46. Stud 90 is used in attaching ankle 34 and foot 10 to the artificial limb or stump of the amputee wearing the foot 10. Stud 90 can move within slot 46 in the directions indicated by arrows 94, 96, (FIG. 11). Longitudinal movement of stud 90 within slot 46 provides a means for adjusting the point of attachment between the artificial limb and plate 42. The adjustability of this point of attachment is helpful since persons of varying weights require varying points of attachment. For example, a very obese person having a large concentration of body weight in the anterior aspects of the body could achieve more natural movement with the ankle if stud 90 were positioned slightly anteriorly to the position of post 44. However, a lighter person could more comfortably and naturally achieve locomotion if stud 90 were placed a few millimeters more in the anterior direction 94. Exact positioning of stud 90 is often a matter of trial and error, but the adjustability of the point of attachment represents a significant advance in the art of biomechanical ankles by recognizing the varying requirements of patients.

In operation, foot 10 is affixed to ankle 34 using nuts 40 threaded in snug engagement on bolts 33. Stud 90 is then fixedly attached to an artificial limb or human stump using tightened nuts (not shown) threaded on stud 90. The position of stud 90 within slot 46 is determined by calculation or trial and error positioning of stud 90 at different places in the directions of arrow 94 or 96.

Once the foot 10 and ankle 34 are attached to the wearer, locomotion can begin. As previously explained, post 44 should in operation be disposed substantially colinearly with the trochanter-knee-ankle (TKA) line of the patient, preferably 3 to 7 millimeters posterially to the TKA line. The walking cycle, by definition, will begin at the point of heel contact. As the heel 14 of foot 10 contacts the ground, the coil 82 of ankle 34 will assume the extended position shown in FIG. 2. At the point of "toe off", just before the swing phase of the walking cycle, coil 82 will be at its maximum depression, as shown in FIG. 4. At an intermediate stage of the walking cycle between those stages shown in FIGS. 2 and 4, the spring will assume a neutral position, such as that depicted in FIG. 3. Use of the coil spring gives a degree of control to the wearer of ankle 32 that largely approximates the muscular control a person usually has over a natural foot. The resilient, anterior support provided by this coil is a significant advance over the prior art.

At the beginning of the walking cycle, inversion occurs as shown in FIG. 14. During the arc-like transfer of weight from the lateral to the medial aspect of the sole, the plate 36 will pass through a substantially flat, intermediate position as shown in FIG. 13. Progressive eversion then occurs until plate 36 assumes a position similar to that shown in FIG. 12.

Lateral rotation is also occurring simultaneously with dorsiflexion-plantar flexion and inversion-eversion to provide smooth movement of the ankle 34, thereby imitating the natural movements of a human ankle.

A second, less preferred embodiment of the invention is shown in FIGS. 15–17. This embodiment is similar to that shown in FIGS. 1–8 and 11–14. A substantially flat, rectangular sole plate 100 is elongated along the longitudinal axis of the foot and is adapted for attachment to an elongated base embedded in the artificial foot (not shown, but similar to base 28 described above). A substantially rectangular limb supporting plate 102 is elongated along the longitudinal axis of the foot and held in spaced, substantially parallel relationship to plate 100. Plates 100, 102 are made of steel and are of appropriate dimensions to fit within an artificial foot. Plate 100 is provided with an upwardly inclined toe 104.

Plates 100, 102 are held in spaced, substantially parallel relationship by an upright post 106 that is positioned for placement substantially colinearly with the trochanter-knee-ankle line of an amputee (see FIG. 9). The post 106 and plate 102 are coupled with a ball and socket joint 108. The most natural point for placement of post 106 is 3–7 mm posterior to the TKA line.

A helical spring coil 110 is disposed anterior to post 106 and is disposed in fixed engagement between plates 100, 102. The inferior edge 112 of coil 110 is fixed to plate 100 in a lower collar 114 which is provided with an internal groove (not shown) in which edge 112 is fixedly disposed. Superior edge 116 of coil 110 is fixed to plate 102 in similar fashion, being fixedly disposed within an internal groove of upper collar 118. The longitudinal axis of coil 110 is offset from a vertical plane by 5°–10°, superior edge 116 of spring 110 inclining toward the medial aspect of the amputee's body.

A threaded stud (not shown) similar to stud 90 disposed in a longitudinal slot may be used to affix the ankle shown in FIGS. 15–17 to an amputee or artificial limb. However, a fixed stud may also be used.

Having described my invention, what I claim as new and desire to secure Letters Patent for is:

1. A biomechanical ankle for use in an artificial foot adapted for attachment to an amputee, said ankle comprising:

a. a substantially flat sole plate adapted for attachment to said artificial foot;

b. a limb supporting plate held in spaced, substantially parallel to said sole plate by an upright post that is positioned for placement substantially colinearly with the trochanter-knee-ankle line of said amputee, a joint member disposed between at an upper end portion of said post and the limb supporting plate, said joint member rotatably coupling the post to the limb supporting plate such that the sole plate and the limb supporting plate can rotate in any direction about the post with respect to each other; and

c. a spring positioned anterior to said post and disposed in fixed engagement between said sole plate and limb supporting plates, one end portion of the spring being fixed to said sole plate and the other end of the spring being fixed to said supporting plate.

2. The biomechanical ankle of claim 1 wherein the spring having a longitudinal axis offset from the vertical plane by 5 degrees–10 degrees with a superior end of the spring being inclined toward the medial aspect of said amputee body.

3. The biomechanical ankle of claim 1 further provided with adjustment means for selectively adjusting the position of attachment between said supporting plate and the amputee.

4. The biomechanical ankle of claim 3 wherein said adjustment means is comprised of a screw threaded stud with an enlarged head, said head being disposed in sliding engagement within an elongated longitudinal slot in said supporting plate, the diameter of said head being greater than the width of said slot, said stud extending upwardly from the surface of said supporting plate.