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ARTIFICIAL FOOT (TWO LINK)

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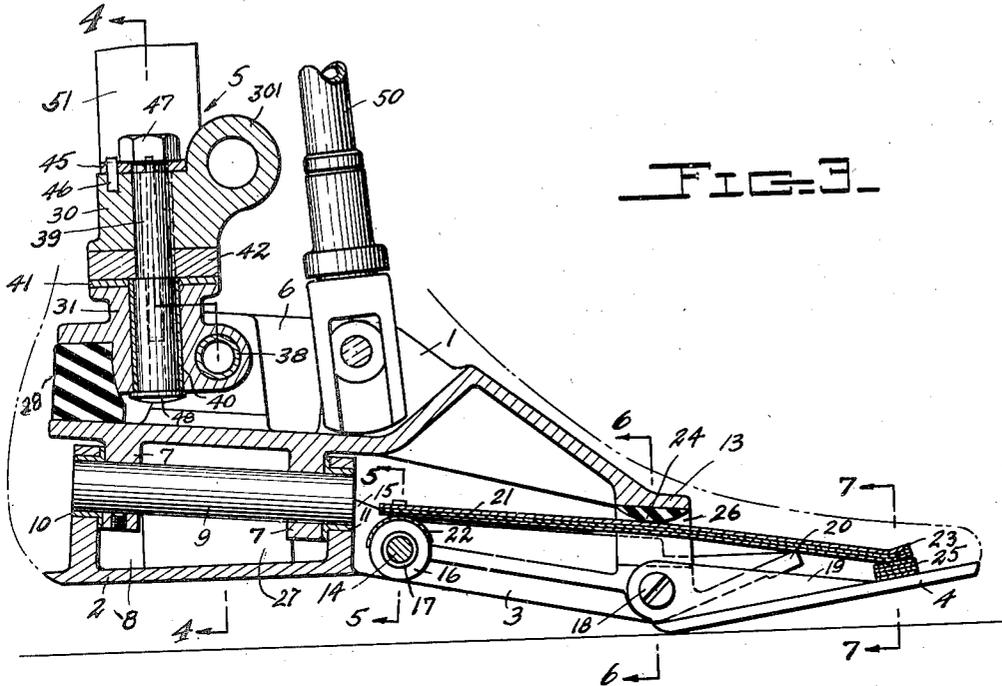


FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

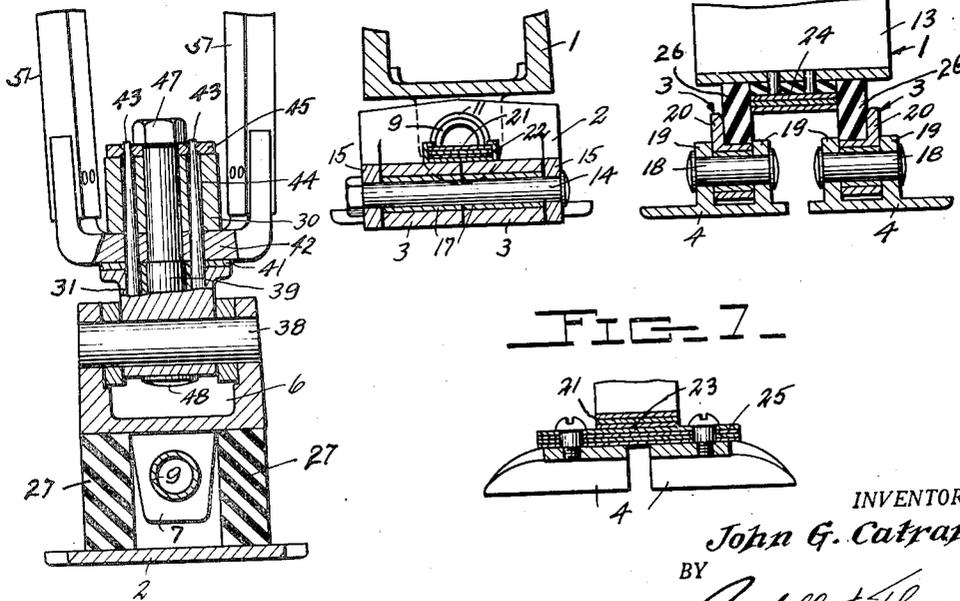


FIG. 7.

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## ARTIFICIAL FOOT (TWO-LINK)

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14 Claims. (Cl. 3-6)

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**1**  
This invention relates to artificial leg and foot structures, and has for its object a sectional foot structure, the sections of which are pivotally connected or articulated together, and have movement during the walking cycle against spring resistance, all so as to effect lateral flexion and progressive dorsiflexion.

More specifically, it has for its object a foot structure consisting of an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivotal or hinged joint, a metatarsal section consisting of right and left divisions hinged to the front end of the lower tarsus section, phalanges sections consisting of right and left divisions hinged on a transverse axis to the front end of the metatarsal divisions, the upper tarsus having a rigid forward extension overhanging the metatarsal section, and spring means interposed between the metatarsal and phalanges sections and the rigid overhanging portion of the upper tarsus section to resist pivotal movements of the metatarsal and the phalanges sections and divisions.

The invention consists in the novel features and in the combinations and constructions hereinafter set forth and claimed.

In describing this invention, reference is had to the accompanying drawings in which like characters designate corresponding parts in all the views.

Figure 1 is a side elevation of an artificial foot structure and the contiguous portion of the leg structure embodying this invention.

Figure 2 is a plan view of parts seen in Figure 1, part of the upper tarsus section being removed.

Figure 3 is a longitudinal sectional view of the foot structure and the contiguous portion of the leg structure.

Figures 4, 5, 6 and 7 are sectional views taken respectively on line 4-4, 5-5, 6-6 and 7-7, Figure 3.

The reference numeral 1 designates the upper tarsus section, 2 the lower tarsus section, 3 the metatarsal section, and 4 the phalanges section. 5 designates the contiguous portion of the leg structure.

The upper tarsus section 1 is formed with a recess 6 in its upper side, or is in the general form of a box, and is provided with depending spaced lugs 7 on its lower side which extend into a recess 8 in the lower tarsus section 2. It is pivoted or hinged to the lower tarsus section as by a forward and rearward extending pivot or spindle 9 extending through the lugs 7 into bearings 10, 11, in the adjacent walls of the lower tarsus. The

upper tarsus section is also formed with a forward extending rigid portion 13 constituting the in-step part of the foot structure, this overhanging the metatarsal section 3. The metatarsal section 3 is hinged or pivoted at its rear end at 14 to forwardly extending bearing lugs 15 at the front end of the lower tarsus section 2, this pivot extending transversely on a substantially horizontal axis. The metatarsal section 3 is here shown as formed with a bearing hub 16 extending transversely thereof and mounted on the pivot 14, there being a bushing 17 between the hub and the pivot 14. As seen in Figures 2 and 5, the metatarsal section consists of right and left divisions or links, each pivoted at its rear end at 14 to the front end of the lower tarsus section, and at 18 to one of the divisions of the phalanges section.

The phalanges section 4 is hinged at its rear end on a transverse axis at 18 to the front ends of the right and left divisions of the metatarsal section 3. As seen in Figures 1 and 6, the phalanges section 4 is composed of right and left divisions, or halves. There is a transverse pivot 18 for each division. As here shown, each division of the phalanges section is formed with a pair of upward extending bearing lugs 19 between which stop arms 20 on the metatarsal section extend, the stop arms having bearings for the hinge pins 18 which also extend through the bearing lugs 19.

The spring means for resisting the pivotal movement of the metatarsal and phalanges sections 3, 4, is here illustrated as a laminated leaf spring 21 having a saddle 22 at its rear end seated on the hub 16, the front end of the spring pressing on the phalanges section at 23, and the intermediate part of the spring being fulcrumed at 24 on the under side of the front end of the rigid extension 13 of the upper tarsus. As the phalanges section is composed of right and left divisions, see Figure 6, the front end of the spring 23 presses on a flexible fibrous bridge 25 connecting the sections, as shown in Figure 7. The stop arms 20 are located to limit the flexing action of the phalanges divisions relative to the metatarsal section 3. Rubber bumpers 26 are interposed between the forward extension 13 of the upper tarsus section and the divisions of the phalanges section, these being located above the joints 18. Also rubber bumpers 27 are interposed between the upper and lower tarsus sections 1, 2, in the recess in the latter, on opposite sides of the spindle or hinge 9. Also a rubber bumper 28 is located between the leg structure and the upper tarsus section 1 in the rear of the ankle joint.

The leg structure 5 includes a tibia member which includes upper and lower sections 30 and 31 connected together by a swivel joint located just above the upper face of the upper tarsus section. The lower section 31 extends into the upper tarsus section, or the recess 6 thereof, and is pivoted to the upper tarsus section by a transversely extending ankle joint or hinge 38, this extending crosswise and in front of the axis of the swivel joint between the sections 30 and 31. The swivel joint, as here shown, includes a pin 39 extending axially of the sections 30 and 31, a bushing 40 in the lower section 31 into which the pin extends, the bushing having an annular flange 41 overlying the upper side of the section 31, and resilient spring means for applying resistance to the turning movement of the section 30 relative to the section 31. The leg structure also includes a frame or tibia member 51 extending on opposite sides of the swivel joint, and a transverse member 42 extending between the sections 30 and 31 and thrusting against the flange 41.

As here shown, the resilient means are spring arms or prongs 43 anchored at their lower ends in the lower section 31 on opposite sides of the pin 39 and extending through the flange 41, into and through aligned arcuate slots 44 in the member 42 and the upper section 30, and into holes in a washer 45 anchored to the section 30, as by a dowel pin 46. The swivel pin 39 has heads 47 and 48 at its opposite ends for holding it from displacement. During the swiveling movement of the section 30 relative to the section 31, obviously the spring prongs 43 will have space to flex slightly within limits due to the arcuate slots 44, and resist the swiveling movement. The swiveling movement takes place when the weight of the amputee is on the artificial leg and foot, and also the pivotal movement of the upper tarsus about the axis 9 takes place while the weight of the amputee is on the artificial leg and foot, and the amputee shifts his body laterally in one direction or the other while the artificial foot is planted on the ground. The swiveling action permits the leg to change its radial angle relatively inward or outward to the foot during certain movements in walking and other shifts of the leg, these different relative radial angles being illustrated by the positions designated A, B and C, in Figure 2.

During the walking cycle, the metatarsal and phalanges sections 3 and 4 shift about their hinged axes while the amputee is applying his weight to the artificial foot and lifting the heel off the walking surface while the toe is on the walking surface, the spring 21 applying enough resistance to make the pivotal movement analogous to that of a natural foot, and also to return the sections to normal position when the amputee lifts the artificial foot from the walking surface.

The leg structure in addition to the tibia includes a fibula link 50 which performs its function analogous to that of the fibula of a natural leg. The section 30 of the leg structure has a bearing 301 for connection to a knee brake or lock forming no part of this invention.

This foot structure is particularly advantageous in that it simulates quite closely the movements of a natural foot during the walking cycle and conditions encountered in normal walking, and permits progressive dorsiflexion during walking.

What I claim is:

1. An artificial foot structure, the foot structure including an upper tarsus section and a low-

er tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and spring means between the lower tarsus section, the phalanges section and the overhanging portion of the upper tarsus section to oppose flexing of the metatarsal and phalanges sections about their hinged axes.

2. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section.

3. An artificial leg and foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and spring means between the lower tarsus section, the phalanges section and the overhanging portion of the upper tarsus section to oppose flexing of the phalanges section about its hinged axis, the leg structure including upper and lower sections swiveled together on an upright axis adjacent the upper side of the upper tarsus section, the lower section of the leg structure being connected to the upper tarsus section by a transverse ankle joint extending crosswise of the axis of the swiveled joint.

4. An artificial leg and foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section, the leg structure including upper and lower sections swiveled together on an upright axis adjacent the upper side of the upper tarsus section, the lower section of the leg structure being connected to the upper tarsus section by a transverse ankle joint extending crosswise of the axis of the swiveled joint.

5. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus sec-

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tion having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section, the leaf spring extending in a general direction in alignment with the axis of the hinged joint between the upper and lower tarsus sections.

6. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section, the leaf spring pressing at its rear end on the hinge between the lower tarsus and the metatarsal sections in the vertical plane of the axis of the hinge joint between the lower tarsus and metatarsal sections, the spring pressing at its front end on the front end portion of the phalanges section and fulcrumed between its ends on the under side of the front end of the rigid extension of the upper tarsus section.

7. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section, the leaf spring pressing at its rear end on the hinge between the lower tarsus and the metatarsal sections in the vertical plane of the axis of the hinge joint between the lower tarsus and metatarsal sections, the spring pressing at its front end on the front end portion of the phalanges section and fulcrumed between its ends on the under side of the front end of the rigid extension of the upper tarsus section, and the spring extending in a general direction in alignment with the hinge joint between the upper and lower tarsus sections.

8. An artificial leg and foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, and a leaf spring pressing at its opposite ends on the lower tarsus section and the phalanges section and fulcrumed between its ends on the under side of the rigid extension of the upper tarsus section, the leaf spring pressing at its rear end on the hinge between the lower tarsus and the metatarsal sections in the vertical plane of the axis of the hinge

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joint between the lower tarsus and metatarsal sections, the spring pressing at its front end on the front end portion of the phalanges section and fulcrumed between its ends on the under side of the front end of the rigid extension of the upper tarsus section, and the spring extending in a general direction in alignment with the hinge joint between the upper and lower tarsus sections, the leg structure including upper and lower sections connected together by a swivel joint adjacent the upper tarsus section, the lower joint of the leg structure being pivoted to the upper tarsus by an ankle joint extending transversely of the axis of the swivel joint.

9. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, the phalanges section consisting of right and left divisions pivoted independently of each other at the front end of the metatarsal section, and spring means between the lower tarsus section, the divisions of the phalanges section and the overhanging portion of the upper tarsus section to oppose flexing of the metatarsal and the phalanges sections about their hinged axes.

10. An artificial foot structure including an upper tarsus and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section including right and left divisions hinged to the front end of the lower tarsus section, a phalanges section including right and left divisions hinged on a transverse axis to the front ends of the divisions of the metatarsal section respectively, and yielding means between the lower tarsus section and the phalanges divisions to oppose the flexing of said divisions about their hinged axes.

11. An artificial foot structure including an upper tarsus and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section including right and left divisions hinged to the front end of the lower tarsus section, a phalanges section including right and left divisions hinged on a transverse axis to the front ends of the divisions of the metatarsal section respectively, yielding means between the lower tarsus section and the phalanges divisions to oppose the flexing of said divisions about their hinged axes, said yielding means being common to the divisions of the metatarsal and phalanges sections.

12. An artificial foot structure including an upper tarsus and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section including right and left divisions hinged to the front end of the lower tarsus section, a phalanges section including right and left divisions hinged on a transverse axis to the front ends of the divisions of the metatarsal section respectively, yielding means between the lower tarsus section and the phalanges divisions to oppose the flexing of said divisions about their hinged axes, said yielding means being common to the divisions of the phalanges section and including a leaf spring extending lengthwise of the metatarsal and phalanges sections and pressing at its ends on the lower tarsus sections at the joint between the lower tarsus section and the rear

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ends of the divisions of the metatarsal section, at its front end on the divisions of the phalanges section, and between its ends on the front end of the upper tarsus section.

13. An artificial foot structure, the foot structure including an upper tarsus section and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section hinged on a transverse axis to the front end of the lower tarsus section, a phalanges section hinged on a transverse axis to the front end of the metatarsal section, the upper tarsus section having a forward extending rigid portion over the metatarsal section, spring means between the lower tarsus section, the phalanges section and the overhanging portion of the upper tarsus section to oppose flexing of the phalanges sections about their hinged axes, and compressible bumpers between the upper and lower tarsus sections on opposite sides of the forward and rearward extending axis of the hinged joint connecting them.

14. An artificial foot structure including an upper tarsus and a lower tarsus section hinged together by a forward and rearward extending pivot, a metatarsal section including right and

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left divisions hinged to the front end of the lower tarsus section, a phalanges section including right and left divisions hinged on a transverse axis to the front ends of the divisions of the metatarsal section respectively, yielding means between the lower tarsus section and the phalanges divisions to oppose the flexing of said divisions about their hinged axes, said yielding means being common to the divisions of the metatarsal and phalanges sections and including a leaf spring extending lengthwise of the metatarsal and phalanges sections and pressing at its ends on the lower tarsus sections at the joint between the lower tarsus section and the rear ends of the divisions of the metatarsal section, at its front end on the divisions of the phalanges section, and between its ends on the front end of the upper tarsus section, and compressible bumpers between the upper and lower tarsus sections, on opposite sides of the forward and rearward extending axis of the hinged joint connecting them, and compressible bumpers between the joint between the divisions of the metatarsal and phalanges sections, and the front end of the upper tarsus section.

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No references cited.