Nov. 14, 1950 J. G. CATRANIS 2,530,286

FOOT CONTROL FOR ARTIFICIAL LEGS

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FIG. 1.

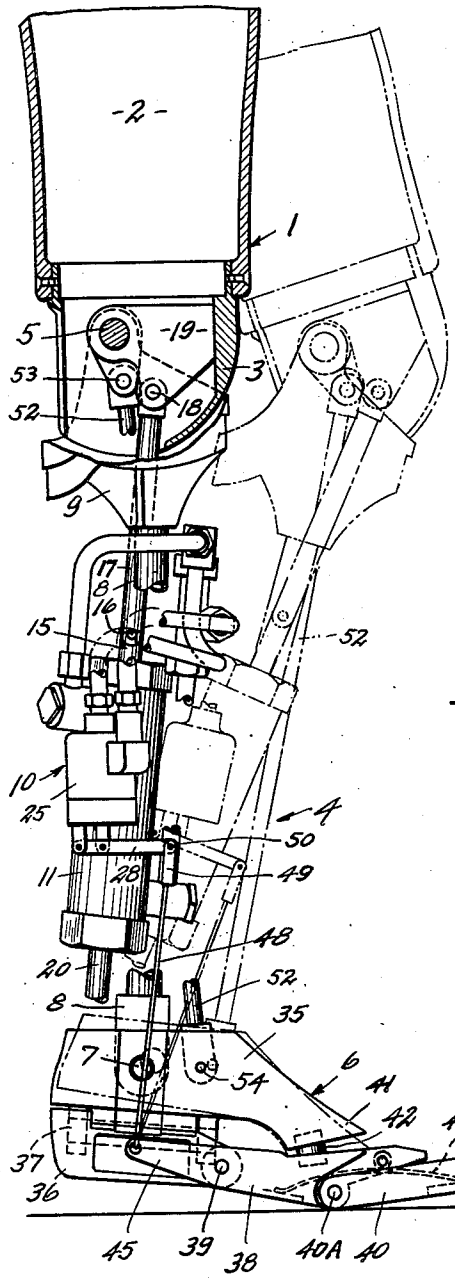


FIG. 2.

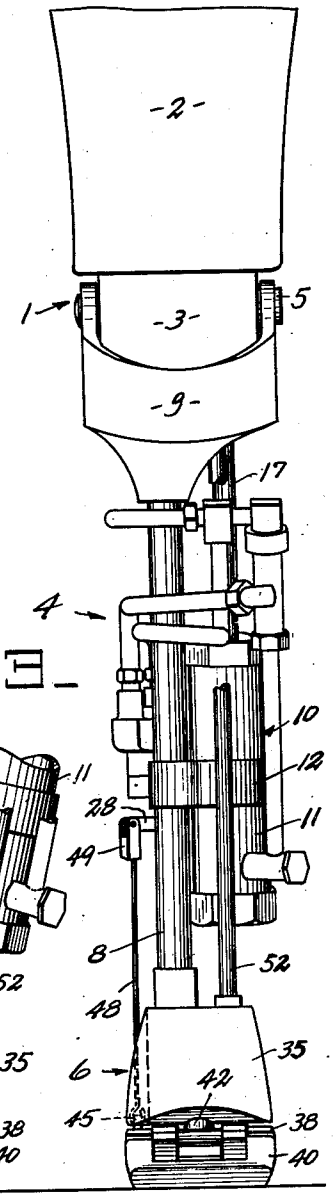
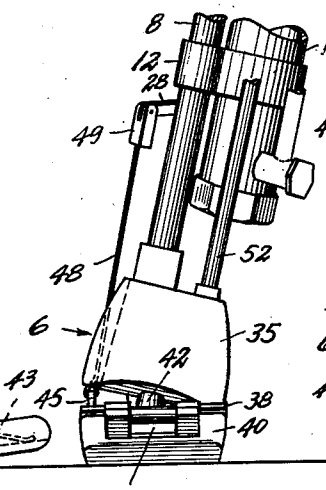


FIG. 3.



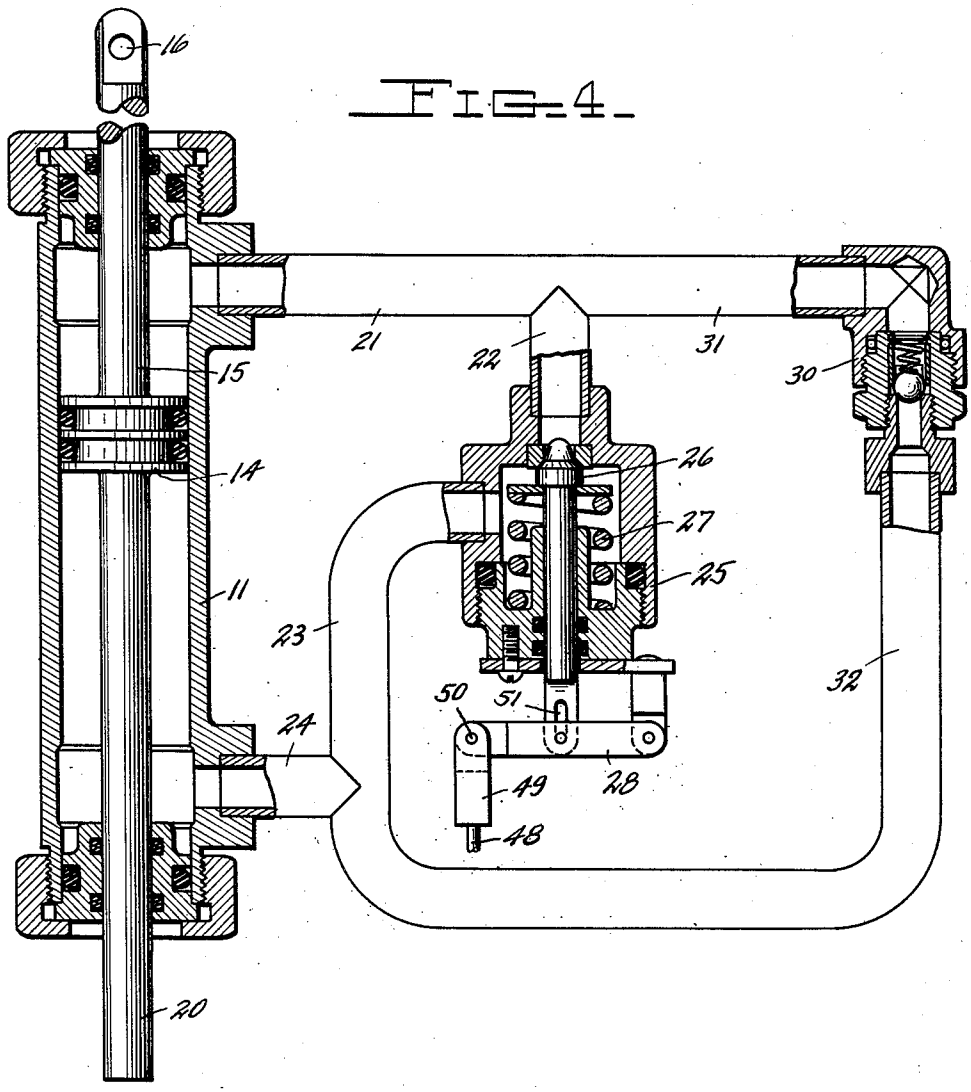
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FIG-4



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FOOT CONTROL FOR ARTIFICIAL LEGS

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6 Claims. (Cl. 3—2)

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This invention relates to artificial legs for above the knee amputees embodying a knee lock which normally locks the knee joint from bending, and particularly to a control for the knee lock, which control is operated progressively by dorsiflexion of the foot, and also by the movement of the leg structure about a forward and rearward horizontally extending axis between it and the foot structure, and by both of these movements occurring during the walking cycle.

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 leg embodying this foot control.

Figure 2 is an elevation looking to the left in Figure 1.

Figure 3 is a fragmentary elevation looking to the left in Figure 1 showing the operation of the operating member for the knee lock by the movement of the leg about a forwardly and rearwardly extending axis within the foot structure.

Figure 4 is a schematic view of the knee lock mechanism.

The numeral 1 designates the upper leg structure which is provided with a stump receiving socket 2, and a knee cap bracket or frame 3. 4 designates the lower leg structure, this being hinged at 5 to the knee cap frame 3 by a knee joint shaft or pin. 6 designates the foot to which the lower leg structure is hinged at 7 by an ankle joint.

The lower leg structure includes a frame member or tibia 8 which has a bifurcated head 9 at its upper end mounted on the knee joint pin 5, and the tibia at its lower end is connected to the foot by the ankle joint 7. 10 designates the knee lock mechanism as a whole. The mechanism here shown is hydraulic and includes a cylinder 11 mounted by a strap 12 on the tibia 8, and a piston 14 in the cylinder having its rod 15 pivoted at 16 to a link 17 which, in turn, is pivoted at its upper end at 18 to a bearing bracket 19 rigid with the frame 3. The radius of the pivot 18, relative to the knee joint pin 5, is such that during bending of the knee, the joint 18 moves in an upwardly curved arc and hence, tends to pull the piston 14 upward. The piston is also formed with a tail rod 20. The cross sectional areas of the two rods 15 and 20 is such as to equalize the pressure areas on opposite sides of the piston.

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The cylinder 11 is connected in a closed hydraulic system including a by-pass around the piston from the upper to the lower end of the cylinder including pipes 21, 22, 23 and 24, in which is located a control member, as a valve 25. The valve includes a normally closed, self-closing valve member 26 pressed against its seat by a spring 27 and operable off its seat different distances by an operating member 28 which is actuated by the flexions of the foot, as will hereinafter appear.

The hydraulic system further includes a second by-pass around the valve 25, this having a self-closing check valve 30 therein arranged to check the flow of fluid from the upper end of the cylinder to the lower, but to permit comparatively free flow from the lower end of the cylinder to the upper. This second by-pass includes pipe 31 forming extension of the pipe 21, and pipe 32 connected to the pipe 24 at the lower end of the cylinder.

When the knee flexes, as indicated by the broken line position of the socket and lower leg structure in Figure 1, the piston pulls upwardly in the cylinder 11, thus tending to move the fluid through the control valve to the lower end of the cylinder. The fluid can not flow unless the foot is flexing and hence, the control valve member 26 open. When the leg straightens, the piston 14 tends to move downward in the cylinder 11 and circulates the fluid through the by-pass around the control valve controlled by the check valve which opens when the hydraulic fluid is moved by the pressure of the piston 14 downward in the cylinder 11.

The operating member 28 is actuated by the flexions of the foot, as will now be described. The foot includes an upper tarsus section 35, a lower tarsus section 36, these sections being hinged together by a forwardly and rearwardly extending horizontal hinge pin 37. The foot further includes a metatarsal section 38 hinged at 39 on a horizontal axis to the forward end of the lower tarsus section 36, the metatarsal section carrying a phalanges section 40 at its front end and hinged or pivoted at 40A thereto. The upper tarsus section is provided with a rigid forward extension 41 extending over the metatarsal section and spaced therefrom at its front end to permit pivotal movement of the metatarsal section 38 about its axis or hinge 39. There is a block 42 of yield ing material between the front end of the extension 41 and the metatarsal section, and also a spring 43 acts on the phalanges section to resist pivotal movement thereof relative to the meta-

tarsal section. The upper and lower tarsus sections constitute the rear portion of the foot structure to which the lower leg is connected by the ankle joint to the upper tarsus section.

The foot structure per se forms no part of this invention, and the invention relates primarily to the operation of the control for the knee lock. The foot control for the knee lock is operated by the dorsiflexion, or the movement of the metatarsal section about its pivot 39, and by the movement of the upper tarsus 35 about the forward and rearward axis 37 between it and the lower tarsus section 36.

The foot control includes a lever 45 extending rearwardly from the metatarsal section along the lower tarsus section 36 and in a plane at one side of the vertical plane of the hinge axis 37, and a motion transmitting link 48 connecting the rear end of the lever 45 and the operating member 28, the link 48 having a clevis 49 at its upper end which is pivoted at 50 to the operating member 28. The operating member 28 is connected to the stem of the valve 26 by a lost motion, as a pin and slot connection 51 arranged to permit the valve 26 to open under sudden or excessive pressure relative to the operating member 28 and thus act as a relief valve.

The upper leg structure also includes a fibula link 52 pivoted at its upper end at 53 to the bracket 19 at the lower end of the stump socket 1, eccentric to and below the knee joint pin 5, and at its lower end at 54 to the upper tarsus section 35 of the foot in front of the ankle joint 7. It embodies a friction slip clutch at its lower end which permits the foot to fulcrum about the heel of the foot and pivot about the ankle joint so that the foot comes flatwise on the ground in taking a step and creates a lost motion gap in the fibula. During the taking of the step and the knee action, the fibula, due to its pivotal connection, moves downward, and then when the leg is again straightened, returns the foot to its normal position due to the friction of the slip joint taking up the lost motion. The fibula forms no part of this invention and, as its name implies, simulates the function of a natural fibula.

The valve member 26 is closed and hence, the knee lock locked when the leg is in straight or extended position and the foot normal, or not flexed about the metatarsal joint 39 and the joint 40A.

In operation, during a walking cycle, assume that the subject is in standing position with the feet of the natural and artificial legs together and starts walking by taking a step with the artificial leg. He shifs his weight to the natural leg, lifts the straight artificial leg and foot off the ground, swings it forward about the hip joint stiff legged fashion, and plants the heel of the artificial foot on the ground, the knee joint being locked. The body progresses forward during this action so that the natural leg is inclining rearward from the hip. He then shifts his weight onto the artificial leg. The artificial foot then pivots as a unit about the ankle joint so that the foot comes flat on the ground, this operation being permitted by the fibula link. He swings up on the toe of the artificial foot, the phalanges section pivoting at the joint 40a against the action of the spring 43. The body in the meantime is progressing forward and hence the artificial leg moves toward and into a rearward inclined position from the body, and the artificial foot pivots about the metatarsal joint 39, operating the actuator 28 progressively to open the valve 26, letting the leg begin to bend slightly at the knee joint at the time the foot of the natural leg, which has been swinging forward to take a new step, is about to be planted on the ground. The subject may hasten the knee unlocking operation by voluntarily swinging the artificial leg about the forward and rearward pivot 37, as shown in Figure 3, or unlock the knee lock at any time by swinging the leg about the pivot 27 while the artificial foot is on the ground. The opening of the valve 26, when the natural foot is about to be planted on the ground, causes the step to be taken by the natural leg with a slight limp. When the natural foot is planted on the floor, and the weight transferred thereto, the artificial leg, slightly bent at the knee, is lifted off the ground and it swings as a pendulum from rearward inclined position to forward inclined position to take another step. The artificial leg also straightens at the knee joint, the fluid passing freely past the check valve 30 during the downward movement of the piston 14.

The operating member 28 is additionally actuated by the movement of the upper tarsus section 35 about the pivot or hinge 37 by an inward swinging of the artificial leg about the pivot 7 relative to the foot when planted on the floor. The leg and foot here illustrated is for the right leg in which the movement of the artificial leg is to the left about the hinged axis 37 of the right artificial leg, as seen in Figure 3.

The artificial leg, when fitted to the amputee, is arranged so that the foot is straight, or toes outward in accordance with the requirements of the amputee. Hence, during the walking cycle the movements about both axes or hinges 39 and 37 may take place during that cycle and hence, the valve 26 opens progressively and involuntarily. The knee may be unlocked at any time by the subject voluntarily swinging the leg laterally about the pivot 37 when the foot is on the floor or ground.

In descending inclines and steps, the amputee places the foot of the artificial leg, while the leg is extended, onto the next lower step, and when he applies his weight thereto and the body progresses forward by the taking of a step with the natural leg, the flexing of the foot occurs partly opening the throttle valve 26 and releasing the knee joint, permitting the knee to bend under the restrained flow of fluid past the partly open valve 26 while the foot of the natural leg is being placed on the step below that on which the artificial foot is located. With the foot of the natural leg on the step, and the artificial leg flexed with the foot on the next upper step, the amputee lifts the artificial leg by lifting up on the hip joint, or lifting up on the stump, and the artificial leg being unlocked at the knee joint, will swing toward straightened position into a position to be planted in its straight position on the step next lower to that on which the natural foot is planted. However, in ascending inclines or steps, the amputee takes one step upward with the natural leg and by shifting and tilting his weight thereon, lifts the artificial leg which is locked in straightened position up onto the next level or step. In other words, he takes one step at a time and this with the natural leg. In normal walking, and in descending inclines and steps, the unlocking of the knee lock is controlled by the dorsiflexion and the flexion of the foot about the joint between the tarsus sections.

What I claim is:

1. A foot control for the knee lock of an artificial leg which includes a stump receiving socket,

a lower leg structure hinged by a knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to lock the knee joint against hinging movement; the knee lock mechanism including a control member and an operating member therefor, the control member being in position to lock the knee joint when the leg is in straight or extended position, the foot including a rear portion and a metatarsal section hinged on a transverse axis to the rear portion of the foot, the ankle joint being between the lower leg structure and the rear portion of the foot, and motion transmitting means between the metatarsal section and the operating member to transmit the relative hinging movement of the metatarsal section and the rear portion of the foot to which it is hinged, to the operating member.

2. A foot control for the knee lock of an artificial leg which includes a stump receiving socket, a lower leg structure hinged by the knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to lock the knee joint against hinging movement; the knee lock mechanism including a control member and an operating member therefor, the control member being in position to lock the knee joint when the leg is in straight or extended position, the foot including an upper tarsus section and a lower tarsus section hinged together on a forward and rearward horizontal hinged axis, the ankle joint being between the lower leg structure and the upper tarsus section, and motion transmitting connections between the foot and the operating member to transmit the relative hinging movement of the upper and lower tarsus sections to the operating member.

3. A foot control for the knee lock of an artificial leg which includes a stump receiving socket, a lower leg structure hinged by the knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to lock the knee joint against hinging movement; the knee lock mechanism including a control member and an operating member therefor, the control member being in position to lock the knee joint when the leg is in straight or extended position, the foot including an upper tarsus section, a lower tarsus section hinged to the upper by a forwardly and rearwardly extending horizontal hinged joint, and a metatarsal section hinged to the front end of the lower tarsus section, and motion transmitting connections between the metatarsal section and the operating member to actuate it upon relative hinging movements of the metatarsal section and the lower tarsus section, and of the upper and lower tarsus sections.

4. A foot control for the knee lock of an artificial leg which includes a stump receiving socket, a lower leg structure hinged by a knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to normally lock the knee joint against hinging movement when the leg is in extended or straightened position; the knee lock mechanism including a control member self-returnable to normal position and an operating member therefor, the foot including an upper

tarsus section, a lower tarsus section hinged to the upper by a forwardly and rearwardly extending horizontal hinged joint, and a metatarsal section hinged to the front end of the lower tarsus section, a lever pivoted to the metatarsal section and extending lengthwise of the metatarsal section and the lower tarsus section at one side of the vertical plane of the hinged joint between the tarsus sections, and a motion transmitting link connected at its opposite ends to said lever and to the operating member to operate the same on pivotal movement of the lever about its own axis upon relative pivotal movement of the metatarsal section and the lower tarsus section about the hinged connection between it and the lower tarsus section.

5. A foot control for the knee lock of an artificial leg which includes a stump receiving socket, a lower leg structure hinged by the knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to lock the knee joint against hinging movement when the leg is in straight or extended position; the foot including upper and lower tarsus sections and a metatarsal section hinged to the front end of the lower tarsus section, the knee lock mechanism including a control member and an operating member therefor, the control member being normally in position to lock the knee joint when the leg is in straight or extended position, a lever pivoted to the metatarsal section and a motion transmitting link between it and the operating member to actuate the same upon relative movement of the metatarsal section and the tarsus sections about the hinged joint of the metatarsal section.

6. A foot control for the knee lock of an artificial leg which includes a stump receiving socket, a lower leg structure hinged by a knee joint to the lower end of the socket, a foot hinged to the lower leg structure by an ankle joint, and a knee lock mechanism carried by the lower leg structure and operable to lock the knee joint against hinging movement when the leg is in straight or extended position, the knee lock mechanism including a control member and an operating member therefor; the foot including an upper tarsus section, a lower tarsus section hinged to the upper by a forwardly and rearwardly extending hinged joint, and a metatarsal section hinged to the front end of the lower tarsus section by a transverse hinged joint, a lever hinged to the metatarsal section and extending rearwardly along one side of the tarsus section at one side of the vertical axis of the joint between the tarsus sections, and a motion transmitting link between said lever and the operating members.

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