Sept. 11, 1951 E. C. ELLERY 2,567,195

ORTHOPEDIC DROP FOOT BRACE

Filed March 5, 1946 2 Sheets-Sheet 1

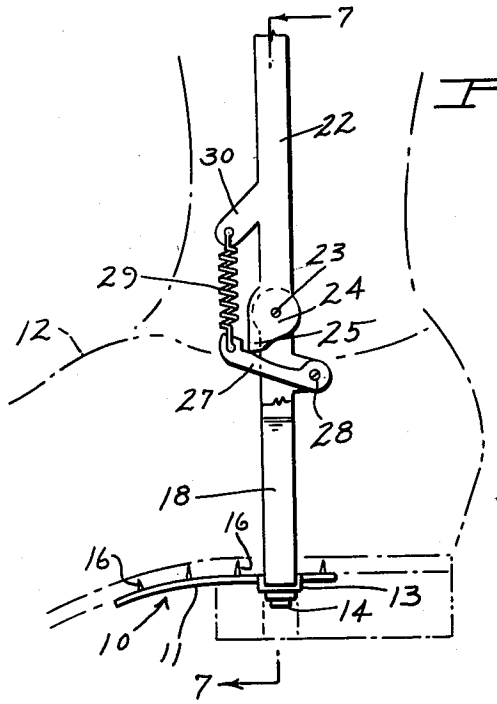


Fig. 1

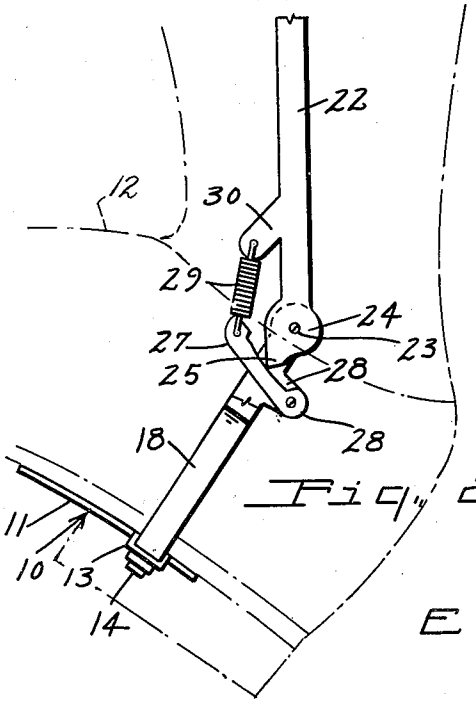


Fig. 2

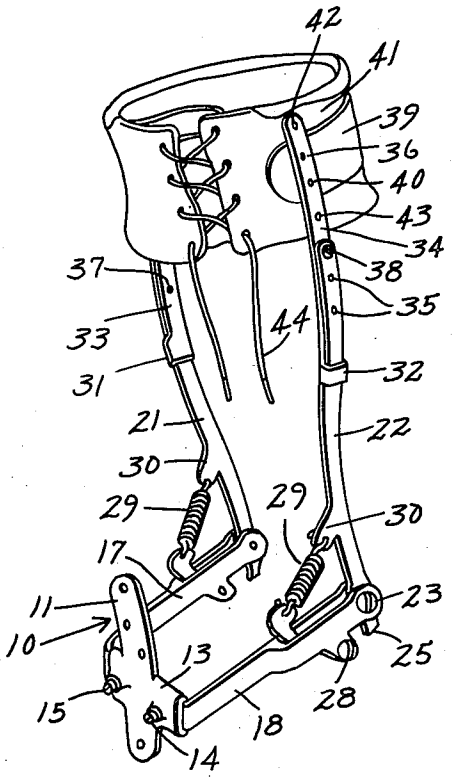


Fig. 3

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ORTHOPEDIC DROP FOOT BRACE

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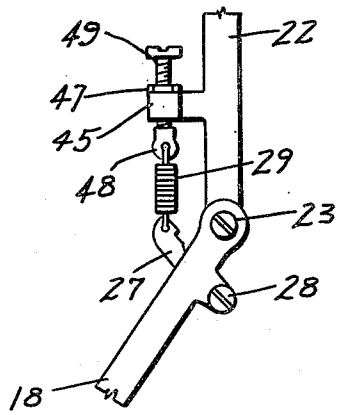


Fig. 4

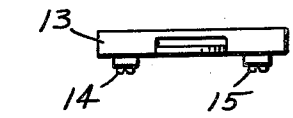


Fig. 6

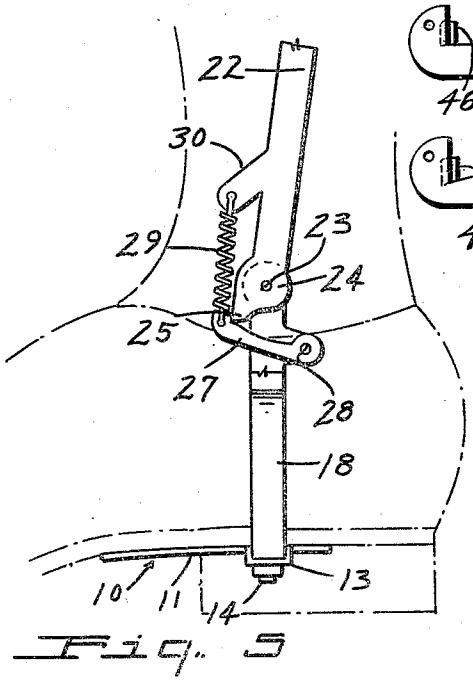


Fig. 5

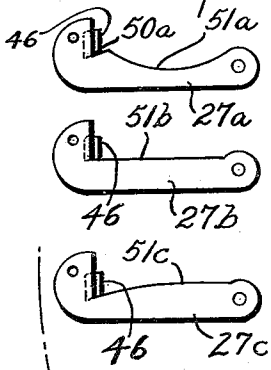
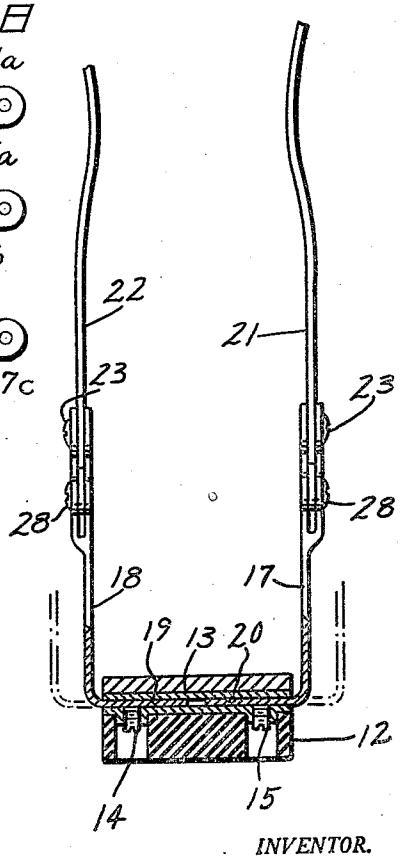


Fig. 8

Fig. 7



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ORTHOPEDIC DROP-FOOT BRACE

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Application March 5, 1946, Serial No. 652,016

10 Claims. (Cl. 128—80)

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My present invention relates to a brace, and has reference more particularly to an orthopedic brace for use in the correction of paralysis of leg muscles which control the lifting of the foot.

Paralysis of certain leg muscles which control the lifting of the forward portion of the foot about the ankle, produces a condition known as "drop-foot." This condition is a frequent result of poliomyelitis, and one having a drop-foot is unable to walk satisfactorily without using some means for preventing the toe from dropping down, since the natural tendency is for the toe of the foot to hang down and drag along the ground at each step.

Various expedients have been used to make it possible for one having drop-foot to walk and get about. One such expedient comprises an elastic cord having one end thereof secured to the toe of the wearer's shoe and the other end secured to the wearer's leg below the knee. With this device the toe portion of the foot is raised automatically at each step. This arrangement provides a constant upward resilient tension on the toe of the foot, and such action tends to hold the toe portion of the foot raised even when the person is not walking. This stretches the muscles at the back of the leg, thereby causing discomfort, and tending to elongate these rear-of-leg muscles.

Another expedient comprises the use of a brace which holds the foot in fixed position relatively to the leg at the ankle. Still another expedient involves the use of a brace having a hinged foot piece with a stop set to limit the degree of downward pivotal movement allowed the toe of the foot. None of these devices approximates even remotely the natural movements of the foot during walking.

It is extremely desirable that the foot be permitted as much freedom of movement as possible, since in walking the pivotal action of the foot about the ankle tends alternately to stretch and release the paralyzed muscles, thus in effect exercising them. This action is of great benefit as it helps to re-educate the nerves and muscles of the affected leg and thereby aids in restoring these muscles to use in many instances, particularly when the paralysis is a result of poliomyelitis. It also promotes proper circulation of the blood in the paralyzed limb, and thus helps to prevent atrophy of the limb.

With the exception of the elastic cord, the above enumerated devices for use in cases of drop-foot either prevent entirely or limit quite definitely the movement of the foot about the ankle joint. The use of the elastic cord is not

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only so conspicuous as to make its use undesirable by most people, but also it is not capable of use by those having spastic tendencies since in such cases the spastic action would force the foot downward and would overcome the tension of the elastic cord.

An object of the present invention is to provide an improved drop-foot brace, which will reduce the need for the wearer to raise the hip to swing the leg through a step and also will reduce limp.

Another object is to make a drop-foot brace providing for toe raising action during a forward step, and having a restrictive effect against such toe raising action in an attitude of rest.

Another object is to make a drop-foot brace which will lift the foot in a natural manner with each step taken, and will permit the foot to assume a normal position of rest when the wearer is not walking.

Another object is to construct a drop-foot brace which will have toe raising characteristics during a movement of the leg relatively to the foot which normally precedes a forward step, but which characteristics will be restrained upon moving the leg relatively to the foot to a position which is normal to sitting or standing still.

Another object is to make an improved drop-foot brace which can be adjusted for lateral internal clearance without changing its action characteristics.

Another object is to make a swivelled ankle brace with an improved arrangement for securing it removably to a wearer's shoe, so that it can be worn with any of several pairs of shoes.

These and other objects and advantages of the invention will be apparent from a perusal of the following description of a specific embodiment of the invention, and the accompanying drawings thereof, in which like reference characters are employed to designate similar parts throughout the various views.

Referring to the drawings, of which there are two sheets:

Fig. 1 is a fragmentary view in side elevation of the lower portion of a drop-foot brace embodying the present invention, showing the brace mounted on a shoe of a wearer, the shoe and ankle of the wearer being indicated in dotted lines, as they would appear with the wearer seated or standing in a normal upright position, a portion of a joint portion of the brace being broken away to show the construction of the joint;

Fig. 2 is a view similar to that of Fig. 1 with

the lower portion of the brace swung forwardly to the limit of toe-up movement.

Fig. 3 is a view in perspective of the complete brace assembly with the lower portion of the brace moved pivotally to an extreme forward position as it would appear when removed from the wearer's leg, and without the stirrup plate secured to a shoe;

Fig. 4 is a fragmentary view of a joint portion of the brace showing a modified adjustable spring support member;

Fig. 5 is a fragmentary view similar to that of Figs. 1 and 2, showing the lower portion of the brace in its extreme rearwardly pivoted or toe-down position;

Fig. 6 is a view in rear elevation of a stirrup member for mounting on the shoe of a wearer as shown in Fig. 1;

Fig. 7 is a vertical sectional view taken on the line 7—7 of Fig. 1; and

Fig. 8 is a view in elevation of three differently contoured cam levers which may be used to vary the action of the brace for variations in the requirements of the wearers.

In the particular embodiment of the invention illustrated, a stirrup member 10 comprises an elongated strap portion 11 which is curved to fit beneath a shoe 12, and which is fastened by screws 16 to the sole and heel of a shoe on which it is mounted. The stirrup member 10 has a transverse socketed portion 13 with set screws 14 and 15 mounted one near each end thereof. The socketed member 10 is mounted to lie substantially beneath the ankle joint of a wearer of the device.

A pair of lower side brace members 17 and 18 are formed with the lower end portions 19 and 20 thereof bent inwardly at right angles, these lower end portions being shaped to have a telescoping fit in the side openings of the socketed member 10. The upper end portion of each of the lower side brace members 17 and 18 is divided to receive the lower end of one of a pair of upper side brace members 21 and 22 therebetween. A pivot pin 23 secures the upper and lower brace members of each side together for free pivotal movement. The joint thus formed is located so as to be substantially co-axial with the ankle joint of the wearer, although it frequently is desirable to have the axis of this brace ankle joint offset forwardly a slight amount from the axis of the wearer's ankle.

The lower end portion of each of the upper side brace members 21 and 22 extends downwardly below the pivotal connection of the joint. This lower end portion is shaped, as best illustrated in Fig. 1, in the form of a cam 24, the lower end or nose 25 of which engages a cam lever 27. Each of the cam levers 27 is pivoted at its rearward end to a lug 28 which projects rearwardly from each of the lower side brace members 17 and 18. The forward end of each of the cam levers 27 is connected by means of a tension spring 29 to a lug 30 which projects forwardly from each of the upper side members 21 and 22.

The tension of the spring 29 on the lever 27 tends to rotate the lower side brace members to a toe-up, or in clockwise direction, from the position of Fig. 1. However, this same tension causes frictional engagement of the cam nose 25 with the cam lever 27 which resists this movement. By changing the shape of the cam surface on the cam lever 27, the action characteristics of the brace can be varied as required to

suit the needs of each individual for whom the brace is required.

The upper surface of the cam lever 27 and the nose portion 25 of the cam 24 are hardened to resist wear since, in the use of the brace, the nose of each cam will travel back and forth along the upper surface of its associated cam lever at each step of the wearer. Furthermore, the cam levers should be made of tough, strain resisting metal, such as chrome vanadium steel, in order to withstand the very considerable stresses to which they are apt to be subjected at times.

It is desirable that the cams 24 be ground carefully to accurate shape and dimensions. A plurality of cam levers 27 in the various shapes in which they will be required should be available to one fitting the braces so that the fitter may be able to provide any of several desired action characteristics in the brace. A number of springs 29 of suitable tensions should likewise be available, since variation in the spring tension also affects the action of the brace. In such manner, one skilled in fitting these braces may, after conducting necessary tests, fit the brace to a wearer's requirements as accurately and as scientifically as, for example, the fitting of a pair of eyeglasses for a known eye condition.

The upper side brace members 21 and 22 as illustrated are constructed so as to be adjustable as to length. In order to provide this adjustability, the lower end portions 31 and 32 of each of a pair of extension members 33 and 34 are formed in the shape of keepers to receive the upper end portions of the side brace members 21 and 22 therein. The upper end portions of the side brace members 21 and 22 are each provided with a plurality of openings 35 therein and the extension members 33 and 34 are each provided with a threaded opening 37 therein, see Fig. 3.

Screws 38 are provided which pass through a selected opening 35 in the side brace member 21 or 22 and threadedly engage the threaded opening 37 in the extension member to secure these members together at a height suitable for the wearer.

A thin, flexible spring metal band 39 is riveted as at 36 and 40 to the upper ends of the extension members 33 and 34 and is adapted to pass around the rear of the calf of a wearer's leg. A padded leather lacing member 41 is secured, as by rivets 42 and 43, to the inner side of the flexible metal leg band 38 and is adapted to be laced around the wearer's leg by means of a lacing cord 44.

The full measure of adjustability of the brace thus provided insures proper fit which is essential in the prevention of atrophy, which frequently is considered a result of a poorly fitting brace. This arrangement also provides support for a person whose knee tends to bend backward into a so-called "back knee" when placing one's weight on it. In such case, the cam nose 25 abuts against the foward end of the cam lever 27, as shown in Fig. 5, and supports the leg against back knee bending.

In the modified spring mounting arrangement illustrated in Fig. 4, a lug 45 extends forwardly from each of the upper side brace members 21 and 22 with a vertical internally threaded hole therein through which a spring tension adjusting screw 49 is threaded. A lock nut 47 is provided to secure the screw in an adjusted position. An eye member 48 is swivelled on the lower end of the screw and the spring 29 is hooked into the open-

ing in the eye member and also into a hole in the forward end of the cam lever **27**.

In fitting the brace to a wearer, the fitter, who should be a thoroughly trained and experienced person, should be supplied with a complete report of requirements from the wearer's doctor. All necessary measurements should of course be taken, and the patient's foot and leg actions should be tested. The proper size brace should then be selected, and the socketed stirrup member **10** may be applied to the wearer's shoe. In view of the full adjustability provided by the present brace, it has been found that only three sizes of brace will be necessary in order to be able to fit most persons for whom the brace may be required.

The stirrup member **10** should not be secured finally in place on the shoe until after a trial fitting of the brace has been made to insure that its position on the shoe is such as to locate the brace, and particularly the axis of pivotal movement of the joints **23**, in proper relation to the wearer's foot and ankle.

It is a feature of the present brace that it is capable of being fitted properly even over a badly swollen ankle. As illustrated in Fig. 7, it will be noted that the inturned lower end portions **19** and **20** of the lower side brace members **21** and **22** may be inserted less than their full length in the socketed stirrup member, and may be secured in such partly inserted position by the set screws **14** and **15**. On reduction of the swelling in the ankle, the only adjustment required will be to move the end portions **19** and **20** more fully into the sockets to bring the side brace members closer together.

The fitting of the brace should be carefully checked after it has been worn a few days to insure that the shoe sole is wearing properly. If not; for example, if it is wearing more on one side than on the other, the stirrup member **10** should be reset on the shoe to correct the deficiency. This point is important as a matter of service, since it is the practice of some brace fitters to attempt adjustments by bending the various brace members. While such methods may be necessary and desirable with some types of braces, it is not considered either necessary or desirable for the present brace, which approximates quite closely the natural muscle controlled movements of the foot and ankle.

Where the particular requirements of a wearer call for a rather positive lock in the full toe-down position with little restrictive action by the cam on a toe-raising movement of the brace, a cam such as that shown at **27***a* at the top of Fig. 8 may be required. This cam lever has a notch **50***a* in the forward end of the cam surface **51***a* to act as a latch to hold the foot rather securely in toe-down position, although of course it is releasable by bending the leg forward at the ankle in the natural movement precedent to taking a forward step. The cam surface **51***a* of this cam is concave, which reduces frictional action by the cam during a toe-raising operation of the device under the action of the tension spring **29**.

On the other hand, if the wearer has some use of his rear calf muscles, a cam lever such as that shown at **27***b* in the center of Fig. 8 may be required. This cam lever has no toe-down notch but rather strong frictional action will be provided in the toe-down position by the straight upper cam surface **51***b*. In another case it may be desirable to make the cam lever with a high rear portion and with a slight convex curve such

as that indicated by the numeral **51***c* on the cam lever **27***c* at the bottom of Fig. 8.

It is desirable that these and other shapes of cam levers shall be available to the fitter, together with data showing the action characteristics produced by each design of cam. Such data will be merely the charting of test results on the various types of cams and with different spring tensions. However, these tests have not been completed and such data therefore is not available at this time.

In using the brace, the three principal attitudes of a wearer thereof are sitting, standing, and walking.

Whether one is paralyzed or not, a normal sitting position is one wherein the feet are placed flat on the floor and the lower legs are substantially upright as shown in Fig. 1. This attitude is permitted by the present brace with no tendency on the part of the brace to lift the toe, since the cam action between the rearward portion of the cam surface on the cam lever and the nose of the cam counteracts the normal tendency of the spring to raise the toe beyond this normal position. Any movement of the toe above this normal position moves the nose of the cam back beyond the low point of the cam surface on the lever, thereby forcing the cam lever downward and stretching the spring. If a cam lever is shaped to have a pronounced downward and rearward slope on the forward end thereof as shown in the cam lever **27***a*, Fig. 8, this low spot should be located so that the nose of the cam **25** will be in the low point of the cam when the brace parts are in a desired normal position relatively to each other. Usually this normal position will be with the upper and lower brace parts in substantial alignment with each other as shown in Fig. 1.

When rising from a sitting to a standing position, one's feet will be brought inwardly or rearwardly beneath the body, and the body will be shifted forwardly on the seat, so as to bring the weight of the body over the feet. In this position the feet still will be flat on the floor, but the lower legs will be bent forwardly. The relative positions of the feet and lower legs then will be as shown in Fig. 2, but with the entire view swung in a counterclockwise direction to bring the foot flat on the floor.

In the standing position, the feet and lower legs again will assume the attitude shown in Fig. 1.

The action of the brace may best be visualized by considering the three separate and distinct forces that affect its action within the limits of movement of the body joint which the brace controls. In the form illustrated this is the ankle.

These three forces are; first, tension of the spring eccentrically of the joint pivot which tends (*a*) to rotate the brace members in a direction to shorten the spring, and also (*b*) to swing the spring connected end of the cam lever upwardly about its pivot; second, cam action under the impulse of the spring which tends to rotate the brace members to urge the nose of the cam toward the low side of the cam surface, which also lets the cam lever swing upwardly about its pivot, and; third frictional engagement of the nose of the cam with the cam surface on the lever which tends to hold the brace parts against relative rotative movement.

With respect to the first of the above forces, the constant tension of the spring **29** tends to

draw the spring-connected end of the cam lever toward the spring support lever 30. If the cam lever were fixed in position relatively to its brace member 18 like the spring support lever 30 is to its brace member 22, then on a toe-down pivotal movement the ends of the supports would be separated to stretch the spring, and on a toe-up pivotal movement the reverse would occur.

With respect to the cam action, where, as in lever 27 and in lever 27a (Fig. 8) the forward portion of the cam surface of the cam lever slopes downwardly from the left hand or front end of the cam surface toward a low point rearwardly thereon, the cam action assists the spring action to swing the brace parts toward a toe-up pivotal movement.

Beyond this low point of the cam, however, continued pivotal movement of the joint causes the nose of the cam to move rearward on the cam lever, and ride up on a rearwardly upwardly sloping surface of the cam. This tends to force the cam lever downwardly about its pivot 28, thereby increasing the distance separating the lever 30 from the spring connected end of the cam lever and stretching the spring. Since the cam action alone of this rearwardly rising portion of the cam surface would tend, of itself, to swing the joint in the opposite direction from that induced by the tension of the spring alone, these two forces counteract each other. This allows the frictional engagement of the nose of the cam with the cam lever to exert a braking action against pivotal movement of the joint which tends frictionally to hold the brace parts in any adjusted position in which the nose of the cam is rearwardly of a low spot and riding on a rearward upward sloping cam surface.

In walking, as the leg is raised and swung forward and planted on the ground ahead of the other, the foot will remain in the position it was in when it left the ground. The frictional engagement between the cam nose 25 on the rearward upwardly sloping cam surface of the associated cam lever will retain the foot in such position during the forward swing of the leg. The retention of the foot in the relatively slightly toe-up position in which it leaves the ground on a forward step insures that the toe will be kept thus raised sufficiently to clear the ground if the shoe is properly mounted on the stirrup in the first place. If the ground is slightly rough, for example an unpaved area, the wearer can increase the elevation of the toe during a forward swing of his leg, by bending his knee slightly before raising his foot on the forward step.

The cam, acting as a frictional positioner to hold the foot in the toe-up position for the forward swing through of the leg in taking a step, automatically compensates for slight variations in the slope of the surface being walked over. For example, when one is walking on the level the toe must be raised to a certain angular position relatively to the lower leg in order to clear the ground on each forward swing through of the leg. In walking up a slight incline however, if the toe should be raised only to that same relative angular position it will not clear the ground, but will cause one to stub his toe. With the present brace, however, when walking up a slight incline, the increased slope of the ground causes the wearer to tilt his body further forward relatively to the ground, than when walking on the level. This causes the nose of the cam to travel further back on the cam lever, and, by frictionally holding the foot at this increased elevation, automatically leaves the toe in a higher position upon raising the foot for each step for the swing through. Wearers of a brace embodying the present invention who formerly, with other braces, had difficulty in negotiating such inclines, now have no such trouble.

Regardless of how much the toe is elevated for a forward step, when the foot reaches the forward end of the swing through, and the weight of the body is placed on it, the foot will tend to swing down to lie flat on the ground.

The extreme limit of toe-down movement permitted by the cam lever stop shown in Fig. 5 is only slightly below the normal position of Fig. 1. Such a limit of toe-down movement would be necessary only in cases where the wearer has strong spastic tendencies. The limit of toe-down movement can be increased as desired, of course, by moving the stop provided by the vertical forward face of the cam lever further forward. This can be accomplished by filing or grinding away this stop a required amount, or by providing a longer cam lever.

With a hard metal cam and cam lever, a slight clicking noise may be produced as the cam nose strikes the stop at the forward end of the cam lever upon reaching the limit of toe-down movement. In order to eliminate this noise, a bumper, which may be in the form of a pad 46, is shown mounted on the stop face at the forward end of the cam lever. This pad may be of any suitable material, such as fibre or rubber.

While I have illustrated and described a specific form of my invention, and also some modifications thereof, it will be apparent to those skilled in the art that the device is capable of several other modifications without departing from the spirit and scope of the invention. It is desired, therefore, not to limit the invention except as defined in the following claims.

I claim:

1. An orthopedic brace comprising an upper brace member, means for securing the upper brace member to the leg of a wearer, a lower brace member, means for securing the lower brace member to the foot of a wearer, an ankle joint connecting the upper and lower brace members, a spring support mounted to project from one of said brace members, a lever pivoted to the other of said brace members, a cam carried by the brace member having the spring support, the cam having a nose portion engaging a side of the lever, and a spring engaging the spring support and the lever to draw the lever into graduated cam and braking engagement with the cam during a relative pivotal movement of the brace members about the joint.

2. An orthopedic brace comprising an upper brace member, means for securing the upper brace member to the leg of a wearer, a lower brace member, means for securing the lower brace member to the foot of a wearer, an ankle joint connecting the upper and lower brace members, a spring support mounted to project from one of said brace members, a lever support mounted to project from the other of said brace members oppositely from the spring support, a lever pivoted on the lever support and having a free end thereof projecting beyond the brace to which it is connected in the direction of the spring support, said lever having a cam surface formed thereon, a cam carried by the brace member other than that having the lever pivoted thereon, said cam being positioned to have braking engagement

with the cam surface on the lever, and a spring mounted between the spring support and the lever to urge the brace members pivotally about the joint toward a predetermined angular position relatively to each other.

3. In an orthopedic brace having an upper brace member, a foot piece pivoted to said member, substantially at ankle height, comprising a stirrup member adapted to be secured to the sole of a shoe, said stirrup member having a pair of laterally disposed sockets therein, a pair of side brace members insertible one in each of said sockets, and securing means acting between said stirrup member and each of said side brace members releasably securing said side members in adjusted position in said sockets.

4. An orthopedic brace comprising a pair of upper brace side members, a pair of lower brace side members pivotally connected one to each of said upper side members substantially at ankle height, the lower ends of said lower side members being bent inwardly at right angles toward each other, a stirrup member having a planiform portion adapted to be secured beneath a shoe, said stirrup member having a pair of laterally disposed sockets to receive the inwardly bent lower end portions of said side members therein, and securing means acting between the stirrup member and said side members adjustably to secure said inturned end portions to said stirrup member in different degrees of insertion, thereby to vary the inner clearance between said side members.

5. An orthopedic drop-foot brace comprising an upper brace member, means for securing the upper brace member to the leg of a wearer, a lower brace member, means for securing the lower brace member to the foot of a wearer, a freely pivoted ankle joint connecting the upper and lower brace members, a spring support mounted to project forwardly from one of said brace members, cam brake means including a lever pivotally mounted to project forwardly from the other brace member, a tension spring operatively connecting the spring support and said lever in a line longitudinally offset from the ankle joint pivot, said cam brake means lever being positioned relatively to said ankle pivot to frictionally engage a portion of said upper brace member to provide a gradually increasing braking action during relative pivotal movement of the brace members about the joint in a toe-down direction.

6. An orthopedic drop-foot brace comprising an upper brace member, means for securing the upper brace member to the leg of a wearer, a lower brace member, means for securing the lower brace member to the foot of a wearer, a freely pivoted ankle joint connecting the upper and lower brace members, a spring support mounted to project laterally from one of said brace members, a pivoted lever mounted to project laterally from the other of said brace members, a spring connecting the spring support to the free end of said lever, and a cam brake member carried by said one brace member and positioned to have varying spring-pressed braking engagement with said lever during a pivotal movement of the brace members about said ankle joint pivot, thereby to provide gradually increasing braking action during relative movement of the brace members about the joint in a toe-down direction.

7. An orthopedic drop-foot brace comprising an upper brace member, means for securing the upper brace member to the leg of a wearer, a lower brace member, means for securing the lower brace member to the foot of a wearer, a freely pivoted ankle joint connecting the upper and lower brace members, a cam secured to one brace member to move pivotally therewith, a spring pressed lever carried by the other brace member to move pivotally therewith, and positioned frictionally to engage said cam eccentrically of the ankle joint pivot to have graduated pivot-braking engagement therewith, to provide a gradually increasing braking action during a relative pivotal movement of the brace members about the ankle joint in a toe-down direction.

8. A joint for an orthopedic appliance comprising in combination; an upper brace member adapted to be secured to a body limb above the location of a limb joint, a lower brace member, a freely pivoted joint connecting the upper and lower brace members, a first cam member mounted to rotate with one of said brace members and disposed radially outwardly from the pivotal axis of said joint, a cooperating cam member having a cam surface thereon mounted on the other brace member to rotate therewith about the pivotal axis of said joint, and resilient means mounted cooperatively to urge the first cam member and the cam surface of the cooperating cam member toward each other.

9. An orthopedic brace comprising an upper brace member constructed and arranged to be attached to the leg of a wearer, a lower brace member pivotally connected to the upper brace member and constructed and arranged to be attached to the shoe of a wearer, brake means on said members for resisting pivotal movement of the members, said brake means including a stationary element on one of said members and a movable element on the other of said members frictionally engaging the stationary element, and a resilient means connected between the member carrying the stationary element and the movable element of the other member for operating said movable element, said resilient means being so positioned with respect to the pivotal connection between said members as to urge said members pivotally to a predetermined position.

10. An orthopedic brace comprising an upper brace member constructed and arranged to be attached to the leg of a wearer, a lower brace member pivotally connected to the upper brace member and constructed and arranged to be attached to the shoe of a wearer, a lever pivoted to one of said brace members, a cam carried by the other brace member, the cam having a nose portion engaging a side of the lever, and a spring connecting the lever to said other brace member to draw the lever into graduated braking engagement with the cam during a relative pivotal movement of the brace members.

EMMETT C. ELLERY.

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