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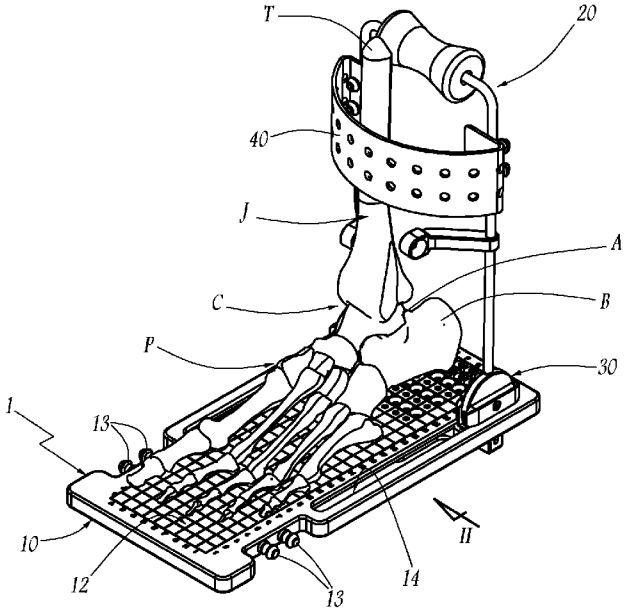

Fig. 1

(57) Abstract: The inventions aims at immobilizing an ankle (C) during a surgical procedure on this ankle, using a device (1) which is not very invasive and can be used for surgical procedures of various kinds, particularly in terms of the route via which these procedures are tackled. To this end, the device comprises a plate (10) on which the plantar face of the foot (P) associated with the operated-on ankle can rest, a rigid frame (20) on which the leg (J) associated with this ankle can rest, and mechanical means (30) for adjusting the relative positioning between foot and leg, these means being adapted both to connect the plate and the frame such that they can move and to lock them reversibly relative to one another.

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SURGICAL DEVICE FOR IMMOBILIZING A PATIENT'S OPERATED-ON ANKLE

This application claims priority to US provisional patent 61/057,133 filed May 29, 2008, herein incorporated by reference.

The present invention relates to a surgical device for immobilizing a patient's operated-on ankle. This device is intended to immobilize the patient's ankle joint during a surgical procedure on this ankle, without the invention in any way being limited to any specific type of surgical procedure. For example, the ankle is immobilized via a device according to the invention so that it can undergo an arthrodesis or alternatively so that it can be fitted with a joint prosthesis.

At the present time, no device of this kind is available. Specifically, devices that allow a patient's ankle to be immobilized do exist, but these are so that this patient's knee can undergo operation: using such devices, the ankle is completely strapped in a rigid enveloping splint, generally L-shaped, thus preventing any surgical procedure on the actual ankle itself. Furthermore, for its part, US-A-2006/0229730 proposes a surgical tool that allows the ankle to be aligned with the tibia when fitting a specific ankle prostheses: the patient's foot is placed on an elaborate support which allows fine adjustment of the anterio-posterior and medio-lateral orientation of the ankle with respect to a plate on which the plantar face of the foot rests, while the patient's leg rests against a dedicated rest. In service, this rest is mechanically independent of the aforementioned support insofar as the unadjustable reference for the positioning between the ankle and the tibia is obtained using an intramedullary nail introduced through the ankle from the side of the support opposite to the foot, and as far as the tibia.

It is an object of the present invention to propose a device for immobilizing an ankle during a surgical procedure on this ankle which is not very invasive and can be used for surgical procedures of various kinds, particularly in terms of the route via which these surgical procedures are tackled.

To this end, the subject of the invention is a surgical device for immobilizing a patient's operated-on ankle as defined in claim 1.

The idea underlying the invention is that of positioning, relative to one another, the foot and leg associated with the operated-on ankle in a way that is simple, effective and adjustable, without in any way impeding the movements of the surgeon. To do this, the foot and the leg, here considered with their anatomical meaning, that is to say as denoting respectively the distal segment of the lower limb and that segment of this lower limb that lies between the knee and the foot, are respectively placed at rest and resting against the plate and the frame of the

device according to the invention, while this plate and this frame are mechanically connected such that they can move in order, prior to the actual acts of surgery or, alternatively, peroperatively, to adjust the positioning of the frame with respect to the plate. What this means is that the device fits a very wide range of foot and leg sizes and does so with the same efficacy insofar as the operated-on ankle is immobilized reliably in a configuration chosen by the surgeon. This also means that there are various possible routes via which the surgery can be performed on the operated-on ankle, and in particular, there are at least one anterior route, one lateral route, and one posterior route, depending on the relative positioning of the frame and of the plate, which positioning is adjusted and locked.

In practice, two degrees of relative mobility between the frame and the plate, considered alone and/or jointly, are preferred in order to make the surgery easier and improve patient comfort in terms of the operated-on ankle, as specified in dependent claims 2 and 3. One advantageous embodiment which combines these two degrees of mobility is defined in claims 4 and 5.

Other advantageous features of the device according to the invention, considered separately or according to any technically feasible combination, are specified in the dependent claims 6 to 15.

The invention will be better understood from reading the description which will follow, which is given solely by way of example and with reference to the drawings in which:

- figure 1 is a perspective view of a device according to the invention, shown in combination with a schematic depiction of certain bones of the foot and of the leg of a patient who is undergoing an operation on his ankle;

- figure 2 is an elevation on II of figure 1;

- figure 3 is an elevation on III of figure 2, without including the bones shown in figures 1 and 2;

- figure 4 is an elevation on IV of figure 3;

- figures 5 and 6 are sections on V-V and VI-VI of figure 3, respectively;

- figures 7 and 8 are views respectively similar to figures 1 and 2, showing the device in a different configuration of use to that shown in figures 1 and 2; and

- figures 9 and 10 are views respectively similar to figures 1 and 2, showing yet another different configuration of use.

Figures 1 to 6 depict a surgical device 1 designed to immobilize the ankle C of a patient during a surgical procedure on this ankle.

As depicted schematically in figures 1 and 2 only, the ankle C forms the joint between the foot P and the leg J of a patient, only some of the bones of which

have been depicted in these figures, those depicted being, inter alia, the talus A and the calcaneus B of the foot P and the tibia T of the leg J.

The device 1 comprises three main sets of components, namely a plate 10, a frame 20 and mechanical means 30 connecting this plate and this frame, which will be detailed gradually hereinafter.

As is clearly visible in figures 1 and 4, the plate 10 has a parallelepipedal overall shape of small thickness. The length and width of the plate, particularly of its flat upper face 10A intended to face upwards in use, are sized so that the plantar face P_A of the foot P can rest on this face 10A as depicted in figures 1 and 2. Thus, when the foot P is resting on the face 10A, the anterio-posterior direction of the foot runs substantially parallel to the longitudinal direction of the plate 10, being more or less centered relative to one another, insofar as neither the front and rear ends of the foot, nor the medial and lateral edges thereof lie outside the peripheral contour of the face 10A. The plate 10 thus forms a stable and precise reference plane on which to position the foot P.

Advantageously, the plate 10 is made of a radio-transparent material so that the device 1 can be used during surgical procedures carried out under radioscopy or fluoroscopy.

As is clearly visible in the right-hand part of figure 5, the rear longitudinal part of the plate 10, that is to say that part of this plate on which the rear of the foot is intended to rest when the device 1 is in service, has, passing right through its thickness, a number of holes 11 which thus each connect the top face 10A and the opposite underside 10B of the plate 10. Each of these holes 11 is dimensioned to accept a nail, not depicted, for osseus positioning in the foot P: in particular, one or more of such nails may be used to interface with the calcaneus B of the foot P having passed through one or more of the holes 11. In this way, the foot P is firmly immobilized with respect to the plate 10.

Furthermore, the top face 10A of the plate 10 has a visual identification pattern, here in the form of a grid pattern 12 (figure 1), the elementary elements of which are identified by a series of letters and a series of numerals respectively inscribed in the widthwise direction and the lengthwise direction of the plate 10. By way of example, each element of the grid pattern 12 corresponds to a geometric square, with a side length of one centimeter. Other geometric shapes for these grid pattern elements, or, more generally, for these elements for visually dividing up the face 10A are conceivable. This grid pattern 12 thus forms a pattern that the surgeon can see, allowing him to identify, on the face 10A, how the foot P is positioned. In practice, this spatial identification is used to position the foot P in a preset position with respect to the plate 10 at the start of the surgical procedure or

alternatively to return to a precise position during the surgical procedure, if, for example, it has been necessary to temporarily shift the foot P relative to the plate 10.

In its front part, the plate 10 is equipped, on each of its lateral edges, with projecting pegs 13 designed to attach a strap, not depicted, for strapping the front end of the foot P as will be better understood later on.

The frame 20 is chiefly made up of a bent rigid rod that forms a U-shaped overall structure facing towards the plate 10. This rod structure thus comprises two parallel branches 21 which are separated from one another by a distance substantially corresponding to the width of the plate 10 and of which the free ends 21_1 (figure 6) engage mechanically with the plate 10, with the interposition of the means 30 as detailed later on. The aforementioned rod structure also comprises a bar 22 connecting the ends 21_2 of the branches 21 which are the opposite ends to their free end 21_1, thereby running in a direction both parallel to the face 10A of the plate 10 and perpendicular to the longitudinal direction of this plate, as is clearly visible in figure 3.

The frame 20 is equipped with a roller 23 mounted coaxially on the bar 22 such that it can rotate freely on itself, as indicated by the arrow F_{23} in figure 5. This roller 23 is thus designed to form a support for the leg J, as depicted in figures 1 and 2. In practice, as will be appreciated by studying figures 1 and 2, it is the posterior soft parts, not depicted, of the leg J which rest directly on the roller 23 in the configuration of use of the device 1 considered in these figures.

To improve the way in which the leg J rests on the frame 20 via the roller 23 and to induce an effect of centering the leg J with respect to the longitudinal direction of the plate 10, the roller 23 advantageously has the overall exterior shape of a diabolo, as is clearly visible in figure 3.

In addition, the frame 20 is equipped with two lugs 24 for osseus fixation in the leg J, these being mounted respectively on the main part 21_3 of the branches 21 so that they can rotate freely about the central longitudinal axis X_{21}-X_{21} of these branches 21 as shown in figure 6. Each of these lugs 24 delimits, at its opposite end to the end that is mounted on the main part 21_3 of the corresponding branch 21, a through-hole 24A designed to accept an osseus positioning nail, not depicted. In practice, the aforementioned nail is intended to interface, preferably, with the tibia T of the leg J, having been passed through the hole 24A in the lug 24, it being pointed out that the direction in which this nail is implanted through the hole 24A is directly dependent on the angular position of the lug 24 about the axis X_{21}-X_{21}, this position being set by the surgeon.

The frame 20 is also equipped with protruding pegs 25 situated in the main part 21_3 of the branches 21 so that these pegs collaborate, through mutually complementing shapes, with associated perforations 41 in a strap 40 used to strap the leg J to the frame 20. Thus, as can be seen in figure 2, the strap 40 is used to strap the leg J, wrapping around the anterior face of the leg J with the main part of the strap while the opposite ends of the strap are attached to the respective pegs 25 of the branches 21, the strapping tension obtained by the strap 40 being adjusted by selecting which perforations 41 to engage with the pegs 25. This immobilizing of the leg J with respect to the frame 20 by strapping, as shown in figures 1 and 2, also explains how the front end of the foot P is immobilized with respect to the plate 10 by strapping using a strap similar to the strap 40 that is attached to the pegs 13.

In practice, the strap 40 is made of a flexible material such as a silicone rubber.

The means 30 comprise a carriage 31 essentially arranged under the plate 10, as can be seen in figure 4. This carriage 31 comprises two brackets 32 respectively supporting the branches 21 of the frame 20, these two brackets being joined together rigidly by a spacer piece 33 positioned facing the underside 10B of the plate 10.

Each bracket 32 is accommodated with sliding in a guide slot 14 delimited by the plate 10, through its thickness. These two slots 14 run in a straight line in the longitudinal direction of the plate 10, being located one along each of the two longest opposite sides of the plate as is clearly visible in figure 4.

By sliding in each of these slots 14, the brackets 32 can be moved, relative to the plate 10, translationally along respective axes X_{14} which in this instance run in the longitudinal direction of this plate and can do so, at most, between the two opposite longitudinal ends of the slots 14, as indicated by the arrows F_{32} in figure 4. Furthermore, in the configuration of use considered in figures 1 to 6, the brackets 32 occupy the respective rear ends of the slots 14, which is the same as saying that the carriage 31 has undergone translational movement to the rear end of the plate 10.

The carriage 31 is associated with a locking mechanism 34 allowing the ability of the carriage to effect translational movement relative to the plate 10 to be prevented reversibly. In the exemplary embodiment considered here, this mechanism 34 is in the form of a manually operated lever of which the end 34_1, the opposite end to its free end, is mounted such as to pivot on the main part of the spacer piece 33, as is clearly visible in figure 5: this lever end 34_1 forms a cam that wedges the spacer piece 33 with respect to the plate 10 such that when the

lever 34 is running substantially perpendicular to the plate 10, as depicted in chain line in figure 5, the spacer piece 33, and therefore the carriage 31, are free to undergo translational movement with respect to the plate, through the sliding of the brackets 32 in the slots 14, which is the same as saying that the mechanism 34 is unlocked, whereas when the aforementioned lever is running substantially parallel to the plate, the spacer piece 33 is fixedly wedged by the end 34_1 against the underside 10B of the plate, which is the same as saying that the mechanism 34 is locked, preventing any additional translational movement of the carriage 31 along the axes X_{14}.

The means 30 further comprise two wheels 35 respectively mechanically interposed between the branches 21 and their support bracket 32. More specifically, as depicted in figure 6, each wheel 35 is rigidly connected to the corresponding branch 21, for example by pushing the end 21_1 of this branch into a complementary bore 35_1 delimited radially in the thickness of the wheel 35. At the same time, each wheel 35 is housed in a complementary housing 32_1 delimited by the corresponding bracket 32, this housing 32_1 being substantially in the shape of half a disk coaxial with the wheel 35 when the means 30 are in the assembled state. Each wheel 35 is thus mounted on the bracket 32 such that it can rotate on itself about its central axis X_{35}, the two axes X_{35} of the wheels being substantially aligned with one another, running both parallel to the top face 10A of the plate 10 and perpendicular to the longitudinal direction of this plate, as shown by figure 3. Thus, the frame 20 is assembled with the carriage 31 such that it can pivot about coincident axes X_{35} as indicated by the arrow F_{35} in figure 6. In other words, by virtue of the wheels 35 rotating on themselves with respect to the carriage 31, the pivoted position of the frame 20 about the coincident axes X_{35} can be modified.

In order to set a pivoted position of the frame 20 with respect to the plate 10, the means 30 further comprise a locking mechanism 36, separate from the mechanism 34, to prevent the wheels 35 from rotating with respect to their bracket 32. In the exemplary embodiment considered here, this mechanism 36 includes a bent rod 36_1, which runs lengthwise under the plate 10 transversely to the longitudinal direction of this plate, and the opposite ends of which each bear a pawl 36_2 shaped to be housed through complementary shapes in one of a number of radial bores 35_2 delimited by the wheel 35 and opening onto the external periphery of this wheel, as clearly visible in figure 6. Thus, as long as the pawl 36_2 is not housed in any of the bores 35_2, the wheel 35 is free to move in terms of rotation about the axis X_{35} inside the bracket 32 whereas, when the pawl occupies one of these bores, as in figure 6, it prevents the wheel 35 from rotating. The pawl 36_2 is made to disengage from the external periphery of the wheel 35 manually

using the rod 36_1, whereas the pawl is made to engage with one of the bores 35_2 by releasing this rod 36_1, a compression spring 36_3 being interposed between the pawl and a dedicated part of the bracket 32.

One example of use of the device 1 is as follows.

If we consider the configuration of use shown in figures 1 and 2, it may be seen that the frame 20 has, on the one hand, undergone maximum translational movement rearward with respect to the plate 10, the brackets 32 occupying the rear ends of the guide slots 14 and, on the other hand, has been pivoted to 90° with respect to the plate 10, the pawl 36_2 occupying the bore 35_2 situated in the radial continuation of the bore 35_1, as shown in figure 6. In this configuration, the surgeon can be sure that the leg J is positioned precisely, resting against the frame 20, with respect to the foot P, resting on the plate 10, so that he can perform surgery on the ankle C via an anterior route, which is particularly well accessible and clear of any component belonging to the device 1. This positioning is fixed reliably by virtue, on the one hand, of the fact that the foot P is immobilized with respect to the plate 10 under the action of one or more osseus positioning nails housed in one or more of the holes 11 and/or under the action of a strap that straps the front end of the foot and is attached to the pegs 13 and, on the other hand, of the fact that the leg J is immobilized resting against the frame 20 under the action of the strap 40 and/or of one or two tibial positioning nails fitted through the lugs 24. Furthermore, this positioning is reproducible, by virtue of the spatial identification using the grid pattern 12.

The device 1 can be used in a configuration other than that of figures 1 and 2, particularly in the configuration shown in figures 7 and 8. In that configuration, the frame 20 has undergone the greatest possible translational movement forward with respect to the plate 10, the brackets 32 of the carriage 31 occupying the front ends of the guide slots 14 while, at the same time, the frame 20 is pivoted backward, by comparison with its 90° position of figures 1 and 2, with respect to the plate 10 by means of a corresponding setting of the wheels 35 of which another of the bores 35_2 than the one used for the configuration of figures 1 and 2 accepts the pawl 36_2. By virtue of this forward translational movement and this backward inclination of the frame 20, the foot P and the leg J are positioned in such a way that the surgeon has good lateral access to the ankle C that is to be operated on, as clearly visible in figure 8, without being impeded by the components of the device 1.

Like with the configuration of figures 1 and 2, the relative positioning of the frame 20 and of the plate 10 in the configuration of use of figures 7 and 8 is precise, reliable and reproducible. It will be noted that, in this configuration of use,

it is the anterior soft parts of the leg J that rest against the roller 23, while the strap 40 is strapped around the posterior face of the leg, which is basically the opposite situation to that of figures 1 and 2.

It will thus be understood that the device 1 is remarkably adaptable in terms of the various conceivable routes via which the surgical operation on the ankle C can be tackled. This adaptability is also good for the comfort of the patient being operated on, insofar as the device lends itself to any preference the patient may have for a specific angle between his foot and his leg while the surgical procedure is being performed.

Of course, there are other conceivable ways of configuring the device 1 in order to achieve fine adjustment of the relative positioning between the foot P and the leg J by means of corresponding adjustments of the translated position of the carriage 31 along the axes X_{14} and of the pivoted position of the branches 21 about the coincident axes X_{35}-X_{35}. In all cases, once these settings have been made, the relative position of the frame 20 and of the plate 10 is immobilized by locking the mechanisms 34 and 36.

What is more, the device 1 can advantageously be folded down on itself into a configuration illustrated in figures 9 and 10. In this configuration, which is used for example to store the device 1 when it is not in use, the frame 20 has undergone translational movement to the rear end of the plate 10, while at the same time having been pivoted as far forward as possible, until it is pressed against the top face 10A of the plate 10. The device 1 therefore occupies a particularly small amount of space.

Various arrangements and variants of the device 1 are also conceivable. By way of examples:

- other shapes, possibly less elaborate, than the diabolo shape may be used for the roller 23; thus, a cylinder with a circular base is conceivable;

- rather than allowing the roller 23 to rotate on itself about the bar 22, this roller could be securely attached to this bar so that it then becomes more generally likenable to a comfortable covering against which the leg J can rest;

- the axes of translation X_{14} may be directed other than perpendicular to the axes of pivoting X_{35} without incidentally there being any compulsory spatial relationship with the longitudinal direction of the plate 10; thus, in particular, depending on the shape of the exterior contour of this plate, which may be other than rectangular, the aforementioned axes may run in any directions in the plane of the plate; and/or

- as an option, the plate 10 and/or the frame 20 may be equipped with removable means for holding open the soft tissues on each side of an incision

during surgery, to make the surgical procedures performed on the osseus parts of the operated-on ankle C easier.

CLAIMS

1. A surgical device (1) for immobilizing an operated-on ankle (C) of a patient, this device comprising:

- a plate (10) on which the plantar face (P_A) of the foot (P) associated with the operated-on ankle can rest,

- a rigid frame (20) on which the leg (J) associated with the operated-on ankle can rest, and

- mechanical adjusting means (30) for adjusting the relative positioning between foot and leg, these adjusting means being adapted both to connect the plate and the frame such that they can move and to lock them reversibly relative to one another.

2. The device as claimed in claim 1, in which the adjusting means (30) are adapted to connect the plate (10) and the frame (20) with mobility by translation (F_{32}) along a translation axis (X_{14}) parallel to the plate.

3. The device as claimed in one of claims 1 and 2, in which the adjusting means (30) are adapted to connect the plate (10) and the frame (20) with mobility by pivoting (F_{35}) about a pivoting axis (X_{35}) parallel to the plate.

4. The device as claimed in claims 2 and 3 considered together, in which the translation axis (X_{14}) and the pivoting axis (X_{35}) run substantially perpendicular to one another.

5. The device as claimed in claim 4, in which the adjusting means (30) are adapted to simultaneously effect a translational movement of the frame (20) as far as one end of the plate (10) and pivot the frame until it is pressed against the plate (figures 9 and 10).

6. The device as claimed in any one of claims 2 to 5, in which the plate (10) is of elongate shape such that the translation axis (X_{14}) runs in the longitudinal direction of this plate and/or such that the pivoting axis (X_{35}) runs substantially perpendicular to the longitudinal direction of this plate.

7. The device as claimed in any one of claims 2 to 6, in which the adjusting means (30) comprise, on the one hand, a carriage (31) that supports the frame (20), this carriage being mounted on the plate (10) such that it can slide along the translation axis (X_{14}) and, on the other hand, a reversible mechanism (34) for immobilizing the carriage in terms of translation.

8. The device as claimed in any one of claims 3 to 7, in which the adjusting means (30) comprise, on the one hand, at least one wheel (35) for mounting the frame (20) on the plate (10), this wheel being borne by the plate

such that it can rotate on itself about the pivoting axis (X_{35}) and, on the other hand, a reversible mechanism (36) for immobilizing the wheel in terms of rotation.

9. The device as claimed in claims 7 and 8 considered together, in which the or each wheel (35) is secured to the frame (20) and mounted such that it can rotate on the carriage (31).

10. The device as claimed in any one of the preceding claims, in which the plate (10) is provided with at least one through-hole (11) to accept a bone positioning nail in the foot (P).

11. The device as claimed in any one of the preceding claims, in which the plate (10) has a visual identification pattern, such as a grid pattern (12), dimensioned to identify the position of the plantar face (P_A) of the foot (P) on the plate.

12. The device as claimed in any one of the preceding claims, in which the frame (20) has a U-shaped overall structure, in which the respective free ends (21_2) of the two branches (21) engage with the adjusting means (30) and in which the respective opposite ends (21_1) of these branches are connected by a bar (22) substantially parallel to the plate (10).

13. The device as claimed in any one of the preceding claims, in which the frame (20), particularly the bar (22) thereof, is provided with a coating that is comfortable to rest on, particularly with a roller (23) that rotates freely on itself, particularly in the form of a diabolo, adapted to support the leg (J) equally well on either side of the frame.

14. The device as claimed in any one of the preceding claims, in which the frame (20), particularly one and/or the other of the branches (21) thereof, is equipped with at least one lug (24) for osseus fixation in the leg (J), particularly for tibial fixation, which lug is mounted on the frame such that it can move, particularly such that it can rotate about the longitudinal axis (X_{21}-X_{21}) of the branch.

15. The device as claimed in any one of the preceding claims, in which the plate (10) and/or the frame (20), particularly the branches (21) thereof, are provided with respective elements (13, 25) for attaching a strap (40) in order, respectively, to strap the foot (P) to the plate and to strap the leg (J) to the frame.

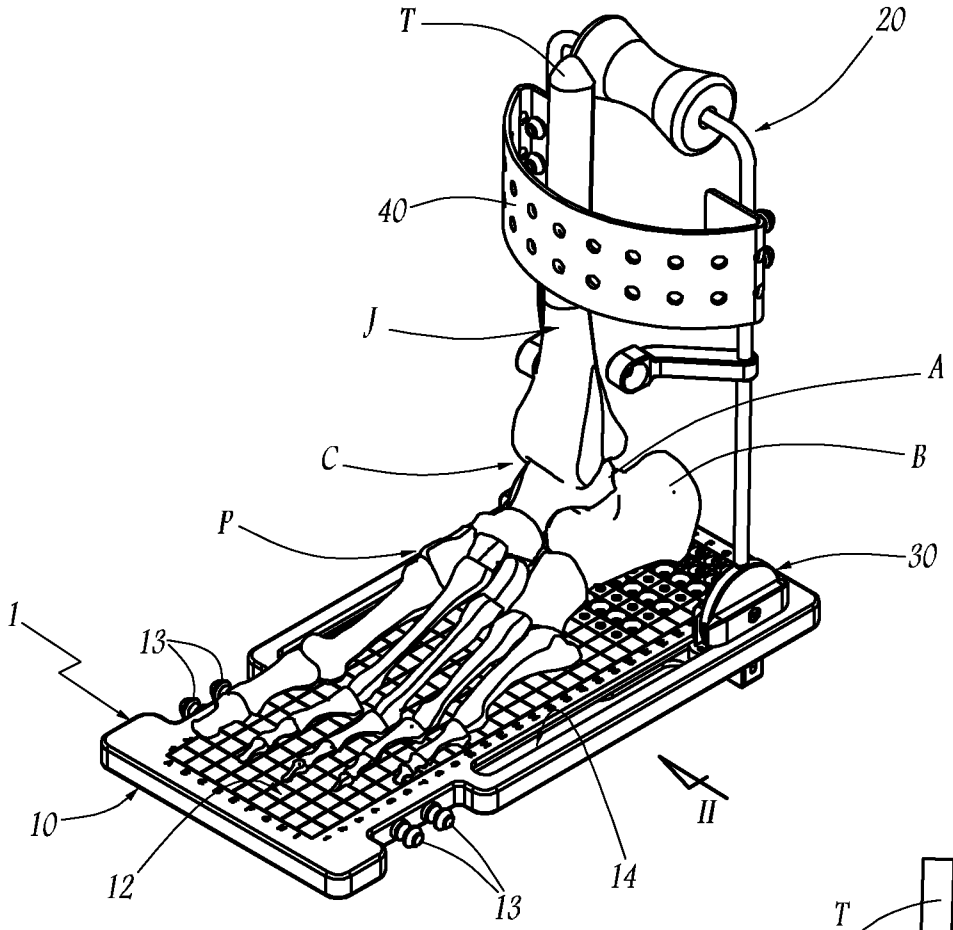

Fig.1

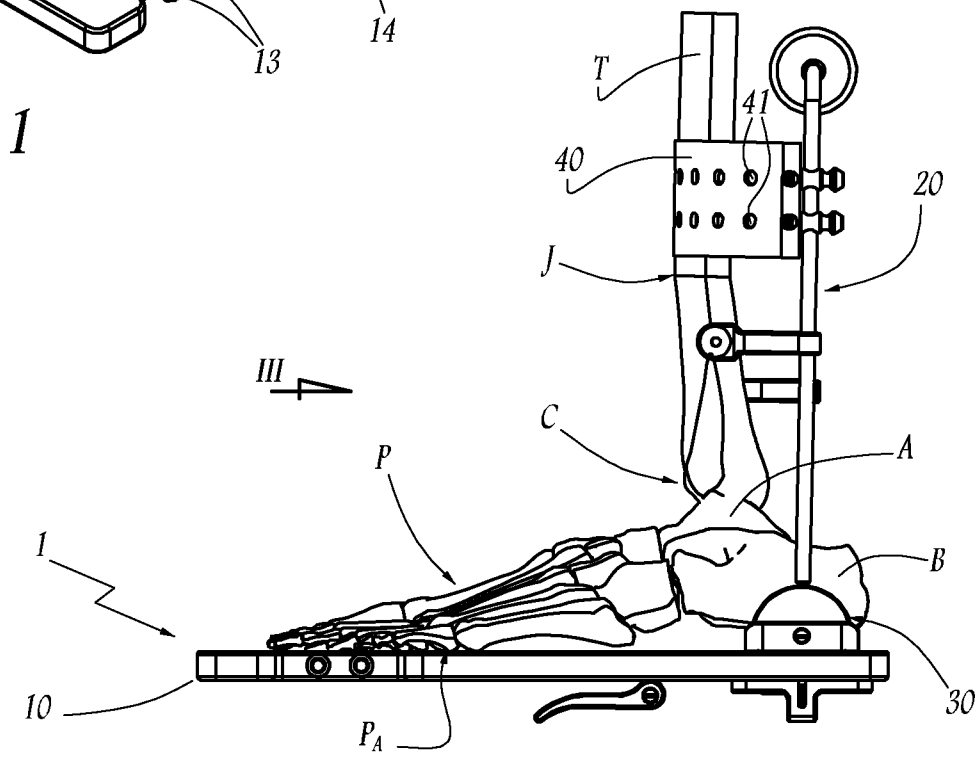

Fig.2

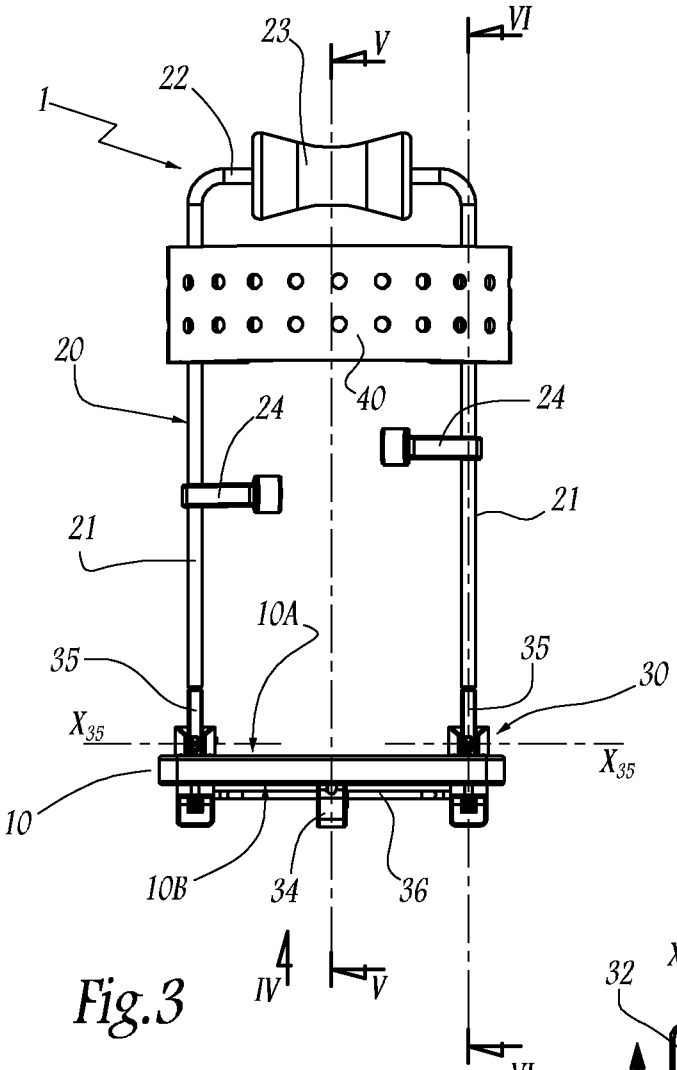
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Fig.3

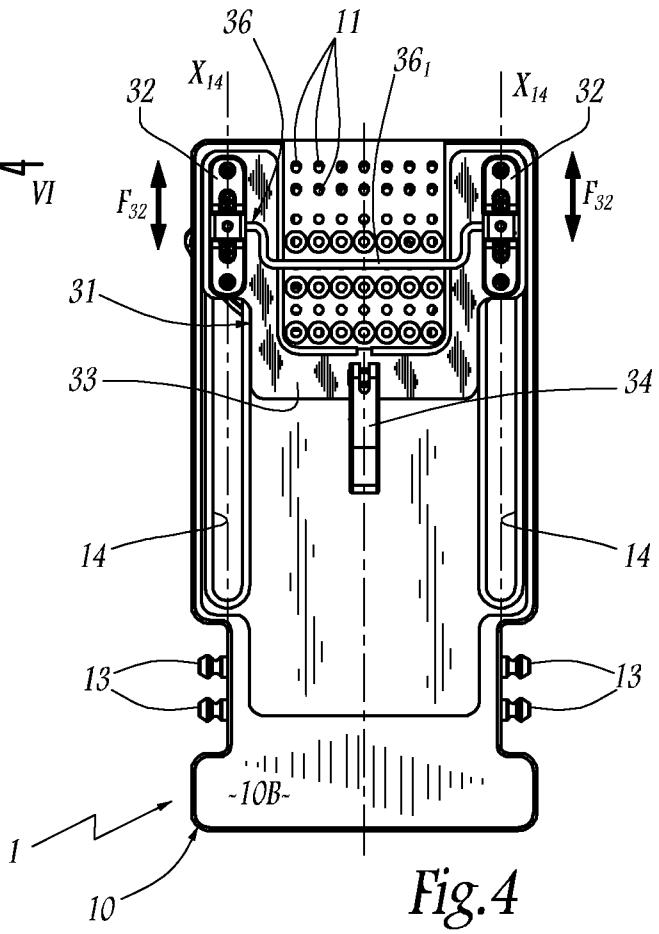
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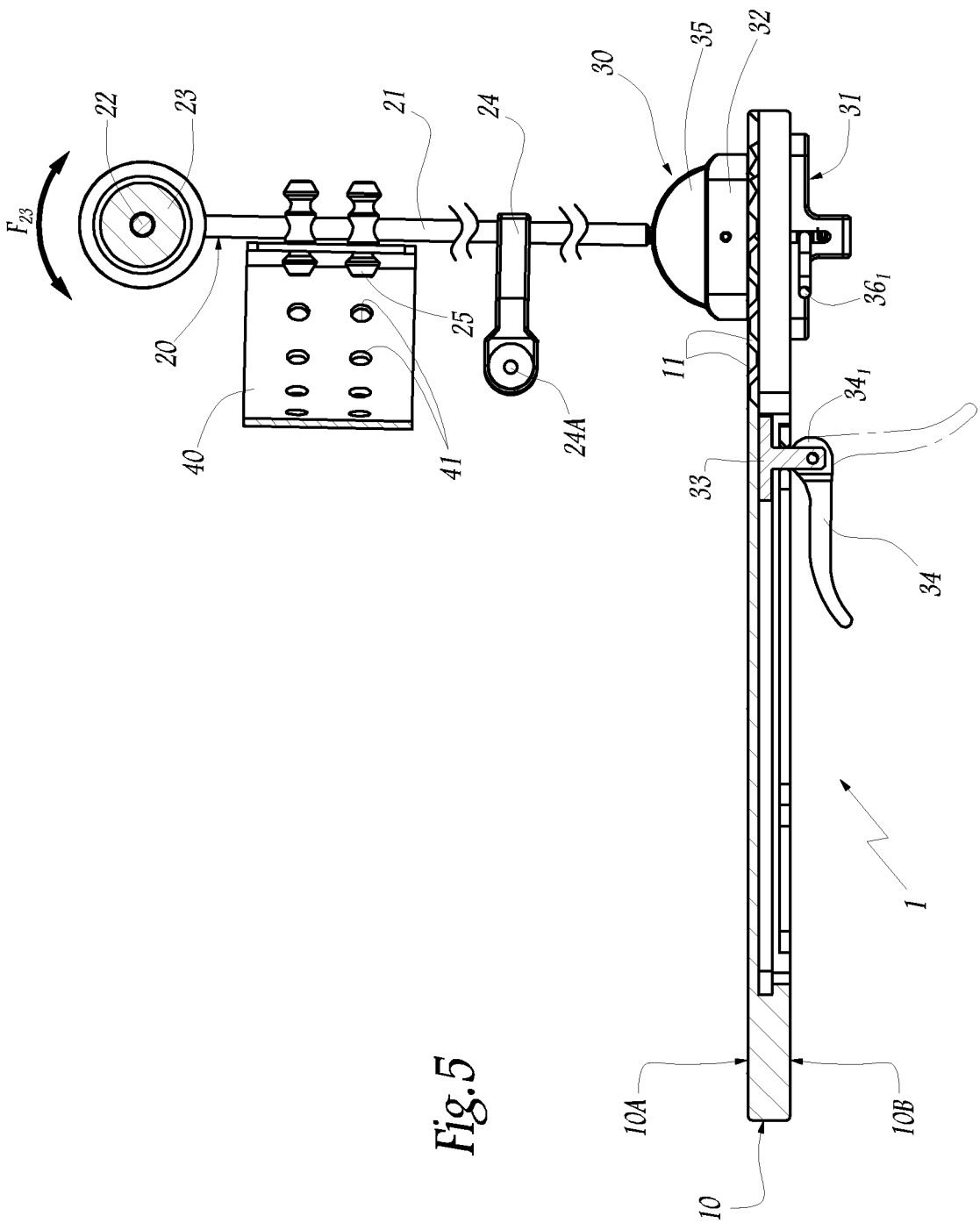
Fig.4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41
24A
33
34
1
10A
10B
10

Fig.5

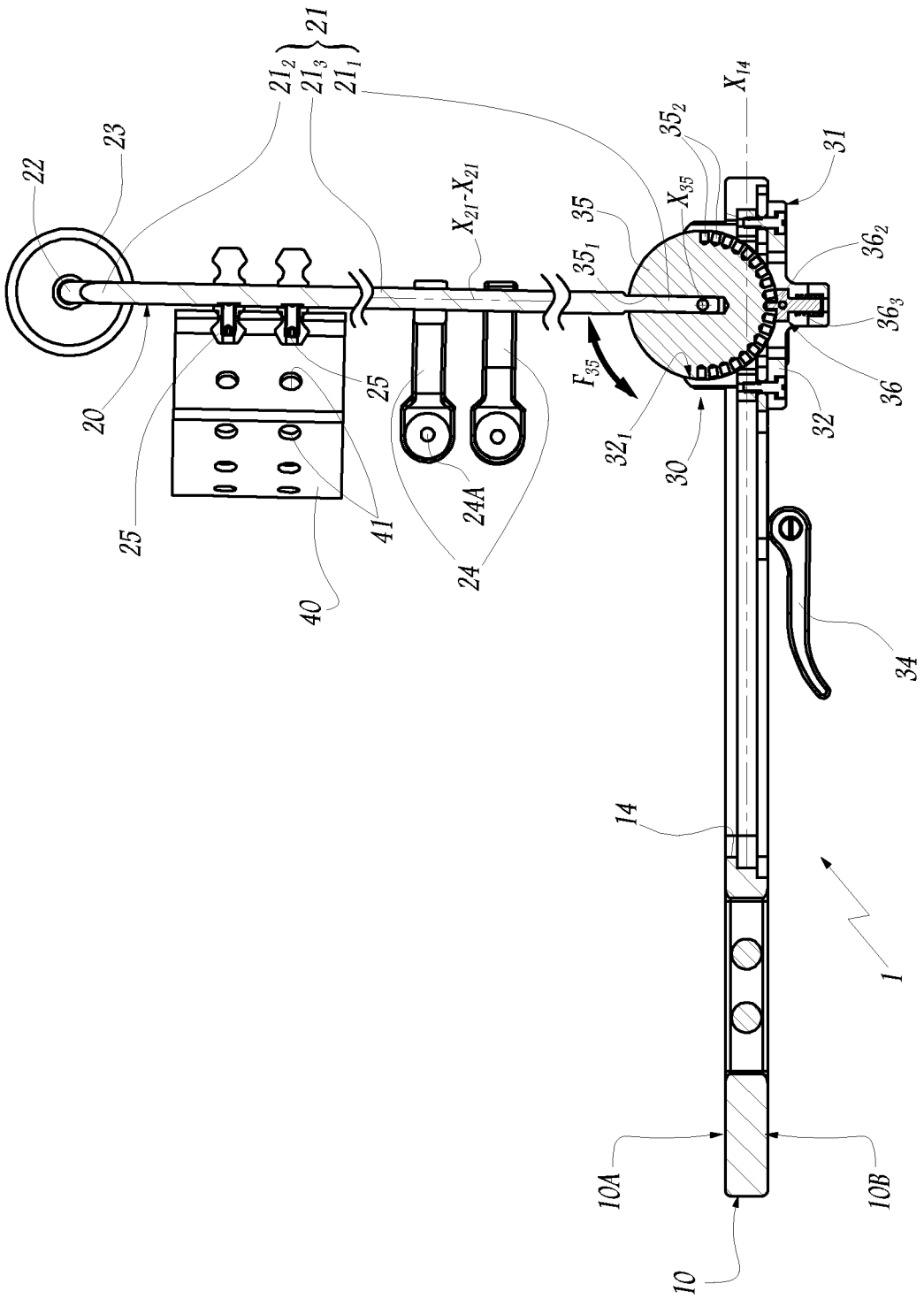
21
21_2
21_3
21_1
22
23
20
25
25
41
40
24
24A
X_{21}-X_{21}
35
35_1
35_2
X_{35}
F_{35}
32_1
30
X_{14}
31
36_2
36_3
36
32
34
14
1
10A
10B
10

Fig.6

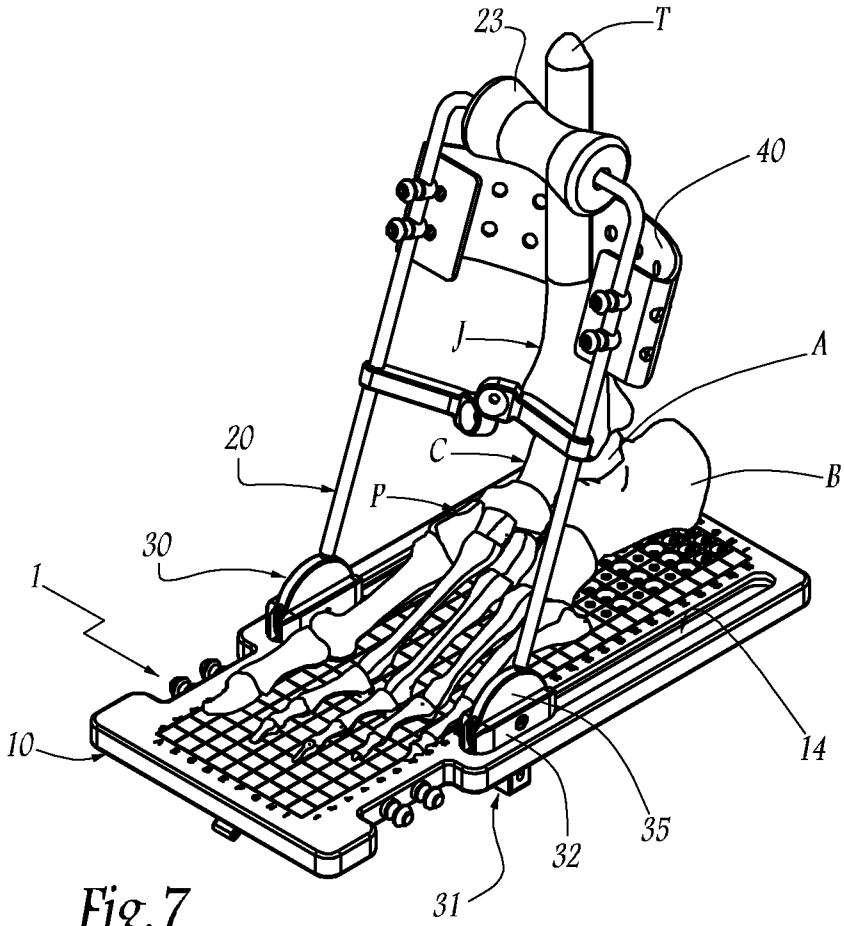
23
T
40
J
A
20
C
B
P
30
1
10
14
35
32
31

Fig.7

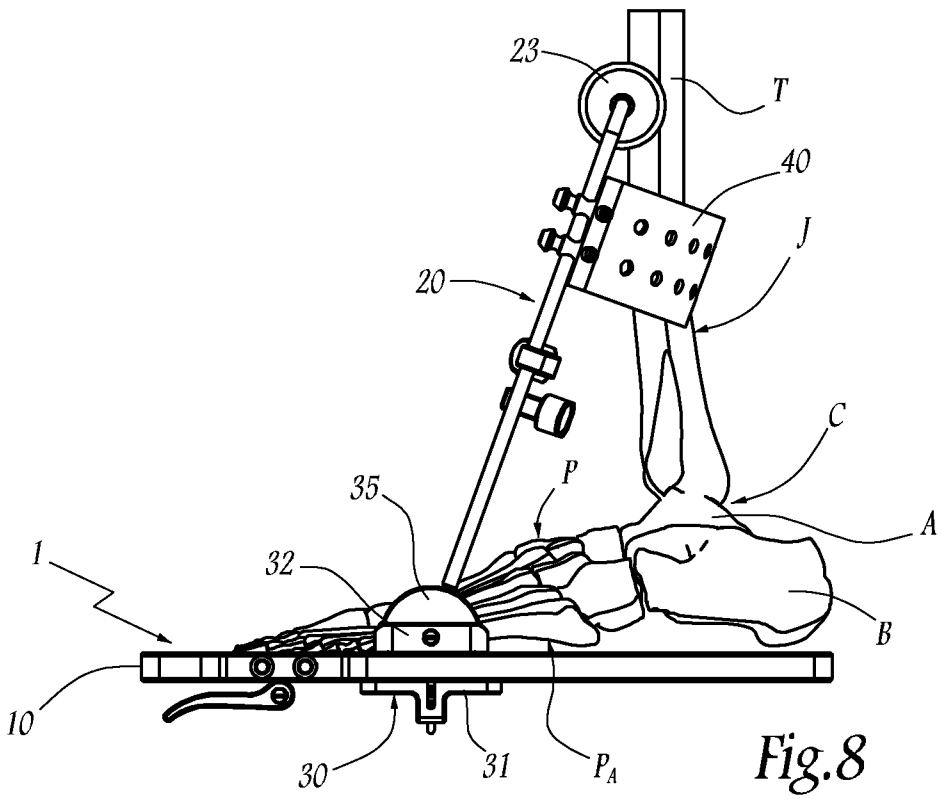
23
T
40
J
20
C
35
P
A
1
32
B
10
30
31
P_A

Fig.8

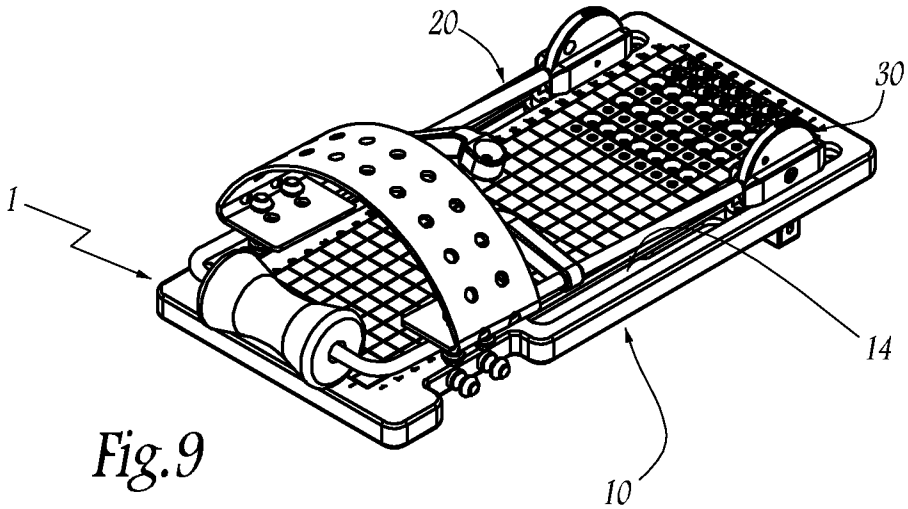

Fig.9

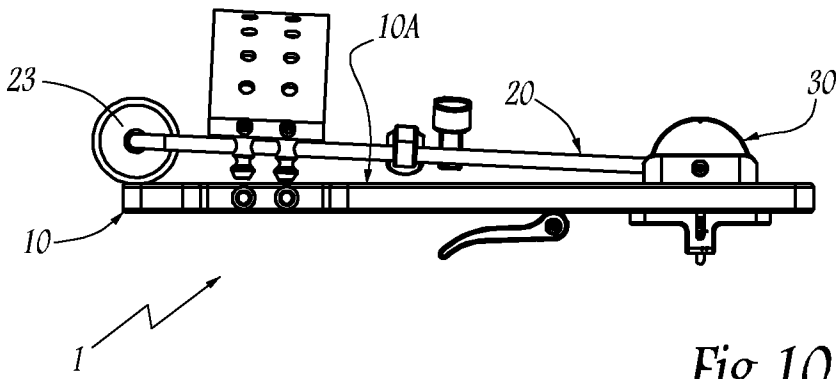

Fig.10