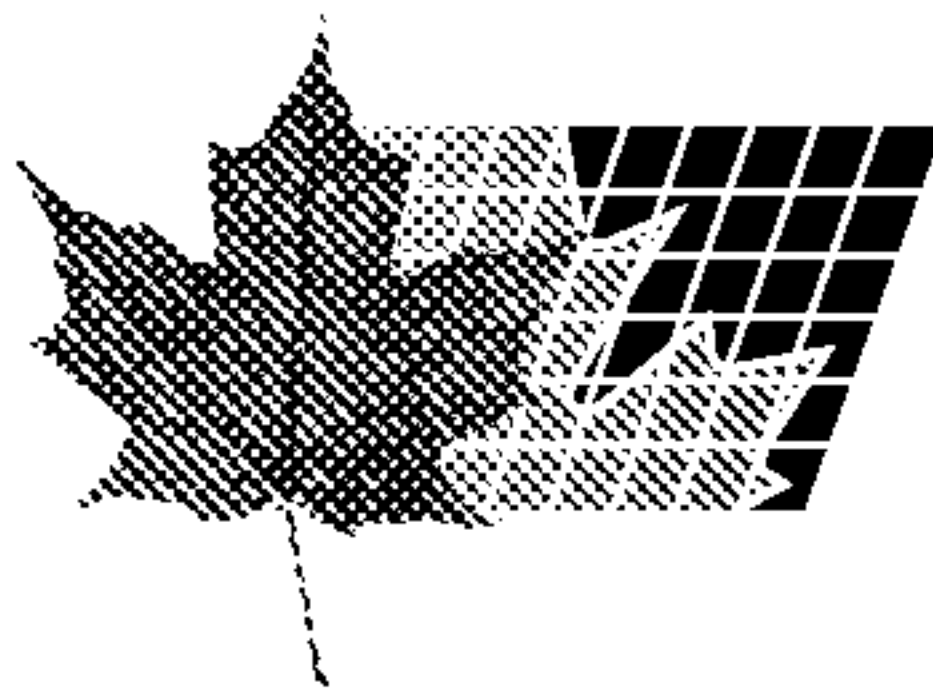




(72) PAOLITTO, ANTHONY, CA

(72) VALENTINI, VALERIO, CA

(72) CARTIER, RAYMOND, CA

(71) PAOLITTO, ANTHONY, CA

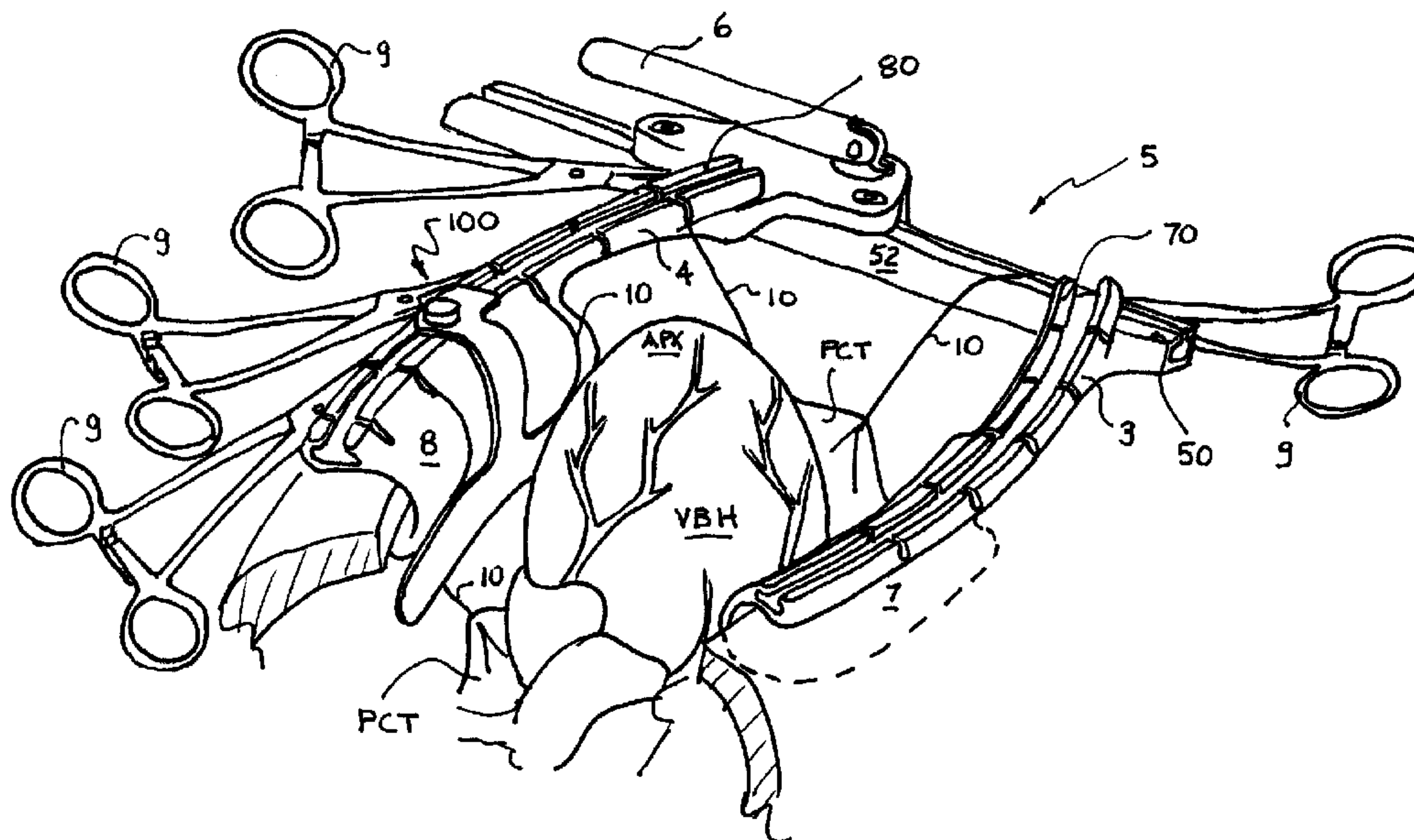
(71) VALENTINI, VALERIO, CA

(71) CARTIER, RAYMOND, CA

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(54) **OUTIL DEFLECTEUR CHIRURGICAL**

(54) **SURGICAL DEFLECTOR TOOL**



(57) The present invention provides a variety of surgical deflector tools intended to improve surgical access and surgeon's visibility to a target site on the patient's body organ by deflecting a tissue retraction means used to position and orient the said patient's body organ through traction loads applied to said body tissue anatomically attached to said body organ. The deflection of the tissue retraction means is in a general direction away from the site where a surgical intervention is intended to take place.

ABSTRACT

The present invention provides a variety of surgical deflector tools intended to improve surgical access and surgeon's visibility to a target site on the patient's body organ by deflecting a tissue retraction means used to position and orient the said patient's body organ through traction loads applied to said body tissue anatomically attached to said body organ. The deflection of the tissue retraction means is in a general direction away from the site where a surgical intervention is intended to take place.

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SURGICAL DEFLECTOR TOOL

FIELD OF THE INVENTION

5 The present invention relates to the field of surgical apparatus and more specifically, to a surgical apparatus for deflecting a tissue retraction means.

BACKGROUND OF THE INVENTION

10 Cardiac surgery generally requires an incision through the patient's skin, underlying muscle and tissue, and often a retraction of the patient's ribcage in order to access the patient's underlying coronary organs. Traditional cardiac surgery has been commonly performed through a midline sternotomy incision, where the patient's sternum is incised and the ribcage retracted to obtain access to
15 the patient's heart and major blood vessels. More recently, in minimally invasive procedures, smaller parasternal incisions (mini-sternotomy) or intercostal thoracotomy approaches have also been employed. In thoracotomy approaches, two adjacent ribs are spread apart at times even removing a length of rib to improve access into the patient's thorax and the patient's heart. In both
20 approaches, a chest retractor is used to spread apart the patient's skin and thoracic bone structure to maintain an incised opening or surgical window onto the underlying cardiac tissue.

 Chest retractors exist in many sizes and shapes and have been
25 present since the dawn of cardiac surgery. Most known chest retractors have an elongate rack bar and two retracting arms, namely a fixed retracting arm and a movable retracting arm. Both arms typically extend in a direction normal to the rack bar. The movable arm can be displaced along the rack bar, and relative to the fixed arm, by using a crank to activate a pinion mechanism which engages teeth on
30 the rack bar. Two blades are generally provided, usually disposed below the retractor arm and extending into the surgical incision, to interface with the

patient's skin and thoracic bone structure. These two blades apply the retraction that creates the surgical window by the relative movement and an ensuing spacing apart of the two retractor arms. In addition, chest retractors may also serve as a substantially stable surgical platform for engaging surgical apparatus used in the course of the surgical intervention. Through this engagement with the chest retractor, the surgical apparatus may be set in a substantially stable position or orientation relative to cardiac tissue implicated in the surgical intervention. Cardiac tissue includes pericardium, epicardium, myocardium, endocardium, tissue of the septal wall, aorta tissue, vena cava tissue, cardiac valves, heart muscle, the coronary arteries and veins, the pleurae, the thymus, and other like anatomical tissue.

One type of cardiac surgery known as coronary artery bypass graft (CABG) surgery has been traditionally performed with the support of a cardio-pulmonary machine, whereby the patient's blood is oxygenated outside the body through extracorporeal circulation (ECC). This allows the surgeon to perform surgical procedures on a perfectly still heart while the patient's life support is maintained by cardiopulmonary assistance. During traditional CABG surgery, the surgeon or assistant may manually or otherwise manipulate the arrested heart into a position and orientation that yields the best access to the target artery requiring the bypass graft. The great majority of CABG surgeries (approximately 70%) are triple vessel bypass surgeries; that is, at least one bypass graft is performed on each of the anterior, inferior and posterior artery beds of the patient's heart.

Recently, in an aim to render CABG surgery less invasive to the patient, beating heart CABG surgery is being developed whereby ECC, one of the most invasive aspects of cardiac surgery, is eliminated and coronary artery revascularization is performed directly on the beating heart. One of the challenges in performing beating heart CABG surgery lies in positioning and orienting the beating heart in order to obtain access to the inferior and posterior artery beds, while aiming to minimize physiologically undesirable effects such as

hemodynamic instability, arrhythmia, or a precipitous drop in arterial pressure, that may occur as a result of such beating heart manipulation. Furthermore, a manipulation-enabling surgical device or position-restraining device directly in contact with the beating heart tends to impose loads and restraints on the beating heart that may impede the normal beating function of the heart considerably and induce the onset of the physiologically undesirable effects described above. In traditional CABG surgery, the heart is arrested and therefore heart manipulations are well tolerated.

During CABG surgery or beating heart CABG surgery, the pericardium, namely a substantially thin membranous tissue forming a sac in which the heart and the commencement of the major blood vessels connecting with the heart are contained, is generally incised and unraveled to expose at least a portion of the heart surface which is to receive the bypass graft. The pericardium tissue, unlike the heart, is not beating and it may be separated from the heart surface except in certain locations where it is anatomically attached to the heart. Thus, it is surgically possible in CABG surgery, to position and orient the heart through retraction of the pericardium tissue to obtain access to the inferior and posterior coronary artery beds. In beating heart CABG, heart manipulations achieved through retraction of the pericardium tissue tend to reduce the likelihood of inducing trauma to the beating heart, tend to not distort the heart's chambers that may compromise blood ejection capacity, and tend to minimize the physiologically undesirable effects mentioned above, since direct contact with the beating heart is avoided. One such beating heart manipulation consists of "verticalizing" the heart in order to gain access to the posterior artery bed. In this maneuver, the pericardium is engaged close to the base of the heart with one or more tissue retraction means, preferably 1 to 1.5 inches away from the pericardial reflection, and the heart's apex is rotated outward from the retracted chest cavity through the tensile loads applied to the engaged pericardium. The longitudinal axis of the beating heart thereby assumes substantially vertical orientation.

Pericardial retraction may be achieved through a variety of tissue retraction means. Sutures such as traction or stay sutures have been generally employed in cardiac surgery and are one such means of achieving pericardial traction. Sutures generally consist of a tissue piercing member such as a relatively sharp needle and a length of wire-like filament such as a suture line integrally attached to the blunt end of said needle. In the application of pericardial traction sutures, the needle pierces the pericardium tissue, a certain length of suture line is then threaded through the pierced pericardium tissue, and the resultant two ends of the suture line (i.e. the length between the pierced tissue and the free end of the suture line and the length between the pierced tissue and the needle-bearing end of the suture line) are then simultaneously pulled to impart the retraction load on the pericardium tissue and consequently displace the beating heart which is anatomically attached to said pericardium tissue.

In order to “verticalize” a beating with pericardial traction sutures, a number of such sutures must be inserted through and engaged with the pericardium tissue preferably along its pericardial reflection in order to get the desired lifting of the apex and consequently the best exposure to the posterior coronary bed. For example, one traction suture may be placed between the superior and inferior pulmonary vein, a second one below the inferior pulmonary vein, a third one midway between the apex of the heart and the inferior pulmonary vein, and a fourth one towards the diaphragmatic face near the inferior vena cava. Pericardium retraction loads are subsequently applied to each of these traction sutures independently. The resulting lengths of suture line must then be secured to a stable surgical platform such as the chest retractor to maintain the desired retraction load on the pericardium tissue. Standard surgical clamps may be used to secure the two lengths of suture line relative to the chest retractor through a variety of methods. Alternatively, a tissue retraction means consisting of a suture line with an associated anchoring means may also be used to apply and maintain the pericardial traction loads and the resultant heart position and orientation relative to the chest retractor. Such types of tissue retraction means are described

more fully in co-pending Canadian patent application Serial No. 2,242,295 filed on August 10, 1998 in the names of Paolitto et al. and entitled "Surgical Instruments for Tissue Retraction", for which a corresponding PCT application has been filed on August 10, 1999 in the names of Paolitto et al. and entitled "Surgical Suture and Associated Anchoring Mechanism for Tissue Retraction". In both these methods of applying pericardial retraction, the engagement of the pericardium tissue is achieved through piercing of said pericardium tissue.

Alternatively, another type of tissue retraction means may consist of engaging the pericardium tissue with a negative pressure suction force. The suction force may be applied through a flexible suction port and the retraction load imposed by pulling on the flexible tubular conduits which communicate the negative pressure to the suction port from the negative pressure source. The retraction load is maintained by securing a part of this negative pressure apparatus, most commonly the flexible tubular conduit, relative to a stable surgical platform such as a chest retractor. Such types of negative pressure tissue retraction means are described more fully in co-pending Canadian patent application Serial No. 2,242,766 filed on August 17, 1998 in the names of Paolitto et al. and entitled "Pericardium Retraction Device for Positioning a Beating Heart", for which a corresponding PCT application has been filed on August 17, 1999 in the names of Paolitto et al. and entitled "Pericardium Retraction Device for Positioning a Beating Heart." In yet other types of tissue retraction means, the pericardium tissue may be engaged by tissue-grasping or tissue-clamping members which grasp or clamp at least a portion of said pericardium tissue.

To maintain the position and orientation of the beating heart achieved through pericardial traction, the tissue retraction means is secured at its anchoring location to a suitable substantially stable surgical platform such as a chest retractor. As will be illustrated and described more fully below, once the pericardial retraction load is secured, a vector may be defined originating from the point of engagement of the tissue retraction means with the pericardium tissue and

generally directed along the tissue retraction means towards a point of anchoring on the surgical platform.

Often times in a retracted chest cavity, the projected distance
5 between a deployed tissue retraction means and the heart surface may be small and restrictive for certain types of surgical interventions. This is more often the case when the patient's ribcage is retracted a minimum amount, when the patient's heart is enlarged due to disease, or when the pericardium tissue is engaged with a tissue retraction means in a deep location close to the pericardial reflection. For
10 instance, in a beating heart revascularization of a posterior coronary artery, with the patient's heart verticalized through pericardial retraction, the projected distance between the pericardial traction sutures and the posterior heart surface may be small or restrictive that it may hinder not only the deployment of coronary stabilizers that immobilize the portion of beating heart around the posterior target
15 artery but may also compromise the quality of the posterior artery bypass graft.

It would therefore be advantageous to provide a surgical deflector tool that displaces at least a portion of the deployed tissue retraction means engaged with pericardium tissue, away from the portion of the heart tissue that is
20 situated in the general vicinity of where the surgical intervention is intended to take place. Consequently, the surgical access and surgeon's vision tends to be improved at the site of the surgical intervention.

The pericardium tissue is generally incised along the anterior surface
25 of the heart and generally along the heart's major axis. In certain instances when the tissue retraction means engages the pericardium tissue at a location close to the pericardial incision (and closer to the anchoring point on the chest retractor arms), a deployed surgical deflector tool may be in contact with and deflect a portion of the pericardium tissue.

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As described above, heart verticalization that may be achieved through substantially stable beating heart manipulations in conjunction with the deployment of a surgical deflector tool tends to improve the likelihood of achieving complete coronary artery revascularization on the beating heart.

- 5 Complete revascularization is considered by most to be the gold standard in revascularization surgery, which till date has been mostly achieved through traditional CABG.

In another type of cardiac surgery such as mitral valve surgery,
10 surgical access to the diseased mitral valve is mostly achieved through a surgical incision of the left atrium. To attempt to achieve optimal exposure, the heart is elevated out of the chest and rotated, allowing the apex to drop posteriorly while elevating the right side of the heart. This maneuver tends to bring the posterior mitral valve leaflet toward the right side of the patient in a plane which tends to
15 face the surgeon, often permitting better visualization of the mitral valve and subvalvular structures.

Following the median sternotomy, the pericardium is opened slightly to the right of the midline and the right side of the pericardium is sutured under
20 tension to the chest wall or secured under tension to a point on a stable surgical platform in the nature of the chest retractor. This helps to provide the elevation of the right side of the heart. The pericardial edges on the left side of the incision are usually not suspended. After bicaval cannulation, the superior vena cava is usually mobilized by incising the pericardium above it. A tourniquet is often
25 placed on the inferior vena cava and traction is applied in a general direction toward the patient's feet. This tourniquet may also be secured to the chest retractor. This procedure further helps to elevate the right side of the patient's heart. The left atrium is incised parallel to the intra-atrial groove. This incision is usually extended below the superior vena cava and a considerable distance below
30 the inferior vena cava.

It may be advantageous to provide a surgical deflector tool tending to displace at least a portion of the pericardium retraction suture, or a portion of the retracted pericardium tissue which is at some location engaged with the pericardium retraction suture, away from the heart tissue thereby tending to improve surgical access to the diseased mitral valve.

At times during cardiac surgery, the patient's heart surface or cardiac tissue is constrained by, or in close vicinity to, the patient's pleura and lungs. Access to the surgical intervention site on the patient's heart surface may have to be obtained by assistant-hand-held retractors deployed to displace the pleura and lungs. It would therefore be advantageous to have a surgical deflector tool which displaces the pleura and lungs, or other like anatomic tissue, in a direction generally away from the heart surface where the surgical intervention is intended to take place. In another instance, the pleura may be engaged with a tissue retraction means which is in turn secured relative to a chest retractor. The surgical deflector tool may subsequently be deployed to displace a lung through the deflection of a tissue retraction means that is in turn engaged with pleura tissue, or alternatively through the deflection of the pleura which is engaged at some location with a tissue retraction means anchored to a chest retractor.

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It is therefore an object of the present invention to provide a surgical deflector tool which attempts to improve surgical access to a portion of the heart which is positioned and oriented through retraction of the pericardium tissue anatomically attached to said heart, by deflecting at least a portion of the pericardium tissue which is engaged at some location with a tissue retraction means, or at least a portion of the tissue retraction means engaged with pericardium tissue, away from said portion of said heart.

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It is a further object of the present invention to attempt to improve the efficacy and quality of bypass grafts performed on an inferior or posterior coronary artery of a patient's heart by tending to enhance the surgeon's visibility

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and surgical access to the target artery by providing a surgical deflector tool which maintains at least a portion of the pericardium tissue which is engaged at some location with a tissue retraction means, or at least a portion of a tissue retraction means engaged with the pericardium tissue, away from the portion of the patient's heart where the surgical intervention will take place.

It is a further object of the present invention to provide a surgical deflector tool which tends to improve surgical access and visibility to the patient's heart, coronary vessels, or heart's major vessels by displacing at least a portion of the patient's lung or pleura, in a direction generally away from the patient's heart, coronary vessels, or heart's major vessels where the surgical intervention is intended to take place.

These and other objects of the present invention will become apparent from the description of the present invention and its preferred embodiments which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

For better understanding of the present invention and to show more clearly how it may be carried into effect, reference will now be made by way of illustration and not of limitation to the accompanying drawings, which show an apparatus according to the preferred embodiments of the present invention, and in which:

Figure 1 is a perspective view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a first embodiment of the present invention;

Figure 2 is an enlarged perspective view of the surgical deflector tool illustrated in Figure 1, with the verticalized beating heart removed for clarity;

Figure 3 is an exploded view of the surgical deflector tool illustrated in Figure 1;

5 Figure 4 is a perspective view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a second embodiment of the present invention;

10 Figure 5 is an enlarged top view of the surgical deflector tool illustrated in Figure 4;

Figure 6A is a section view through the surgical deflector tool illustrated in Figure 5, illustrating said deflector tool in its non-deployed state;

15 Figure 6B is a section view through the surgical deflector tool illustrated in Figure 5, illustrating said deflector tool in its deployed state;

20 Figure 7 is a top view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a third embodiment of the present invention;

Figure 8A is a section view through the surgical deflector tool illustrated in Figure 7, illustrating said deflector tool in its non-deployed state;

25 Figure 8B is a section view through the surgical deflector tool illustrated in Figure 7, illustrating said deflector tool in its deployed state;

30 Figure 9A is a top view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a fourth embodiment of the present invention;

Figure 9B is a section view through the surgical deflector tool illustrated in Figure 9A, illustrating a pivot-type support frame of said surgical deflector tool;

5 Figure 9C is a section view through the surgical deflector tool illustrated in Figure 9A, illustrating a yoke-type support frame of said surgical deflector tool;

10 Figure 10A is a top view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a fifth embodiment of the present invention;

15 Figure 10B is a side elevational view through the surgical deflector tool illustrated in Figure 10A, illustrating a louver-type deflector of said surgical deflector tool;

20 Figure 10C is a section view through the surgical deflector tool illustrated in Figure 10B, illustrating an adjustment mechanism of said surgical deflector tool;

Figure 11A is a top view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a sixth embodiment of the present invention;

25 Figure 11B is a section view through the surgical deflector tool illustrated in Figure 11A, illustrating a solid-flange support frame of said surgical deflector tool;

30 Figure 11C is a section view through the surgical deflector tool illustrated in Figure 11A, illustrating a sliding-flange support frame of said surgical deflector tool;

Figure 11D is a section view through the surgical deflector tool illustrated in Figure 11A, illustrating a sliding flange support frame of said surgical deflector tool;

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Figure 11E is a section view through the surgical deflector tool illustrated in Figure 11A, illustrating a support frame with integral housing for adjustment mechanism of said surgical deflector tool;

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Figure 11F is a section view through the surgical deflector tool illustrated in Figure 11A, illustrating a housing and adjustment mechanism of said surgical deflector tool;

Figure 12A is a top view illustrating a securing mechanism in the nature of a T-nut of a surgical deflector tool, according to a seventh embodiment of the present invention;

Figure 12B is a section view through the surgical deflector tool illustrated in Figure 12A, illustrating a securing mechanism in the nature of a T-nut of said surgical deflector tool;

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Figure 13A is a top view illustrating a securing mechanism in the nature of a modified T-bolt of a surgical deflector tool, according to a eighth embodiment of the present invention;

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Figure 13B is a section view through the surgical deflector tool illustrated in Figure 13A, illustrating a securing mechanism in the nature of a modified T-bolt of said surgical deflector tool;

Figure 14A is a side elevational view illustrating a securing mechanism in the nature of a radially-engaging cam of a surgical deflector tool, according to a ninth embodiment of the present invention;

5 Figure 14B is a section view through the surgical deflector tool illustrated in Figure 14A, illustrating a securing mechanism in the nature of a radially-engaging cam of said surgical deflector tool;

10 Figure 15A is a side elevational view illustrating a securing mechanism in the nature of a grommet-type expansion joint of a surgical deflector tool, according to a tenth embodiment of the present invention;

15 Figure 15B is a section view through the surgical deflector tool illustrated in Figure 15A, illustrating a securing mechanism in the nature of a grommet-type expansion joint of said surgical deflector tool;

20 Figure 16 is a side elevational view illustrating a securing mechanism in the nature of a C-shape flange of a surgical deflector tool, according to an eleventh embodiment of the present invention;

 Figure 17 is a side elevational view illustrating a securing mechanism in the nature of a retaining clip of a surgical deflector tool, according to a twelfth embodiment of the present invention;

25 Figure 18 is a perspective view illustrating a surgical deflector tool and a surgical apparatus with which the said surgical deflector tool may be used, according to a thirteenth embodiment of the present invention.

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DETAILED DESCRIPTION OF THE INVENTION

The features and principles of this invention can be applied, in whole or in part, to other types of cardiac surgery or other surgery whereby a body organ
5 is positioned or oriented through the retraction of a body tissue anatomically attached to said body organ, and the setting of the desired position or orientation of said body organ is achieved through the securing of the retraction load relative to a substantially stable surgical platform. The embodiments of the present invention that follow will however be described and illustrated in the context of
10 cardiac surgery and more specifically CABG surgery.

In part, the embodiments of this invention may be advantageously applied, if desired, to the chest retractor described in copending Canadian patent application Serial No. 2,216,893 filed on September 30, 1997 in the names of
15 Cartier and Paolitto and entitled "Sternum Retractor for Performing Bypass Surgery on the Beating Heart" and in copending Canadian patent application Serial No. 2,237,877 filed on June 26, 1998 in the names of Paolitto et al. and entitled "Chest Retractor for Performing Cardiac Surgery", for which a corresponding PCT application has been filed on June 25, 1999 in the names of Paolitto et al. and
20 entitled "Surgical Retractor Having Low-Friction Actuating Means and Contoured Blade Arms", the contents of which are incorporated herein by reference. Alternatively, the embodiments of the invention may also be applied to other types of chest retractors capable of securing the surgical deflector tool according to the present invention in a substantially stable orientation and position relative to the
25 chest retractor. Alternatively, the chest retractor may be replaced by other substantially stable surgical platforms that may be engaged with the surgical deflector tool according to the present invention. Such surgical platforms would include: a surgical table, a surgical bridge or truss or truss member attached to a surgical table and spanning the patient or set adjacent to the patient, or other like
30 platforms.

In part, the embodiments of this invention may be advantageously applied, if desired, to the tissue retractor described in copending Canadian patent application Serial No. 2,242,295 filed on August 10, 1998 in the names of Paolitto et al. and entitled "Surgical Instruments for Tissue Retraction", for which a
5 corresponding PCT application has been filed on August 10, 1999 in the names of Paolitto et al. and entitled "Surgical Suture and Associated Anchoring Mechanism for Tissue Retraction", the contents of which are incorporated herein by reference.

By way of a general overview and with reference to Figure 1, a
10 surgical apparatus with which the invention may be used is comprised of three main components, a surgical deflector tool 1, a tissue retraction means in the nature of a surgical suture 10, and a chest retractor such as sternum retractor 5. The sternum retractor 5 is illustrated in its deployed state, thereby creating and maintaining the surgical window that provides the surgeon with access to the
15 patient's cardiac tissue.

The sternum retractor 5 includes four major parts: (i) an elongated rack bar 52, (ii) a first retractor spreader arm 3 being preferably fixed to the rack bar 52, (iii) a second retractor spreader arm 4 being preferably movable with
20 respect to the rack bar 52, and (iv) an crank handle 6 for effecting movement of the retractor spreader arm 4 relative to retractor spreader arm 3.

Retractor spreader arms 3 and 4 extend in a direction substantially transversely with regard to the rack bar 52, generally in the same direction
25 therefrom and in a parallel orientation with respect to one another. The movable arm 4 can be displaced along the rack bar 52, and relative to the other arm 3, preferably through the rotation of the crank handle 6 activated by the surgeon. The crank handle 6 is operatively connected to the rack bar 52 and to the other spreader arm 4, and is translatable along the length of the rack bar 52. This is
30 preferably achieved by the engagement of a pinion mechanism (not shown) of crank handle 6 with the rack teeth on rack bar 52. Two retractor blades 7 and 8

are respectively provided with the retractor spreader arms 3 and 4, preferably disposed below the rack bar 52 when the sternum retractor 2 is deployed on a patient. The retractor blades 7 and 8 engage with and serve to retract a portion of the patient's incised skin, the two halves of the patient's incised sternum and the patient's ribcage thereby exposing the cardiac tissue to be operated on through the resultant surgical window. When viewing the resultant surgical window from above the patient, the retractor arms 3 and 4 of the deployed sternum retractor 5 each have a generally arcuate orientation.

The sternum retractor 5 advantageously comprises arcuate rails 70 and 80 along the top of arcuate retractor spreader arms 3 and 4, respectively. The rails 70 and 80 configure an inverted T-slot arcuate passage 71 and 81, respectively, preferably centrally located within said rails, and preferably extending throughout the entire arcuate length of said rails. A similar linear longitudinal rail 50, may also be configured along the top of rack bar 52. Longitudinal rail 50 is also configured with an inverted T-slot longitudinal passage 51, preferably extending throughout its entire longitudinal length. These said rails form a mounting perimeter that can advantageously serve to engage a surgical deflector tool 1 in virtually any substantially stable position and orientation within a surgical workspace. As well, these rails can also be utilized to engage other surgical apparatus, that may need to be secured along the perimeter of the sternum retractor 5 during cardiac surgery. For instance, these rails may advantageously serve to engage a positioning and articulation mechanism utilized to place a variety of heart stabilizers during beating heart bypass surgery, for instance, as described in previously mentioned Canadian application Serial No. 2,216,893. Alternatively, the positioning and articulation mechanism may also be utilized to set a cardiac tissue contacting member used in cardiac surgery, such as a valve tissue retractor for example. As well, these rails can also be utilized to engage other surgical apparatus, that may need to be secured along the perimeter of the sternum retractor 1 during cardiac surgery.

A plurality of slit-like channels 72 and 82 are configured along the arcuate arms 3 and 4 and cut through the arcuate rails 70 and 80, respectively. Figure 1A illustrates a plurality of such slit-like channels 72 on the retractor spreader arm 3 and a plurality of such slit-like channels 82 on the retractor spreader arm 4. The slit-like channels 72 and 82 extend downwards from the top of the rails 70 and 80 to a depth preferably below the entire depth of the inverted T-slot arcuate passages 71 and 81, preferably by an amount equivalent to the width of said slit-like channel. Similar slit-like channels were introduced in above mentioned Canadian patent application Serial No. 2,232,795, in order to provide passages for the placement of sutures serving to retract body tissue, for example pericardium tissue. The slit-like channels in the present invention and in Canadian application 2,232,795 are configured so that a suture line or other like wire-like filament will not restrict or otherwise hinder the functionality of the surgical deflector tool 1 or a positioning and articulation mechanism when such devices becomes engaged in said passages 71 and 81 of said rails 70 and 80, provided the suture line or other wire-like filament is placed in the deepest position within said slit-like channel.

Figure 1 illustrates an example of one possible surgical set-up whereby the patient's heart is verticalized through pericardial retraction, prior to possibly performing beating heart bypass graft surgery on a posterior or inferior coronary artery. Coronary stabilizers that may be used to immobilize a portion of the beating heart surface around the target artery requiring grafting are not shown. In this example, four tissue retraction means in the nature of a surgical suture are used to apply pericardial traction to the patient's incised pericardium tissue (depicted as PCT). Once the desired pericardial retraction load is applied to each surgical suture 10, both ends of the surgical suture are inserted into one of slit-like channels 82 (or 72 in other surgical set-ups), and the desired retraction load is maintained by securing the two ends of the surgical suture 10 relative to sternum retractor 5 with surgical clamp 9. Alternatively, both ends of a surgical suture 10 may also be placed over rack bar 52 and in between two rack bar teeth (not

shown), and secured relative to said rack bar by a surgical clamp 9. The longitudinal axis of the heart assumes a substantially vertical orientation with the apex (depicted as APX) of the verticalized beating heart (depicted as VBH) resting substantially proud above the plane formed through the top of deployed sternum retractor rails 70 and 80. In this example, the patient is in a substantially horizontal supine position on the surgical table. In this example, rack bar 52 is placed towards the patient's feet. As illustrated, the anterior coronary arteries are most visible. The surgical deflector tool 100 is subsequently deployed.

As further illustrated in Figures 2 and 3, the first embodiment of a surgical deflector tool 100 according to the present invention is comprised of a sheet-like deflector baffle 110 and a securing mechanism in the nature of a cam assembly 120. Surgical deflector tool 100 is capable of simultaneously engaging more than one surgical suture 10. Sheet-like deflector baffle 110 is configured in an inverted T-shape profile. The longitudinal axis of the horizontal portion 111 of inverted T-shape is formed in a substantially arcuate shape of similar curvature to the arc of the retractor spreader arm 8 when said retractor spreader arm is viewed from above the surgical window. The longitudinal axis of the vertical portion 112 of inverted T-shape is also bent in a substantially arcuate shape to conform closely to the shape and curvature of the blade 8 so as to create the minimum obstruction within the surgical window when the surgical deflector tool 100 is engaged with sternum retractor 5. When the surgical deflector tool 100 is deployed and secured to the retractor spreader arm 4 such that the cam assembly 120 is in a location along arcuate rail 80 approximately mid way between the lateral ends of arcuate blade 8, the at least a portion of horizontal portion 111, and more specifically its contours 114 and 115, are tucked below blade 8 and laterally outward away from VBH. When viewed from above the surgical window at least a portion of horizontal portion 111 would not be visible since it is hidden by blade 8 and in a position laterally outward beyond the retracted sternum half. This is further illustrated in Figure 12A with cam assembly 120 replaced by T-nut assembly 730.

Cam assembly 120 is comprised of a clamping knob 130, a wave spring washer 140, and a cam 150. The mechanical assembly of the surgical deflector tool 100 consists of inserting cam shaft 152 of cam 150 through hole 116 in baffle 110 and subsequently through hole 141 in wave spring 140. Cam shaft end 152 is then rigidly engaged with knob 130 either through a press fit, or secured by a set screw (not shown), or by brazing, or by other like means. Once mechanically assembled, the cam 150 and knob 130 are free to rotate relative to baffle 110 and wave spring 140.

Cam 150 is configured with two diametrically opposite ramp-like cam surfaces 153, 154. The narrower width 156 of cam 150 allows it to be inserted within passage 81 (or 71 or 51) when its length 157 is aligned substantially tangent to the longitudinal axis of said passage. Once inserted, the face 117 of baffle 110 rests on top of rail 80 (or 70, or 50), and the contact surface 113 of baffle 110 becomes engaged and deflects surgical sutures 10 that come in contact with said surface 113. A clockwise rotation of knob 130 will simultaneously rotate into engagement the ramp-like surfaces 153, 154 of cam 150 with faces 83 of arcuate passage 81. Similar faces to face 83 exist in longitudinal passage 51. Height 155 of cam 150 is inferior to height 84 of passage 81 to allow free rotation of said cam within said passage 81 (71 or 51) and, if installed, to not interfere with surgical sutures 10 placed within slit-like channels 82 (or 72). Clockwise rotation of knob 130 engages cam surfaces 153, 154 to faces 183 of passage 81 thereby causing wave spring 140 to be progressively compressed and flattened thereby exerting a clamping load on baffle 110 in the vicinity of perimeter of hole 116. Once engaged, cam shaft 152 is in tension while baffle 110, wave spring 140 and rail 80 are in compression and clamped between knob face 131 and a portion of ramp-like cam surfaces 153, 154. Counterclockwise rotation of knob 130 disengages the cam surface 153, 154 and relieves the clamping load. The surgical deflector tool 100 is slidably engaged within passage 81 (or 71 or 51) and may be repositioned in-process along the entire length of rail

80 (or 70 or 50) without withdrawal of cam assembly 120 from within passage 81 (or 71 or 50).

A texture or a series of substantially horizontal ridges or
 5 substantially horizontal depressions may be configured onto the contact surface 113 of baffle 110 to tend to improve adherence between surgical suture 10 and said contact surface 113 when the surgical deflector tool 100 is deployed.

In another example of a usage of the surgical deflector tool 100
 10 according to this first embodiment of the present invention, the surgical deflector tool 100 may be used without tissue retraction means. In this method of use, the surgical deflector tool 100 serves the purpose of deflecting or constraining the patient's expanding breathing lung in a position away from the patient's heart thereby tending to improve the surgical access and surgeon visibility to the
 15 patient's heart during a cardiac surgical intervention and tending to avoid the need for lung deflation to increase surgical access. This also tends to avoid the need for assistant-hand-held tissue retractors in order to obtain the desired surgical access.

Figures 4 – 6 illustrate a second embodiment according to the
 20 present invention. A surgical deflector tool 200 is comprised of a rod-like deflector 205, a securing mechanism in the nature of a threaded clamp 230, and an adjustment mechanism in the nature of a wedge pin assembly 250.

Rod-like deflector 205 consists of two arcuate members 220 and 210,
 25 joined in substantially perpendicular end-to-side mechanical joint 215. Mechanical joint 215 is preferably rigid. It may form a permanent assembly between members 210 and 220 such as may be achieved through a weldment, a brazed joint, or other like means. Alternatively, it may form a demountable joint such as may be achieved through a threaded interface, bolted assembly, riveted
 30 assembly, or other like mechanical joining means. The horizontal spanning arcuate rod 210 is configured with a substantially circular cross section and radius

of curvature R1. The vertical spanning arcuate member 220 is illustrated with a substantially rectangular cross-section and radius of curvature R2. The cross-section profile of arcuate member 220 is configured with at least a flat portion along outboard surface 221 serving as a rolling surface suitable for engagement with wedge pin 251. The remaining cross-section profile of member 220 will be slightly inwardly offset from the mating cross-section profile of housing passage 246 through housing 240 to create a slight clearance that allows relatively free arcuate translation of member 220 through housing 240 when wedge pin 251 is disengaged from contact with either outboard surface 221 or wedge surface 245 in housing 240. These said cross-section profiles must be such to achieve anti-rotation of cross-section of member 220 relative to cross-section of housing passage 246.

Housing 240 is configured with two passages, one in the form of a hole to engage with threaded clamp 230, the other in the form of an arcuate housing passage 246 to engage rod-like deflector 205. Arcuate passage 246 and wedge surface 245 are machined out of housing 240 and preferably permanently capped by face plate 241. Once housing 246 and face plate 241 are assembled, wedge pin 251 is inserted through an opening in housing 240, transverse to arcuate passage 246, and through a similar opening in face plate 241 that is in-line with opening in housing 240. Wedge pin 251 is configured with two actuation wheels 252, 253. One actuation wheel 252 may be integral to wedge pin 251 while the opposing actuation cylinder 253 is engaged with wedge pin 251 only after said wedge pin is inserted through openings in housing 240 and face plate 241. Wedge pin 251 is thereby slidingly and rotatingly engaged with housing 240.

Flat face 280 on housing 240 rests atop of the arcuate rail 80 (or 70 or 50) when the surgical deflector tool 200 is secured relative to sternum retractor 5. Flat face 280 is offset towards bottom of arcuate passage 80 to create anti-rotation island 247 which becomes engaged with lateral faces of passage 80 (or 70 or 50). Anti-rotation island 247 maintains longitudinal axis of member 220 in a

substantially perpendicular orientation to arcuate rail 80 and provides the anti-rotation feature to react the tightening torque applied to knob 230. Flat face 280 is offset upwards away from arcuate passage 81 to define face 242. Resulting thickness between face 242 and 280 defines flange 243 through which a hole is
5 machined to engage threaded clamp 230.

Threaded clamp 230 is comprised of a threaded knob 231, and clamping plate 233 with integral threaded shaft 232. Threaded shaft 232 is inserted through hole in flange 243 and engaged with threaded knob 231 to form a
10 demountable mechanical assembly. Clamping plate 233 is configured with dimensions that allow it to slide freely, together with surgical deflector tool 200, through passage 81 (or 71 or 51) when threaded knob 231 is not tightened. Clamping plate 233 is preferably configured with a rectangular profile when viewed along the axis of threaded shaft 232. The narrower width of this
15 rectangular profile is slightly smaller than the width of passage 80 (or 70 or 50) at its narrowest topmost location. The longer width of this rectangular profile is slightly longer than the width of passage 80 (or 70 or 50) at its widest bottommost location. This allows the clamping plate 233 to be inserted into passage 80 by vertically bringing into contact face 280 of surgical deflector tool 200 with rail 80
20 of sternum retractor 5 when narrower width of said rectangular profile is aligned with width of said passage 80. With face 280 in contact with top face of rail 80, a rotation of threaded knob 231 may at first rotate threaded shaft 232 until clamping plate 233 is rotated into contact with the sides of passage 80 thereby providing an anti-rotation feature allowing the further rotation of knob 231 to apply a clamping
25 load across flange 243 and rail 80. At this point, surgical deflector tool 200 is secured relative to sternum retractor 5. Other variants for a securing mechanism in the nature of a threaded clamp are possible and will be described more fully below.

30 Figure 6A illustrates surgical deflector tool 200 secured to sternum retractor 5, with its arcuate rod 210 engaged with a tissue retraction means in the

nature of a surgical suture 10, but prior to the deployment of the surgical deflector tool 200 (i.e. non-deployed configuration). The tensile retraction load exerted on the PCT by the surgical suture 10 is secured relative to sternum retractor 5 by surgical clamp 9 (not shown in Figures 6A – 6B) at the anchoring point AP. To

5 deploy surgical deflector tool 200, the surgeon applies a manual push load at proximal end 222 of arcuate member 220, thereby causing a clockwise arcuate translation of said member 220 through passage 246 of housing 240. As a result, rod 210 will apply a deflection load to at least one surgical suture 10. When rod 210 tries to deflect surgical suture 10, the tissue retraction load which the said

10 surgical suture applies to the PCT (which places said surgical suture in tension) will tend to resist deflection and want to rotate in an opposing counterclockwise rotation arcuate member 220 through housing 240 when the surgeon-applied load is sufficiently decreased or removed (clockwise and counterclockwise directions are defined relative to Figure 6A – 6B). When the surgeon releases proximal end

15 222, there will be a slight counterclockwise rotation of member 220 thereby entraining wedge pin 251 to substantially roll along outboard surface 221 of arcuate member 220 and become wedged between housing face 245 and said surface 221. This stops the counterclockwise arcuate translation of said member 220 through said housing 240. Consequently, the position of rod-like deflector

20 210 is set relative to housing 240 and sternum retractor 5, thereby also deflecting surgical suture 10 the desired amount.

During the surgical intervention, if it is desired to increase the deflection on surgical suture 10 and extend arcuate rod 210 deeper into chest

25 cavity and laterally outward below the patient's ribcage and away from VBH, a manual push load is re-applied to proximal end 222 to overcome the resistance load exerted by surgical suture 10 on rod 210. By this action, wedge pin 251 is un-wedged as it rolls over contact surface 221 allowing clockwise arcuate translation of member 220 relative to housing 240. Once the desired position is

30 obtained, releasing proximal end 222 will cause a very slight counterclockwise arcuate translation of member 220 through housing passage 246 thereby re-

engaging wedge pin 251 and re-securing the position of the deployed surgical deflector tool. During the surgical intervention, if it is desired to decrease the deflection on the surgical suture 10, actuation wheel 252 or 253 may be rotated by the surgeon, thereby un-wedging pin 251 between contact surfaces 245 and 221,
 5 and allowing the arcuate member 220 to be retracted through passage 246 of housing 240 in a counterclockwise direction. The surgical deflector tool 200 is capable of providing in-process readjustments to the deflection amount on the surgical sutures 10 that are engaged with said tool 200.

10 Figure 6B illustrates a deployed surgical deflector tool 200 secured to sternum retractor 5, with its arcuate rod 210 engaged with a tissue retraction means in the nature of a surgical suture 10 and having deflected said suture 10 from its initial position as illustrated in Figure 6A. This will be referred to as the deployed configuration.

15 Referring to Figure 6A, Px depicts a target point on the verticalized beating heart VBH, in the general vicinity of where a surgical intervention is intended to take place. Distance D1 is a laterally projected distance between the target area Px and a surgical suture 10 applying pericardial traction. V1 is a
 20 vector emanating from the engagement point (depicted as EP) of the tissue retraction means on the pericardium tissue, in this example the piercing point of suture 10 through PCT. Vector V1 is directed along surgical suture 10 in a direction generally towards the anchoring point AP of said suture on chest
 25 retractor 5. θ_1 is an angle in the plane containing V1 and Px, between vector V1 and the heart surface profile HSP that is seen in said plane containing V1 and Px.

Often times in a retracted chest cavity, the laterally projected distance D1 may be small and restrictive for certain types of surgical interventions. For instance, in a beating heart revascularization of a posterior
 30 coronary artery, this distance D1 may be small or restrictive that it may hinder not only the deployment of a coronary stabilizer that immobilize the portion of beating

heart around the posterior target artery in the vicinity of point Px, but it may also compromise the quality of the posterior artery bypass graft. The intended benefit that may be obtained by deploying a surgical deflector tool 200 is illustrated in Figure 6B. This intended benefit also applies to other embodiments according to
5 the present invention.

With the deployment of surgical deflector tool 200, vector V1 is redirected to become vector V2. Laterally projected distance D1 is increased to D2 as at least a portion of the surgical suture 10 engaged with the pericardium
10 tissue is moved laterally away from the heart surface profile at location of target point Px. Angle θ_1 also increases to θ_2 as vector V1 is redirected to assume a more perpendicular orientation, V2, relative to the heart surface profile HSP. The increase in distance D1 to D2 tends to improve surgical access and surgeon's vision at the site of the surgical intervention. It also tends to facilitate the
15 deployment of a coronary stabilizer and the posterior artery bypass grafting procedure. The surgical field in the vicinity of Px is thereby increased.

The deployment of surgical deflector tool 200, depending on the magnitude of desired surgical suture deflection, may also assist in further
20 verticalizing the apex of the heart, or cause a substantially clockwise rotation of the verticalized beating heart tending to improve access to Px. This clockwise rotation is in reference to the Figures 6A and 6B.

In broad terms, a surgical procedure for a set-up and deployment of a
25 surgical deflector tool 200 utilized in a beating heart CABG surgery, and relating to the present invention consists of:

- (a) performing a full or partial midline sternotomy incision;
- (b) cauterizing of any bleeding vessels subsequent to the sternotomy incision;

- (c) if an internal thoracic artery (ITA) will be used as a bypass conduit, retracting the two halves of the patient's incised sternum with a surgical retractor suitable for exposing the ITA and the surgical harvesting thereof;
- (d) retrieving the surgical retractor used for ITA harvesting, and inserting blades 5 7 and 8 of sternum retractor 5 along the sternotomy incision;
- (e) retracting the patient's ribcage to expose the underlying mediastinum and pericardium tissue;
- (f) incising the pericardium sac to expose at least a portion of the patient's beating heart requiring the bypass graft;
- 10 (g) engaging tissue retraction means with a portion of the patient's incised pericardium tissue, as for example by piercing the pericardium tissue PCT with needle 11 of surgical suture 10 at point EP;
- (h) applying tensile traction loads to the surgical suture 10 to position or orient the patient's beating heart through the retraction of pericardium tissue 15 anatomically attached to said beating heart;
- (i) to perform bypass grafts on the inferior or posterior coronary artery beds, preferably placing the beating heart in a verticalized position with the longitudinal axis of the heart assuming a substantially vertical orientation through the rotation of the apex of the heart relative to the base of the heart 20 outwardly through the retracted ribcage;
- (j) maintaining the pericardial retraction loads, and in part the position and orientation of the beating heart, by securing surgical suture 10 to a substantially stable surgical platform such as sternum retractor 5;
- (k) securing surgical deflector tool 200 relative to the sternum retractor 5 at a 25 location along one of the perimeter rails 70, 80, or 50 such that the subsequent deployment of said deflector tool 200 will result in the engagement of arcuate rod 210 with at least one surgical suture 10 and subsequently the deflection of said surgical suture 10;
- (l) deploying the surgical deflector tool 200 by applying a manual push load to 30 the proximal end 222 of arcuate member 220 resulting in an arcuate translation of said member 220 through housing 240 and a simultaneous

movement of arcuate rod 210 which causes the deflection of surgical suture 10;

- (m) within the enlarged surgical field created by the deflection of surgical sutures 10, deploying a coronary stabilizer to immobilize a portion of the beating heart in vicinity of Px;
- (n) performing arteriotomy, anastomosis, and other surgical interventions on the target coronary artery;
- (o) verifying the quality of the bypass graft by Doppler ultrasonography, or other like means, and redoing the bypass graft if not satisfied with the flow quality through the said bypass graft;
- (p) disengaging the coronary stabilizer, or other like means, from the surface of the beating heart after the completion of the bypass graft;
- (q) retrieving surgical deflector tool 200 from its deployed configuration to its non-deployed configuration;
- (r) disengaging securing mechanism of surgical deflector tool 200, and retrieving said tool 200 from sternum retractor 5;
- (s) disengaging tissue retraction means from pericardium tissue thereby removing the pericardial traction loads;
- (t) delicately easing the beating heart back to into its substantially horizontal anatomic position within the retracted chest cavity;
- (u) if desired, re-wrapping the incised pericardium tissue over patient's heart and securing said halves of incised pericardium to each other through the placement of surgical sutures;
- (v) installing chest drainage tubes;
- (w) closing retractor arms 3 and 4 and retrieving sternum retractor 5;
- (x) closing the full or partial midline sternotomy incision.

The surgical procedure defined above, in broad terms also applies to the other embodiments of a surgical deflector tool according to the present invention, with the exception of specific references to the constituent components of surgical deflector tool 200.

Figures 7A – 7B illustrate a third embodiment according to the present invention. A surgical deflector tool 300 is comprised of a rod-like deflector 305, a securing mechanism in the nature of a threaded clamp 330, and an
5 adjustment mechanism in the nature of a ratchet mechanism 350. Threaded clamp 330 is similar to threaded clamp 230 in the second embodiment.

Rod-like deflector 305 is similar to rod-like deflector 205 except for outboard surface 221 of the second embodiment which is replaced by a toothed
10 surface 321. Housing 340 is also similar to housing 240 of the second embodiment except for the provisions to receive an adjustment mechanism in the nature of a ratchet mechanism 350 instead of the wedge pin assembly 250 of the second embodiment. Ratchet mechanism 350 prevents the counterclockwise
15 arcuate translation of arcuate member 320 through housing passage 346 unless the surgeon depresses lever 353 of pawl 357. Depressing lever 353 rotates pawl 357 out of engagement with the teeth on toothed surface 321 of arcuate member 320, thereby allowing the free arcuate translation of member 320 through housing 340. When deploying the surgical deflector tool 300, the surgeon applies a manual push
20 load on the proximal end 322 of arcuate member 320. This manual push load causes the pawl 357 to rotate slightly as it disengages one tooth and engage the next tooth on toothed surface 321 of arcuate member 320. The counterclockwise rotation of pawl 357 is reacted in part by the spring preload imposed on it by spring element 351. Spring element 351 is attached to housing 340 through two
25 mechanical fasteners or pins 352. Spring element 351 keeps the pawl 357 in contact with the toothed surface 321 and only allows clockwise arcuate translation of member 320 through housing 340 unless the action of the spring loaded pawl is manually overridden by depressing lever 353 at which point the member 320 is free to rotate in either a clockwise or counterclockwise arcuate translation.

30 Figures 9A – 9C illustrate a fourth embodiment according to the present invention. A surgical deflector tool 400 is comprised of an arcuate

deflector member 410, a securing mechanisms in the nature of two threaded
clamps 430, a yoke support frame 420, and a pivot support frame 440. Threaded
clamp 430 is similar to threaded clamp 230 in the second embodiment. Variations
of threaded clamps which may apply to some or all of the embodiments according
5 to the present invention are illustrated and described more fully below.

The two threaded clamps 430 are slidably engaged within rails 80,
70 or 50 of sternum retractor 5. The two threaded clamps 430 are rotatably
engaged with their respective support frames 420 or 440. Once the desired
10 position for the support frames 420 and 440 along the said rails is determined, the
threaded clamps 430 are secured to the sternum retractor 5. The distance between
both support frames 420 and 440 is variable depending on the surgical set-up and
the number of tissue retraction means 10 to be engaged and deflected. Deflector
member 410 is preferably formed in an arcuate shape of similar curvature to the
15 arcuate spreader arms 3 and 4 when viewed from the top of the surgical window.
The outboard surface 411 of member 410 is configured with a number of ridges or
depressions which tend to improve adherence with tissue retraction means 10
when said tissue retraction means 10 is deflected by the deployment of surgical
deflector tool 400. The ridges or depressions are preferably oriented such that
20 their longitudinal axes are substantially parallel to the centerline defining arcuate
curvature of member 410. Alternatively, outboard surface 411 may be configured
with a texture to tend to improve adherence with said tissue retraction means 10.

Hole 441 in the proximal end of pivot support frame 440 rotatably
25 engages threaded clamp 430. The distal end of pivot support frame 440 pivotally
engages one end of deflector member 410. Threaded hole 444 in support frame
440 is engaged by a screw 414 after said screw 414 is inserted through hole 413 in
member 410. Screw 414 acts as an axis of rotation for deflector member 410 when
it rotates about the support frame 440. The other end of deflector member 410 is
30 slidably engaged in yoke 427 configured at the distal end of support frame 420.
Spring member 423 is housed in hole 424 in distal end of support frame 420, and

energizes detent member 422. Detent member 422 will engage dimple 412 in deflector member 410 when said member 410 is inserted into yoke 427. The spring load exerted by detent member 422 on dimple 412 must be sufficient to keep deflector member 410 engaged within yoke 427 when the surgical deflector tool 400 is deployed and the deflecting load is applied to tissue retraction means 10.

Support frame 440 is preferably configured with a generally arcuate shape in the vertical direction as illustrated in Figure 9B, in order to clear the profile of blade 8 when support frame 440 is engaged with, and secured to, sternum retractor 5 through rail 80. Similarly, support frame 420 is preferably configured with a generally arcuate shape in the vertical direction as illustrated in Figure 9C, in order to clear the profile of blade 7 when support frame 420 is engaged with, and secured to, sternum retractor 5 through rail 70. Surgical deflector tool 400 is illustrated in Figure 9A with both support frames 420 and 440 engaged in rail 80 through threaded clamps 430. Alternatively, it may be deployed with both said support frames engaged in rail 70, or rail 50. Alternatively, it may be deployed with one said support frame engaged in a different rail than the other cooperating support frame. Pivot support frame 440 facilitates this since the deflector member 410 may assume a variety of angular orientations relative to pivot support frame 440 in order to engage yoke 427 of support frame 420 at its free end when both support frames are not on a common rail. The pivoting action of deflector member 410 may also allow the deflector member 410 to engage a tissue retraction means 10 and progressively deflect it as it pivots about screw 414 and finally comes to engage its free end with yoke 427.

Figures 10A – 10C illustrate a fifth embodiment according to the present invention. A surgical deflector tool 500 is comprised of a louver-type deflector 510, a securing mechanisms in the nature of two threaded clamps 530, two support frames 520 and 540, and an adjustment mechanism in the nature of threaded member 590. Threaded clamp 530 is similar to threaded clamp 430 in the

fourth embodiment. Support frames 520 and 540 engage sternum retractor 5 in a similar fashion and provide similar functionality as support frames 420 and 440 in the fourth embodiment except for differences at their distal ends where they engage louver-type deflector 510.

5

Louver-type deflector 510 is configured as a flat plate of thickness T and width W. A width W to thickness T ratio of approximately 4 to 7 is generally preferred. Two cylindrical extensions extend laterally beyond the length of louver 510 in opposing directions. One cylindrical extension is comprised of a shoulder 10 515 and a shaft member 516 which becomes rotatably engaged with boss 521 on support frame 520. The other cylindrical extension is comprised of a shoulder 511, a shaft member 512 which becomes rotatably engaged with boss 541 on support frame 540, and a thread 513 for engagement with threaded member 590. The centerline of both said cylindrical extensions are coincident to each other and 15 define the pivot axis of louver-type deflector 510. This pivot axis is preferably offset a distance of $0.5T - 1T$ in board from the width of said louver-type deflector 510.

Boss 541 is pivotally engaged to support frame 540 through pivot 20 joint 549 (schematically represented) and similarly boss 521 is pivotally engaged to support frame 520 through pivot joint 529. This allows the centerlines of hole 542 and centerline of hole 522 to always be aligned relative to each other when they engage shaft 512 and shaft 516 regardless of the position of support frames 520 and 540 along arcuate rail 80 or 70.

25

With reference to Figure 10A, the louver-type deflector 510 is illustrated in a slightly-deployed state (shown in solid line engaged with surgical suture 10 in vector direction V1) and its more-deployed state (shown in dashed line engaged with surgical suture 10 in vector direction V2). After the pericardial 30 traction sutures 10 have been secured to the sternum retractor in a manner as described above, the surgical deflector tool 500 is engaged and secured in place

along rail 80, for example, through the threaded clamps 530. At this point,
 louver-type deflector 510 is in its non-deployed or slightly-deployed state. To
 achieve the deflection of surgical suture 10, from a vector V1 to vector V2
 orientation, louver-type deflector 510 is rotated by the surgeon (clockwise with
 5 reference to Figure 10A) until the desired surgical suture 10 deflection is
 achieved. At this point, threaded member 590 is tightened thereby clamping the
 lateral faces of boss 541 between shoulder 511 and lateral face of threaded
 member 590. This secures the louver-type deflector in the desired angular
 orientation about its pivot axis. In-process readjustments may be made by the
 10 surgeon by loosening threaded member 590, readjusting the angular orientation of
 louver-type deflector 510 about its pivot axis, and re-tightening said threaded
 member 590. Alternatively, other types of adjustment mechanisms may be used
 in place of threaded member 590. For instance, a ratchet mechanism consisting of
 a pawl housed in boss 541 that engages with teeth added to outer surface of shaft
 15 512.

Figures 11A – 11F illustrate a sixth embodiment according to the
 present invention. A surgical deflector tool 600 is comprised of a continuous
 band-type deflector 610, a securing mechanisms in the nature of a plurality of
 20 threaded clamps 630 (four illustrated), a plurality of support frames 640, 650, 660,
 670, and an adjustment mechanism in the nature of a worm-gear assembly 690.
 Threaded clamp 630 is similar to threaded clamp 430 in the fourth embodiment.
 Support frames 640, 650, 660, and 670 engage sternum retractor 5 in a similar
 fashion as support frames 420 or 440 in the fourth embodiment.

25

Continuous band-type deflector 610 is intended to simultaneously
 engage and deflect all surgical sutures 10 that may be deployed and secured
 around the perimeter of sternum retractor 5. Deflector 610 is rigidly engaged to
 flange 641 of support frame 640 by either a welded joint or a mechanically
 30 fastened joint or other like means. Deflector 610 is preferably a sheet metal strip
 configured with a rectangular cross-section. The thickness of deflector is

considerably narrower than the cross-sectional height of the deflector. This provides flexibility along the length of the deflector and substantial rigidity along the height of the deflector.

5 The band-type deflector 610 is free to slide through rectangular opening 652 in flange 651 of support frame 650, free to slide through rectangular opening 662 in flange 661 of support frame 660.

10 Support frame 670 is configured with a housing 671 that contains worm-gear assembly 690 rotatably engaged within cylindrical opening 673. Band-type deflector 610 is not free to slide through rectangular opening 672 of housing 671, but may translate through said rectangular opening 672 by virtue of a rotation of knob 680 which rotates helical worm 682 thereby entraining serrations 611 and the said translation of deflector 610.

15 Each support frame has a substantially flexible portion 649, 659, 669, and 679 along its arcuate vertical length. With the threaded clamps 630 securing the position of their respective support frames 640, 650, 660, and 670 on the rails 80, 70, and 50 of sternum retractor 5, rotating knob 680 in one direction
20 causes the length of band-type deflector 610 between flange 641 and housing 671 to increase. The flexible portions 649, 659, 669, and 679 will consequently flex in a direction laterally away from the patient's beating heart (or the center of the retracted chest opening), thereby also tending to increase the amount of deflection simultaneously exerted on the plurality of surgical sutures 10 that may be
25 deployed and secured along the perimeter of sternum retractor 5. During the flexing of support frames 650 and 660, the deflector 610 slides through the openings 652 and 662 of said support frames 650 and 660.

30 Figures 12 – 15 illustrate a variety of embodiments for the securing mechanism. Figures 12A-12B illustrate a securing mechanism in the nature of a T-nut assembly 730 comprising T-nut 732 and co-operating bolt 731. In this

embodiment, the T-nut 732 is installed into arcuate passage 81 (or 71 or 51). Then, contact surface 113 of baffle 110 is brought into contact with tissue retraction means. The tissue retraction means is deflected until a hole in baffle is aligned with threaded hole in T-nut 732. Bolt 731 is then engaged with co-
 5 operating T-nut 732 and baffle secured in place by the resulting clamping force between the said T-nut 732 and bolt 731.

Figures 13A-13B illustrate a securing mechanism in the nature of a modified T-bolt assembly 830 comprising T-bolt 832 and co-operating nut 831.
 10 The parallelogram shape of the modified T-bolt 832 allow the surgical deflector tool 800, comprising the securing mechanism 830 and baffle 810, to become engaged and secured relative to rail 80 without having to insert bolt 832 prior to the other components comprising the surgical deflector tool 800.

Figures 14A-14B illustrate a securing mechanism in the nature of a radial engaging cam 930 comprising a radial engaging cam 933, a shaft 935, a wave spring washer 932 and a knob 931. Radial engaging cam 930 is rotatably engaged with deflector baffle 910 as an integral mechanical assembly. The surgical deflector tool 900 is secured relative to sternum retractor 5 in within
 15 arcuate passage 81 when the knob 931 is rotated thereby radially engaging the two opposing cam surfaces 934 with the lateral walls defining arcuate passage 81 (or 71 or 51).
 20

Figures 15A-15B illustrate a securing mechanism in the nature of a grommet-type expansion joint 1030 comprising a bolt 1031, an elastic annular washer 1032, and a clamping plate 1034. Prior to installation, clamping plate 1034 is in substantial contact with elastic washer 1032. Once the grommet-type expansion joint 1030 is inserted into arcuate rail 80 (or 70 or 50) a rotation of bolt 1031 produces an axial compression of washer 1032 and a simultaneous radial
 25 expansion of 1032. This expansion produces the engagement between washer 1032 and the lateral walls of arcuate passage 81 (or 71 or 51). The friction
 30

between clamping plate 1034 and elastic washer 1032 keeps said plate 1034 from rotating relative to said washer 1032 when knob 1031 is tightened.

Figure 16 illustrates a securing mechanism in the nature of a C-shaped flange 1100 comprising a bolt 1030, two extensions 1113 and 1112, and a joining section 1111. Surgical deflector tool is engaged with rail 80 of sternum retractor 5 through a clockwise rotation that brings into contact extension 1112 with underside surface 83 in arcuate passage 81. Bolt 1030 is subsequently tightened to prevent a reverse counterclockwise rotation and disengagement of said deflector tool.

Figure 17 illustrates a securing mechanism in the nature of a retention clip 1250. Deflector baffle 1200 is inserted into arcuate passage 81 (or 71 or 51) through the engagement of anti-rotation block 1230 extending from flat surface 1211. Retention clip 1250 is then installed such that its surfaces 1251 and 1252 simultaneously contact the bottom surface of retractor arm 4 and the top surface of baffle 1211.

Figure 18 illustrates a surgical deflector tool 200 from the second embodiment, engaged with tissue retraction means in the nature of suction device 12 which is comprised of a deformable suction port 14 engaged with the patient's pericardium tissue PCT, and conduit 13 providing the negative pressure suction force from the source to the deformable suction port 14.

In the embodiments of the present invention described herein, it is intended to produce the bulk of the surgical apparatus from reusable components, whose assembly may be at least partially dismantled, if necessary, for ease of sterilization. All components are manufactured in either surgical grade stainless steel, titanium, aluminum or any other reusable sterilizable material suitable for surgical use. Components that may be produced from polymeric materials are either reusable through specific sterilization procedures tailored to these

component materials, or must be replaced after every use or after a predetermined number of uses if the polymeric material properties are not suitable for sterilization or degrade after repeated sterilization cycles. However, any number of the said reusable components may also be produced from disposable surgical
5 grade plastics, if the case for disposable components is warranted and if the engineering and functional intent is maintained when the said component is produced from plastic.

The above description of the embodiments of the present invention
10 should not be interpreted in any limiting manner since variations and refinements are possible without departing from the spirit of the invention.

We claim:

- 15 1. A surgical deflector tool comprising a deflector portion and a securing
mechanism, for deflecting at least a portion of a tissue retraction means, said
tissue retraction means simultaneously engaged with a body tissue
anatomically attached to a body organ and with a substantially stable surgical
platform, said securing mechanism slidably engaged with said surgical
20 platform, said securing mechanism capable of being fixed in a plurality of
locations to said surgical platform, said deflector portion engaged with said
tissue retraction means, said deflector serving to deflect at least a portion of
said tissue retraction means in a direction substantially away from the surface
of said organ relative to its initial position with respect to said organ prior to
25 engagement of said deflector portion with said tissue retraction means.
2. A surgical deflector according to claim 1 further comprising an adjustment
mechanism, said deflector portion slidably engaged with said securing
mechanism, said deflector portion capable of being fixed in a plurality of
30 location to said securing mechanism by action of said adjustment mechanism.

3. A surgical deflector tool comprising a deflector portion and two securing mechanisms, for deflecting at least a portion of a tissue retraction means, said tissue retraction means simultaneously engaged with a body tissue anatomically attached to a body organ and with a substantially stable surgical platform, said securing mechanisms slidably engaged with said surgical platform, said securing mechanisms capable of being fixed in a plurality of locations to said surgical platform, said deflector portion engaged with said tissue retraction means, said deflector serving to deflect at least a portion of said tissue retraction means in a direction substantially away from the surface of said organ relative to its initial position with respect to said organ prior to engagement of said deflector portion with said tissue retraction means, said deflector portion spanning at least the distance between said two securing mechanisms, said deflector portion rigidly engaged to at least one said securing mechanism.

4. A surgical deflector tool according to claim 3 whereby said deflector portion is pivotally engaged to one securing mechanism and slidably engaged to the other securing mechanism.

5. A surgical deflector according to claim 1 further comprising an adjustment mechanism, said deflector portion rotatably engaged with said securing mechanism, said deflector portion capable of being fixed in a plurality of angular orientations relative to said securing mechanism by action of said adjustment mechanism.

6. A surgical deflector tool comprising a deflector portion, an adjustment mechanism and two securing mechanisms, for deflecting at least a portion of a tissue retraction means, said tissue retraction means simultaneously engaged with a body tissue anatomically attached to a body organ and with a substantially stable surgical platform, said securing mechanisms slidably engaged with said surgical platform, said securing mechanisms capable of

being fixed in a plurality of locations to said surgical platform, said deflector portion engaged with said tissue retraction means, said deflector serving to deflect at least a portion of said tissue retraction means in a direction substantially away from the surface of said organ relative to its initial position with respect to said organ prior to engagement of said deflector portion with said tissue retraction means, said deflector portion spanning at least the distance between said two securing mechanisms, said deflector portion rotatably engaged with both securing mechanisms, said deflector portion capable of being fixed in a plurality of angular orientations relative to said securing mechanisms by action of said adjustment mechanism.

7. A surgical deflector tool comprising a deflector portion, an adjustment mechanism and a plurality of securing mechanisms, for deflecting at least a portion of a tissue retraction means, said tissue retraction means simultaneously engaged with a body tissue anatomically attached to a body organ and with a substantially stable surgical platform, said securing mechanisms slidably engaged with said surgical platform, said securing mechanisms capable of being fixed in a plurality of locations to said surgical platform, said securing mechanism having a flexible portion, said deflector portion engaged with said tissue retraction means, said deflector serving to deflect at least a portion of said tissue retraction means in a direction substantially away from the surface of said organ relative to its initial position with respect to said organ prior to engagement of said deflector portion with said tissue retraction means, said deflector portion spanning at least the distance between each of the securing mechanisms in the said plurality, said deflector portion rigidly engaged to at least one securing mechanism and slidably engaged to the remainder of securing mechanisms in the plurality, said deflector portion capable of being fixed in a plurality of lengths spanning between any two adjacent securing mechanisms by action of said adjustment mechanism.

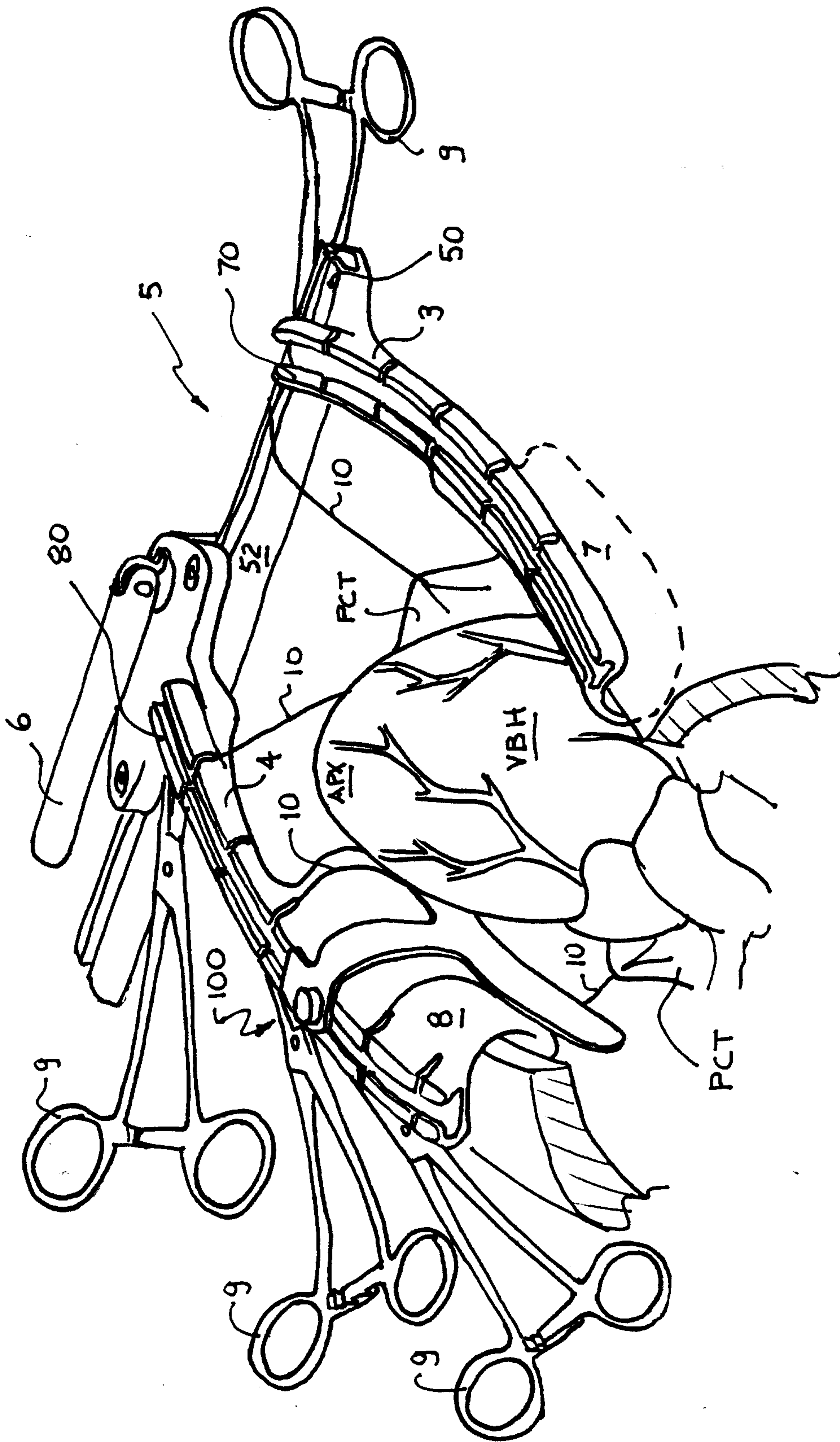


FIGURE 1

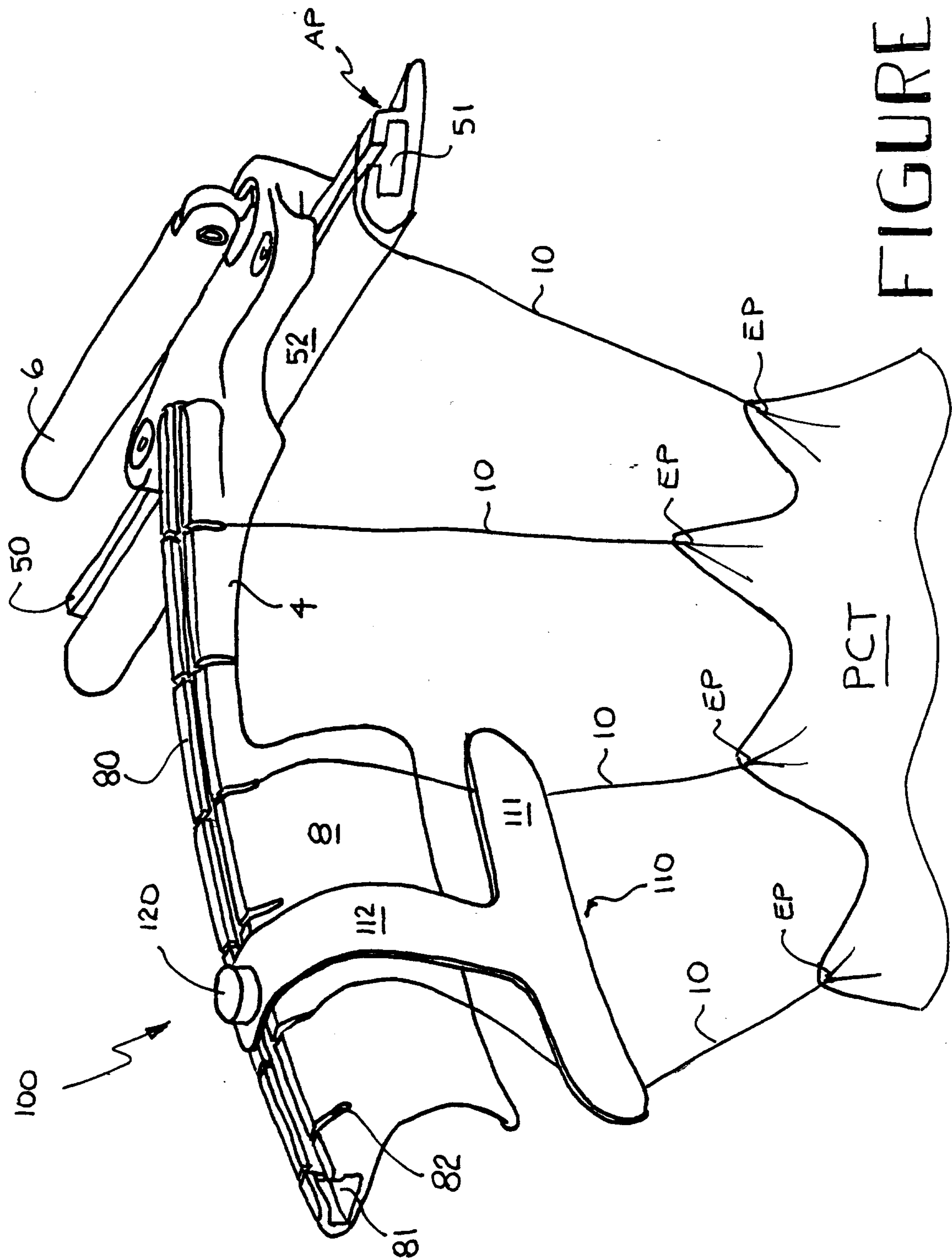


FIGURE 2

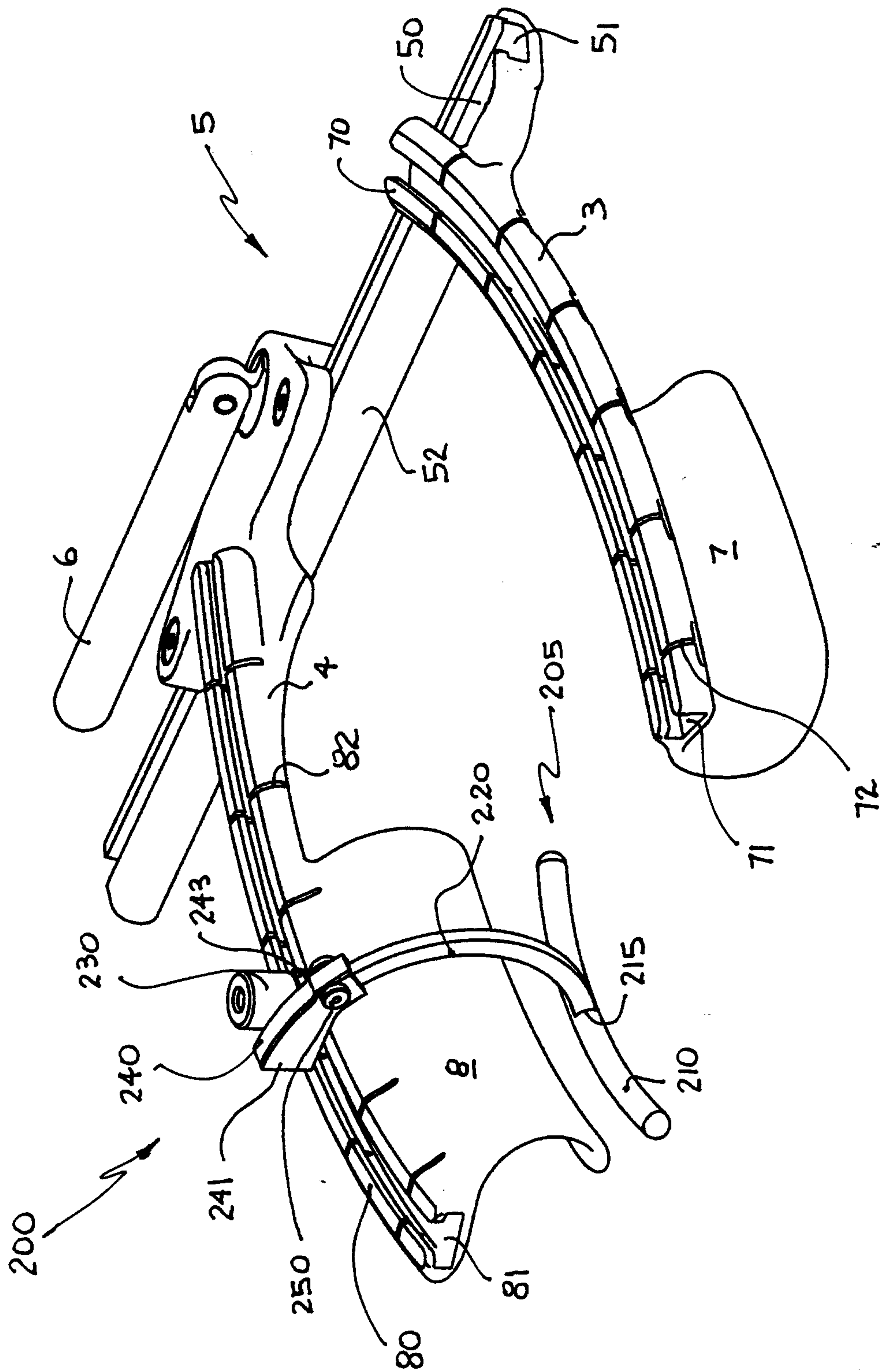


FIGURE 4

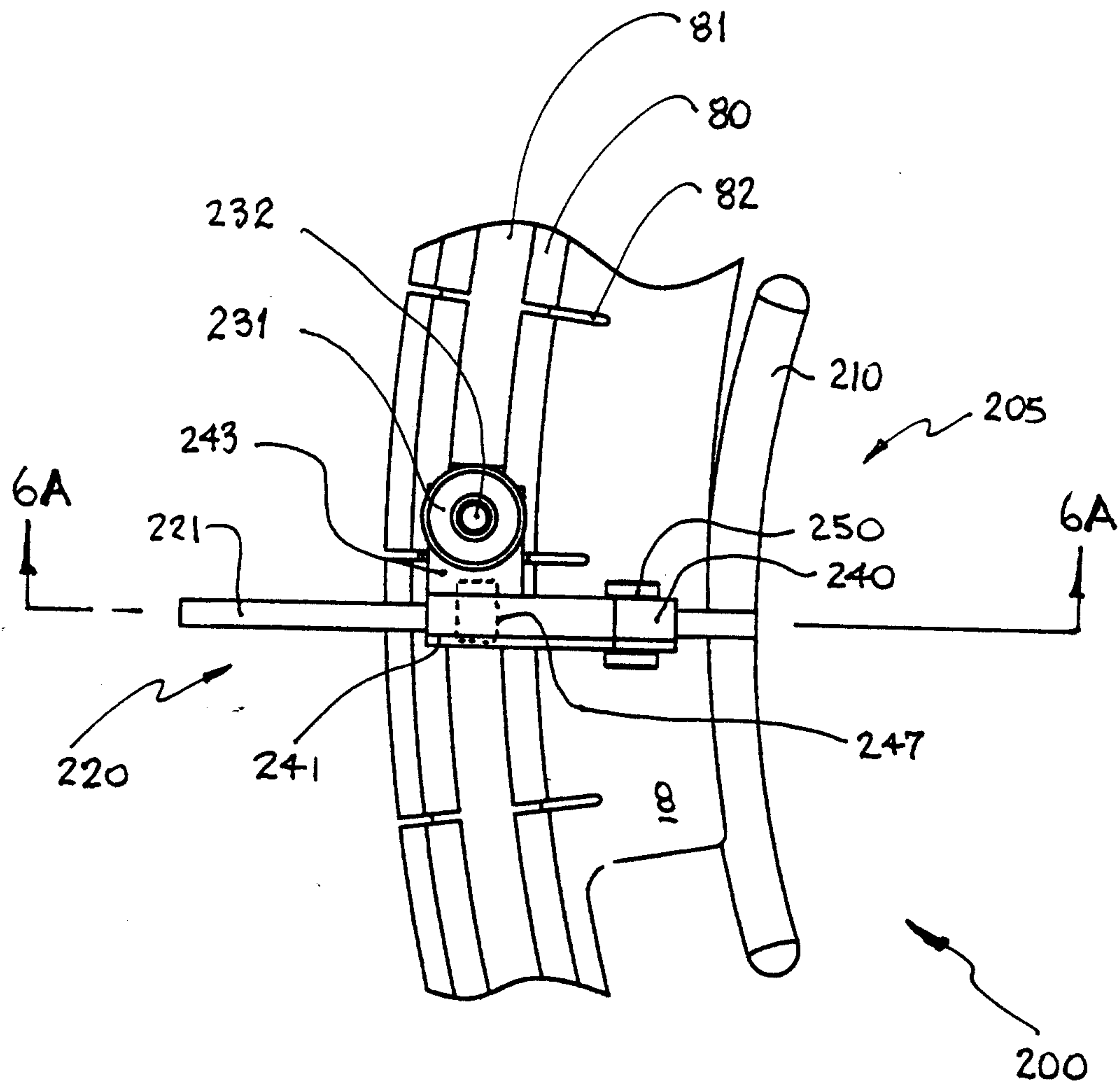


FIGURE 5

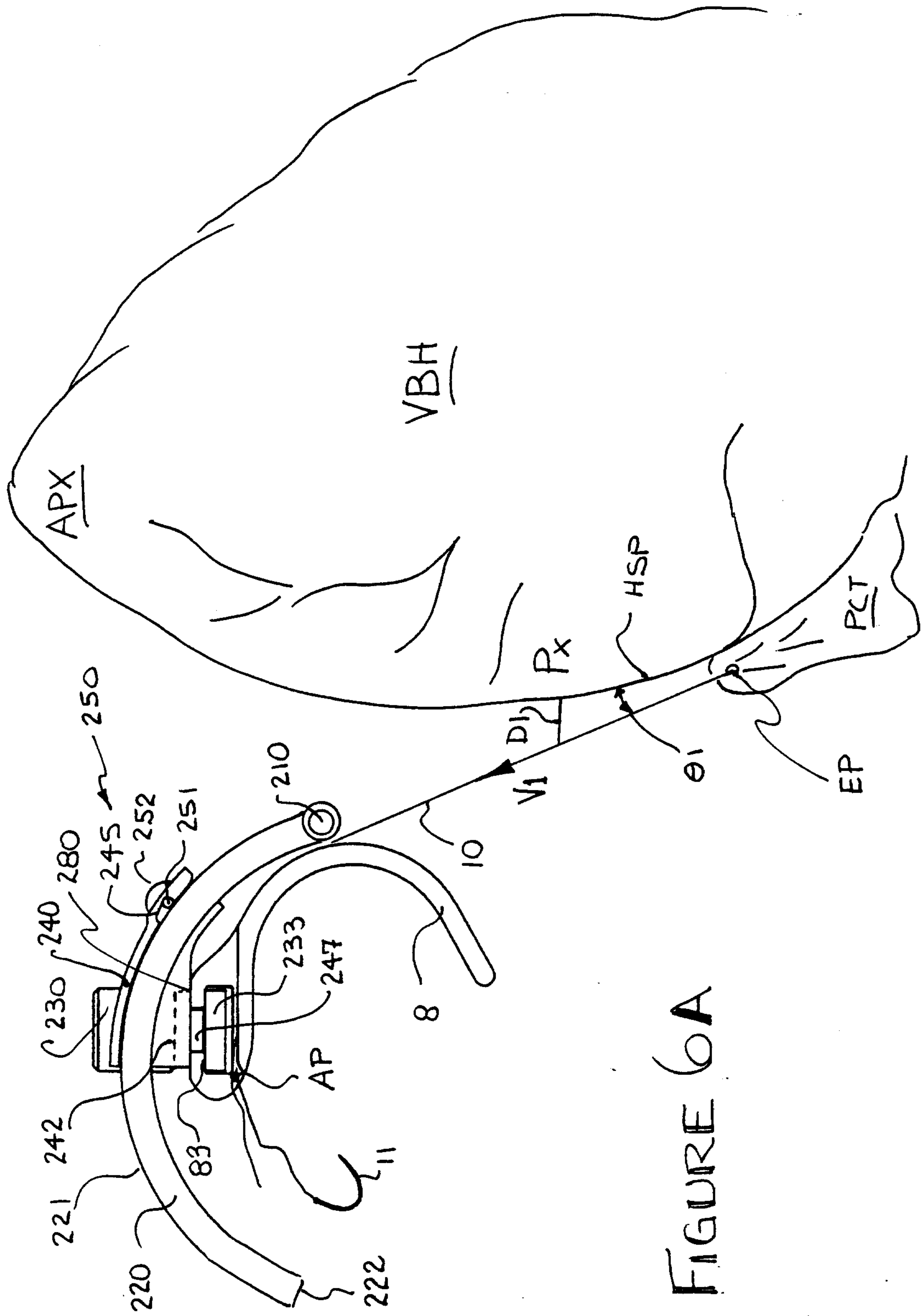


FIGURE 6A

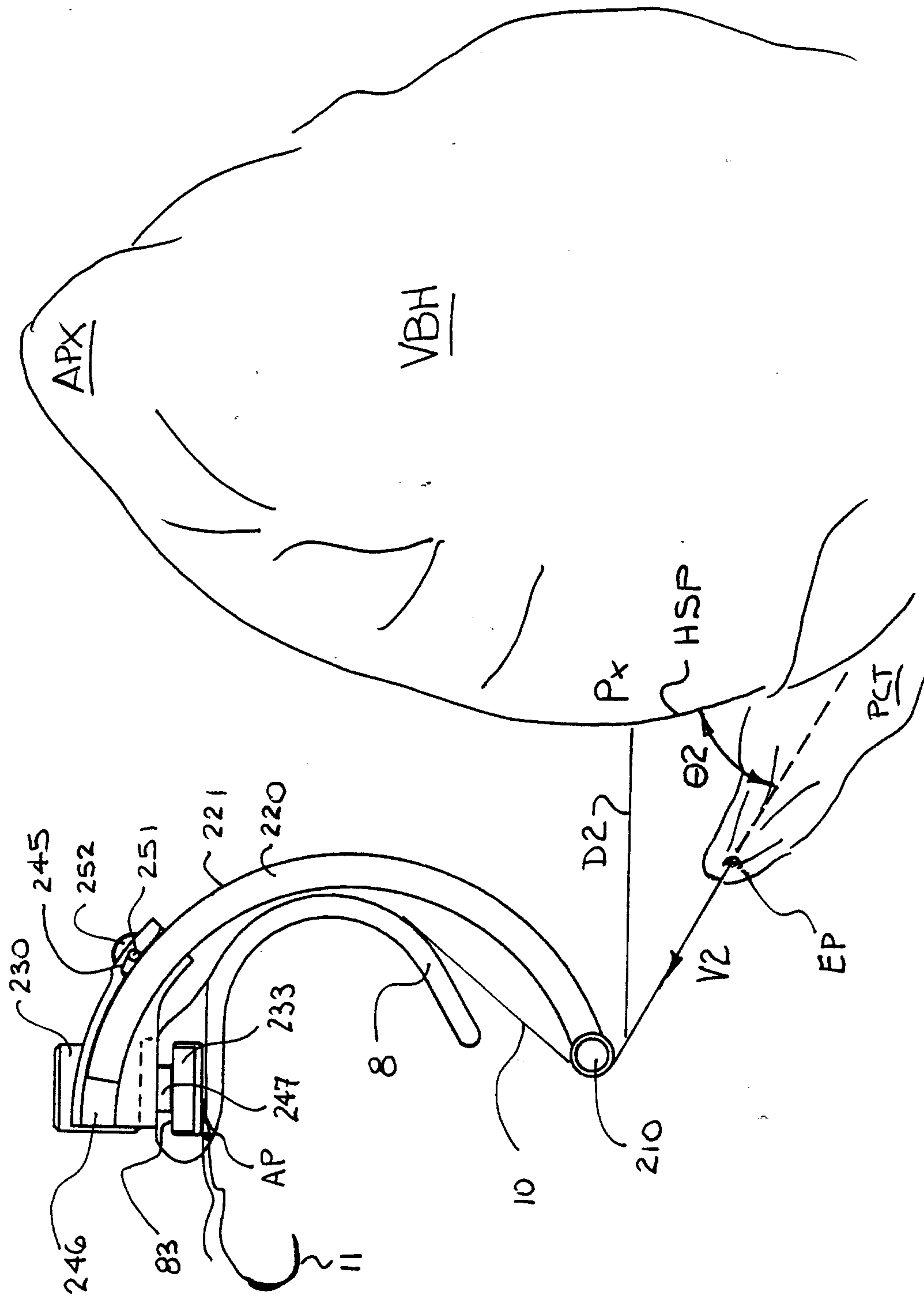
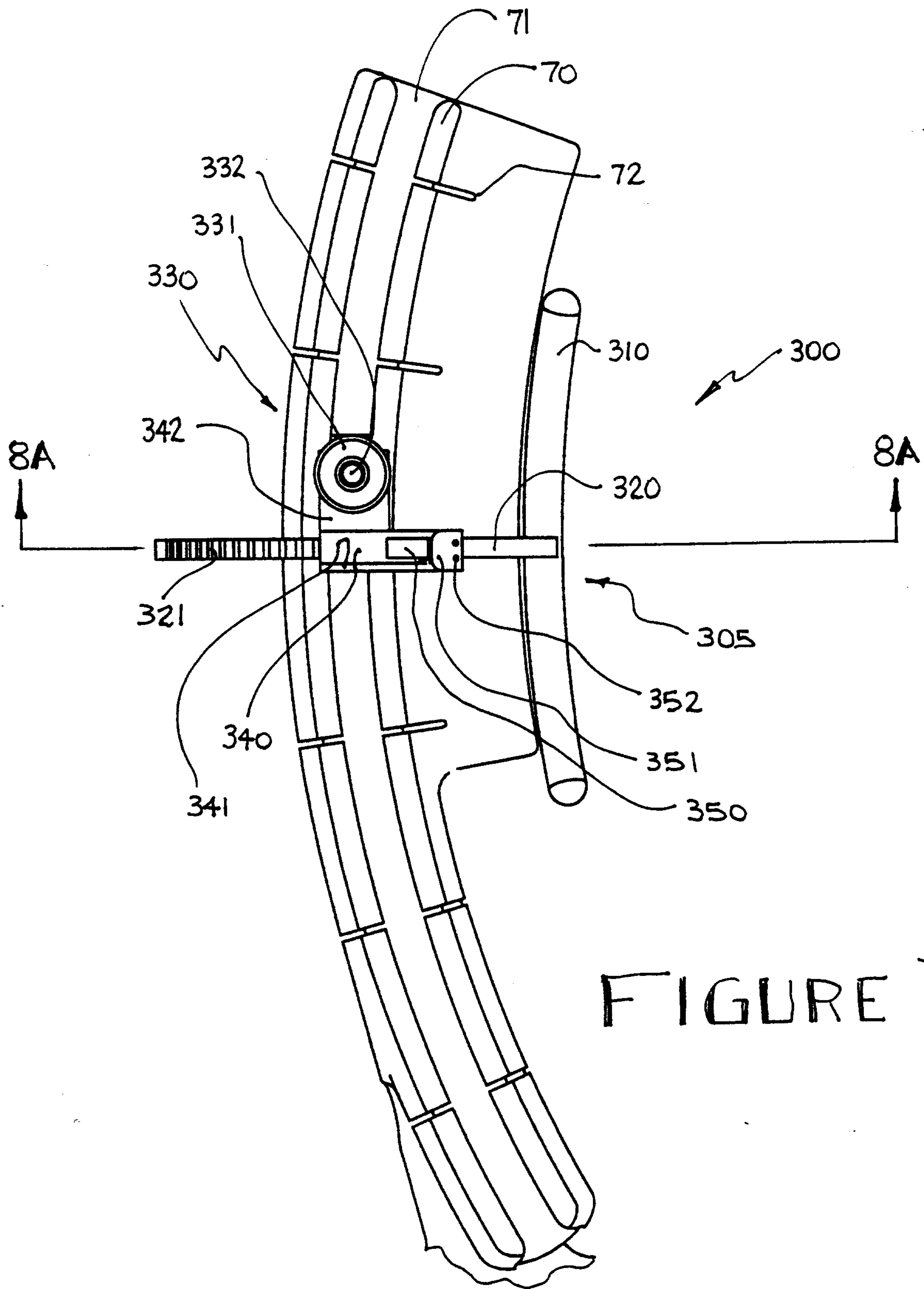


FIGURE 6B



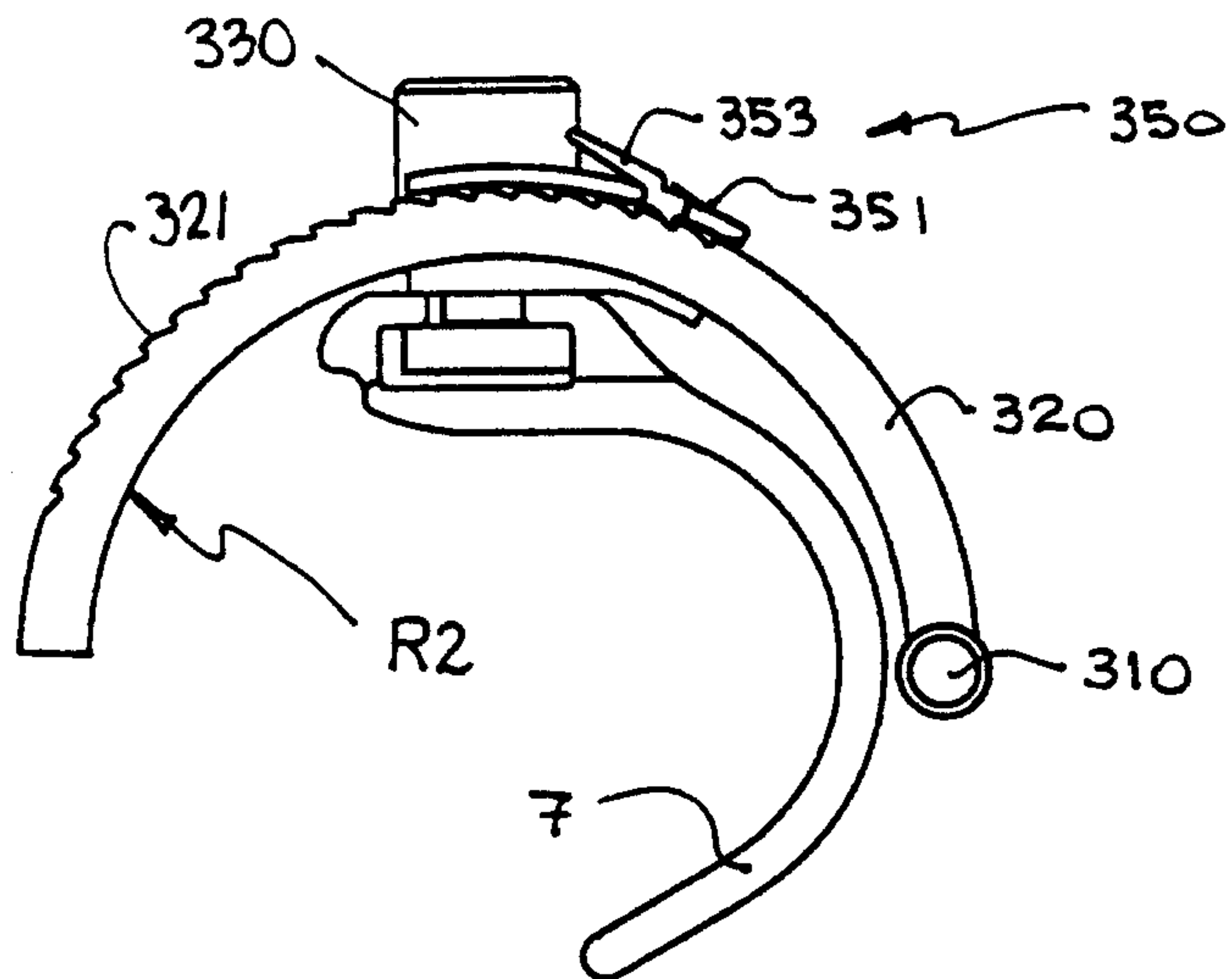


FIGURE 8A

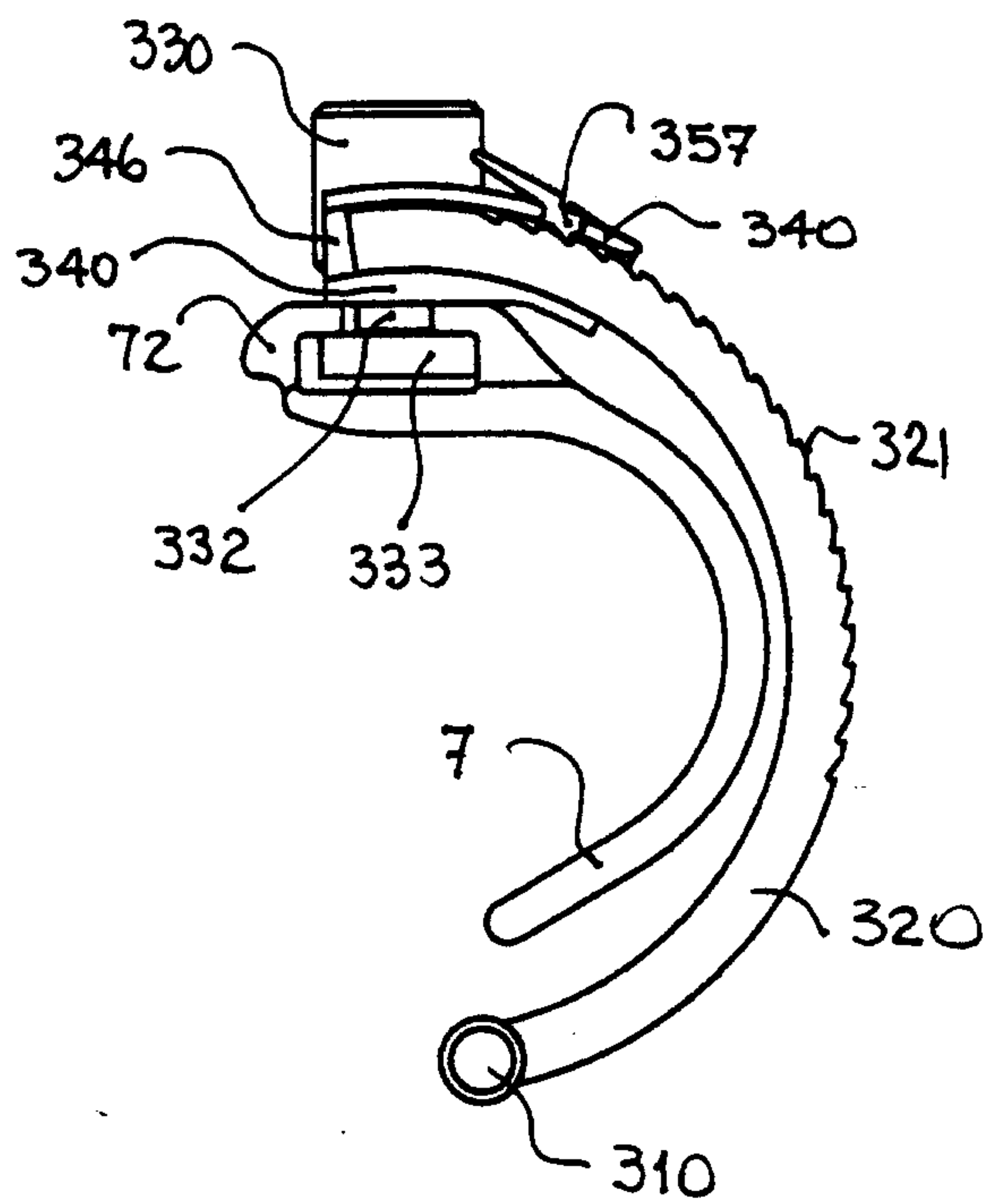


FIGURE 8B

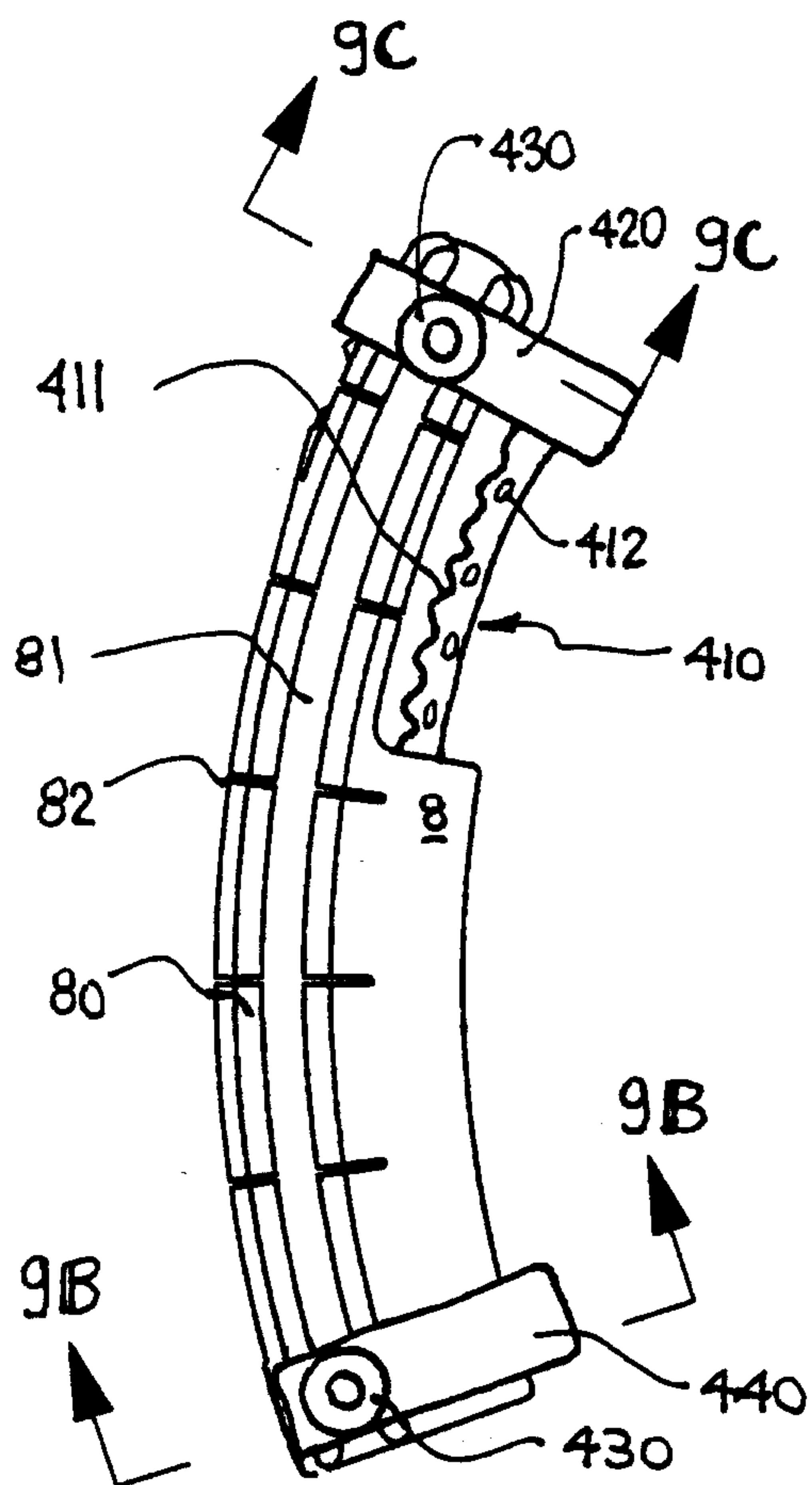


FIGURE 9A

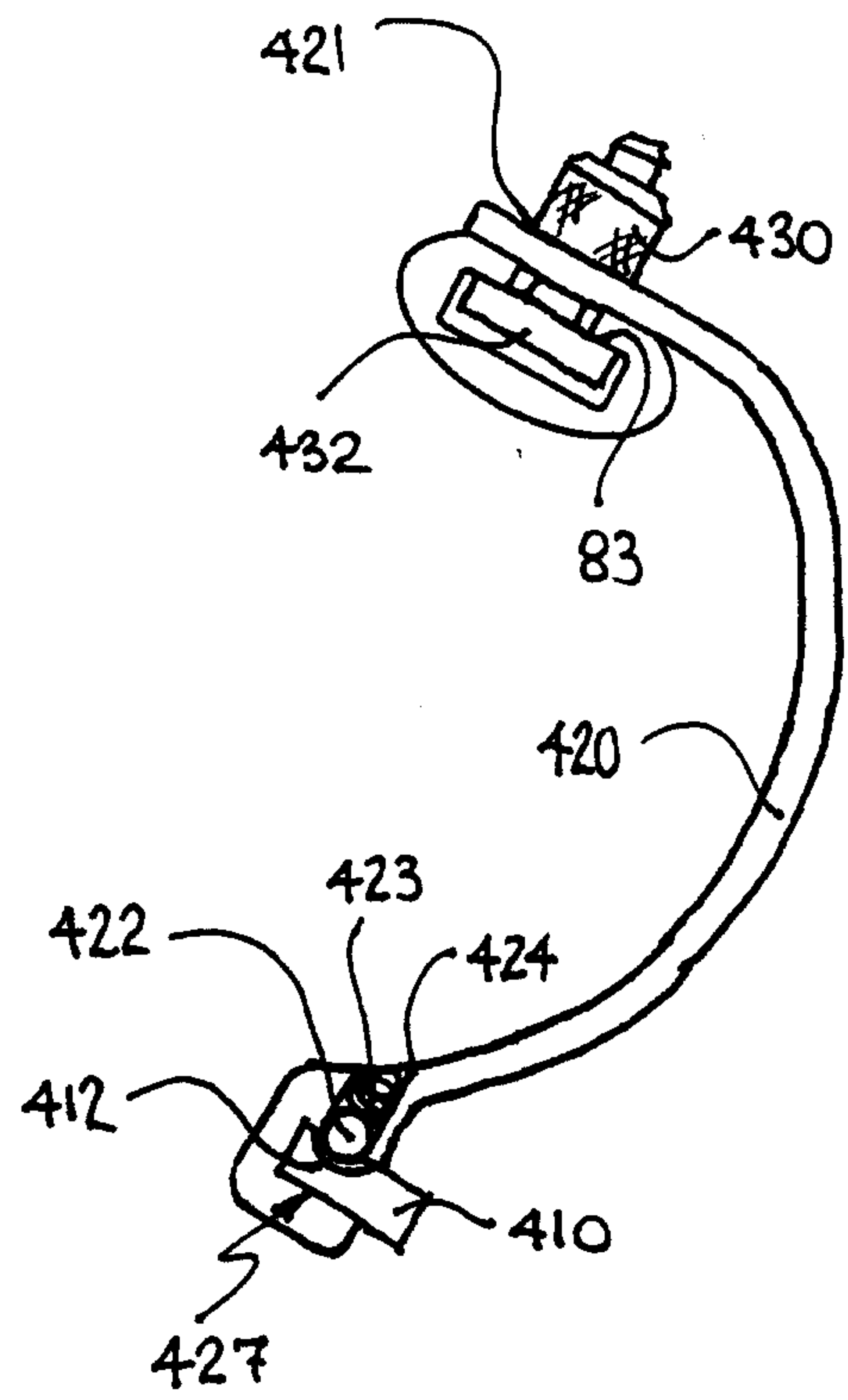


FIGURE 9C

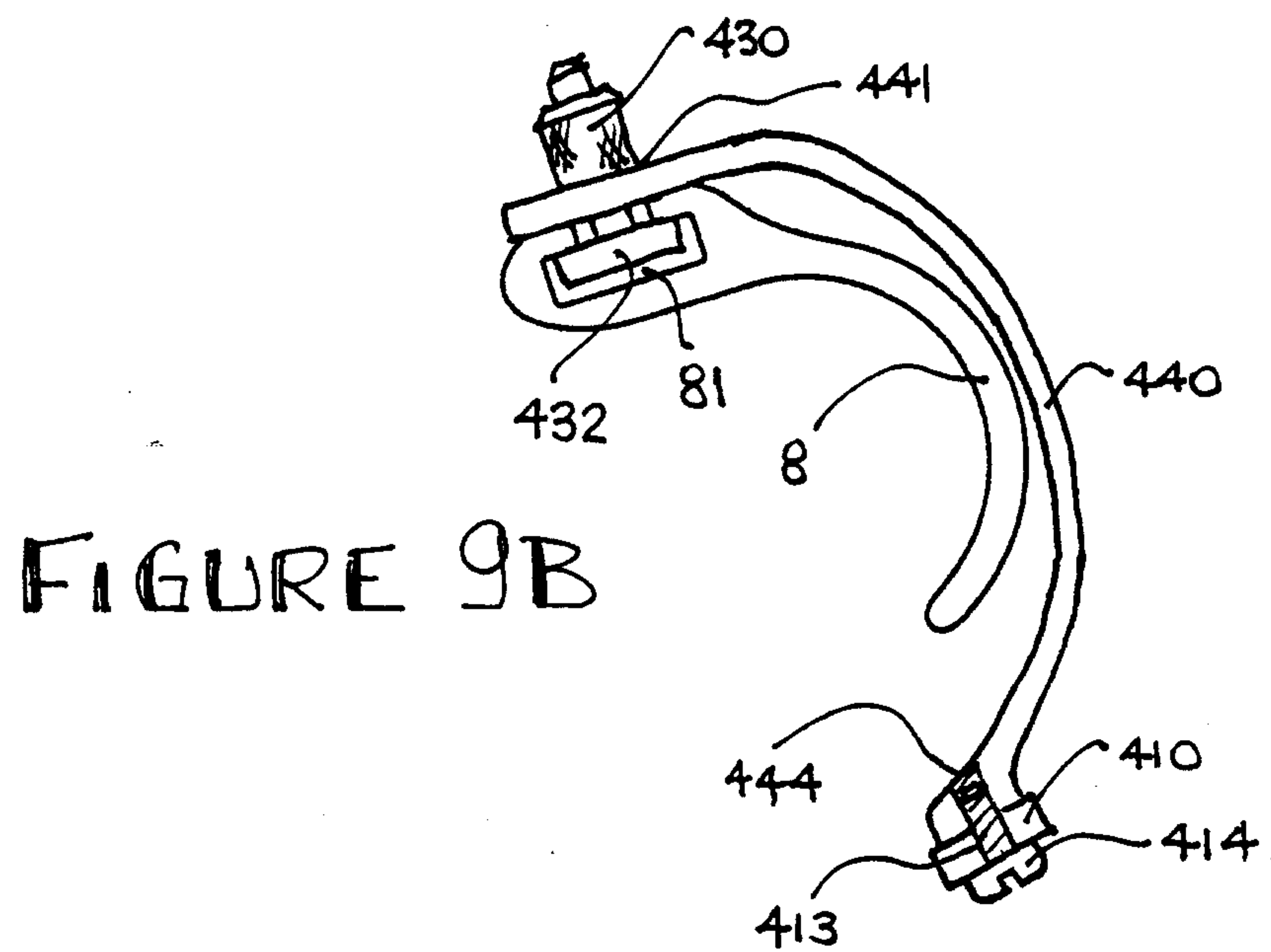
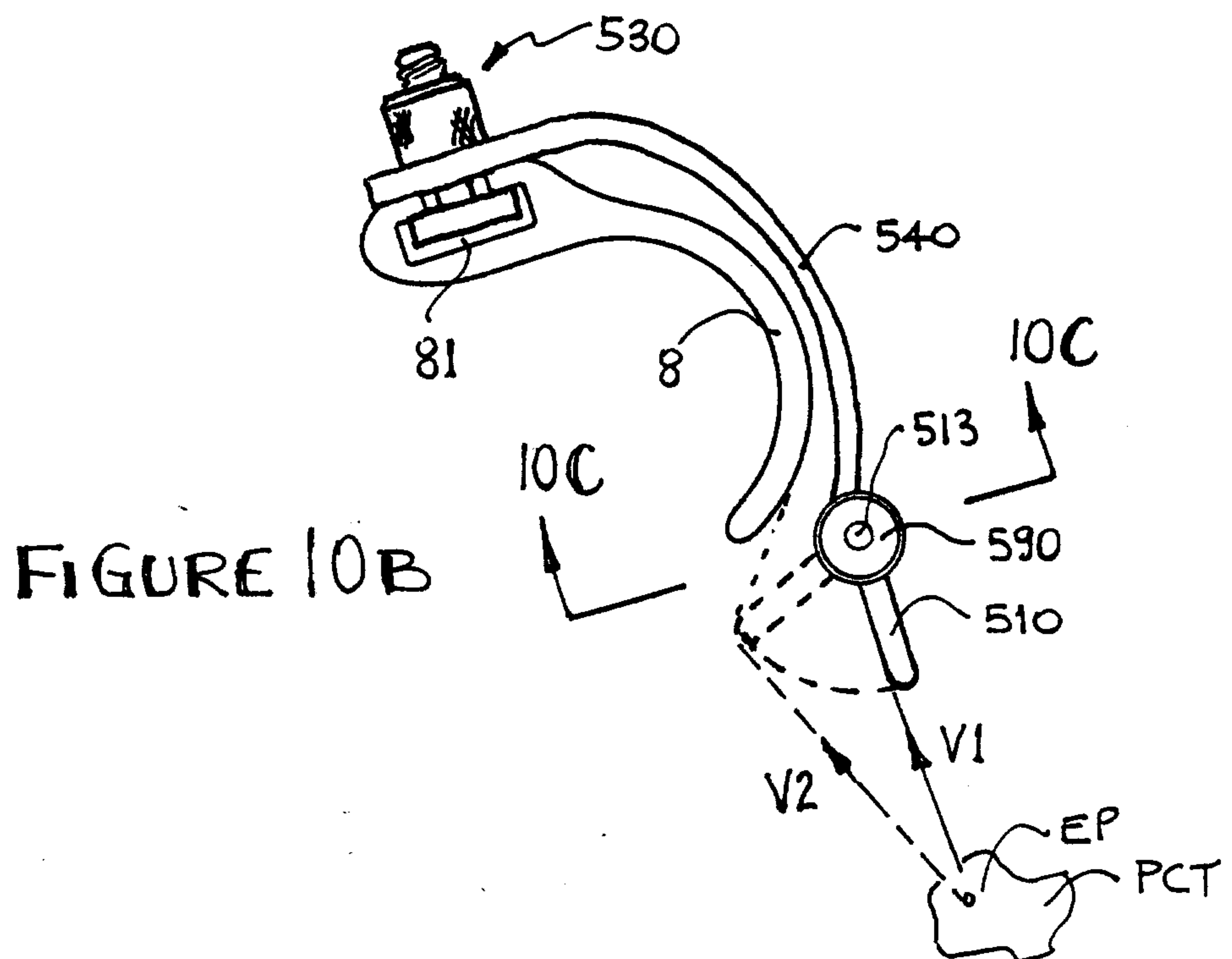
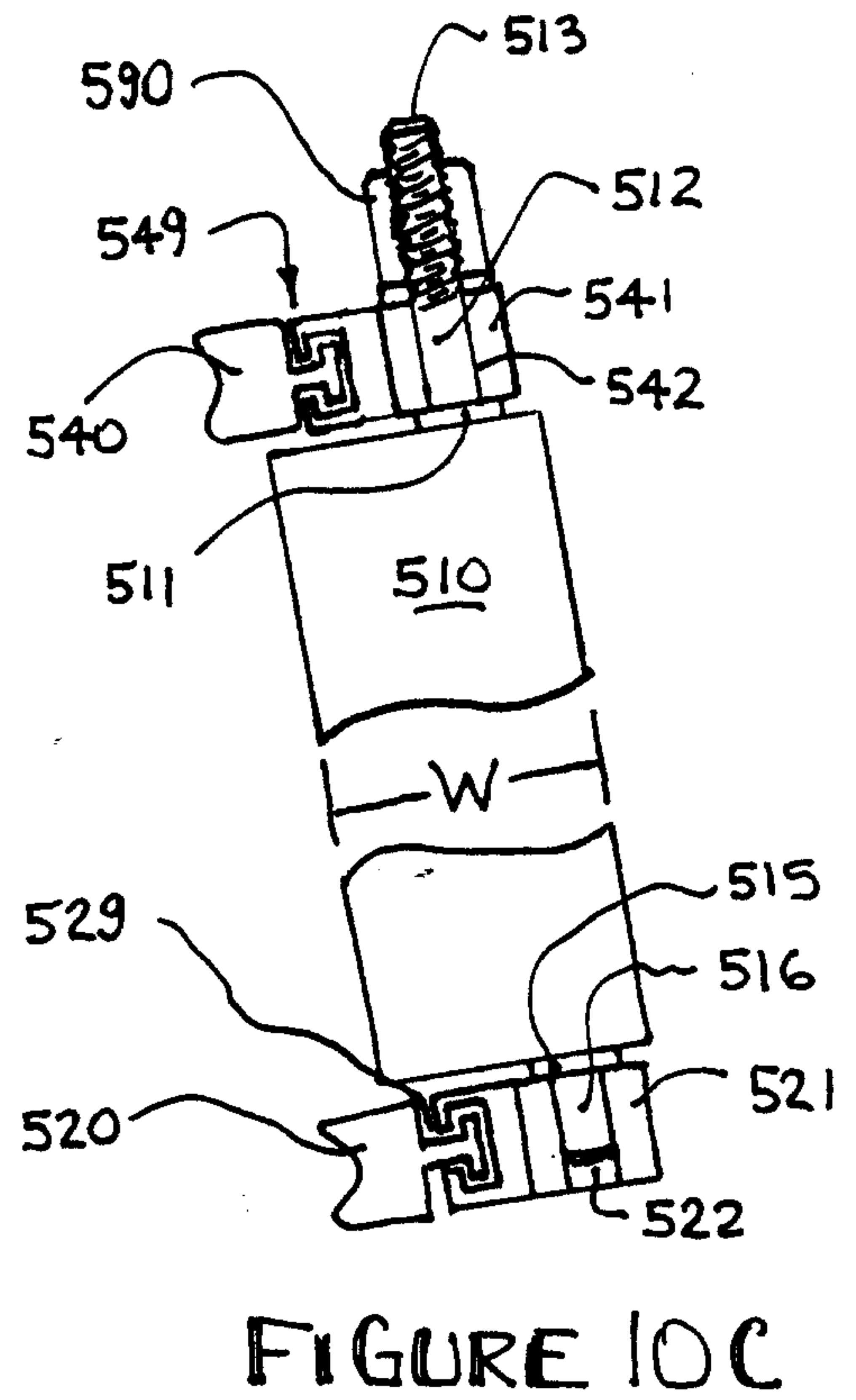
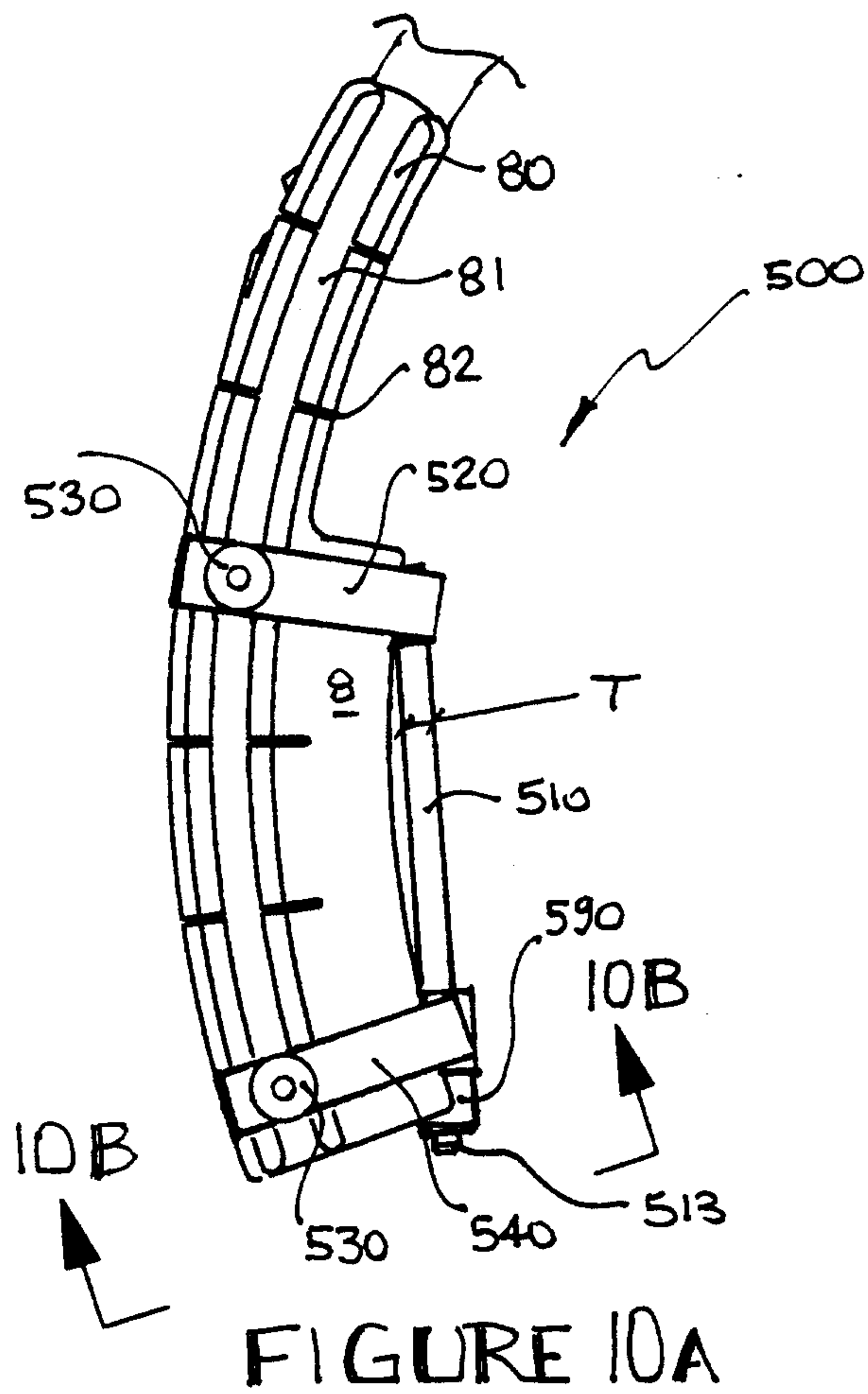
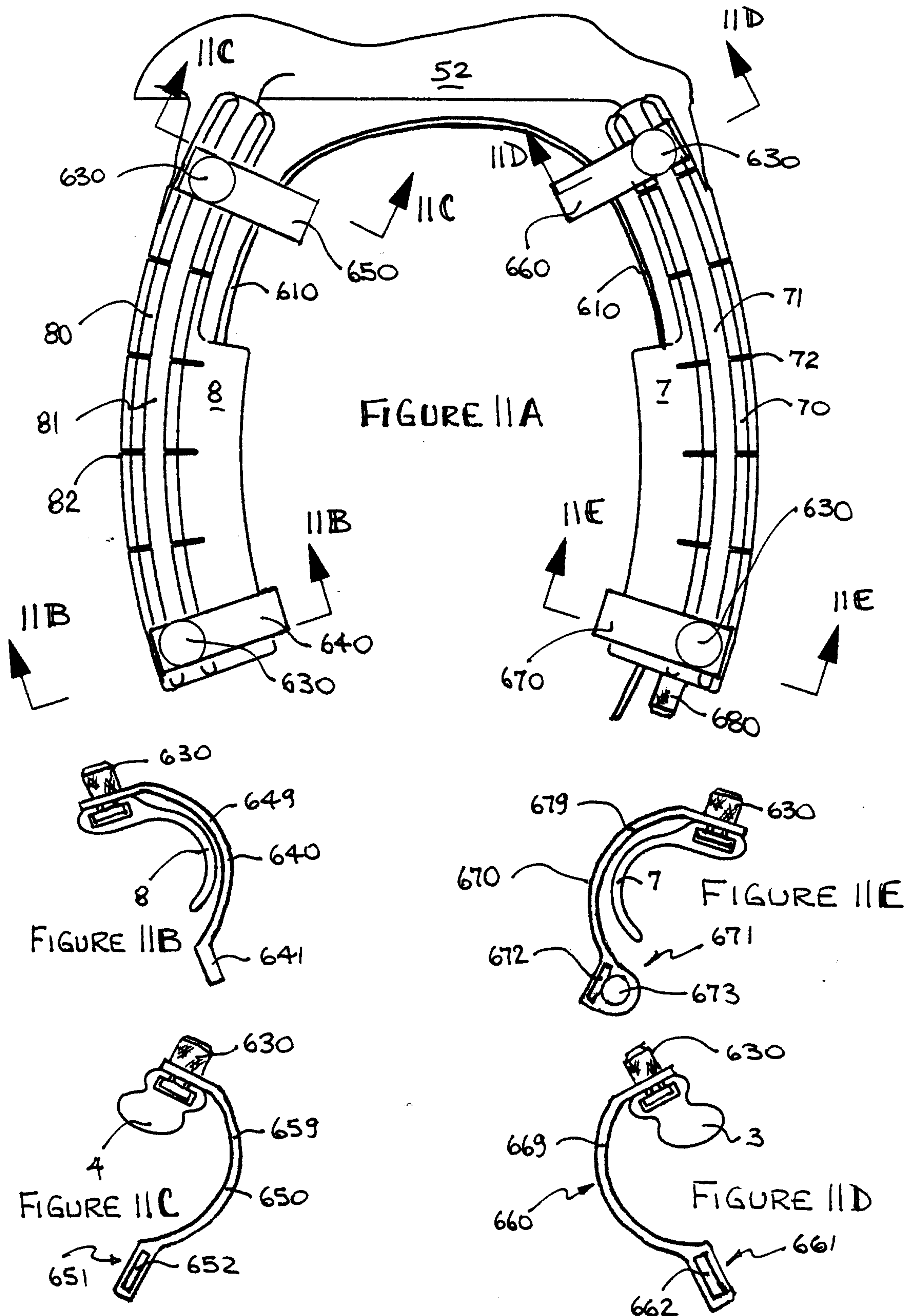


FIGURE 9B





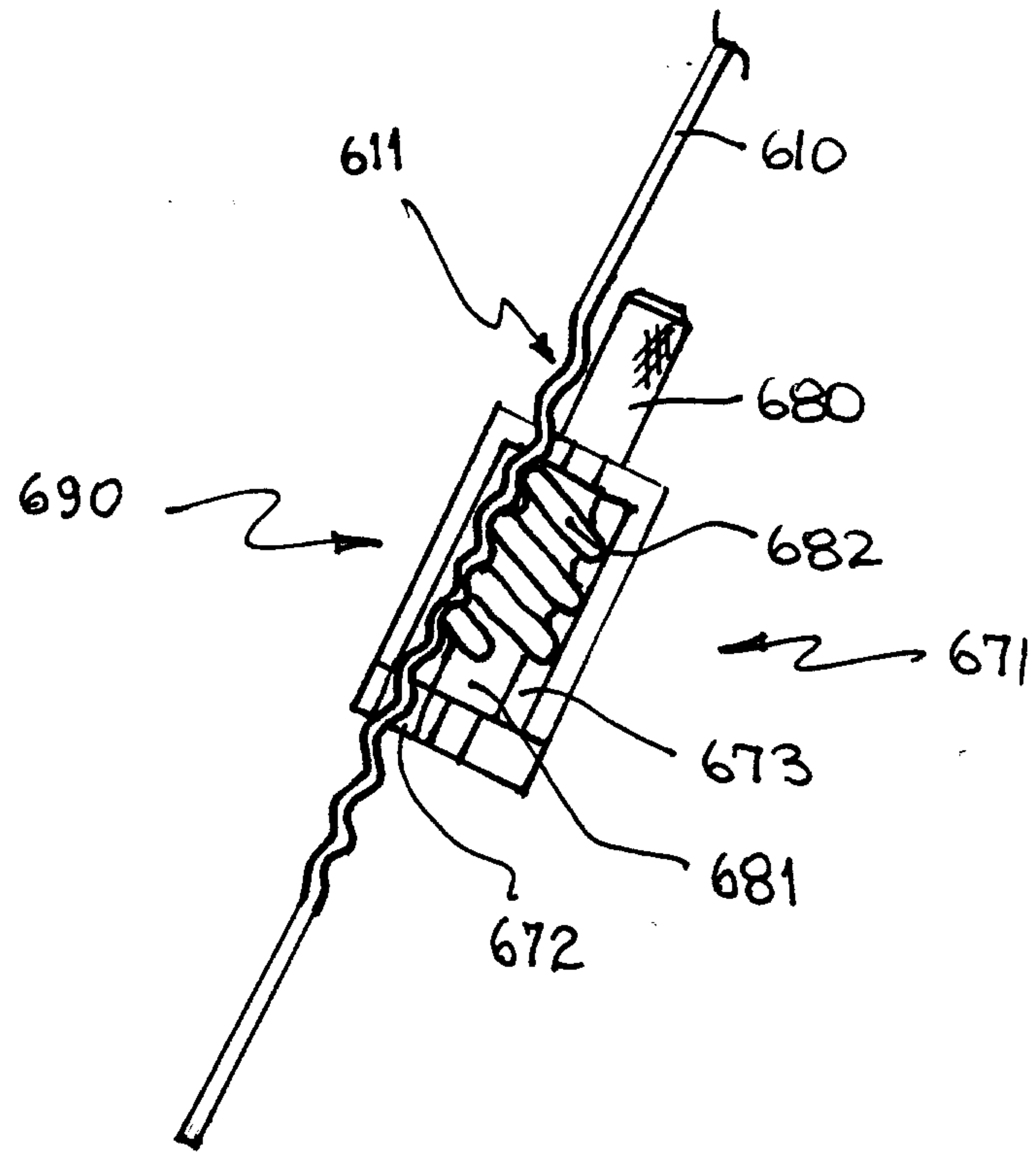
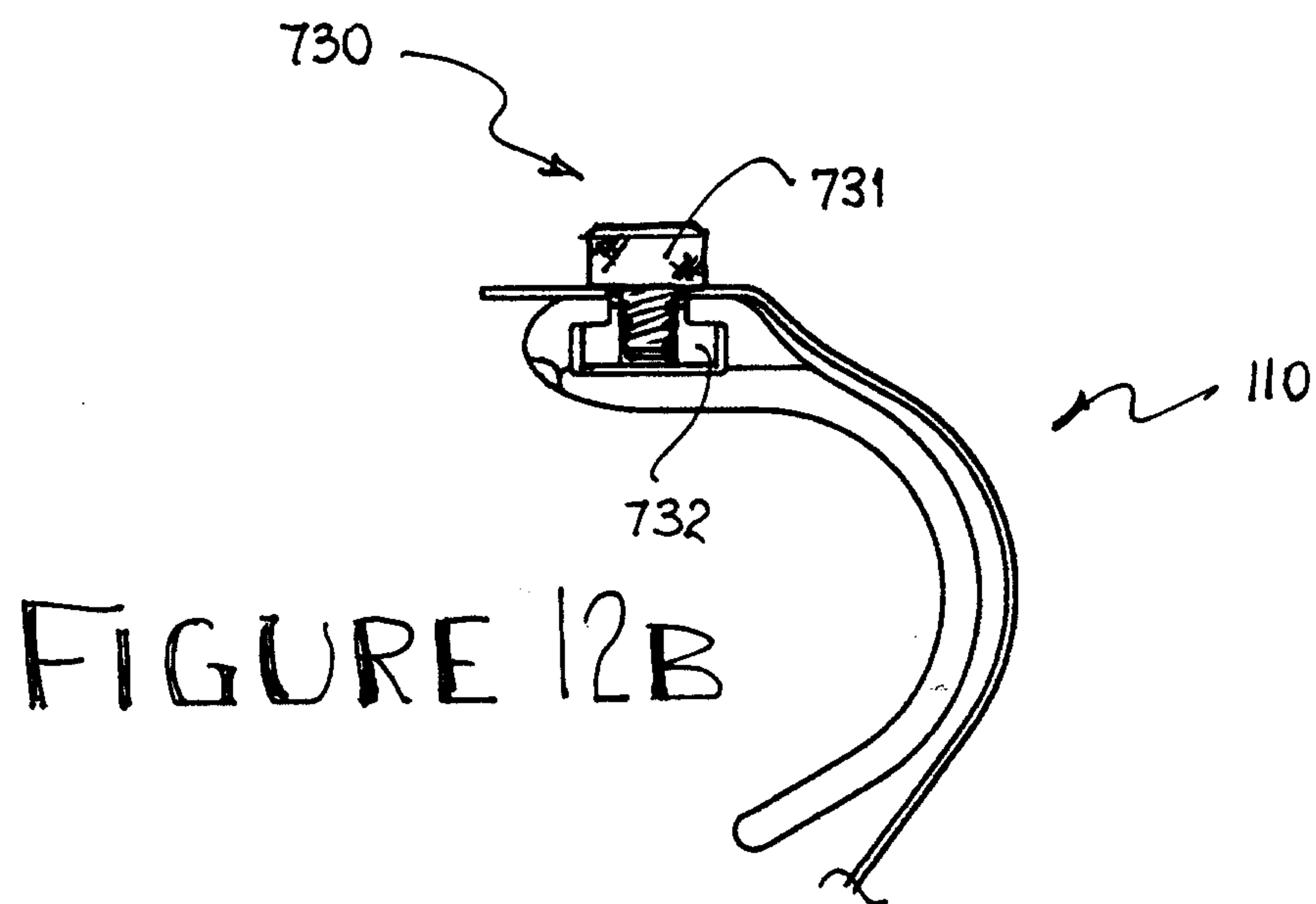
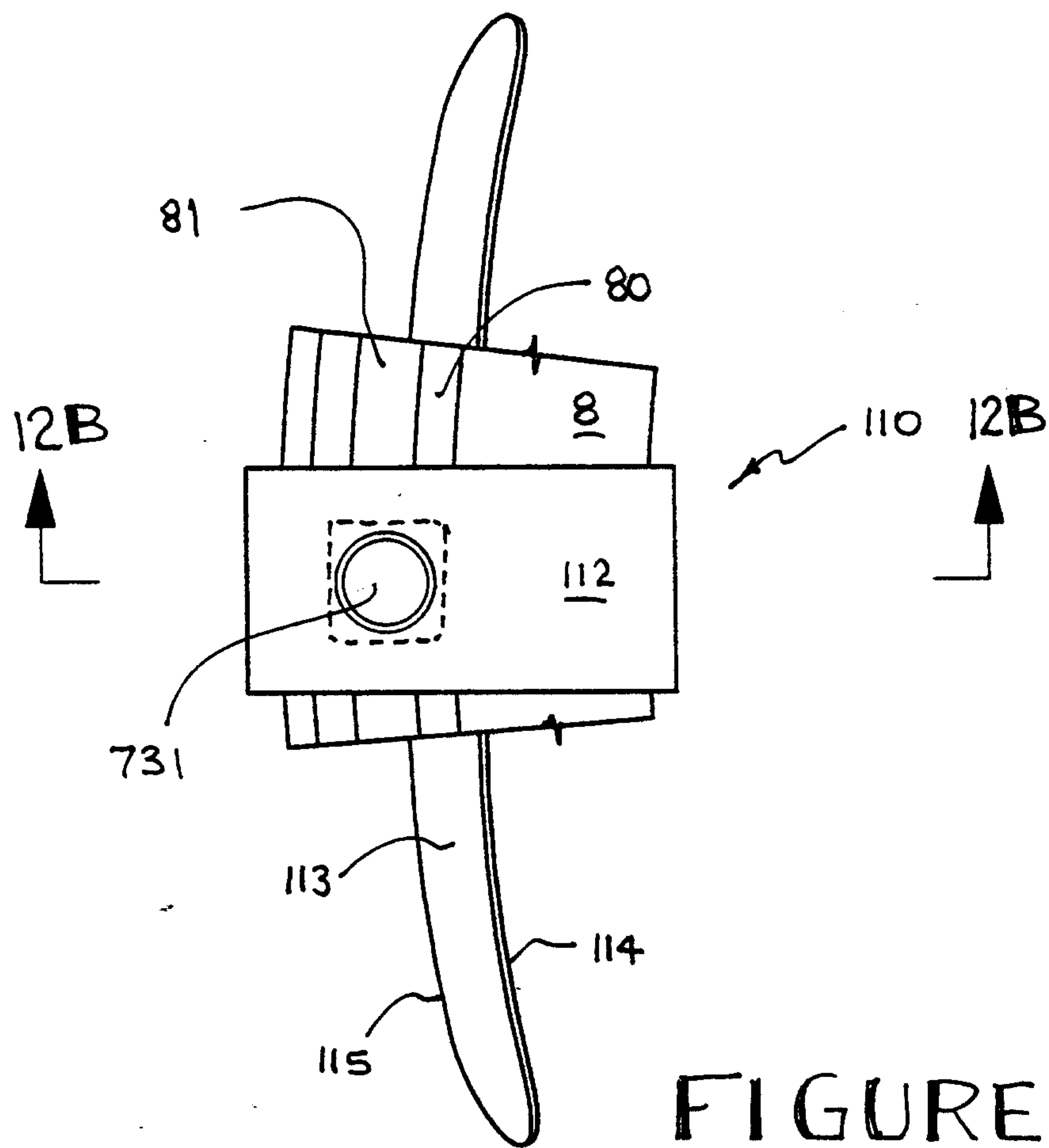
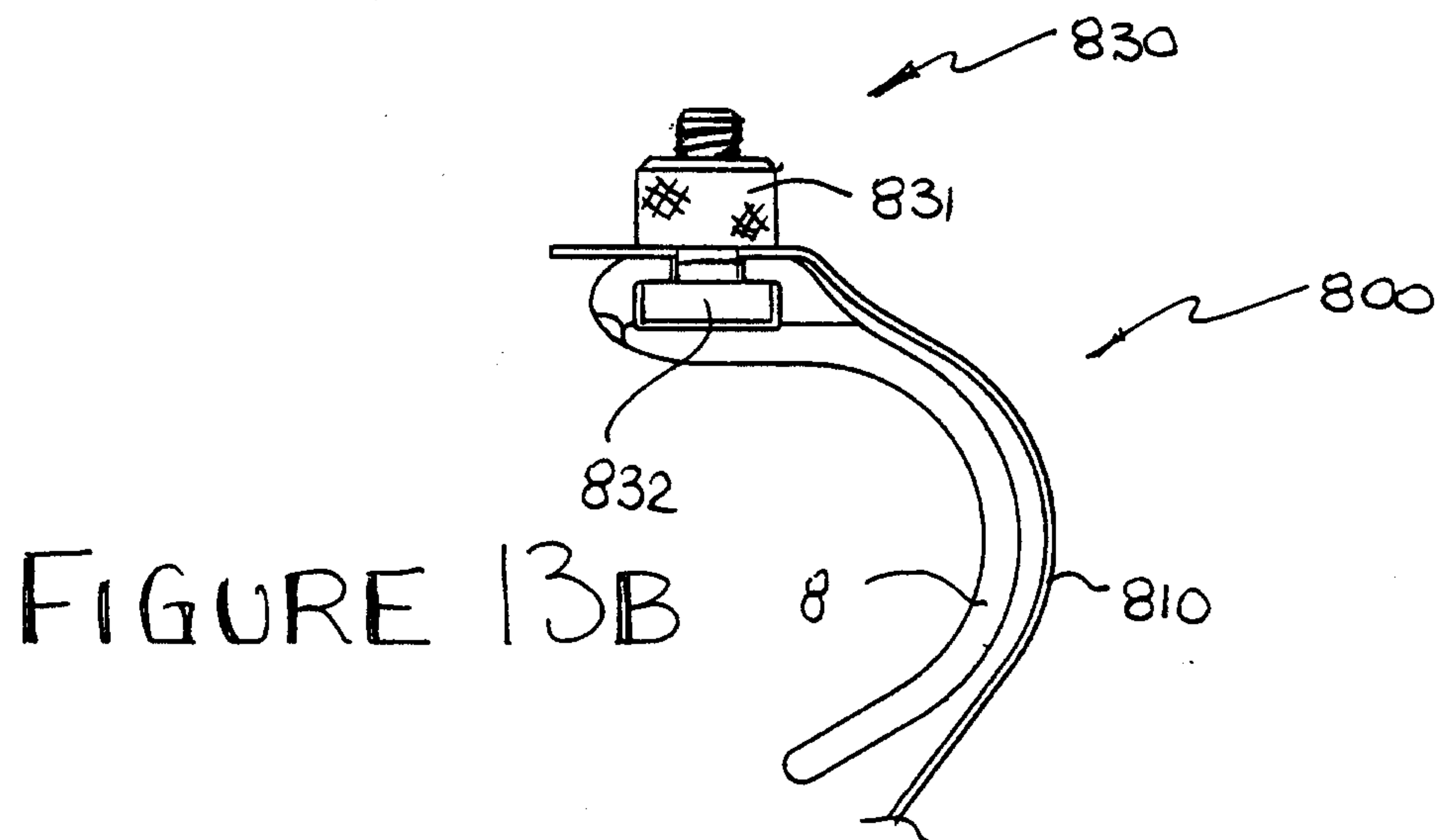
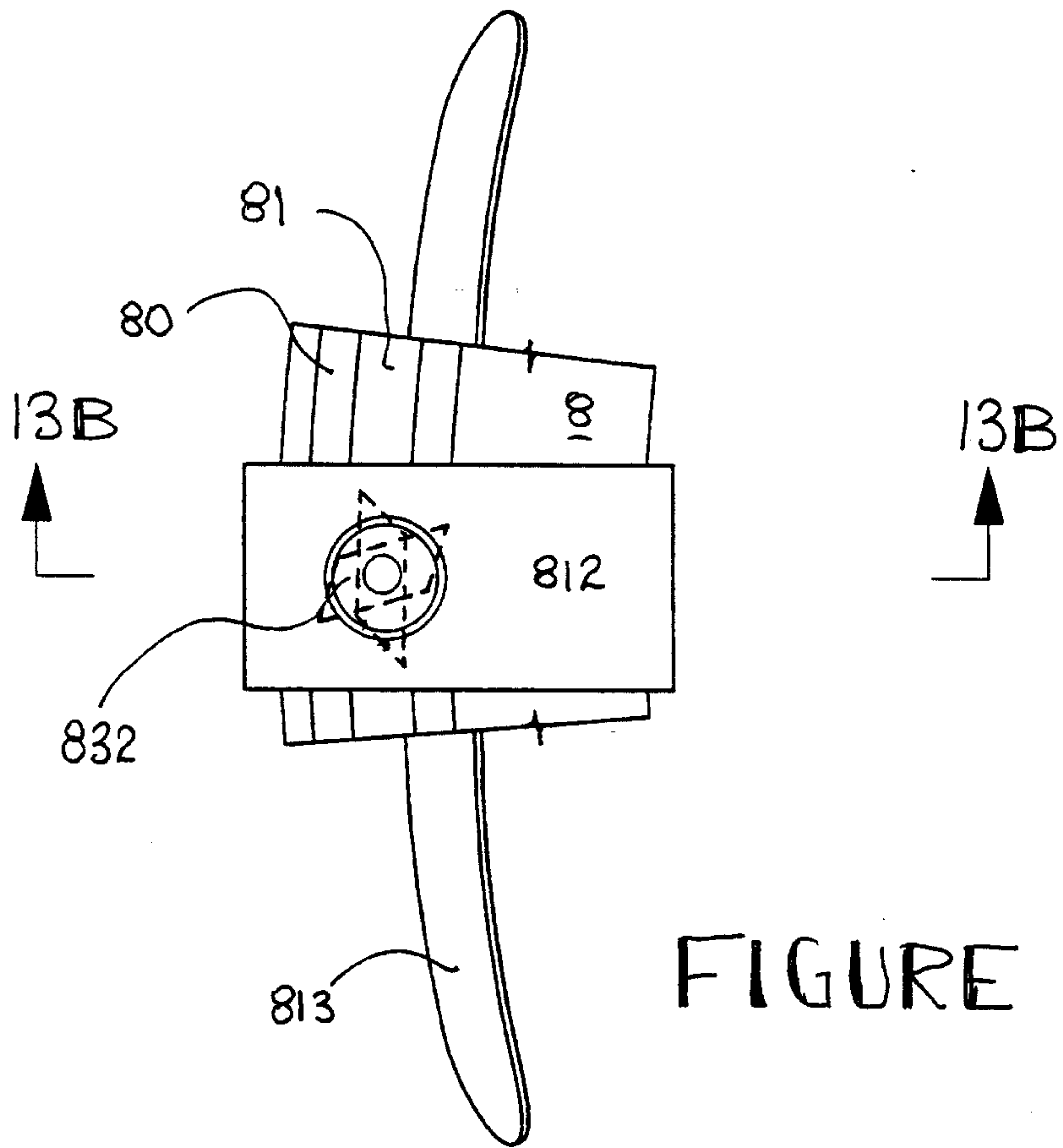
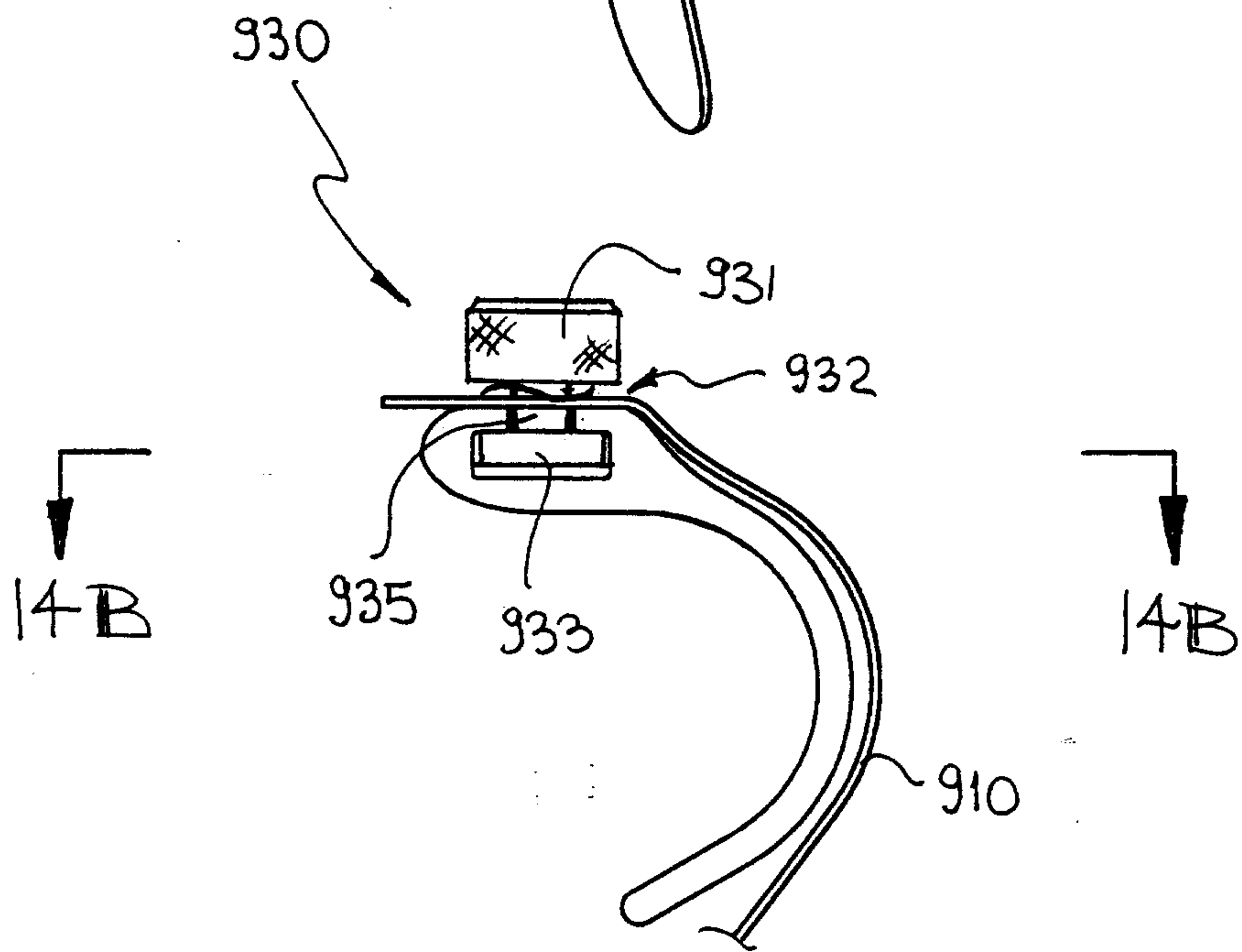
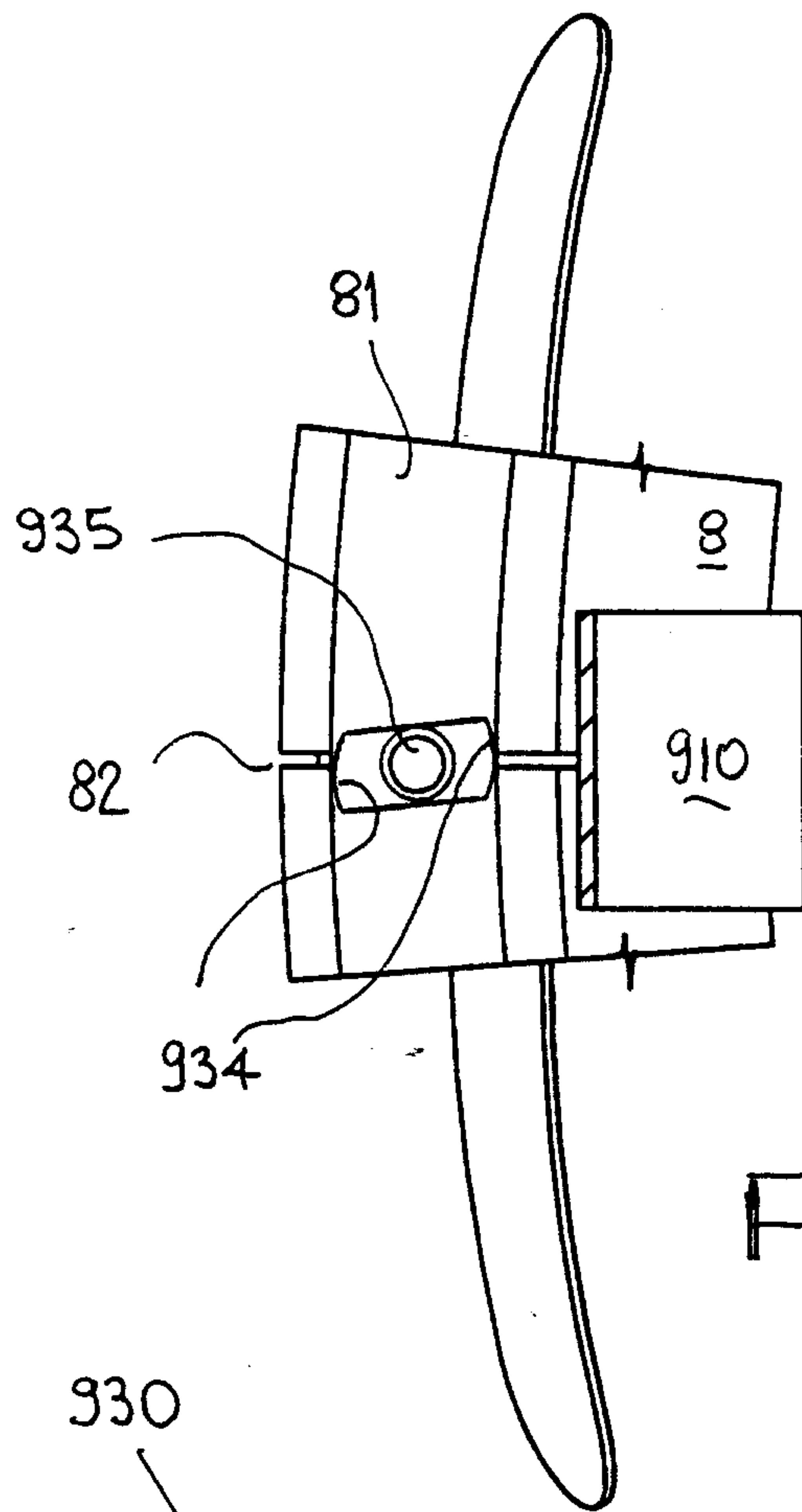


FIGURE 11F







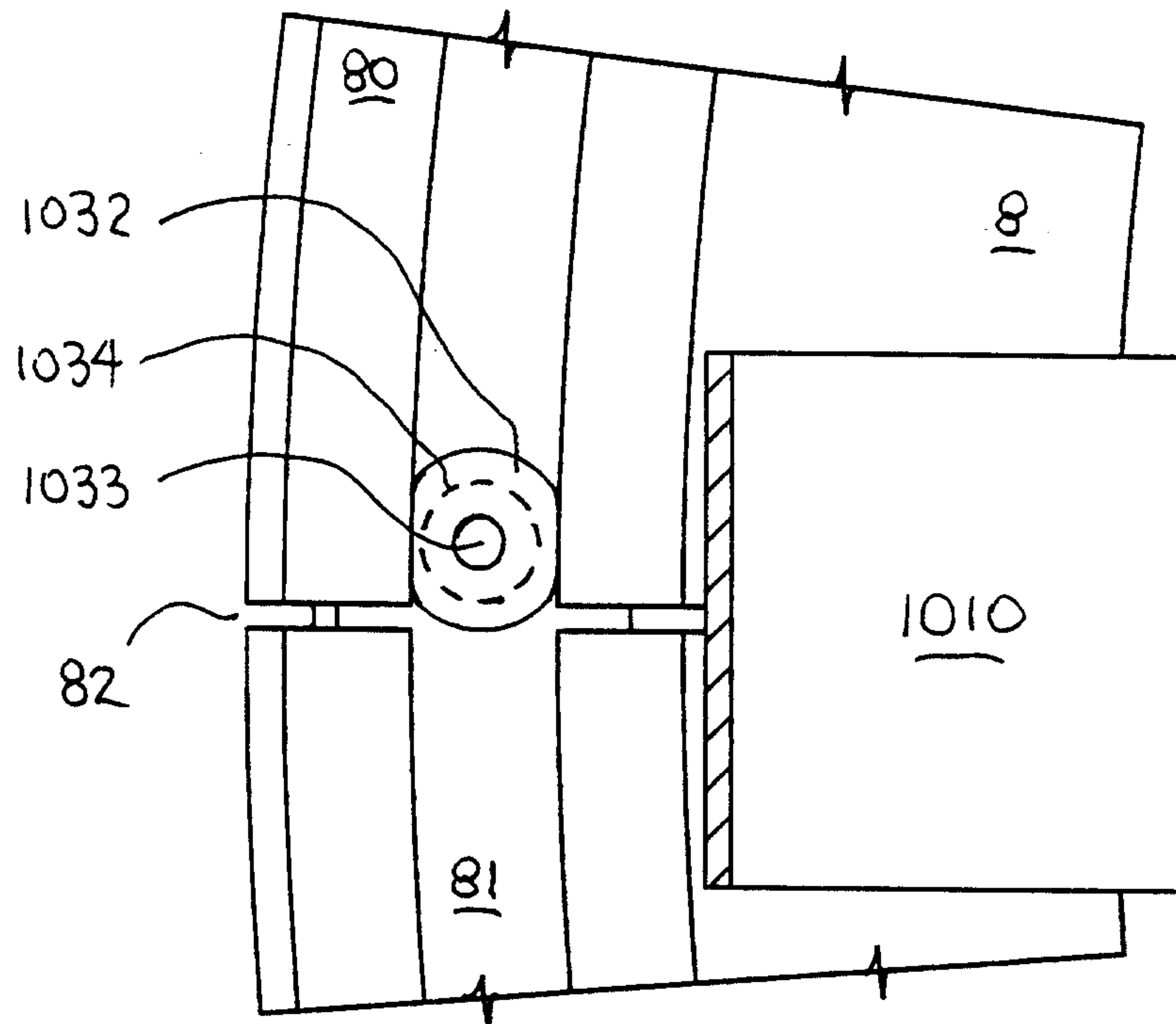


FIGURE 15B

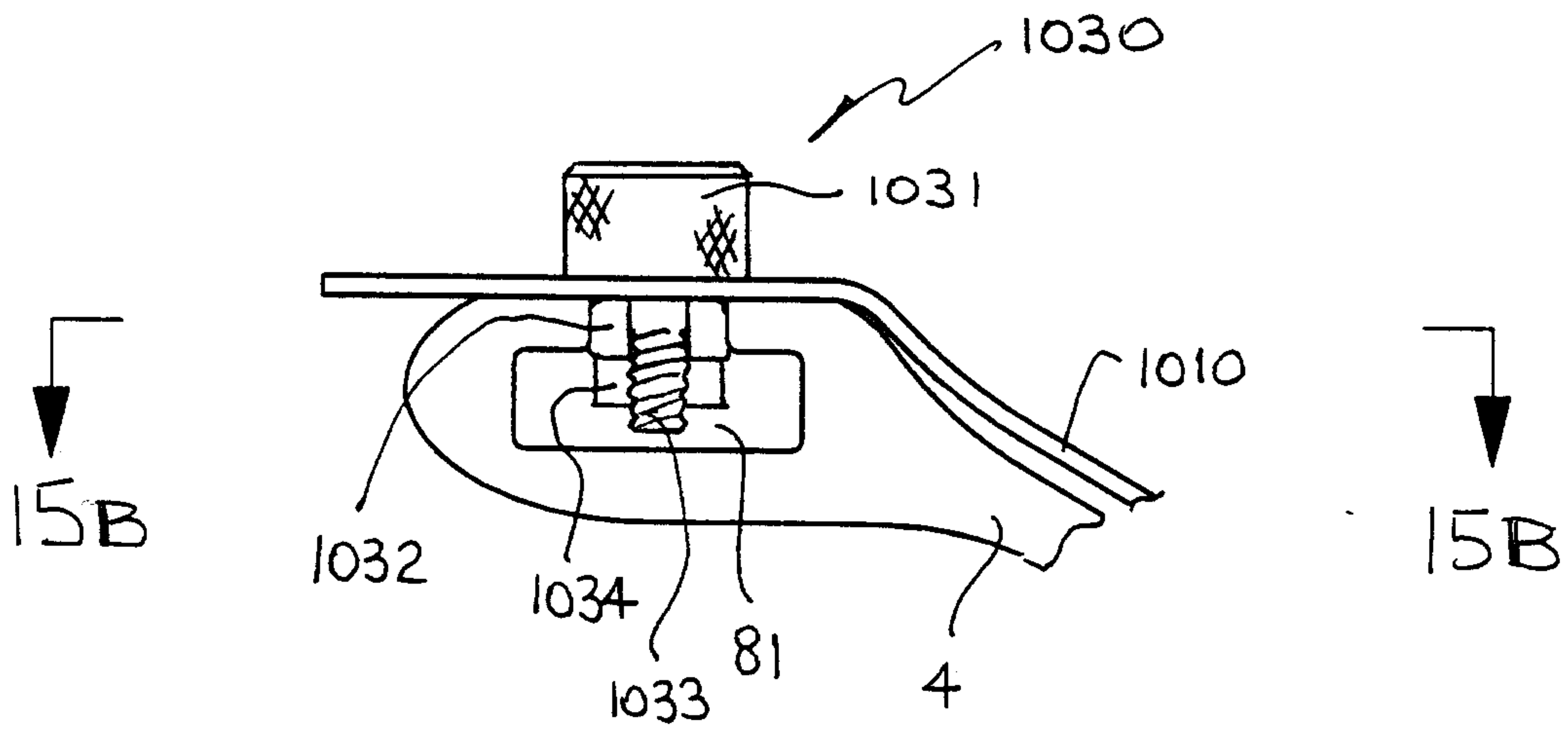


FIGURE 15A

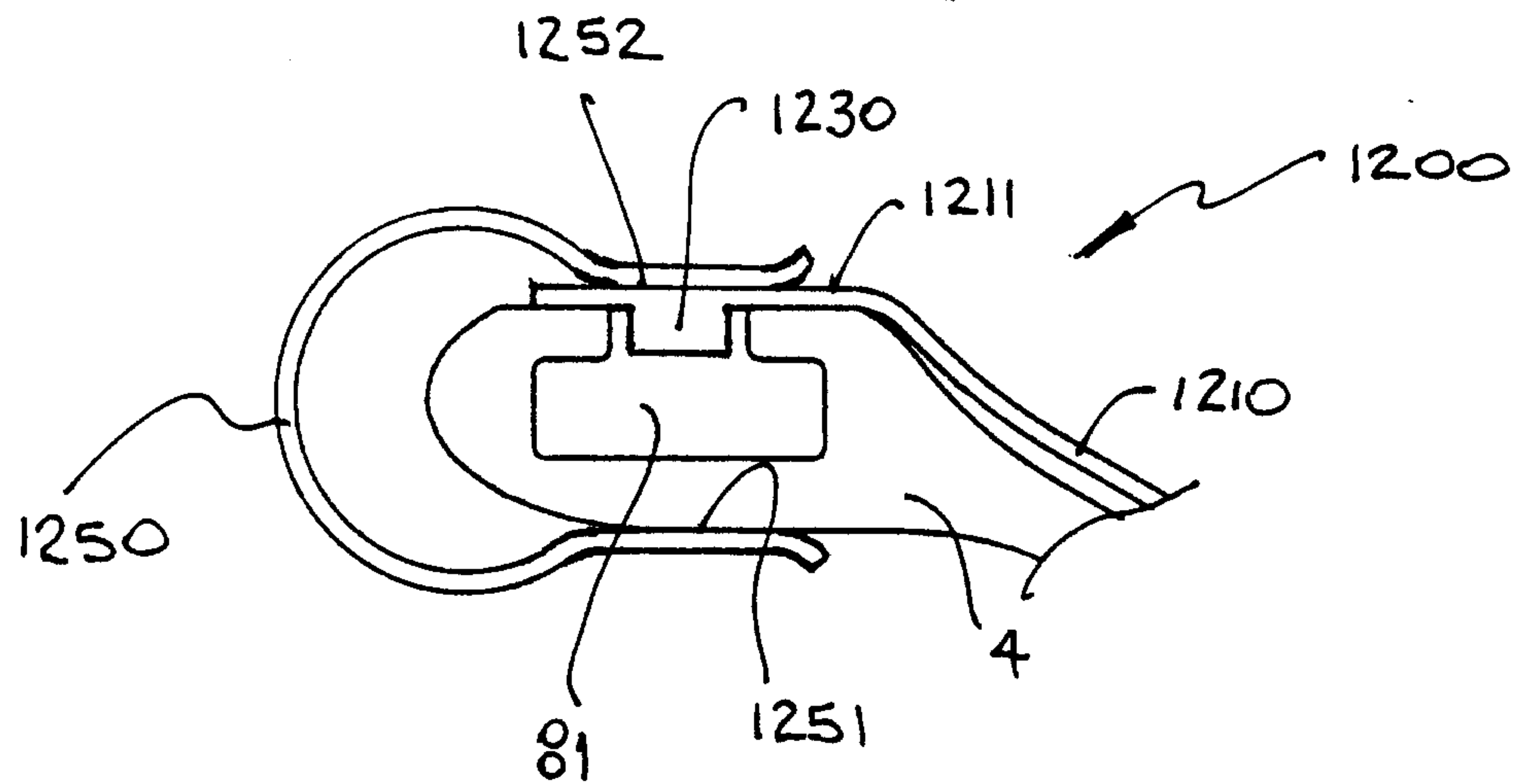
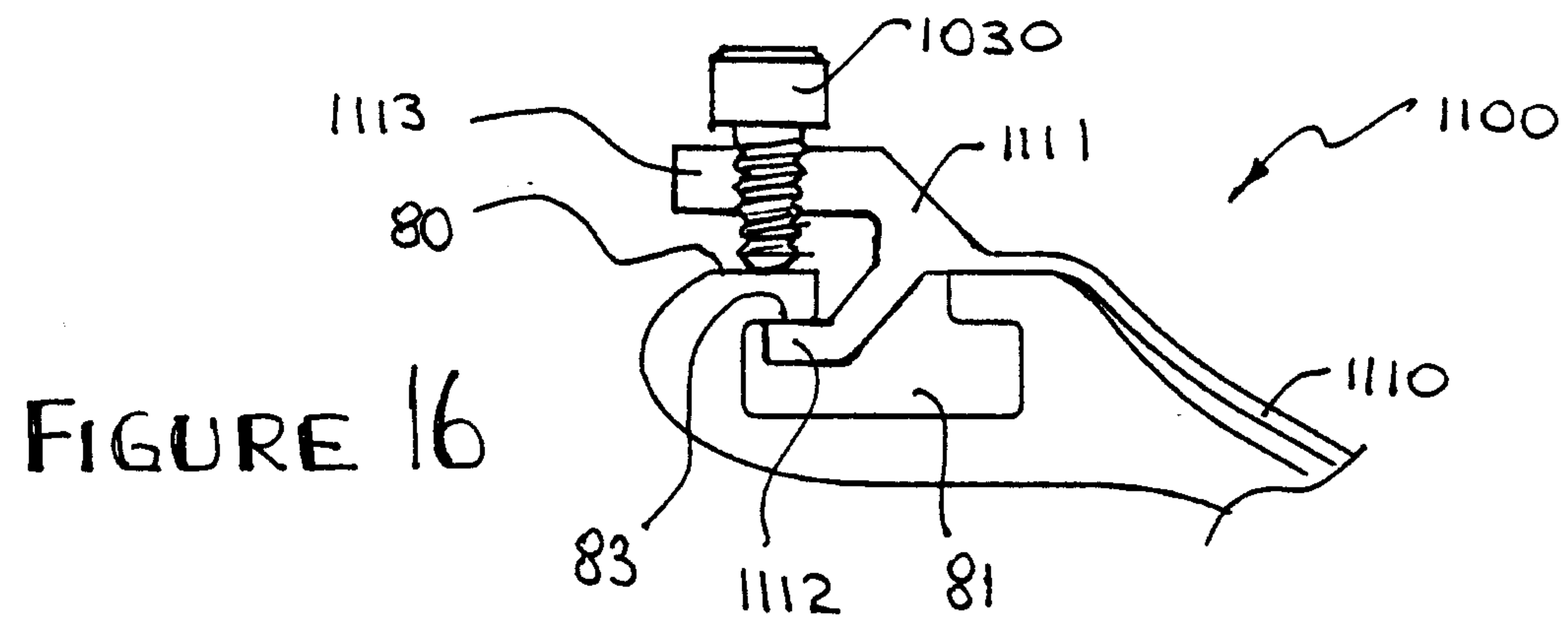


FIGURE 17

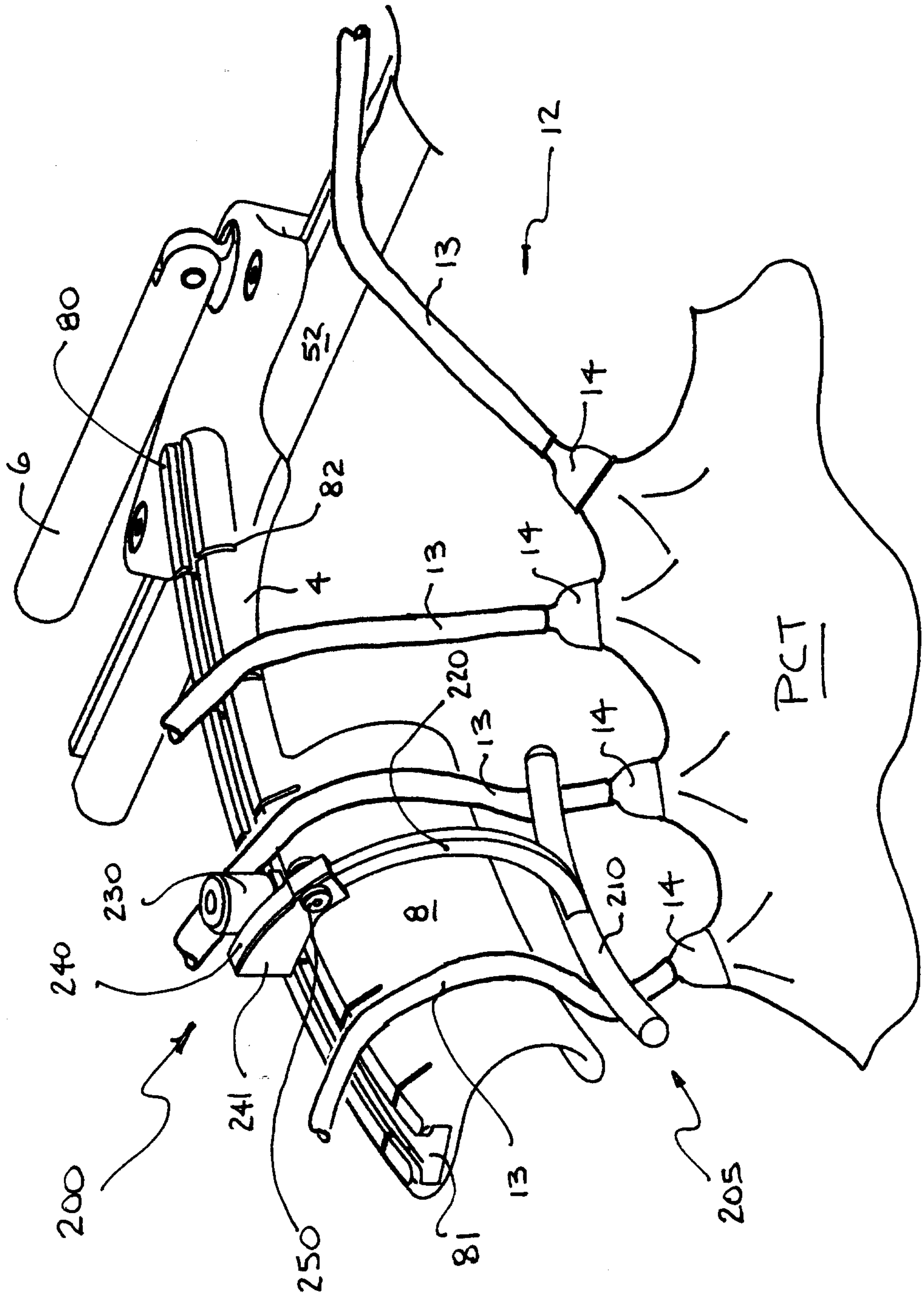


FIGURE 18

