US 20030060339A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0060339 A1**

Ravikumar et al. (43) **Pub. Date: Mar. 27, 2003**

(54) **SOLEUS PUMP**

(76) Inventors: **Sundaram Ravikumar**, Briarcliff Manor, NY (US); **Will Isaksson**, New York, NY (US)

Correspondence Address:
Ronald Abramson
Hughes Hubbard & Reed LLP
One Battery Park Plaza
New York, NY 10004-1482 (US)

(21) Appl. No.: **10/100,271**

(22) Filed: **Mar. 15, 2002**

Related U.S. Application Data

(60) Provisional application No. 60/323,410, filed on Sep. 18, 2001.

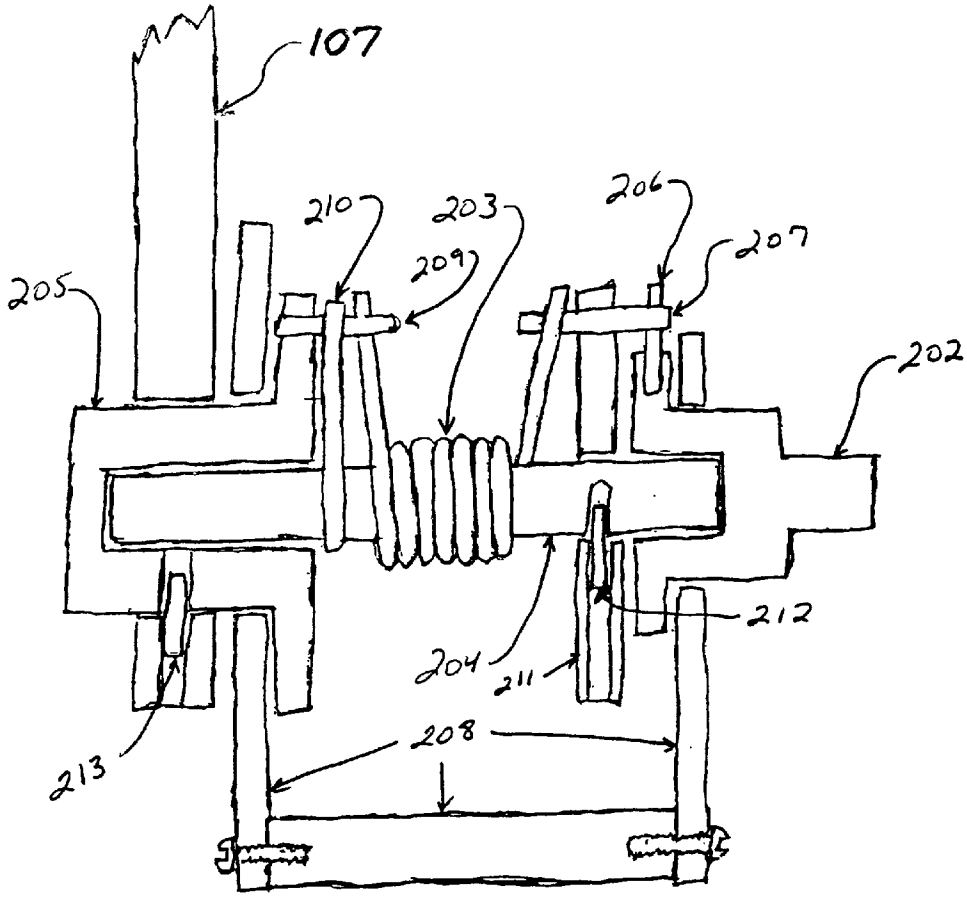
Publication Classification

(51) **Int. Cl.**[7] **A63B 71/00**; A63B 22/00; A63B 23/10

(52) **U.S. Cl.** **482/80**; 482/51

(57) **ABSTRACT**

A "soleus pump" (foot pump) applies an oscillatory movement to the sole of the foot so as to exercise the calf muscle and thereby prevent development of deep venous thrombosis. In one embodiment, the apparatus is placed under the lower leg of the patient, holding the leg in an optimal position without the necessity of strapping the apparatus to the patient or to the bed or table. The foot motion is applied through a foot pedal incorporating a safety feature which keeps the apparatus from jamming the patient's foot. In another operating mode, the motor drive may be withdrawn, so that the patient may drive the plate by voluntarily flexing the leg muscles, as a form of exercise. In another embodiment, two monopedal embodiments may be joined together to create a bipedal version of the invention, permitting both legs to be exercised at the same time. In yet another embodiment, the apparatus may be adapted for use by a patient sitting upright, for example, in a chair or airline seat.



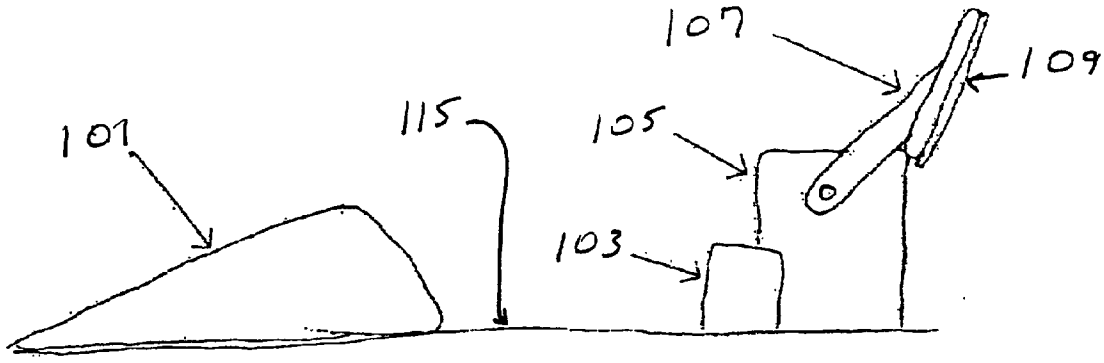


Fig. 1a

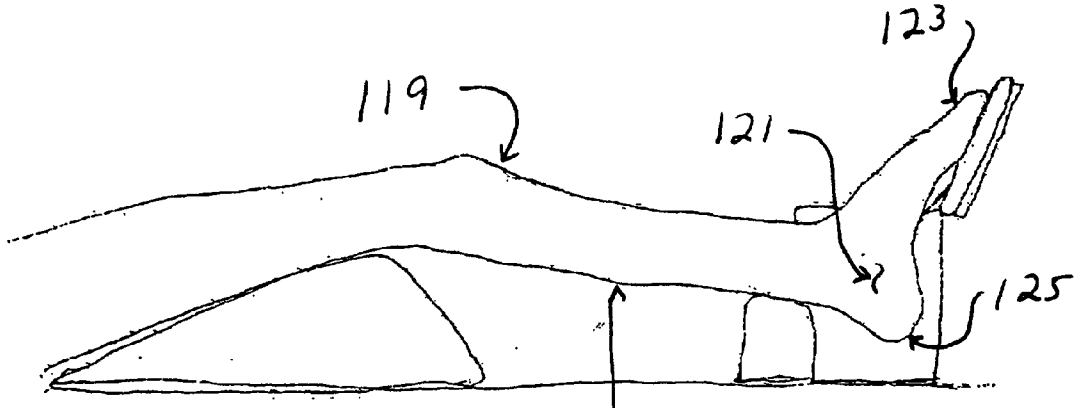


Fig. 1b

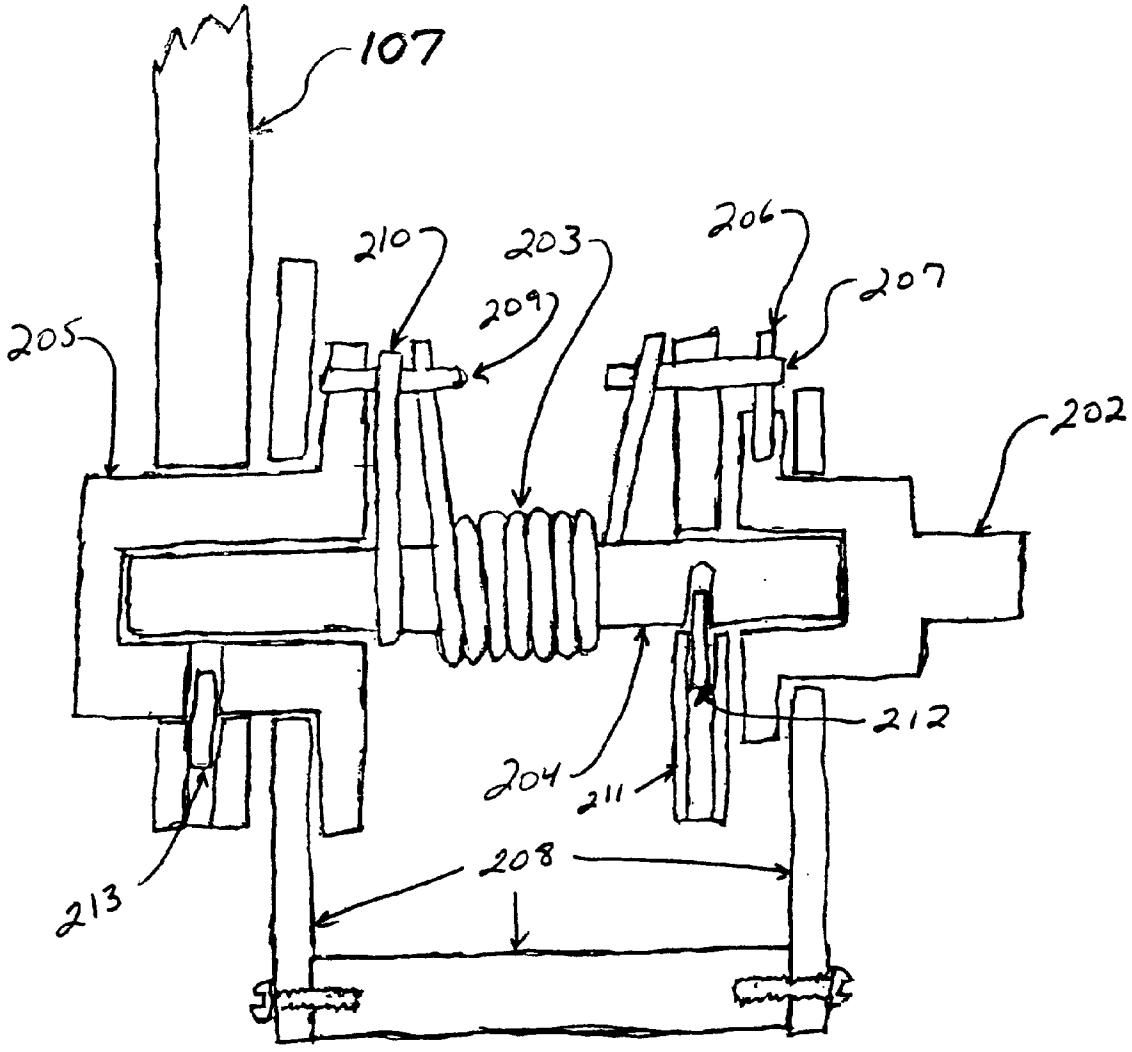


Fig. 2

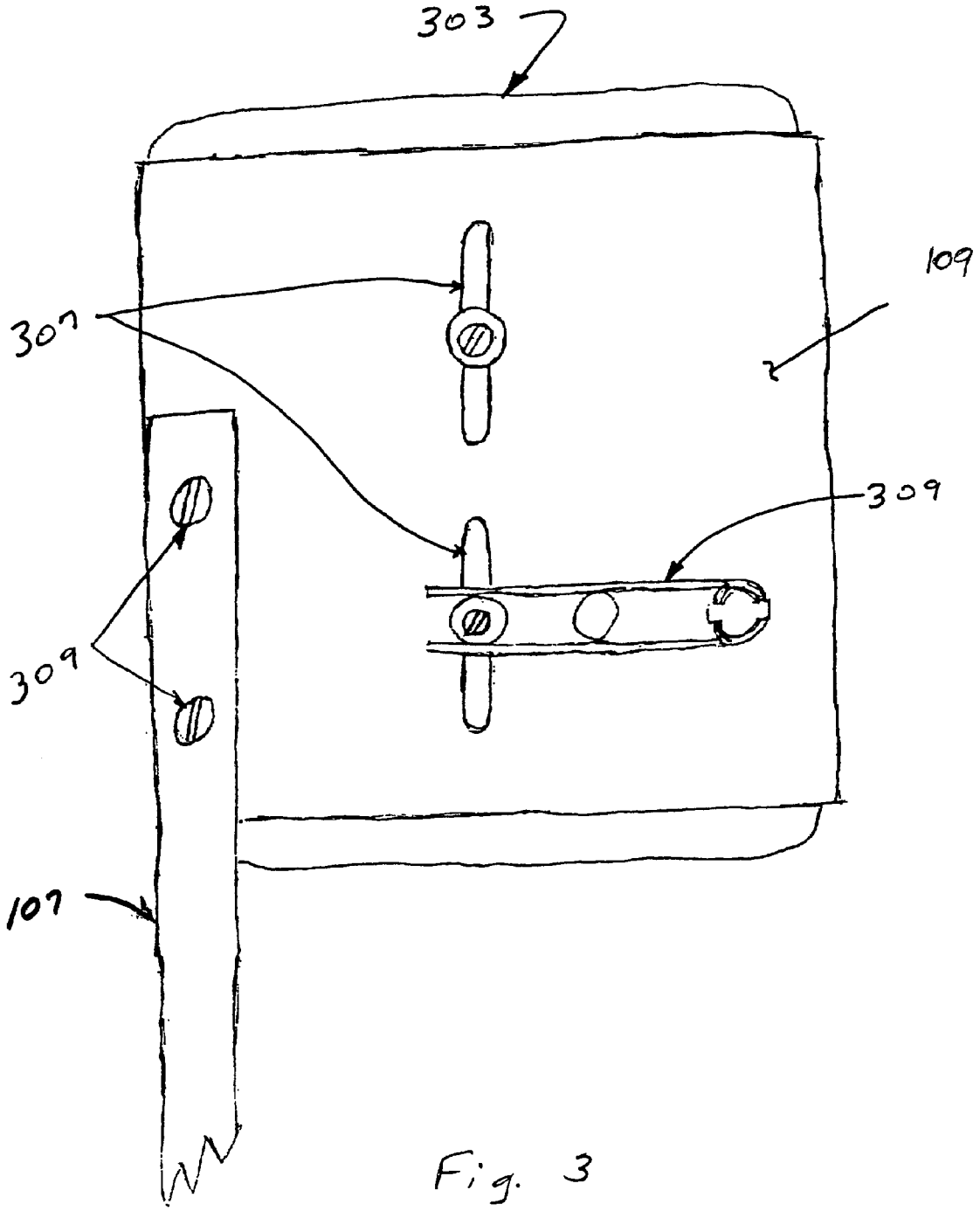


Fig. 3

Device in forward or pressure applying position.

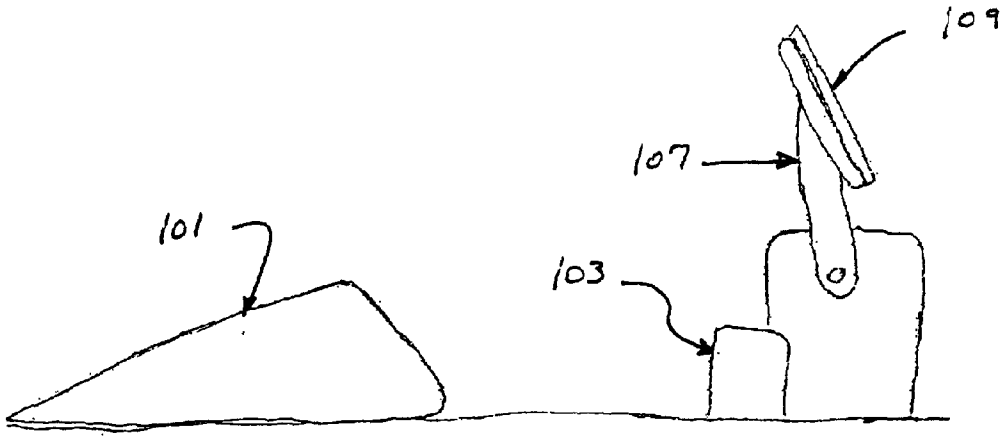


Fig. 4a

Device in rearward or non pressure applying position (foot hanging freely).

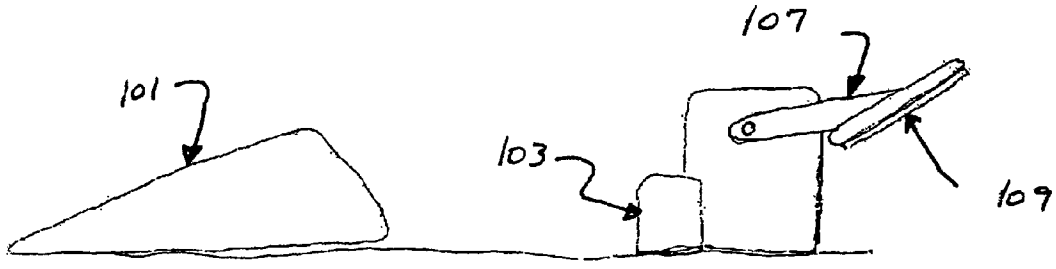


Fig. 4b

Fig. 4

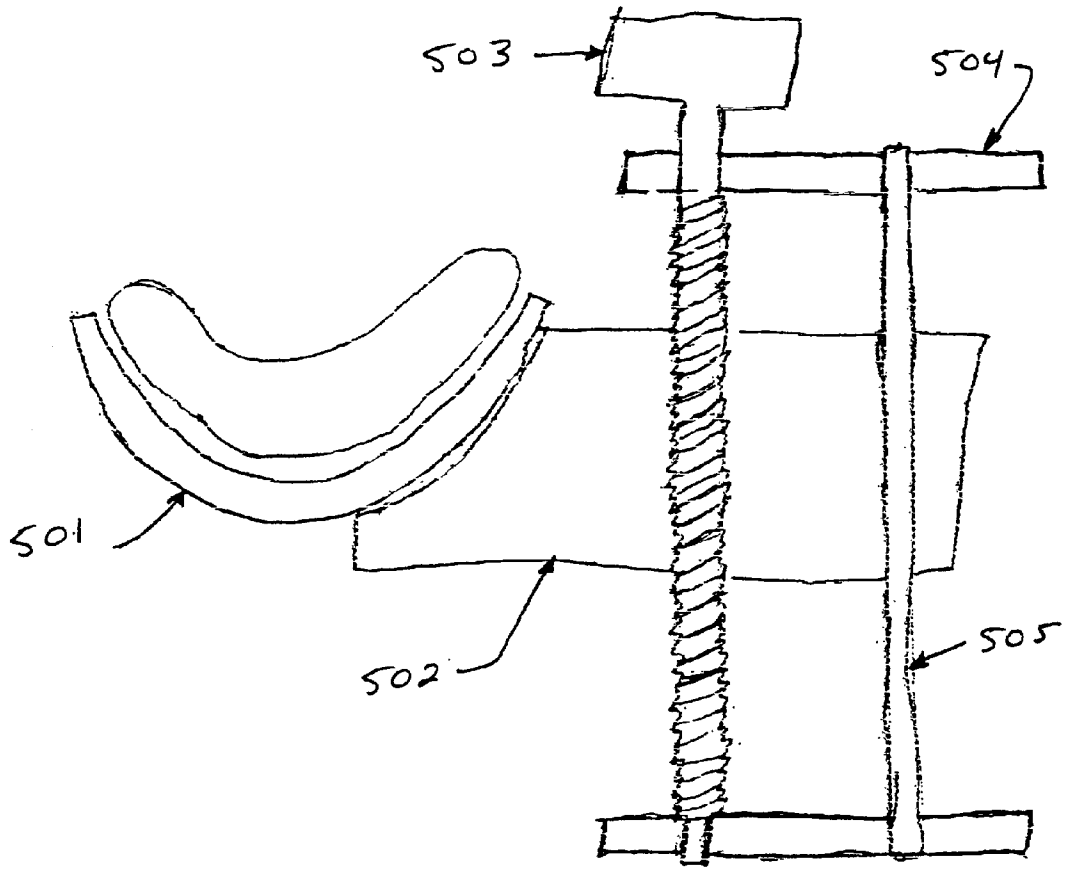


Fig. 5

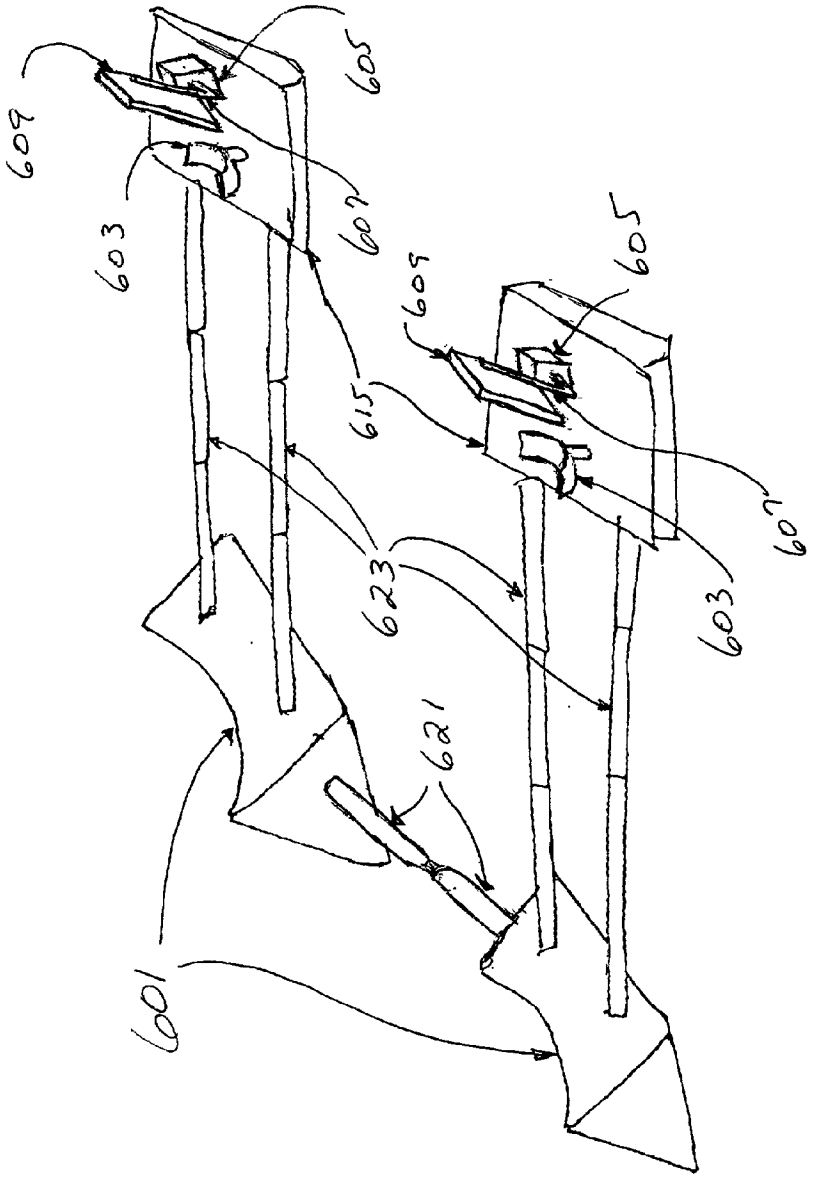


Fig. 6

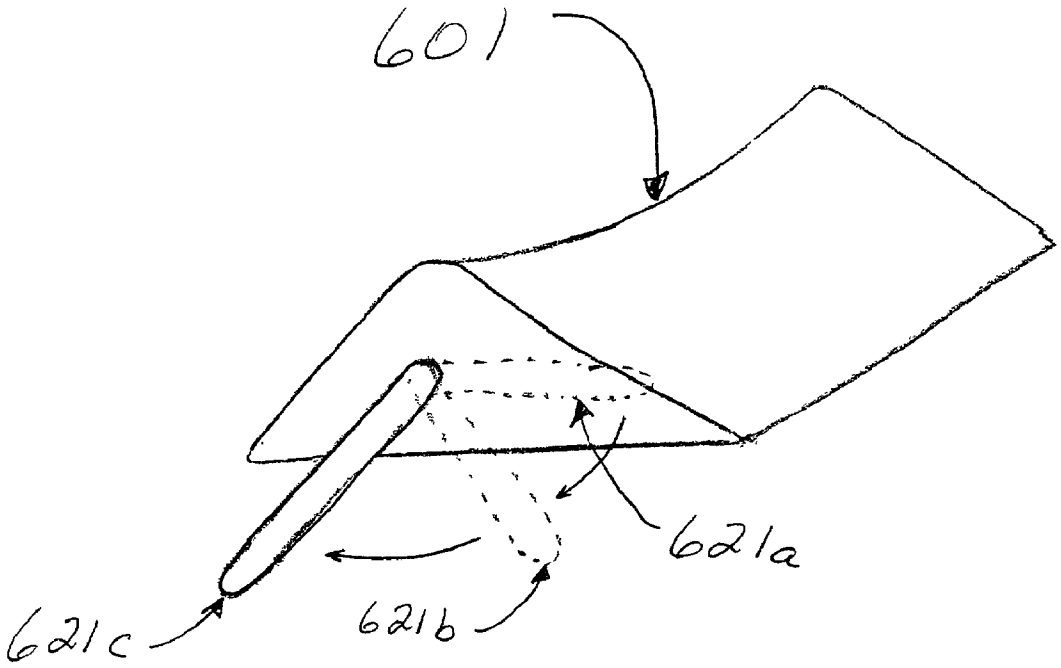


Fig. 7

Fig 8a

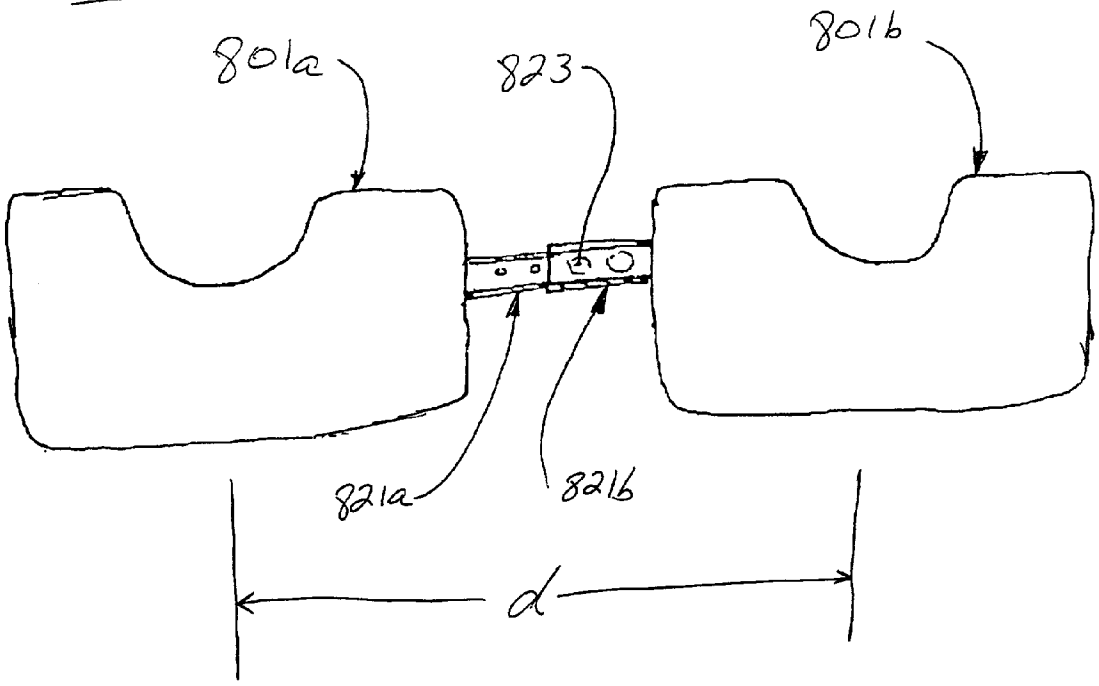


Fig. 8b

(prior art)

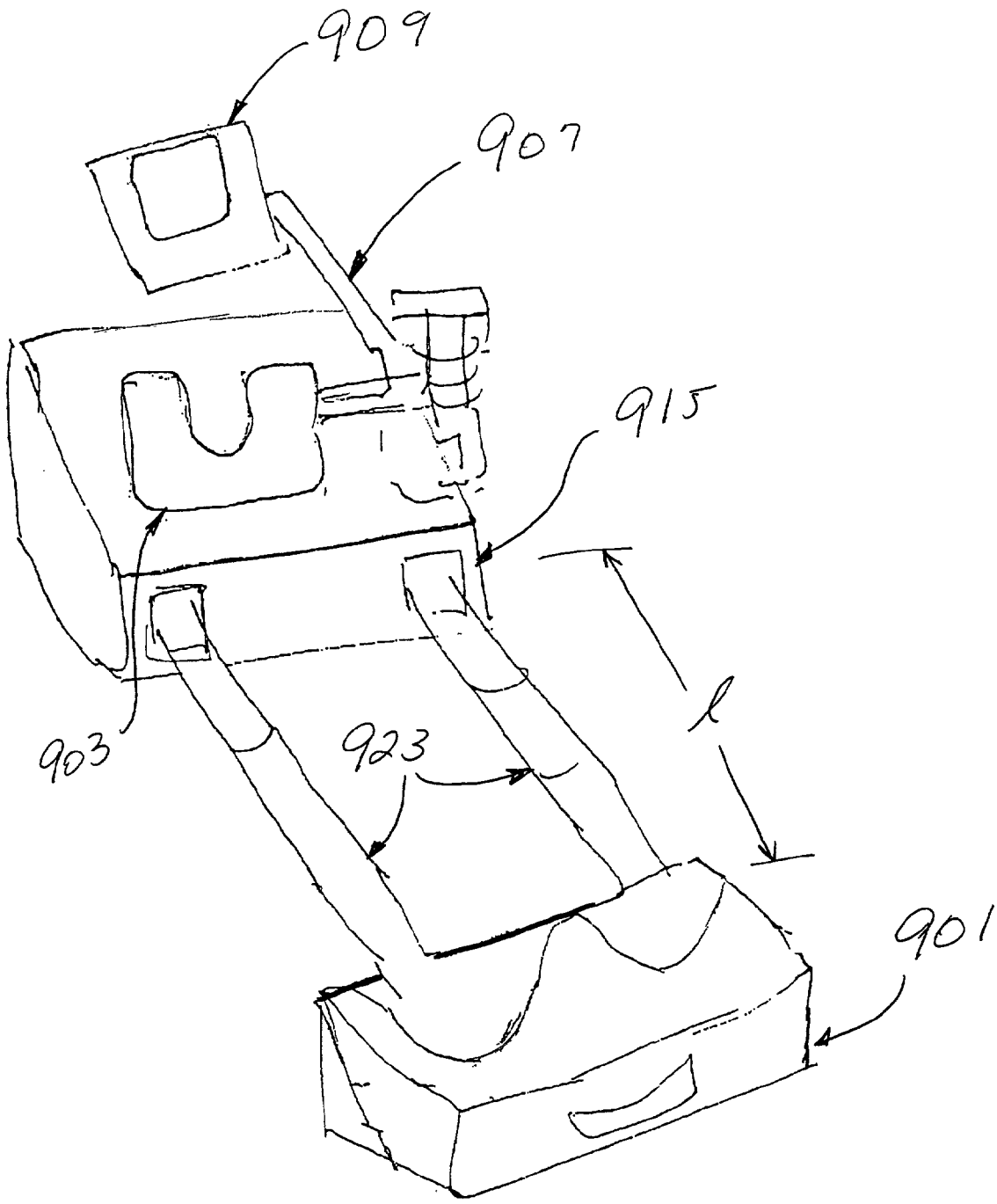


Fig. 9

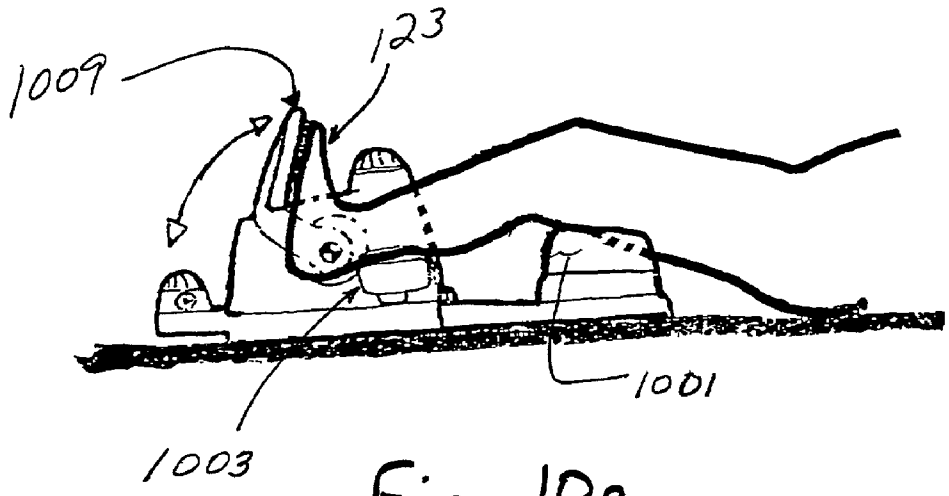


Fig. 10a

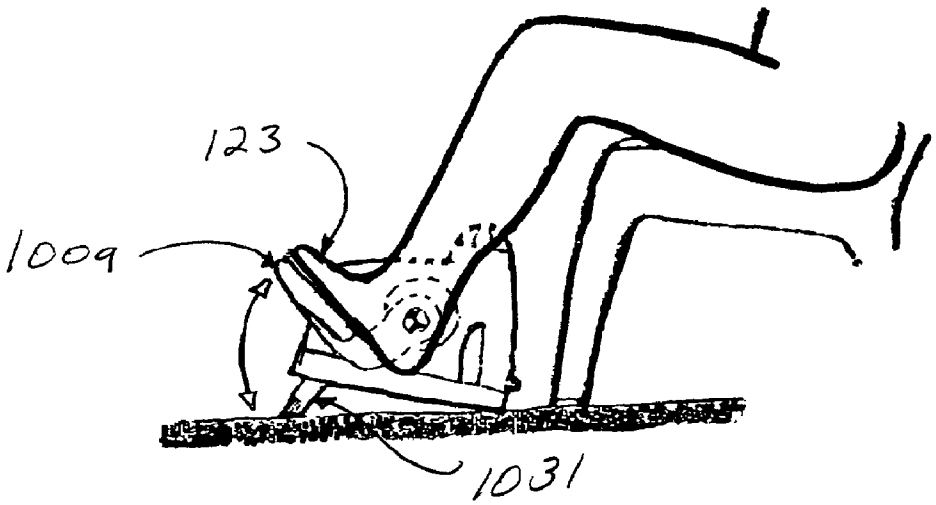


Fig. 10b

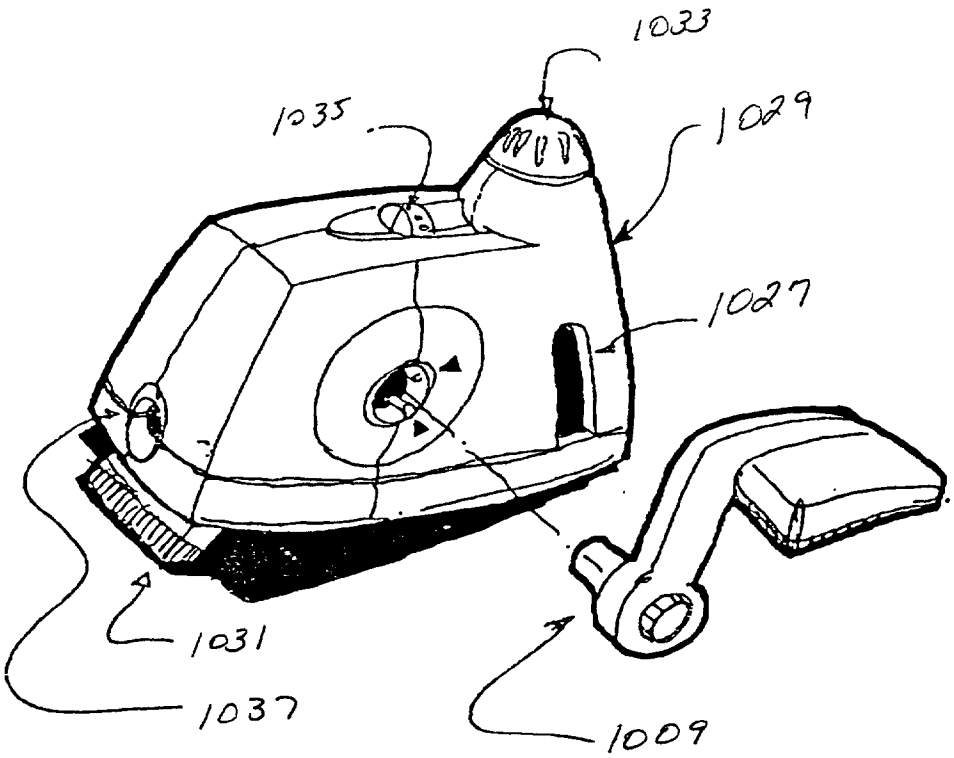


Fig. 11a

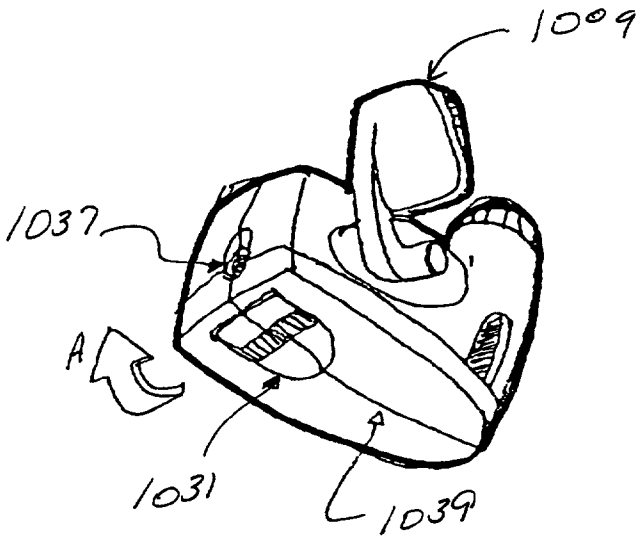


Fig. 11b

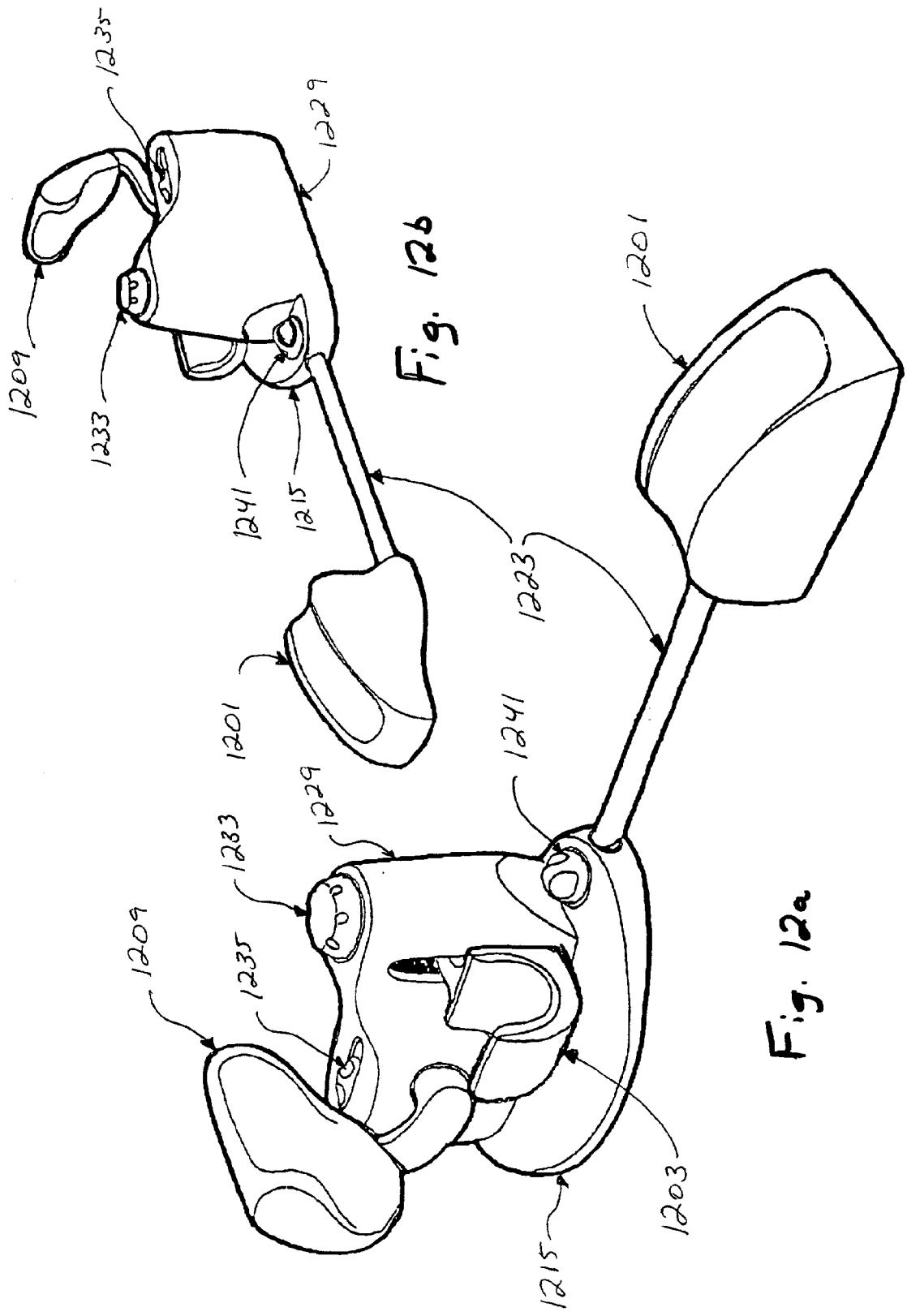


Fig. 12b

Fig. 12a

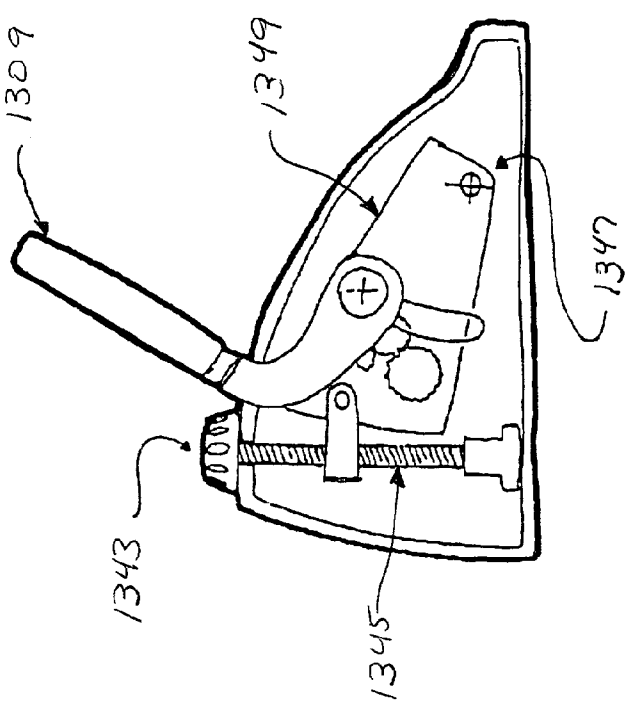


Fig. 13b

Fig. 13a

SOLEUS PUMP

[0001] This application claims benefit of U.S. provisional patent application serial no. 60/323,410, filed on Sep. 18, 2001.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention is in the medical device field, and more particularly relates to a pedal-actuated device to prevent development of deep venous thrombosis (DVT).

[0004] 2. Description of Related Art

[0005] DVT has been of concern in situations where people are immobile for relatively long periods, such as after surgery, or during long airplane flights. Generally, muscle contraction in the leg sends blood back to the heart, through the veins. If the muscles are not used for an extended period of time, the lower limbs tend to swell with stationary blood, and a clot may develop. Such clots can be very dangerous, resulting in life-threatening situations such as pulmonary embolisms, aneurisms, strokes, heart attacks, etc., or less dramatic, but long lasting disabilities of various sorts, as a result of clotted blood adhering to vein walls.

[0006] Because of this potential danger, preventive measures against DVT are standard in postoperative care. A number of techniques have been developed. The current state of the art technique of choice for doing this is to employ an apparatus in the form of a cuff that slides over the leg, which provides an undulating compression to the calf muscle to help drive blood back to the heart. Among the drawbacks of the current cuff technology is the relatively high cost of the pumping apparatus for the cuff, and of the cuff itself, which must be disposed of after about three days of use. Another drawback is that the cuff is not usable if the leg is in a cast or has had incisions.

[0007] In other existing techniques, the patient's foot is flexed in order to exercise the calf muscle. However, prior art versions of foot pumps have numerous disadvantages, including that they require the apparatus to be strapped to the patient's leg and to the bed or table; they don't hold the leg in an optimal position for allowing the lower leg muscle to act as a pump; and they apply pressure to the back of the knee joint or calf, thereby restricting blood flow in the lower leg. Thus, when these prior art versions release tension on the muscle, the weight of the leg is still on the muscle and vein. As a result, the vein in the leg is not allowed to easily or completely fill with blood, therefore producing a much less efficient pumping action.

BRIEF SUMMARY OF THE INVENTION

[0008] Accordingly, it is an object of the present invention to provide a more cost effective and versatile apparatus for preventing DVT than those currently available, consistent with other important objects including safety, comfort and ease of use. It is another object of the invention to provide both active and passive modes of operation, so that the patient can either allow the machine to provide the movement (passive), or supply the moving force himself or herself (active) as a form of exercise. It is a further object of the invention to provide an apparatus that holds the patient's leg in an optimally comfortable position, which position is also optimal for the function of the lower leg muscle to act as a pump.

[0009] These and other objects of the invention are achieved with an apparatus we refer to as a "soleus pump" (foot pump), which, in one embodiment, applies an oscillatory movement to the ball of the foot so as to exercise the calf muscle and thereby prevent development of deep venous thrombosis. In this embodiment, the apparatus is placed under the lower leg of the patient, who is lying down, and the weight of the leg serves to locate the apparatus without the need to strap the leg to the apparatus or to fasten the apparatus to the bed or table that the patient is lying on. The apparatus holds the leg in an optimally comfortable position, which position allows the lower leg muscle to go completely slack. This position allows the large vein in the leg to easily fill with blood, which is optimal for the functioning of the lower leg muscle to act as a pump. The foot motion is applied through a foot plate or pedal that is driven through a spring mechanism by an electric motor. The spring mechanism allows the plate to be stopped by foot resistance without stopping the motor, thereby preventing the apparatus from jamming the patient's foot. In another operating mode, the apparatus may be adjusted so as to withdraw the motor drive, so that the patient may drive the plate by voluntarily flexing his or her own muscles, as a form of exercise.

[0010] The details of this and other embodiments will be more apparent from a review of the accompanying drawings and of the description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIGS. 1***a* and **1***b* are side views of the elements of one embodiment of the invention.

[0012] **FIG. 2** is a detailed view of the drive mechanism of an embodiment of the invention.

[0013] **FIG. 3** is a detailed view of the foot pedal of an embodiment of the invention.

[0014] **FIGS. 4***a* and **4***b* are side views of an embodiment of the invention, showing two different positions of the foot pedal, representing, respectively, two operating modes.

[0015] **FIG. 5** is a side view of a vertically adjustable ankle support of an embodiment of the invention.

[0016] **FIG. 6** is a perspective view of a bipedal embodiment of the invention.

[0017] **FIG. 7** is a detailed view of an adjustable connection mechanism that may be used in a bipedal embodiment of the invention.

[0018] **FIG. 8***a* is a detailed view of an adjustable connection mechanism between two thigh cushions in a bipedal embodiment of the invention, which embodiment eliminates the need for an abduction pillow, shown in **FIG. 8***b*.

[0019] **FIG. 9** is a perspective view of a lengthwise adjustable embodiment of the invention.

[0020] **FIG. 10** shows an embodiment of the invention which may be adapted for use by a patient lying down (**FIG. 10***a*) or sitting up (**FIG. 10***b*).

[0021] **FIG. 11** is a detailed view of the support frame and drive mechanism housing of the embodiment shown in **FIG. 10***a* and **FIG. 10***b*.

[0022] **FIG. 12***a* and **FIG. 12***b* are perspective views of an alternate embodiment of the invention.

[0023] **FIG. 13***a* is a perspective view of an alternate embodiment of the invention with an adjustable foot pedal, while **FIG. 13***b* shows a detailed side view of the adjustable foot pedal mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] One particular embodiment of the invention is illustrated in FIGS. **1-5**, and is described in the text that follows. Other embodiments of the invention, showing adjustable monopedal and bipedal versions of the invention, are illustrated in FIGS. **6-9**. FIGS. **10-13** show additional embodiments and features of the invention. Although the invention has been most specifically illustrated with particular embodiments, its should be understood that the invention concerns the principles by which the claimed apparatus may be constructed, and is by no means limited to the specific embodiments shown.

[0025] The first embodiment of the invention as referenced above comprises a monopedal anti-embolic device that facilitates the exercising of the lower leg, calf and foot muscles, while lying down. The device may be used by people convalescing in beds. One purpose of the invention is to attenuate the likelihood of the development of vascular emboli (and the consequences thereof) during long and extended periods of inactivity.

[0026] This embodiment safely and easily facilitates the exercising of the lower leg by applying a preset amount of force to the bottom of the foot causing the foot to pivot at the ankle and stretch the calf muscle. This embodiment of the invention then reverses and allows the foot to hang freely from the ankle and thus allow the calf muscle to go slack. The invention may use the weight of the leg to locate itself with respect to the bed and thus locate the device in relation to the body, so that the device is not required to be strapped to the body of the patient or strapped or bolted to the bed frame (although in another embodiment, this device could be strapped to the leg or externally affixed to the bed, if desired). The invention also supports the leg in such a way as to prevent heel sores and, by supporting the leg in a slightly bent-knee manner, helps to align the foot to the pedal. This leg position is also optimal for the functioning of the lower leg muscle to act as a pump, because the weight of the leg is not resting on the calf muscle, and there is no support point or pressure in the area behind the knee joint. One embodiment of the invention has a vertically adjustable ankle support to accommodate different ankle shapes and diameters. In other embodiments, the lower leg may be supported either at the ankle or higher up the leg, under the calf.

[0027] Another embodiment of the invention has a sprung sliding member on the foot pedal so as to accommodate an incorrectly located ankle and help prevent the possible resultant friction burn. In another operating mode, the invention can also be used unpowered as an exercise machine by setting a switch to the exercise pedal that will move it into its full compression position. In this case, the patient then simply pushes against the pedal causing the pedal and arm to move back and forth against the preset spring.

[0028] The mechanism for one embodiment of the invention comprises a reversible motor, a geartrain providing a very slow final output to the arm and a torsion spring indirectly connecting the final output shaft of the geartrain to the arm. The final output shaft of the geartrain only engages the spring in its torqued direction so that in the backward direction of the geartrain the arm is not being pulled backward away from the foot but is only falling back with gravity. This safety feature ensures that the pedal is only driven in one direction and in that direction is only driven through the spring with a safe preset amount of force.

[0029] Any of the foregoing features and embodiments may also be incorporated in a bipedal embodiment of the invention, which would allow a patient to exercise both legs simultaneously, if desired.

[0030] **FIG. 1***a* is a side view of one embodiment of the invention, showing the various elements that comprise the invention, while **FIG. 1***b* shows the same side view of the apparatus with the patient's leg in position. The apparatus comprises a thigh pad **101**, an ankle pad **103** and a foot pedal **109** that is attached through an arm **107** to a drive mechanism **105**. The drive mechanism **105** momentarily applies a measured or preset amount of pressure to the bottom of the foot **123** of someone in the prone position so as to flex and extend the foot at the ankle **121** in order to tighten and release the calf muscles **117**.

[0031] As shown in **FIG. 1**, this embodiment of the apparatus comprises a thigh pad **101** and an ankle pad **103** to support the leg **119** in a slightly bent position so as to help locate the foot **123** and allow the foot **123** to hang freely. The slightly bent and elevated position of the leg **119**, aside from being an ideal resting position for the leg, would also prevent bed sores on the back of the heel **125**. The thigh pad **101** and ankle pad **103** also sit on (or may be affixed to or slidably affixed to) the frame **115** of the device, thus using the weight of the leg **119** to anchor the device to the bed, without the need for attaching the device to the bed or table, or strapping the device to the patient.

[0032] The drive mechanism **105** comprises a simple motor-driven device that puts a measured amount of pressure on the sole of the foot **123** causing the foot to pivot at the ankle **121** and stretch the calf muscle **117**. The device then reverses and allows the foot **123** to hang freely from the ankle **121**, thus allowing the calf muscle **117** to go slack. The device can only apply a preset amount of pressure to the bottom of the foot **123** because the arm **107** is spring loaded to the drive mechanism **105**, so even if a particular patient has a very limited range of motion the device will only apply a given amount of pressure to the bottom of the foot **123** and not try to force the foot **123** and ankle **121** beyond what it is capable of moving.

[0033] **FIG. 2** is a detailed view of the drive mechanism **105**. In this embodiment, the mechanism comprises a reversible shaded pole alternating current (AC) motor (not shown), a geartrain (not shown) which reduces rotation to about one revolution per minute (RPM) final output to the arm **107**, and a torsion spring **203** indirectly connecting the final output shaft of the geartrain to the arm **107**. The motor is

driven back and forth by limit switches on the final output shaft of the geartrain. The final output shaft rotates backward and forward about 70 degrees. The mechanism is supported through frame members **208**.

[**0034**] The final output shaft of the geartrain is indirectly connected to the arm **107** through the torsion spring **203**. The arm **107** with foot pad attached (not shown) is affixed to the output flanged shaft **205** by a pin **213**. One end of the torsion spring **203** is connected to the arm **107**, and the other end is torqued against a stop that is also connected to the arm **107**. This means the spring **203** always has some preset torque on it (in one embodiment, this preset torque is preferably approximately fifty in-lb) so that as soon as the device engages, the foot **123** is engaging the foot pad **109** with, in this preferred case, approximately fifty in-lb of torque. The arm **107** can be pushed backwards with slightly increasing force as the spring **203** is wound tighter.

[**0035**] The output of the motor/geartrain is connected to the input flanged shaft **202** and transmitted to the torsion spring **203** only in the counterclockwise direction through pin **206** that pushes against pin **207**. Pin **207** pushes against torsion spring **203**. The other end of torsion spring **203** pushes against pin **209** which is affixed to output flanged shaft **205**.

[**0036**] The preload of torsion spring **203** is maintained by shaft **204**. Pin **210** is affixed to shaft **204** and stops pin **209** which in turn stops one end of the torsion spring **203**. Disk **211** is affixed to shaft **204** by pin **212** and stops the other end of the torsion spring **203** with pin **207** which is affixed to disk **211**.

[**0037**] This arrangement allows for driving the output shaft **205** in only the counterclockwise direction and then only through the preloaded torsion spring **203**. Output flanged shaft **205** only rotates counterclockwise when either the foot pushes against arm **107** or the weight of arm **107** itself is over center enough to induce a clockwise torque on output flanged shaft **205**.

[**0038**] As a safety feature, the final output shaft of the geartrain only engages the spring **203** in its torqued direction so that in the backward direction of the geartrain the arm **107** is not being pulled backward away from the foot **123** but only falling back with gravity. The design of the mechanism completely isolates the geartrain and motor from misuse. The geartrain and motor can only have the preset torque of the spring **203** applied to it. This design is also safe for the user because it only applies a preset amount of pressure to the bottom of the foot **123** no matter how badly misaligned the device is to the foot/leg/body of the user. In the release or backward stroke the arm **107** is not driven, allowing the arm **107** to stop if it encounters any resistance. For example, if the foot **123** slips off the pedal **109**, the motor will not drive the pedal **109** against the top of the foot **123**.

[**0039**] **FIG. 3** shows a detailed view of the foot pedal and pad of the invention. In this embodiment, the foot pedal **109** is attached to the arm **301** through two fasteners **309**. The foot pad **303** is on the side of the foot pedal **109** that engages the bottom of the foot **123**. The foot pad **303** is attached to the foot pedal **109** through two vertical slots **307** with a spring **309**. These slots allow the foot pad **303** to slide up and down on the foot pedal **109** so as to accommodate an incorrectly located ankle and to help prevent possible resultant friction on the bottom of the foot.

[**0040**] **FIG. 4** illustrates two different operating modes of the invention. In one embodiment of the invention, the apparatus comprises a switch for the motor with three positions: Off, On and Exercise. With the switch in position **1** (Off), as shown in **FIG. 4***b*, the motor causes the arm **107** to be angled down away from the foot, exerting no pressure on the foot, allowing the foot to hang freely. With the switch in position **2** (On) (not shown), the motor causes the arm to move back and forth slowly from close to vertical (maximum pressure on foot), to close to horizontal (foot hanging freely). With the switch in position **3** (Exercise), as shown in **FIG. 4***a*, the motor causes the arm **107** to be close to vertical (maximum pressure). In this position, the user simply pushes against the foot pad **109**, causing the spring-loaded arm **107** to rotate backwards and forwards with a preset amount of resistance. In the presently preferred embodiment, this preset amount of resistance is approximately 50 in-lb of torque.

[**0041**] **FIG. 5** shows an alternate embodiment of the ankle pad, allowing vertical adjustment of the pad to allow better alignment of the ankle with the pivot axis of the arm. In this embodiment, the pad **501** is attached through a threaded support member **502** to the support frame **504** using a threaded rod **503**. As the threaded rod **503** is turned, the support member is kept from turning by a rod **505** that fits through a hole in the support member **502** and is attached to the support frame **504**. Turning the threaded rod **503** causes the support member **502** to slide up or down on the rod **505**, allowing the pad **501** to be adjusted to the optimum vertical height.

[**0042**] In **FIG. 6**, two adjustable monopedal embodiments of the invention may be joined together to create a bipedal version of the invention, which permits both legs to be exercised at the same time, if desired, with a separate motor for each leg. In this embodiment, each monopedal half of the invention comprises a thigh pad **601** with an adjustable connecting rod **621**. A frame **615** supports drive portion of the device, including drive mechanism **605** and ankle pad **603** (which may be vertically adjustable, and which may also be slidably affixed to the support frame **615**). The drive mechanism **605** is connected through an arm **607** to a foot pedal **609**. A foot pad (not shown) may be slidably attached to foot pedal **609** to allow the foot pad to slide up and down on the foot pedal **609** so as to accommodate an incorrectly located ankle and to help prevent possible resultant friction on the bottom of the foot. The thigh pad **601** in this embodiment may be lengthwise adjustably connected to the support frame **615**, for example through telescoping tubes **623**. Two thigh pads **601** can be connected to each other using adjustable connecting rod **621**, resulting in a bipedal apparatus.

[**0043**] In additional bipedal embodiments (not shown), an adjustable connection may be made between support frames **615**, in place of or in addition to an attachment between thigh pads **601**, to provide additional stability and/or to help maintain the correct distance between the two halves of the bipedal apparatus.

[**0044**] **FIG. 7** and **FIG. 8***a* show detailed views of thigh pad **601** and adjustable connecting rod **621** of the bipedal embodiment shown in **FIG. 6**. In **FIG. 7**, adjustable connecting rod **621** is affixed to thigh pad **601** such that connecting rod **621** may be placed in a variety of positions, depending upon the particular configuration of the apparatus

desired. In a monopedal embodiment, connecting rod **621***a* is placed in a "stored" position, lying along thigh pad **601** so that the longitudinal axis of connecting rod **621** is generally parallel to the lengthwise direction of the apparatus. In alternate monopedal embodiments (not shown), connecting rod **621** may be simply detached from thigh pad **601**, or may slide into a hole in thigh pad **601** for storage. To configure the apparatus for the bipedal embodiment as illustrated, connecting rod **621** swings through position **621***b* and is placed in "connection" position **621***c*, projecting outward from thigh pad **601** in the direction of a second thigh pad (not shown). The connecting rod of a second thigh pad is similarly (but oppositely) positioned to project out from second thigh pad toward first thigh pad **601**. Connecting rods (e.g. **621***c*) are then affixed to each other for a bipedal embodiment.

[**0045**] **FIG. 8***a* shows details of one embodiment of adjustable connecting rods for the bipedal embodiment described. In the embodiment shown in **FIG. 8***a*, two connecting rods **821***a* and **821***b* of two thigh pads **801***a* and **801***b*, respectively, are slidably attached to each other. In this embodiment, connecting rods **821***a* and **821***b* have attachment holes **823** along the longitudinal axes of both connecting rods **821***a* and **821***b*. When thigh pads **801***a* and **801***b* are positioned a distance "d" apart, holes **823** of connecting rods **821***a* and **821***b* are aligned so that attachment means (not shown) can pass through aligned holes **823** of both connecting rods **821***a* and **821***b*, thus affixing connecting rod **821***a* to connecting rod **821***b*. Attachment means may be, for example, nut and bolt, pin, screw, or any other means that serves to affix connecting rods **821***a* and **821***b* to each other such that they are restrained from moving relative to each other and such that distance "d" between thigh pads **801***a* and **801***b* is maintained.

[**0046**] Distance "d" is determined as appropriate according to the requirements of each individual patient, and may depend upon various factors, including the size of the patient or any injury that the patient may have suffered. For example, in patients with fractured hips or hip replacements, an abduction pillow as shown in **FIG. 8***b* is often kept between the patient's legs to prevent dislocation of the hip joint. Using the bipedal embodiment as described, thigh pads **801***a* and **801***b* may be adjusted to the correct distance "d" to maintain the patient's hip position and eliminate the need for an abduction pillow.

[**0047**] As shown in **FIG. 9**, an additional embodiment of the invention comprises an adjustable connection between thigh pad **901** and drive mechanism support frame **915**, allowing the overall length of the apparatus to be adjusted to accommodate each particular patient's leg size. In the embodiment shown, the adjustable connection comprises telescoping tubes **923** which may be slidably adjusted to a distance "**1**" so as to properly position the patient's thigh in thigh pad **901** and the ankle in ankle pad **903**. However, the invention is by no means limited to this particular embodiment, and the adjustable connection may be any means which allows the distance "**1**" to be maintained between thigh pad **901** and support frame **915**.

[**0048**] The invention may also be adapted for use by patients in an upright, sitting position (for example, during a long airplane flight). In the embodiment shown in **FIG. 10***a*, the patient is shown lying down with the leg located in the apparatus in the optimal knee-bent position, supported by thigh pad **1001** and ankle support **1003**. Foot **123** rests against foot pedal **1009**. In **FIG. 10***b*, thigh pad **1001** and ankle support **1003** are detached from the apparatus, and the position of foot pedal **1009** is adjusted to accommodate foot **123** for a patient in the upright position.

[**0049**] As shown in the detailed view of **FIG. 11***a*, foot pedal **1009** has two positions in this embodiment: one for sitting and one for lying down. For the sitting position, ankle support **1003** (see **FIG. 10***a*), which in this embodiment is attached through a slot **1027** in housing **1029**, may be detached from the apparatus. A flip-stand **1031** helps to position foot pedal **1009** for comfortable use in the sitting position. As shown in **FIG. 11***b*, flip-stand **1031** rests against underside **1039** of housing **1029**, but may be flipped out in the direction shown by arrow A to form a support which raises the front of the housing from the ground (see **FIG. 10***b* and **FIG. 11***a*). In this embodiment, ankle support **1003** is vertically adjustable using height adjustment control **1033**, and the speed of the drive motor may be controlled by use of a speed control dial **1035**. Two monopedal versions of this embodiment may be joined together through an attachment bar (not shown) connected through tandem-bar socket **1037** to create a bipedal version.

[**0050**] Another embodiment of the invention is shown in a front view (**FIG. 12***a*) and back view (**FIG. 12***b*). Foot pedal **1209** and vertically adjustable ankle support **1203** are attached to housing **1229**. Vertical height of ankle support is adjusted through height adjustment control **1233**, and motor may be controlled through speed control switch **1235**. Thigh support **1201** is attached through connection rod **1223** to support frame **1215**. Length may be adjusted, or thigh pad **1201** and connection rod **1223** may be detached from support frame **1215**, using adjustment knob **1241**.

[**0051**] In another embodiment, shown in **FIG. 13***a*, the position of foot pedal **1309** may be adjusted through a height adjustment knob **1343**. As shown in the detailed view of **FIG. 13***b*, turning height adjustment knob **1343** causes foot pedal **1309** and mechanism **1349** to be raised or lowered along threaded rod **1345**. As the height changes, mechanism **1349** rotates at pivot point **1347**, and foot pedal **1309**, which is attached to mechanism **1349**, changes position.

[**0052**] Other embodiments or variations are possible without going beyond the scope of the invention as described herein. For example, the invention could be adapted to a different bipedal version that would work similarly to the monopedal embodiment as shown in **FIG. 1**, having a single motor driving two pedals either in a parallel fashion or in an opposing fashion (one pedal up, one down). Another type of reversible motor could be used, or even a nonreversing motor, driving the arm back and forth through a crank. The embodiment as shown in **FIG. 10***b* could be adapted to attach to the back of a seat in an airplane, train, bus, car or other conveyance for use by travelers. An embodiment in which the motor is replaced by a pneumatic pump is possible, where the pneumatic pump supplies energy to the drive mechanism as required. The spring provides an optional exercise function and a safety factor. The exercise function would be excluded and the safety factor accomplished by either a torque-limiting device or a torque- or power-sensing circuit. The pivoting arm with the pad on it could be replaced by an arced piston or arced member with

gear teeth on it that would move in and out of a device, but still roughly match the motion of the foot being rotated about the ankle.

[0053] It is apparent from the foregoing that the present invention achieves the specified objects, as well as the other objectives outlined herein. While currently preferred embodiments of the invention have been described in detail, it will be apparent to those skilled in the art that the principles of the invention are readily adaptable to a wide range of other pedal-actuated anti-embolic devices without departing from the scope and spirit of the invention.

We claim:

1. An apparatus for exercising a leg, comprising:

means for supporting the leg so that the sole of the foot rests against a movable member, and the weight of the lower leg is not resting on the calf muscle or the back of the knee joint;

said movable member being secured in relation to said supporting means;

means for applying an oscillatory force to said movable member.

2. The apparatus of claim 1, further comprising;

compressible means for linking said oscillatory means to said movable member, said compressible means limiting said force applied by said oscillatory means to said movable member, and providing a mode whereby said foot may apply a force to move said movable member in opposition to said force applied by said compressible means.

3. The apparatus of claim 2, wherein said linkage of said compressible means is unidirectional.

4. The apparatus of claim 3, wherein said compressible means comprises a torsion spring.

5. The apparatus of claim 1, wherein said movable member is pivotally attached to said supporting means.

6. The apparatus of claim 1, wherein said means for applying said oscillatory force is deactivated.

7. The apparatus of claim 2, wherein said apparatus further comprises:

second means for supporting a second leg so that the sole of the second foot rests against a second movable member, and the weight of said second leg is not resting on the second calf muscle or the back of the second knee joint;

said second movable member;

second means for applying an oscillatory force to said second movable member;

second compressible means for linking said second oscillatory means to said second movable member, said second compressible means limiting said force applied by said second oscillatory means to said second movable member, and providing a mode whereby said second foot may apply a force to move said second movable member in opposition to said force applied by said second compressible means;

means for connecting said first support means to said second support means.

8. The apparatus of claim 7, wherein said means for connecting said first support means to said second support means is adjustable.

9. The apparatus of claim 1, wherein said movable member is slidably attached.

10. The apparatus of claim 9, wherein said means for supporting the leg comprise:

a thigh support; and

an ankle support connected to said thigh support.

11. The apparatus of claim 10, wherein said ankle support is vertically adjustable.

12. The apparatus of claim 11, wherein said connection between said ankle support and said thigh support is lengthwise adjustable.

* * * * *