Jan. 5, 1971 C. WOODALL 3,551,914

NATURAL ACTION TOE LIFT ARTIFICIAL FOOT

Filed May 9, 1968

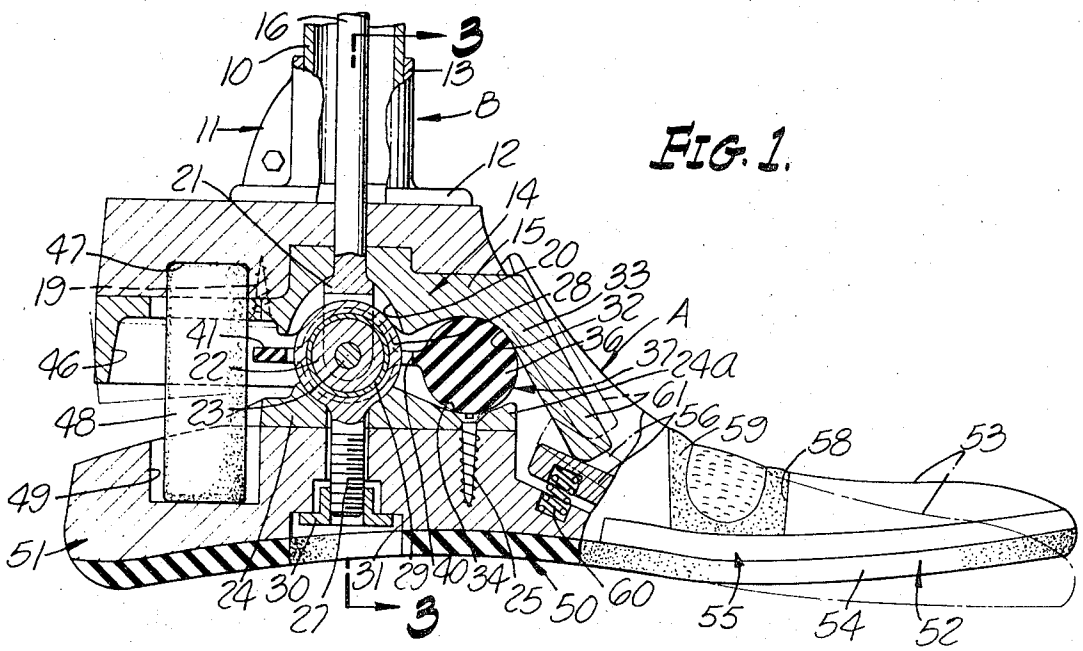


FIG. 1.

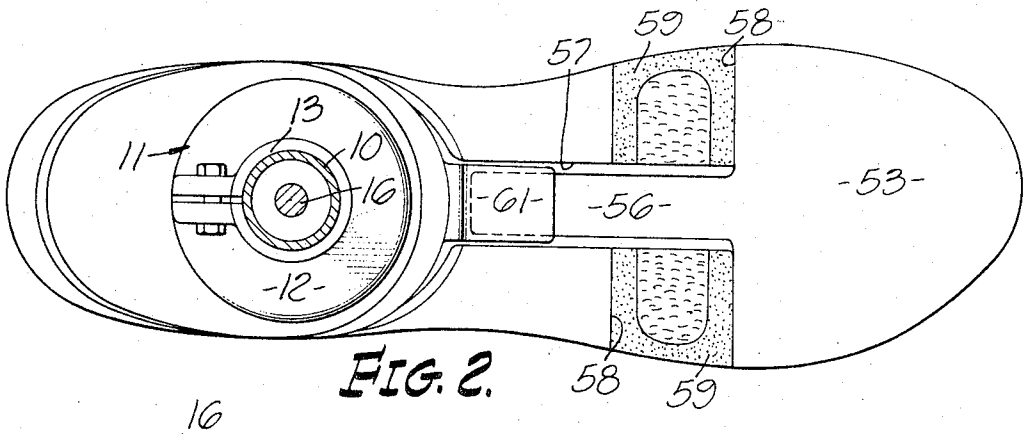


FIG. 2.

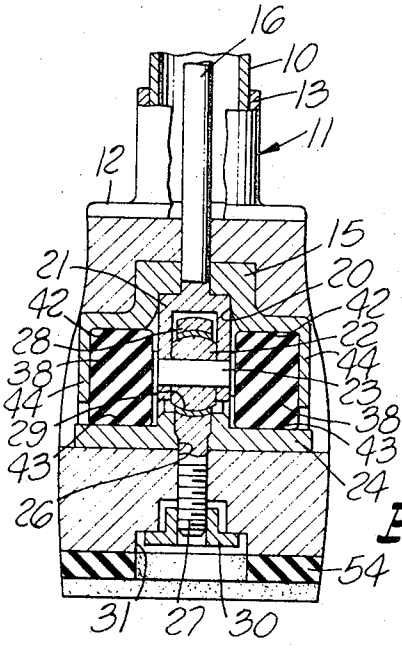
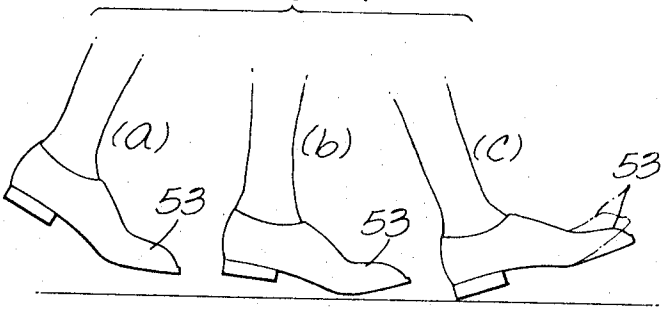


FIG. 3.

FIG. 4.



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NATURAL ACTION TOE LIFT ARTIFICIAL FOOT

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U.S. Cl. 3—6 9 Claims

ABSTRACT OF THE DISCLOSURE

An artificial foot having a natural toe lift, in which a hinged toe section of the foot is interconnected with a pivotally connected shank member through a motion transmitting connection so that the toe section will be raised and lowered in a natural manner during the walking process, resilient means being utilized to effect articulated movement between the shank member and foot to raise or lift the toe section when walking pressure upon the heel section of the foot is relieved, and lower the toe section when walking pressure is applied to the heel section.

BACKGROUND OF THE INVENTION

The present invention relates to the field of artificial body members, particularly the foot.

Heretofore, artificial limbs have in the main embodied a foot structure having a hinged toe section adapted to flex during the walking process. This flexing of the toe section resulted solely from the application of pressure and withdrawal of pressure in the toe section when walking. Such known structures are exemplified by the arrangement disclosed in my United States Letters Patent No. 2,731,645, and the present invention constitutes an improvement over the arrangement shown in this and similar prior art patents.

In the patented structure, it will be observed that the toe section in the absence of any applied pressure thereon, normally will assume a non-lift or lowered position, but as the weight is shifted from the heel to the toe section, during walking, the toe section will flex in a normal manner. However, in raising the foot to take another forward step, the toe section will straighten out and assume a normal or lowered position. In order to swing the foot forward without dragging the toe section, it became necessary for the wearer of the device to raise his hip in a most unnatural manner so that the extended toe section in its lowered position would clear the ground during the forward swing of the foot.

In the structure of the present invention, the undesirable action required in a walking process as explained above for the heretofore known devices has been overcome by providing a structure wherein the toe section is automatically raised or upwardly tilted during the forward swing of the foot. The walking process is thus possible of accomplishment in a normal and natural manner, without having to resort to artificial movements of the hip or other part of the body.

SUMMARY OF THE INVENTION

The present invention relates generally to artificial body members, and is more particularly concerned with improvements in the foot part of an artificial leg or limb structure, and especially in the action of the toe section.

Having in mind the inherent disadvantages of the prior art devices as previously explained, it is one object of the present invention to provide in an artificial limb, a foot section in which the toe lift has a controlled natural action, and which permits the walking process to be accomplished smoothly and naturally.

A further object of the herein described invention is to provide an improved artificial foot wherein a toe section is controlled in its movements to a raised position and to be a lowered position in a natural manner in response to the action of associated parts of the leg or limb and foot during the walking process.

Another object is to provide a foot having a swingable toe section in which toe lift and reverse movements are coordinated with respect to the relative movements of an interconnected shank and foot part during the walking process.

Still another object is to provide an articulated artificial foot of simple construction, and with a movable toe section having a natural and smooth operating characteristic.

Further objects of the invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing the invention without placing limitations thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the accompanying drawings, which are for illustrative purposes only:

FIG. 1 is a side elevational view of an artificial foot structure embodying the features of the present invention, portions being shown in section to disclose the cooperative relationship of certain of the parts;

FIG. 2 is a top plan view of the same;

FIG. 3 is a sectional view taken substantially on line 3—3 of FIG. 1; and

FIG. 4 is a view diagrammatically illustrating different positions of the foot and the operation of the toe section during the walking process.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more specifically to the drawings, there is shown in FIG. 1 an artificial foot structure A embodying the features of the present invention, the foot structure being operatively connected with an associated shank structure B which forms a part of an artificial leg or limb.

As best seen in FIG. 1, the shank structure includes a cylindrical spacer member **10** having its lowermost end seated in appropriate socket means **11** fabricated of suitable material, but preferably of metal formed to provide an attaching flange **12** and an upstanding tubular clamping type extension **13** adapted to receive and clamped to the lowermost end of the spacer member **10**. The flange **12** connects with an ankle unit, indicated generally at **14**, and thus provides for articulated movements between the foot structure A and the shank structure B. The ankle unit **14**, as will be described herein, conforms in general to that disclosed in the hereinbefore mentioned Pat. No. 2,731,645.

The ankle unit includes a shank plate **15** secured to the adjacent end of the shank structure by means of a bolt **16** which extends upwardly through the spacer member **10** and is secured by suitable means (not shown) to the associated limb structure. The shank plate is further secured to the shank structure by means of screws **19** which prevent rotation of the shank plate relative to the adjacent end of the shank structure. The shank plate is provided with a recess **20** adjacent the center thereof, in which is disposed a clevis **21** formed integral with the adjacent end of the bolt **16**. Between the side members of the clevis is disposed a ball **22**, this ball being secured between the clevis members by a rivet **23**.

The foot structure A is provided with a foot plate **24** secured to the foot by screws **25** and provided with a forward extension **24***a*. The foot plate also has an opening **26** therein, which tapers upwardly and outwardly at the front and back, and in which is received a bolt **27** having an eye **28** with a bearing **29** which engages the ball **22** to thereby form a universal ball and socket connection. The bolt **27** is secured by a nut **30** which is disposed in a recess **31** in the bottom of the foot structure.

The shank plate is provided adjacent the front end with a transversely extending recess **32** which is concave in cross section and defined at the front by a depending portion **33**. The extension **24***a* of the foot plate **24** is also provided with a transverse recess **34** which corresponds to the recess **32**. The recesses **32** and **34** receive a transversely extending cylindrical instep portion **36** of a shock absorber and control cushion indicated generally at **37**. The cushion also includes a pair of aligned cylindrical torque and lateral action portions **38—38**, which are spaced apart as shown in FIG. 3 to provide space for the ball and socket joint therebetween. The cylinders **36** and **38** are formed of any suitable resilient material such as rubber, and are connected together by a web **40**. The opposite sides of the cylinders **38** are also connected together by a web **41**.

The shank plate **15** is provided with recesses **42** on opposite sides of the recess **20**, and the foot structure is provided with corresponding recesses **43**. The recesses **42** and **43** are concave in cross section and receive the respective cylindrical portions **38—38** of the cushion **37**. The outer end of each of the recesses **42** is provided with a flange **44** which engages the respective sides of the portions **38** and retain the cushion **37** in position.

The rear end portion of the shank plate **15** is provided with a recess **46** which has an opening in the bottom thereof in register with the recess **47** in the shank for reception of one end of a bumper **48**. The opposite end of the bumper is received in a recess **49** in the heel of the foot structure, said bumper being of any suitable resilient material such as rubber or the like.

In use, the portion **36** will yield under compressive action between the bottom of the recesses **32** and **34**, and the portions **38—38** permit limited torque action and lateral action which together with the ball and socket, provide the various actions required and effect close simulation of the actions of the natural ankle. It has been found that this mechanism permits the foot to accommodate itself to uneven surfaces in a most natural manner.

In the ankle joint described above, the universal ball and socket is adapted to be the primary weight-carrying part. The shank plate **15** is carried by the shoulders at the upper end of the clevis **21**, and the foot plate **24** carries the weight transferred through the ball and socket connection.

It is desirable to have the ankle swing in the same plane as the plane of swing of the knee joint. However, the foot of the individual does not necessarily have the same alignment. With some individuals, the toe may be turned inwardly, while in others, it might be turned outwardly. Thus, the foregoing described structure provides means whereby the ankle joint will swing in the same plane as the plane of swing at the knee joint while at the same time, positioning the foot in accordance with the natural position of the individual's foot. The positioning of the foot is accomplished by attaching the foot plate **24** to the foot structure so that it will have the normal position without interfering with the position of the ball and socket joint of the ankle with respect to its plane of swing.

It will now be observed that the ankle unit is positioned in an instep section **50** which lies between a heel section **51** and toe section **52** so that the heel section and toe section will alternately receive applied pressure during the walking process, and will be affected in their operation at the beginning and end of each step. Advantage is taken of the functional operational characteristics of the heel and toe sections to provide controlled movement of the toe section so that it will have a natural raising or lift and lowering, as will now be explained.

As shown in FIGS. 1 and 2, the toe section includes a swingable toe cap member **53** constructed of wood or other appropriate material. This toe cap is attached to the underlying sole member **54** of appropriate flexible material which thus provides a flexible hinge connection **55**

between the toe cap and the instep section. As shown in FIG. 2, the toe cap carries a projecting integrally formed tongue **56** which extends towards the ankle unit and is positioned within a slot **57**. At the hinge connection, the adjacent confronting portions of the toe cap and the instep portion are spaced apart to provide lateral cavities **58—58** on opposite sides of the slot **57** to permit flexing movements of the toe section. These cavities may be used to receive suitable filler members **59—59** of sponge like or other material for providing the desired configuration in the hinged area. At the outer end of the tongue **56**, there is provided a resilient member in the form of a compression spring **60** which normally urges the toe section in a clockwise direction with respect to the hinge **55**, as viewed in FIG. 1.

The shank plate **15** of the ankle unit is provided with an integrally formed tongue portion **61** which extends forwardly into the slot **57** to a position in which its outer end portion overlies the adjacent end portion of the tongue **56**. As thus arranged, the tongues **56** and **61** comprise lever members which function as transmission means to coordinate movements of the shank structure B and the toe section **52** during the walking process, in a manner which will hereinafter be described in detail.

As will be seen in FIG. 1, under normal conditions in which the foot structure is out of contact with a surface during the walking process, the urging force of the bumper **48** is above the effective urging force of spring **60** with respect to the toe section, and as a consequence the toe section will be automatically moved to a raised position as shown in full lines in FIG. 1. However, when walking pressure is applied at the heel section **51**, compression of the bumper member **48** will relatively move the tongue **61** with respect to the tongue **56** to positions which will permit the compression spring **60** to move the toe section to a position as shown in phantom lines in FIG. 1. It will also be apparent that in the phantom line position of the toe section, which is the extreme lowered position, the urging force of the resilient bumper **48** is ineffectual in opposing the action of compression spring **60** to move the toe section to the limit of its lowered position.

With an arrangement as just described, the positioning of the toe section will be automatically accomplished during the walking process, and the toe section will be raised and lowered smoothly in a natural manner. This is a great advantage and permits the user to walk without the necessity of having to resort to unnatural movements of the hip or other parts of the body during the walking process. In FIG. 4, the operation of my improved foot structure is diagrammatically illustrated. As shown at (*a*), the foot is shown as having completed its movement to the rear end of the walking step. At this point the foot has been raised for forward movement to the beginning of the next step. It will be observed that since there is no contact of the foot with the underlying surface, the action of the resilient means will be such as to elevate the toe section to the position shown in FIG. 1. With the toe section thus elevated, the foot may swing forwardly in a natural manner, and the elevated toe section will thus travel freely without dragging or contacting the underlying surface, as would be the case if the toe section were not elevated and was in the position shown in phantom lines in FIG. 1. The foot is thus movable through the intermediate position (*b*) to a forward position of the stride as shown at (*c*). At this position, as the heel section is brought into contact with the under surface, the resilient bumper **48** will be compressed so as to change the relative position of the tongue **61** with respect to the tongue **56**, and permit the latter under the urging of spring **60** to automatically move the toe section to the position indicated in phantom lines. As the weight is gradually shifted from the heel section to the toe section, the toe section is free to flex towards its raised position, or be moved towards the raised position by the forward swinging movement of the shank structure B relative to the foot structure A.

Thus the action of the toe section will be natural as the body moves forward.

From the foregoing description and drawings, it will be clearly evident that the delineated objects and features of the invention will be accomplished.

Various modifications may suggest themselves to those skilled in the art without departing from the spirit of my invention, and, hence, I do not wish to be restricted to the specific form shown or uses mentioned except to the extent indicated in the appended claims.

I claim:

1. The combination, comprising:
   (a) an artificial foot having a heel section, and a toe section connected for swinging movements between a raised position and a lowered position;
   (b) shank forming means;
   (c) ankle joint pivot means positioned between said heel section and toe section connecting said shank means and foot for articulated movements;
   (d) a motion transmitting connection between said shank means and said toe section; and
   (e) spring means, including a compression resilient member rearwardly of the ankle joint pivot means, for relatively urging the heel section and the shank means in opposite directions and moving the toe section to its raised position, when walking pressure on the heel section is relieved, and to its lowered position, when walking pressure is applied on the heel section.

2. The invention according to claim 1, wherein the spring means further includes a resilient member forwardly of said ankle joint.

3. The invention acording to claim 2, wherein the resilient members urge said toe section in opposite directions.

4. The invention according to claim 2, wherein the resilient member rearwardly of the ankle joint means urges the toe section towards said raised position, and the resilient member forwardly of the ankle joint means urges the toe section towards said lowered position.

5. The invention according to claim 4, wherein said motion transmitting means includes parts for rendering said rearward resilient member ineffectual in the fully lowered position of said toe section.

6. The combination, comprising:
   (a) leg shank forming means including a shank plate having a forwardly extending tongue;
   (b) foot forming means including a heel section and a toe section hingedly connected to the heel section for movements to raised and lowered positions, said toe section having a rearwardly projecting tongue;
   (c) ankle forming means including a pivot connection providing articulated movement between said shank plate and said heel section; and
   (d) said tongues coacting through a sliding interconnection to move the toe section to its raised position in response to forward swinging movement of the shank means and shank plate relative to said heel section on said pivot.

7. The combination according to claim 6, wherein the outer end of the shank plate tongue overlies the outer end of the toe section tongue.

8. The combination according to claim 7, including biasing means rearwardly of the ankle means pivot forcing the heel section away from said shank plate.

9. The combination according to claim 8, including spring means forwardly of the ankle means pivot forcing the tongue of the toe section in a direction towards the tongue of the shank plate.

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