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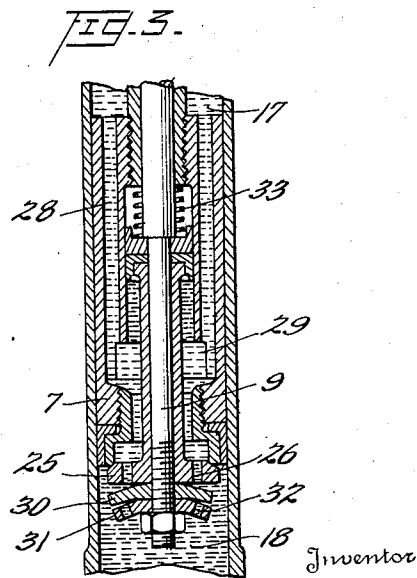
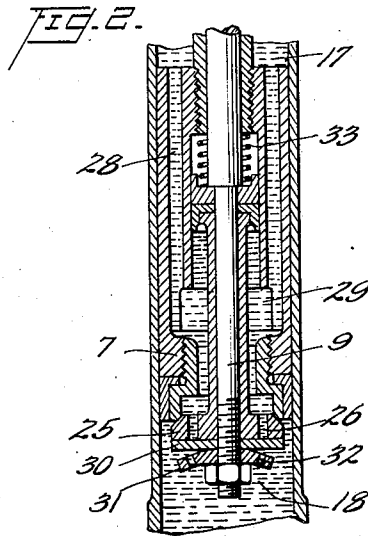
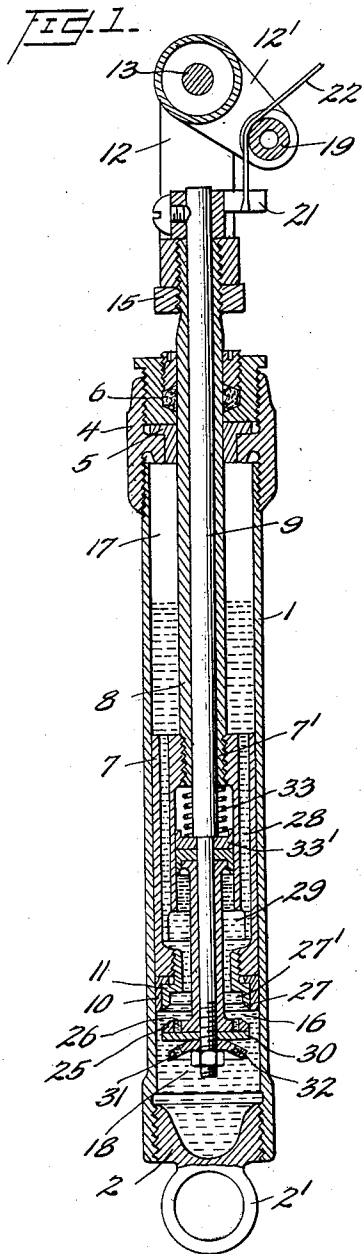
P. FILIPPI

2,305,291

DEVICE FOR THE AUTOMATIC CONTROL OF THE ARTICULATION
OF THE KNEE APPLICABLE TO A PROTHESIS OF THE THIGH

Filed June 24, 1937

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 4

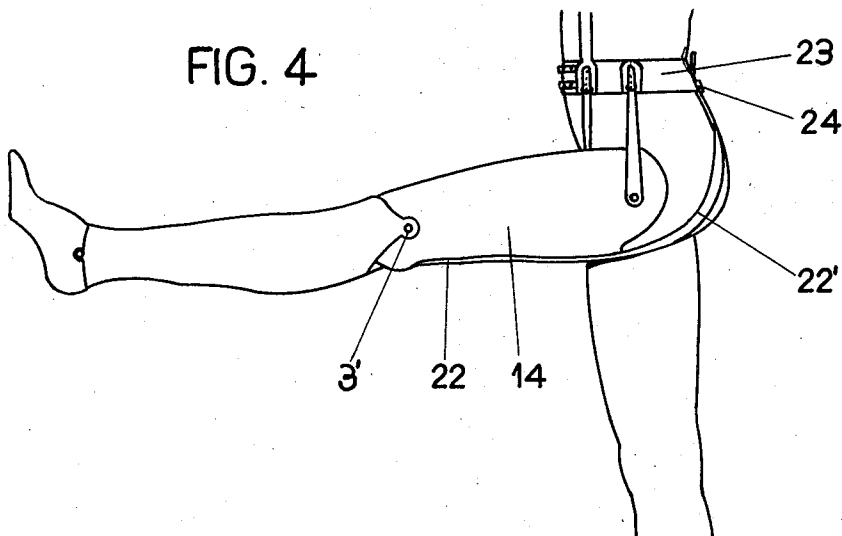


FIG. 5

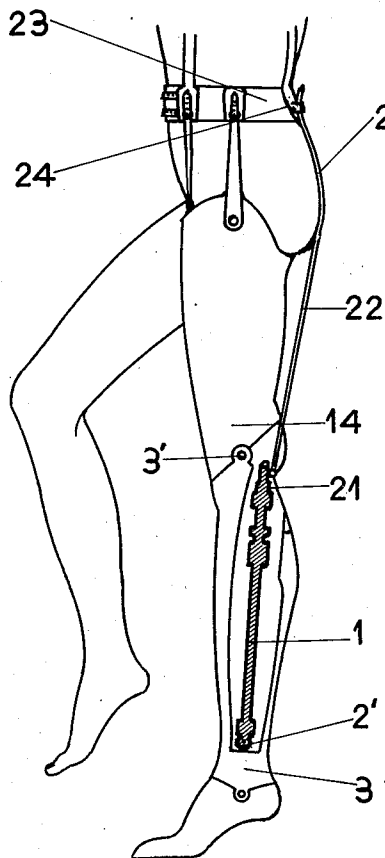
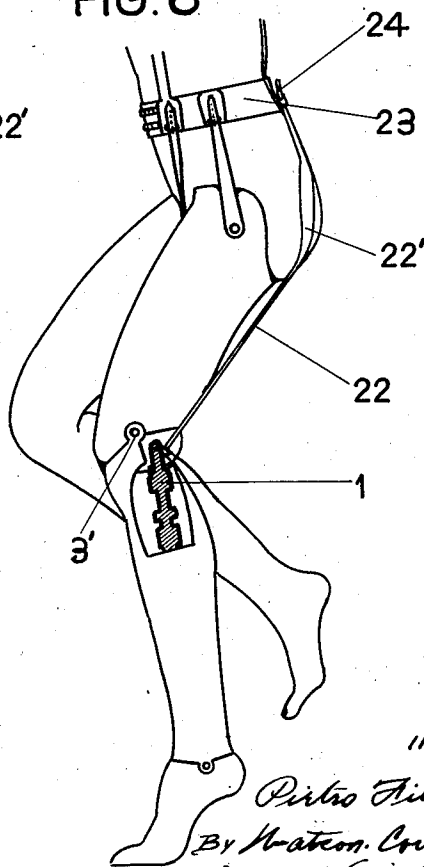


FIG. 6



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UNITED STATES PATENT OFFICE

2,305,291

**DEVICE FOR THE AUTOMATIC CONTROL OF
THE ARTICULATION OF THE KNEE AP-
PLICABLE TO A PROTHESIS OF THE
THIGH**

Pietro Filippi, Macerata, Italy; vested in the
Alien Property Custodian

Application June 24, 1937, Serial No. 150,176
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9 Claims. (Cl. 3—2)

This invention relates to a device for the automatic control of the articulation of a joint in an artificial limb, and more particularly to such devices as are applicable to a knee joint in a prosthesis of the thigh.

The general object of the invention is to provide a novel and improved device of this character which is of simple and compact construction, light in weight, and easily and automatically operative by the natural movements and postures of the body.

Another object of the invention is to provide in a device of this type, mechanism which will permit the knee joint full freedom of movement when desired, but is capable of being blocked either deliberately or automatically (as when balance of posture has to be regained in walking), and then released for permitting flexion of the joint after the limb is extended.

Further objects of the invention include the provision of an extensible and contractible hydraulic system associated with the joint of the prosthesis and adapted to be blocked and released by means of a tension member attached to the torso of the wearer and responsive to certain deliberate and involuntary movements of the body.

In its preferred form, the invention contemplates the provision of a hydraulic cylinder having a piston working therein, one of these elements being connected to the lower leg portion of the prosthesis and the other to the upper leg portion or thigh. Valves are provided in the piston member to permit the by-passing of hydraulic fluid, and the actuation of certain of these valves is effected by a tension member which operatively connects a movable portion of the piston with a belt forming part of the harness for attaching the limb to the wearer so that when he leans forwardly, either deliberately or instinctively (as in regaining his balance lost by placing his foot on the ground with the knee bent), or when he lifts the thigh upwardly, the connecting tension member actuates the valve to block the contraction of the system. On the other hand, further extension of the joint is permitted by another valve which is of the one-way or check valve type.

Other and further objects and features of novelty will be apparent from the following specification when read in connection with the accompanying drawings in which one embodiment of the invention is illustrated by way of example.

In the drawings:

Figure 1 is a vertical cross-sectional view of

the apparatus proper which is preferably disposed inside of the lower leg portion of the artificial limb; the parts being in the position affording the knee joint full freedom of movement;

Figure 2 is a fragmentary view similar to Figure 1 with the parts in position to prevent the flexion of the articulation;

Figure 3 is a similar view showing the parts in position as when extension of the hydraulic device begins;

Figure 4 is a view in side elevation of the whole artificial limb when raised as high as possible;

Figure 5 is a similar view showing the leg in vertical position; and

Figure 6 is a view also in side elevation showing the limb bent.

The prosthesis or artificial limb may be of any suitable form and is somewhat diagrammatically shown in Figures 4, 5 and 6 as comprising the upper leg or thigh portion 14 and the lower leg portion 3 hinged together to provide an articulated knee joint indicated at 3'. The limb is attached to the torso of the wearer by a suitable harness which includes the belt 23.

The novel means for controlling the articulation of the joint 3' comprises the hydraulic cylinder 1 which is closed at its lower end by the plug 2 which is secured as by means of the ring 2' to the lower portion of the lower leg member 3. The cylinder is provided at its upper end with a bushing 4 provided with a leather packing ring 5 and stuffing box arrangement 6 through which a piston rod is adapted to pass. Within the cylinder 1 there is adapted to reciprocate the piston 7 to which there is threaded as at 7' the tubular piston rod 8 which extends through the packed opening at the upper end of the cylinder and is attached to the bifurcated element 12 carried by the pivot pin 13 which is connected to the base of the thigh portion 14 of the limb. A nut 15 serves to vary the connection between the tubular piston rod 8 and the member 12 in order to adjust the degree of opening of a control valve as will be later described. A leather packing ring 10 and bushing 11 provide a tight fit for the piston 7 in the bore of the cylinder 1.

The hollow tubular piston rod 8 encloses a rod or shaft 9 which carries at its lower end a valve assembly for controlling the by-passing of the hydraulic fluid. At the upper end of this shaft 9 there is secured a block or bracket 21 to which is attached the cable 22 forming a part of the tension member by which the valve is operated.

The cable 22 passes around the pulley 19 carried

by an arm 12' provided on the member 12. The cable 22 forms an inelastic portion of the tension member which also comprises the elastic part 22' the upper end of which is adjustably attached to the belt 23 in any suitable manner as at 24; the inelastic portion 22 of the tension member extending along the thigh 14 and the elastic portion passing over the rear portion of the hips to its point of attachment to the belt.

At the lower end of the shaft 9 which extends through the tubular piston rod 8, a conical valve 25 is mounted, the valve being provided with a series of openings 26. The valve 25 is adapted to seat against the conical surface of the annular base portion 27 of the piston and thus control the passage of fluid through the passageways 27', the interior chamber 29 and the upper series of passageways 28 all providing communication between the upper fluid chamber portion 17 and the lower portion 18. In Figure 1 the valve 25 is shown in the open position which it occupies during flexion of the knee joint. Beneath the valve 25 there is provided a flexible valve 30 which is preferably faced with leather and is supported by the washer 31 carried by the end of the valve stem or shaft 9. This washer 31 is also provided with a series of openings 32. A spring 33 which is disposed between the upper portion of the piston 7 and an abutment 33' carried by the shaft 9, serves to continually urge the valve 25 downwardly toward open position. By a suitable adjustment of the nut 15 the lowermost position of the block 21, and thus the lower portion of the rod 9, are determined and thus the width of the opening 16 afforded by the valve 25 may be varied.

The operation of the controlling device will now be described in connection with the three typical positions illustrated in Figures 1, 2 and 3 of the drawings. In the first position, shown in Figure 1, the valve 25 is open and the hydraulic fluid may flow freely through the valve opening 16 and the passageways and chambers 27', 28, and 29 to and from the upper and lower fluid chambers 17 and 18; in other words, the piston 7 is permitted to slide within the pump cylinder and allow the free articulation of the knee joint in either a flexion or extension direction.

In Figure 2, the device is shown wherein the valves 25 and 30 have been closed by the upward movement of the shaft 9 under the influence of the tension member 22, 22'. In this position the fluid can no longer flow through the by-pass passageways in the piston 7 and contraction of the hydraulic system connecting the portions of the limb is prevented. Consequently flexion of the knee joint is also prevented, as for example when the limb is bent as shown in Figure 6. The wearer may thus rest his whole weight upon the artificial limb while lifting the other foot to take a step.

In the position illustrated in Figure 3, the valve 25 remains closed, but the flap valve 30 is opened as the knee is stretched or extended, the piston 7 moving upwardly and the hydraulic fluid flowing from the upper chamber 17 to the lower chamber 18 through the openings 26 in the main valve body member 25. Thus, the limb which is still in the blocked position as respects flexion, may begin to extend in order to reach the position where free articulation may take place. At the slightest flexion movement, however, the valve 30 closes immediately bringing the device again into the second position as illustrated in Figure 2.

Tension in the valve actuating member 22, 22' results when the body leans forward or when the thigh is lifted, the elastic portion 22' being extended and the inelastic part 22 drawn tight. As already mentioned, the body may lean forward voluntarily and deliberately, or involuntarily as in response to the spontaneous reaction engendered by loss of balance through insufficient support upon the foot of the prothesis.

The oil or other hydraulic fluid should not occupy the whole of the space inside the cylinder 1 but the level should remain slightly below the bushing 4 in order to leave a layer of air in the upper portion of the chamber 17 by means of which the displacement of the piston 7 is kept more elastic and the leakage of oil between the rod 8 and the packing 5, 6 is rendered more difficult.

The device may be made of any suitable materials but it is suggested that the cylinder and its closures may be made of steel and the piston 7 may be constructed of aluminum.

It is understood that various changes and modifications may be made in the device as illustrated and described herein without departing from the scope of the invention as determined by the subjoined claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. The combination with an artificial limb having at least two articulated members and means for attaching the limb to the wearer's body, of a device for the automatic control of the joint between said articulated members, said device comprising an extensible and contractible hydraulic system including a cylinder pivotally connected to one of said members and a piston working in the hydraulic fluid contained in the cylinder and connected with another of said members, a multiple by-pass valve assembly disposed in said hydraulic system and controlling the flow of fluid from one side of said piston to the other, and valve operating means adapted to be connected to the torso of the wearer so as to be automatically and positively actuated by the natural flexion of the torso to operate said valve assembly to prevent flow of fluid from one side of the piston to the other to prevent contraction of the system and consequently prevent flexion of the joint, said multiple valve assembly being automatically operative upon movement of the piston in a direction to extend said system to permit flow in the opposite direction to allow further extension of the joint.

2. The combination with an artificial limb having at least two articulated members and means for attaching the limb to the wearer's body, of a device for the automatic control of the joint between said articulated members, said device comprising an extensible and contractible hydraulic system including a cylinder pivotally connected to one of said members and a piston working in the hydraulic fluid contained in the cylinder and connected with another of said members, and a by-pass valve on said piston and controlling the flow of fluid from one side of the piston to the other, said attaching means including a portion adapted to be applied to the torso of the wearer, means associated with said attaching means and adapted to be operated by flexion of the torso, said means also being connected with said by-pass valve to actuate the latter to block the contraction of the hydraulic system and thus prevent flexion of the joint.

3. A device as set forth in claim 2 in which

a check valve element is also provided in said hydraulic system to control the by-passing of said fluid in one direction, whereby further extension of the system is permitted even when contraction of the system is prevented by said first named valve.

4. The combination with an artificial limb having at least two articulated members and means for attaching the limb to the wearer's body, of a device for the automatic control of the joint between said articulated members, said device comprising an extensible and contractible hydraulic system including a cylinder pivotally connected to one of said members and a piston working in the hydraulic fluid contained in the cylinder and connected with another of said members, and provided with an opening therethrough, a main valve member carried by said piston, means adapted to be connected with the torso of the wearer and responsive to the changes in posture for causing said valve member to close said opening and prevent contraction of the system, said valve member also being provided with an opening controlled by a supplemental flap valve adapted to permit flow in one direction to allow further extension of the system even when the main valve member is closed.

5. The combination with an artificial limb having at least two articulated members and means including a belt for attaching the limb to the wearer's body, of a device for the automatic control of the joint between said articulated members, said device comprising an extensible and contractible hydraulic system including a cylinder pivotally connected to one of said members and a piston working in the hydraulic fluid contained in the cylinder and connected with another of said members, and a by-pass valve on said piston and controlling the flow of fluid from one side of the piston to the other, an elastic tension member adapted to extend along the thigh and hips and connecting said by-pass valve with said belt, whereby upon occurrence of certain changes in posture of the wearer's body, said system is blocked and collapsing flexion of the joint prevented.

6. A device as set forth in claim 2 in which the cylinder of said hydraulic system is only partially full of the hydraulic fluid, a layer of air remaining above the level of the fluid for imparting a certain amount of elasticity to the system.

7. The combination with an artificial limb having at least two articulated members and means including a belt for attaching the limb to the wearer's body, of a device for the automatic control of the joint between said articulated members, said device comprising an extensible and contractible hydraulic system including a cylinder pivotally connected to one of said members and a piston working in the hydraulic fluid contained in the cylinder, a tubular piston rod extending through packing at one end of the cylinder and connected with another of said members, a by-pass passageway leading through said piston, a main by-pass valve controlling the passage of hydraulic fluid through said passageway from one side of the piston to the other, a valve stem adapted to support said valve and extending through said tubular piston rod, a tension member secured to one end of said stem and operatively connecting the valve to the belt of the wearer, said main by-pass valve being provided with openings therethrough, a flap main by-pass valve carried by said main valve and adapted to control the flow of hydraulic fluid through the openings in said main by-pass valve in one direction only.

8. An artificial limb including upper and lower members hingedly connected, a plunger mounted for reciprocation in one of the members, means carried by the other member for reciprocating the plunger when one member is swung relative to the other, an incompressible fluid in the path of the plunger, a valve, and means controlled by the movement of the artificial limb relative to the body to which it is attached, for opening and closing the valve to release or to trap the fluid in the path of the plunger.

9. In an artificial limb the combination with hingedly connected members, a plunger mounted to reciprocate in one of the members, and cooperating means on the other member and plunger for reciprocating said plunger when the members are swung relative to each other, of a liquid in the path of the plunger, means for attaching one of the members to the body of the user for swinging movement, and means controlled by the swinging movement of the limb relative to the body of the user for successively trapping and releasing the fluid to lock and unlock the plunger respectively.

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