The invention relates to an improved unilateral telescopic external fixator (10) comprising a telescoping unit (11) which includes telescopically engaging inner and outer parts (12, 13) arranged for limited axial reciprocal movement relative to one another along the longitudinal axis of the unit, the outer part (12) having a central bore extending therethrough, the inner part (13) engaging with sliding fit in the bore and extending the full length thereof, the inner part (13) being non-rotatable about said axis, wherein the bore comprises hard polymeric material whilst the inner part (13) is preferably formed of metal, a pair of orthopaedic pin clamp assemblies (20), one of which is carried by the inner part (13) adjacent its proximal end, the other being adjusably carried on the outer part (12) for selective positioning along the length thereof, and releasable locking means (60) for releasably locking said parts (12, 13) against said axial movement.
fractured bone can be corrected. In addition, there are limitations on the extent to which the spatial orientation of each set of retainer pins relative to the main body of the fixation unit can be varied, such variation being required to enable the unit to be easily installed and to permit the body of the fixator to be positioned parallel to the long axis of the bone, regardless of where the bone fracture occurs - whether in a wide or narrow part of the bone.

Whilst certain prior art external fixation devices are designed to provide dynamic axial motion, a problem common to such devices is the high bending moments which occur in the retainer pins and therefore the main body of the fixation unit, during ambulation. Studies have shown that these high bending moments cause the telescoping parts of the unit to jam especially where sliding friction is relied upon and the telescoping parts are made of the same metal, or metals having a high coefficient of friction. These units may provide a consistent dynamic axial motion (i.e. axial telescoping motion) at the fracture site by the application of a load through the fixator pins by an externally applied motor (referred to as "active dynamisation"), but they cannot generally be relied upon to provide consistent and reliable passive dynamisation through ambulation.

It is important that the fixator be sufficiently stable so that dynamic axial motion is ensured through telescoping of the device and not by instability of the fixator. Repeated axial movements may cause the telescoping unit to loosen or jam with time, which in turn may alter drastically the rigidity of the fixator and the efficacy of dynamisation. For example, a significant problem with certain prior art units is their rotatory instability. One solution to this problem was to use a key-lock system, i.e. where the inner and outer telescoping members are part circular and a key engages within a groove extending along the inner member. Enhanced rotatory stability can be provided by a tighter fitting key-lock, but this results
in stiction of the contact areas of the key-lock. Loose-fitting key-locks, where a keying pin engages in a key-way formed in the inner member, prevent this complication but cannot provide adequate rotatory stability.

Fixators have also been developed relying on rolling friction between the telescoping parts rather than sliding friction, these utilising roller bearings rolling in ball bearing races. However, due to the fact that micromotion required for external fixators is in the order of 1mm or less, such ball or roller bearings providing this motion will not roll but rather rock and will therefore brinell. Such brinelling is a cause of instability and/or jamming, which should be avoided in dynamising external fixators.

A still further deficiency of some known unilateral, telescopic external fixators is their inability to vary or alter the rigidity of the device to axial motion of the telescoping parts during the course of fracture healing. It has been found that greater rigidity is required in the early phases of fracture healing and less rigidity later. It is desirable that means be provided so as to prevent passive motion during early stages of fracture healing of the telescoping parts of the fixator device until a set or predetermined load is exceeded.

One object of the present invention therefore is to provide an improved unilateral, telescopic external fixation device which is of simple design, easy to handle and is more versatile in its ability to vary the orientation and positioning of the pin clamps and in turn the orientation and positioning of the retainer pins fixed in the clamps.

It is another object of the present invention to provide an improved unilateral, telescopic external fixation device which can consistently, reliably and efficiently provide
dynamisation (both active and passive) without jamming of the telescoping parts.

It is yet another object of the present invention to provide an improved unilateral, telescopic external fixation device which can have its resistance to axial motion readily altered during the course of fracture healing.

It is yet a further object of the present invention to provide an improved unilateral, telescopic external fixation device which can provide an extremely stable, rigid structure thereby promoting more rapid healing and early ambulation.

According to one aspect of this invention therefore, an improved unilateral, telescopic external orthopaedic fixation device comprises an elongate telescoping unit comprised of a pair of telescopically engaging inner and outer parts adapted for relative axial reciprocal movement along an axis which coincides with the central longitudinal axis of said unit, and releasable locking means for releasably locking said parts against relative axial movement, a pair of pin clamps respectively carried on the telescoping parts for clamping one or more orthopaedic retainer pins spaced lengthwise of the clamp and extending transversely thereof, clamp connection means on each of the telescoping parts of said elongate telescoping unit for connecting a respective said clamp thereto, each said clamp connection means comprising a clamp holder having a first axis of rotation spaced radially from said longitudinal axis of the telescoping unit whereby said clamp holder when in an unlocked condition, along with its associated said clamp can bodily rotate about said first axis, said clamp holder being adjustably supported for slideable movement lengthwise along its said first axis whereby the spatial position of its associated said clamp can be varied by varying the radial distance (measured along said first axis) between said clamp and the telescoping unit, and wherein each said clamp is rotatably supported by said clamp holder so as to
permit the clamp to bodily rotate about a second axis of rotation extending lengthwise thereof and at right angles to said first axis.

With the above arrangement, the pin clamps of the fixator together with the set of pins can rotate from a transverse through to a vertical plane. This allows the pins to be placed horizontally at the end of the bone which is desirable for metaphysical fractures of long bones.

The arrangement also permits the pin clamps to be tilted through a wide arc, which is required for spiral and vertical fractures which may have a wide angular range of the plane of the fracture.

The ability of the clamps to slide horizontally allows rotation of the bone fragments without loss of axial alignment of the fixator and also a wide variation of the angle of insertion of the pins into the bone. Malalignment of the longitudinal axis of the fixator from that of the tibia lessens the potential for dynamic axial motion of the device. Known dynamising fixators allow rotation of the bone fragments only by axial deviation of the body of the fixator from the longitudinal axis of the tibia.

Preferably each said clamp connection means (or at least that on the outer telescoping part) further comprises bracket or connector means slidably supported on its associated said telescoping part whereby the entire clamp connection means, when in an unlocked condition, along with its associated said clamp can slide longitudinally of said telescoping unit. The positioning of at least one of the pin clamps at any location along the full length of the outer telescoping part ensures minimal separation of the inner pins. Preferably, one of the bracket means is fast with the free end of the inner telescoping part, whilst the other bracket means can slidably locate along the length of the outer telescoping part. In this
way the separation of the pin clamps and the pins does not necessitate any adjustment to the telescoping parts which contrasts with prior art units which require relative axial separation thereof. This also allows the telescoping parts to be in contact with one another over a major portion of the length of the fixator, which gives rise to decreased bending movements and lessens the likelihood of the "jamming" of the unit during dynamic axial motion.

In another preferred form of this invention, said bracket means is rotatably supported on its said telescoping part whereby said clamp connection means can be rotationally adjusted about an axis which coincides with or is parallel with the longitudinal axis of said telescoping unit, to assume different angular positions relative to the telescoping unit.

In another preferred form of this invention, each said clamp connection means comprises a swivel block interconnected between the bracket means and the clamp holder and being rotatable, when in an unlocked condition, about a third axis which extends at right angles to both the axis of the telescoping unit and said first axis. This permits the block along with its clamp holder, to swivel about said third axis and be set in a number of different angular positions relative to the telescoping unit.

Preferably the connector or bracket means comprises an attachment body which encircles the associated telescoping part and is provided with a locking member, e.g. a clamping screw or bolt which when tightened, causes said body to clampingly engage against said telescoping part and locking the connector means against both rotational and longitudinal movement relative to the telescoping unit. Preferably the body comprises a pair of hinged halves which are hingedly joined together along an axis parallel to the axis of the fixator, with the clamping or locking screw clamping together the free ends thereof on the opposite side of the fixator body. This
allows a clamp to be easily removed from or added to the fixator even when the fixator remains attached to a patient.

Preferably, the pin clamps have a 360° horizontal angular range which permits the body of the fixator to be swung around from one side of the leg to the other, thereby providing complete access to the wounds during operative soft tissue closure or wound care.

In yet another preferred embodiment, each said clamp holder comprises a transversely extending short length pin or shaft journalled for rotation about said first axis and fixedly carrying at its distal end a pair of semi-circular fingers or jaw members, the inner peripheral walls of which together define a through opening in which is rotatably received a respective said clamp to enable said clamp to be rotated through 360°, this in turn permitting the orientation of the fixator pins held therein to be similarly varied.

According to another aspect of the present invention, there is provided an improved unilateral telescopic external fixation device comprising a main telescoping unit comprised of a pair of elongate telescopically engaging parts adapted for relative axial sliding movement along the longitudinal axis of said telescoping unit, the outer one of said parts constituting a housing having a bore extending therethrough, the inner one of said parts constituting a rod engaging with a sliding fit in the bore and being non-rotatable about said axis, the profile of said rod and said bore each being non-circular having at least one flat side, and wherein said rod is formed of metal, preferably stainless steel, and the surface of said bore comprises hard polymeric material, whereby sliding friction between the parts, during said relative axial sliding movement, is minimised.
Preferably, the housing has a cylindrical outer wall surface shaped and is comprised of two identical axial halves secured together by clamping screws. The housing may however be formed as a unitary member.

By using dissimilar materials for the inner rod and the bore surface of the cylindrical housing within which the piston moves, the sliding friction is very much reduced (in comparison to using similar metals for example) and there is less likelihood of the unit jamming during dynamisation thereof. Experiments conducted by the inventors have shown that the combination of a suitable polymeric material and stainless steel affords a most significant improvement, in terms of frictional resistance, in comparison to pairs of similar metals or even dissimilar metals, e.g. stainless steel/hard chrome stainless steel, stainless steel/brass.

Preferably the bore of the cylindrical housing is lined with a layer of hard polymeric material, preferably acetal, and in particular material sold under the proprietary name "ERTACETAL", (polyoxymethylene). The lining may be provided by means of elongate flat strips inserted in the bore and co-extensive therewith, each strip bearing against a respective planar bore surface extending along the length of the bore. Any hard polymeric material having high abrasion and wear resistance and a low coefficient of friction would be suitable. In addition to acetals, other examples may include high density polyethylene and polypropylene.

In a preferred arrangement, said bore is rectangular, and said rod has a rectangular cross-sectional shape. The shape may also be triangular.

In another preferred arrangement, said rod comprises flat upper and lower surfaces which are joined along their longitudinal margins by curved sidewall surfaces, and said insert comprises a pair of diametrically opposed approximately
D-shaped insert members fixedly secured to the cylindrical bore with the planar faces of said insert members engaging against respective flat surfaces of the rod, said insert members being formed of hard polymeric material.

Preferably, said rod extends through the entire length of the housing and is provided at its distal end with a limit wall which co-operates with a radial abutment surface at the distal end of the housing to permit limited relative axial movement only between the rod and the housing, such movement preferably being in the order of 5mm. In this manner, the rod maintains contact with the bore over a major portion of the length of the rod, which promotes stiffness and rigidity, and minimises the effect of possible bending moments which in turn facilitates dynamisation.

In yet another aspect of the present invention, an improved unilateral, external fixation device comprises a pneumatically operated or electric motor at the distal end of said cylindrical housing and being co-axially aligned therewith, said motor being adapted to provide dynamic axial motion or dynamic axial loading of the bone fragments of the fractured bone.

Preferably the motor is arranged to provide micromotion at a frequency of approximately 0.5 Hz and at an adjustable excursion of 0.1 mm to 1.0 mm.

In a further aspect of this invention, the telescoping unit is provided at its distal end with removable calibrated axial distraction means comprising a longitudinally extending threaded rod arranged co-axially within the unit for effecting axial separation of the telescoping parts and in turn distraction of the bone parts, so as to allow bone lengthening procedures.
In yet another aspect arrangement, the telescoping parts of the telescoping unit co-operate with an adjustable spring mechanism removably housed at the distal end of the outer part of the unit and arranged to provide an adjustable axial loading force to resist motion of the telescoping parts and to prevent relative axial movement of the telescoping parts until a set (predetermined) load is exceeded. The adjustable spring will not allow dynamic axial motion to occur before said set load is applied. This load will be set high during the early phase of fracture healing and set low during the latter phase of fracture healing.

In order to more fully explain the Applicants' invention, several embodiments are described hereunder in some further detail but with reference to and illustrated in the accompanying drawings in which;

FIG. 1 is a perspective view of an external fixator according to a first embodiment of the invention;

FIG. 2 is an end elevational view of the fixator looking in the direction of arrow 2 of FIG. 1;

FIG. 3 is an exploded perspective view of one of the clamp assemblies shown in FIG. 1;

FIG. 4 is a longitudinal sectional view of the telescoping unit shown in FIG. 1 (omitting the clamp assemblies for the sake of clarity);

FIG. 5 is a fragmentary perspective view, partly sectioned, of the telescoping unit of FIG. 4;

FIG. 6 is a radial cross-sectional view along the lines 6-6 of FIG. 4;
FIG. 7 is a sectional view similar to FIG. 6 of a telescoping unit according to a second embodiment of the invention;

FIG. 8 is a longitudinal sectional view of an axial distraction unit for use with the fixator shown in FIG. 1;

FIG. 9 is a longitudinal sectional view of an axial loading unit for use with the fixator shown in FIG. 1; and

FIG. 10 is a schematic elevational view of the fixator of this invention which shows some of the adjustments which can be achieved with the clamp assembly shown in FIG. 1.

In the embodiment illustrated in FIGS. 1 to 4, an orthopaedic external fixation device 10 comprises a main telescoping unit 11 which itself includes an outer cylindrical housing 12 in which is reciprocally housed a telescoping rod 13, clamp connectors 15, 16 on the cylindrical housing 12 and the head end of the rod 13 respectively, clamp holders 17, 18 associated with each said clamp connector 15, 16 and pin retainer clamps 19, 20 rotatably supported by the clamp holders 17, 18 respectively. Each of the clamps 19, 20 comprises pairs of opposed grooved clamp plates 19', 19'', and 20', 20'', which are clamped together by means of clamping screws 24 so as to form transversely extending through-openings 25 for receiving fixator retainer pins 27 arranged to be spaced lengthwise of the clamps 19, 20 and projecting transversely thereof. The pins 27 are of known construction.

In this embodiment, the clamp connectors 15, 16 each comprises a pair of hinged connector portions 28, 29, arranged to encircle the cylindrical housing 12 and the circular enlarged head 30 (formed by two halves) at the free end of the rod 13 respectively, the connector portions 28, 29, when in their loosened condition, permitting the clamp connectors 15, 16 to be rotated about an axis which coincides with the central longitudinal axis of the telescoping unit 11 and, in the case
of connector 15 also slidably displaced longitudinally along the length of the housing 12. With the clamping screws 33 (refer FIGS. 2 and 3) in their tightened condition, the inner bore surfaces of the connector portions 28, 29 clampingly engage against the outer cylindrical surface of the cylindrical housing 12 and the piston head 30 respectively so as to immobilise the brackets 15; 16.

As shown in FIG. 3, each clamp 19, 20 is a 3-piece assembly comprising two identical plates 19' and a unitary member 31 containing the plates 19''. The pieces may be die cast of aluminium or aluminium alloy. With this arrangement, the pins 27 can be removed without removing the clamp from its holder.

Supported on portion 28 of the connectors 15, 16 are swivel blocks 34, radially spaced from the cylindrical housing 12 of the telescoping unit 11, each block 34, being formed with a transverse horizontal slot 35 extending inwardly from one end of the block and communicating with a transversely extending circular through-opening 37 in which is rotatably received a solid cylindrical pin or shaft 39 which forms part of the clamp holder 17, 18. Each block 34, is rotatably mounted on a stub shaft 38 projecting radially from a side of portion 28, and releasably locked therewith by means of clamping screws 32, whereby, with the screws 32 loosened, the blocks 34, along with the holders 17, 18 can swivel about an axis which intersects the central axis of the unit 10 at right angles and is also at right angles to the axis of the shaft 39.

The rotation of the holders 17, 18 along with their pin clamps 19, 20 and pins 27 about the axis of the shaft 39 permits the pins to be inserted longitudinally or transversely, which is desirable in situations involving bones of varying diameter.
A cover member 40 having a threaded stem which threadably engages in a threaded central bore formed in the shaft 38, prevents dislodgement of the block 34.

Clamping screw 41, when tightened, frictionally clamps the shaft 39 against both rotational and slidable movement relative to the block 34. It will of course be appreciated that when the screw 41 is in its untightened condition, the clamp holders 17, 18 can be rotated about the axis of the shaft 39 and locked in any desired orientation and also slidably adjusted lengthwise of the axis of the shaft 39.

Each clamp holder 17, 18 also includes a pair of semi-circular lugs 43, 43' which co-operate together to form a circular opening for clampingly receiving the clamps 19, 20. An adjustment screw 44 is used to fasten the lugs 43, 43' together, and which, when untightened, allows the clamp 19, 20 to be bodily rotated (along with its pins 27) to any desired angular setting.

The ability of the clamp holder 17, 18 to both rotate about the axis of shaft 39 and to slide longitudinally along that axis has been shown to greatly facilitate the placement of the retainer pins into the bone fragments and also the correction of any rotational misalignment of the bone fragments without altering the longitudinal alignment of the housing 12 to the axis of the bone, e.g. tibia, whilst the ability of the clamps 19, 20 to bodily rotate about an axis at right angles to the axis of the shaft 39 lends the unit suitable for approaching the bone through a wide angular range. These features can be clearly seen from FIG. 10 of the drawings which shows how the pin clamp 19 can be horizontally displaced from the housing 12, and its orientation altered, which ensures a wide range of available pin angles.
The ability of the clamp connectors 15, 16 to slide along the cylindrical housing 12 facilitates optimal positioning of the retainer pins 27 relative to the fracture site. It is an advantage of the present invention that more than one clamp connector can be supported on the cylindrical housing 12 and by virtue of the versatility of the range of movements which the clamp connector, holder and clamp can undergo, one is able to position pins on opposite sides of the housing 12 of the unit 11, so as to allow "triangulation" and provide enhanced rigidity.

The hinge 45 which pivotally joins the portions 28, 29 of the connectors 15, 16 permits the connectors to be readily removed from the housing 12 even with the unit 11 attached to a bone.

Referring to FIGS. 4 to 6 of the drawings, the rod 13 of the telescoping unit 11 is formed of stainless steel having highly polished outer surface and is of square cross-section. The rod 13 slidably engages with a sliding fit in a bore 46 which extends through the full length of the housing 12 the bore 46 also being of square cross section. The housing 12 is preferably formed of aluminium and comprises two diametral halves 12', 12'' secured together by screws 47. The bore 46 is lined by means of replaceable strips 49 of hard polymeric material, e.g. ertacetal, which is abrasion resistant, has a low co-efficient of friction and good surface lubricity, such an arrangement minimising the sliding friction between the rod 13 and the bore surface 46, as a result of which the moving parts of the unit 11 are less likely to jam when subjected to bending moments, in comparison with existing art. Of course, the liner 49 may be in the form of angle inserts snugly fitted into the bore 46 of the housing 12. The four strips 49 are held loosely in the bore 46 against respective planar surfaces formed therein and can be easily replaced if and when necessary.
The outer end of the rod 13 terminates in an enlarged head 30 fast therewith, and around which is clamped connector 16, whilst the inner or distal end of the rod 13 threadably connects to a limit block 50 via a threaded stem 52, co-axial therewith. The block 50 is housed in an extension piece 53 of the housing 12 and fixed thereto and is designed to limit axial movement of the rod 13 through a preset range, depending on the healing requirements of the fracture, the block 50 co-operating with a radial abutment flange 54 to constrain rod movement in the extension direction. Movement in the retraction direction of the rod is constrained by the end wall of the rod 13 abutting against the other side of the flange 54.

The extension piece 53 supports a slidable joining collar 57 which has an internal thread 58 for receiving a threaded end plug 59.

The proximal end of the housing 12 is provided with a locking collar 60 which has an internal thread which threadingly engages an external thread on end block 61 secured to the end of the housing 12, the block 61 having a central opening through which passes the rod 13. The arrangement is such that as the locking collar 60 is rotated to its locked position, the end wall 62 of the collar 60 bears against the facing wall 64 on the head 30 of the rod 13 and upon further tightening, the rod 13 is axially displaced in the extension direction until the limit block 50 abuts against the flange 54, whereupon the rod 13 is locked against any movement, the housing 12 and rod 13 thereby being fixedly secured with respect to one another. The locked condition is required when any shortening or collapse of the rod 13 is to be prevented.

With the locking nut 60 in its loosened or unlocked condition, the unit can be subjected to dynamic axial loading which can either be "passive" achieved through the action of ambulation or "active" effected through a motor unit (not shown) attached via the collar 57 at the distal end of the
cylindrical housing 12 and co-axially aligned therewith. Preferably the motor is pneumatically or electrically operated.

In an alternative embodiment shown in FIG. 7 the rod 65 is formed with two flat sides joined by two curved side walls, whilst the bore of the housing 12 is circular and has fitted therein a pair of inserts 66 formed of hard polymerical material. The inserts 66 are D-shaped and are restrained against rotation by means of grub screws (not shown) extending through the wall of the housing 12. Once again, the presence of the polymeric inserts 66 significantly reduces the effect of sliding friction.

In the above-described embodiments, each of the clamping screws comprises a hexagonal recess or depression in the head thereof, and rotational adjustment of such screws is effected by means of a known hexagonal key spanner.

Referring to FIG. 8 of the drawings, a calibrated lead screw device 67 is shown and which can be attached to the unit 11 (by removing end plug 59) via the collar 57, the device 67 co-operating with the rod 13 to effect controlled relative axial movement between the rod 13 and the cylinder 12 which in turn effects distraction of the bone fragments, this being necessary to allow the bone lengthening procedures. The device 67 comprises an adjustment member 68 having a threaded stem 69 which is screwed into a threaded bore of body portion 70 which in turn is screw connected to the collar 57. The stem 69 projects through the body portion 70 and bears against an intermediate insert located between the rod 13 (the block 50 having been removed).

Referring to FIG. 9 of the drawings, there is shown an axial loading device 71 attachable to the collar 57 of the unit 11 to lie co-axial therewith, the device 71 being provided with an adjustable nut 72 which is screwed to a tubular body 73, and a resilient compression spring 74 housed within the nut and the
body 73, the spring 74 in turn making pressure contact against a pin 75 which projects axially from the end of the body 73 and bears against the end of the rod 13, when the device 71 is so attached. The device 71 thus co-acts with the rod 13 to provide an adjustable spring resistance to movement of the rod 13 in such a manner that any movement of the rod 13 is inhibited until such time as a set or predetermined load is exceeded. As explained hereinbefore, greater rigidity is required in the early phases of fracture healing and less rigidity later on. The adjustable spring mechanism is designed so as not to allow dynamic axial motion to occur before the set load is applied. The required load will be set high during the early phase of fracture healing and in turn set low during the late phase of fracture healing.

It will be realised that the material selection for the telescoping parts 12, 13 can be different to that stated above. For example, the rod 13 may be formed of titanium or anodised aluminium, whilst the housing 12 may be of a suitable hard plastics material. The rod 13 may even be lined or coated with a suitable wear resistant plastics material having good surface lubricity and a low co-efficient of friction, e.g. teflon. Still further, it may be possible to coat the bore surface of the housing 12 with a layer of hard polymeric material.

A brief consideration of the above-described embodiments will indicate that the invention provides an improved unilateral external fixation device which is extremely versatile, completely adjustable, easy to use and provides consistent reliable and effective dynamic axial motion.

SUBSTITUTE SHEET
CLAIMS

1. An improved telescopic external fixation device comprising a main telescoping unit itself comprised of a pair of elongate telescopically engaging parts adapted for relative axial sliding movement along the longitudinal axis of said unit, the outer one of said parts constituting a housing having a bore extending therethrough, the inner one of said parts constituting a rod housed with a sliding fit in the bore and being non-rotatable about said axis, said rod and said bore having a non-circular profile which has at least one planar surface, wherein the surface of said bore comprises hard polymeric material, whereby sliding friction between the parts during said relative axial sliding movement is minimised.

2. An improved telescopic external fixation device according to claim 1 wherein said rod and said bore have a profile which is rectangular or square.

3. An improved telescopic external fixation device according to claim 2 wherein each of the planar surfaces of the bore is lined with a layer of said hard polymeric material.

4. An improved telescopic external fixation device according to claim 2 comprising replaceable elongate flat strips of said polymeric material co-extensive with said bore and contiguous with the bore surface.

5. An improved telescopic external fixation device according to any one of the preceding claims wherein said rod is formed of metal, preferably stainless steel, and said polymeric material is acetal.
6. An improved telescopic external fixation device according to any one of the preceding claims wherein said housing has a cylindrical outer wall and comprises two identical axial halves secured together by securing means.

7. An improved telescopic external fixation device according to claim 6 wherein said securing means comprises screws.

8. An improved telescopic external orthopaedic fixation device comprising an elongate telescoping unit itself comprised of a pair of telescopically engaging inner and outer parts adapted for relative axial reciprocal movement along an axis which coincides with the central longitudinal axis of said unit,

   a pair of pin clamps respectively carried on the telescoping parts for clamping one or more orthopaedic retainer pins spaced lengthwise of the clamp and extending transversely thereof,

   clamp connection means on each said part for connecting a respective said clamp thereto, each said clamp connection means comprising a clamp holder, means for locking said holder in either a locked or unlocked condition, said clamp holder having a first axis of rotation spaced radially outwards of said outer part whereby said clamp holder when in an unlocked condition, along with its associated said clamp can bodily rotate about said first axis, said clamp holder being adjustably supported for slidable movement lengthwise along its said first axis whereby the spatial position of its associated said clamp can be varied by varying the radial distance measured along said first axis between said clamp and the telescoping unit, and wherein each said clamp is rotatably supported by said clamp holder so as to permit the clamp to bodily rotate about a second axis of rotation extending lengthwise thereof and at right angles to said first axis.
9. An improved telescopic external fixation device according to claim 8 wherein each said clamp connection means comprises a connector slidably supported on its associated said telescoping part, means for releasably securing said connector to its associated said telescoping part, which when released, permits the connector along with its associated said clamp to slide longitudinally of said telescoping unit.

10. An improved telescopic external fixation device according to either claim 8 or claim 9 wherein each said connector is rotatably supported on its said telescoping part whereby its associated said clamp connection means can be rotationally adjusted about an axis which coincides with the longitudinal axis of said telescoping unit, to assume different angular positions relative to the telescoping unit.

11. An improved telescopic external fixation device according to any one of claims 8, 9 or 10 wherein there are two said connectors, one of which is fast with the free end of the inner telescoping part, the other being slidably located along the length of the outer telescoping part.

12. An improved telescopic external fixation device according to any one of claims 8 to 11 wherein each said clamp connection means comprises a swivel block interconnected between its associated said connector and said clamp holder and being rotatable, when in an unlocked condition, about a third axis which extends at right angles to both the axis of the telescoping unit and said first axis.

13. An improved telescopic external fixation device according to any one of claims 8 to 12 wherein each said connector comprises a pair of halves which surround its associated telescoping part, and locking means for clampingly engaging said halves against the periphery of said part to thereby lock same against both rotational and sliding movement relative to the telescoping unit.
14. An improved telescopic external fixation device according to claim 13 wherein said halves are hingedly joined together along an axis parallel to the axis of said telescoping unit, and said locking means comprises a clamping or locking screw clamping together the adjacent ends of said halves on the side opposite to said hinge axis.

15. An improved telescopic external fixation device according to any one of the preceding claims wherein each said clamp holder comprises a transversely extending short length pin or shaft journalled for rotation about said first axis and fixedly carrying at its distal end a pair of semi-circular fingers or jaw members, the inner peripheral walls of which together define a through opening in which is rotatably received a respective said clamp to enable said clamp to be rotated through 360°, to in turn permit the orientation of the fixator pins held therein to be similarly varied.

16. An improved telescopic external fixation device according to claim 15 wherein each said pin clamp is a three-piece assembly comprising a pair of separate identical axially aligned spaced apart half plates each having a plurality of transverse grooves spaced lengthwise thereof and extending across an inner face thereof, and a unitary member comprising a central circular bearing portion which makes bearing contact with said inner peripheral walls of said fingers or jaw members, and a pair of plate portions projecting from opposite sides of said bearing portion and which co-operate with said half plates to form transversely extending through openings for clampingly receiving said fixator retainer pins, there being clamping screws for clamping together each said pair of plates.

17. An improved telescopic external fixation device according to any one of the preceding claims further comprising releasable locking means for releasably locking said inner and outer parts against relative axial movement.
18. An improved telescopic external fixation device according to claim 17 wherein limit means are provided for limiting the range of axial movement of said inner telescopng part relative to said outer part, when said locking means is released.

19. An improved telescopic external fixation device according to claim 18 wherein said limit means comprises an abutment surface at the inner or distal end of said inner part which co-operates with a radial wall on the outer part.

20. An improved telescopic external fixation device according to any one of claims 17 to 19 wherein said releasable locking means comprises a locking collar having an internal thread which threadably engages an external thread at the proximal end of said outer part, said locking collar being moveable between a locked or tightened condition which locks said parts against relative axial movement, and a loosened or release condition which allows said parts to undergo relative axial movement.

21. An improved telescopic external fixation device according to any one of the preceding claims further comprising an axial loading device which comprises an adjustable spring mechanism attachable to the distal end of said housing and co-operable with said inner part to provide an adjustable axial loading force to resist motion of said inner part and to prevent relative axial movement of the telescoping parts until a set or pre-determined load is exceeded.

22. An improved telescopic external fixation device according to any one of claims 1 to 20 further comprising an adjustable axial distraction device attachable to said housing at its distal end and comprising a longitudinally extending threaded rod arranged co-axially with said unit for effecting axial separation of the telescoping parts and in turn distraction of the bone parts, so as to allow bone lengthening procedures.
23. A telescopic external fixator, comprising:
   an elongate telescoping unit comprising
   telescopically engaging inner and outer parts arranged for
   limited axial reciprocal movement relative to one another along
   the longitudinal axis of the unit, the outer one of said parts
   constituting a housing having a central bore extending the
   whole length thereof, the inner one of said parts constituting
   a rod which engages with a sliding fit in the bore and
   extending the full length thereof, said rod being non-rotatable
   about said axis, wherein said rod is formed of metal, and the
   surface of said bore comprises hard polymeric material,
   co-operable limit means and limit engaging means
   between the rod and the housing for limiting movement of the
   rod relative to the housing within predetermined limits,
   arranged so that during said limited reciprocal movement, the
   rod maintains sliding contact with the bore approximately along
   the whole length thereof.

24. An improved telescopic external fixation device according
    to claim 23 comprising locking means for releasably locking the
    rod and housing against said axial movement.

25. An improved telescopic external fixation device according
    to either claim 23 or claim 24 wherein said limit means
    comprises a limit block carried at the distal end of said rod
    co-axial therewith, and said limit engaging means comprises a
    radially inwardly directed wall at the distal end of the
    housing.

26. An improved telescopic external fixation device according
    to any one of claims 23 to 25 comprising a pair of orthopaedic
    pin clamp assemblies, one of which is carried by the rod
    adjacent its proximal end, the other being adjustably carried
    on the housing for positioning along the length thereof, each
    assembly comprising pin clamps for removably securing one or
    more pins therein.
27. An improved telescopic external fixation device
substantially as hereinbefore described and with reference to
and as illustrated in FIGS. 1 to 6 of the accompanying
drawings, or as modified as shown in any one of FIGS. 7 to 9 of
the drawings herein.
INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl. A61B 17/60, A61F 5/04

II. FIELDS SEARCHED

Minimum Documentation Searched 7

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Documentation Searched other than Minimum Documentation to the extent that such documents are included in the fields searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

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<th>Category*</th>
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<th>Relevant to Claim No</th>
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<td>GB,A, 2110094 (PER HELLAND) 15 June 1983 (15.06.83). See page 2 line 79 - page 4 line 30.</td>
<td>1-7, 23-26</td>
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<td>Y</td>
<td>DE,A, 3822742 (POLITECH SLASK PETROWSKI) 26 January 1989 (26.01.89). See columns 3 and 4.</td>
<td>(continued)</td>
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* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"*" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 7 May 1991 (07.05.91)

International Searching Authority Australian Patent Office

Date of Mailing of this International Search Report 20 May 1991

Signature of Authorized Officer A. HENDERICKSON

Form PCT/ISA/210 (second sheet) (January 1985)
V. [] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSearchable

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:
1. [] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2. [] Claim numbers ..., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [X] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This International Searching Authority found multiple inventions in this international application as follows:
The independent claims 1, 8 and 23 have a common subject matter i.e. the use of an external fixator with a pair of elongate telescopically engaging inner and outer parts. However this common subject matter cannot be considered to be novel. The following documents clearly disclose this feature:

GB 2110094 by Per Helland
EP 104044 by Edwards
EP 177270 by University College London
FR 256984 by Jaquet Orthopedie
DE 3722595 by Sturtzkopf

Therefore there is lack of unity a posteriori.
1. [] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. [] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. [] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. [X] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest
[] The additional search fees were accompanied by applicant’s protest.
[] No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (supplemental sheet (2)) (January 1985)
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Form PCT/ISA/210 (extra sheet) (January 1985)
ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00036

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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END OF ANNEX