Dec. 15, 1953 C. H. BENNINGTON 2,662,228

ORTHOPEDIC AND PROSTHETIC APPLIANCE

Filed April 13, 1951

FIG. 1.

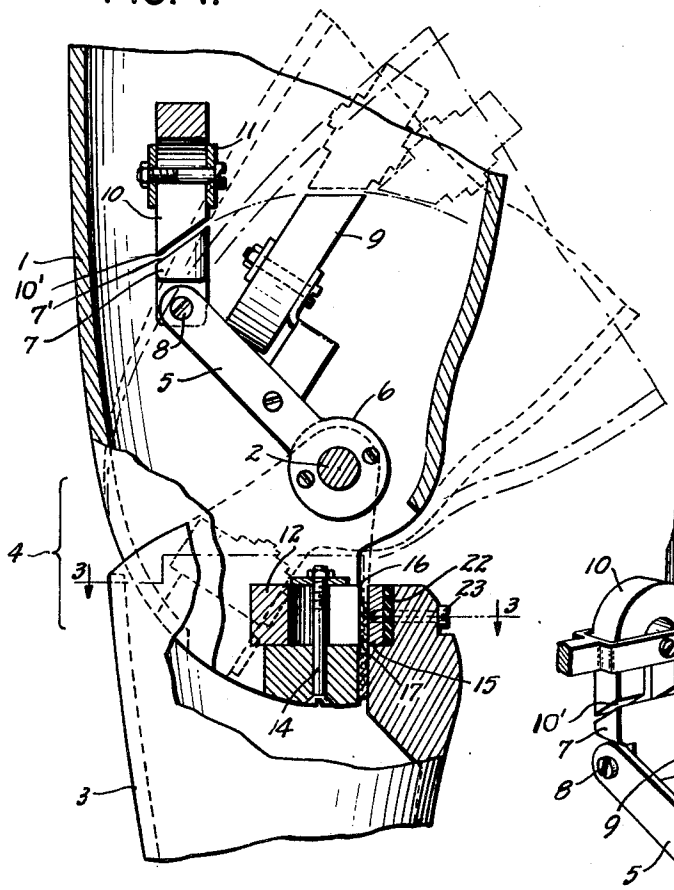


FIG. 2.

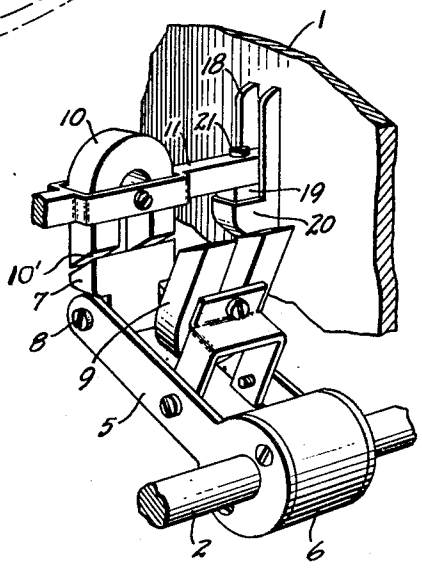


FIG. 3.

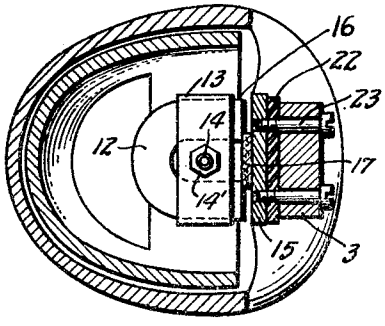
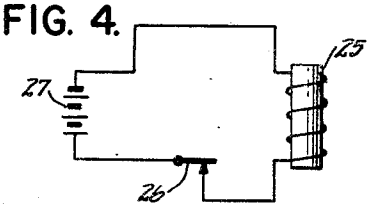


FIG. 4.



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Patented Dec. 15, 1953

2,662,228

UNITED STATES PATENT OFFICE

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ORTHOPEDIC AND PROSTHETIC APPLIANCE

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Application April 13, 1951, Serial No. 220,853

13 Claims. (Cl. 3—1.1)

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This invention has to do with magnetically controlled orthopedic appliances, such as braces, and prosthesis such as artificial legs, arms, hands and other appliances having movable joints.

Many suggestions have been made particularly in prosthesis to enable them to approximate the movements of natural limbs by employing solenoids and other electric motors; electronic, hydraulic, pneumatic and other relatively complicated devices. However, the structures proposed were heavy, cumbersome, complicated and, therefore, expensive, and likely to fail. Further, the wearer often had consciously to operate buttons, levers, or the like, to control the functioning of the limb.

In the natural leg, a person can control his leg to hold it flexed to support his weight at any position between the two limiting positions—extension and fully flexed. Heretofore, control of the flexion of the leg was by frictional braking mechanisms which exerted a constant drag in all positions.

While the strength of a brake can be increased so that the leg will support weight in any flexed position, it would prevent the leg's free operation as is necessary in walking. Consequently, a brake could never be made strong enough so that the leg could take weight while flexed.

According to the invention, resistance to flexion in the knee or leg is not constant but is introduced only in certain positions of flexion; in the intermediate positions the leg is free to move. The limiting positions selected are the ones in which resistance is required to aid the user in walking, sitting down, etc. For instance, the resistance may be made maximum in the extended position of the leg, somewhat less when the leg is first flexed from the extended position, normal in the next range of flexion, more than normal but less than maximum in the next range, etc. This is accomplished by the provision of magnets which in various positions of flexion will exert attractive or repulsive forces in opposition to the continuing of the flexing movement.

The object of the present invention is to provide an artificial limb performing movements simulating nature and which is simple, light, inexpensive and fool-proof.

According to the present invention, permanent or electro magnets are provided which in various positions of flexion will exert attractive or repulsive forces in opposition to the continuing of the flexing movement.

The invention will be described and illustrated as applied to the knee joint of an artificial leg,

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but it will be obvious to those skilled in the art that it is applicable to a wide variety of orthopedic and prosthetic appliances in which one member is moved relative another.

In normal walking the knee joint is flexed only slightly as the leg is carried from rearmost position to extended position, at which point weight is placed on the leg at the start of a step. When a wearer moves into and out of sitting position the knee joint must also be capable of greater flexion than is required in walking.

In accordance with the present invention, magnetic elements are located in each of the pivotally connected members so that an attractive or repelling magnetic field is set up as the members approach at least certain predetermined positions.

The artificial limb according to the invention is used and worn in the customary manner, i. e. elements are brought together and separated by the shifting of the weight of the wearer and by the inertia of the members as the wearer walks, sits down, etc. For instance, as the leg is carried forward in walking, it will be locked in the extension by the magnets so that when the wearer bears down at the beginning of a step the maintenance of the knee in extension will be insured. While there have been many suggestions for locking devices, a common objection to them was that the wearer could never be sure whether the limb would hold him or buckle under his weight, and even where the locking action was certain, unlocking could fail. Wearers of artificial legs have, therefore, been reluctant to put too much faith in the device and tended to keep as much weight as possible on their good leg rather than stepping out on both legs. This is a common cause for their walking with a decided limp. With the magnetic limb constituted according to the invention, it will be possible for a wearer to walk almost indistinguishably from a person having natural legs.

Referring to the drawings:

Fig. 1 is a side elevation partly in section of the invention;

Fig. 2 is a fragmentary perspective view of a portion of Fig. 1;

Fig. 3 is a top plan view on lines 3—3 of Fig. 1; and

Fig. 4 is a schematic circuit diagram of an electro magnet which may be used in the invention.

The leg comprises an upper or femur portion 1, which is pivotally connected by a pin 2 to a lower or shin portion 3. A socket (not shown)

is provided on member 1 for an amputee's stump. Members 1 and 3 are suitably shaped to simulate a knee joint, generally indicated at 4, and may be moved through a range of positions between two limiting positions, one of said limiting positions being when the leg is extended, and the other when the leg is fully flexed or at an intermediate point of flexure.

A pair of arms 5 are mounted on a bushing 6 surrounding pin 2 and have a bar of magnetic material 7, e. g. soft iron, mounted by means of screws 8 at the free ends of arms 5. A permanent magnet 9 is suitably fastened to arms 5 between bushing 6 and bar 7.

A second permanent magnet 10 is fastened inside upper member 1 by means of a bracket 11 extending between the walls of member 1. When the leg is in extended position, i. e. when members 1 and 3 are in alignment (as shown in solid lines Fig. 1), face 10' of magnet 10 is in close cooperation with the face 7' of bar 7, resulting in maximum attraction between the two elements. When the leg is partially flexed (as shown in dotted lines in Fig. 1) magnet 10 is moved away from bar 7 and into cooperative relation with magnet 9. Magnet 9 is poled similarly to magnet 10 (the magnets have like poles facing each other), so that one tends to repel the other. The repulsion reaches its maximum force when the magnets are aligned as shown in dotted lines. When the leg is further flexed and magnet 9 is moved into position shown in dot-dash lines, magnets 9 and 10 are moved out of each other's fields, and the flexion of leg members 1 and 3 is not only unopposed but aided by the magnetic force.

A third permanent magnet 12 (Fig. 3) is mounted by means of a bracket 13, bolt 14 and nut 14' in the lowermost posterior portion of member 1, and cooperates through an opening 16 with a plate of magnetic material 15 fastened to member 3. A stop 17, comprising a felt pad or the like, is mounted on member 3 just below magnetic material 15 and limits the movements of magnets 10 and 12 towards the faces of their respective pieces of magnetic material when the leg is in extended position.

The magnetic attraction or repulsion between the different cooperating elements will depend on the respective strength of the magnets as well as the width of the air gap between a magnet and its cooperating element.

Magnet 10 is mounted so that it can be vertically adjusted in the following manner: Opposite ends of bracket 11 (only one of which is shown, Fig. 2) rest between guideways 18 on the inside wall of member 1. A block 19 of rubber or other resilient material lies between the bottom of each end of bracket 11 and a projection 20 from guideways 18. A screw 21 passes through the bracket and rubber block and screws into projection 20. When screws 21 on either end of the bracket are tightened, blocks 19 will be compressed, thereby moving magnet 10 down and closer to bar 7 and increase the pull between the elements. Loosening screws 21 has the opposite effect.

The horizontal distance between magnet 12 and plate 15 may be adjusted in the following manner: Plate 15 is mounted on a piece of rubber or other resilient material 22. Screws 23 extend through member 3, rubber 22 and plate 15. By turning screws 23 the air gap between the magnet and bar is varied.

While the magnetic means have been illustrated with cooperating pole faces which are cut at an angle to the longitudinal axis of the magnet, the pole faces may be cut at right angles to the longitudinal axis. Probably the only difference will be the range of movement within which the two magnetic elements affect one another. The important point is that the magnetic means must offer a resistance to the flexing of the knee to the extent and over a range which will satisfy the requirements of the wearer. This can be done by the shaping and positioning of the magnets, and the selection of permanent magnets of suitable strengths.

Instead of a permanent form of magnet, an electromagnet 25, in circuit with a suitable switch 26 and battery 27 as shown in Fig. 4, may be employed.

The strength of the magnets and their adjustment in the leg will, of course, depend on the age, weight and activity of the user, as well as his walking characteristics. It will be possible for the user, by simply turning a screw to adjust the magnetic action in the leg to suit himself.

Assuming that the leg is being flexed, the range over which the magnets act to restrain or oppose relative movements of members 1 and 3 and hold them in locked position is from the point at which magnet 10 is in alignment with bar 7 until the magnet is moved sufficiently far to the right to stop attracting bar 7. At the same time, magnet 12 attracts plate 15 until the air space between them is great enough to prevent attraction which is usually before bar 7 is out of the field of magnet 10. Members 1 and 3 then move through a neutral position in which there is no magnetic action until the point at which magnets 9 and 10 come into each other's fields and oppose flexion of the members. This opposition continues until magnet 10 is moved sufficiently to the right to be repulsed by magnet 9.

When the leg is moved from flexed to extended position, the effect of the magnets just described is reversed and magnets 10 and 12 aid the movement of members 1 and 3 into the extended position.

The operation of the leg in walking will be somewhat as follows:

As the user starts to swing the artificial leg forward to take a step on it and shifts his weight to his good leg, the combination of the movement of member 1 and the frictional drag against the ground of member 3 breaks the locking action between magnets 10 and 12 and their respective magnetically cooperating pieces. The degree of flexion of the leg will depend on the walking habits of the person. In the average step, magnet 10 will be moved short of complete alignment with magnet 9. As the femur member is swung forward by the stump, the combination of momentum and the action of magnets 9, 10 and 12 and elements 7 and 15 will move the shin member forward and lock the leg in extended position just before the user steps down on it.

The locking of the artificial limb in extension simulates the full extension and locking of a normal knee joint by the combination of the final contraction of the quadriceps and rotation of the femural condyles on the tibia.

In sitting down, dancing and in other activities which call for a restraining or supporting action in the knee joint, the repulsion between magnets 9 and 10 is particularly important. For instance, in sitting down, a person wearing an

artificial limb will not have to shift all his weight to his good leg, but will be able to sit down as a normal person because as his artificial leg is flexed, he will be partially supported by the repulsion between magnets 9 and 10. When seated, magnet 10 will have moved out of the field of magnet 9. There will be no magnetic force between the two and the leg will remain in a neutral flexed position.

While the embodiment here described shows a combination of three permanent magnets and a bar and plate of magnetic material, it is not necessary for a leg to have all of these elements to operate according to the invention. For instance, the use of one magnet such as 10, cooperating with an iron bar, such as 7, would give a locking action which would be of great benefit to the user. It would also be possible, simply by the use of magnets 9 and 10, to provide a satisfactory artificial leg. However, if only the repelling magnetic action were utilized, it might be necessary to increase the strength of magnets 9 and 10 beyond that which is necessary when they are used in combination with magnetic attraction.

What is claimed is:

1. An artificial leg comprising upper and lower members forming a knee joint, means for pivotally connecting said members whereby they are movable into extended and flexed positions, a magnet mounted on one of said members, magnetic material on the other member cooperating with said magnet in the extended position.

2. The device according to claim 1, and in which a second magnet is mounted in said other member to cooperate with the first magnet, said second magnet being mounted to attract said first magnet.

3. The device according to claim 1, and in which a second magnet is mounted in said other member in cooperative relation with said first magnet, said second magnet being mounted to repel said first magnet.

4. An artificial leg comprising upper and lower members forming a knee joint, means connecting said members whereby the leg is movable into extended and flexed positions, a first piece of magnetic material mounted in said lower member, a first permanent magnet mounted on said lower member and a second permanent magnet mounted on said upper member, said first and second magnets mounted so that their like poles face one another whereby when the leg is in extended position said second magnet will be exercising maximum attraction to said magnetic material, when the leg is partially flexed said first and second magnets will be exercising maximum repulsion, and when the leg is additionally flexed said magnets are moved out of each other's fields.

5. The device according to claim 4, and a bracket for supporting said second magnet extending between opposite walls of said upper member, a block of resilient material at either end of said bracket, projections from the walls for supporting said blocks, and screws passing through the ends of said brackets, blocks and into said projections whereby the position of said second magnet may be vertically adjusted.

6. An artificial leg comprising upper and lower members forming a knee joint, a pin pivotally connecting said members whereby the leg is movable into extended and flexed positions, a pair of arms extending from said pin, a first piece of magnetic material mounted at the free ends of said arms, a first permanent magnet mounted on said arms intermediate the pin and said magnetic material, and a second permanent magnet mounted on said upper member, said first and second magnets mounted so that their like poles face one another whereby when the leg is in extended position said second magnet will be exercising maximum attraction to said magnetic material, when the leg is partially flexed said first and second magnets will be exercising maximum repulsion, and when the leg is additionally flexed said magnets are moved out of each other's fields.

7. An artificial leg comprising upper and lower members forming a knee joint, a pin pivotally connecting said members whereby the leg is movable into extended and flexed positions, a pair of arms extending from said pin, a bar of magnetic material mounted at the free ends of said arms, a first permanent magnet mounted on said arms intermediate the pin and said magnetic material, a second permanent magnet mounted on said upper member, said first and second magnets mounted so that their like poles face one another whereby when the leg is in extended position said second magnet will be exercising maximum attraction to said magnetic material, when the leg is partially flexed said first and second magnets will be exercising maximum repulsion, and when the leg is additionally flexed said magnets are moved out of each other's fields, a plate of magnetic material mounted in the posterior portion of said lower member, and a third permanent magnet mounted in the bottom of said upper member to exercise maximum attraction to said plate when the leg is in extended position.

8. The device according to claim 7, and a piece of resilient material supporting said plate of magnetic material, and screws extending through said resilient material whereby the horizontal position of said plate of magnetic material may be adjusted.

9. The device according to claim 7 and in which the faces of said bar piece of magnetic material and said first magnet are cut at an angle to their longitudinal axes and the face of said second magnet is cut at the same angle to its longitudinal axis.

10. An artificial leg comprising a thigh section and a calf section, hinge means connecting said sections for limited relative movement therebetween, a permanent magnet secured to said thigh section, and a magnetically permeable means secured to said calf section whereby said magnet is adapted to oppose movement between said sections when in extended position.

11. An artificial leg comprising a thigh section and a calf section, hinge means connecting said sections for limited relative movement therebetween, magnetically permeable means carried by said calf section and said hinge means, and a pair of permanent magnets carried by said thigh section in cooperable relation with said permeable means whereby said magnets are adapted to influence and control relative movement of said sections into an extended position.

12. An artificial leg comprising a thigh section including a knee portion, a calf section, hinge means connecting said sections for limited relative movement therebetween, a permanent magnet secured transversely of said knee portion, a magnetically permeable means secured to the upper posterior portion of said calf section whereby said magnet is adapted to op-

pose movement between said sections when in extended position, and yieldable means carried by said calf section engaging said knee portion when said sections are extended whereby to maintain an air gap between said magnet and permeable means.

13. An artificial leg comprising a thigh section including a knee portion, a calf section, hinge means connecting said sections for relative movement therebetween, said hinge means including a magnetically permeable member and a permanent magnet movable with said calf section, a permanent magnet secured intermediate said thigh section, a permanent magnet secured transversely of said knee portion, and a magnetically permeable member secured to said calf section, said second and third named magnets acting to oppose relative movement of said sections when in extended position, and said first and second named magnets acting to repel said sections in certain positions of flexion.

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