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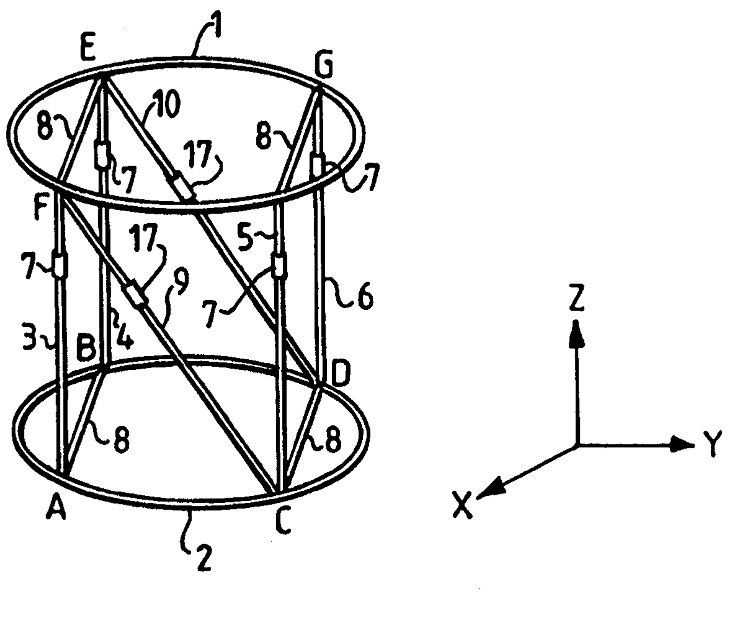


**(57) Abstract**

An orthopaedic frame for the correction of bodily deformities has axially–spaced first and second mounting rings (1, 2) which can be connected to longitudinally–spaced portions of bone in a conventional way. An arrangement of main length–adjustable struts (3, 4, 5, 6) connects the rings together. The struts (3, 4, 5, 6) are joined to the mounting rings (1, 2) at pivoting connections (A–H) which restrict the pivoting movement to a single pivoting plane. Adjustment of the relative angular disposition of the two mounting rings (1, 2) can be made only in this plane, and is locked after adjustment e.g by length–adjustable locking struts (9, 10) extending obliquely. By adopting this uniplanar pivoting action a simple construction and use are achieved, while enabling a large range of corrective re–alignments.

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# ORTHOPAEDIC DEVICE

## FIELD OF THE INVENTION

The present invention relates to an orthopaedic frame for use in correction of bone and soft tissue deformities, limb lengthening or treatment of fractures.

## BACKGROUND

One apparatus which has been widely used for these purposes is known as the "Ilizarov frame". In its simplest form it consists of two mountings interconnected by four rods. Each mounting itself has two axially-spaced rings, and each two ring mounting in use is firmly attached to a segment of bone by wires or pins. The rings are typically parallel, spaced apart perpendicular to their planes and aligned at right angles to the long axis of the bone segment to which they are attached. The two ring mountings are themselves connected together by four extensible struts attached to one of the rings of each mounting so that the two segments of bone can be compressed together or moved apart by gradual or rapid shortening or lengthening of the struts, so compressing or distracting the "focus" of activity which lies between the two bone segments. Note the term "bone" as used herein may be used with reference to parts of the body including a number of bone elements. For example, the Ilizarov frame may be located on a patient's leg with its two mountings respectively attached to the tibia and femur so that the frame is attached across the knee joint as the focus.

A more complex Ilizarov frame may have more than two mountings, so that two or more foci can be independently controlled by adjacent mountings. Furthermore, each mounting may have more or less than two rings and the simple ring may be modified at special sites according to the local anatomy. Thus when applied to the thigh bone (femur) for example, the upper rings may be replaced by open arcs for patient comfort. At the knee, the full rings are often replaced by arcuate elements which make up only five eighths of a circle in order to allow a fuller range of knee movement.

The actions that the Ilizarov frame described above can perform on a bone are limited to stretching (distraction) or compressing the focus. In order to correct a deformity at a focus, it is known to include a hinge in each of the interconnecting struts. Such frames may allow correction of other deformities, including any one or more of angulation and translation of the bone segments with respect to each other, rotation of one bone segment with respect to the other in an axis parallel to the long axis of the bone segment, and shortening or lengthening of the focus.

The devices used to interconnect the mounting rings are complex, cumbersome and heavy and relatively inflexible; it is for example extremely difficult to perform rotation and angulation simultaneously using the traditional frame system. For this reason variations of the Ilizarov frame have been proposed, including "translation/rotation" boxes, which are simpler to fit than the original frame and allow simple translation or rotation to be performed easily, often with the addition of an extra ring between the mountings.

Recently, Dr J. Charles Taylor has proposed an alternative frame (the "Taylor frame" or "Spatial frame") in which the two mountings are connected by six variable length struts, each of which is connected at its two ends to the respective mounting rings by universal joints. The connections between the rings and struts are regularly spaced around the rings, with 3-fold rotational symmetry. Variations in the lengths of the struts can produce any desired relative orientation of the mountings and hence of the underlying bone segments, including rotation, angulation, translation, elongation or any combination of these. However, control of the device is extremely complicated, because it is impossible to determine intuitively what changes in the length of each strut are needed. For this reason, deformity correction must usually be carried out using a microcomputer. Measurements of the deformity are entered into the computer, which calculates the exact strut length changes required to correct the deformity. The process of measurement of deformity and computer calculation may have to be performed several times. The electronic circuitry necessary to perform this operation raises the cost of the frame considerably. Furthermore, the Taylor frame is unnecessarily complex for the majority of deformity corrections, which require correction of angulation and translation in one plane only, without a simultaneous rotational deformity correction around the long axis of the bone segments.

Concerning the deformities which may exist between two bone segments, angulation and translation in one plane are interconnected. Angulation may be defined as a relative rotation of the bone segments about a central axis at right angles to the longitudinal axis of the bone segment, and translation may be considered as an angulation in which the radius of the curve is infinitely long. It follows that where there is a need for both angulation and translation, angulation by rotation of one bone segment with respect to the other through an appropriate axis of the angulation can also perform the required translation, while angulation through an incorrect axis will induce unwanted translation. In the simple Ilizarov frame, angulation is accomplished by the use of frame hinges about which the mountings and therefore the attached bone segments rotate. If unwanted translation is to be avoided during the correction of the angulation, the hinges must be placed precisely at the axis of the deformity. This may be difficult or impossible. There may also be a need to modify the axis of the deformity during correction, because of imprecise initial assessment or because the frame buckles or the mounting wires distort.

SUMMARY OF THE INVENTION

The present invention seeks to provide an orthopaedic frame that at least partially alleviates some of the above problems by providing a hinge system, which allows independent control of angulation and translation in one plane.

In its most general terms, the invention proposes that the mounting rings are interconnected by a variable length strut arrangement which allows the segments of bone to be relatively angulated and translated independently in a single plane. This device is simpler than the Taylor frame described above, but when appropriately located in relation to the axis and plane of the focus and deformity, is capable of performing the bone correction operations obtainable from the Taylor frame provided that, as is often the case, misalignments lie substantially in one plane. This is because the plane in which the bone connection members are allowed to move relative to one another can be selected in accordance with the bone correction operation to be performed. The simpler geometry of the frame means that it can be much simpler to install and may not require complicated control circuitry or mechanical components thus reducing its cost.

Aspects are set out in the claims.

In one aspect the invention provides an orthopaedic frame comprising:

two mounting members for connection to a bone or to respective bone segments;

one or more variable length struts extending between the mounting members, the or each strut being pivotable with respect to both the mounting members in respective pivoting planes, the pivoting planes of said strut or all said struts with both the mounting members being parallel; and

means for selectively fixing the angles the or at least one strut makes with each of the mounting members;

wherein the first mounting member is not pivotable relative to the other mounting member perpendicular to the pivoting planes.

Preferably, the first mounting member is prevented from rotating relative to the second mounting member perpendicular to the pivoting planes by ensuring that the connections between (some or all of) the struts and the mounting members only allow relative rotation in a single plane (the pivoting plane).

In a second aspect the invention provides an orthopaedic frame comprising:

two mounting members for connection to a bone or to respective bone segments;

one or more variable length struts extending between the mounting members, the or each strut being pivotable with respect to both the mounting members in respective pivoting planes, the pivoting planes of said strut or all said struts with both the mounting members being parallel; and

means for selectively fixing the angles the or at least one strut makes with each of the mounting members;

wherein the length of any one of said one or more struts and said angles determine the relative orientation of the mounting members.

As in the prior art, the mounting members are preferably rings which encircle the limb of the patient. It is to be understood that as in the prior art, the mounting members need not be connected directly to the bone of the patient, but may instead be connected via an auxiliary ring spaced from the mounting member and co-planar therewith. In this case, the auxiliary ring may carry pins which project inwardly to contact and/or penetrate the bone of the patient. Optionally, the auxiliary ring may be rotatable relative to the mounting ring between different fixed rotational alignments, to torsion or rotate the bone around its longitudinal axis.

The ends of the struts are preferably arranged so that there is a plane of mirror symmetry parallel to the pivoting plane. Certain elements of the frame are related by this mirror symmetry, as explained in more detail below.

Preferably the struts of the frame include four primary struts arranged in two pairs, a first pair on one side of the plane of symmetry, and a second pair on the other side of the plane of symmetry. For each pair, the four end points of the two primary struts are the points of a trapezoid, and the trapezoid is the mirror image of a trapezoid defined by the four ends of the other pair of struts.

Preferably the angle which the primary struts make with the mounting members is fixed by providing for each pair of primary struts a variable length support strut having one end located at or near the connection point between the primary strut and the first of the mounting members, and the other end located at or near the connection point between the other primary strut of the same pair and the other of the mounting members. In other words, the support struts then extend substantially diagonally relative to the trapezoid referred to above. The support struts are pivotable in the pivoting plane about both of their ends. Thus, by varying and then fixing the length of the support struts, and by varying and then fixing the lengths of the primary strut(s), the angle which each primary strut makes with each of the mounting members can be independently altered and fixed, for example to deform the trapezoids into trapezia.

Preferably, for each mounting member, the pivotal connection between the mounting member and one primary strut of the first pair is a common pivot with the connection between the mounting member and a primary strut of the other pair. Thus, for each mounting member there are only two pivots connecting the mounting member to the primary struts. Since all the pivoting planes are parallel, the two pivots of each mounting member are also parallel. Thus the four ends of those two pivots are the points of a trapezium, having the two pivots as the two parallel sides of the trapezium.

Each of the struts (primary struts and support struts) is preferably substantially straight, but this is not a necessary feature of the invention. Rather, any or all of the struts may, for example, have an S-shaped configuration, for example including a linear section of variable length.

Note that the two pivoting planes of each strut need not be coplanar (although this is preferable for simplicity) although they must be parallel. Furthermore, although preferably the pivoting plane of one of each pair of primary struts with one mounting member is coplanar with the pivoting plane of the other of the pair of primary struts with the other mounting member, this too is not a necessary feature. Instead, the support struts may extend obliquely (i.e. having a component of their direction perpendicular to the pivot mirror plane. However in this case, elongation of the strut will usually need to be substantially parallel to the pivoting plane). However, for increased simplicity, the four connection points between the primary struts and each mounting member are preferably arranged so that they define a rectangle by arranging the two primary struts of each pair so that the pivoting planes of the two pairs of struts are the same. In fact, this concept constitutes a further, independent aspect of the invention.

According to that third aspect, the invention provides an orthopaedic frame comprising:

two mounting members for connection to a bone;

four struts extending between the mounting members, each strut being pivotable with respect to both the mounting members in respective pivoting planes, the pivoting planes of all of the struts with both the mounting members being parallel; and

means for selectively fixing the angle at least one strut makes with each of the mounting members;

wherein the connections between the first mounting member and the four struts are arranged in a substantially rectangular configuration, preferably in a substantially square configuration.

Generally speaking the struts used herein are preferred to be axially rigid, not being hinged except to the respective mounting members.

The invention also provides a method of treating a bone or soft tissue deformity, misalignment, contracture, discontinuity or any other abnormality using any apparatus according to the invention as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects and preferred embodiments of the invention will now be described in detail with reference to the accompanying figures in which:

Figure 1 shows a first embodiment of the invention;

Figure 2 illustrates re-arrangements of the embodiment of Figure 1;

Figure 3 illustrates the embodiment of Figure 1 in place on a bone;

Figure 4 illustrates a second embodiment of the invention;

Figure 5 illustrates a third embodiment of the invention;

Figure 6 illustrates a fourth embodiment of the invention;

Figure 7 illustrates a fifth embodiment of the invention; and

Figure 8 illustrates a sixth embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring firstly to Figure 1, a first embodiment of a frame according to the invention is shown in relation to a set of three dimensional axes X-Y-Z. The frame has two ring-shaped mounting members, "rings", 1,2, mutually connected by primary struts 3,4,5,6. In this arrangement of the frame, the rings 1,2 lie in the X-Y plane, whereas the primary struts 3,4,5,6 are all in the Z-direction. Each of the struts 3,4,5,6 is of variable length, with a screw device 7 is located at an intermediate portion along each strut for controllably and incrementally varying its length. Such variable-length struts are well known in this field. Generally they are straight, but the invention is not limited in this respect.

In this embodiment, there are two pairs of primary struts, a first pair 3,5 and a second pair 4,6. Their ends are labelled A-H in Figure 1. The upper ends F,E of the struts 3,4 each pivot bar about the ring 1 on a pivot 8 extending in the X-direction. Other, parallel pivots 8 are provided to connect upper, or respectively lower, ends of two struts from different pairs (i.e. A and B; C and D; and G and H). Since all of the pivots 8 are parallel (in the X-direction) the struts 3,4,5,6 are constrained to pivot in the Y-Z plane. Thus, the rings 1,2 can be relatively rotated around the X-axis in the Y-Z plane. The traversing pivot bars 8 are not essential but provide a useful practical way of maintaining all the pivoting planes parallel.

It should be noted that when the primary struts 3,4,5,6 are all of equal length, the rings 1,2 are parallel, and remain so on relative movements of the rings 1,2 due to pivoting of the primary struts 3,4,5,6 in the Y-Z plane. The rings 1,2 can be relatively separated in the Z-direction by varying the lengths of the struts 3,4,5,6 using their length adjusters 7. As explained below, a combination of rotation in the Y-Z plane and translation in the Z-direction provides the option of translation in the Y-direction. However, no relative rotation of the rings 1,2 is possible about either of the Y-axis or the Z-axis.

Support struts 9,10 extend between the primary struts 3,4,5,6. Considering the parallelogram AFHC, primary struts 3,5 compose two sides of the parallelogram and support strut 9 extends across the diagonal CF. Accordingly, variations in the length of the support strut 9, using a length adjuster 17, control the angle between the primary struts 3,5 and the Z-axis. For example, shortening of the support struts 9 requires that the struts 3,5 rotate away from the Z-axis and towards the Y-axis: translation in the Y-Z plane. The length adjuster 17 therefore provides selective adjustment and fixing of the angle between the struts 3,5 and the rings 1,2.

The points of connection between the struts 3,4,5,6 and the rings 1,2 are selected so that at each ring 1,2 the connection points are the points of a square ABDC, FEGH. However, in other embodiments of the invention the points of connection may be chosen otherwise. Although the pivots 8 ensure that the shape ABDC is a trapezium, the trapezium need not be a square, and need not even be rectangular or indeed quadrilateral.

It will be noted that the relative orientation of the rings 1,2 is fully determined by the lengths of the primary struts 3,5 and support struts 9 (i.e. from two primary struts of the same pair and the support strut which connects them). The second pair of struts 4,6 and the support strut 10 provide mechanical support. Movements of the struts 3,5,9 must be matched by movements of the struts 4,6,10. In principle, if the struts 3,5,9 and their pivots were strong and strict enough, the extra set of struts 4,6,10 could be omitted.

Turning now to Figure 2, various arrangements of the embodiment of Figure 1 are illustrated schematically. For simplicity the pivots 8 and support struts 9,10 have been omitted. The arrangement in Figure 2(a) is as in Figure 1: the rings lie in the X-Y plane and the struts extend in the Z-direction. The separation of the rings in the Z-direction is referred to herein as $h_z$.

With adjustment of the length of the support struts 9,10 (not shown in this figure) the frame may be moved to the arrangement of Figure 2(b). The rectangular form AFHC of Figure 2(a) is distorted to a parallelogram AFHC having a smaller height $h_z$. This represents a relative translation of the rings 1,2 in both the Z and Y-directions. However, it is possible to counteract the Z-translation by increasing the lengths of all of the struts 3,4,5,6 by the same amount; the arrangement of Figure 2(c) where the height is as in Figure 2(a), but the upper ring 1 is displaced in a Y-direction relative to the lower ring 2.

Angulation of the rings 1,2 about the X-axis is adjustable by differentially adjusting the length of the struts 3,4 vis à vis the struts 5,6; see Figure 2(d).

Thus, the frame can be easily adjusted in any combination of translational motions in the Z-direction and/or Y-direction or rotations about the X-axis. However, no rotations about the Y-axis or Z-axis are possible.

Turning to Figure 3, the first embodiment is shown attached to a bone 12. Two auxiliary rings 13,14 are shown, each attached conventionally by a plurality of pins 15 to a respective portion of the bone 12. The rings 1,2 of the first embodiment are rigidly attached to the auxiliary rings 13,14 by connection struts 17. It is possible to connect each auxiliary ring 13,14 to its rings 1,2 in a way that allows rotational adjustment of the auxiliary rings 13,14 in their own planes relative to the rings 1,2, e.g. with a drive to actuate this rotation. Thus, it is possible to torsion the bone about the Z-axis. Combining this torsion with the re-arrangements illustrated with reference to Figure 2, it is clear that the only impulses which cannot be applied to the bone 12 are flexing about the Y-direction and translation in the X-direction. However, if the frame of the embodiment is attached to the limb in a desired orientation, this flexing is unnecessary, provided that all deformities lie substantially in the YZ-plane.

Turning now to Figure 4, in a second embodiment the support struts 19,20 are not connected at their ends to pivots 8, but instead at pivot positions slightly displaced around the rings 1,2. The support struts 19,20 nevertheless, as before, are pivotable in planes parallel to those of the primary struts 3,4,5,6. Once again the lengths of the support struts 19,20 determine the angles which the struts 3,4,5,6 make with the two rings 1,2. It would equally be possible, although it is less mechanically convenient, to attach the support struts 19,20 to intermediate positions along the two struts of each respective pair of struts (e.g. such that support strut 19 extends between intermediate positions of the struts 3 and 5).

A third embodiment of the invention is illustrated with respect to Figure 5. In this embodiment there are only three primary struts 3,4,25 extending in the Z-direction. As before, each of the primary struts is arranged to pivot at both ends about the ring 1,2. As illustrated, the support struts 29,30 extend from a first ring 1 to end portions of the pivot 28 on which the primary strut 25 rotates. The pivots 8 and 28 are parallel, so that at the primary struts 3,4,25 pivot in parallel planes.

It would alternatively be possible to connect the lower portions of the support struts 29,30 directly to the point 32 at which the support strut 25 connects with the ring 2, the support struts in this case extending diagonally in the X-direction also.

Note that in all three embodiments the struts are arranged such that the frame has a plane of mirror symmetry parallel to the pivoting plane and half way between the struts 3 and 4. Under the mirror symmetry, for example, the struts 3 and 5 of the first embodiment correspond respectively to the struts 4 and 6, that is the other pair of struts. The mirror symmetry of all three embodiments is preserved on rotation of the primary struts about the rings 1,2 in the pivoting plane.

Some variants do not have mirror symmetry, e.g. by having pivoting planes shifted in the X-direction.

Figure 6 shows a fourth embodiment of the invention in which the rings 1,2 are connected by only a single primary strut 3 of high rigidity and strength, which is connected to the rings 1,2 at its ends A,F. At each of the ends of the primary strut 3 is a pivotal connection element 31,33. Each of the pivotal connection elements 31,33 permits the primary strut 3 to rotate about the corresponding mounting ring 1,2 in a pivoting plane parallel to the Y and Z axes and perpendicular to the X-axis. These two pivoting planes are parallel. The pivotal connection elements 31,33 are each capable of fixing the adjustable angle which the primary strut 3 makes with the respective mounting ring 1,2. The length of the primary strut 3 can be varied by variation of the length adjuster 7. The length of the primary strut 3, together with the angles between the primary strut 3 and the mounting rings 1,2 together completely define the relative orientation of the mounting rings 1,2. Note that this embodiment does not have a plane of mirror symmetry. An analogous two-strut construction could have such symmetry, and be stronger.

In general, the mountings do not have to be rings or even arcs of a circle. Any shape of mounting may be used in line with current practice. They do not always have to encircle the bone, and may each be, e.g. a simple block (or a bar, or a set of connected bars) attachable by pins to one side of the bone.

Figure 7 shows a fifth embodiment of the invention in which the primary struts 3,4,5,6 extend in a direction having a component parallel to the X-direction, but, as before, are each constrained by their mechanical pivots to pivot in the XY plane. This fifth embodiment can have traversing common pivot bars 8 corresponding to the pivots 8 shown in Figure 1, and support struts corresponding to support struts 9,10 shown in Figure 1, but for simplicity these are not shown in Figure 7. In this embodiment also, a mirror plane of symmetry exists perpendicular to the X-axis. This plane of symmetry is useful for simplicity but is not essential, providing that all the pivoting planes are parallel and the connection points E,G,B,D are displaced from the connection points F,H,A,C by displacement in the X-direction only.

Figure 8 shows schematically a portion of a sixth embodiment of the invention. This sixth embodiment of the invention is identical to the fifth embodiment of the invention, except that each of the primary struts 3,4,5,6 is replaced by a respective strut which is not straight along its entire length. For simplicity, only a single primary strut 36 (e.g. corresponding to primary strut 5 in Figure 7) is illustrated. This primary strut has curved end regions, and a substantially straight central section (designated generally by the reference numeral

38), and a variable length component 39. In contrast to the fifth embodiment of the invention, in the sixth embodiment the end portions of each primary strut are perpendicular to the X-direction (that is lie in the pivoting plane), although (as in the fifth embodiment) the two pivoting planes at the end of each strut are not the same as each other, but are relatively displaced in the X-direction. The pivoting planes remain parallel. In this embodiment, the elongation of the variable length component 39 must be parallel to the pivoting plane.

CLAIMS

1. An orthopaedic frame comprising first and second spaced mounting members (1,2) for connection to respective body parts whose relative orientation is to be controlled, and a strut arrangement connecting the first and second mounting members together to hold them in a desired fixed relative orientation which may be altered by adjustment of the strut arrangement, said strut arrangement being length-adjustable and angle-adjustable for variation of the relative orientations and axial spacings at which the first and second mounting members (1,2) can be fixed,

characterised in that

the strut arrangement comprises

one or more length-adjustable struts (3,4,5,6) each having a first pivoting connection (E,F,G,H) at a first end to the first mounting member (1) and a second pivoting connection (A,C,B,D) at a second end to the seond mounting member (2), said pivoting connections (A-H) providing angular adjustability of relative orientation between the first and second mounting members (1,2) which is mechanically constrained to angular movements in a single pivoting plane, and

a locking arrangement (9,10;19,20;29,30;31,33) for fixing the mounting members (1,2) at the selected relative orientation by locking the angular relationship between the mounting members (1,2) the strut arrangement.

2. An orthopaedic frame according to claim 1 in which the pivoting connections (A-H) are uniplanar pivoting connections with their pivot planes parallel, to provide the technical constraint of the angular movements to a single pivoting plane.

3. An orthopaedic frame according to claim 1 or claim 2 in which the locking arrangement comprises one or more locking struts (9,10;19,20;29,30) of the strut arrangement, extending obliquely to at least one of said one or more length-adjustable struts (3,4,5,6).

4. An orthopaedic frame according to claim 3 in which said locking struts are length-adjustable.

5. An orthopaedic frame according to claim 3 or claim 4 in which the or each said locking strut is pivotally connected to the mounting members (1,2).

6. An orthopaedic frame according to any one of claims 3 to 5 in which the or each locking strut is pivotally connected to a said length-adjustable strut (3,4,5,6).

7. An orthopaedic frame according to any one of claims 3 to 6 in which the pivot axes of the or each locking strut are aligned with pivot axes of the pivoting connections (A-H) of said length-adjustable struts (3,4,5,6).

8. An orthopaedic frame according to any one of the preceding claims in which the locking arrangement has locking elements (31,33) comprise in one or more of said pivoting connections (A-H), for locking the relative angular disposition of strut and mounting member at said pivoting connections.

9. An orthopaedic frame according to any one of the preceding claims in which length-adjustable struts of the strut arrangement are incrementally length-adjustable by means of respective screw adjusters (7,17).

10. An orthopaedic frame according to any one of the preceding claims in which said strut arrangement and mounting members (1,2) form a cage for surrounding a patient's limb.

11. An orthopaedic frame according to any one of the preceding claims in which the mounting members (1,2)

comprise rings or part-rings.

12. An orthopaedic frame according to claim 11 in which plural said pivoting connections (A-H) to the mounting members (1,2) are at circumferentially distributed locations on said rings or part rings.

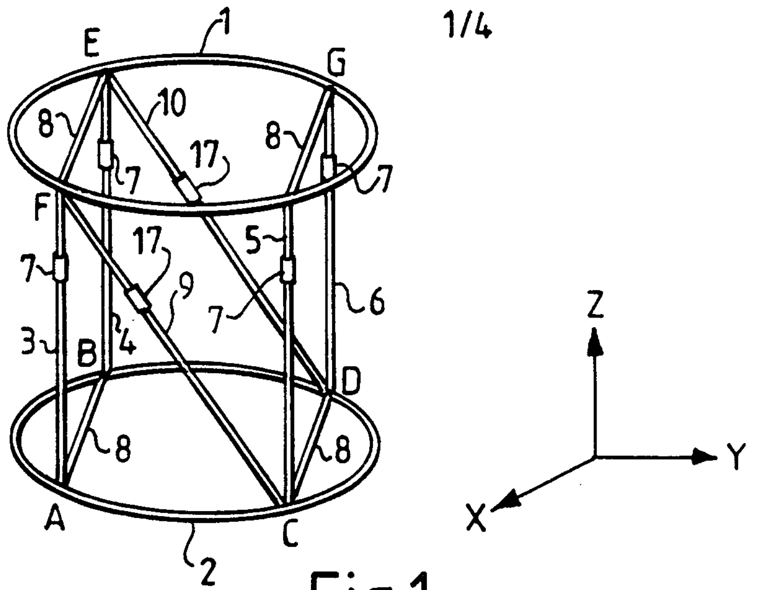


Fig.1.

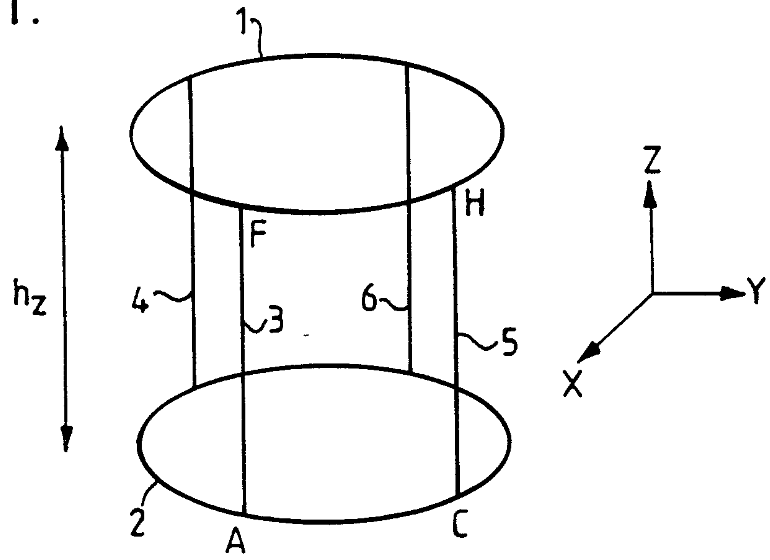


Fig.2a.

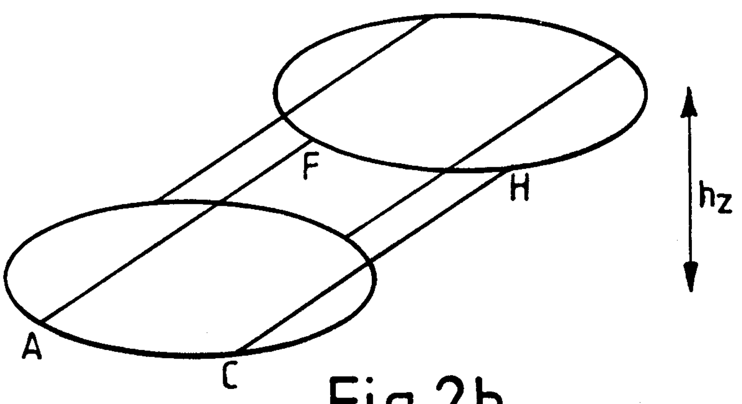


Fig.2b.

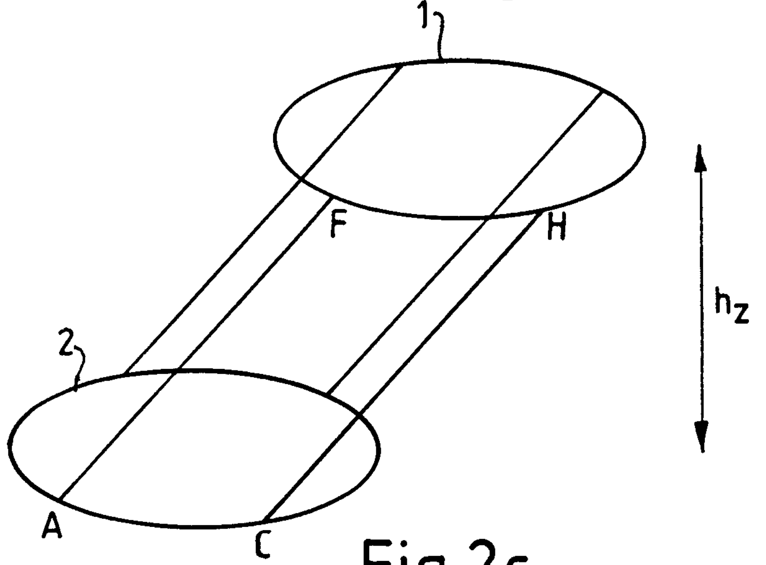


Fig.2c.

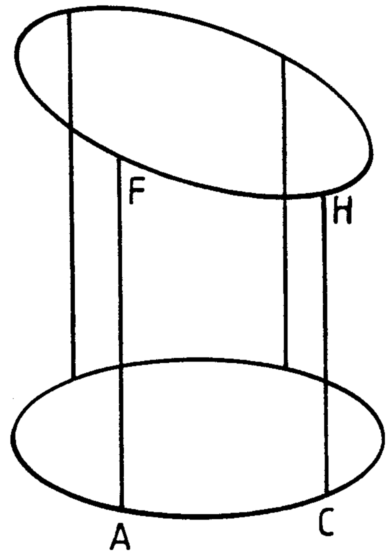


Fig.2d.

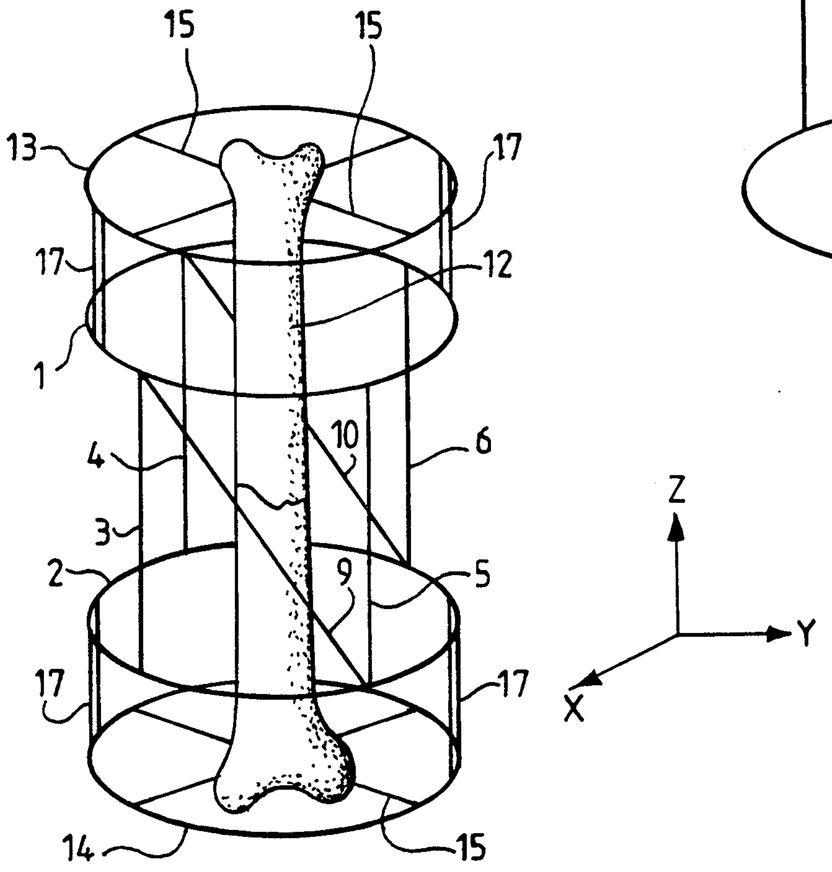


Fig.3.

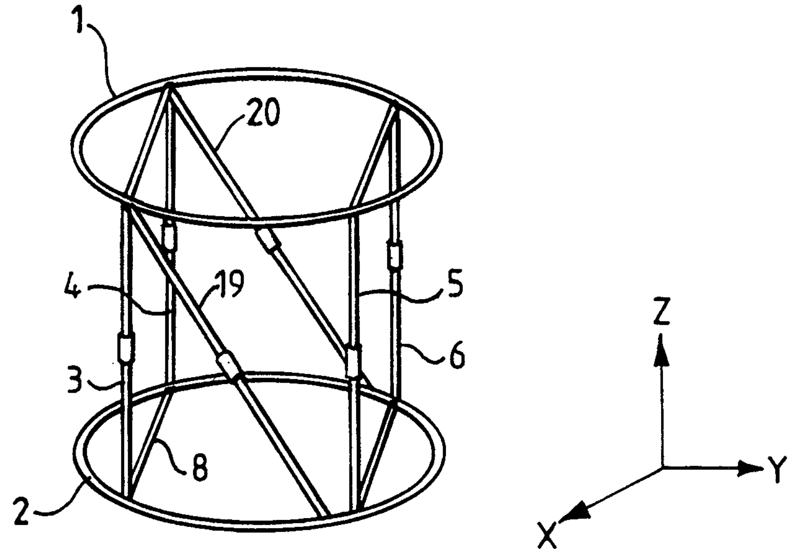


Fig.4.

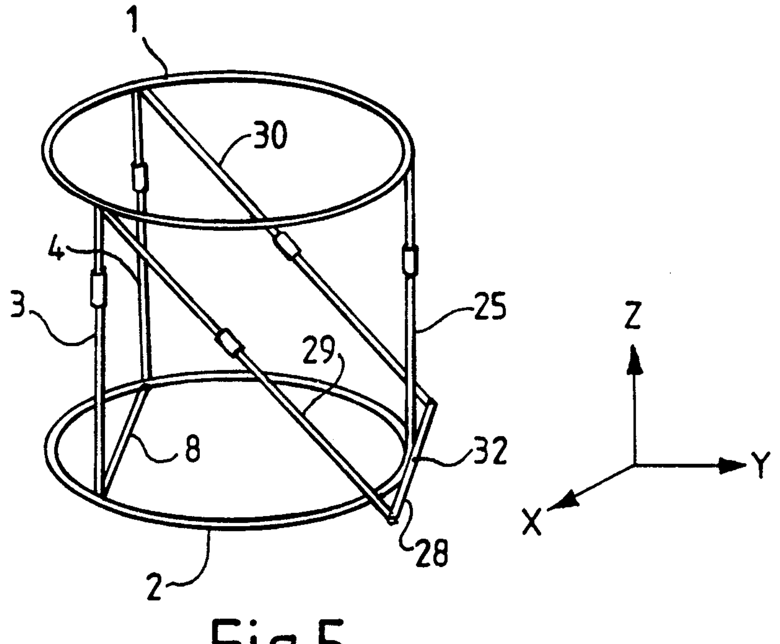


Fig.5.

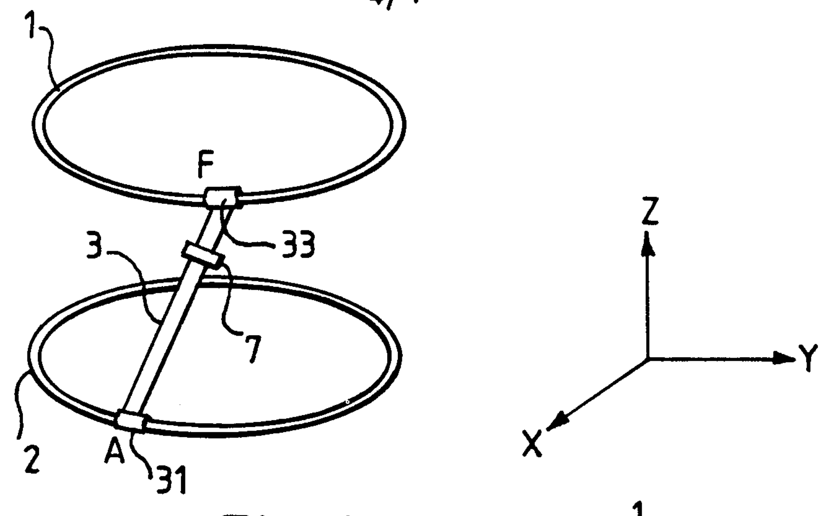


Fig.6.

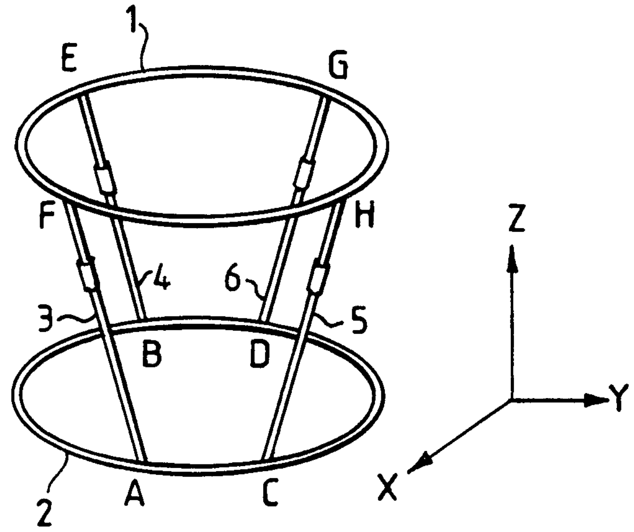


Fig.7.

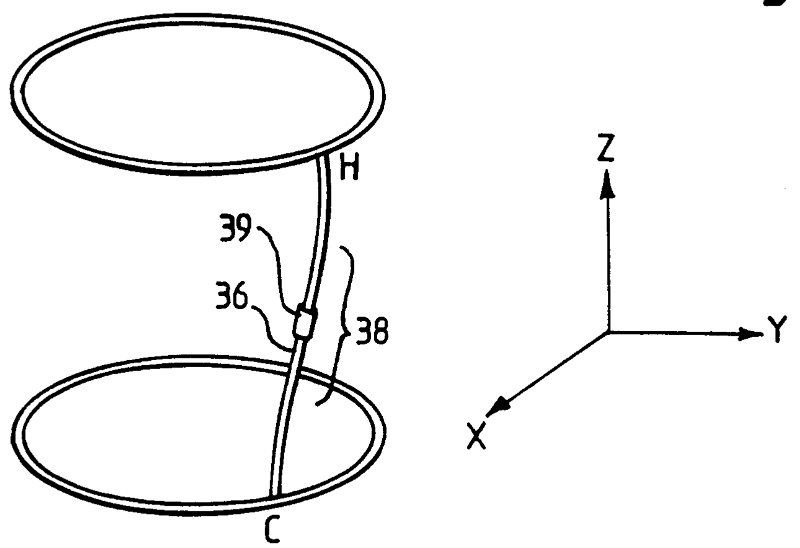


Fig.8.

# INTERNATIONAL SEARCH REPORT

In ıtional Application No
PCT/GB 99/02291

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 A61B17/60

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 1 November 1999 | 08/11/1999 |

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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31–70) 340–2040, Tx. 31 651 epo nl,<br>Fax: (+31–70) 340–3016 | Nice, P |

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International Application No
PCT/GB 99/02291

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