March 12, 1957 W. H. GOODWIN ET AL 2,784,416

MECHANICAL ACTION FOR PROSTHETIC JOINTS

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fig. 1.

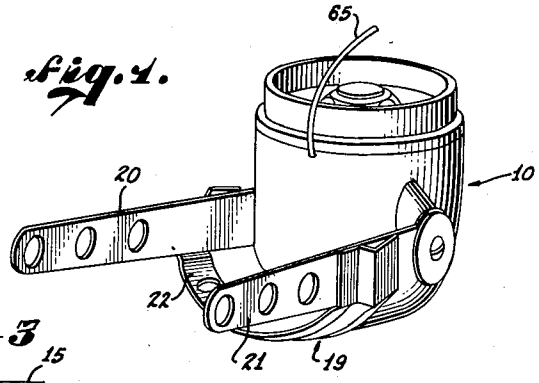


fig. 2.

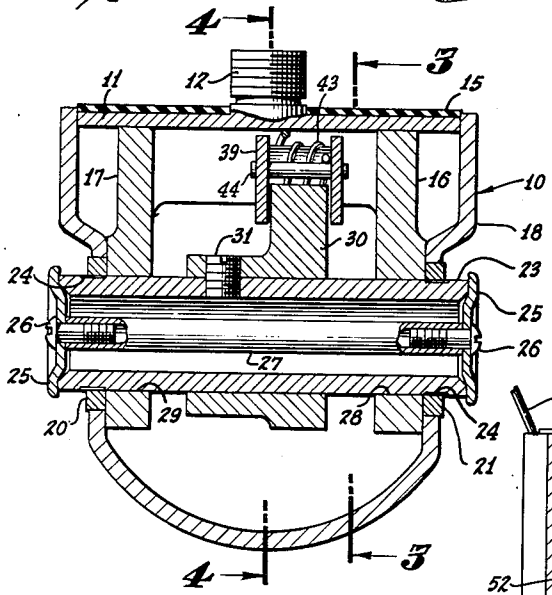


fig. 3.

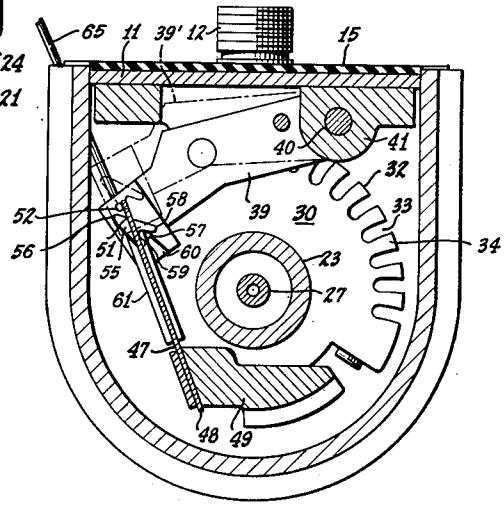
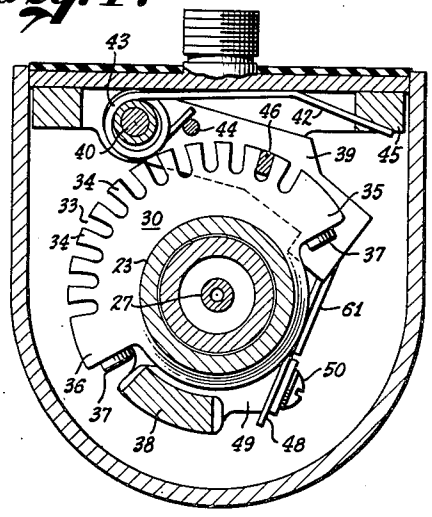


fig. 4.



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MECHANICAL ACTION FOR PROSTHETIC JOINTS

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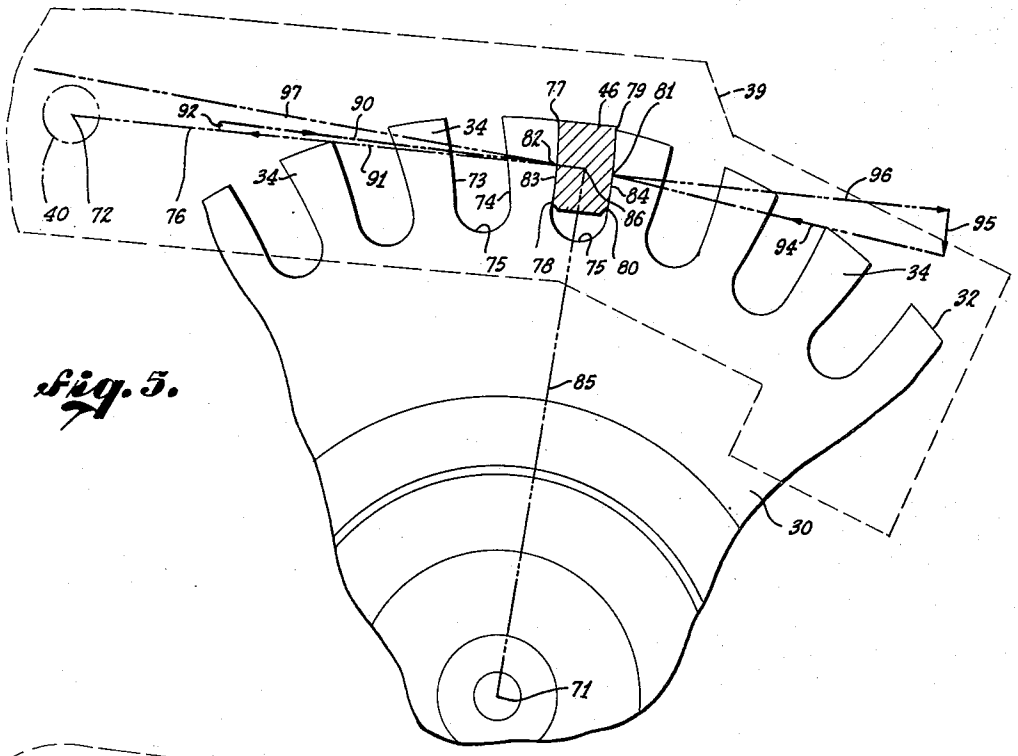


Fig. 5.

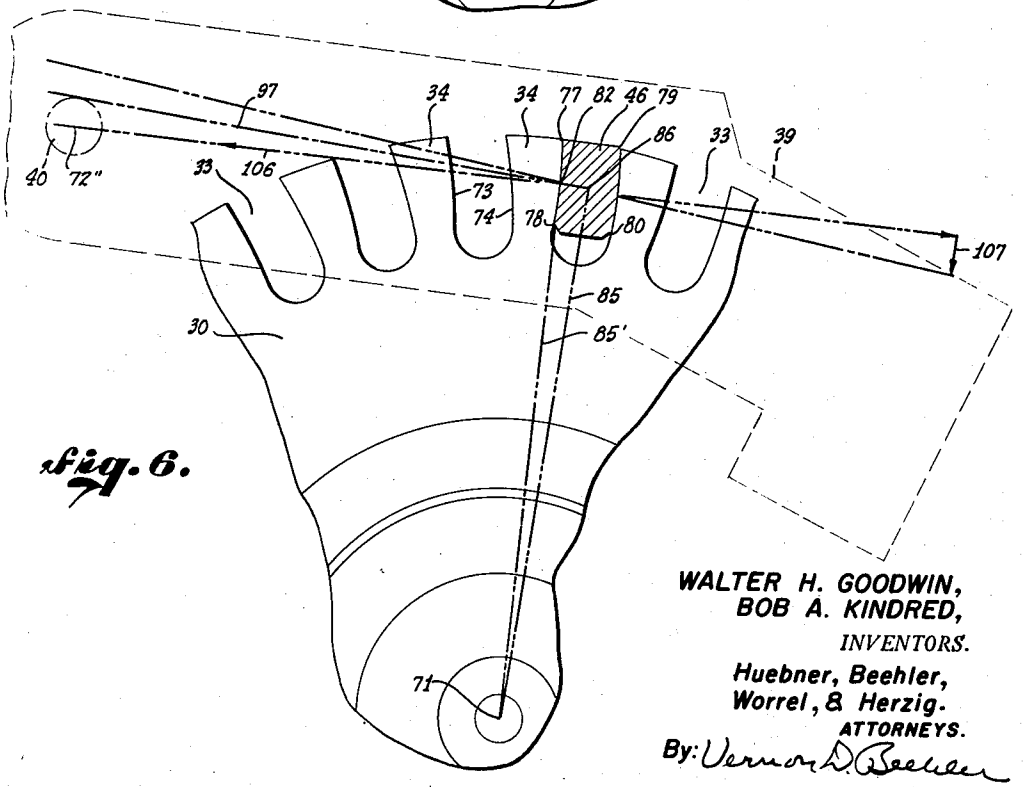


Fig. 6.

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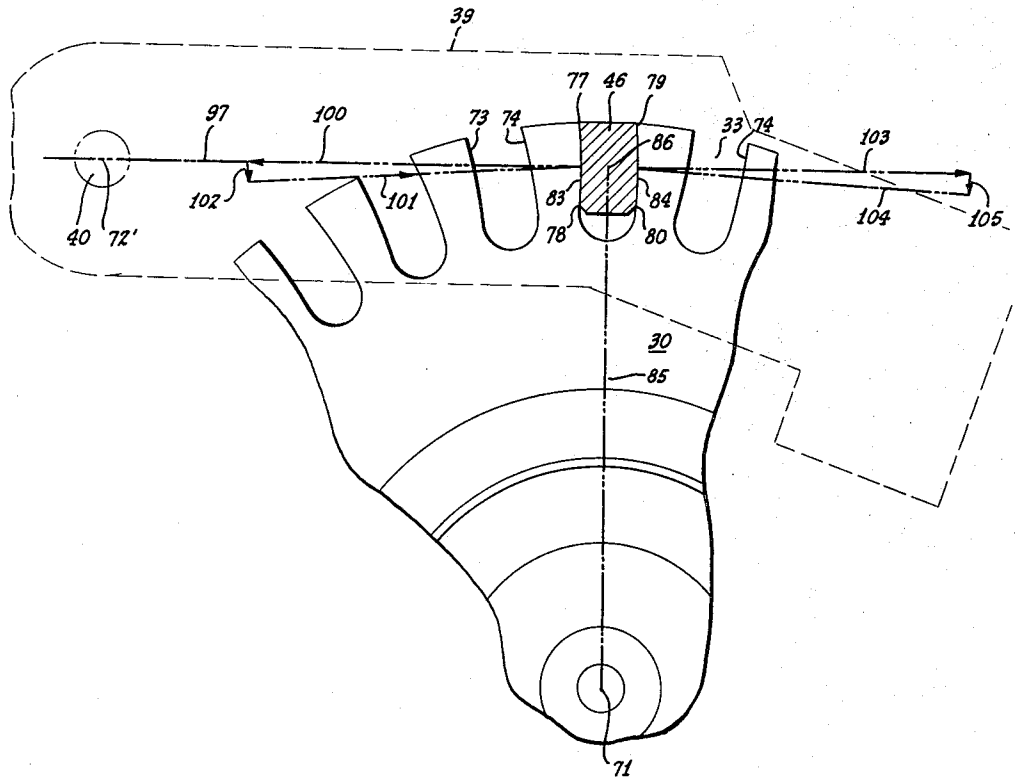
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Fig. 7.



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2,784,416

MECHANICAL ACTION FOR PROSTHETIC JOINTS

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Application April 4, 1955, Serial No. 498,906

7 Claims. (Cl. 3—12.2)

The application relates to prosthetics and has particular reference to a joint for an artificial limb wherein the joint is adapted to be locked and unlocked at will by use of a mechanical alternator. More particularly the device is an improvement on the means for locking disclosed in patent application Serial No. 436,284, filed June 14, 1954, of which this is a continuation-in-part.

In recent years great reliance has been placed upon the use of mechanically actuated aids for persons deprived in particular of an arm extremity by use of which a person so afflicted is enabled to perform a great variety of the usual tasks which are expected to be performed by a human arm. The mechanical aids have been such as to make use of whatever portion may remain of the natural arm. To make such use of the natural arm substitute joints have been provided. These joints may be either intermediate the ends of the artificial limb or adjacent one end on those occasions where the artificial limb, for example, might be attached to the stub of a natural limb. Joints which heretofore have been resorted to have to a large extent been located indiscriminately with respect to the natural jointing location of the limb. The result of these expedients has been an awkward appearing and somewhat awkwardly usable mechanical aid not sufficiently natural to admit of the regular motion of the natural limb. Such aids frequently have been such as to attract unnecessary attention to the necessity for use of such prosthetic devices. Moreover, devices heretofore relied upon have been somewhat complicated in structure, have not been easy to adjust, and more particularly have been stiff and hard to operate to the extent that manipulation often has become a burden upon the person so afflicted. When these occasions exist the artificial limb fails in giving proper encouragement to those persons forced to rely upon such mechanical aids.

More particularly where the mechanical aid has been developed to a point where it is capable of application to jobs requiring considerable force and expertness, those joints which have been relied upon in mechanisms previously available have either tended to ratchet out of proper locked position under heavy stress or, if so designed that they cannot ratchet out of position, then the adjustment at the volition of the user to unlock the joint has been such as to need more force than the user can readily manipulate or can manipulate with sufficient rapidity and dexterity to make full and unrestricted use of the mechanical appendage.

It is therefore among the objects of the invention to provide a new and improved joint for an artificial limb which is capable of being operated with considerably greater ease than those heretofore employed and which is permissive of temporarily locking the artificial limb in any one of a considerable number of desired positions.

Another object of the invention is to provide a new and improved joint for an artificial limb which is compact in its structure, which is relatively light in weight, and which is so formed that the user can wear it with

a considerable degree of comfort and more particularly in a perfectly natural fashion.

Still another object of the invention is to provide a new and improved joint for an artificial limb which includes an alternator mechanism adapted to operate on a relatively short throw so that the artificial limb can be quickly and readily moved to a desired new position and there immediately fixed for manipulation, the object further including a locking device featuring with sufficient ease and operating in virtual silence without, however, in any way sacrificing the positiveness of the lock when the joint needs to be locked.

Still further among the objects of the invention is to provide a new and improved joint for an artificial limb which is simple in its construction thereby to greatly facilitate assembly as well as operation and to make possible the manufacture of these prosthetic aids at a price which is as economical as is permissible in view of the positive operation needed, thereby to make such aids available to all who might be in such need.

Also among the objects of the invention is to provide a new and improved prosthetic joint wherein the joint can be immovably locked in position without impairing ease of entry or exit of the locking member, the lock being as capable of adjustment to operate in both directions as to lock in one direction and to ratchet in the other at a predetermined torque.

With these and other objects in view, the invention consists in the construction, arrangement and combination of the various parts of the device whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

Figure 1 is a perspective view of an artificial joint of the type in which the invention herein described is employed.

Figure 2 is a longitudinal sectional view of the device on the central vertical axis.

Figure 3 is a longitudinal sectional view at right angles to the view of Figure 2 taken on the line 3—3 of Figure 2.

Figure 4 is a vertical sectional view through the vertical axis of the device taken on the line 4—4 of Figure 2.

Figure 5 is a fragmentary view drawn to a larger scale and with parts removed so as to clearly illustrate the structure and action of the locking arrangement of the present invention.

Figure 6 is a fragmentary view similar to Figure 5 showing a slightly different location of pivot point for the locking bar of the invention.

Figure 7 is another fragmentary view similar to Figure 5 showing still a third possible location for the pivot point of the locking arrangement.

In the form of the invention chosen for the purpose of illustration a prosthetic elbow joint is shown adapted especially to an amputation in the upper arm at some distance above the elbow. In this form a relatively stationary member in indicated generally by the reference character **10**. This is that portion adapted to be fastened to the body of the user. For that purpose a flat plate **11** has a threaded base **12** centrally mounted thereon for securement by an appropriate fixture, not shown, to the arm stub of the user. A washer **15** may be provided at the connection to provide a resistance to rotation.

The plate **11** which may be considered as a platform serves as a means for mounting thereon a pair of spaced parallel plates **16** and **17**, the plates and platform preferably constituting a single integral piece. A jacket **18** is provided to serve as a finishing cover for the stationary member. For attachment to the movable artificial member there is provided a relatively movable joint member

indicated generally by the reference character **19**. The movable joint member is here illustrated as comprising longitudinal extensions **20** and **21** joined by a band **22**, both portions being provided with suitable apertures for attachment to the appropriate artificial limb. The extensions **20** and **21** are attached to a pivot tube or hollow shaft **23**, the extensions being non-rotatably fixed relative to the shaft by means of splines **24**. Washers **25** may be provided over the exterior ends of the shaft anchored to each other by means of screws **26** extending into a tube **27**. The shaft **23** is so constructed that it pivots freely within appropriate bearing apertures **28** and **29**, respectively, in the plates **16** and **17**.

Intermediate the plates **16** and **17** and non-rotatably mounted on the shaft **23** is a positioning segment **30**. The segment is non-rotatably secured to the shaft by means of a set screw **31**. The positioning segment has an arcuate perimeter **32** in which is a series of spaced notches **33** separated by sections **34**, the outer ends of the sections lying in the plane of the arcuate perimeter. Shoulders **35** and **36** on opposite ends of the arcuate perimeter are provided with suitable pads **37** adapted for abutment against a stop block **38**, thereby to limit rotation of the movable member **19** relative to the stationary member **10**. The stop block is secured to and forms a part of the stationary member **10**.

A catch is provided on the stationary member **10** for engagement with the movable member **19** in order to anchor it in any one of its various positions of adjustment. The catch comprises in part a lever **39** pivotally jointed by means of a pin **40** to a bracket **41**. The lever is therefore permitted a limited rotation about the pin **40**. The lever is normally urged in a direction clockwise, as viewed in Figure 4, by means of a spring **42**, one end **43** of which is wound loosely around the pin **40** and brought into abutment against a pin **44** on the lever. The other end of the spring presses upwardly against a portion **45** of the stationary member **10**.

The lever **39** in the form here shown comprises parallel side elements overlying opposite faces of the positioning segment and includes a locking bar or block **46** extending between the sides in a position adapted to fall into one or another of the notches **33**. The lever is designed to be held in one of two positions, namely, in a disengaged position wherein the locking bar is engaged in one of the notches **33** and a position withdrawn therefrom, permitting the movable member **19** to pivot freely with respect to the stationary member **10**. For holding the lever in either one of these two positions there is provided a leaf spring **47**, one end **48** of which is anchored on a portion **49** of the stop block **38** by means of a pad and screw **50**. A free end **51** of the spring has a hook in the form of a pin **52** attached thereon, the pin being adapted to extend beyond the edge of the spring into positions of engagement with a cam **55**. The cam **55** has a tapered end **56** facing obliquely upwardly, as viewed in Figure 3, at one side of the pin **52**. On the face of the cam opposite from the tapered end **56** is a recess **57** located between round ends **58** and **59**. A guide **60** fastened upon one side of the lever **39** as is also the cam has a tapered end extending into the recess **57** providing thereby a guideway or track within which the pin **52** is confined when it enters and leaves the recess **57**. A damping pad **61** is secured to and extends throughout a substantial portion of the length of the spring **47** in order to minimize vibration of the spring during operation and resultant noises which might be disconcerting to the user.

For manipulating the mechanism thus described, there is provided a cable **65** adapted to be attached to a conventional shoulder harness, not shown. The cable **65** is appropriately fastened to the lever **39** near its free end thereby to provide a means for moving the lever against tension of the spring **42**.

In operation when the parts have the positions illustrated in Figure 4 the locking bar **46** is in engagement with one of the notches **33** of the positioning segment. The movable member **19** is thus fixed in angular position with respect to the stationary member **10**. When it is the desire of the user to change that angular position, the cable **65** is pulled on moving the lever in a direction counter-clockwise, as viewed in Figure 4. The new position is the broken line position **39'** shown in Figure 3. While that movement is taking place, the pin **52** slides down the adjacent face of the cam moving toward the right, as viewed in Figure 3, until it passes the rounded end **58**, at which point the pin will be sprung back by spring action against the guide **60** preparatory to entrance into the channel or guide-way provided between the recess **57** and the guide **60**. The guide and the side of the recess opposite thereto prevent the pin **52** from being sprung past the cam at this point. When the cable **65** is then released, the spring **42** moves the lever **39** a slight distance counter-clockwise, as viewed in Figure 3, until the bottom of the recess **57** is pushed against the pin **52**. The relationship of the parts is such that in this position the locking bar **46** will be clear of the perimeter **30**. Consequently the movable member **19** may be rotated at will by some appropriate conventional attachment, well known in this branch of prosthetics.

When the movable member is moved to the desired position, the member can be anchored there by a succeeding pull upon the cable **65**. When the cable is pulled upon at this time, the cam **55** is pulled away from the pin **52** which rides out of the channel adjacent the rounded end **59** and is sprung past the rounded end **59** by tension in the spring so that the pin **52** is in a position adapted to ride against the lower cam face of the cam **55**. Then when the cable **65** is released, the pin will ride along the lower cam face until it passes the tapered end **56**, after which it will be sprung back to the initial position illustrated in Figures 4 and 6. In that position the lever **39** will have been sprung back against the positioning segment until the locking bar **46** enters the appropriate notch **33**. Here also should the locking bar fall against one of the sections **34** between notches **33**, the weight of the forearm will be sufficient to cause the locking block to fall into the next adjacent notch. Should this additional movement be not desirable, the sections **34** may be rounded slightly so that the locking bar will automatically enter the nearest adjacent notch.

In prosthetic joints of the type herein described the importance of a secure but easily operated lock has already been stressed. The lock moreover must be one which can be easily manipulated by, for example, a slight hitch or movement of the shoulder of the user whereby some form of harness is adapted to transmit the movement through the cable **65** to the alternator and the lever in order to lift it out of locking position and to again lift it to a new position wherein it can be spring-pressed into locking engagement. The locking bar must slide quickly and easily into the notch provided for it. There must be a relative minimum amount of clearance, thereby to improve the ease of operation and to make the locking engagement and disengagement as silent as possible.

In a form of the invention illustrated in Figure 5 the segment **30** is shown adapted to rotate about an axis **71** which is the axis or center of rotation of the tube or shaft **23** previously referred to. The notches **33** and sections **34** are duplicated in Figure 5, spaced as previously described about the arcuate perimeter **32**.

The lever **39** is shown by use of a broken line so positioned that it is adapted to rotate about an axis **72** which is the center of the pin **40**.

Each of the notches consists of opposite faces **73** and **74** which extend from the perimeter **32** inwardly to a point tangent to a rounded bottom wall **75**. The notches **33** are identical such that a description of one will suffice for all.

In the form illustrated in Figure 5 the faces **73** and **74**

are arcuate and described in the case of the face **73** by a radius **76** which is equal to the distance between the axis **72** and the center of the face **73** intermediate its outside and inside ends, indicated by the points **77** and **78**, respectively.

The face **74**, being arcuate as noted, is of slightly different radius in that it is an arcuate form described by a radius equal to the distance between the axis **72** and a point **81** midway between the points **79** and **80**. The point **81** is separated by a distance from point **82** immediately opposite, which distance is in excess of the thickness of the locking bar **46** plus an appropriate clearance. The clearance should be no more than enough to permit the locking bar to slide freely into the notch to the position illustrated in Figure 5.

The locking bar **46** is also provided with opposite faces **83** and **84** which are arcuate and which are complementary to the respective faces **73** and **74**. The curvatures of the arcuate faces **83** and **84** are again determined by a radius equal to the distance between the axis **72** and the center of the respective faces **83** and **84**.

A radius **85** is indicated by the distance between the axis **71** and a point **86** which is on the line between the points **81** and **82** mid-way between outside and inside ends of the faces of the locking bar, these being points identical with mid-points between outside and inside ends of the faces **73** and **74** of the notches **33**.

In the arrangement of Figure 5, which may be considered as a practical and workable arrangement, the forces and their effect upon the mechanism can be explained with reference to a vector diagram predicated upon application of force to the extensions **20** and **21**, which force is transferred through the tube or shaft **23** to the segment **30**. Assuming the application of this force to be in a clockwise direction, the force exerted by the segment on the locking bar and lever may be represented by a tangential vector **90**. This force is resisted by the locking bar and lever and the resistance may be expressed by a radial vector **91** through the axis **72** as a center and by a tangential vector **92**. Similarly should the application of force to the segment be in a counter-clockwise direction, it would result in a force expressed by the vector **94** resisted by the tangential vector **95** and the radial vector **96**. It will be noted that the vectors **92** and **95** represent forces which act either to engage or disengage the locking bar. In the case shown in Figure 5 the bar is forced into engagement by operation of a counter-clockwise loading. There is present a small force tending to disengage the bar should the loading be clockwise. This force, by reason of the fact that it is less than the force of friction between the bar and the tooth, is not sufficient to disengage the bar and hence the bar remains in engagement when the segment is loaded in this or the opposite direction.

It will be noted further that a line **97** lies tangent to the circle described by the radius **85** at the point **86** and that this in the specific instance shown shows an angle of four degrees and 20 minutes between the tangent line **97** and the radius **76** about the center **72** struck through the point **86**. The point **72** which is the center of rotation of the lever **39** therefore lies in this chosen example inside of the tangent line **97** which is drawn to the circumference struck by the radius **85** at the location of bar engagement with a notch.

With the structure already described there are some variations permissible in the location of the axis of the pin **40** with respect to the tangent line **97** already referred to. In Figure 7, for example, the axis is indicated by the reference character **72'** and is made to lie upon the tangent line **97**, which line is that previously described as tangent to the perimeter of an arc struck by the radius **85** at the center of engagement of the bar **46** with the engaging notch **33**. This represents a theoretically ideal arrangement for equal locking in both directions of application of force to the segment **30**. Practice indicates, however, that where mechanical expediencies indicate some different arrangement to be feasible, it is not essential to maintain the theoretically perfect or ideal arrangement to secure the desired operation of the principle herein disclosed.

In the theoretically ideal arrangement of Figure 7 a clockwise force applied to the segment **30** results in a force expressed by the vector **100**. This force is resisted by a radial vector **101** and a tangential vector **102**. It will be noted that under those circumstances where the force is applied in an opposite direction to the segment **30** vectors **103**, **104** and **105** are equal in value to the vectors **100**, **101** and **102**. This means that there will be no tendency to disengage the locking bar **46** regardless of which direction force is applied to the extensions **20** and **21**. Moreover, in this theoretically ideal arrangement the lifting force necessary to lift the locking bar out of engagement with the notch when that occasion requires may be slightly greater than the lifting force required of the arrangement of Figure 5 where there is a slight tendency to disengagement in one direction. The balance, however, in the opposite direction is contrary and hence the required lifting force when action in either direction is contemplated will be substantially the same for both arrangements.

The arrangement of Figure 6 shows location of the axis **72''** on a line **106**, which line is tangent to the radial line **85'**, namely, the radial line **85** shifted to the position where it intersects the point **82**. In point of fact the arrangement thus described sets the axis **72''** at an angular distance from the tangent **97** previously referred to of three degrees. In this arrangement there is no force corresponding to the force indicated by the vector **92** of Figure 5. Consequently there is a state of equilibrium existing and a locking force indicated by the vector **107** is double that of the vector **105** or **102** of Figure 7. This indicates that the locking bar and segment arrangement will be positively locking for centers of the pin **40** located between lines drawn tangent to the radial lines through the centers of both tooth faces **73** and **74**.

It will be clear from the explanation that there is some variation possible in the location of the axis of the pin **40** but that variation will need to be within certain limits dependent upon the frictional force existing between the face of the tooth and the face of the locking bar which are in engagement depending upon the direction of rotation of the segment. When the axis of the pin is located outside of those limits, there will be a tendency of the locking bar to ratchet out of engagement in one direction of rotation for the segment and to lock with great force in the opposite direction, depending upon whether or not the pin is above or below the range indicated, as viewed in Figures 5, 6 and 7, for example. The workable range, however, has been described. Moreover, in the event of a tendency to ratchet, the tendency may be controlled by varying also the amount of spring force applied to the lever **39** and hence the locking bar in addition to the selection of location for the axis of the pin **40**.

There has accordingly been described herein a precise and effectively working structural arrangement of locking bar and tooth segment which is productive of a particularly effective and efficient lock and unlock alternating device for such use as in prosthetic joints which greatly facilitates the smoothness of their operation and enhances to a great degree the value of such joints to those persons afflicted with injuries which necessitate their use.

While we have herein shown and described our invention in what we have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of our invention, which is not to be limited to the details dis-

closed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A mechanical action for artificial limb joints comprising a relatively stationary member and a ratchet segment rotatably mounted on the member, a lever rotatably mounted on the member with the rotational axis adjacent to the circumference of the ratchet segment, a locking bar on said lever having opposite curved faces positioned generally perpendicular to the radius from the rotational axis of the lever, said segment having a series of spaced generally radially extending bar receiving notches with faces complementary to the respective faces of the bar when in bar receiving position, said rotational axis of the lever being at a point adjacent a line tangent to an arc about the axis of said segment struck through the centers of the faces of said notch.

2. A mechanical action for artificial limb joints comprising a relatively stationary member and a ratchet segment rotatably mounted on the member on the axis of rotation of the joint, a lever rotatably mounted on the member with the rotational axis adjacent to and exterior of the circumference of the ratchet segment, a locking bar on said lever having opposite faces positioned generally perpendicular to the radius from the rotational axis of the lever and the faces, said segment being subject to a rotative load and having a series of spaced generally radially extending bar receiving notches with faces complementary to the respective faces of the bar when in bar receiving position, said rotational axis of the lever being within an angular distance of a line tangent to an arc about the axis of said segment struck through the centers of the faces of said notch such that the component of the force resulting from application of a rotative load tending to disengage the bar from the notch is less than the frictional force on the respective contacting faces.

3. A mechanical action for artificial limb joints comprising a relatively stationary member and a ratchet segment rotatably mounted on the member on the axis of rotation of the joint, a lever rotatably mounted on the member with the rotational axis adjacent to and exterior of the circumference of the ratchet segment, a locking bar on said lever having opposite arcuate faces positioned generally perpendicular to the radius from the rotational axis of the lever and the faces, said segment having a series of spaced generally radially extending bar receiving notches with arcuate faces complementary to the respective faces of the bar when at bar receiving position, said rotational axis of the lever being within an angular distance of five degrees inside of a line tangent to an arc about the axis of said segment struck through the centers of the faces of said notch.

4. A mechanical action for artificial limb joints comprising a relatively stationary member and a ratchet segment rotatably mounted on the member on the axis of rotation of the joint, a lever rotatably mounted on the member with the rotational axis adjacent to and exterior of the circumference of the ratchet segment, a locking bar on said lever having opposite arcuate faces of radius of curvature determined by the distance between the rotational axis of the lever and the respective face, said segment having a series of spaced generally radially extending bar receiving notches with arcuate faces complementary to the respective faces of the bar, said rotational axis of the lever being at a point within an angular distance of 15 degrees on either side of a line tangent to an arc centered at the axis of said segment and through the centers of the faces of a notch in bar engaging position, the faces of said notches having positions wherein said last faces are in engagement substantially throughout their areas with the respective faces of the bar when in bar engaging position.

5. A mechanical action for artificial limb joints comprising a pair of members wherein one member is adapted for attachment to a natural limb, parallel plates on one of the members, the other of said members comprising a tubular sleeve rotatably mounted on said plates providing thereby an articulating joint for said action, a ratchet segment fixed on said sleeve having a series of spaced generally radially extending notches, a lever pivotally mounted at a center of rotation on said one member, a locking bar fixed transversely on the lever, and an alternator connected between the lever and one of said members adapted to releasably hold said bar out of notch engagement position, said bar having opposite notch contacting faces curved in the same general direction and said notches having opposite curved bar engaging faces complementary to and adapted to engage the respective faces of the bar when in bar engaging position.

6. A mechanical action for artificial limb joints comprising a relatively stationary member adapted for attachment to a natural limb, parallel plates on said member and a tubular sleeve rotatably mounted on said plates providing thereby an articulating joint for said action, a ratchet segment fixed on said sleeve having a series of spaced generally radially extending notches, a lever pivotally mounted at a center of rotation on said member, a locking bar fixed transversely on the lever, a spring on said member normally urging said bar toward a notch engagement position, and an alternator connected between said member and the lever adapted to releasably hold said bar out of notch engagement position, said bar having opposite notch contacting faces of arcuate form and of radius determined by the distance between the respective face and said center of rotation of the lever, said notches having opposite bar engaging faces of arcuate form complementary to and adapted to engage the respective faces of the bar when in bar engaging position.

7. A ratchet resistant mechanical action for artificial limb joints comprising a base, a ratchet segment rotatably mounted on the base and a locking bar having a pivotal mounting on said base, said locking bar having opposite segment-engaging faces curved in the same general direction about the axis of said pivotal mounting, said segment having a series of peripheral bar receiving notches with opposite faces respectively complementary to the faces on said bar.

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