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The title of the invention has been amended (Guidelines for Examination in the EPO, A-III, 7.3).

(54) **Continuous passive motion device for limbs.**

(57) A device for the passive movement of limbs comprising co-operating inflatable bags and associated inflation and deflation means, wherein a first bag is adapted, when inflated to raise the joint and a second bag is adapted, when inflated to straighten the limb, said inflation and deflation means being arranged to alternately inflate one bag and deflate the other bag thereby allowing the limb to be alternately bent and raised at the joint and then straightened and lowered.

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**Description**

# CONTINUOUS PASSIVE MOTION DEVICE

The present invention relates to a device for moving body joints and more particularly to the passive movement of joints ie. where joints are moved by the application of external forces.

The joints of humans or other animals can, after surgery or injury, become stiff during the period whilst the joint is healing. Slow and continuous movement of the joint during the period of healing can reduce the stiffness of the joint, stimulate healing of the joint and reduce the pain associated with the healing joint.

Machines designed to move the healing joint slowly and continuously exist. However they are large and cumbersome and use electric motors to provide the motive power. These machines are potentially dangerous to use in hospital beds and are also inconvenient to use in, for example, the patients home.

The present invention seeks to provide a safe and lightweight means of moving body joints in a slow and continuous manner, avoiding the disadvantages of human devices.

According to the present invention there is provided a device for the passive movement of limbs comprising co-operating inflatable bags and associated inflation and deflation means, wherein a first bag is adapted, when inflated to raise the joint and a second bag is adapted, when inflated to straighten the limb, said inflation and deflation means being arranged to alternately inflate one bag and deflate the other bag thereby allowing the limb to be alternately bent and raised at the joint and then straightened and lowered.

The invention as applied to the passive movement of legs, provides apparatus which comprises two inflatable bags and associated inflation and deflation means wherein the first bag is adapted to be placed under the knee and the second bag is adapted to be placed at the back of the leg, whereby inflation of the first bag and deflation of the second bag by the inflation and deflation means bends the leg at the knee and deflation on the first bag and inflation of the second bag by the inflation and deflation means straightens the leg.

The first bag is adapted to be placed under the knee and may be shaped such that when inflated, it also aids in the support of the thigh. Suitably the first bag has a base which is preferably rectangular or trapezoidal, two end walls which can be for example trepezium in shape or, more preferably triangular and two or more side walls which can be for example rectangular. Typically the base of the first bag when rectangular in cross section is 20cm wide and 30cm long. The triangular end walls have a base 30cm long with two equal sides each 25cm long. The two side walls are 20cm wide and 25 high.

In a preferred arrangement the sides of the triangular end walls are all unequal in length. Thus the bag may be rotated through the axis of the triangular end walls to provide three different apical heights.

The base of the first bag can for example rest upon the surface eg. bed on which the patient is lying. Optionally the first bag may be attached to react against the second bag and may permanently or removably affixed thereto.

Although the first bag may comprise several independant chambers, it preferably comprises one inflatable chamber. More preferable ribs or septums are provided within the chamber to provide interconnecting chambers and more rigidity to the structure.

The first bag may also be part of a bellows arrangement whereby the bag fills the space between two hinged rigid or semi-rigid supporting members.

According to the embodiment of the invention, the second bag may be suitably shaped to support the flexor surface of the limb, and is preferably 'U' shaped in cross section, although bags which encircle the limb may also be employed. Thus when applied to a leg the bag is adapted to be placed under the leg so that it covers the back and sides of the knee and the back and sides of both upper and lower leg, with the base of the 'U' shaped second bag covering the back of the leg and the arms of the 'U' shaped second bag covering the sides of the leg. The 'U' shaped second bag can optionally extend down the leg to cover the heel and plantar region of the foot. Typically the 'U' shaped second bag is long and thin, for example about 70cm long and the side walls of the 'U' are between 5 and 15cm high. It is intended that where the second bag is described as being in the shape of the letter 'U', this description shall also include second bags in the shape of the letter 'C', a horseshoe and second bags in the shape of an interrupted circle. The 'U' shaped second bag can be retained over the knee and leg by any conventional means such as straps passing over the dorsal surface of the limb or adhesives.

Like the first bag, the second bag preferably comprises a single inflatable chamber. However first bags comprising more than one chamber may be employed. The chambers may be internally supported with ribs or septa, preferably to form a number of interconnecting chambers.

Optionally there may be a pivotal means fitted to one end of the second bag which allows said second bag to move backwards and forwards when it is resting on a surface. This pivotal means may consist of a third inflatable bag of circular cross-section which is attached to the second bag so as to allow the two to move in relation to each other.

According to another embodiment of the invention, the second bag may be arranged to raise, lower and support only the lower part of the limb. In such an arrangement the construction of the second bag may be similar to that of the first, with the triangular end wall shape being preferred.

With such a preferred arrangement only the apical ridge of the bag will abut the limb. It is therefore more preferred to interpose a load spreading plate between the ridge of the bag and the flexor surface

of the limb. This plate may be connected by suitable pivotal means to another plate functioning in similar manner to support the upper limb and being interposed between the first bag and the flexor surface of, for example, the thigh. Both plates may be suitably shaped to generally conform to the contour of the limb surface.

In the arrangement whereby the upper limb is supported by a plate and the first bag is part of a bellows arrangement ie. the bag is surrounded in two sides by the hinged support, means may be provided to adjustably secure the plate to the support to accomodate different leg lengths. Thus a number of holes may be provided in both arms of the support cooperating with pegs provided on the plate.

The inflation and deflation means can comprise either a single co-operating means or two or more separate means adapted to permit fluid, such as air to be passed into or withdrawn from the bags alternately. Preferably the inflation and deflation means comprises for example an air pump, valves and a controlling means for regulating operation of the pump. The pump and valves are so arranged that when one bag of the device is being inflated the other bag is being deflated. The controlling means is used to regulate the rate of and times between inflation and deflation of the two bags of the device.

Alternatively the inflation and deflation means can comprise two separate air pumps, valves and controlling means. One of the air pumps is used to deflate and inflate the first bag of the device whilst the other air pump is used to deflate and inflate the second bag of the device.

The inflation and deflation means can be connected to the device by for example flexible plastic tubing.

When uninflated the device can be fitted easily to a joint such as a knee joint and then inflated. The first and second bags are attached by tubing to the inflation and deflation means. In the first cycle the first bag is inflated whilst the second bag is deflated. This has the first bag is then deflated and the second bag is inflated causing the joint to straighten. By alternating and repeating the two cycles the joint can be moved slowly and continuously

An embodiment of the present invention will now be described in detail by way of example; with reference to the accompanying drawings, in which

Figure 1 is a side view of the device in place on a leg with the first bag inflated and the second bag deflated,

Figure 2 is a side view of the device on a knee joint with the first bag deflated and the second bag inflated, and

Figure 3 is a side view of an alternative construction the device according to the invention.

Referring to figures 1 and 2 the second bag (12) 'U' shaped in cross-section is placed under the back and sides of the thigh, knee and calf of the leg and the heel of the foot. The first bag (11) which is triangular in cross-section is placed so that its apex is opposite the angle of the knee and contacting the surface of the second bag (12) not in contact with the knee. The second bag (12) is retained around the knee joint (13) by straps (14).

The bags may be fabricated from sheets and a transfer coated polyurethane fabric, welded together by radio frequency welding to form the bags. The pivotal means (15) attached to the second bag (12) allows the second bag (12) to move backwards and forwards when it is resting on a surface. The first and second bags (12 and 11) are attached by tubing (16) to the inflation and deflation means (17).

In operation bag (11) is inflated whilst bag (12) is deflated. This causes the leg to be raised in the region of the knee and for the leg to bend at the knee. After a lapse of a predetermined period of time bag (12) is inflated whilst bag (11) is deflated causing the leg to be straightened and for the knee region to be lowered. Alternating cycles cause the leg to be repeatedly flexed

Referring to Figure 3 bag (11) is surrounded on two sides by a semi rigid support (18). This is constructed from thermoplastic (Sansplint).

The support is to endow a certain degree of rigidity to the device. It is hinged at the bag corner (19). This is achieved by either bonding in a hinge, by using a special hinged moulding, or by simply using a partial thickness slit on the plastic. This latter allows adequate flexion.

The plastic support will be designed to be as adjustable as possible to accommodate different leg lengths. This is achieved by using unequal lengths from the hinge and a series of holes (20) to which the thigh plate (21) is mounted. This allows adjustment by reversal of the hinge plates and secondly by sliding the thigh plate to an appropriate mounting hold. This is then pegged (22).

The maximum angle to which the hinge plates will open (upon inflation of the bag) is determined by placing adjustable strap (25) between the open ends of the plates. These serve the dual purpose of also retaining the air bag.

The air bag is inflated and deflated on a timed cycle to raise and lower the upper leg of a prone patient. A lower leg plate is attached to the thigh plate again by a simple hinge (24). The length of this may or may not be adjustable.

This plate is raised and lowered by a second air bag (12). The motion generated by this bag will oppose that of the thigh bag, ie. the thigh bag will inflate whilst the lower leg bag deflates and vice versa. Bag (12) may or may not have a semi rigid support (18) similar to that for the thigh bag. The aim of the support is to enhance the stability of the bags.

The pump (17) used to control the bags may be of a simple diaphragm type and may incorporate a pressure regulating device (not shown) and will supply a motorised valve (not shown). This will direct the air supply to each bag in turn, allowing the other to deflate. The cycle may or may not be adjustable and may vary from 2 to 15 minutes.

## Claims

1. Device for the passive movement of limbs comprising co-operating inflatable bags and associated inflation and deflation means, wherein a first bag is adapted, when inflated to raise the joint and a second bag is adapted, when inflated to straighten the limb, said inflation and deflation means being arranged to alternately inflate one bag and deflate the other bag thereby allowing the limb to be alternately bent and raised at the joint and then straightened and lowered.

2. A device as claimed in claim 1 wherein the fist bag is adapted to be placed behind a knee joint.

3. A device as claimed in any of the preceeding claims in which the first bag has a rectangular or trapezoidal base, two triangular or trapezium shaped walls and two rectanguar side walls.

4. A device as claimed in claim 3 wherein the end walls are triangular in shape, each side of the triangle being of different length.

5. A device as claimed in claim 4 wherein two of the side walls are additionally supported by a hinged rigid or semi-rigid support member.

6. A device as claimed in any one of the preceeding claims in which the second bag is adapted to be placed around the flexor surface of the joint and the limb on either side of the joint.

7. A device as claimed in claim 6 in which the second bag is 'U' shaped in cross-section.

8. A device as claimed in either claim 6 or claim 7 in which the second bag is attached to the joint and limb by attachment means passing over the dorsal surface of the joint and limb.

9. A device as claimed in any of claims 6 to 8 in which the second bag extends to cover the heel and plantar surface of the foot.

10. A device as claimed in any of claims 6 to 9 in which a pivotal means is attached to the second bag whereby the limb is enabled to move backwards and forwards when the joint is raised and lowered.

11. A device as claimed in claim 11 in which the pivotal means is attached to the portion of the second bag which covers the heel and said pivotal means comprises a third inflatable bag.

12. A device as claimed in anyone of claims 1 to 6 wherein said second bag is adapted to support only one half of the limb.

13. A device as claimed in claim 12 wherein the second bag has a rectangular base and two triangular end walls.

14. A device as claimed in claim 13 wherein the sides of the triangular end wall are all unequal.

15. A device as claimed in any of claims 12 to 14 wherein a rigid support is adapted to the interposed between said second bag and said half of the limb.

16. A device as claimed in claim 15 where a rigid support is adapted to be interposed between said first bag and the other half of the limb.

17. A device as claimed in claim 16 wherein both rigid supports are hinged together and adapted to pivotaly move around the hinge point in the region of the joint.

18. A device as claimed in any of the preceeding claims wherein the first and second bag comprise more than one chamber.

19. A device as claimed in any of the preceeding claims in which the inflation and deflation means comprises an air pump, a valve and a controlling means.

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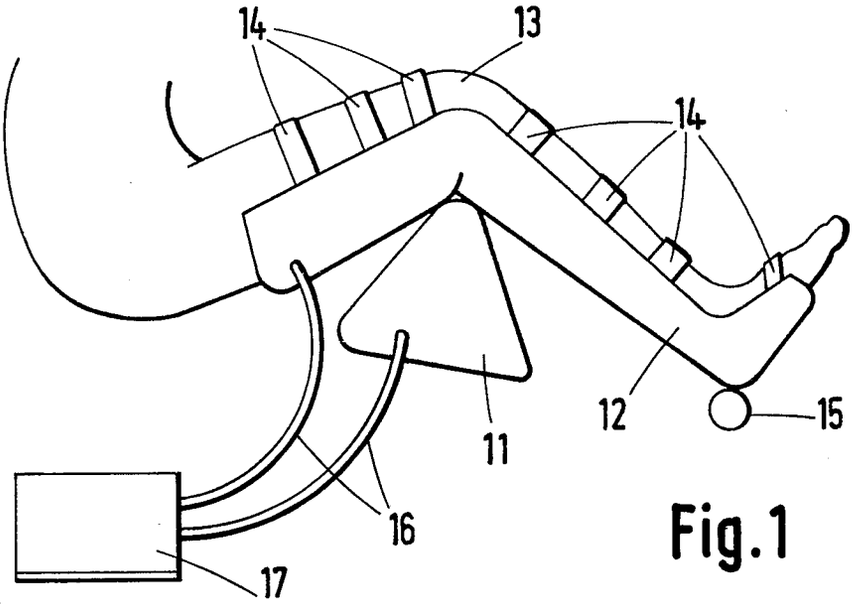


Fig.1

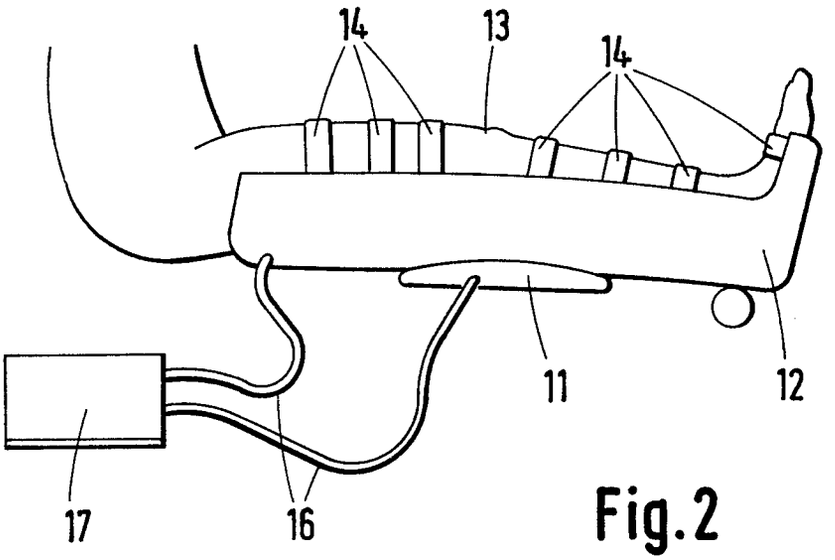


Fig.2

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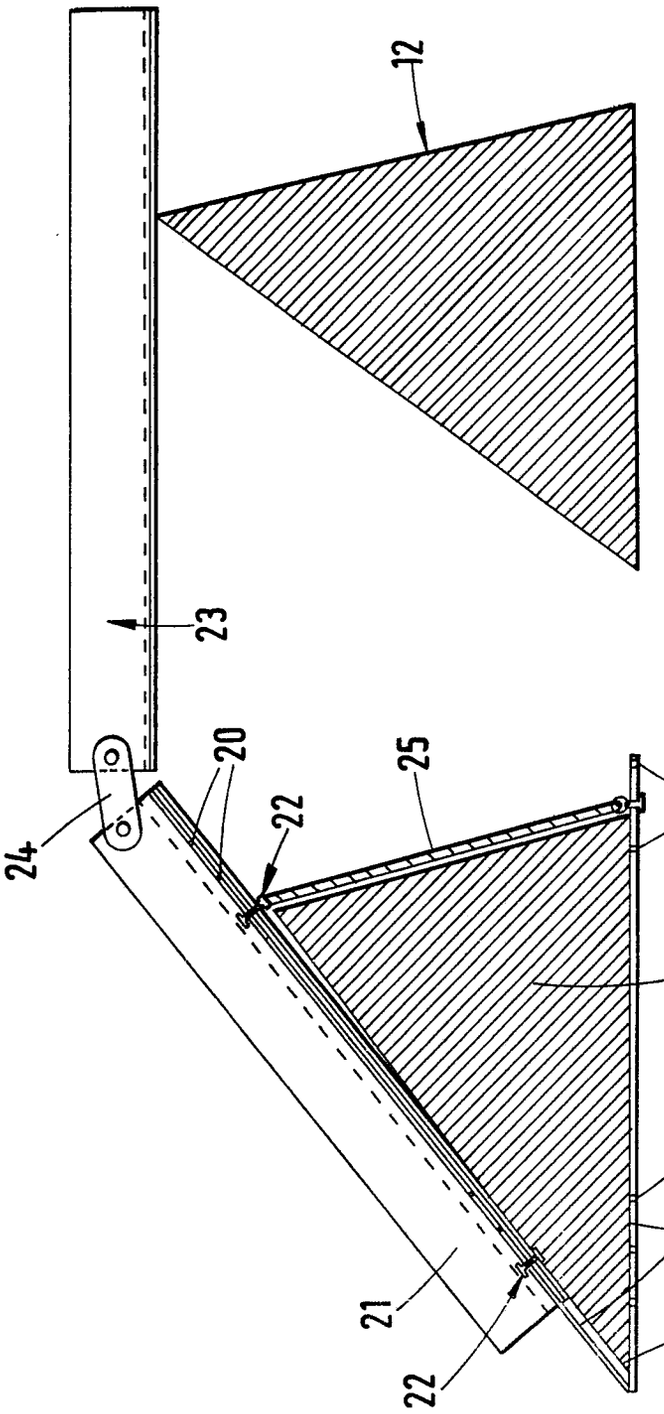


Fig.3