

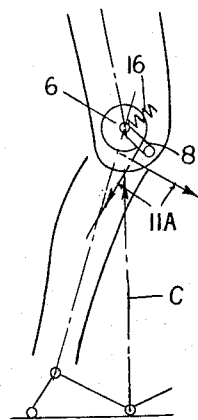
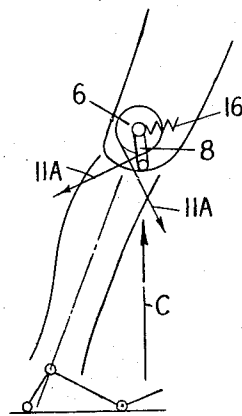
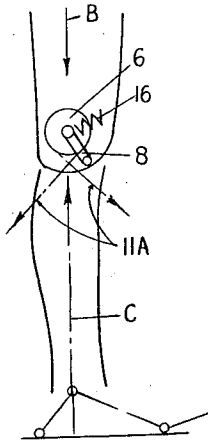
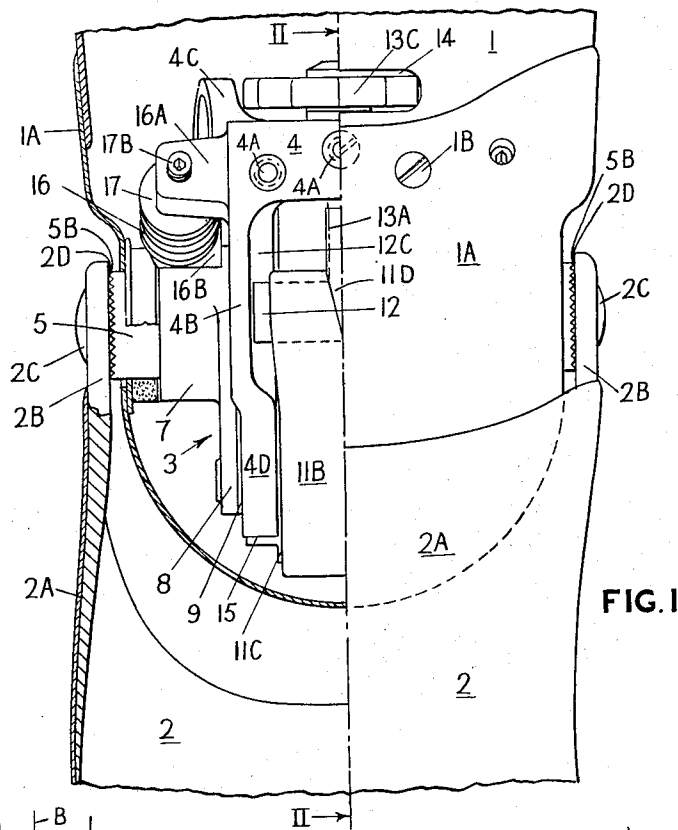
Jan. 9, 1962

B. G. BLATCHFORD
ARTIFICIAL LIMBS

3,015,825

Filed May 22, 1959

3 Sheets-Sheet 1



Jan. 9, 1962

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3 Sheets-Sheet 2

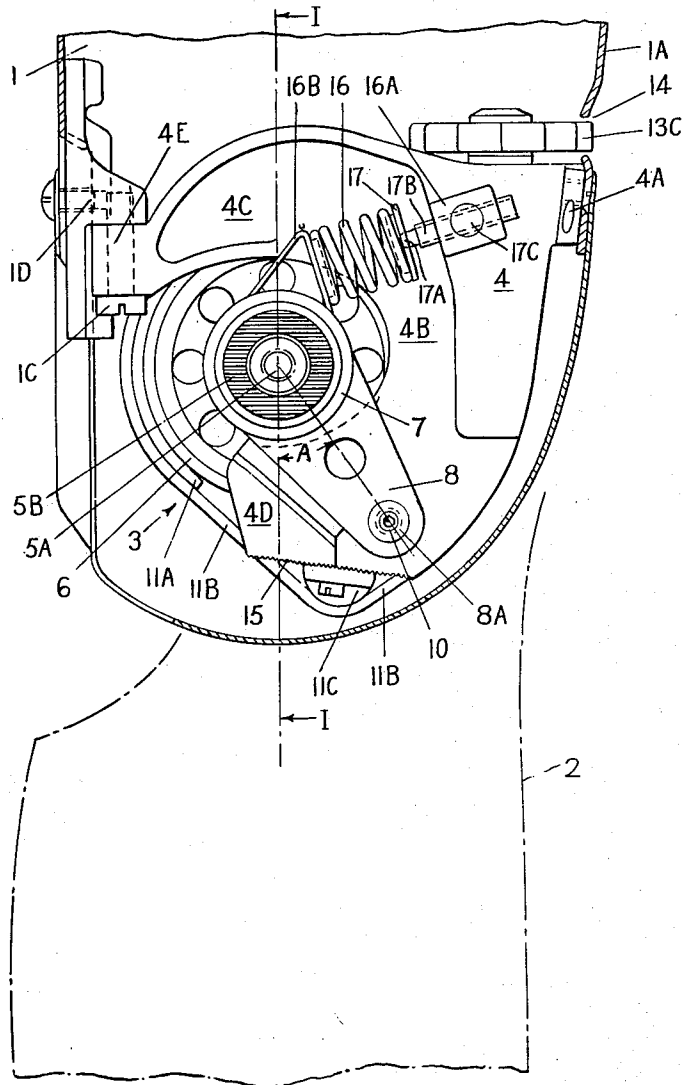


FIG. 2

Jan. 9, 1962

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3 Sheets-Sheet 3

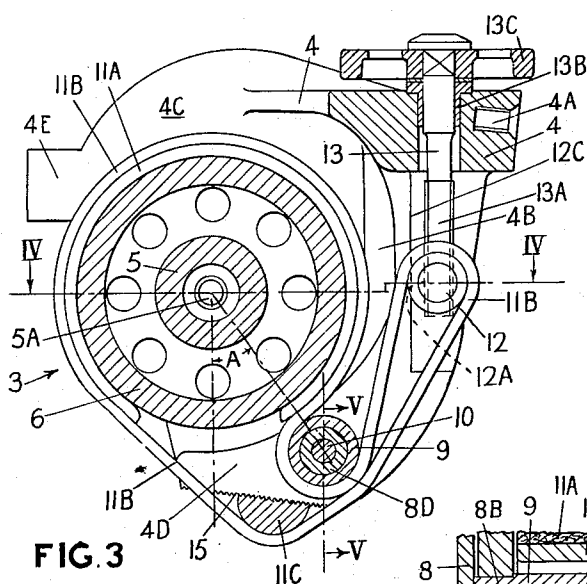


FIG. 3

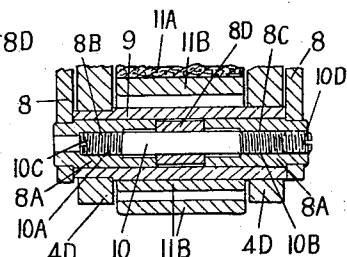


FIG. 5

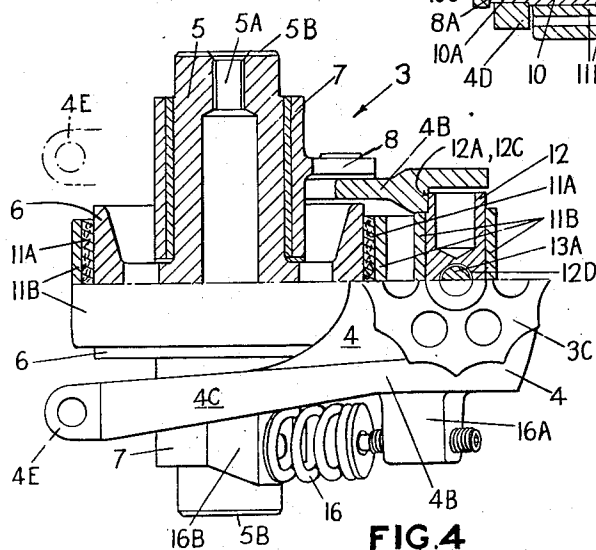


FIG. 4

1

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ARTIFICIAL LIMBS

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This invention relates to artificial limbs and particularly to the knee joints of artificial limbs.

For many years the problem of "locking the knee" has engaged the attention of artificial limb manufacturers because it is desirable that the knee should be locked, when the artificial limb is bearing the wearer's weight, to prevent collapse of the leg. "Collapse" in this sense refers to accidental and unintentional flexion of the knee when the leg is bearing weight. The danger of collapse is restricted in artificial legs not having a knee lock by setting up the leg so that the knee joint axis is slightly behind the load-bearing plane between body and foot. This is not a natural arrangement and tends to give a jerky walk.

To improve walking and to give confidence to the wearer it has long been desired to provide a device which will lock the knee when it is bearing weight, so as to prevent collapse and so that the knee joint axis may take up a natural position. Many knee locks have been proposed, but none has found general acceptance and in fact at present artificial legs generally in use are of the non-locking type.

It is not sufficient merely to ensure that the knee is locked whenever the leg is bearing weight since this means that the knee will be locked whether bearing the full weight or only part of the weight of the wearer. The latter does occur in walking. Assume that in making a step the artificial foot is placed on the ground, then the body moves forward and over the artificial leg, which then bears the full weight and finally the body moves ahead of the artificial leg and on to the other foot. Towards the end of the step the weight on the artificial foot and leg is decreasing, until a moment of time is reached when the weight is transferred to the other leg, just before the artificial foot leaves the ground. This is termed herein the "appropriate moment." Just before the artificial foot leaves the ground it is desirable that the knee lock should be free and the leg able to flex about the knee and swing forward naturally ready for the commencement of the next step. In practice this has not been generally achieved and it has been found that while the artificial foot is in contact with the ground the knee remains either locked or at least stiff, and the wearer, at the end of the step, has to make a deliberate lifting movement to raise the artificial foot from the ground so as to free the knee. If satisfactory freeing of the knee has been achieved, it has been at the expense of satisfactory normal stability when the weight is on the toe with the knee flexed.

It is an object of this invention to provide a simple and effective knee joint which will prevent collapse and give confidence to the wearer. It is a further object of this invention to provide an artificial limb the use of which will improve the walking gait of the wearer.

According to this invention an artificial leg has a thigh, a shin, and knee joint mechanism which includes a drum on the knee axis, the drum being fixed to and movable with the shin, a band or bands connected to the thigh and embracing the drum, and a connection between the shin and the thigh which permits relative movement between the shin and thigh, the ends of the band or bands being so arranged that it or they grip the drum and thus lock the knee when the leg is bearing weight, the connection between the shin and the thigh being so arranged geometrically that, at or shortly before the ap-

2

propriate moment, relative movement in the locking direction is prevented or reduced, whereby the lock is released or conditioned for release.

The word "embracing" used herein means that the band or each band is positioned about the drum over an arc of less than 360°. The term "relative movement" used herein means a relative movement between the shin and the thigh which movement is linear and is to be distinguished from the angular movement of flexion about the knee axis. "Relative movement" also includes the corresponding movement permitted by the mechanism when the knee is flexed. The term "appropriate moment" has been defined above.

One embodiment will now be described as an example of construction in accordance with the invention. In the accompanying drawings:

FIGURE 1 is a front elevation of the knee portion of an artificial leg, with the outer casings shown partly removed on the plane I—I of FIGURE 2, to reveal the knee mechanism;

FIGURE 2 is a side elevation, with the outer casing of the thigh in section on the plane II—II of FIGURE 1, and with the shin shown in outline in dot and dash lines;

FIGURE 3 is a section of the knee mechanism alone (when removed from the leg) on the plane II—II of FIGURE 1;

FIGURE 4 is a part top plan and part horizontal section of the knee mechanism alone, the section being on the plane IV—IV of FIGURE 3;

FIGURE 5 is a detail section on the plane V—V of FIGURE 3; and

FIGURES 6, 7 and 8 are diagrams showing the operation of an artificial leg in accordance with this invention.

Referring to the drawings, FIGURE 1, a thigh 1 is connected to a shin 2 by knee mechanism indicated generally by 3. The right-hand side of FIGURE 1 shows the external appearance of the completed leg, whilst the left-hand side of FIGURE 1 shows the leg with its outer casings 1A and 2A removed, showing the frame 4 of the knee mechanism. The frame 4 has countersunk threaded holes 4A for fixing the mechanism to the lower end of the thigh 1 by screws such as 1B. At each side the frame has webs 4B, each web having an upper, rearwardly extending part 4C, and a lower, downwardly extending part 4D. Each of the two ends of the parts 4C is formed with a drilled lug 4E to receive a screw 1C by which screws the frame is fixed to the back of the thigh at 1D (FIGURE 2). In this manner the knee mechanism is fixed to the thigh.

The shin 2 has upwardly extending connecting pieces 2B at each side. These are fixed to the knee spindle 5 by screws 2C threaded into the bore 5A of the spindle, and co-operating grooved faces 2D and 5B ensure that the shin and spindle move in unison.

Midway of its length the spindle 5 is formed integrally with a drum 6, and, on either side of the drum, the spindle is journaled in bearing housing 7. The axis of the spindle and drum is the axis of flexion of the artificial leg. In other words, it is the knee joint axis.

The bearing housings 7 are mounted on link means comprising a pair of radius arms 8, one arm for each housing, the arms being outside the frame parts 4D (see FIGURES 4 and 5 particularly). The arms are pivotally carried by the lower parts 4D of the frame webs 4B. A bushing 9 is fixed at each end in the parts 4D and the bushing receives spigots 8A fixed to, and extending oppositely from, the radius arms 8. The spigots are internally oppositely threaded at 8B and 8C to receive a rod 10, correspondingly oppositely threaded at 10A and 10B. When the rod is rotated in one direction, by a screwdriver engaging the slot 10C, the spigots 8A and the radius arms 8 are pulled inwardly until they

abut a distance piece 8D. This is the assembled state. In dismantling the mechanism the rod 10 is rotated in the other direction, to force the spigots 8A and arms 8 apart. When assembled the rod 10 is locked in position by a grub screw 10D.

Thus the spindle 5 and drum 6 are fixed to the shin 2 and can move on the radius arms 8 about the axis of the spigots 8A and rod 10, which are carried in the frame 4 in the thigh. With this arrangement limited relative movement of the shin and thigh can occur. Assume that (referring to FIGURE 2) the shin 2 is stationary (with the foot, not shown, on the ground). Then if downward pressure occurs on the thigh 1, such as by the effect of a wearer's weight, then the axis of the spigots 8A and rod 10 will move arcuately downwardly about the axis of the spindle 5 and drum 6.

The drum 6 is embraced by a brake band which is formed of a strip 11A of brake-lining material bonded on to an endless band 11B fabricated from laminated glass fibre tape, a very strong material. As seen in FIGURE 3, the band 11B passes over a bar 11C, round the bushing 9, and also round a tension adjusting bar 12. The bar 12 has flats 12A which ride on surfaces 12C of the frame 4, and further the bar has a threaded bore 12D (see FIGURE 4) receiving the threaded portion 13A of a rod 13, journaled in a bearing 13B in the frame 4 (see FIGURE 3). The rod is rotatable by a manually rotatable wheel 13C which projects through a slot 14 (FIGURES 1 and 2) in the thigh casing 1A. Rotation of the wheel 13C and rod 13 either raises or lowers the bar 12, and so either increases or decreases the tension of the brake band. The band 11B is split at 11D (FIGURE 1) to enable it to pass the threaded portion 13A of the rod 13. The position of the bar 11C may be varied by moving it along the lower milled faces 15 of the frame parts 4D, so that the distance over which the brake band is in contact with the drum may be varied.

It will now be seen that, because the drum 6 (fixed to the shin) can move relatively to the frame (fixed to the thigh) and also because the brake band is anchored to the frame, then the drum can move relatively to the anchoring points of the brake band, so that the braking effect of the brake band on the drum may be varied. Given the correct tension setting on the brake band, the mechanism can be arranged so that when the knee is bearing full weight, movement of the shin and thigh about the knee axis is prevented, and so that when the knee is bearing no weight or reduced weight, the braking effect is removed or reduced and flexion can take place.

Strong compression coil springs 16 are mounted between frame lugs 16A and lugs 16B on the bearing housings 7. These springs tend to counteract the wearer's weight and thus to move the thigh and shin apart. In other words, they act to reduce the braking effect of the brake band on the drum, and thus to assist in releasing the lock on the knee.

It is desirable that the compression of the springs 16 should be variable and this is provided for (see FIGURE 2) in that the upper or front end of each spring abuts a shouldered disc 17 which is held by the spring against the end 17A of a screw 17B which is threaded in the lug 16A. Adjustment of the screws 17B increases or decreases the degree of compression of the springs 16. Loosening of each screw 17B is prevented by a nylon insert 17C in the lug 16A, the screw passing through the insert.

In FIGURES 2 and 3 the mechanism is in the state in which the artificial leg is in the normal vertical position, the vertical being shown by the line representing the section plane I—I in FIGURE 2. It will be seen that the radius arm 8 is at an angle of approximately 35° to the vertical. This angle is marked A.

FIGURES 6, 7 and 8 are diagrams showing operation of the knee mechanism in accordance with the invention. FIGURE 6 shows the normal upright position. The

wearer's weight on the thigh produces a downward component of force B and an equal and opposite reaction C. The knee axis is stationary, the thigh moves slightly downwardly on the radius arms 8, the brake is thus engaged on the drum, and the knee locked, so that collapse cannot occur. FIGURE 7 shows the situation just before the end of a stride. This is the "appropriate moment" previously referred to. The radius arms 8 have now been brought substantially into alignment with the component C so that no relative movement can take place between the thigh and the shin, which are kept fully apart by the radius arms so that full brake pressure cannot be exerted. Assisted by the springs 16, the lock has been released and flexion may now occur, as required, for proper walking.

When the artificial foot is clear of the ground, there are no substantial upward or downward components of force on the knee, which continues flexing freely until the start of the next stride. When the artificial foot is placed on the ground at this start, the force components at once cause the knee to lock and so prevent collapse. Release of the lock at the end of the stride does not happen suddenly; as the angle between the radius arms 8 and the vertical decreases, so the lock effect decreases.

The angle between the radius arms and the vertical when the leg is upright and extended is such that an angular movement of the upward thrust relatively to the thigh, which movement is equivalent to an angular movement from a point through the ankle to a point through the toe or toe joint causes appreciable reduction of the locking or braking effect when the leg is substantially extended.

This variation of the locking or braking effect is sufficient to enable the knee to be free at the appropriate moment when walking and yet to lock the knee during normal weight-bearing or at times of emergency.

In practice it is found that if the angle between the radius arms and the vertical lies within the range of 45° to 10° the best effects are obtained.

In the state illustrated by FIGURE 8 the foot is on the ground, the knee is flexed and the leg is bearing weight, and in this state it will be seen that the angle between the radius arms and the vertical is again such as will produce the braking effect, thereby locking the knee.

If weight is placed by the wearer on the thigh, whether in the extended position or in a flexed position of the knee, during standing or walking, the thigh moves slightly downward relatively to the shin and pulls the ends of the band down causing the band to grip the drum and so prevent flexion at the knee. This locking action is brought about by the downward thrust (the weight) acting through the lower ends of the radius arms and the upward thrust acting through the upper ends of the radius arms. Since the radius arms are normally inclined to the vertical, the thigh and the band move downward relatively to the shin. However when during walking the appropriate moment is reached, the radius arms become substantially aligned with the upward thrust which can then no longer cause the thigh and the shin to approach. Thus the lock of the band on the drum is freed. In practice the amount of movement from the locked to the unlocked position is very small and no positive or sudden unlocking takes place, nor is it desirable. Nevertheless the effect produced by arranging the radius arms in accordance with this invention is that of causing the knee lock to be released or to be reduced in its effect before the artificial foot leaves the ground. The compression springs tend to move the spindle and drum in the unlocking direction. The springs are always tending to do this, but until the appropriate moment is reached or nearly reached, the springs are ineffective to overcome the lock. As the geometrical arrangement of the radius arms in relation to the upward thrust takes effect, its effect is added to that of the springs, to ensure that the lock is released. Thus the geometrical arrangement

5

may cause release of the lock by itself or it may condition the lock for release by the combined effects of the springs and the geometrical arrangement.

It should be understood that the usual extension spring and stop are provided, although for clarity they have been omitted from the drawings.

What I claim is:

1. In an artificial leg comprising a thigh, a shin, and knee joint mechanism which includes a drum on the knee axis, the drum being fixed to and movable with the shin, and at least one band connected to the thigh and embracing the drum, the improvement comprising: link means pivotally connecting said thigh and said drum, said link means being connected to said thigh and said drum, respectively, by pivot means lying on a plane inclined downward and forward of the longitudinal axis of said thigh at a predetermined acute angle; said link means being rigid so as to prevent converging movement of said thigh and said drum along said inclined plane, said link means permitting downward arcuate movement of said thigh relative to said shin responsive to the application to said thigh of a weight vector directed downwardly within said predetermined acute angle forward of the longitudinal axis of said thigh, said downward movement bringing said band into locking engagement with said drum, and said link means preventing downward movement of said thigh responsive to a weight vector directed downwardly at an angle forward of said longitudinal axis of said thigh in substantial alignment with said inclined plane to avoid locking engagement of said band and drum.

2. An artificial leg having a shin, a thigh and knee joint mechanism, said knee joint mechanism comprising a frame fixed in said thigh, a spindle fixed to said shin, the axis of said spindle being the axis of knee flexion, brake means having co-operating first and second braking elements, said first element being fixed to said spindle and said second element being fixed to said frame, mounting means pivotally connected to said frame and pivotally supporting said spindle, the angle between the axis of said thigh and the axis extending between said spindle and mounting means pivot point and said frame and mounting means pivot point being not more than 45° and not less than 10°, whereby the application to said thigh of a weight vector directly downwardly at an angle to said thigh not in excess of said first named angle causes downward pivotal movement of said thigh carried frame relative to said shin carried spindle thereby bringing said frame carried second braking element into braking engagement with said spindle carried first braking element, said mounting means preventing downward movement of said thigh relative to said shin responsive to a weight vector directed downwardly at an angle to said thigh as great as said first named angle to avoid braking engagement of said first and second braking elements.

3. An artificial leg as defined in claim 2 having spring means associated with said frame and said spindle mounting means, said spring means acting to oppose the braking effect of said brake means.

4. An artificial leg having a shin, a thigh and knee joint mechanism, said knee joint mechanism comprising a

6

frame fixed in said thigh, a spindle fixed to said shin, a drum on said spindle, the axis of said spindle and drum being the axis of knee flexion, a brake band embracing said drum, the ends of said band being anchored to said frame, a pair of bearing housings on said spindle, one said housing on either side of said drum, and a pair of parallel radius arms, one said arm being fixed to each said housing and said arms being pivotally carried in said frame, the angle each said arm makes with the vertical when said leg is upright being not more than 45° and not less than 10°, whereby the application to said thigh of a weight vector directly downwardly at an angle to said thigh not in excess of said first named angle causes downward pivotal movement of said thigh carried frame relative to said shin carried spindle, thereby bringing said frame carried brake band into braking engagement with said spindle carried drum, said radius arms preventing downward movement of said thigh relative to said shin responsive to a weight vector directed downwardly at an angle to said thigh as great as said first named angle to avoid braking engagement of said band and drum.

5. An artificial leg as defined in claim 4 having a pair of compression coil springs, one said spring being mounted between one said bearing housing and said frame and acting to oppose the braking effect of said brake band on said drum.

6. An artificial leg as defined in claim 2 having adjusting means effective on said second braking element for varying the braking effect of said second element on said first braking element.

7. An artificial leg as defined in claim 4 having manually rotatable adjusting means effective on said brake band for varying the braking effect on said drum.

8. An artificial leg as defined in claim 4 having means carried on the frame for varying the position of one end of the brake band.

9. An artificial leg as defined in claim 4 in which the brake band comprises a strip of brake lining material carried on a strip fabricated from glass fibre tape.

10. An artificial leg as defined in claim 2 having compression spring means mounted between said frame and said spindle mounting means, said compression spring means acting to oppose the braking effect of said brake means, and means for adjusting the compression exerted by said spring means.

11. An artificial leg as defined in claim 4 having a pair of compression coil springs, each said spring being mounted between one of said bearing housings and said frame and acting to oppose the braking effect of said brake band on said drum, and means for adjusting the compression of the springs.

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