# United States Patent

**Webb et al.**

[15] **3,670,341**

[45] **June 20, 1972**


## [54] FLUID PRESSURE CONTROL DEVICE FOR AN ARTIFICIAL LEG


[72] Inventors: **Frank Allan Webb**, Farnham; **John Jeffrey Shorter**, East Oakley, both of England

[73] Assignee: **Chas. A. Blatchford & Sons Limited**, Hampshire, England



[22] Filed: **Dec. 1, 1969**

[21] Appl. No.: **881,100**

[30] **Foreign Application Priority Data**

Dec. 2, 1968 Great Britain ..... 57,061/68

[52] **U.S. Cl.** ..... **3/1.2**, 188/313, 188/322, 16/84, 16/DIG. 21

[51] **Int. Cl.** ..... **A61f 1/00**, A61f 1/08

[58] **Field of Search** ..... 3/1, 1.2, 22–29; 188/311, 313, 318, 322; 92/13; 16/DIG. 21, 66, 84



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,918,040 | 12/1959 | Lieser | 3/1.2 UX |

FOREIGN PATENTS OR APPLICATIONS

| | | | |
|---|---|---|---|
| 748,770 | 5/1956 | Great Britain | 16/84 |
| 982,527 | 2/1965 | Great Britain | 3/1.2 |
| 24,035 | 11/1921 | France | 3/1.2 |
| 416,341 | 9/1934 | Great Britain | 3/28 |

OTHER PUBLICATIONS

" UC–BL Pneumatic Swing–Control Unit for Above–Knee Prostheses" by C. W. Radcliffe et al., Bulletin of Prosthetic Research, Fall, 1960, pages 73– 83, 88 & 89



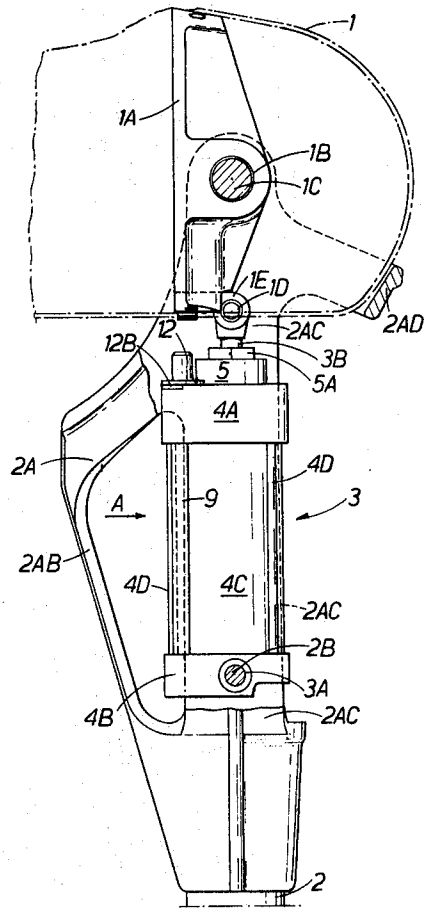
*Primary Examiner*—William E. Kamm
*Assistant Examiner*—Ronald L. Frinks
*Attorney*—Cushman, Darby & Cushman



[57] **ABSTRACT**

A fluid pressure control device has a piston and cylinder. The cylinder includes a cylindrical wall and a pair of end parts. The piston rod extends slidably through one end part, which end part is adjustably axially movable for varying the piston stroke length. The device is of especial interest in the control of flexion and extension motions of an artificial leg.


**7 Claims, 8 Drawing Figures**



PATENTED JUN 20 1972 3,670,341



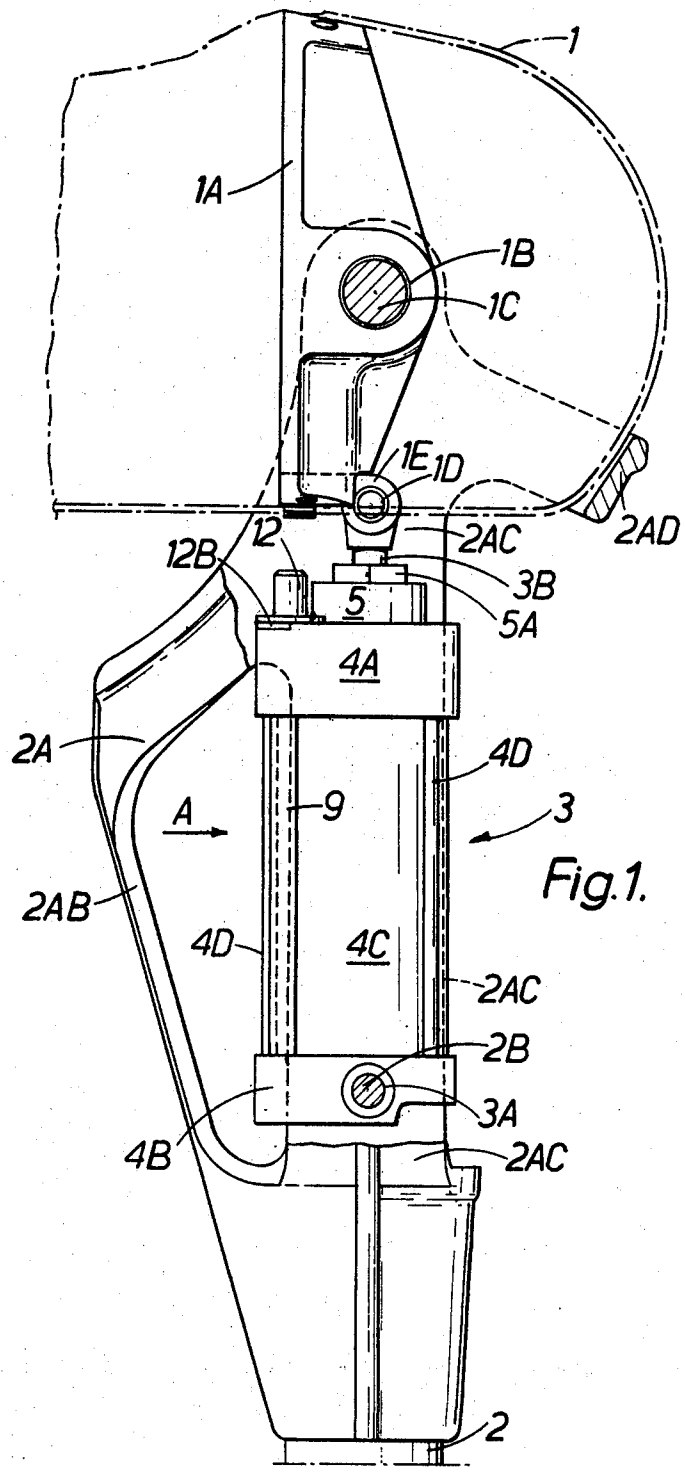



Fig.1.

INVENTORS
Frank Allan Webb
John Jeffrey Shorter
By Cushman, Darby & Cushman
ATTORNEYS

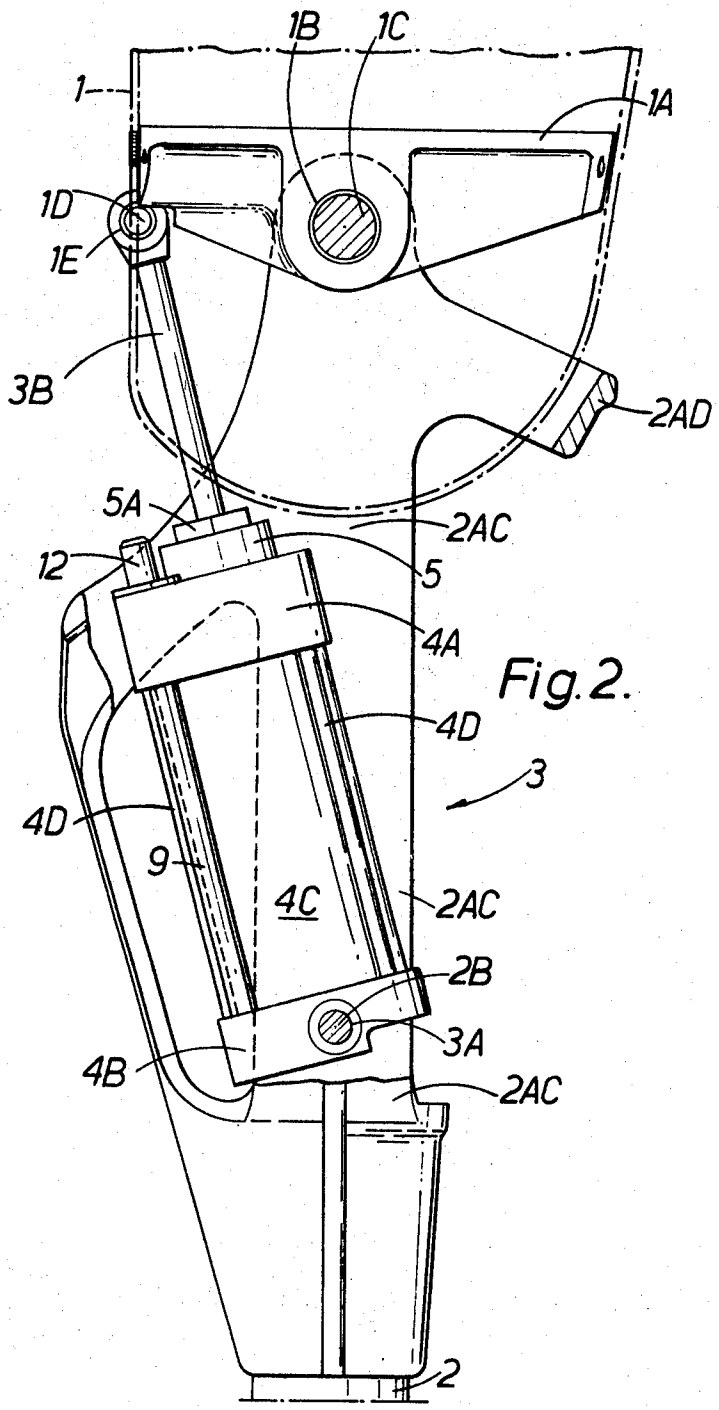



Fig. 2.

Fig.3.

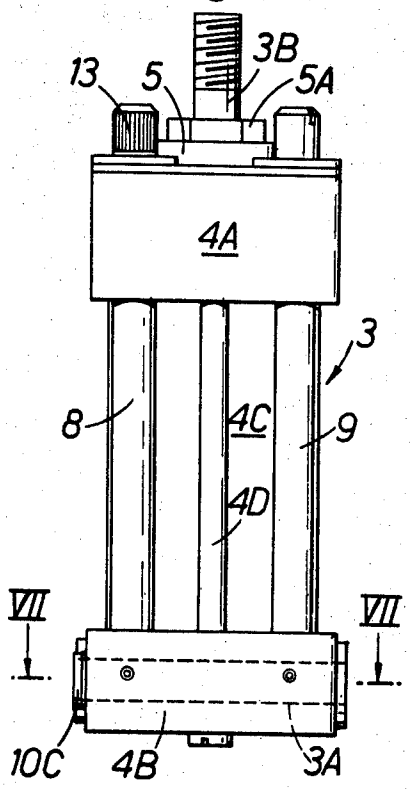
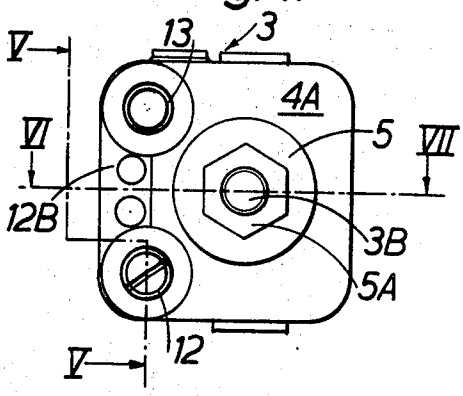



Fig.4.



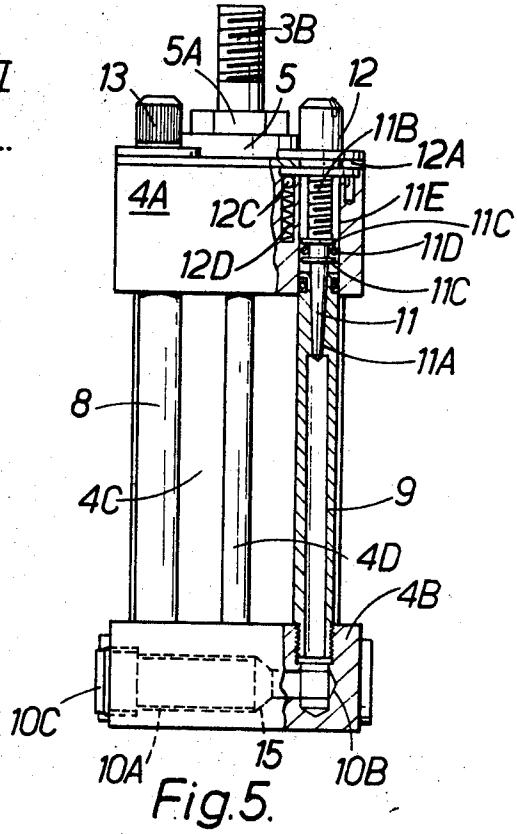




Fig.5.

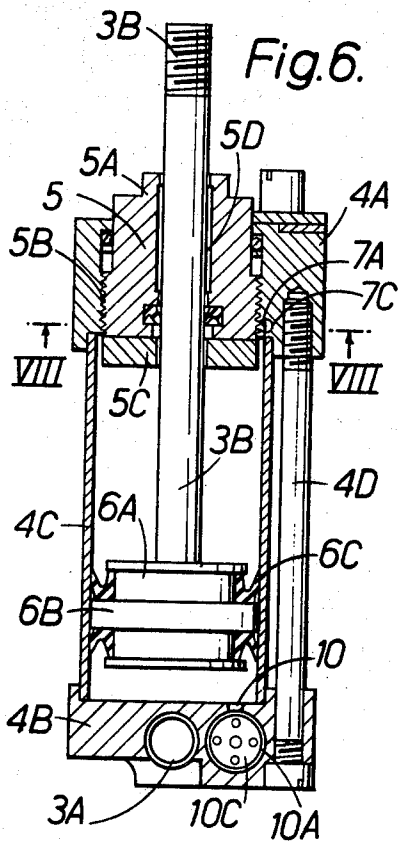



Fig.6.

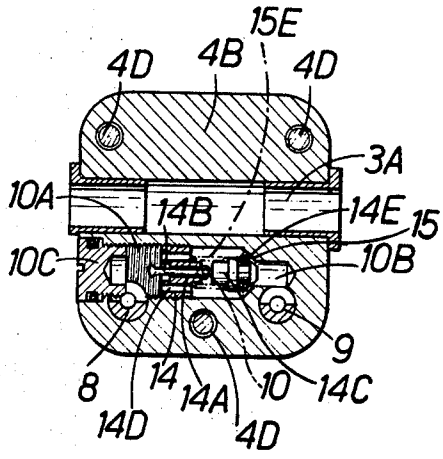



Fig.7.

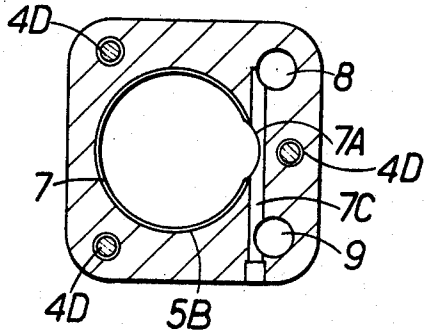



Fig.8.

# FLUID PRESSURE CONTROL DEVICE FOR AN ARTIFICIAL LEG

## FIELD OF THE INVENTION

This invention relates to a fluid pressure control device which finds particular, although not exclusive, use in artificial legs.

## BACKGROUND OF THE INVENTION

A known pneumatic pressure control device has a piston and cylinder, the cylinder including a cylinder wall and a pair of end parts; the piston rod is connected to the piston and is also mounted slidably in one of the cylinder end parts. It is also known to construct the piston in two parts and also to construct the piston rod of inner and outer parts; the two piston parts are connected to respective piston rod parts; the latter are adjustably relatively movable in axial direction, so that the piston parts can be moved towards or away from each other to vary the axial length of the piston. In this way the length of the piston stroke can be adjusted. This arrangement has disadvantages: the construction of the piston and the piston rod each in two parts is relatively complex and therefore relatively costly. Further, adjustment of the piston rod parts, to vary the axial piston length, is not very convenient.

## SUMMARY OF THE INVENTION

To overcome the disadvantages referred to above the invention is characterized in that the cylinder end wall through which the piston rod passes, is adjustably axially movable whereby the length of stroke of the piston and piston rod can be adjustably varied. Preferably the end part of the cylinder in which the piston rod is slidably mounted, is adjustably axially movable. By providing the end part with an integral external extension for engagement by a tool, for example a hexagonal extension for engagement by a spanner, the piston stroke can be easily varied.

In accordance with a feature of the invention fluid, for example air, is conveyed during piston movement from one side of the piston to the other (the device being a closed circuit device) through two passages which are outside the cylinder and extend parallel to its axis. Near its upper end each passage is formed with a tapering seat for a needle valve and a needle valve is mounted in the device for co-operating with the respective valve seat in regulating air flow. Preferably the two axially extending air passages lead into a transverse bore in a housing at the lower end of the cylinder, this transverse bore communicating also with the interior of the cylinder below the piston. In the bore a non-return valve is arranged so as to control fluid flow through one of the two air passages, but not the other. In this way, movement of the piston in both directions can be regulated to a like extent by adjustment of one of the needle valves, and movement of the piston can also be regulated in a differential manner by adjustment of the other needle valve.

The invention also includes an artificial leg having upper and lower leg members which are relatively movable about a horizontal axis for flexion of the leg, comprising:

a fluid pressure control device having a piston and cylinder, the piston being movable with the upper leg member, the cylinder being fixed to the lower leg member, and the cylinder including a cylinder wall and a pair of end parts; and

a piston rod connected to the piston and to the upper leg member, the piston rod being mounted slidably in one of the pair of cylinder end parts;

characterized in that the said one end part is adjustably axially movable relative to the cylinder wall whereby the length of stroke of the piston and piston rod can be adjustably varied so that the position of maximum extension of the upper and lower leg members about the horizontal axis can be adjustably varied.

The invention will now be described by way of example, with reference to the accompanying drawings.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic side elevation of parts of an artificial leg in the flexed position, partly broken away to show the fluid pressure control device;

FIG. 2 is similar to FIG. 1, but showing the artificial leg in the fully extended position;

FIG. 3 is an elevation of the control device as seen in the direction of the arrow "A" of FIG. 1;

FIG. 4 is a top plan of the control device;

FIG. 5 is a section on the plane V—V of FIG. 4;

FIG. 6 is a section on the plane VI—VI of FIG. 4;

FIG. 7 is a section on the plane VII—VII of FIG. 3; and

FIG. 8 is a section on the plane VIII—VIII of FIG. 6.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The fluid pressure control device of the invention will now be described as used in an artificial leg.

Referring to FIGS. 1 and 2, an artificial leg has an upper leg member 1, which is shown diagrammatically as a thigh, and a lower leg member 2, which is the upper end of a shin tube of known construction. In the member 1 is fixed in known manner a platform 1A (on which for example a stump-receiving socket (not shown) can be mounted); this platform 1A has axially aligned journals 1B (of which only one is seen) rotatably receiving a horizontal knee bolt or axle 1C, the axis of which is the axis of flexion of the leg. The shin tube 2 is substantially radial to that axis and is rigidly connected to the knee axle 1C by a framework 2A, known as a "shin cradle." This framework 2A has a rear member 2AB and two side members 2AC which are connected by an arcuate front member 2AD. (It will be understood that the outer covering of the shin is arranged in well known manner around the shin tube 2 and the framework 2A). The framework 2A is partly broken away in FIGS. 1 and 2 to show a pneumatic pressure control device 3, which is swingably connected to the framework 2A by a rod 2B which extends freely through a bore 3A (see also FIG. 7) in the device 3, the rod 2B being fixed at each end on the framework members 2AC. This arrangement permits the control device 3 to swing between the positions of FIGS. 1 and 2.

The device 3 is connected to the platform 1A by a piston rod 3B which is pivotally connected at 1D to a journal member 1E fixed to the platform 1A.

In FIG. 1 the artificial leg is shown in virtually fully flexed position and in FIG. 2 in fully extended position. The device 3 prevents movement of the artificial leg beyond the FIG. 2 position; that is, it prevents "hyperextension" and thus acts as "back-check" device. As will be explained, the position at which full extension of the artificial leg occurs can be adjusted in a simple manner, to suit the requirements of the person wearing the artificial leg.

The device 3 also provides for control of the swing phase of the artificial leg, that is, that phase of movement of the artificial leg when the artificial foot is not in contact with the ground. During the swing phase it is desirable to control the flexion and extension movements about the knee axle 1C. The use of a pneumatic piston and cylinder control device is known for this purpose, but the improved device of the invention provides for simple yet effective adjustment of the air flows.

Referring also to FIG. 3, the device 3 comprises an upper housing 4A, a lower housing 4B, and a circular cylinder wall 4C extending between, and received at each end by, the two housings, FIG. 6. The housings are held together by three tie rods 4D, only one of which is seen in FIG. 3. The lower housing 4B closes the lower end of the cylinder, the upper end of which is closed (FIG. 6) by an axially adjustably movable plug 5 which has an integral hexagonal upward extension 5A. The plug 5 is screwed into a threaded bore 5B in the upper housing 4A, so that by rotating the hexagonal extension 5A the plug 5 can be moved axially inward or outward, whereby the position of the lower end 5C of the plug 5 in the cylinder can be varied. The lower end 5C constitutes the top wall of the cylinder.

The piston rod 3B is slidably mounted in an axial bore 5D in the plug 5, air seals being provided as necessary. Carried on the lower end of the piston rod is a piston which includes a body 6A with a large wear ring 6B preferably of P.T.F.E. and cylinder-wall-engaging members 6C. The piston is of substantial axial bearing length to give good wear properties.

Upward movement of the piston and piston rod is stopped when the piston abuts the lower end 5C of the plug 5, so that by axially adjusting the position of the end 5C the position of full extension of the artificial leg can be readily adjusted. This arrangement provides for a simpler and more compact construction than previously known.

On the upward stroke of the piston air leaves the cylinder through an enlargement 7A of the threaded bore 5B (FIG. 8) of the upper housing 4A. Opening into the enlargement 7A is a transverse air passage 7C which communicates at its respective ends with vertical air tubes 8 and 9, which extend parallel to the cylinder axis, outside the cylinder, from the upper housing 4A to the lower housing 4B.

On the downward stroke of the piston air leaves the cylinder through a short air passage 10 (FIGS. 6 and 7) which communicates with a transverse bore 10A in the lower housing 4B, this bore 10A being blind at its inner end 10B and closed by a screw-in plug 10C at its outer END. The lower ends of the two air tubes 8 and 9 communicates with the bore 10A, FIG. 7.

The device has three valves: a respective needle valve at the upper end of each air tube 8, 9, and a non-return valve in the bore 10A.

The two needle valves are the same; one is shown in FIG. 5. A needle valve stem 11 co-operates with a valve seat 11A formed in the tube 9. The stem 11 is integral with a threaded shank 11B and has flanges 11C and seals 11D, for mounting the valve in a vertical bore 11E in the upper housing 4A. Threaded on the shank 11B is a rotatable valve-adjusting knob 12; this has a deep circular groove 12A in which is received one end of an elongated retainer plate 12B, see FIG. 4 and 5. The air tube 8 has a like needle-valve arrangement, with a milled valve-adjusting knob 13. (The knob 12 however is not milled, but has a screw-driver slot, not shown).

The underside of each knob 12, 13 has angularly spaced recesses (not shown) for engagement by balls 12C (one of which is seen in FIG. 5) each upwardly urged by a compression coil spring 12D (one of which is seen in FIG. 5). This provides a "click-stop" action as either knob is rotated for opening or closing movement of its respective needle valve.

It will thus be understood that air flow in either direction through the tubes 8 and 9 is variably controllable by operation of the knobs 13 and 12 respectively.

The non-return valve is shown in FIG. 7 and it permits only a one-way air flow between the lower end of the air tube 9 and the underside of the piston in the cylinder (via the bore 10A, 10B and the air passage 10). A plug 14 is threaded in the bore 10A and has five small bores extending through it — one a central bore 14A which receives a guide pin 14B of a valve head 14C; the other four bores 14D are distributed around the central bore 14A and provide for air flow past the plug. The valve head 14C carries a rubber O-ring 14E which co-operates with a frusto-conical seat 15 of the bore 10A, the ring 14E being held against the seat 15 by a compression coil spring 15E. Thus this non-return valve permits air flow from the air tube 9 during the up stroke of the piston, but prevents air flow to the air tube 9 during the down stroke of the piston. On the other hand, air flow to and from the air tube 8 is not affected by the non-return valve, since the air passes freely through the passage 10 and the bores 14D. By this arrangement of valves a differential action on flexion of the artificial leg is obtained, and this differential action can be adjusted by turning the knob 12 to adjust the relevant needle valve 11. Turning of the knob 13 on the other hand controls flexion equally in either direction, that is, in the direction towards full flexion, or in the direction towards full extension of the artificial leg. The use of a pneumatic device for control of the swing phase of an artificial leg in this manner is known, but the device of the invention provides a simpler construction than previously known, and one which is easily and quickly yet accurately adjustable. The two knobs can each be rotated for six turns, to cover the range of needle valve movement from fully open to fully closed. The "click-stop" arrangement permits simple yet positive and accurate adjustment of the needle valves to desired settings.

For efficiency in a pneumatic piston and cylinder control device, it is necessary to have a minimum clearance volume at each end of the piston stroke. On the other hand it is desirable to have good breathing, that is, the flow of air in the device must not by unduly restricted, except when necessary by the valves. Good breathing requires larger air passages; but this increases the clearance volumes. The present arrangement of the valves, with the needle valves close to the upper end of the cylinder and with the non-return valve close to the lower end of the cylinder, has been found to provide a satisfactory compromise between minimum clearance volumes and good breathing.

What we claim is:

1. An artificial leg comprising:
an upper leg member,
a lower leg movable relatively to the upper leg member for flexion of the leg,
an integral one-piece cylindrical tube constituting a clylinder,
a pair of end parts one of which is swingably connected to the lower leg member,
locating means to locate respective ends of the cylinder against the end parts and to hold the end parts in spaced relation,
a piston slidable in the cylinder,
a piston rod connected to the piston and extended through one of the end parts, the piston rod being connected to the upper leg member for movement therewith,
a member adjustably secured in one of the end parts and having means constituting an end face for restricting the axial displacement of the piston in one direction,
air conveying tubes extending from one end part to the other for conveying air from side to side of the piston,
means for allowing passage of air in both end parts for conveying air from respective sides of the piston through the air conveying tubes,
an air flow control means mounted in one end part and extending transversely across said air conveying tubes for allowing air to flow freely from side to side of the piston through all air conveying tubes except one,
said air flow control means having means for allowing air to flow in one direction in one air conveying tube but restricting flow in the opposite direction in the same tube, and
valves adjustably mounted in a first end part, each valve being operatively associated with a seating in an end of an air conveying tube for controlling air flow therethrough.

2. An artificial leg according to claim 1, wherein the said adjustably secured member is an externally threaded plug mounted in an internally threaded bore in one end part.

3. An artificial leg according to claim 1, wherein the locating means comprises connecting rods extending from one end part to the other and operative to locate and clamp the cylinder between the end parts.

4. An artificial leg according to claim 1, wherein the said adjustably secured member has an axial bore in which the piston rod is slidably movable.

5. An artificial leg according to claim 1, wherein the adjustably mounted valves are needle valves each axially and non-rotatably movable in the said first end part, and each having a threaded shank received in a knob rotatably mounted in the said first end part.

6. An artificial leg according to claim 1, wherein said air flow control means includes a plug mounted in said air passage means in one end part, said plug having small bores extending through it.

7. An artificial leg according to claim 6, wherein said air flow control means further includes a non-return valve seated in one of said air passage means.

* * * * *