

[54] **ENDOPROSTHESES, ESPECIALLY FOR HIP JOINTS**

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[22] Filed: **Feb. 4, 1970**

[21] Appl. No.: **8,647**

[30] **Foreign Application Priority Data**

Feb. 8, 1969 Germany P 19 06 284.1

[52] U.S. Cl. 3/1, 128/92 C, 128/92 CA

[51] Int. Cl. A61f 1/24

[58] Field of Search 3/1, 1.2; 128/92 R, 92 C, 92 CA

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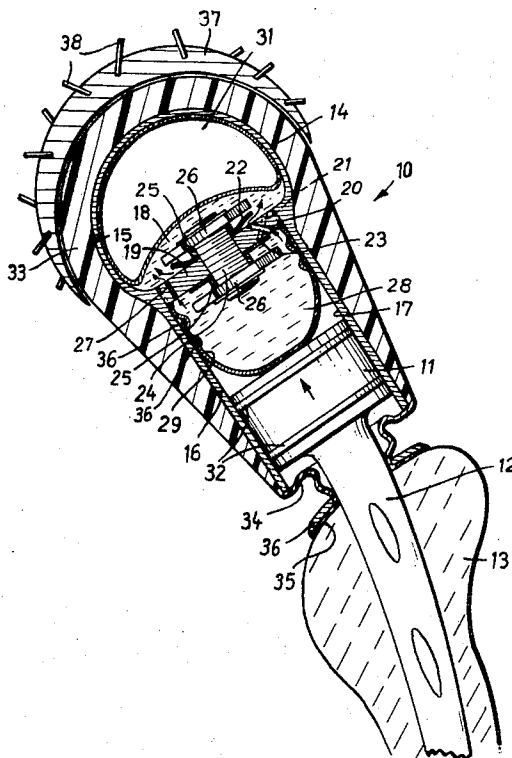
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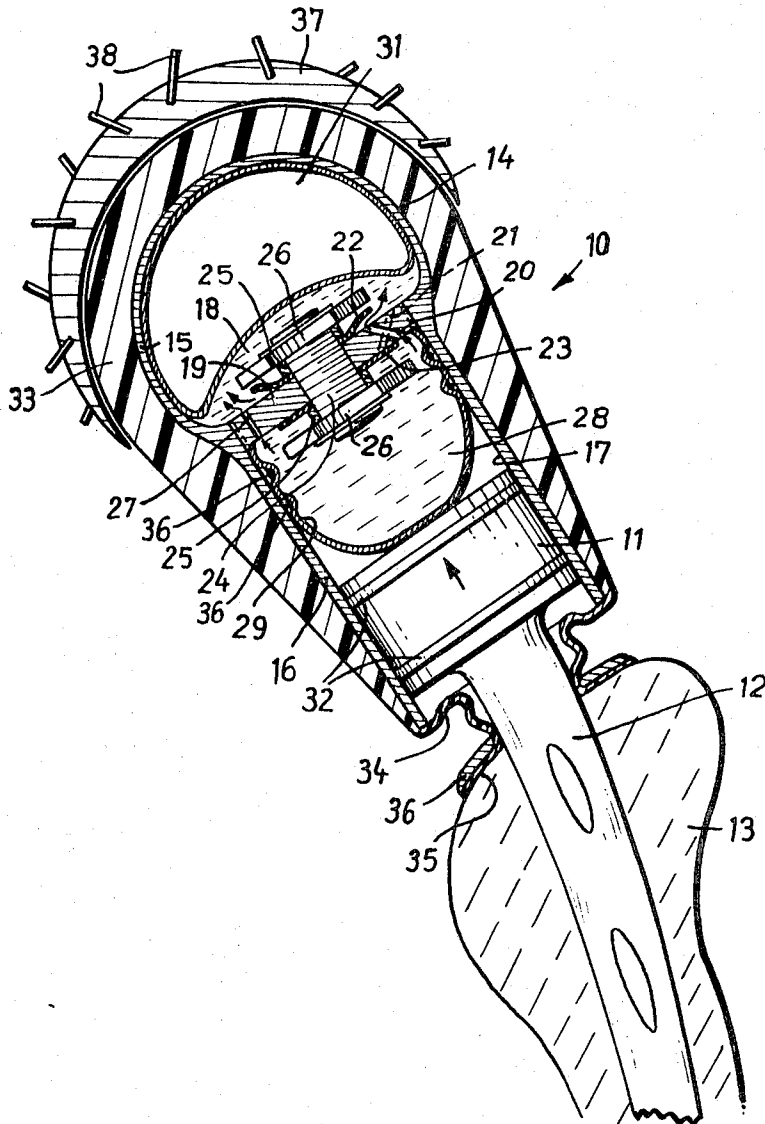
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ABSTRACT

Disclosed are endoprostheses which include a piston forming a joint head and mounted on a bone and a cylinder for receiving the piston and mounted in the mating bone. The cylinder is divided into two sections, the section for receiving the piston contains a liquid, advantageously in bellows, which liquid is forced into the other section of the cylinder to compress a gas, the compressed gas therein thereby cushioning shocks. Flow of liquid between the sections is controlled by back pressure valves.

12 Claims, 1 Drawing Figure





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ENDOPROSTHESES, ESPECIALLY FOR HIP JOINTS

The invention is concerned with an endoprosthesis, especially for hip joints, consisting of an artificial joint head which is fastened to the proper bone and fits into the joint socket.

Endoprostheses of this kind are already known which are inserted by means of an operation in the case of fractures of the upper thigh neck or injuries to the hip as a replacement for the destroyed joint head or the joint ball, no longer able to grow together with the femur, and which are connected with the upper thigh bone by long pins. These known joint heads which are usually made of corrosionproof metal transmit the jolts produced in the act of walking directly to the joint socket.

If a partial prosthesis is involved, in the case of which the natural joint socket is still preserved, the direct friction between metal and bone leads in a relatively short time to the destruction of the joint socket. Moreover, the continuous jolts and frictional forces bring about a sensitization of the socket, loosening of the prostheses in the shaft of the upper thigh, the formation of excessive bone growth and eventually breaking through of the socket into the pelvis.

In the case of complete prostheses in which also the joint socket is lined with, or replaced by, a metal shell the jolts and the compressive loads are introduced into the pelvic bone by way of the artificial joint socket. By the continuous jolts in the act of walking and running the joint socket is gradually loosened. Friction leads to a sensitization of the pelvic bone and to a progressive development of bone growth which cause pains, increasing in intensity as time goes on, to the wearer of the prostheses with each movement of the leg. The same process also takes place in the shaft of the upper thigh. Although attempts were made to overcome the foregoing difficulties and other disadvantages, none, as far as I am aware, was entirely satisfactory when practiced on a large scale.

It has now been discovered that these disadvantages can be avoided and endoprostheses can be produced with which impacts in the joint can be absorbed to a large extent and a sensitization of the joint socket and the development of pain connected with it can either be avoided or at least greatly reduced.

In accordance with the present invention, there is provided endoprostheses, of the type described herebefore, including a joint head which consists of two parts, movable against each other in an axial direction, between which impact-absorbing spring elements are arranged.

The direct transmission of jolts of the limbs over the joint head upon the joint socket are avoided by this design, since the impact energy is absorbed inside the joint head. Limbs provided with such a prostheses display limited amounts of elasticity which makes compression of the leg or the arm in an axial direction within certain limits possible.

In accordance with a more limited aspect of the present invention, one part of a joint head is formed by a piston which is firmly connected with the bone and the other part by a cylinder, fitting over the piston, which carries on its end away from the front surface of the piston a dome the interior of which is separated from the cavity of the cylinder by a partition. The cylinder is filled with a liquid which can enter into the interior of the dome through intake channels and return to the interior of the cylinder through outlet channels in the partition.

In accordance with an even more limited aspect of the present invention, there is included in endoprostheses of the type described immediately hereinabove a closed elastic bladder containing a compressible gas which bladder, placed within the dome, is acted upon by the liquid entering the interior. If the piston is pushed against the liquid, the liquid flows through the intake channels into the interior of the dome, whereby the gas contained in the elastic bladder is compressed until the forces are balanced. The pressure transmission from the joint head to the joint socket occurs therefore not fitfully but in a more uniform manner than in the case of an artificial joint head which is rigidly connected with the bone. When the load is then taken off the limb provided with the prosthesis, the liquid which has forced into the interior of

the dome is pushed again into the interior of the cylinder through the outlet channels by the pressure of the expanding bladder, in which process piston, receding with the load reduction, produces an underpressure in the cylinder which facilitates the return flow of the liquid.

In accordance with another aspect of the present invention, the intake channels and the outlet channels in the partition can be closed by means of back pressure valves. Depending on the intensity of the impact these back pressure valves open up a more or less restricted cross section of passage. For closing the intake and outlet channels elastic or spring-loaded valve plates are appropriately provided. There is, in accordance with a further aspect of the present invention, provided at least one constantly open pressure-balance channel in the partition which connects the interior of the cylinder with the interior of the dome. A complete return flow of the liquid which has been forced into interior of the dome is thereby achieved, even if the expansion of the elastic bladder inside the dome does not provide sufficient pressure to push the liquid back into the cylinder. Moreover, the pressure-balance channel permits a gradual shifting of the piston in the cylinder if the load on the limb provided with the prosthesis is rather slowly applied, for instance, if the person is standing and shifts the weight of his body from one leg to the other.

In order to enable the piston in the case of severe jolts to shift sufficiently and to press a large enough volume of the liquid into the interior of the dome, the total cross section of passage of the intake channels is substantially larger than the cross section of passage of the pressure-balance channels. The displacement of the piston in the case of only a slight load or small jolts can be regulated by the initial stress in the springs of the valve plates.

The liquid in the cylinder is advantageously contained in a compressible pleated bag (bellows) which is acted upon by the piston. This prevents the liquid necessary for the function of the joint from leaking out of the joint in case of leaky piston rings. For the same purpose, a sealing cuff of some elastic plastic material is provided which is arranged on the end of the cylinder, embracing the piston and enclosing as well as sealing, the piston rod inserted into the bone, and which is clamped with its free edge between the upper boundary of the bone and a doughnut-disk plate fastened to it.

To prevent friction between the joint head and the joint socket, the joint head, made of stainless steel, is covered by a cap of a wear-resistant synthetic material which is connected with the sealing cuff. The joint socket can be formed in a similar manner of a wear-resistant synthetic material and fastened to the pelvic bone.

It is a principal object of the present invention to provide endoprostheses which minimize the pain associated with sudden jolts encountered during use.

Another object of the present invention is to provide artificial joints which minimize the discomfort associated with sensitization.

Yet another object of the present invention is to provide endoprostheses in which the effects of friction are minimized.

A still further object of the present invention is to provide artificial joints which reduce the effects of shifting weight and other gradual movements.

The invention may take physical form in certain elements and arrangements of elements, a preferred embodiment which be described in detail in this specification and illustrated in the accompanying drawing which forms a part hereof and in which the Figure depicts an artificial hip joint in vertical section.

Referring now to the drawing wherein the showings are for the purpose of illustrating the preferred embodiment of the invention only and not for the purpose of limiting same, the FIGURE shows an artificial hip joint.

The artificial joint head 10 is constructed in two parts and consists of a piston 11 of stainless steel whose piston rod 12 has the shape of a pin with three lamellae and is inserted into the bone 13 of the upper thigh and solidly cemented into it.

The other part of the joint head is the ball head 14 proper which consists of a dome 15 of high-grade alloy steel to the base of which a cylinder 16 is joined in which the piston 11 is movably guided. The inside 17 of the cylinder is separated from the interior 18 of the dome 15 by a partition 19 which is provided with a number of intake channels 20 and outlet channels 21 in an annular arrangement.

The intake channels 20 are closed in the interior 18 of the dome 15 by elastic valve plates 22 and the outlet channels 21 by elastic valve plates 23. The valve plates 22 and 23 are ring-shaped and slipped over a bolt 24. They are firmly clamped by spacer rings 25 which are held by nuts 26 screwed on to the bolts 24. The nuts 26 serve at the time as catch plates and limit the deflection of the springy valve plates 22 and 23. In place of the spacer rings 25 coil springs or spring plates can also be used between the catch plates and the valve plates 22 and 23.

Beside the intake and outlet channels 20 and 21 a few pressure-balance channels 27 are also provided in the partition 19 which connect the interior 17 of the cylinder with the interior 18 of the dome and constantly open. However, their cross section of passage is altogether substantially smaller than the cross section of passage of the intake channels 20 and the outlet channels 21.

In the interior 17 of the cylinder is contained a liquid of appropriate viscosity, for instance a mineral oil 28, which is enclosed in a pleated bag 29 which is, however, open on its side facing the partition 19 and which is acted upon by the piston 11. Steel rings 36 inserted into the pleats of the bellows 29 prevent jamming of the bellows 29 when the bag is compressed by the piston 11.

In the interior 18 of the dome 15 is arranged a completely closed bladder 31 of a synthetic material or some other elastic material resistant to aging which is filled with a compressible gas, such as nitrous oxide (N_2O) and forms a closed and compressible gas chamber which fills the inside 18 of the dome 15 almost completely.

The piston 11 is sealed against the wall of the cylinder 17 by two gaskets 32 of a self-lubricating synthetic material. It can also be provided with a wear-resistant plastic coating.

The dome 15 and the cylinder 16 connected with it are covered by a cap 33 of a wear-resistant synthetic material on whose lower end embracing the rim of the cylinder 16 a sealing cuff 34 of an elastic synthetic material is arranged which encloses and seals the piston rod 12 embedded in the bone 13 and is clamped with its free border between the upper boundary 35 of the bone and a ring plate 36 fastened to it. The ball head 14 joined together by the cap 33 fits into the joint socket 37 of the same wear-resistant synthetic material of which the cap 33 is made. The joint socket 37 is fastened to the pelvic bone (not shown in detail) by means of appropriate fastening devices 38.

The mode of operation of the prostheses is as follows:

When the leg is weighted in the act of walking, the piston 11 is displaced in the cylinder 16 in the direction towards the partition 19 and compresses the bellows 29. The liquid 28 enclosed in the bellows is hereby pressed through the pressure-balance channels 27 into the interior 18 of the dome 15 and compresses there the gas bladder 31.

With a heavier load and especially if it occurs as a shock, the piston 11 exerts such a high pressure upon the liquid 28 that the valve plate 22 is lifted from its seat and the liquid flows also through the intake channels 20 into the interior 18 of the dome 15 and compresses the gas bladder 31, by which process the gas enclosed in this bladder is compressed. The jolts are hereby absorbed in the joint head 10 and not or only to a very slight degree transmitted to the joint socket 37.

When the load is taken off the leg, the gas compressed in the bladder 31 pushes the liquid which has penetrated into the interior 18 of the dome 15 through the outlet channels 21 and, with the gas pressure subsiding, through the pressure-balance channels 27 back into the membrane 29 in the interior 17 of the cylinder, whereby the piston 11 is pushed back.

Polyurethanes or also polyethylenes of high molecular weight are suitable as material for the cap 33 and the joint socket 37.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

Having thus described my invention, I claim:

1. In endoprosthesis including an artificial head joint adapted to be fastened to a preselected bone and having first and second portions axially movable relative to each other and a jointsocket receiving said head, the improvement comprising: means for absorbing impact disposed between said first and second portions, said impact absorbing means comprising a piston including a piston rod extending therefrom adapted to mount said piston to said preselected bone; a cylinder having one portion defining a chamber for closely receiving said piston and another portion forming a dome; and, a partition separating said chamber and said dome from each other, said partition including means transmitting a cushioning liquid therethrough between said chamber and said dome in response to axial movement of said piston within said chamber.

2. In endoprosthesis described in claim 1, wherein said transmitting means comprises intake and outlet channels in said partition, said liquid filling at least said chamber such that axial movement of said piston in said chamber toward said partition forces said liquid into said dome through said intake channels, said dome including means for forcing said liquid back into said chamber through said outlet channels as said piston is moved axially away from said partition in said chamber.

3. In endoprosthesis described in claim 2, said forcing means comprising a closed and compressible bladder in the interior of said dome which bladder is acted upon by the liquid entering said dome.

4. In endoprosthesis described in claim 3, further including back pressure valves opening and closing said intake and outlet channels in said partition.

5. In endoprosthesis described in claim 2, further including at least one constantly open pressure-balance channel in said partition interconnecting said chamber with said dome.

6. In endoprosthesis described in claim 4, wherein said valves are elastic valve plates for closing said intake and outlet channels.

7. In endoprosthesis described in claim 4, wherein said valves are spring-loaded valve plates for closing said intake and outlet channels.

8. In endoprosthesis described in claim 5, wherein the total cross section of said intake channels is substantially larger than the cross section of said pressure-balance channels.

9. In endoprosthesis described in claim 2, further including a compressible pleated bag disposed in said chamber adjacent said partition containing said liquid in said chamber, said piston acting against said bag.

10. In endoprosthesis described in claim 9, further including a plastic sealing cuff disposed adjacent the end of said cylinder embracing said piston for enclosing and sealing said piston rod; and, a ring plate surrounding said cuff adapted to clamp the free edge of said cuff to the upper boundary of said preselected bone.

11. In endoprosthesis described in claim 10, wherein said cylinder is made of stainless steel and is coated with a wear-resistant synthetic material which is connected with said cuff.

12. In endoprosthesis described in claim 11, said joint socket for receiving said head is formed of a wear-resistant synthetic material and is adapted to be fastened to a pelvic bone.

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