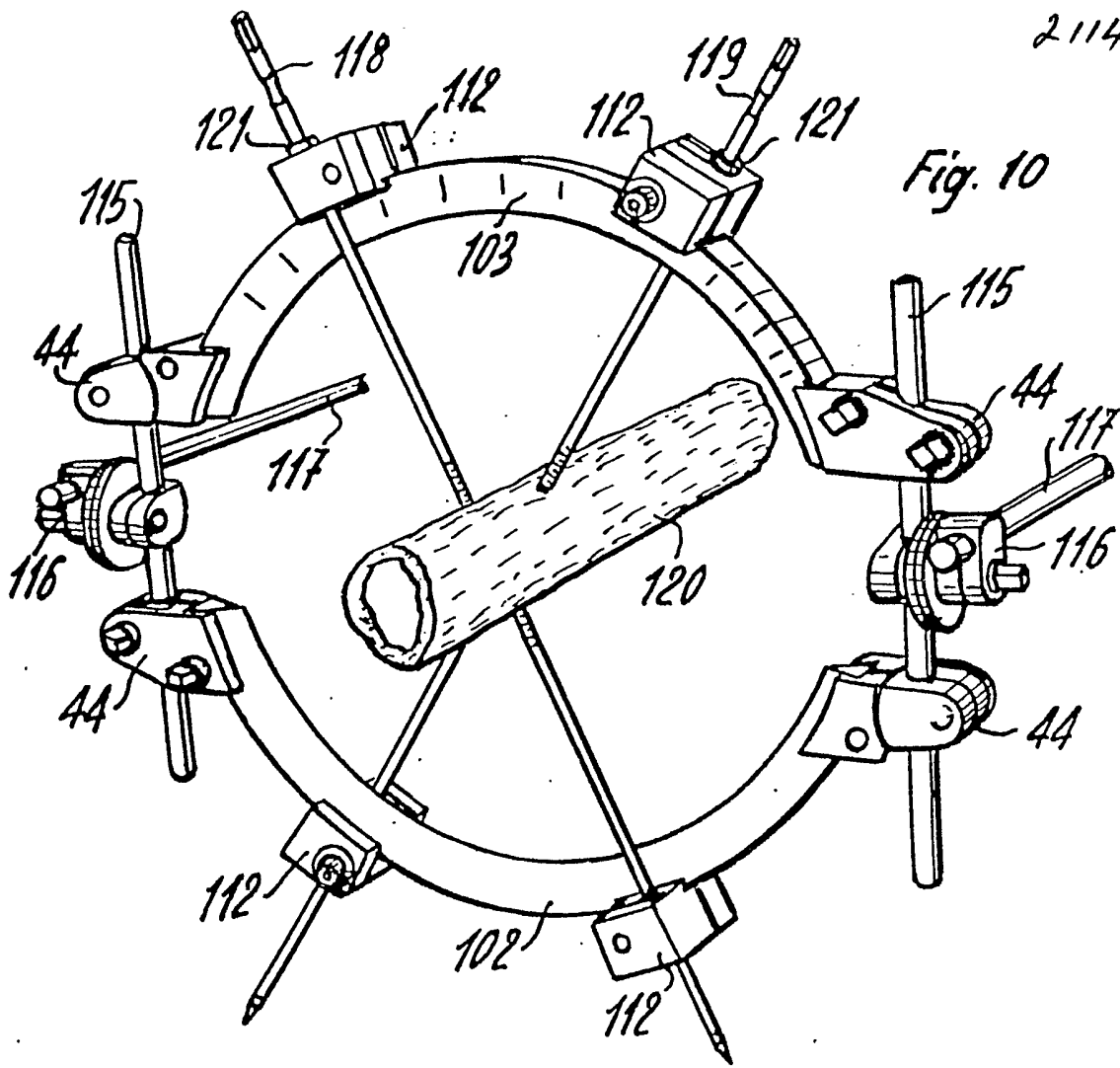


Fig. 4





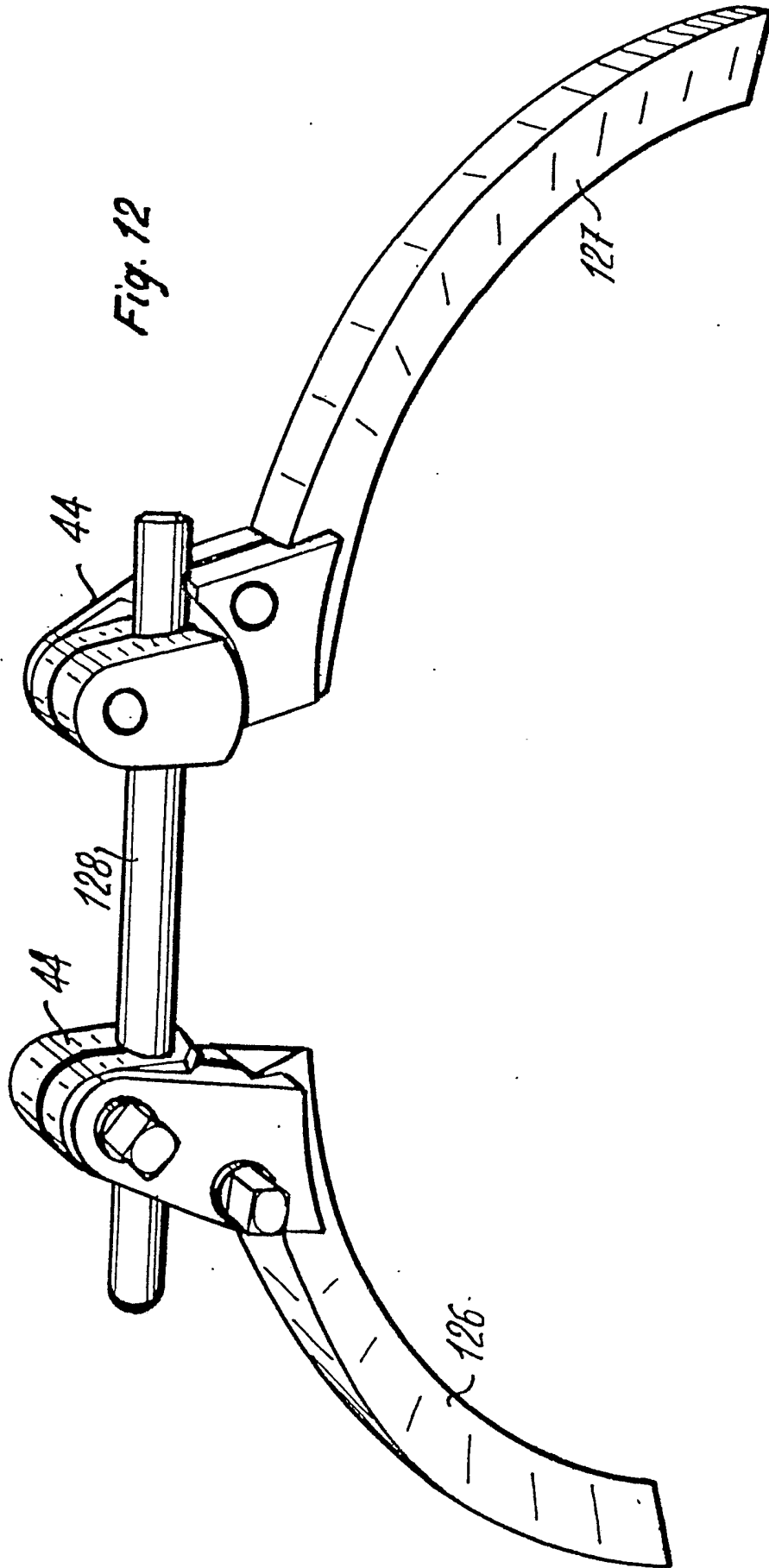


Fig. 12

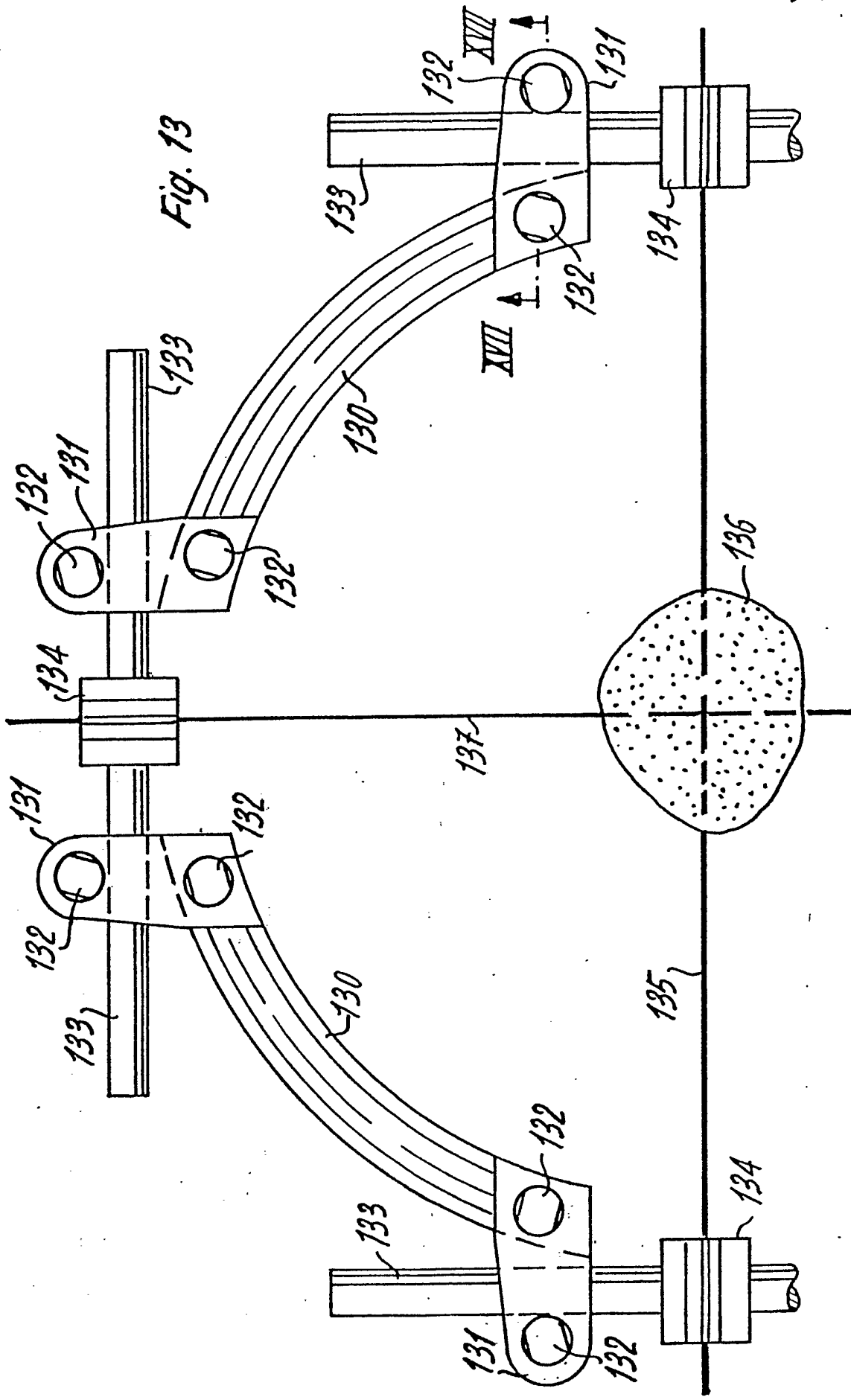
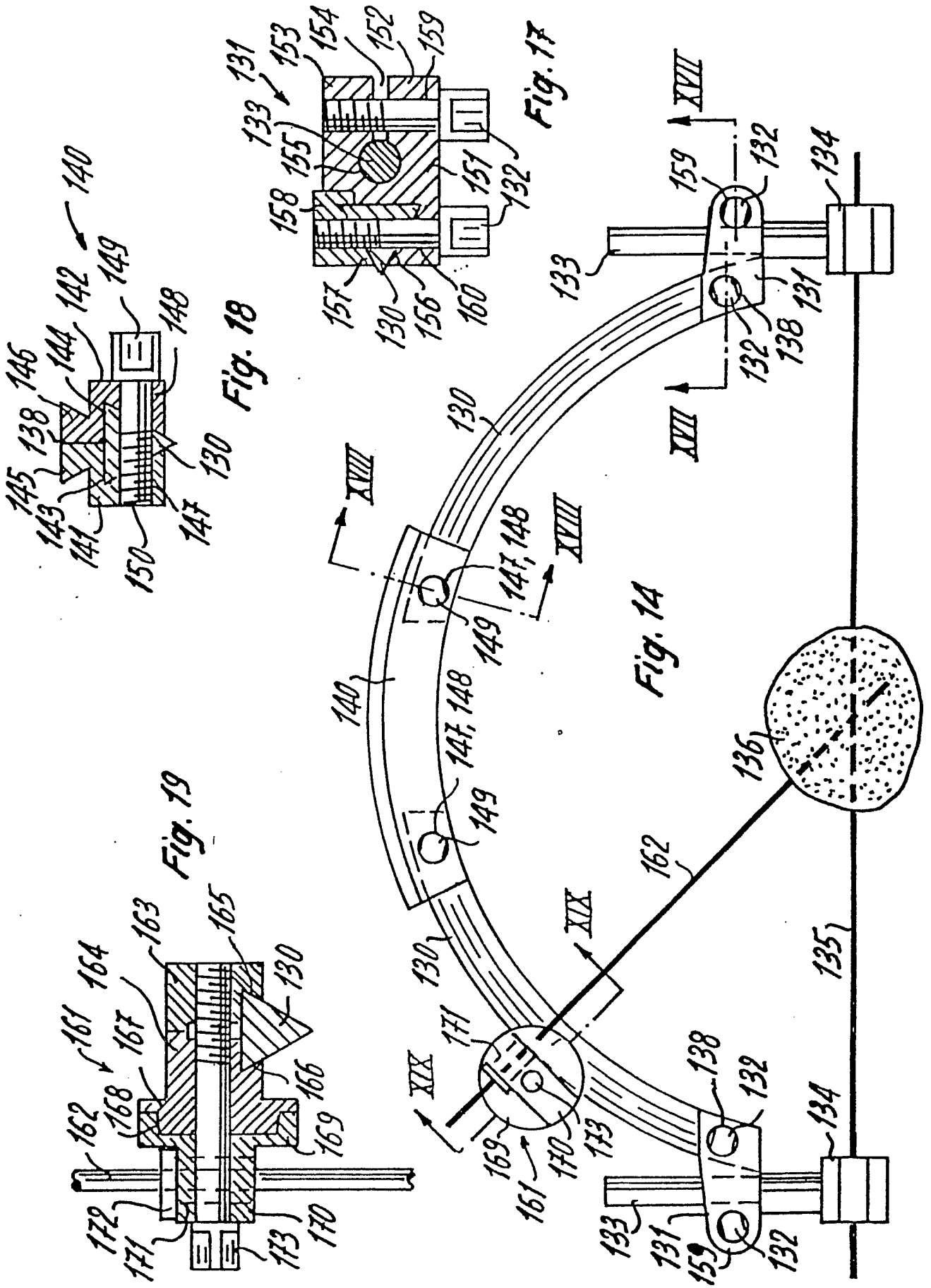


Fig. 13



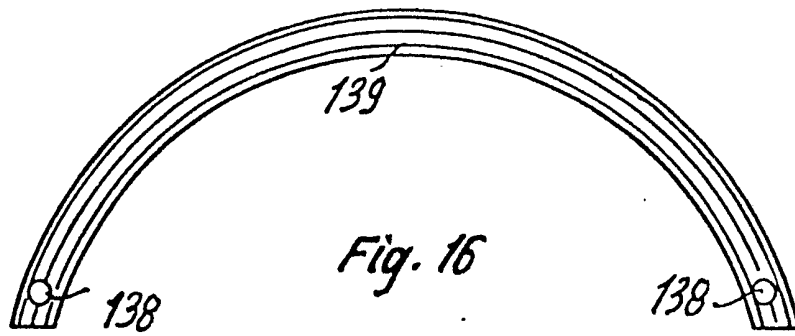


Fig. 16

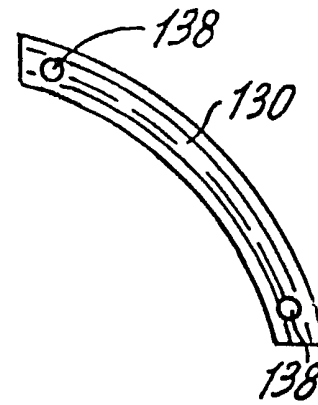


Fig. 15

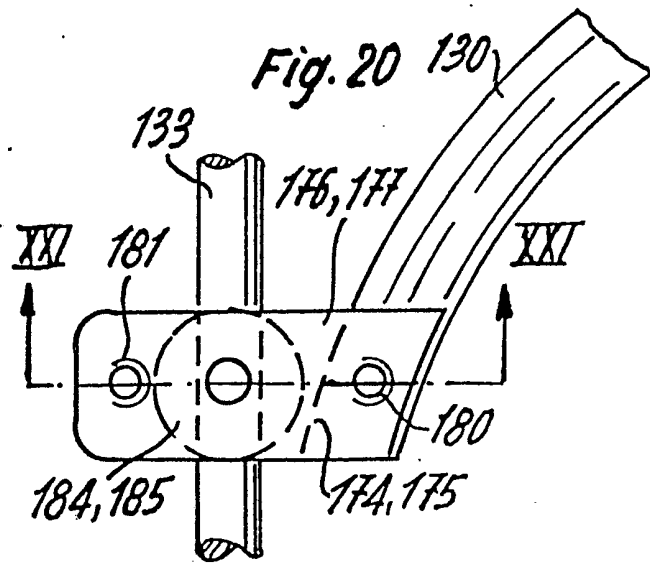


Fig. 20

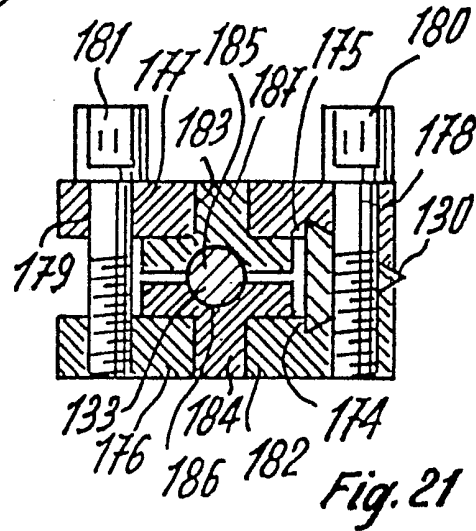


Fig. 21

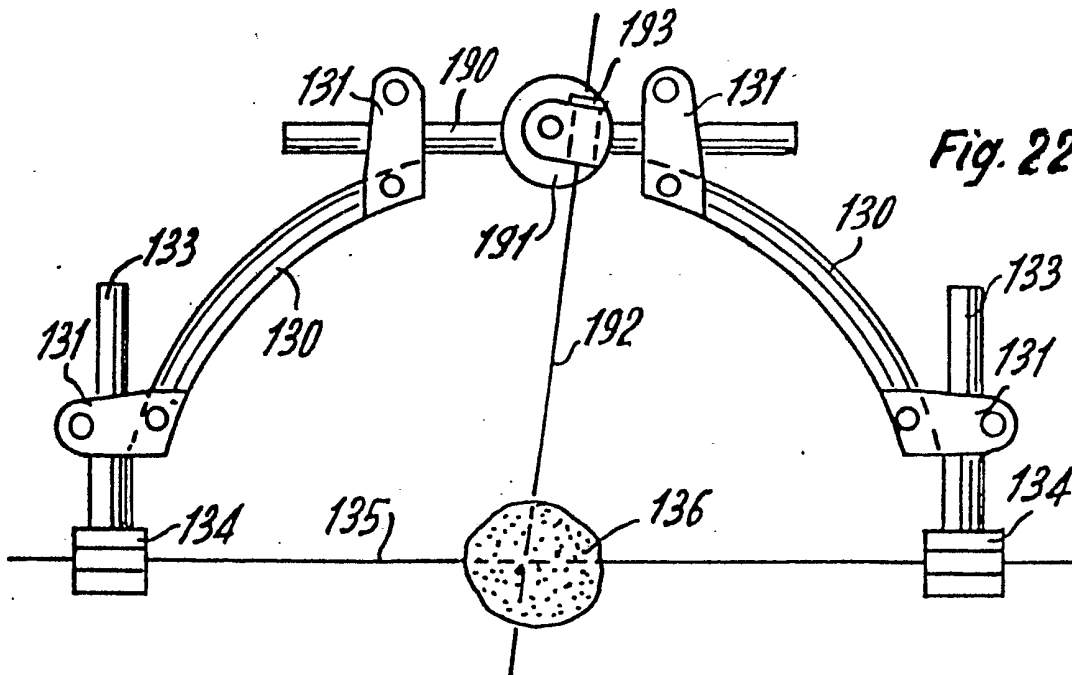


Fig. 22

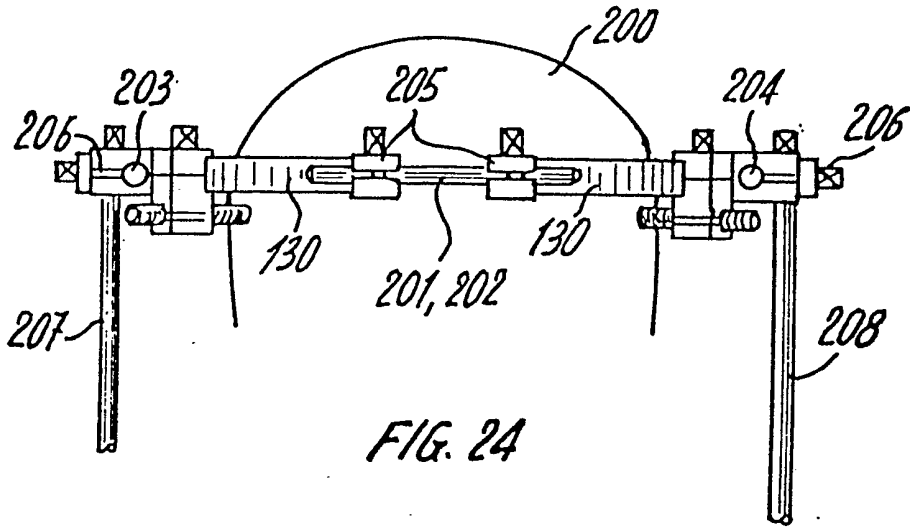


FIG. 24

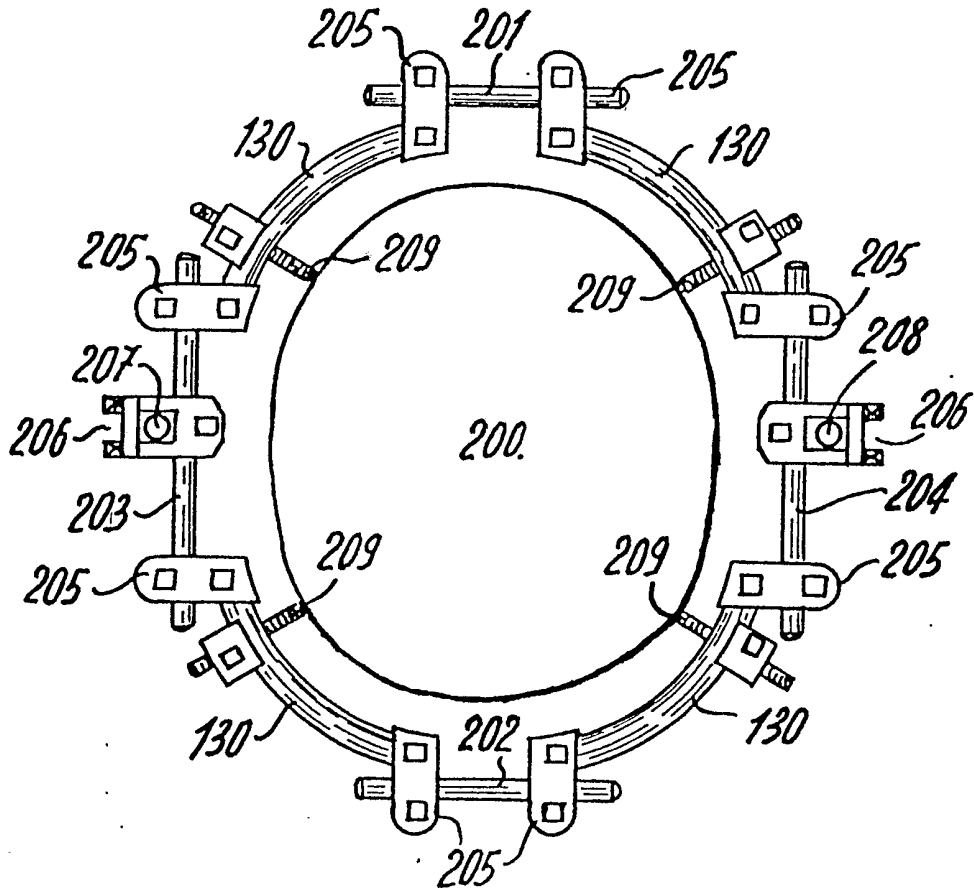


FIG. 23

SPECIFICATION

External bone-anchoring element

The invention relates to an external bone-anchoring element.

5 External anchoring of bones is an old surgical technique which was first used a century ago and the application of which has for a long time been limited to complicated fractures in traumatology and consequently in orthopaedics, that is to say to
10 the secondary treatment of fractures, infections slow knitting of the bones, pseudarthroses, difficult bone-settings etc.

External anchoring is used more particularly in the case of long bones such as the femur, the tibia,
15 the humerus, the radius, the cubitus and, in particular, in the leg.

The Applicant has extended the use of the external anchoring means that he manufactures to the pelvic basin, the clavicle, to joints such as the
20 the knee, elbow and shoulder, and to the skull for the treatment of the cervical and lumbar vertebrae, etc.

The Applicant also manufactures a small anchoring means which can be used on small
25 bones such as the metatarsals and the metacarpals, and in maxillofacial surgery as well as in experimental surgery on small animals.

External bone-anchoring elements enable two kinds of bone-anchoring to be carried out:

30 — transfixing anchoring wherein the pins extend from one side of the limb to the other, and
— non-transfixing anchoring wherein the pins are introduced into the bone without completely transversing it.

35 Transfixing anchoring, which is mostly used on the leg, is more rigid than non-transfixing anchorage.

Fitted at both sides of the leg are two rods or frames which are anchored on two groups of pins
40 disposed on either side of the fracture. The two frames or the two rods are interconnected by a brace which is as stable as possible and which may comprise sliding rods or bars, the length of which can be increased or reduced.

45 Also in existence are external anchoring means made up of rings. Such anchoring means are described for example in Swiss Patent No.

50 579 385 and 596 826 which relate to the use of external anchoring means using the "Russian" method. The anchoring means described in the two above-mentioned Patents are based solely on the use of circles. These are therefore the circles which form the frames and the braces. These
55 circles can be single or double, that is to say they may surround the bone. It is thought that it is the single circle which will be mostly used if there are two groups of parallel pins on each bone

60 fragment. In certain cases, a different problem arises: if the bone fragment is very short, i.e. near a joint, and the fragment is not long enough to allow two or three parallel pins to be secured, use may be made of another method such as that described by the Russians, in which method a very short bone fragment can be anchored by providing

65 a circular support on which are secured smooth transfixing intersecting pins (see Swiss Patent No. 579 385). This Patent discloses a device for interconnecting the various rings, which device is very complicated in its manipulation and therefore
70 does not permit the fracture to be readily set.

Another manufacturer, Kronner, uses a plastics circular arrangement on which are fitted parallel transfixing pins. This device is also different to use since the pins are offset in relation to the circle.

75 Setting is rendered easier, since the connecting bars are mounted on swivel joints. However it seems to us that on the basis of tests carried out by the Applicant, the immobilising system using swivel-joints may permit sliding after setting.

80 All these systems have one point in common, i.e. that of enabling the bone fragments to be moved away or towards each other as required (retraction of compression).

85 As a general rule, the anchoring means based solely on the use of circles can be extended to apply to the clavicle only with difficulty.

The present invention seeks to obviate these disadvantages and to provide an external bone anchoring means which can be used in
90 combination with existing frames and braces, so that the uses of the anchoring device can thus be extended.

In accordance with the invention there is provided an external bone-anchoring means,
95 comprising two groups of pins, each group being comprised of at least one pin, or wire, for retaining a bone portion, at least one assembly rod for interconnecting the two groups, characterised in that at least one arcuate member of polygonal cross-section is connected to the assembly rod
100 adjacent one of the group of pins, the arcuate member having no discontinuities over its length and having a uniform cross-section over its length for enabling the assembly rod to be connected to
105 the arcuate member anywhere along its length.

At least the pins of one group may be anchored at each of their ends in a clamping device, the two clamping devices being interconnected by an arcuate portion.

110 At least the pins of one group may be secured in a cruciform arrangement to at least one semicircle.

In a preferred embodiment, additional pins designed to hold additional bone fragments in
115 position are secured to the circle with the aid of adequate means adapted to position the additional fragments laterally in relation to the circle.

The preferred cross-sectional shape of the arc is triangular. However, it could be square or of general polygonal shape, but for practical reasons the triangular cross-section is preferred because of its rigidity and the possibility of securing the support and assembly pieces in a simple manner,
120 these enabling a large number of different forms of assembly to be used.

In order that the invention may be better understood, several embodiments thereof will now be described by way of example only and

with reference to the accompanying drawings in which:—

5 Figure 1 is a perspective view of an external bone anchoring means comprising two groups of three transfixing pins held in position by a frame, an element in the form of a semi-circle being mounted on each group of pins, bars for joining up the assembly also being shown;.

10 Figure 2 is a perspective view of a modified form of the Figure 1 anchoring means, the semi-circles being used for supporting anchoring members carrying pins;

15 Figure 3 is a side view showing a clamping piece designed to connect the end of an arcuate part to a rod;

Figure 4 is a section along line VI—VI of Figure 3;

20 Figure 5 is a front view showing a lateral anchoring member on a circle of the type illustrated in Figure 2;

Figure 6 is a side view of the Figure 5 anchoring member;

25 Figure 7 is a front view showing a radial anchoring member on an arc and of the type illustrated in Figure 1;

Figure 8 is a plan view of the Figure 7 anchoring member;

30 Figure 9 is a perspective view illustrating the fitting of a part of an external anchoring means wherein a complete circle, formed by fitting together two semi-circles, is mounted on a group of transfixing pins, the arrangement carrying connecting members for effecting connection with another part, not illustrated, of the external anchoring means;

35 Figure 10 is a view, likewise in perspective, of a first modified form of the Figure 9 assembly, the two semi-circles supporting radial intersecting transfixing pins or wires, each pin or wire being secured by its two ends to the circle;

40 Figure 11 is a perspective view of a second modified form of the Figure 9 arrangement, wherein a semi-circle carries two radial pin-halves;

45 Figure 12 shows the fitting of two quarter-circles forming a semi-circle

50 Figure 13 is a front view of an arrangement comprising two quarter-circles forming a semi-circle, and an anchoring device for the pins being held at each end of the two quarter-circles;

55 Figure 14 illustrates a front view of an arrangement comprising two quarter-circles held in position by an intermediate piece, the upper portion of which has the same cross-section as that of the quarter-circles;

Figure 15 is a front view of a quarter-circle used in the assemblies shown in Figures 13 and 14;

60 Figure 16 illustrates a front view of a semi-circle adapted to replace the quarter-circles, for example, as well as the intermediate assembly piece of Figure 14;

65 Figure 17 is a transverse section through an end clamping piece for a ring, on line XVII—XVII of Figure 14, the clamping piece being a modified form of the corresponding pieces shown in Figures

3 and 4 and being designed for use with the quarter-circles or semi-circles of the type illustrated in Figures 15 and 15;

70 Figure 18 is a section along line XVIII—XVIII of Figure 14;

Figure 19 is a cross-section through a swivel-joint which carries a pin and is secured to a quarter-circle, this view being shown along line XIX—XIX of Figure 14;

75 Figure 20 is a front view of a modified form of the end piece of the semi-circles of Figures 13, 14 and 17;

Figure 21 is a view along line XXI—XXI of Figure 20;

80 Figure 22 is a front view of a modified form of the Figure 14 arrangement;

Figure 23 is a plan view of an arrangement made up of four quarter-circles arranged to form a ring for holding a patient's head in position, and

85 Figure 24 is a side view of the arrangement illustrated in Figure 23.

The external bone-anchoring means illustrated in Figure 1 comprises two groups of pins 2 and 3 designed to hold and retain relatively to each other two bone fragments 4 and 5. Each of the groups of pins 2 and 3 comprises respectively three pins 6, 7, 8 and 9, 10, 11 which pass completely through the bone fragments that they are to hold in position. The pins 6 to 11 are called transfixing pins and have at one of their ends a point 12 as illustrated in the case of the pin 6, and a median threaded portion 13, while each has at its other end a head 14 of square cross-section which enables each pin to be screwed into the bones with the aid of a tool, not illustrated.

The pins 6, 7, 8 of group 2 and the pins 9, 10, 11 of group 3 are each retained at their ends by anchoring clamps 15, 16 and 17, 18 respectively. Each of the clamps 15 to 18 comprises two jaws 19, 20 having on their inner adjacent surfaces appropriate grooves for receiving the pins 6 to 11. The jaws 19 and 20 forming each clamp are pressed against each other by means of two square-headed screws 21. The jaws 19 of the clamps 15 and 16 as well as the jaws 19 and 20 of the clamps 17 and 18 are integral with a rod 22 disposed vertically of the plane of the clamp. The upper rods 22 of the jaws 19 of the clamps 15 to 18 enable semi-circles 23 and 24 respectively to be fitted. The jaws 20 of the clamps 15 and 16 are integral with a swivel-joint 25 designed to receive the stem of a slide bar 26. The swivel-joint 25 comprises two lateral pieces 27 and 28 permitting the gripping of a central circular piece, not illustrated, adapted to turn about a spindle 29 and into which is introduced a stem of the slide bar 26. The circular central piece may turn about the spindle 29, and the two lateral pieces 27 and 28 are held in a circular recess, not illustrated, located within a collar 30 integral with the jaw 20. The clamping action of the swivel-joint is achieved by means of a wing-nut 31. The slide bars 26 comprises a stem 32 at the end of which is secured a piece 33 having a small roller 34 which meshes with a screw-threaded part 35 of a

second stem 36. The piece 33 is clamped to the end of the stem 32 by means of a square-headed screw 37. Provided at the end of the screw-threaded part 35 of the stem 36 is a sliding piece 38 designed to slide on the stem 32 when the roller 34 is turned in one or other direction so as to lengthen or shorten the slide bar 26. The sliding piece 38 may also be immobilized on the stem 32 by means of a square-headed screw 39. As already mentioned above, the slide bars 26 located below the plane defined by the pins 6 to 11 are secured, on the one hand, in the swivel-joints 25 integral with the lower jaws 20 of the clamps 15 and 16 and, on the other hand, in toothed swivel-joints 40 secured to the stems 22 of the jaws 20 of the clamps 17 and 18. The toothed swivel-joints 40 each comprises two discs 41 which are applied to each other and the adjacent surfaces of which are toothed. The outer surfaces of the discs comprise parts 42 designed to receive and retain by friction stems, for example the stems 36 of the slide bars 26 on the one hand, and on the other hand, the stems 22 of the lower jaws of the clamps 17 and 18. The toothed swivel-joints 40 are immobilized by means of a square-headed screw 43.

The semi-circles 23 and 24 are each secured to the stems 22 of the upper jaws 19 of the clamps 15, 16, 17 and 18 with the aid of assembly pieces 44 which enable the ends of the semi-circles 23 and 24 and the stem 22 to be gripped by friction. The assembly pieces 44 will be described in detail hereinafter by reference to Figures 3 and 4. After the semi-circles 23 and 24 have been positioned and immobilized on the stems 22 of the clamps 15 to 18 with the aid of the pieces 44, support pieces 25 in which the rods 46 are clamped are secured to said semi-circles. The pieces 45 are support pieces adapted to be secured on the semi-circles 23 and 24 and to retain the rod 46 by friction and radially of the semi-circle, by means of a single screw 47. The pieces 45 will now be described in detail with reference to Figures 7 and 8. Secured to the rods 46 are toothed swivel-joints 40 identical to those described above, and a slide bar 26 is placed between the two swivel-joints 40 secured to the rod 46.

In the embodiment of the external anchoring means which has just been described, the two groups 2 and 3 of pins 6, 7, 8 and 9, 10, 11 respectively retain two bone fragments which can be held in any required position relatively to each other. The two slide bars 26 located below the plane defined by the groups 2 and 3 of pins form, together with the swivel-joints 25, the toothed swivel-joints 40 and the rods 22, a lower fitting. The two semi-circles 23, 24, the assembly pieces 44 and 45 and the swivel-joints 40 mounted on the rods 46 and used for mounting the upper slide bar constitute the upper fitting of the external anchoring means of Fig. 1.

The external bone-anchoring means 1 illustrated in Fig. 1 is positioned in the following way:

The two groups 2 and 3 of pins 6, 7, 8 and 9,

10, 11 respectively are placed in position with the aid of a template or guide and a brace, not illustrated. Since a template is used, the pins of the two groups 2 and 3 are perfectly parallel with each other and are equidistant from each other so that they can be introduced and clamped without difficulty between the jaws 19 and 20 of the clamps 15, 16, 17 and 18. The next step is to position the lower fitting formed by the assembly consisting of the two slide bars 26 and the swivel-joints 25 and 40, and the upper fitting formed by the semi-circles 23 and 24, the pieces 44 and 45, the rods 46, the swivel-joints 40 and the third slide-bar 26. The two pieces of bone 4 and 5 can be positioned as required by suitably selecting the positions of the swivel-joints 25 and 40 before immobilization. On the other hand, it is possible to move the pieces of bone away from or towards each other by lengthening or shortening the slidebars 26 by turning the rollers 34 on the bars in the required direction. The presence of the semi-circles 23 and 24 impart very great rigidity to the system.

In connection with the variant illustrated in Fig. 2, three bone fragments are to be positioned relatively to each other instead of the two fragments 4 and 5. In fact, an additional fragment 50 is placed between the two fragments 4 and 5. As shown in Fig. 2 one of the arcs, i.e. the arc 23, is to carry a support element, described below, which enables the bone fragment 50 to be held in position. In this variant the two groups 2 and 3 of three pins 6, 7, 8 and 9, 10, 11 respectively are again held in position between the jaws 19 and 20 of the clamps 15, 16, 17 and 18. The rods 22 of the lower jaws 20 of the clamps 17 and 18, as in the Fig. 1 embodiment, support toothed swivel-joints 40, and the lower jaws 20 of the clamps 15 and 16 carry joints with wing-nuts 25, and sliding bars 26 are placed between the joints 25 and 40 to form the lower fitting. The rods 22 of the upper jaws 19 of the clamps 15, 16, 17 and 18 carry assembly pieces 44 which enable the semi-circles 23 and 24 to be held in position and clamped. The assembly pieces are identical to those of Fig. 1 and will be described in detail hereinafter by reference to Figs. 3 and 4. Placed on the semi-circle 23 is a support piece 51 which enables a rod 53 to be secured parallel to the axis of the bone fragments 4 and 5 or perpendicular to the plane of the semi-circles 23 and 24. The piece 51 will be described in detail hereinafter by reference to Figs. 5 and 6. Secured to the rod 52 is a swivel-joint 25 with its clamping wing-nut integral with an anchoring clamp 53 similar to the clamps 15 to 18. Held in the clamp 53 are two pin-halves 54 and 55, the screw-threaded ends 56 and 57 respectively of which are screwed into the bone fragment 50 which is to be positioned between the fragments 4 and 5. As in the case of the pins 6 to 11, the pin-halves 54 and 55 each have, at that end remote from that screwed into the bone fragment 50, a square-section head which enables the pin to be engaged by a spanner for screwing it on to a bone. As illustrated in Figs. 1 and 2, the

pins 54 and 55 are shorter than the pins 6 to 11 which extend completely through the bone. Their screw-thread is provided at one of their ends since they are not intended to extend right through the bone. On the other hand, the pins 6 to 11 in the embodiments shown in Figs. 1 and 2 are transfixing pins and have a screw-threaded portion at their median zone where they are to be retained in the bone fragments 4 and 5. In the variant shown in Fig. 2, it will be seen that the jaws of the clamps 15 to 18, as in the case of the clamp 53, have (see the clamp 18 in Fig. 2) lower linings 58 and 59, the adjacent surfaces of which are provided with grooves 60 designed to accommodate the pins. As illustrated in the case of the clamp 18 (Fig. 2), five pairs of corresponding grooves 60 are provided. It is thus possible to retain one to five pins in each clamp.

In the Fig. 2 variant, the ends of the rods of the upper jaws 19 carry clamps 17 and 18 of toothed swivel-joints 61, supporting rods 62 which enable the upper frame of the external anchoring means to be extended towards the left. It will be possible to secure, on these rods 62, any additional retaining means considered useful, for example, a pin-half, not illustrated, similar to the halves 54 or 55 and serving to reinforce the anchoring of the fragment 4 at the left and thus to avoid any flexure if force is applied to this bone fragment. An additional pin of this kind could also be secured to the semi-circle 23 by means of a support piece 51, a rod 52 and a clamp 53 all similar to the elements illustrated in Fig. 2, and all extending to the left.

The advantage provided by the arc 23 and the mounting of the elements 51 to 55 or any other arrangement of this type based on an arc resides mainly in the fact that the assembly can be positioned at any point along the arc. The fragment 50 that it supports would then be positioned with precision and without difficulty relatively to the two other bone fragments 4 and 5. On the other hand, since the arc 23 is of triangular cross-section, the rod 52 can be very firmly anchored with the aid of the support piece 51 and will not become displaced. It will also be observed that there remains, on the arc 23 as well as on the arc 24, all the space necessary for providing other assemblies, for example, for providing means for increasing the stability of the anchoring means as a whole, or for reinforcing the anchoring of a bone fragment in relation to the arc.

As shown in Figs. 3 and 4, the pieces for fitting the arcs 23 and 24 on the rods 22 enable complete stability to be established between the arc and the rest of the external anchoring means. The end 65 of each of the arcs 23 and 24 of triangular cross-section is held between two oppositely disposed part-circular grooves 66 and 67, the curvature of which corresponds to that of the arcs 23 and 24 and which are formed in two shells 68 and 69 adapted to be pressed against the arcs 23 and 24 by means of a square-headed screw 70. The shell 68 is extended sideways

towards the exterior in relation to the end of the arcs 23 and 24 so as to receive a clamping element 71 having a bore 73 and a slot 72. The bore 73 is provided for receiving the rod 22. The screw 75 extends through the shell 68 as well as the clamping element 71. The screw-threaded part 74 permits immobilization of the rod 22 as well as the clamping element 71 with the shell 68. As shown in Figs. 3 and 4, the clamping element 71 and the rod 22 can pivot about the axis of the screw 75 until the latter is tightened. The assembly piece 44, which has been described by reference to Figs. 3 and 4, is positioned with the arc in the manner described below:

The square-headed screw 70 is loosened to some extent and the two shells 68 and 69 are moved away from each other. The screw 75 is also loosened to some extent to release the clamp element 71 (the slot 72 opens) and thus to enable the rod 22 then to be introduced into the bore 73. The end of each arc 23 and 24 is introduced into the grooves 66 and 67 and the screw 70 is tightened, and this causes the two shells 68 and 69 to be immobilized on the ends of the arc. The rod 22 is then introduced into the bore 73 of the clamp element 71, and the assembly is placed at the required point on the rod 22. Since the clamp element 71 can pivot about the axis of the screw 75, fitting on to the rod 22 will be facilitated when the piece 44 is in position on the rod, and when the screw is blocked and the assembly comprising the rod 22, the assembly piece 44 and the arcs 23 and 24 become rigid. If necessary it is possible first to place the rod 22 in the bore 73 of the clamp element 71, after which the end 65 of each of the arcs 23 and 24 is brought into the grooves 66 and 67 in the shells 68 and 69. When all these parts are in position, the screws 70 and 85 are tightened.

As already mentioned above, the support piece 51, illustrated in detail in Figs. 5 and 6, enables a rod 52 to be secured perpendicularly to the plane of the arcs 23 and 24 on which it is positioned. The piece 51 comprises two clamping devices 76 and 77 having two grooves 78 and 79 suitable for gripping the triangular cross-section of the arcs 23 and 24. As shown in Fig. 6, the grooves 78 and 79 have the same curvature as the arcs 23 and 24. Each clamping device 76 and 77 is provided at one of its sides with a bore 80 and 81 respectively, the axes of these bores being in alignment when the clamping devices are placed opposite each other. At their other sides the clamping devices 76 and 77 are interconnected by a square-headed screw 82. The rod 52 is introduced into the bores 80 and 81 of the clamping devices 76 and 77 respectively which in turn are placed on the arcs 23 and 24. It is only required to tighten the screw 82 to immobilize the clamping devices 76 and 77 on the arcs 23 and 24 and, at the same time, to immobilize the rod 52 by flexion.

The support piece 51, just described by reference to Figs. 5 and 6, permits the fixing, at any point along the periphery of the arcs 23 and

24, a rod 52 which extends perpendicularly from one or both sides of the plane of the arc. This rod can be used for supporting any device for retaining a fragment of bone or for any device for reinforcing the system as a whole or a part of the external anchoring means of which it is a component part. As already stated in other terms, its positioning on the arcs 23 and 24 is not limited to predetermined points. Thus it can be positioned with precision along the entire arc.

As already mentioned in connection with the Fig. 1 embodiment, the support piece 45 illustrated in Figs. 7 and 8 enables a rod to be positioned radially of the arcs 23 and 24. The piece 45 comprises two clamping devices 85 and 86 each having at its lower part two grooves 87 and 88 adapted to grip the arcs 23 and 24. The grooves 87 and 88 have a curvature identical to that of the arcs 23 and 24. The clamping device 86 has a slot 89 which delimits two clamping tabs and runs into a bore 90 designed to receive the rod 46. The two clamping devices 75 and 86 are interconnected by the square-headed screw 47, the screw-threaded portion 91 of which meshes with a screw-threaded portion 92 formed in the outer clamping lug of the element 86. It can be seen from Fig. 8 that tightening of the screw 47 immobilizes, on the one hand, the two clamping elements 85 and 86 on the arc, and on the other hand, the rod 46 in the bore 90. As in the case of the support piece 51 shown in Figs. 5 and 6, the piece 45, illustrated in Figs. 7 and 8 and just described, can be placed at any point along the arcs 23 and 24. The rod 46 that it is to grip can be used either as a support for any means for retaining a bone fragment, or as a support for increasing the stability of the external anchoring means of which it is a component part.

In the mounting means shown in Fig. 9, illustrating a part of an external anchoring means, a group 95 of three pins 96, 97 and 98 is anchored in two clamps 99 and 100 identical to the clamps 17 and 18 used in the embodiment and the variant shown in Figs. 1 and 2. Secured on the rods 101 integral with the jaws of the clamps are two semi-circles 102 and 103 of triangular cross-section, assembly pieces as described by reference to Figs. 3 and 4 being used for this purpose. The semi-circles 102 and 103 are mounted on the rods 101 in such manner that their peripheries substantially describe a circle, the central axis of which coincides with the axis of a bone fragment 104 held by the group of pins 96 to 98. The lower rods 101 of the clamps 99 and 100 are each provided with a swivel-joint 105 each of which grips a slide bar 106, the free end 107 of which will be solidly connected to the other part, not illustrated in Fig. 9, of the external anchoring means. This other non-illustrated part of the external anchoring means may be similar to the part shown in Fig. 9 or to one of the parts in the Fig. 1 embodiment or the Fig. 2 variant, or it may be similar to one of the variants described hereinafter by reference to Figs. 10 to 22.

Secured to the arc 103 is a support piece 108

identical to the piece 45 shown in Figs. 7 and 8; the piece 108 grips a rod 109, supporting a swivel-joint 110, and a further rod 111 substantially parallel with the slide bars 106 and performing the same function.

Secured to the semi-circle 103 is a support piece 112 identical to the piece 45 shown in Figs. 7 and 8, in which piece is secured a pin-half 113, the end of which is screwed into the bone fragment 104. The pin-half 113 is introduced into the bore of the support piece 112, having a cylindrical sleeve or lining, not visible in Fig. 9, for the purpose of adapting the undersize diameter of the pin 113 to suit the bore of the corresponding piece 112 which normally corresponds to the diameter of a rod similar to the rods 101, 109, 111, etc.

The presence of the half-pin 113 in the bone fragment 104 enables the arrangement consisting of the bone and the arc to be considerably strengthened. In effect, without the half-pin 113, the transfixing pins 96, 97 and 98 would be able to flex to a quite considerable extent if force were applied in the vertical direction to one of the ends of the bone fragment. The expert will immediately observe that the semi-circles 102 and 103 provide all the space necessary for accommodating other means for positioning additional bone fragments or for increasing the stability of the external anchoring means. On the other hand, since the two semi-circles 102 and 103 completely surround the limb, the bone of which they anchor, said limb is thus enclosed and protected by the anchoring assembly.

In the first variant of the Fig. 9 assembly that is illustrated in perspective in Fig. 10, the two semi-circles 102 and 103 are connected at each of their ends by a single rod 115 with the aid of assembly pieces 44. Midway along the rods 115 are located swivel-joints 116 at the ends of rods 117 designed to be secured to the second part, not illustrated, of the external anchoring means. Two transfixing pins 118 and 119 between them form an angle of approximately 70° and they transverse and hold in position a bone fragment 120. The transfixing pins 118 and 119 are held against the semi-circles 102 and 103 respectively by means of support pieces 112 identical to the corresponding piece 45 shown in Figs. 7 and 8. In the Fig. 10 variant can be seen the sleeves or linings 121 fitted in the bores of the pieces 112 clamping the semi-circles 102 and 103. The expert will observe that in the Fig. 10 variant, the support pieces 112 are so positioned that the pin 118 extends in front of the two arcs 102 and 103, whereas the pin 119 extends behind them. This method of fitting the pins 118 and 119 renders it possible to avoid crossing the pins in the bone fragment 120. The pins are thus slightly offset from each other, and this offsetting, combined with the fact that the pins do not cross each other and are firmly retained over the entire length of the bores in the pieces 112 by means of the sleeves or linings 121, enables the bone fragment 120 to be positioned in a particularly stable

manner. It is necessary to apply a very considerable force to one end of the fragment 121 to cause it to shift even slightly.

In the second variant shown in Fig. 11, the bone fragment 120 is held in position by two half-pins 122 and 123 which are not transfixing, that is to say they do not completely pass through said fragment 120. The half-pins 122 and 123 are secured on the semi-circle 103 in the same manner as in the preceding variant shown in Fig. 10, that is to say by means of two support pieces 112 and two linings 121. The semi-circle 103 is connected to the external anchoring means, not illustrated, in the same way as in the Fig. 10 variant, that is to say with the aid of assembly pieces 44, rods 115, swivel-joints 116 and rods 117.

In the embodiments and variants of the assemblies described by reference to Figs. 9, 10 and 11, i.e. the embodiments wherein a complete circle is formed by two semi-circles, lend themselves particularly to the use of wires instead of pins or half-pins. The wires will be fitted in the same way as the pins, for example, with the aid of the pieces 112 (Fig. 9 to 11) and sleeves of linings 121 suited to the diameter of the wires. The Applicant has developed a turnbuckle, not illustrated, which is applied to the pieces 112 and enables the wires to be tensioned before immobilizing said pieces 112 by means of screws. It is obvious that if wires are used, they must be transfixing, i.e. they must extend completely through the bone or bone fragment, and this is the reason why complete circles are particularly well suited for use with wires. The embodiment and variant in Figs. 1 and 2 also lend themselves to the use of wire. The wires can be tensioned between the two clamps 15, 16 and 17, 18 held in position by the semi-circles 23 and 24, the turnbuckle, not illustrated, being applied to the clamp before immobilizing the screws 21. The wires used will preferably be made of stainless steel.

In the embodiment shown in Fig. 12, a semi-circle is formed from two quarter-circles 126 and 127 held together by two assembly pieces 44 interconnected by a single rod 128. The Fig. 12 embodiment can replace the two semi-circles described in connection with the embodiments and variants of Figs. 1 to 11. On the rod between the two assembly pieces there can be placed a swivel-joint, not illustrated, for example, which will serve, for instance, for clamping any device for increasing the stability of the external anchoring means on which the two quarter-circles 126 and 127 are fitted, or any device for holding a bone fragment in position. On the other hand, the rod 128 may be replaced by a pin-anchoring clamp, not illustrated, similar to the clamps 15 to 18 used in the previously described arrangements. Each of the quarter-circles 126 and 127 can likewise be provided with any device for holding a bone fragment in position or any means designed to connect the Fig. 12 assembly to a frame of the external anchoring means, not illustrated, of which it forms part, this being done with the aid of the

support pieces 45 and 51 shown in Figs. 5 to 8. Finally, the quarter-circles 126 and 127 do not necessarily have to be used together. The fitting of a single quarter-circle where needed can readily be imagined. The quarter-circle 126 would then be provided with two assembly pieces 44 at each of its ends, or with a piece 44 and a support piece 45 or 51 as in Figs. 5 to 8, or even simply with support pieces 45 or 51, and the quarter-circle would be connected to an external anchoring means, not illustrated.

In the Fig. 13 arrangement, two quarter-circles 130 have at their ends assembly pieces 131 illustrated in section in Fig. 17. The assembly pieces 131 make it possible to connect the ends of the arcs 130 very firmly to rods 133 with the aid of screws 132. Each of the rods 133 is connected to a jaw of an anchoring clamp 134 identical to the clamps 15 to 18 in the embodiment and variants shown in Figs. 1, 2 and 9. The clamps 132 serve to anchor groups of pins 135 and 137 respectively which hold a bone fragment 136 in position. The quarter-circles 130 are illustrated in detail in Fig. 15 and have at their ends holes 138 into which are passed the screws 132 (Fig. 13) of the assembly pieces 131. The two quarter-circles 130 can clearly be replaced by a semi-circle 139 such as is illustrated in Fig. 16. The semi-circle 139 also has at its ends two holes 138 which will enable the screws 132 to be fitted and the assembly pieces 131 to be fixed.

In the Fig. 14 arrangement which represents a variant of the Fig. 13 arrangement, two quarter-circles 130 identical to those of Fig. 13 and consequently to the quarter-circles illustrated in Fig. 15 are provided at their opposite ends with assembly pieces 131 screwed on to the ends of the arcs 130 with the aid of screws 132. The assembly pieces 131 are in turn fitted on rods 133 of the upper jaws of the anchoring clamps 134. Firmly held in the two clamps 134 is a group of transfixing pins 135 which hold a bone fragment 136 in position.

The two quarter-circles 130 are interconnected by a central piece 140 shown in section in Fig. 18. Referring to the section in Fig. 18, it can be seen that the intermediate piece 140 comprises two parts 141 and 142 having interior grooves 143 and 144 respectively enabling the triangular end of the arcs 130 to be gripped. It can be seen from Fig. 14 that the piece 140 has the same curvature as the arcs 130. On the other hand the parts 141 and 142 of the piece 140 have two ribs 145 and 146 along their outer periphery, which ribs together form a triangular cross-section which will permit of the securing, to the piece 140, of the support pieces 45 illustrated in Figs. 7 and 8, or the support pieces 51 illustrated in Figs. 5 and 6, or the modified forms of these pieces, for example, the variant illustrated in Fig. 19 which will be described later. The parts 141 and 142 again each have a bore 147 and 148 which are in alignment and which will permit the introduction of a screw 149 designed to immobilize the two parts 141 and 142 of the piece 140. It will be seen in Figs.

14 and 18, that the screw-threaded part 150 of the screw 149 meshes with a complementary screw-threaded portion in the bore 47 after having passed through the bore 138 at the end of the arc 130. With the screw 149 immobilized, the arcs 130 are retained in a stable and firm manner in the piece 140.

The advantage of the arrangement shown in Fig. 14 and comprising two quarter-circles 130 and the piece 140 resides in the fact that the support pieces, similar to those illustrated in Figs. 5 to 8, can be fitted at any selected position along the entire periphery of the arc, including the back of the piece 140. The pieces 140 are of different lengths such that with the quarter-circles 130 they are able to form semi-circles of different diameter. Thus, the Fig. 14 arrangement offers an extended range of uses of the quarter-circles 130.

Fig. 17 illustrates in section the assembly piece 131 which enables the ends of the arcs 130 to be fitted to the rods 133 in the Fig. 13 and 14 arrangements. The assembly piece 131 comprises a clamp 151, one end of which has two side-faces 152 and 153 separated by a groove 154 and forming at the middle a bore 155 intended to accommodate the rod 133. The other end of the clamp 151 comprises a groove 156 intended to grip the triangular cross-section of the quarter-circle 130 by co-operating with a further corresponding groove 157 formed in a co-operating clamp 158. Two bores 159 and 160 are formed in the two ends of the piece 151 as well as in the piece 158. The bore of the piece 158 is screw-threaded, as is the bore associated with the side-face 153 of the piece 151, and these two bores are designed to accommodate the screw-threaded parts of the screws 132. Examination of Fig. 17 will immediately show that the tightening of the two screws 132 will cause immobilization of the rod 133 on the one hand, and immobilization of the quarter-circle 130 between the pieces 151 and 158, the screw 132 extending through the bore 138 of the quarter-circle 130.

Secured to the quarter-circle 130 located to the left in the Fig. 14 arrangement is a support clamp 161 provided with a swivel-joint and designed to position a rod 162 used for reinforcing the anchorage of the bone fragment 136 achieved with the aid of a group of pins 135. The support piece 161 illustrated in section in Fig. 19 comprises two parts 163 and 164 having grooves 165 and 166 respectively designed to grip the trigangular cross-section of the quarter-circle 130. The part 164 has a small circular collar 167 terminating in a frusto-conical portion 168. The collar 167 and the frusto-conical portion 168 cooperate with a complementary female piece 169 on which is mounted an extension 170. Formed in the extension 170 is a bore 171 in which is provided a lining or sleeve 172 designed to match the diameter of the pin 162 to that of the bore. The entire piece 161, i.e. the parts 163 and 164, the collar 167 and its frusto-conical extension 168, and the corresponding piece 169 as well as

the lining 167, can be immobilized by a single screw 173. The frusto-conical part 168 as well as the corresponding female part of the piece 169 forms an angle of a few degrees so that the swivel-joint formed by the pieces 167, 168 and 169 is completely immobilized when the screw 178 is tightened to secure the piece on the quarter-circle 130. The particular purpose of the piece 161 resides in the fact that the pin 162 which is carries can be turned about the axis of the screw. It is thus possible to position the pin 162 in the bone-fragment 136 precisely at the place required.

Figs. 20 and 21 illustrate a modified form of the assembly piece 131 used in the arrangement illustrated in Figs. 13 to 19. It has been seen that the piece 131 enables the rods 133 (see Figs. 13 and 14) to be gripped only in one direction, that is to say that with these pieces 131 the arcs in the arrangements shown in Figs. 13 and 14 can only be fitted in a symmetrical manner. In the case where it is desired to position the arcs 130 of Figs. 13 and 14 in such a way that, for example, the ends of the arcs are located at a higher level on one of the rods 33 than on the other rod, it is necessary to provide a further assembly piece. To this end, the Applicant proposes, as a variant, the assembly piece illustrated in Figs. 20 and 21. Referring to these two Figures, the arc 130 is gripped in the grooves 174 and 175 of the clamps 176 and 177 respectively. The clamps 176 and 177 have a bore 178 and 179 at each of their ends, these bores being intended to receive screws 180 and 181. At their middle, the pieces 176 and 177 have bores 182 and 183 into which are introduced circular pieces 184 and 185. On their adjacent surfaces, the circular pieces 184 and 185 have two corresponding grooves 186 and 187 adapted to grip the rod 133. It can be clearly seen from Figs. 20 and 21 that immobilization of the screws 180 and 181 causes the clamps 176 and 177 to be pressed against the quarter-circle 130 on the one hand, and compresses the rod 133 by way of the circular pieces 184 and 185, on the other hand. The modified form of the assembly piece shown in Figs. 20 and 21 enables the assembly consisting of the piece and the quarter-circle 130 to be pivoted about the rod 133, or *vice versa*.

In the arrangement shown in Fig. 22, the quarter-circles 130 are secured to the rods 133 of the clamps 134 by way of assembly pieces 131 as illustrated in Fig. 17, or variants of these pieces shown in Figs. 20 and 21. The clamps 134 serve to retain a group of transfixing pins 135 which hold a bone fragment 136 in position. At their upper ends the quarter-circles 130 are connected to a rod 190 by way of two assembly pieces 131. Mounted on the rod is a swivel-joint 191 similar to the toothed swivel-joint 61 shown in the embodiment and variants illustrated in Figs. 1 and 2. Secured in the bore of the toothed swivel-joint 191 is a pin 192 enclosed in a liner 193 which is designed to adapt the diameter of the pin 192 to suit the diameter of the bore in the swivel-joint

191. As in the arrangements shown in Figs. 13 and 14, the Fig. 22 arrangement enables a bone fragment 136 to be held more firmly in position by means of an additional pin 192. Since the swivel-joint is able to turn about the rod 192 in either direction, it can also be used for maintaining a further bone fragment adjacent the fragment 136.

In the fitting of the halo illustrated in Figs. 23 and 24, the surround for the head 200 of the patient is formed by four quarter-circles 130 which are identical to those illustrated in Fig. 13 and the ends of which are connected to bars 201, 202 and 203, 204 respectively by means of clamping pieces 205 illustrated in Figs. 3 and 4, and 17 or 21. Mounted on the bars 203 and 204 are swivel-joint assembly pieces 206 which hold the rods 207 and 208 perpendicular to the plane of the halo formed by the assembly comprising the four quarter-circles 130. The rods 207 and 208 will be secured to a jacket, not illustrated, worn by the patient, by way of a fitting consisting of bars or rods, likewise not illustrated, or by means of a fitting directly secured to the clavicles or shoulder-blades of the patient with the aid of transcutaneous pins. The head 200 of the patient will be held within the halo formed by the quarter-circles 130 by means of pointed screws 209, the point of each screw 209 bearing on the cranial bones of the patient. The screws 209 are held perpendicular to the quarter-circles 130 by means of the assembly pieces 45 shown in Fig. 7 into which will have been fitted a sleeve or lining similar to the lining 121 shown in Figs. 10 and 11, the bore of the lining 121 having a screw-thread corresponding to that of the screw-thread of the pointed screws 209.

The above-described halo supports the weight of the head 200 of the patient, prevents any movement of the head and is used, for example, in the treatment of lesions of the cervical vertebrae, or in the treatment of arthritis or scoliosis.

An arrangement similar to that just described for forming the halo may also be used for the treatment of lesions of the pelvis or lumbar vertebrae. In this case, the system will not necessarily be a closed one as in the case in the arrangement shown in Figs. 23 and 24, and it can be formed by two or three quarter-circles connected to a frame consisting of rods and an assembly member. The system and/or the frame will be secured to the iliac bone and/or to the sacro-iliac bone by means of transcutaneous pins. It is possible for the frame mounts to be formed with the aid of arcuate parts extending from the pelvis to the head by securing the system on the iliac bones, the shoulder-blades and the clavicles with the aid of transcutaneous pins in the case of lesions extending over the entire length of the vertebral column.

In the embodiments and variants that have been described, the anchoring means comprise either complete circles formed by two semi-circles, or semi-circles formed by quarter-circles with intermediate pieces. It is clear that the Applicant will have envisaged a complete circle

which is likewise of triangular cross-section and which would be used in conjunction with the assembly pieces or the support pieces. The main advantages of the embodiments that have been described are as follows:

— The external anchoring means can be fitted either with the aid of a semi-circle which can be in one piece or constituted by two quarter-circles, and intermediate pieces, or a complete circle which can be in one piece or formed by two semi-circles. Thus, generally a semi-circle or a complete circle will be fitted for each bone to be held in position, each semi-circle or complete circle forming what is called a frame. The two frames will then be held in position by a connecting means which may be constituted either by slide bars or single assembly rods. The slide bars offer the advantage of enabling the distance between two frames to be altered, i.e. between two semi-circles or complete circles each holding a bone fragment in position. In a modified form, not illustrated, it is possible to mount the two frames with the aid of the clamps 15 to 18, shown in Fig. 1, and their transfixing pins, the clamps being held in position by means consisting of slide bars or connecting rods, and a single arcuate element being fitted where it is necessary and useful. Such an arrangement can be envisaged in the case illustrated in the Fig. 2 variant where only the arc 23 can be considered as being of use in view of the fact that it enables the further bone fragment 50 to be held in position with the aid of the rod 52, the clamp 53 and the pins 54 and 55. This arrangement, comprising only one part-circle, can be advantageously used for example for an anchoring means which is to retain bone fragments on, for example, the pelvis or the clavicle of a human body.

— In all the embodiments described, the connecting means is an existing one, and it can be used in combination with the arcuate parts. This means consists of the rods, the slide bars, the anchoring clamps, the swivel-joints etc.

The external bone-anchoring elements that have been described by reference to Figs. 1 to 22 offer the following advantages over existing systems:

1. The conventional frames formed by clamps, pins and connecting bars joined by the conventional means, in particular slide-bars and rods, can be used in combination with arcuate parts.

2. The fixing means described enable pins or groups of pins to be located in any plane by virtue of the arrangement of the arcs which serve as fixing means for pins which may extend laterally of them.

3. The fixing means described enable the arcs to be adjusted vertically in relation to soft parts.

4. The fixing means offer the possibility of securing, either on the arc or on the rods, complementary fixing means which may be transfixing or otherwise and are located in another plane.

5. The possibility of providing a complete circle

either in a single piece or made up of semi-circles or quarter-circles.

6. The possibility of connecting the arcs or circles independently of each other, or one to the other, by means of rigid bars or slide-bars permitting adjustment of the distance between the fragments and enabling the mounting means obtained to be rendered more solid.

7. The possibility of using the "Russian" technique, that is to say the method which requires complete circles for the treatment of body extremities.

The parts forming the external anchoring means that have been described will preferably be made of a stainless metal, particularly the pins, wires, swivel-joints, anchoring clamps, rods, slide bars etc. On the other hand, the circles or arcs, as well as the assembly and support pieces designed to be secured to the circles or arcs, can be made of a light alloy particularly one based on aluminium or titanium. The pins which extend through the soft portions of the body as well as the bone are electrically insulated from each other and from the other parts of the anchoring means.

The advantages of the anchoring means described above are as follows:

1) The apparatus can be assembled either with one or two arcs for each bone fragment. It suffices to provide between the two arcs a connecting rod which, depending upon its length, can alter the distance between the two arcs and can therefore be used in a large number of cases with the same size of arc.

2) The connecting device is an existing device, i.e. either a Hoffmann swivel-joint with a slide bar, or an immobilizing unit forming the subject matter of Swiss Patent No. 579438 and now commercially available for very small anchoring devices.

CLAIMS

1. An external bone-anchoring means, comprising two groups of pins, each group being comprised of at least one pin, or wire, for retaining a bone portion, at least one assembly rod connected to each of the two groups for interconnecting the two groups, at least one arcuate member connected to the assembly rod adjacent one of the groups of pins and at least one support piece for supporting said one group of pins on the arcuate member, the arcuate member and the supporting piece being adapted to enable the pins of said one group to be supported on the arcuate member anywhere along its length.

2. An external bone-anchoring means according to claim 1, further comprising at least one support piece movably secured to the arcuate member at a selected location anywhere along its length, said support piece being operable to support at least one pin or wire, which retains at least one piece of bone.

3. An external bone-anchoring means according to claim 1 wherein the support piece comprises jaws having internal recesses adapted to complement at least a portion of the polygonal

cross-section of the arcuate member so as to be capable of being pressed onto and immobilised on the arcuate member without being able to rotate about it or move along it.

4. An external bone-anchoring means according to claim 3, wherein the support piece has a bore therein into which may be introduced a pin or wire.

5. An external bone-anchoring means according to claim 1, wherein the bore is provided with a sleeve lining therein with an opening adapted to match the diameter of the pin or wire.

6. An external bone-anchoring means according to claim 4, wherein the bore is so disposed in the support piece that the axis of the bore extends radially of the arcuate member when the support piece is secured to the arcuate member.

7. An external bone-anchoring means according to claim 1 wherein the arcuate member is comprised of at least one section which is a semi-circle.

8. An external bone-anchoring means according to claim 1, wherein the arcuate member is comprised of at least one section which is of the arcuate length of part of a circle.

9. An external bone-anchoring means according to claim 1 wherein the arcuate member has a triangular cross-section.

10. An external bone-anchoring means according to claim 1 wherein the arcuate member is semi-circular, and the pins of at least one group of pins are supported by respective support pieces and the one group of pins are secured by the respective support pieces in a generally cruciform arrangement to the semi-circular arcuate member.

11. An external bone-anchoring means according to claim 1, comprising at least two of said arcuate members, one respectively for each of the groups of pins, the assembly rod interconnecting the arcuate members.

12. An external bone-anchoring means according to claim 8 wherein the arcuate member is comprised of two of the sections thereof and an intermediate piece for interconnecting the two sections, at least one of the sections of the arcuate member being of the arcuate length of part of a circle.

13. An external bone-anchoring means according to claim 12 wherein each of the two sections of the arcuate member supports a respective support piece along the arcuate length of the respective section of the arcuate member, a respective support piece on each of the sections of the arcuate member being paired with a support piece on the other section of the arcuate member, the arrangement being such that the pins or wires extend between the respective paired support pieces for transfixing a bone.

14. An external bone-anchoring means according to claim 13, wherein the paired support pieces include aligned bores for receiving the respective pins or wires.

15. An external bone-anchoring means according to claim 14 wherein the pins or wires

are threaded along that portion which transfixes a bone.

16. An external bone-anchoring means according to any one of claims 1, 11 or 13, further comprising two of said support pieces located at spaced apart locations along the arcuate length of the arcuate member, a respective pin, or wire, supported by each of the support pieces, and wherein each support piece supports the respective pin, or wire, in such a way that the two pins both extend to and engage a bone being anchored from two different angular directions around the bone.

17. An external bone-anchoring means according to any one of claims 1, 8, 9, 10, 12 or 13, wherein the arcuate member has no discontinuities over its length and has a uniform cross-section over its length thus enabling the pins of the one group to be connected to the arcuate member anywhere along its length.

18. An external bone-anchoring means according to either one of claims 1 or 17 wherein the arcuate member is of polygonal cross-section.

19. An external bone-anchoring means according to claim 1 wherein the support piece is adapted for supporting the pin or wire at various selected tilt orientations with respect to the plane of the arcuate member.

20. An external bone-anchoring means according to claim 19 wherein the support piece is adapted for supporting the pin or wire at various selected tilt orientations parallel to the plane of the arcuate member.

21. An external bone-anchoring means according to claim 19 wherein the support piece is adapted for supporting the pin or wire at various selected tilt orientations into and out of the plane

of the arcuate member.

22. An external bone-anchoring means according to any one of claims 1, 19, 20 or 21, wherein the support piece supports the pin or the like spaced away from the plane of the arcuate member.

New claims or amendments to claims filed on 13 April 1983
Superseded claims 1, 3
New or amended claims:—

1. An external bone-anchoring means, comprising two groups of pins, each group being comprised of at least one pin, or wire, for retaining a bone portion, at least one assembly rod connected to each of the two groups for interconnecting the two groups, at least one arcuate member of polygonal cross-section connected to the assembly rod, said arcuate member having no discontinuities over its length and having a uniform cross-section over its length, and at least one support piece movably mounted on the arcuate member and operable to support said one group of pins on the arcuate member in such a way that the supporting piece and hence the pins of said one group may be supported on the arcuate member anywhere along its length.

3. An external bone-anchoring means according to claim 1 wherein the support piece comprises jaws having internal recesses adapted to complement at least a portion of the cross-section of the arcuate member so as to be capable of being pressed onto and immobilised on the arcuate member without being able to rotate about it or move along it.