

[54] **SERRATED RESILIENT JOINT
ORTHOTIC DEVICE**

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[51] Int. Cl. **A61f 3/00**

[58] Field of Search **128/80 E, 80 R, 80 F;
3/32, 33; 287/86, 99, 101; 174/42, 146**

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[57] **ABSTRACT**

An orthotic device useful in supporting and assisting movement of infirm body limbs is comprised of a pair of support members interconnected for relative resilient motion by a flexure member consisting essentially of elastomeric material. The invention is particularly characterized by a serrated configuration of elements interposed in the mounting of the flexure member in operative relationship with the support members which maintains the parts suitably in place while permitting the intended resilient action.

9 Claims, 4 Drawing Figures

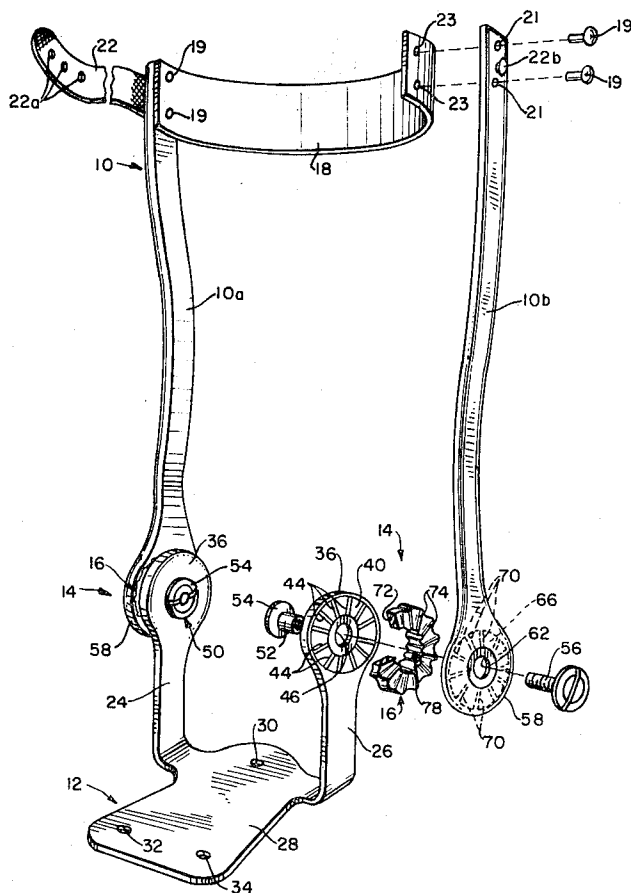
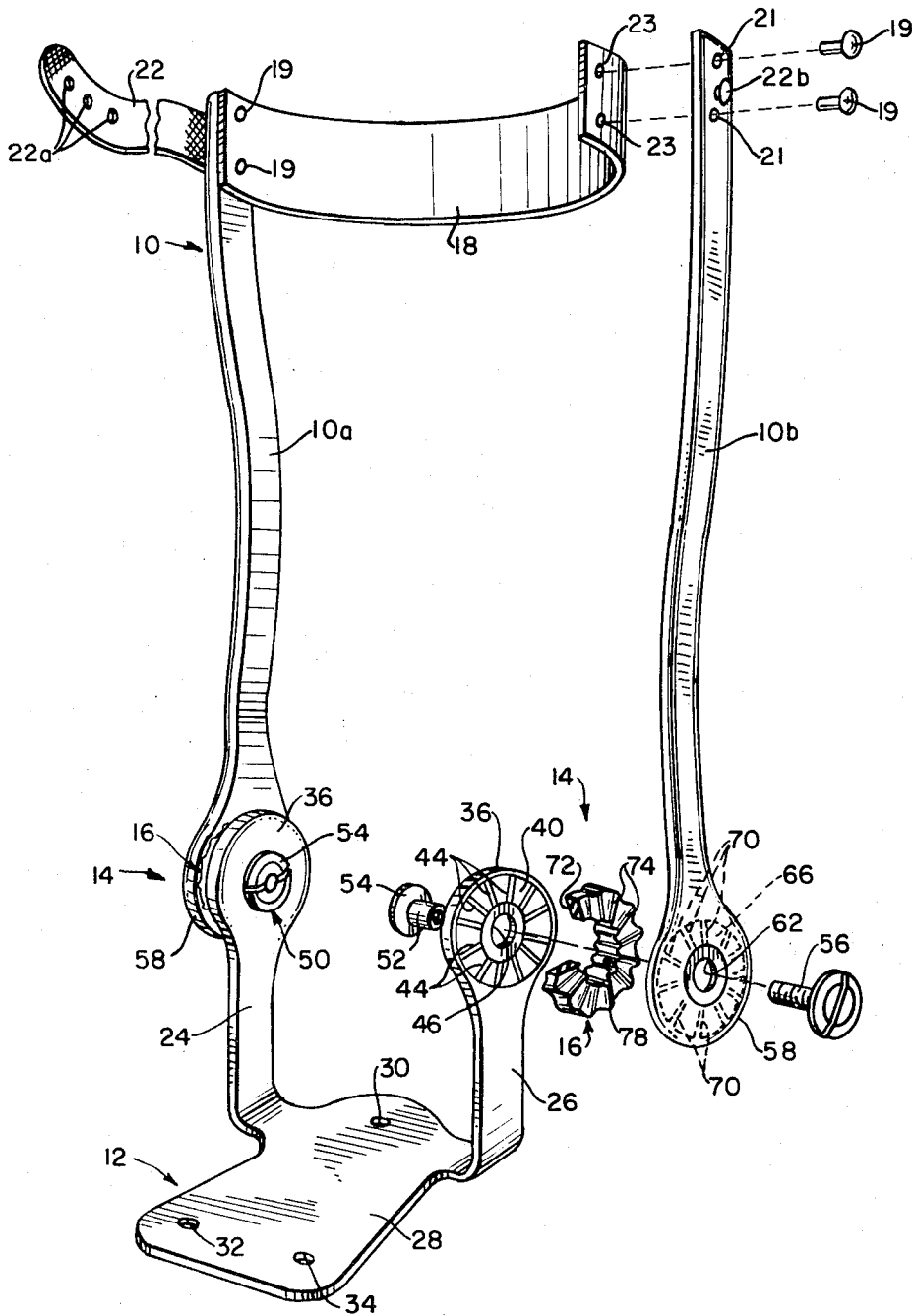


FIG. 1



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FIG. 2

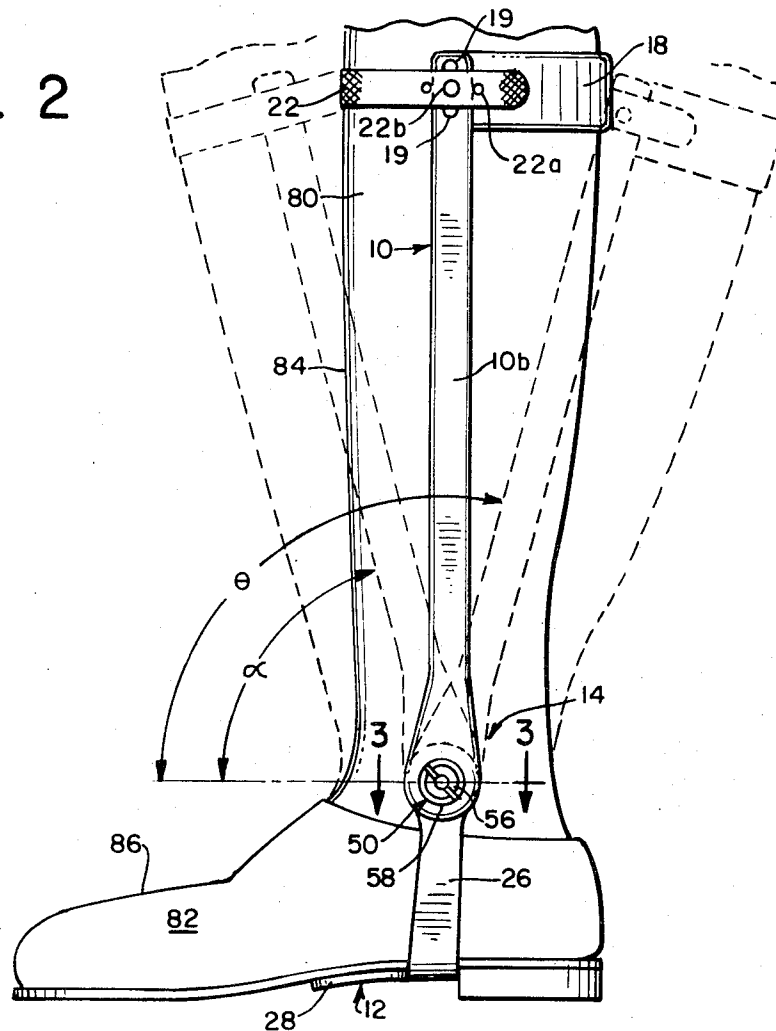


FIG. 4

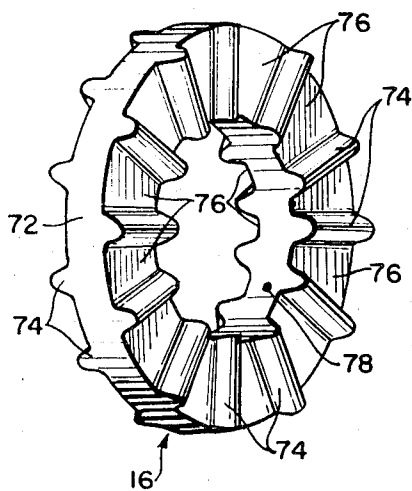
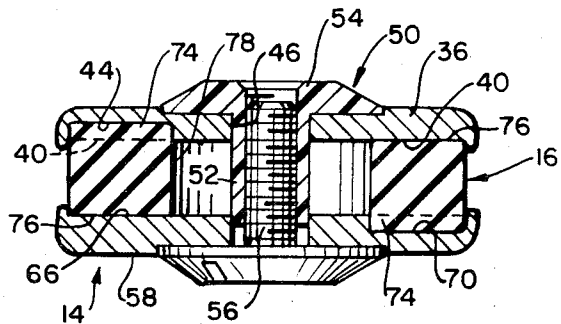


FIG. 3



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SERRATED RESILIENT JOINT ORTHOTIC DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to medical devices, and more particularly to an orthotic support for assisting movement of body limbs which are in an infirm state.

Devices of the type to which the present invention relates are normally referred to as "orthotic" in that they operate to support or assist injured or infirm body limbs as opposed to replacing a missing limb. Accordingly, the term "orthosis" or "orthotic device" as used herein is to be distinguished from a "prosthesis" which is generally defined as an artificial device to replace a missing body part or limb.

2. Discussion of the Prior Art

The present invention is related to a type of orthotic device which operates by resilient spring action in the support of infirm limbs to permit motion thereof in a manner intended to generally simulate normal motion. Such orthotic devices will usually comprise a pair of relatively movable support members attached respectively to different parts of the body, and some form of articulation means providing a resilient interconnecting spring force which is inherent in the appropriate operation of the device.

In the operation of such devices, it is required that the resilient forces imparted to the infirm limb comprise sufficient potency to assist effective functioning while avoiding excesses which might prove discomforting or injurious. Accordingly, a certain amount of adjustability and versatility of motion in the functioning of such devices is desirable and it can prove of significant disadvantage when the device is deficient with regard to these features.

Accordingly, although an orthotic device is generally intended to support a limb for motion in certain limited predetermined directions, some flexibility enabling an appropriate amount of resilient motion in other modes of movement is desirable. Such other modes should be enabled with firm support in a manner most closely resembling normal body motion.

In addition to enabling adjustability and versatility in modes of motion, the orthotic device should be as simple as possible in its arrangement so that it will function unobtrusively while at the same time being appropriately effective.

SUMMARY OF THE INVENTION

Briefly, the present invention may be described as a body support device including first and second support means each adapted for attachment to a respective body part, and articulation means interconnecting said support means in a predetermined relative position and enabling relative resilient motion therebetween, said articulation means comprising flexure means consisting essentially of elastomeric material, and serrated means interposed between said flexure means and said support means to obstruct relative slippage therebetween whereby said first and second support means may be displaced from said predetermined relative position by flexure of said elastomeric material thereby conditioning said flexure means to generate a force tending to return said support means to said predetermined relative position.

By a more specific aspect of the present invention, an orthotic foot supporting device is provided wherein said first support means are attachable to the lower leg with said second support means being attachable in a fixed position relative an infirm foot, whereby movement of said foot is supported and assisted by said relative resilient motion between said support means.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood by reference to the following detailed description of a preferred embodiment thereof taken in connection with the accompanying drawings wherein:

FIG. 1 is an exploded view in perspective showing a foot supporting device embodying the present invention;

FIG. 2 is a side elevation showing the device of FIG. 1 mounted upon the lower portion of a human leg, and depicting the positions to which the device may be actuated when in use;

FIG. 3 is an enlarged sectional view taken along the line 3-3 of FIG. 2; and

FIG. 4 is an enlarged view in perspective showing in greater detail the flexure member of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in more detail to the drawing, the device of the present invention is shown as comprising first support means 10 formed from a pair of upright elements 10a and 10b, and second support means 12 generally configured as a U-shaped stirrup member including a pair of upright elements 24 and 26. The support means 10 and 12 are interconnected for relative resilient motion therebetween by articulation means comprising a pair of joint assemblies 14. The first support means 10 include an upper semicircular brace 18 interconnected between the upper ends of upright members 10a and 10b by fasteners such as rivets 19 or the like which extend through and are secured about openings 21 and 23. A releasable strap 22 may be attached in any appropriate manner to extend between the ends of brace 18, by releasable engagement of one of three openings 22a over the enlarged raised head of a rivet 22b.

The manner whereby the orthotic device of the preferred embodiment of the present invention is most appropriately utilized is particularly depicted in FIG. 2. As shown therein, the first support means 10 is affixed to the lower part 80 of the human leg below the knee, with the second support means 12 comprised of the U-shaped stirrup member being fixed relative to a foot by securement to a shoe 82. The upright elements 10a and 10b extend upon opposite sides of the leg 80 and are secured thereto at their upper ends by the semicircular brace 18 and by the releasable strap 22 which encircles the shin 84 of leg 80. The stirrup member 12 is affixed to the shoe 82 by fastener means (not shown) which extend through the apertures 30, 32 and 34.

The preferred embodiment depicted in the drawings is particularly suitable for utilization in connection with an infirmity known as "drop foot" which is characterized by an inability to normally move the foot by flexure of the ankle in order to vary the included angle between the foot instep and the shin. For example, with reference to FIG. 2, this angle would be formed between the shin 84 and an instep 86 of shoe 82.

In the normal movement of a foot, the included angle between the shin and the instep may be varied within limits to either an acute or an obtuse angle. For example, and again with reference to FIG. 2, during normal walking, as the leg 80 is extended forwardly of the body, the angle between the shin 84 and the instep 86 is a controlled obtuse angle. This angle is labelled θ in FIG. 2, with the leg 80 shown in dotted form extending to the right of the drawing. As a step is executed and the body moves forwardly over the foot, the angle between the shin 84 and the instep 86 becomes acute. This angle is labelled α in FIG. 2, with the leg 80 shown in dotted form extending to the left of the drawing. Lifting of the foot and its forward motion to execute a subsequent step requires muscle control of the leg such that the angle between an instep and a shin be appropriately maintained during walking. The "drop foot" infirmity makes normal control of this type of foot action impossible with the result that the foot will hang in an uncontrolled condition and will flop when walking is attempted. The device depicted in the drawing acts to support and assist foot action during walking in a person afflicted with the "drop foot" infirmity. This is achieved by resilient action, to be described more fully hereinafter, between the first and second support means 10 and 12 resulting from operation of the articulation means comprised of the joint assembly 14.

In the preferred embodiment shown in the drawings, the articulation means of the invention is embodied in a pair of joint assemblies 14 interconnecting, respectively, the upright elements 10a and 10b to the stirrup 12. In the description which follows, only one of the joint assemblies 14 will be described in detail, i.e. the joint assembly 14 interconnecting the upright member 10b with the stirrup 12, it being understood that the other joint assembly 14, i.e. the one interconnecting the upright member 10a with the stirrup 12, will be generally similar in its structure and operation to the one desired. Furthermore, it should be understood that although the preferred embodiment of the invention described herein is configured with two joint assemblies 14, it would be considered as within the knowledge of those skilled in the art to construct an orthotic device utilizing either one joint assembly 14 or more than two such assemblies, without departure from the scope and purview of the invention.

The joint assembly 14 includes, as its most significant element, a flexure member 16 which, in the embodiment described herein, comprises a serrated disc consisting essentially of elastomeric material such as rubber or the like. The flexure member 16 is interposed between the support elements 10 and 12 and is resiliently deformed and returns to its original shape during operation of the device thereby enabling resilient relative motion between the support means 10 and 12.

As shown in the drawings, the upper end of each of the upright elements 24 and 26 includes an engagement section 36 each similarly formed to engage the flexure member 16, and each having a generally circular configuration with oppositely facing outer surfaces 40. The surfaces 40 each define a serrated configuration consisting of a plurality of radially extending angularly disposed grooves 44. Each of the engagement sections 36 includes a central aperture 46 adaptable to receive therethrough fastener means 50 comprising a threaded sleeve 52 including a cap end 54, and a screw 56 en-

gageable therewith in the formation of the joint assembly 14.

Each of the upright members 10a and 10b includes at its lower end a complementary engagement section 58 having an aperture 62 aligned with the aperture 46 to effect passage therethrough of the threaded sleeve and screw 52, 56 in the formation of the joint assembly 14. Each of the engagement sections 58 includes an inner surface 66 comprising a plurality of radially extending angularly disposed grooves 70 which are complementary to the grooves 44 and which operate, in a manner to be more fully described hereinafter, in cooperation therewith to operatively mount and engage the flexure member 16.

The flexure member 16 is generally formed in an annular shape with serrated surfaces on both sides thereof. As shown, the member 16 basically comprises a central annular section 72 having a generally rectangular cross section and an angularly spaced plurality of radially extending bosses 74 provided on both sides of the annular section 72. It will be apparent that each pair of radial bosses 74 forms therebetween a radially extending concavity 76, and it may therefore be said that either side of the flexure member 16 comprises a serrated configuration.

In the formation of a joint assembly 14, the flexure member 16 is positioned between a pair of the complementary engagement sections 36 and 58 with the serrated surfaces 40 and 66 engaged on opposite sides of member 16 with the serrated surfaces thereof. With the parts in this position, the radial bosses 74 will coincide with and extend into the grooves 44 and 70 to obstruct relative sliding motion between the surfaces of the flexure member 16 and the surfaces 40 and 66. It will, therefore, be apparent that the member 16 will be interlocked between the surfaces 40 and 66 in a manner which will enable resilient flexure thereof by opposing relative rotation between the support members 10 and 12.

With the engagement sections 36 and 58 appropriately positioned relative to the opposite sides of the member 16, the screw 56 and the threaded sleeve 52 may be placed to extend through the apertures 62 and 46, and through a central aperture 78 defined through the member 16. By tightening of the screws 56 into the threaded sleeve 52, the member 16 may be held in compression between the engagement sections 36 and 58 with the joint assembly 14 being retained in its operative assembled condition.

When the device of the present invention is in operation, the joint assembly 14 will permit relative resilient motion between the first support means represented by the upper support elements 10a and 10b, and the stirrup 12 by resilient deformation of the flexure member 16. For example, it will be apparent that the upright element 10b may be rotated relative to the stirrup 12 about an axis defined by the central axis of the screw and sleeve 56, 52 in a manner which will cause the material of the flexure member 16 to be resiliently deformed thereby generating a spring force tending to drive the upright member 10b to its original position. More specifically, assuming that the upright member 10b were to be rotated relative to the stirrup member 12 in a clockwise direction as viewed in the drawing of FIG. 2, the flexure member 16 will be deformed by the rotational pressures applied in opposite directions on either side thereof. Due to the engagement of the sides

of the flexure member 16 between the serrations of surfaces 40 and 66, relative sliding motion therebetween will be obstructed thereby enabling deformation of the material to occur. Since the flexure member 16 consists of elastomeric material, it will tend to return to its original shape, thereby generating a force which will tend to drive the upright member 10b back to its original position. Of course, it is to be understood that the upright members 10a and 10b will operate together, and that the foregoing description is intended to apply, with appropriate details reversed, to both the flexure members 16 depicted in their respective joint assemblies 14.

Thus, the first support means 10, comprised of the upright members 10a, 10b and the brace 18, may be rotated leftwardly and rightwardly as viewed in the drawing of FIG. 2 relative to the second support means comprised of the stirrup 12, with both the flexure members 16 operating to permit relative resilient motion between said first and said second support means 10 and 12 in both directions while exerting a spring force tending to return the members to their original relative positions.

It will, therefore, be seen that, with the device attached to a lower leg extremity in the manner depicted in FIG. 2 and as previously described, when a step is commenced with the foot extended in the forward direction, a tendency will be created to develop created obtuse angle θ between the shin 84 and the instep 86. If the leg muscles are infirm and are unavailable to support the foot to maintain an appropriate instep-shin included angle, the foot will tend to dangle uncontrollably. With the device of the present invention installed upon the lower leg extremity, the resilient force which is created between the first support means 10 and the stirrup 12 by deformation of the flexure member 16 will support the weight of the foot and assist foot movement relative to the leg 80 during walking.

In the operation of the device, the weight of the foot upon the stirrup 12 will cause relative rotation between support means 10 and 12. However, due to the resilient spring force created by deformation of the flexure member 16 caused by such rotation, there will be applied a supporting reaction force to the foot whereby relative motion between the foot and the lower leg will be controlled and supported. More specifically, as a step is taken and the included angle between the shin 84 and the instep 86 varies between acute angle α and obtuse angle θ , relative rotation between the support means 10 and 12 will alternately load and unload the flexure member 16. This will occur each time that the first support means 10 moves from the upright position, shown in solid lines in FIG. 2, to either of the dotted positions depicted therein. As this occurs, motion of the foot will be resisted and supported by the resilient spring force developed, and the foot will always tend to return to and be supported in the perpendicular position relative to the leg 80 depicted in solid lines in FIG. 2. This perpendicular relative position, whereby the included angle between shin 84 and the instep 86 is approximately 90°, and may be regarded as a set or regular position to which the parts will tend to return, and which is established by the predetermined relative positioning of the bosses 76 and the grooves 44 and 70 prior to tightening of the fastener means 50.

Thus, when a particular predetermined relative position between the first support means 10 and the second support means 12 is desired, the fastener means 50 may

be tightened with the parts held in the desired predetermined relative position. Engagement of bosses 74 within grooves 44 and 70 combined with resiliency of the material of the flexure member 16, will tend to always return the parts to this predetermined relative position upon displacement therefrom. Furthermore, it should be apparent that this predetermined relative position may be readily changed or adjusted by loosening of the fastener means 50, followed by readjustment of the parts and retightening of the fastener means 50.

As a result of the serrated configuration of the parts which operate to retain the appropriate juxtaposition therebetween, several distinct advantages are afforded by the structure of the present invention. One such advantage relates to the fact that in extreme circumstances, when the force which is applied to cause relative rotation of the members 10 and 12 becomes excessive, disengagement of the bosses 74 from within grooves 44 and 70 to adjacent or succeeding grooves is possible. Thus, in a case such as the occurrence of an accident where the foot may be forced to an extreme position, slippage will occur between the flexure member 16 and the first and/or second support means in a manner resulting, in essence, in an inadvertent readjustment of the relative position between the support means 10 and 12, thereby avoiding injury. Of course, the fastener means 50 may be subsequently loosened to enable adjustment of this relative position back to its desired condition. It should be, of course, understood that such slippage is intended to occur only during abnormal conditions, and that under normal circumstances no slippage between the flexure member 16 and the support means 10 and 12 should occur.

It has been found that in normal operation utilizing the device of the present invention as depicted in FIG. 2, the maximum overall relative rotation between the support means 10 and 12 which should normally occur without slippage will be about 30°. That is, the limits of movement of the first support means 10 relative to the second support means 12 will vary between approximate angular values of α equals 70° and θ equals 105°. Of course, these limits will be dependant upon the resiliency of the elastomeric material utilized and the depth and configuration of the bosses 74 and of the grooves 44 and 70, but in general it has been found that the limits set forth above are most appropriate and preferred for optimum foot support in the embodiment described.

An additional advantage of the invention exists due to the fact that some lateral or twisting motion may occur between the support means 10 and 12 enabling greater comfort while the device is being worn. For example, the member 10b is affixed to the stirrup 12 only by the sleeve and screw fastener 56, 52. Since this connection is not rigid and is limited to maintenance of an appropriate compressive force upon the flexure member 16 which is applied only about the central axis thereof, there may occur some limited lateral and twisting motion between the support means 10 and 12. This motion would include, for example, twisting of the member 10b about its longitudinal axis in a manner whereby the flexure member 16 would be compressed on one side and have a lesser compressive force applied to its opposite side. Additionally, the entire first support means 10 may be laterally driven to tilt slightly to the left or right, when viewed from the front or rear of the wearer. This might occur, for example, by side to

side motion of the leg relative to the foot. When this occurs, the flexure members 16 will once again be compressed or decompressed, respectively, at the upper or lower portions thereof. It will be apparent that this type of motion will enable some versatility in the types of movement which the user may execute thereby enhancing the comfort experienced when the device is worn while simultaneously providing positive, firm foot support.

It will also be apparent that an added advantage of the invention resides in the fact that the flexure members 16 can be readily and easily replaced merely by disengagement of the fastener means 50 and reengagement thereof with a new member in place. Thus, when it is desired to alter the degree of spring force which the device will deliver, this can be accomplished merely by replacement of a member 16 with another member of different material providing a different resiliency characteristic. Of course, replacement of a member 16 may also be necessitated by wear and breakdown of the material, and in either case replacement or substitution thereof is facilitated by the structural arrangement of the present invention.

In the selection of materials for the flexure member 16, the choice will depend upon the particular application involved and it will be apparent that a wide variety of elastomeric materials can be utilized. In the preferred embodiment described herein, the material utilized is rubber and it has been found that materials providing a variety of resiliency characteristics may be suitably adapted for utilization in the device of the invention. For example, it was found that rubber discs available from Uniroyal Corporation under the designation Finger-Flex Mountings and designated in their catalogue 900 as Ring Styles 1504A, 1504B, 1504C and 1504D having a Durameter reading from soft to hard, respectively, of 30, 40, 50 and 60 were effectively utilized and are available for application in the present invention.

It is to be understood that although, in the foregoing description, the specific embodiment of the present invention was described as a foot support device, the invention is intended as having application to devices for supporting other parts of the body and is not to be limited to devices for foot support. Furthermore, it will be clear that the serrated structure of the joint assembly 14 may be applicable in a variety of other devices operable in a manner similar to that of the device described.

Accordingly, although the present invention has been described by reference to a specific structural embodiment thereof, it is to be understood that many variations and modifications within the knowledge of those skilled in the art are possible without departure from the scope and purview of the invention.

What is claimed is:

1. A body support device including first and second support means said first support means comprise a pair of upright members including means for attaching said first support means to the lower leg above the foot, said second means comprise a stirrup member including means for mounting said second means in a fixed relationship relative to said foot, and articulation means interconnecting said first and second support means in a predetermined relative position and enabling relative resilient motion therebetween, said articulation means comprising:

flexure means consisting essentially of elastomeric material;

serrated means interposed between said flexure means and said support means to obstruct relative slippage therebetween, said serrated means being located at interfacing surfaces of said flexure means and said support means;

said flexure means comprising a pair of serrated surface portions located upon opposite sides thereof with said first support means comprising a serrated surface portion mating with one of said flexure means serrated surface portions, and with said second support means comprising a serrated surface portion mating with said other flexure means serrated surface portion, said flexure means being mounted between said first and second support means with said mating serrated surfaces in interfacing relationship; and

means for securing said first and second support means to each other in said predetermined relative position for enabling said relative resilient motion of said first support means in a plurality of different planes with respect to said second support means; whereby said first and second support means may be displaced from said predetermined relative position by flexure of said elastomeric material thereby conditioning said flexure means to generate a force tending to return said support means to said predetermined relative position.

2. A support device according to claim 1 wherein said serrated means obstruct relative sliding motion between said interfacing surfaces of said flexure means and said support means within a limited degree of relative motion therebetween, but permit such relative sliding motion when said support means and said flexure means are driven to move relative to each other beyond said limited degree.

3. A support device according to claim 1 wherein said serrated means comprise a surface portion of said flexure means having a serrated configuration.

4. A support device according to claim 1 wherein said serrated means comprise a surface portion of said support means having a serrated configuration.

5. A support device according to claim 1 wherein said serrated means comprise mating interfacing serrated surfaced defined, respectively, upon said flexure means and said support means.

6. A support device according to claim 1 wherein said securing means comprises means releasably securing said first and second support means in any one of a plurality of said predetermined relative positions and enabling said relative resilient motion therebetween in each of said plurality of predetermined relative positions whereby said predetermined relative position may be varied.

7. A body support device according to claim 1 particularly suited to support an infirm foot wherein said flexure means comprises a pair of flexure members each mounted between said stirrup member and a respective one of said upright members whereby said device may provide resilient support for said infirm foot during walking.

8. A support device according to claim 7 wherein said support device is mounted with said flexure members positioned upon opposite sides of said foot, said securing means enabling flexure of said elastomeric material by variation of an included angle between the

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upper instep side of said foot and the front shin portion of said lower leg, and simultaneously permitting to a significantly lesser extent lateral and twisting motion of said foot relative to said lower leg.

9. A support device according to claim 1 wherein said flexure means serrated surface portions each include a plurality of ribs and said support means ser-

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rated surface portions each include a plurality of corresponding complementary grooves, said ribs being mateable in said grooves, said flexure means ribs on one surface portion being out of phase in position along said surface with respect to said flexure means ribs on the other serrated surface portion on said opposite side.

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