Oct. 4, 1949. H. SARTIN 2,483,506

ARTIFICIAL LIMB

Filed Dec. 2, 1947 2 Sheets-Sheet 1

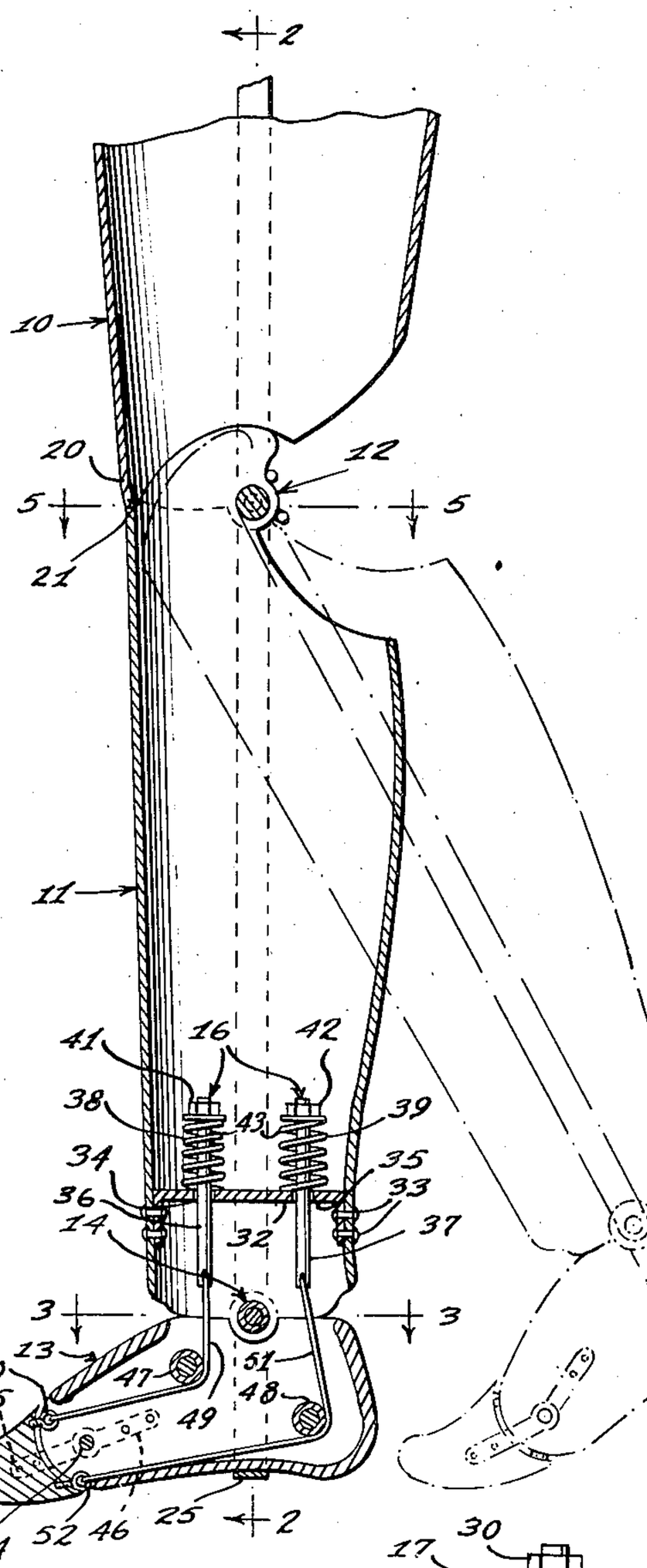

Fig. 1

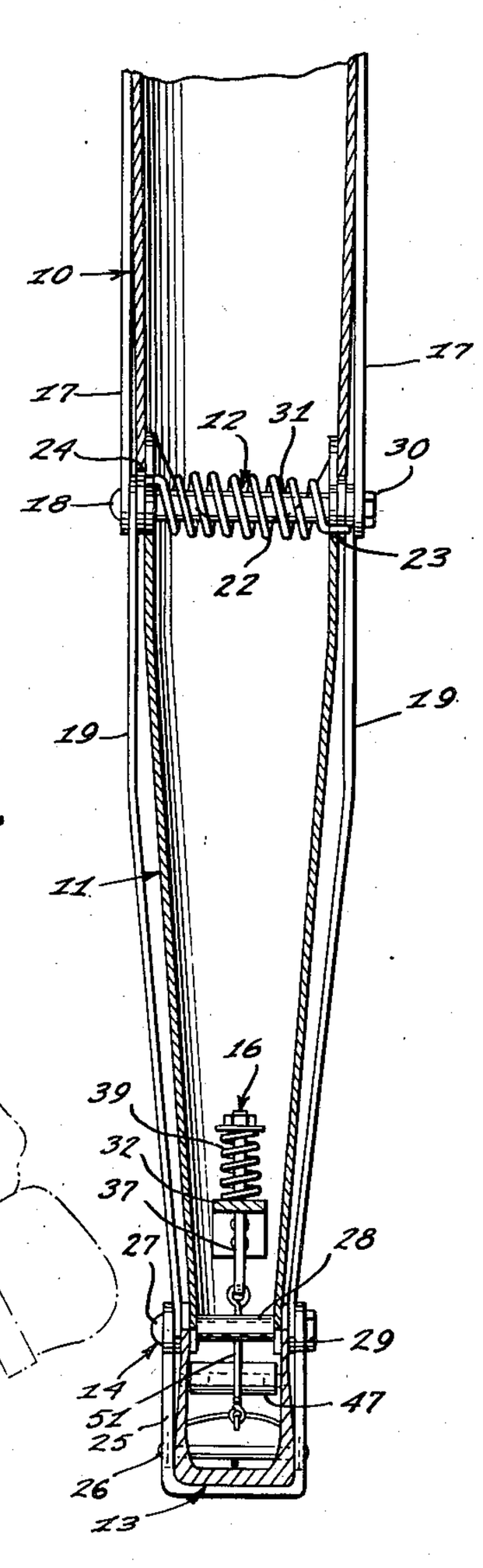

Fig. 2

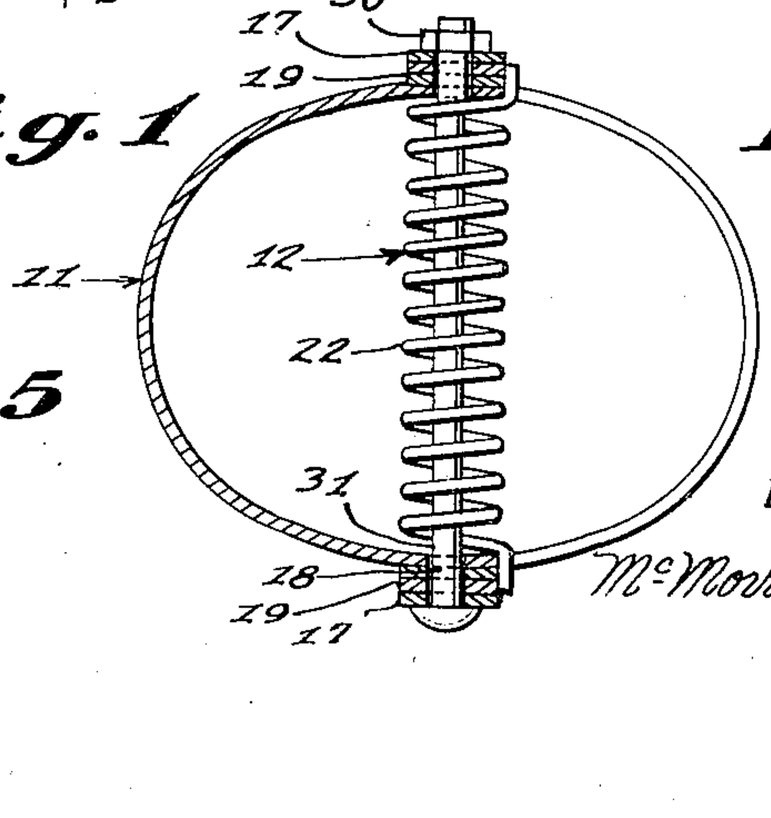

Fig. 5

INVENTOR.
HANSEL SARTIN
BY
McMorrow, Berman & Davidson
ATTORNEYS

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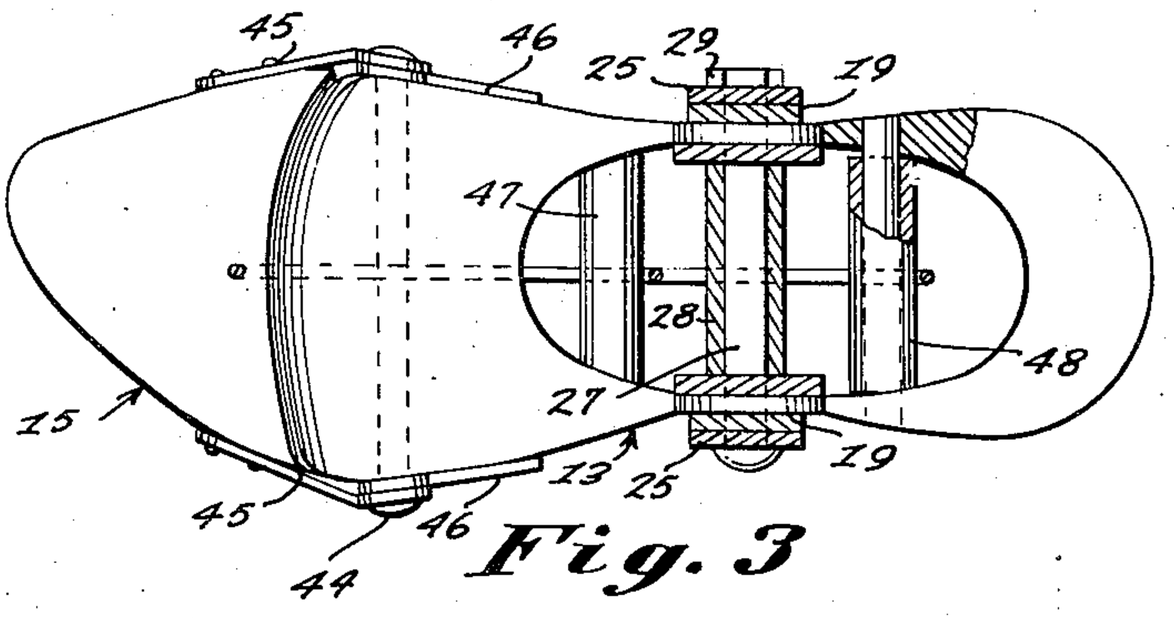

Fig. 3

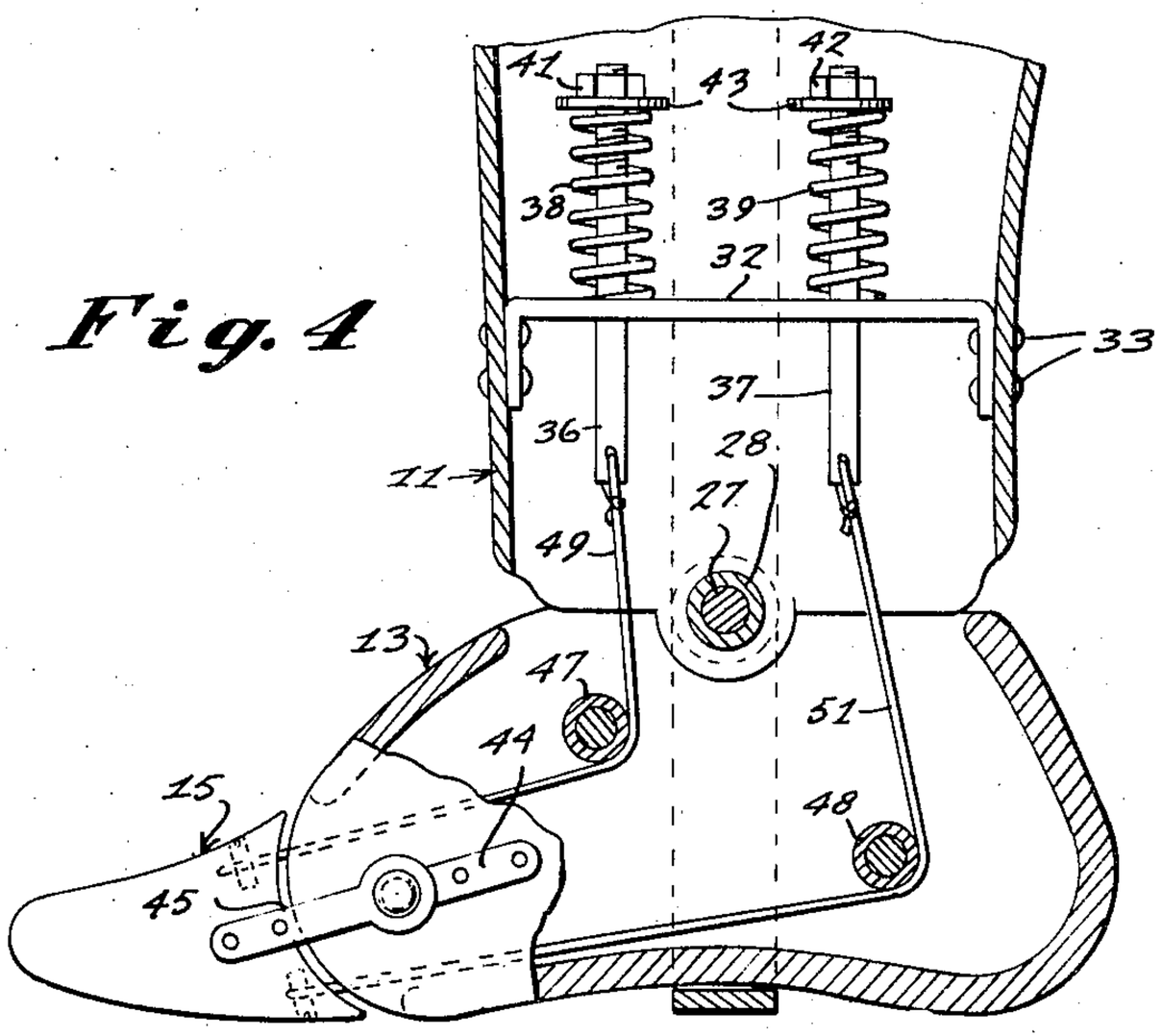

Fig. 4

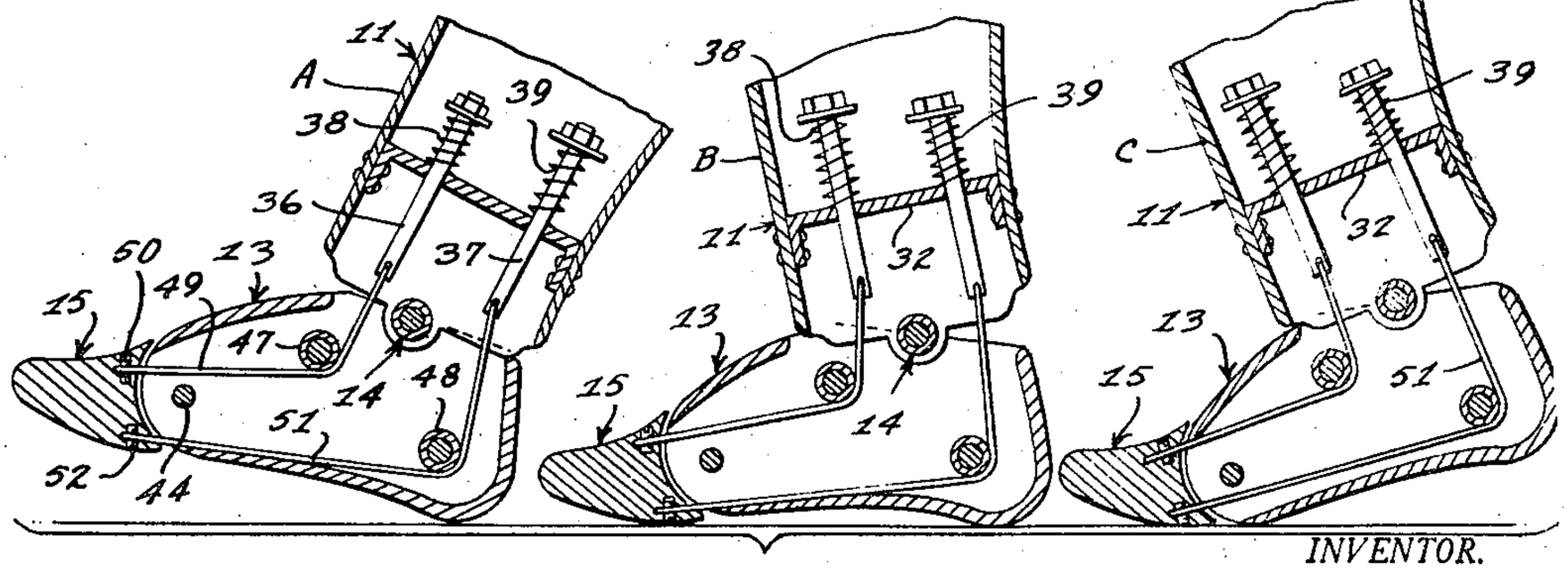

Fig. 6

INVENTOR.
HANSEL SARTIN
BY
McMorrow, Berman & Davidson
ATTORNEYS

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UNITED STATES PATENT OFFICE

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ARTIFICIAL LIMB

Hansel Sartin, Tujunga, Calif.

Application December 2, 1947, Serial No. 789,236

3 Claims. (Cl. 3—6)

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This invention relates to improvements in artificial limbs, and more particularly to an improved artificial leg.

It is among the objects of the invention to provide an improved artificial leg having automatically-operating, spring-controlled toe and ankle joints and a spring-controlled knee joint so constructed and arranged that the leg substantially supports its own weight when in use and performs walking movements with a minimum effort on the part of the wearer, which may be easily and effectively attached to leg stumps of different lengths, is of light weight, easily adjustable, of simple and durable construction, and economical to manufacture.

Other objects and advantages will become apparent from a consideration of the following description in conjunction with the accompanying drawings, wherein:

Figure 1 is a longitudinal cross-section of an artificial leg illustrative of the invention, the section plane extending from the front to the rear of the leg;

Figure 2 is a vertical cross-section of the leg, illustrated in Figure 1, taken substantially on the section plane 2—2 of Figure 1;

Figure 3 is a transverse cross-section on a somewhat enlarged scale taken substantially on the section plane 3—3 of Figure 1;

Figure 4 is a vertical cross-section, similar to Figure 1, of the lower end portion of the artificial leg illustrated in Figure 1, showing the components in an operative position somewhat different from that illustrated in Figure 1;

Figure 5 is a transverse cross-section taken substantially on the section plane 5—5 of Figure 1;

Figure 6 is a combined vertical cross-sectional view of the lower end portion of the artificial leg showing the operative position of the components of this portion of the leg at several positions during a stepping movement of the leg.

With continued reference to the drawings, the improved artificial leg comprises, in general, a hollow thigh member 10, a shank member 11 connected to the thigh member by a knee joint 12, a hollow foot member 13 connected to the lower end of the shank member 11 by an ankle joint 14, a toe member 15 pivotally connected to the front end of the foot member and resilient means 16 extending from the shank member 11 through the foot member 13 to the toe member 15 to control the movement of the toe member relative to the foot member and the movements of the toe and foot members relative to the shank member during stepping or walking movements of the leg.

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A pair of longitudinal braces 17 are secured to thigh member 10, one at each side thereof, and extend somewhat below the lower end of the thigh member. These braces are apertured at their lower ends to provide apertured lugs which receive a pivot pin 18 constituting a component of the knee joint 12. A pair of braces 19 are secured to and extend longitudinally of the shank member 11, one at each side thereof, with their upper ends extending somewhat above the upper end of the shank member. The upper ends of these shank brace members 19 are also apertured to provide apertured lugs receiving the pivot pin 18 so that the shank member 11 is pivotally connected to the thigh member 10 by the pivot pin 18 extending through complementary apertured lugs provided by the thigh braces 17 and shank braces 19. The thigh member 10 and shank member 11 are provided at their forward sides with complementary shoulders 20 and 21 which limit pivotal movement of the shank member relative to the thigh member about the axis of pin 18 in one direction to a substantially straight-line condition, that is, a condition in which the longitudinal center lines of the thigh and shank members constitute a substantially straight line. This provides an operative knee action so constructed and arranged that the shank member swings rearwardly of the thigh member, but cannot swing forwardly thereof.

A coiled torsion spring 22 surrounds the pivot pin 18 within the shank member and is connected at one end to the shank member, as indicated at 23, and at its opposite end to the thigh member, as indicated at 24, and resiliently urges the thigh and shank members to the straight-line condition in which the shoulders 20 and 21 abut.

Spring 22 is of sufficient stiffness to operatively support the weight of a person wearing the artificial leg when the leg is used in walking.

Foot member 13 is provided with a flat metal stirrup 25 which passes under the arch of the foot member, as clearly illustrated in Figure 1, and is secured to the foot member by a rivet 26 extending through the stirrup and to the foot member adjacent the bottom thereof. The ends of the stirrup extend somewhat above the foot member and are apertured to provide apertured lugs which pivotally receive the pivot pin 27. The lower ends of shank braces 19 extend below the lower end of the shank member 11 and are also apertured to provide apertured lugs complemen-

tary to the lugs provided by the stirrup 25 and receiving the pivot pins 27 so that the foot member is pivotally secured to the shank member by a pivotal ankle joint extending transversely of these members substantially midway between the front and back sides of the lower ends of the shank member. A spacer sleeve 28 surrounds the pivot pin 27 between the lower ends of the shank braces 19 to reinforce this joint and the tightness of the joint may be adjusted by means of a nut 29 screw-threaded onto one end of the pivot pin 27. The knee joint pivot pin 18 has a corresponding nut 30 screw-threaded onto one end thereof and a spacer sleeve 31 surrounds this pin between the upper ends of the shank braces 19.

A transverse wall 32 is secured in the lower end portion of the shank member by suitable means, such as rivets 33, passing through the wall of the shank member and through end flanges provided on the wall 32, and this wall is provided with a pair of apertures 34 and 35 disposed one near the front and one near the rear side of the shank member. Respective pins 36 and 37 are slidably received in the apertures 34 and 35 and extend above and below the transverse wall 32, as is clearly illustrated in Figures 1 and 4. Respective coiled compression springs 38 and 39 surround the portions of the pins 36 and 37 above the wall 32 and respective nuts 40 and 41 are screw-threaded onto the upper ends of the pins and bear upon abutment washers 43, which, in turn, bear upon the upper ends of springs 38 and 39, the lower ends of these springs bearing upon the upper surface of the transverse wall 32.

The toe member 15 is pivotally secured to the front end of the hollow foot member 13 by a pivot pin 44 which extends through apertured complementary end portions of straps 45 and 46, respectively, secured to the toe member and the foot member, there being one pair of straps 45 secured to the toe member and a complementary pair of straps 46 secured to the foot member, as is clearly illustrated in Figure 3. One overlapping set of straps, each including a strap 45 and a strap 46, is provided at one side of the interconnected foot and toe members, while a second set is provided at the opposite side, and the pin 44 extends through the complementary apertured lugs provided by these straps to pivotally connect the toe member to the foot member for movement about an axis extending transversely of the foot member at the forward end thereof and substantially parallel to the axis of the pin 37 of the ankle joint.

A cable sheave 47 is pivotally mounted in the hollow foot member adjacent the instep thereof and a similar cable sheave 48 is pivotally mounted in the foot member adjacent the heel thereof. A flexible cable 49 is connected to the lower end of front pin 36 and extends around sheave 47 to the upper edge of the inner end of toe member 15 to which it is connected by suitable means, such as the set screw 50. A second cable 51 extends from the lower end of pin 37 around sheave 48 and is connected to the inner end of toe member 15 at the bottom edge thereof by a set screw 52 similar to set screw 50. The set screws 50 and 52 are disposed one above and one below the axis of the pivot pin 44, as is clearly illustrated in Figures 1 and 4.

Nuts 41 and 42 may be threaded up or down on the respective pivot pins 36 and 37 to adjust the tension applied by the springs 38 and 39 to the cables 49 and 51 to provide the proper operation

of the foot and ankle members of the artificial leg.

The operation of the shank, foot and toe members of the leg and the resilient means 16 is diagrammatically shown in Figure 6. Sketch A of Figure 6 shows the position when the leg has been thrown forward or advanced to begin a step. In this position, the heel of the foot member 13 has been brought into contact with the ground, and, as weight is applied to the artificial leg, the spring 38 is compressed, while the pressure on spring 39 is relieved permitting this spring to expand. Spring 38 carries the weight applied to the artificial leg and resiliently resists pivotal movement of the foot member about the ankle joint 14 to resiliently support the weight then applied to the artificial leg. As the weight applied to the leg is increased and the body of the wearer advances, the foot member is brought to a condition in which its heel and front portions are in contact with the ground and the toe member 14 is also brought into contact with the ground to the position illustrated in sketch B of Figure 6. At an intermediate position wherein the shank member 11 is substantially perpendicular to the foot member 13, the two springs 38 and 39 will be substantially balanced and there will be no unbalanced force at this stage tending to rotate the foot member relative to the shank member about the ankle joint. As the body of the wearer advances, however, the shank member is inclined upwardly and forwardly, as illustrated in sketch B, compressing spring 39 and relieving the pressure on spring 38. This compression of spring 39 shifts the load to the toe members 15, and as the forward inclination of the shank member is continued, the tension exerted by spring 39 on cable 51 becomes sufficient to raise the heel of the foot member from the ground, as illustrated in sketch C of Figure 6. As the weight applied to the artificial leg is now decreased, the spring 39 will begin to return the foot member to its generally perpendicular position relative to the shank member, in which position the tension exerted by the two springs 38 and 39 is substantially balanced. This tends to lift the artificial leg and position it to be sprung forwardly for the next step. Just as the weight is entirely removed when the leg is thrown forwardly, a residual compression of spring 39 snaps the toe member 15 downwardly, which gives the lower end of the artificial leg a slight kick upwardly and forwardly which greatly facilitates advancing the lower end of the leg for the subsequent step. The shank portion of the artificial leg is then swung forwardly and the heel brought into contact with the ground in the position illustrated in sketch A, from which position the stepping movement of the leg, as above described, is repeated. Spring 22 in the knee joint 12 also materially assists in advancing the shank portion of the leg for the subsequent step, since, at the time the weight on the leg is relieved and the leg is swung forward, the knee joint will be slightly bent with the shoulders 20 and 21 separated and the spring 22 consequently loaded. As the weight is released, spring 22 unwinds to straighten the knee joint, thereby adding its force to that of spring 39 acting on toe member 15 to give the lower portion of the leg the forward impulse when the weight of the wearer is taken off of it.

As explained above, the nuts 41 and 42 may be adjusted on the pins 36 and 37 to load the springs 38 and 39 for the weight, stature and stride of the person wearing the leg, so that the leg may

be adjusted to accurate automatic walking operation. The construction is such that there is no clicking or squeaking incident to operation of the leg, and the entire structure is of extremely light weight, is strong and durable and cannot become locked in any bent or abnormal position.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are, therefore, intended to be embraced therein.

What is claimed is:

1. An artificial leg comprising a hollow, thin-walled thigh member, a hollow, thin-walled shank member, a knee joint between said thigh and said shank members, a hollow foot member pivotally connected to the lower end of said shank member, a toe member pivotally connected to the front end of said foot member, and resilient means supported by said shank members and operatively connected to said toe members controlling movements of said toe member relative to said foot member and movements of said toe and foot members relative to said shank member, said resilient means comprising a transverse wall in the lower portion of said shank member, said wall having a pair of apertures therein disposed one near the front and one near the rear of said shank member, a pair of pins slidably received one in each of said apertures, a respective compression spring surrounding each pin above said transverse wall, adjustable abutments one on the upper end of each pin bearing on the corresponding compression springs, a pair of sheaves in said hollow foot member disposed one in the instep and one in the heel portion thereof, a cable extending from the lower end of the rearward of said pins over the sheave disposed in the heel portion of said foot member and connected to the inner end of said toe member at the lower edge thereof, and a cable extending from the front pin member over said sheave disposed in the instep portion of said foot member and connected to the inner end of said toe member at the upper edge thereof.

2. An artificial leg comprising a hollow, thin-walled thigh member, a hollow, thin-walled shank member, a knee joint between said thigh and shank members, a hollow foot member pivotally connected to the lower end of said shank member, a toe member pivotally connected to the front

end of said foot member, and resilient means supported by said shank member and operatively connected to said toe member controlling movements of said toe member relative to said foot member and movements of said toe and foot members relative to said shank member, said resilient means comprising a pair of spaced-apart cables extending through said hollow foot member and secured to said toe member one above and one below the axis of the pivotal connection between said toe member and said foot member, respective springs supported from said shank member and operatively connected with said cables to resiliently resist movement of said toe member relative to said foot member and movement of said toe and foot members relative to said shank member, and adjustable means operatively interposed between said springs and said shank member to adjust the tension applied to said cables by said springs.

3. An artificial leg comprising a hollow, thin-walled thigh member, a hollow, thin-walled shank member, a knee joint between said thigh and said shank members, a hollow foot member pivotally connected to the lower end of said shank member, a toe member pivotally connected to the front end of said foot member, and resilient means supported by said shank member and operatively connected to said toe member controlling movements of said toe member relative to said foot member and movements of said toe and foot members relative to said shank member, said resilient means comprising a pair of spaced-apart cables extending through said hollow foot member and connected to said toe member one above and one below the axis of the pivotal connection between said toe member and said foot member, respective sheaves mounted in said foot member guiding said cables, respective springs supported in said shank member one ahead of and one to the rear of the axis of pivotal connection between said shank member and said foot member and operatively connected with said cables, and adjustable means operatively interposed between said springs and said shank member for adjusting the tension applied to said cables by said springs.

HANSEL SARTIN.

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The following references are of record in the file of this patent:

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