

[54] ERGONOMIC DRIVE FOR BICYCLES AND OTHER HUMAN POWERED MACHINES

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[51] Int. Cl. B62m 1/00

[58] **Field of Search** 280/251, 255, 1.11, 215;
74/135-141, 231 C

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[57]

ABSTRACT

A machine consisting briefly of a frame, a rotatable member mounted for rotation on the frame, a flexible elongated member having a tapered thickness connected to the rotatable member and spirally wound thereon, a foot or hand receiving member connected to the free end of the elongated member so that a person can withdraw portions of the elongated member by alternatively bending and extending his leg or arm and a spring connected to the frame and to the drum for rewinding the elongated member upon the drum after each withdrawal of the elongated member from the drum.

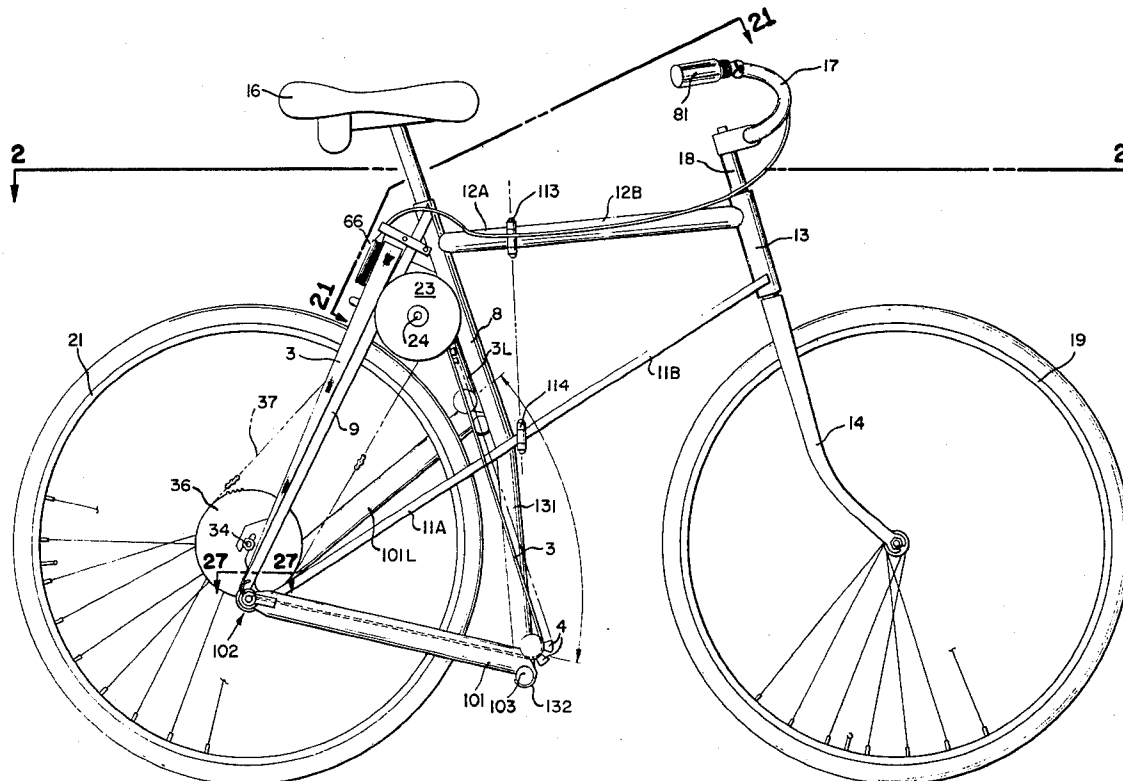
18 Claims, 35 Drawing Figures

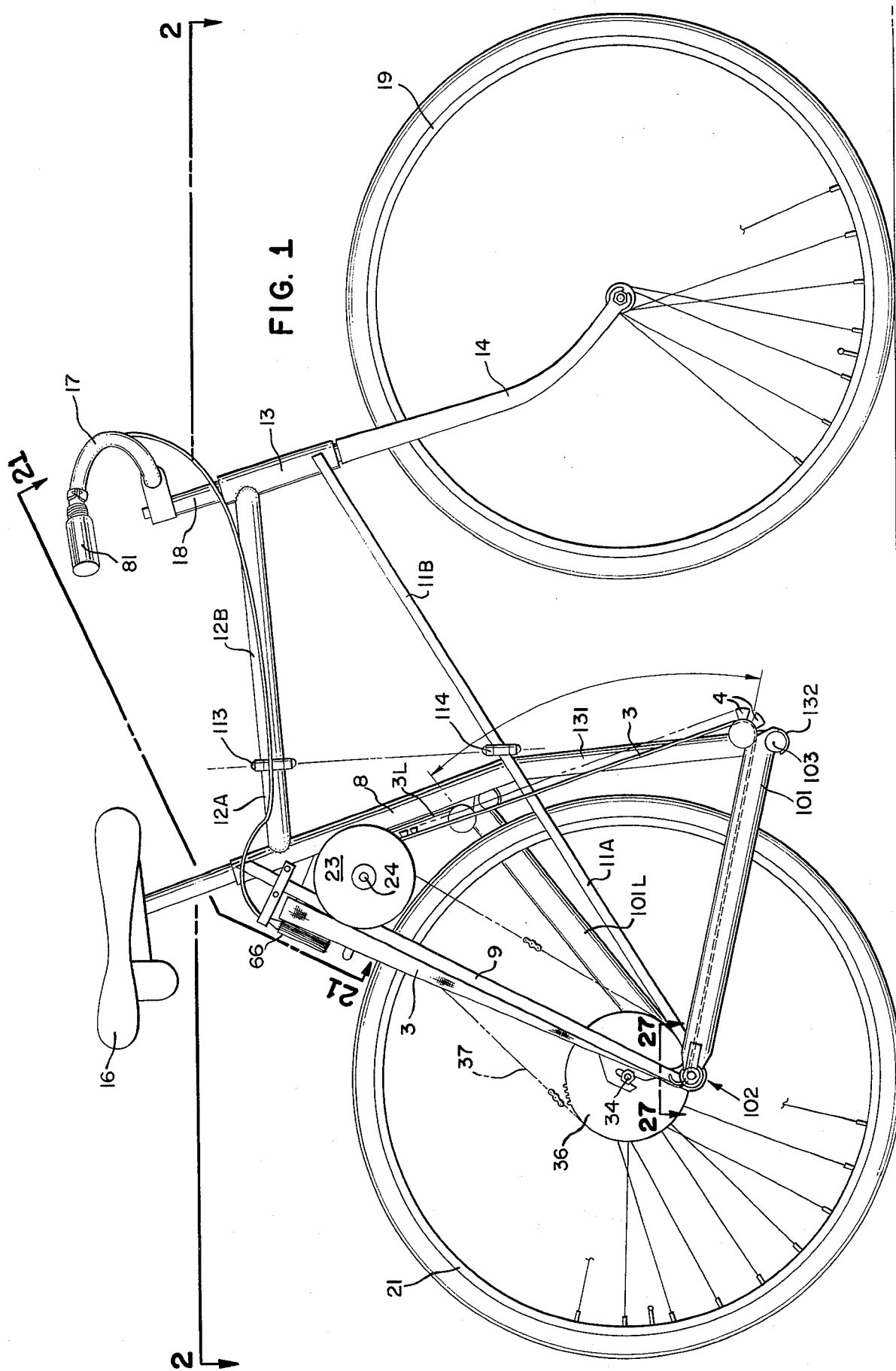
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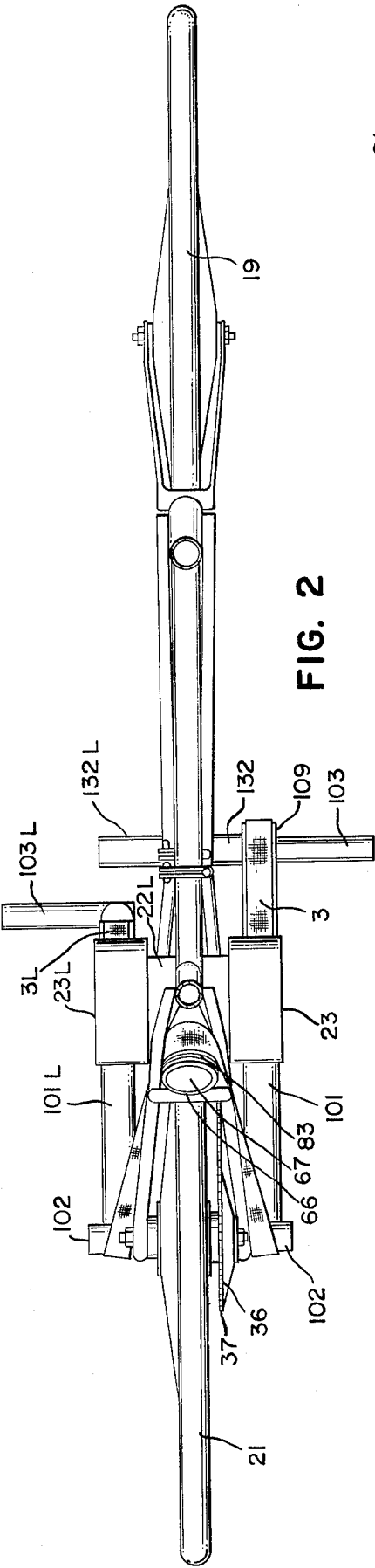


FIG. 2

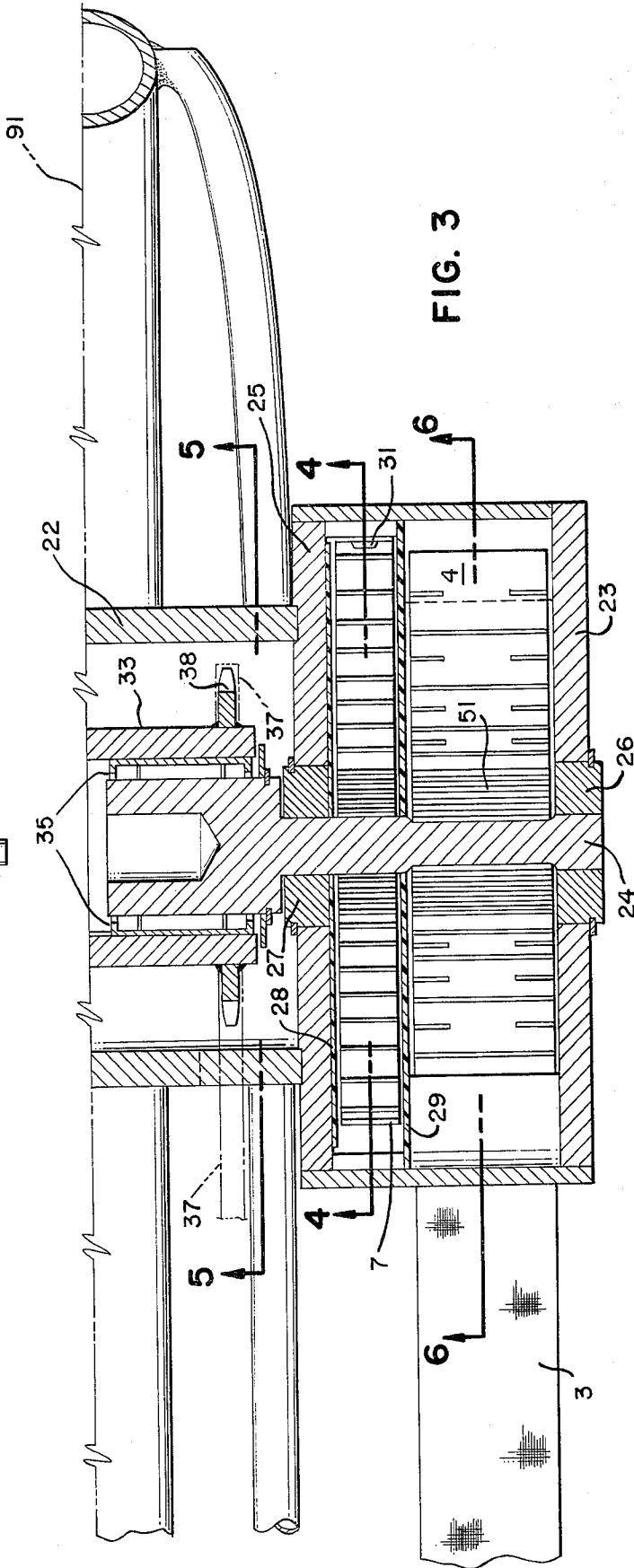
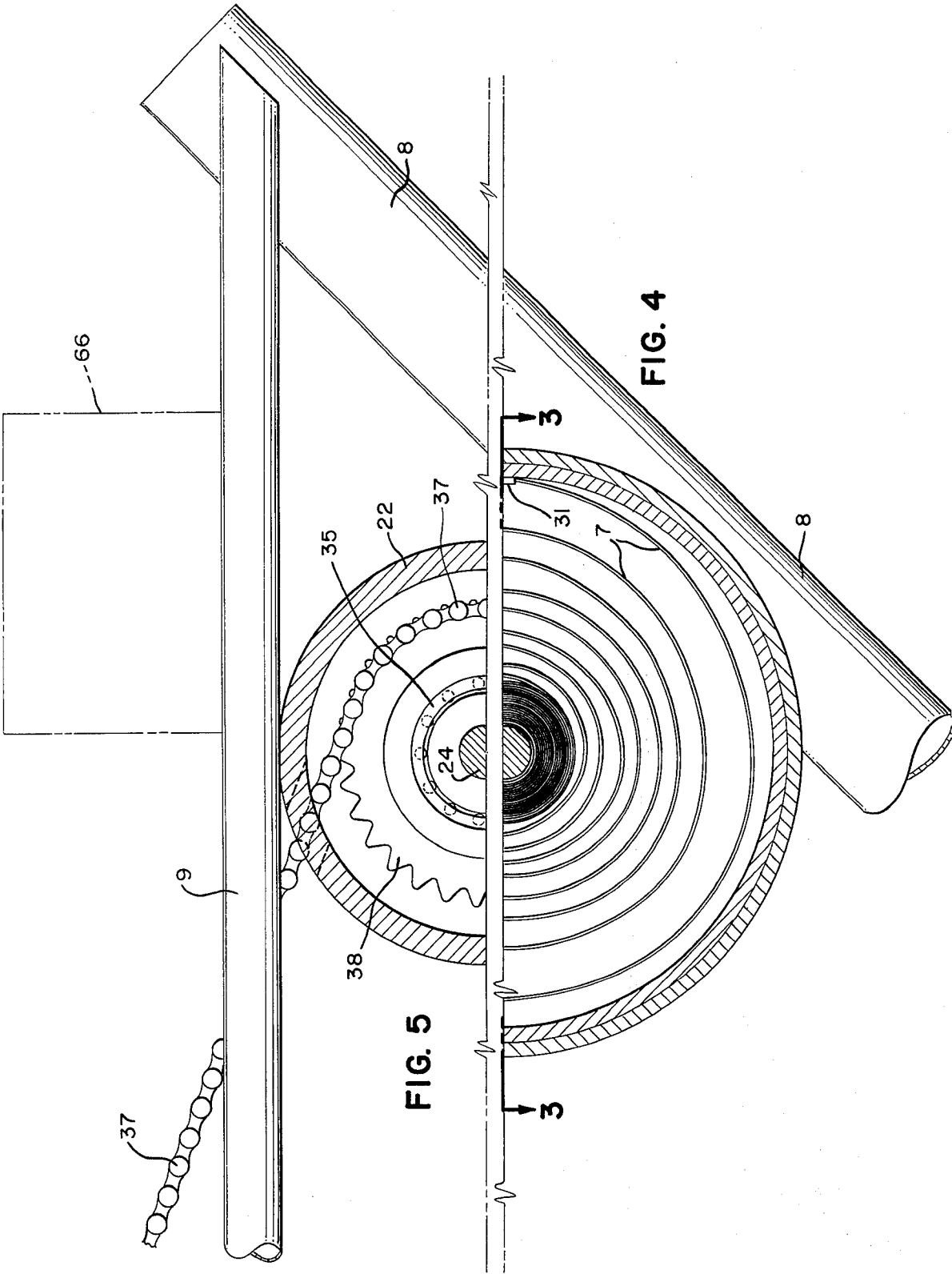


FIG. 3



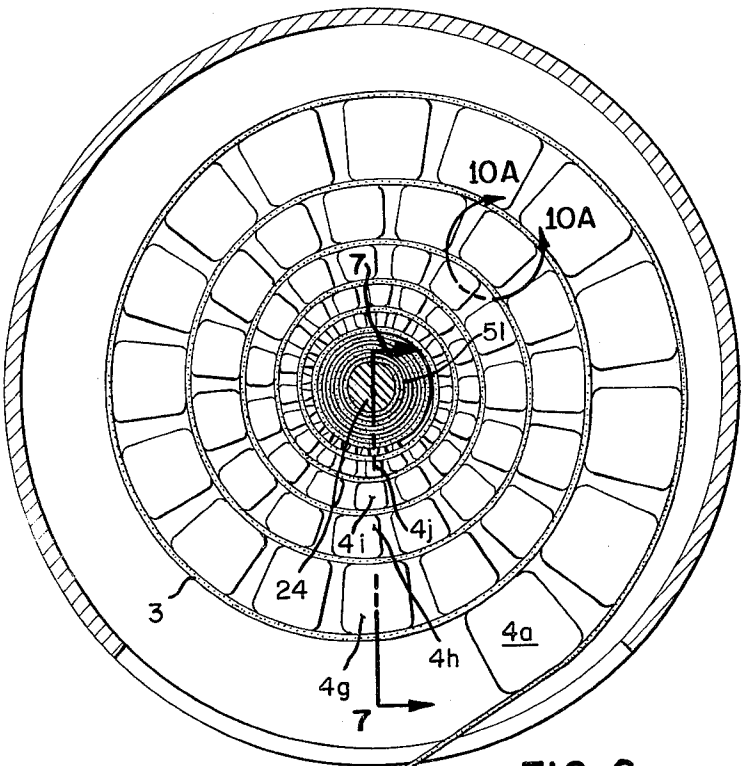


FIG. 6

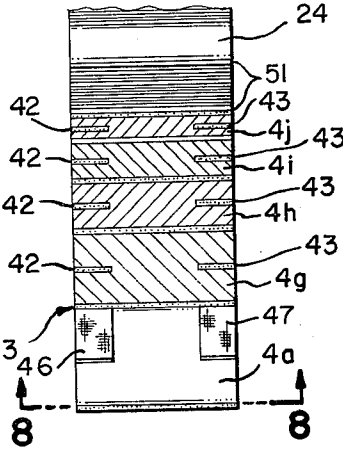


FIG. 7

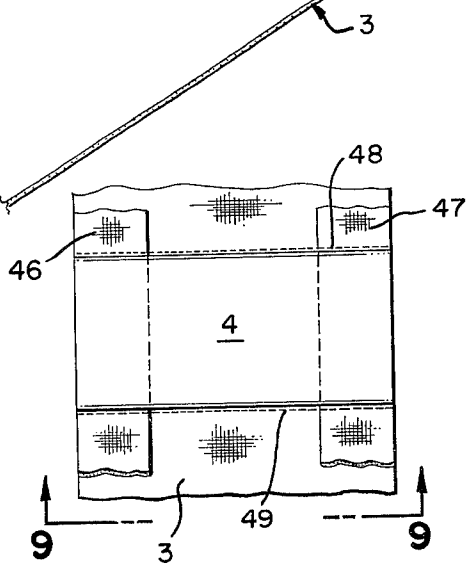


FIG. 8

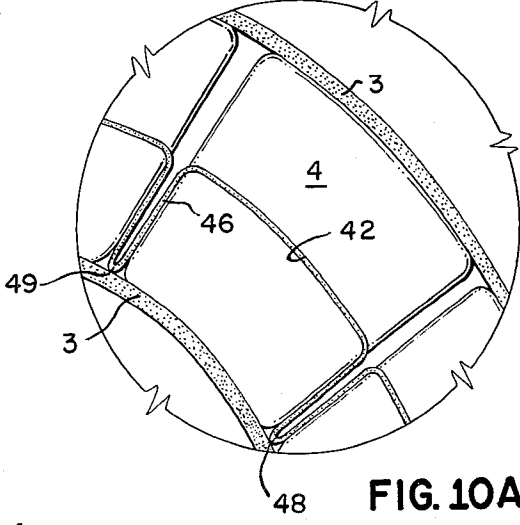


FIG. 10A

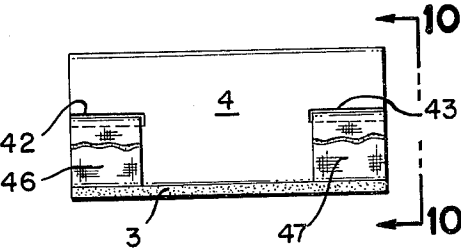


FIG. 9

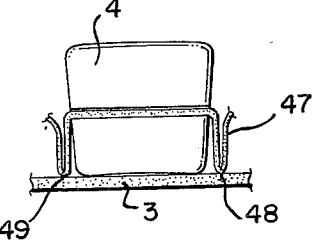


FIG. 10

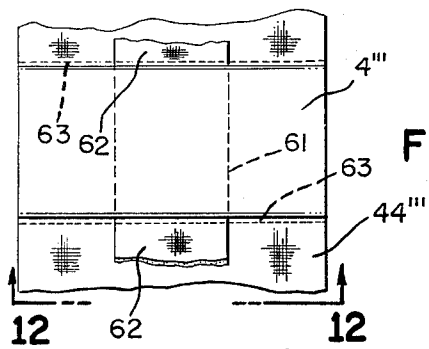


FIG. 11

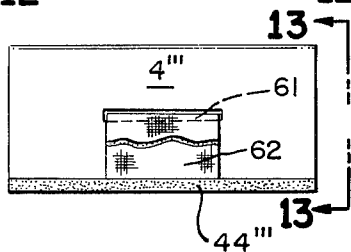


FIG. 12

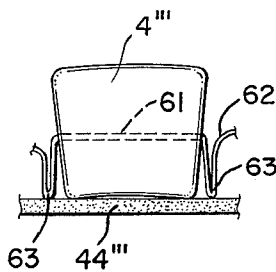


FIG. 13

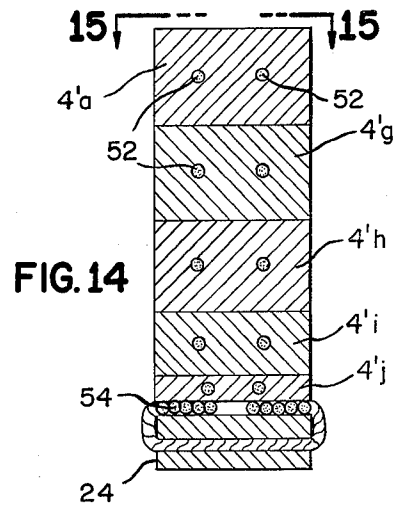


FIG. 14

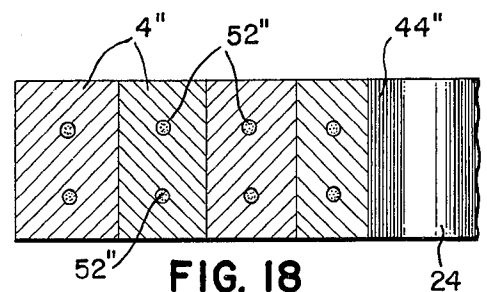


FIG. 18

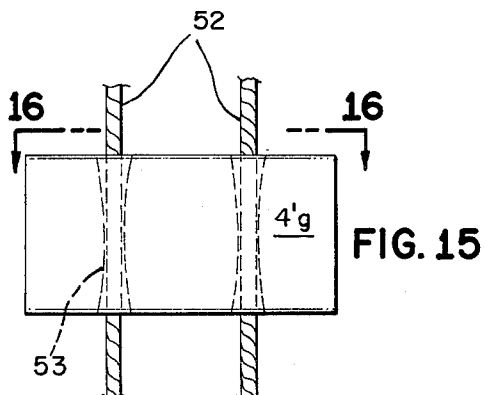


FIG. 15

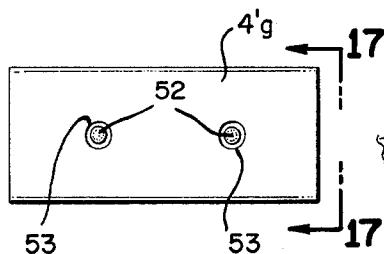


FIG. 16

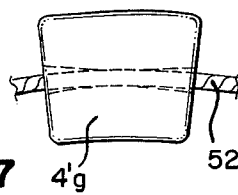


FIG. 17

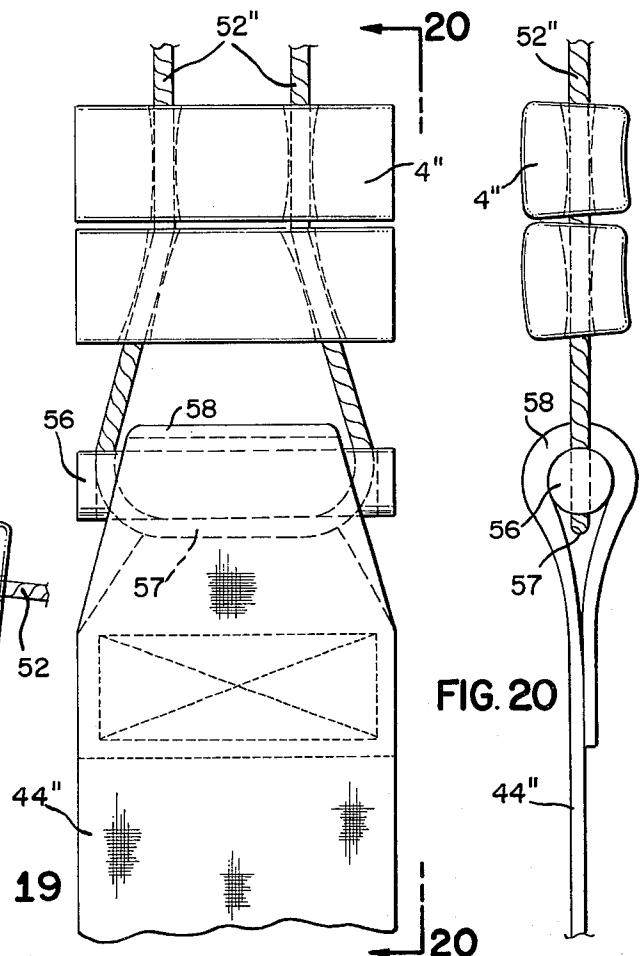


FIG. 19

FIG. 20

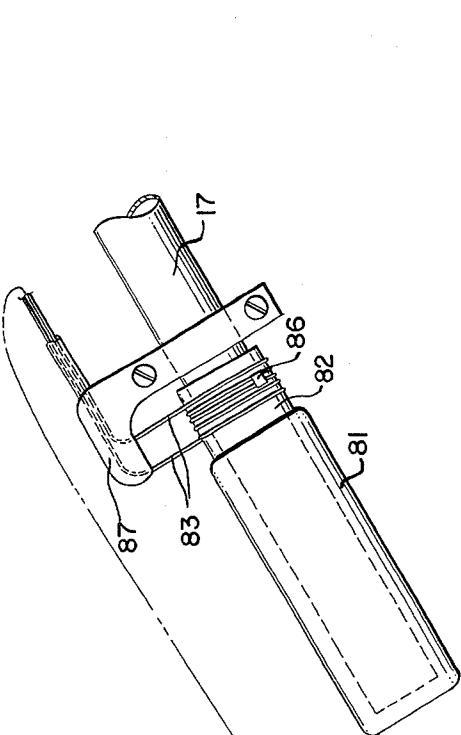


FIG. 21

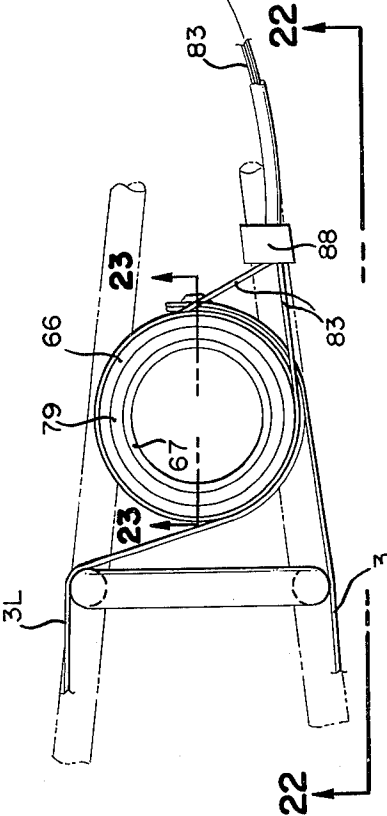


FIG. 22

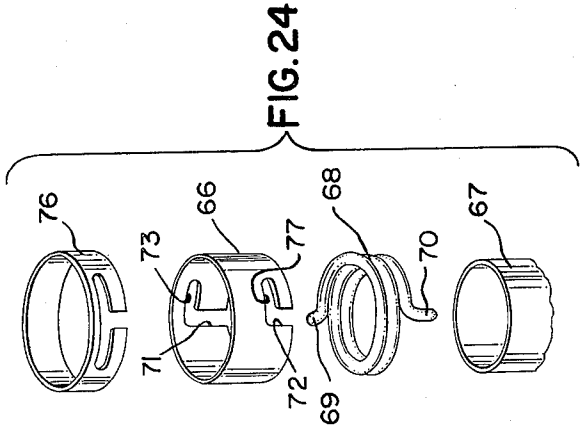


FIG. 23

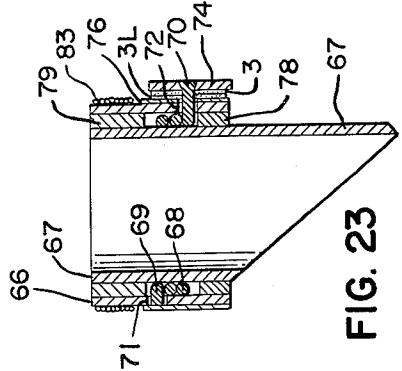


FIG. 24

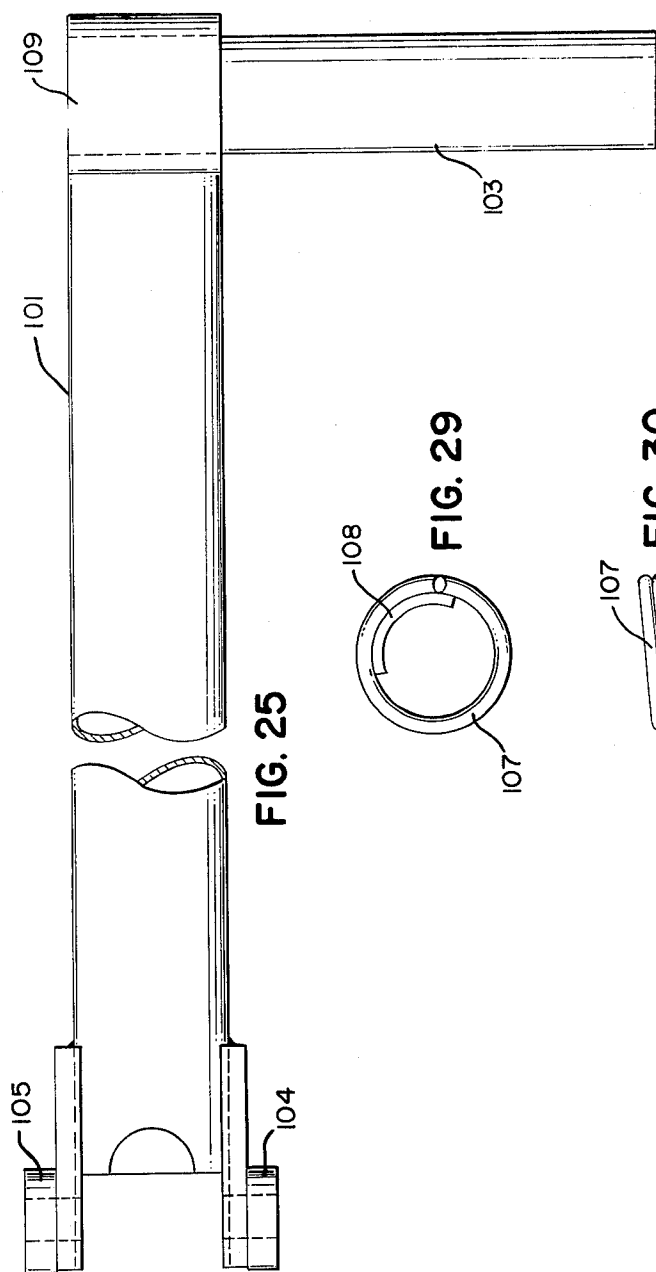


FIG. 25

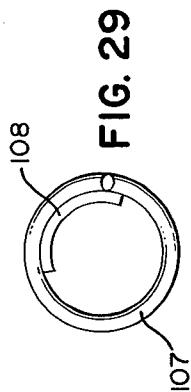


FIG. 29



FIG. 30

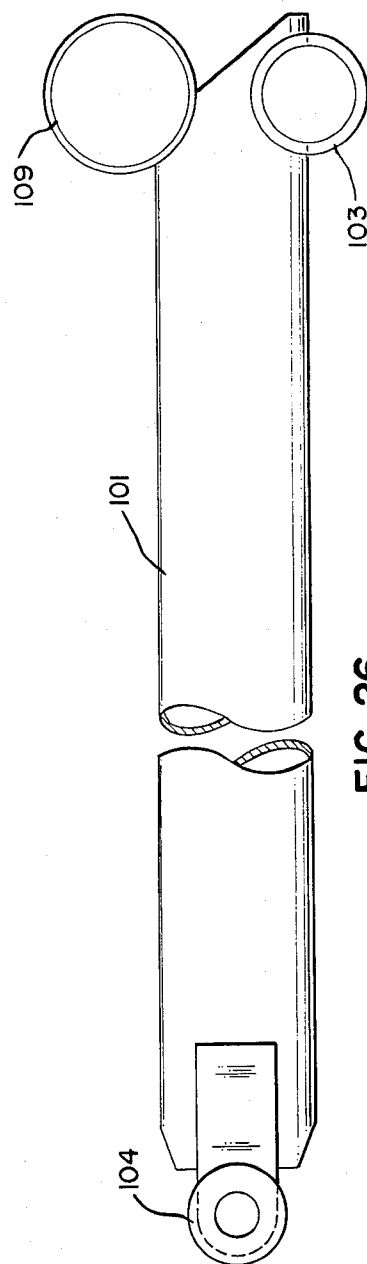


FIG. 26

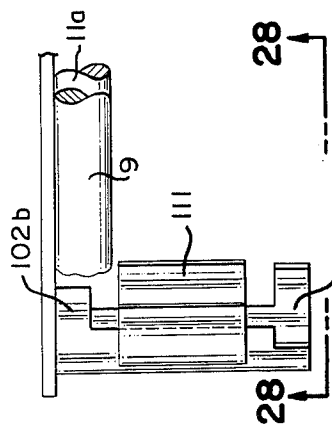


FIG. 27

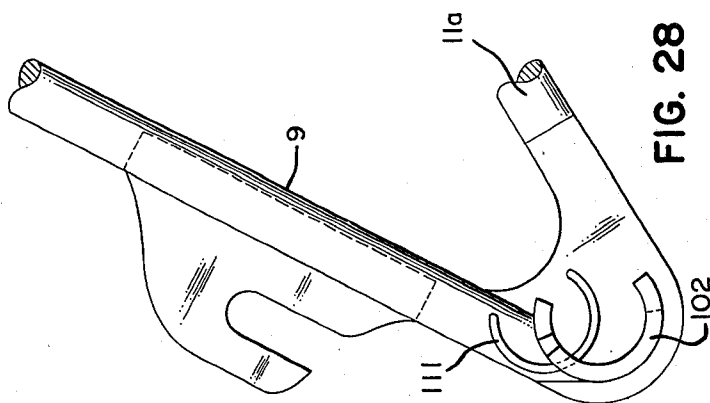


FIG. 28

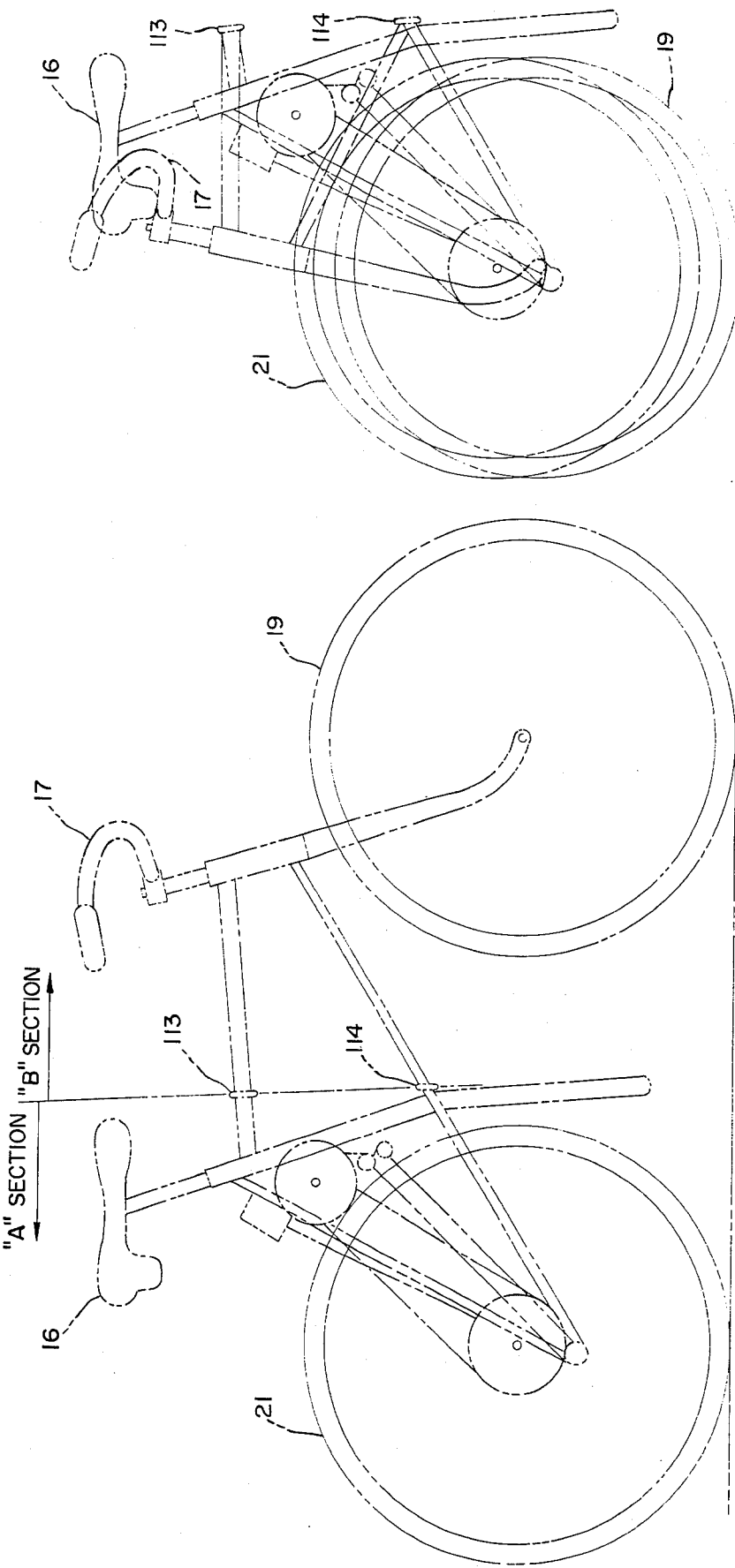


FIG. 32

FIG. 31

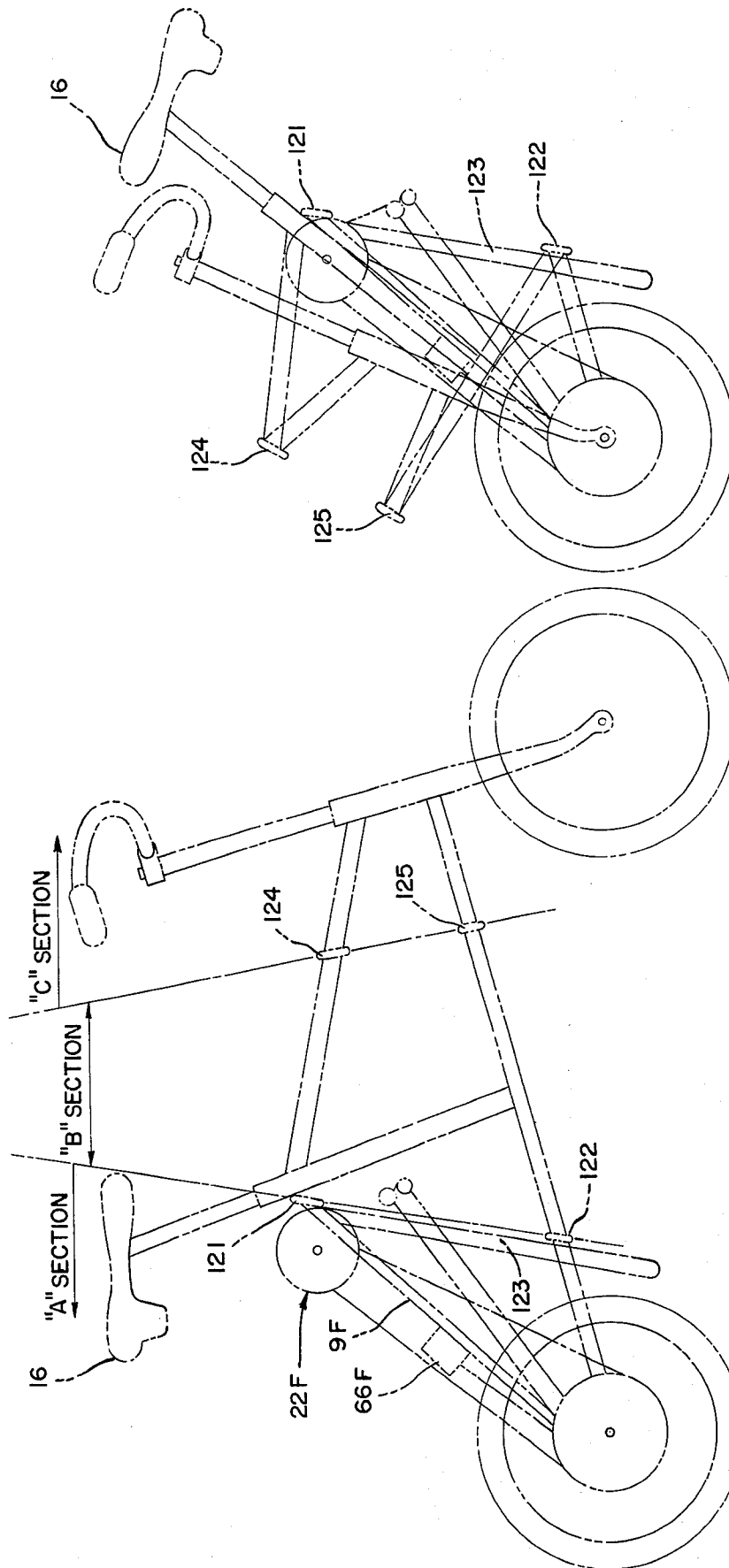


FIG. 34

FIG. 33

ERGONOMIC DRIVE FOR BICYCLES AND OTHER HUMAN POWERED MACHINES

BACKGROUND OF THE INVENTION

This invention relates to human powered machines. Specifically it relates to machines which are powered by "pedaling" i.e., bending and extending the leg or arm. The machine described is potentially useful for driving light machinery of various types such as rotary pumps, grain mills, electrical generators, saws and many other useful machines. The present machine may be useful in remote areas without electrical or other power driven motors, for portable field units, or for emergency equipment.

Because of our present motor oriented society, the most immediate commercial adaptation of the present machine appears to be the bicycle. The remainder of this application will be devoted to the adaptation of this machine to a bicycle but, it is obvious that by slight changes it could be adapted to all of the above mentioned equipment.

BACKGROUND OF THE BICYCLE

Bicycle technology during the 1800's advanced foot powered machines to a high degree resulting in many different types of foot powered mechanisms. Many of these mechanisms included levers, drums and straps but after the advent of the Rover Safety Bicycle introduced in 1885 by J. K. Starley of England, the rear-wheel, chain-and-sprocket drive dominated the art. The introduction of the derailleur change-speed gear of 1899 for changing gears exists to this day with only minor refinements.

The chain-and-sprocket drive system, supplemented by 10 and even 15 speed derailleur systems while capable of first rank efficiency, is not efficient enough to compete with the automobile for most people and is too complicated for many others.

Basically the inefficiency of the chain-and-sprocket drive results from the fact that during the first portion of the upper quadrant of the power stroke when the pedal lever arm is short, the leg is bent and capable of its least amount of thrust. Also, during the mid-portion of the power stroke, when the leg is more nearly straight and capable of nearly its most powerful thrust, the lever arm is longest. Thus, during a large part of the power stroke, the machine and man are not bionomically matched. Further, the chain-sprocket system has "dead spots" at the top and bottom of the cycle where the person must not apply power or he will apply negative input to the system.

The lever-drum-strap system used by early bicycles was probably largely due to an adaptation of the treadle systems known from early colonial days rather than a conscious application of ergonomics, but recent lever bicycles have recognized the lack of efficiency of the chain-and-sprocket system and are returning to the reciprocating lever system. The lever system, like the chain-and-sprocket system, however, lacks a simple means of "changing gears". The derailleur can only change gear ratios in definite step increments and 10 to 15 steps is the upper practical number of increments. Moreover, no power can be applied to a derailleur system during gear changes, nor can a gear change occur unless the bicycle is in motion.

SUMMARY OF THE PRESENT INVENTION

The present system is uniquely adaptable to its power delivery source (the human body) and infinite "gear-ratio" changes are possible over an extremely wide "gear" range. Further, gear changes can occur under full power or even while the bicycle is stopped. Thus, in the machine of the present invention it is unnecessary to "anticipate" a particular gear change before the actual need arises. This can be particularly annoying while proceeding up hill on a "ten-speed" bicycle and then be required to stop. It is impossible to get in the proper gear while stopped and then one must anticipate through prior experience what gear to select.

The gist of the present invention is a unique flexible member, a portion of which is tapered in thickness. This tapered belt not only uniquely provides for the most efficient adaptation of the machine to the power source but it also provides the most efficient element for providing infinitely variable gear change.

While a man on a present day bicycle ranks first in efficiency among traveling animals and machines in terms of energy consumed in moving a certain distance, an objective of the present invention is to advance this efficiency by such a giant step as to enable the bicycle to compete successfully in many more applications which are now almost exclusively dominated by internal combustion engine powered machines.

Another object is to provide a bicycle which achieves the optimum design ergonomically by providing the greatest mechanical advantage at the top of the stroke when the legs are bent at the knee and providing the least mechanical advantage when the legs are extended and capable of their most powerful thrust.

A further object is to provide a bicycle which will provide such a wide range of "gear ratios" that the vast majority of people will be able to traverse all but the steepest present day roads with ease.

Still another objective of the present invention is to provide a bicycle which can be inexpensively mass produced so that it will be within the economic range of nearly everyone: even those of under-developed countries, and will free many from dependence upon fossil fuels to power ever more expensive gasoline powered automobiles.

Still a further objective is to provide a bicycle which is light weight and in which the power train uniquely makes it possible to fold the bicycle for carrying on mass transportation systems as hand luggage or for carrying inside the trunks of even small automobiles.

Another objective is to provide gear change continuously during each repetitive stroke.

Another objective is to provide infinite gear change ratios within a wide range.

Another objective is to eliminate the large torque forces from the hub and to retain all of these large torque changes within the strongest portion of the frame viz. the seat tube.

Another objective is to eliminate the complicated bottom bracket of the standard bicycle frame which has four tube sockets and a threaded barrel to receive the outer races for carrying the pedals. This is by far the most complicated and most expensive area of the present frame.

Another objective is to provide a drive system for a bicycle which will enable the frame to be shorter and

therefore lighter, enabling the bicycle to be more compact for storage.

Another object is to provide a drive system for a bicycle which is sturdier and less subject to damage from ordinary use and falls.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the machine constructed in accordance with the present invention mounted on a bicycle.

FIG. 2 is a top plan view of the bicycle shown in FIG. 1 with the seat and handle bars removed for purposes of clarity.

FIG. 3 is an enlarged composite elevation view of a portion of the machine taken generally in the area of 3—3 as shown in FIG. 4 with portions removed for purposes of clarity and portions in cross section.

FIG. 4 is a cross section of a portion of the machine taken generally along line 4—4 of FIG. 3.

FIG. 5 is an enlarged view taken generally along line 5—5 of FIG. 3.

FIG. 6 is a cross sectional view taken along line 6—6 of FIG. 3.

FIG. 7 is an enlarged cross sectional view of a portion of the elongated member taken along line 7—7 of FIG. 6.

FIG. 8 is a top view of a single compression member mounted on the elongated member taken along line 8—8 of FIG. 7.

FIG. 9 is a front view of a compression member taken along line 9—9 of FIG. 8.

FIG. 10 is a side view of a member taken along line 10—10 of FIG. 9.

FIG. 10A is an enlarged detail taken in the area of line 10A—10A of FIG. 6.

FIG. 11 is a top view of an alternate form of compression member mounted on an elongated member in which the view is similar to FIG. 8.

FIG. 12 is a front view of the alternate form taken along line 12—12 of FIG. 11.

FIG. 13 is a side view of the alternate form taken along line 13—13 of FIG. 12.

FIG. 14 is a sectional view of another alternate form of the invention in which the view would be similar to a view taken along line 7—7 of FIG. 6.

FIG. 15 is an enlarged top view of the alternate system taken along line 15—15 of FIG. 14.

FIG. 16 is an end view taken along line 16—16 of FIG. 15.

FIG. 17 is a side view taken along line 17—17 of FIG. 16.

FIG. 18 is a sectional view of still another alternate form of the invention in which the view would be similar to a view taken along line 7—7 of FIG. 6.

FIG. 19 is a plan view of a portion of the elongated member constructed in accordance with the form of the invention shown in FIG. 18 and showing the connection between the strap and cable portion.

FIG. 20 is a side view of the form of the invention shown in FIG. 19.

FIG. 21 is a plan view of a portion of the machine taken generally along line 21—21 of FIG. 1.

FIG. 22 is a side view of the portion of the device taken along line 22—22 of FIG. 21.

FIG. 23 is a cross sectional view of a portion of the device taken along line 23—23 of FIG. 21.

FIG. 24 is an exploded view of the elements shown in FIG. 23.

FIG. 25 is a top plan view of one of the pedal arms and a portion of the frame showing the pedal bearing housing.

FIG. 26 is a side view of the pedal arm shown in FIG. 25.

FIG. 27 is a top view of the pedal arm housing taken along line 27—27 of FIG. 1.

FIG. 28 is a side view of the pedal arm housing taken along line 28—28 of FIG. 27.

FIG. 29 is a side view of an expandable clamp.

FIG. 30 is a top view of the clamp shown in FIG. 29.

FIG. 31 is a side view of an alternate form of the invention.

FIG. 32 is a side view of the invention shown in FIG. 31 in the folded position.

FIG. 33 is a side view of another alternate form of the invention.

FIG. 34 is a side view of the invention shown in FIG. 33 in the folded position.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

The machine of the present invention for converting human powered reciprocating leg motion or arm motion to rotary motion consists briefly of a frame; a rotatable member 24 mounted for rotation on said frame; a flexible elongated member 3 having an end connected to the rotatable member and wound upon itself; a plurality of non-compressible members 4 of varying thickness attached to a portion of the elongated member forming a belt of tapering thickness; a foot or arm receiving means 103 engaging the free end of the elongated member; and spring means 7 connected to the frame and the rotatable member for rewinding the elongated member.

As set forth previously, the mechanism of the present invention may be used in powering various devices. The mechanism is adaptable to a bicycle which is shown in the drawings. The bicycle follows the somewhat standard design but since the mechanism includes levers instead of pedals on a crank, the frame can be somewhat shorter. Also since the drive mechanism is completely contained on the frame at the rear portion and the crank and pedal arms have been eliminated, the frame may be folded as will be later explained in a very unique and compact manner.

The frame of the bicycle consists of a seat tube 8, a seat stay 9, a rear bottom stay 11A and a rear top tube 12A. All of the above frame members may be assembled as an "A" unit if the bicycle is to be provided with hinges so that it can be folded. The portion of the "B" section of the frame consists of the front top tube 12B, the front Bottom stay 11B, the head tube 13, and the fork 14. The seat 16 is mounted on the seat tube and the handle bars 17 are attached to the head tube by the stem 18. The front wheel 19 and rear wheel 21 are mounted in the usual manner.

The drive mechanism is operable with only a single rotatable member, elongated member and pedal means but, of course, such a mechanism is much more efficient when there is a duplicate mechanism. For purposes of explanation only one of the two mechanisms is described, except in those instances where it is necessary to shown the interrelation of the two mechanisms.

The drive assembly is shown in FIGS. 3, 4, and 5. The drive assembly housing 22 is connected to the seat tube. A drive shaft 24 is journaled at its end by bearing 26 to end member 23 of the housing and at an inner point by bearing 27 mounted in member 25. The elongated member 3 is connected to the shaft and is contained by sides 23 and 25. Teflon rings 28 and 29 cut down friction on the spring. The return spring is connected to the shaft, and to the drum housing by a fastener 31.

Power transmission to the rear wheel is by drive member 33 mounted for rotation on the shaft and connected for rotation with the shaft by an overrunning clutch 35; a driven member shaft 34 remotely located from the drive member; a sprocket 36 mounted for rotation on the driven member shaft; and a flexible endless member 37 coupling the members in a drive and driven relationship. The member 37 could be a belt, toothed belt or a chain as shown in the drawings. Since the torque transmitted to the drive member 33 is relatively low, a very light chain may be used. Either a metal or plastic chain would be suitable. As shown, a first chain sprocket 38 is mounted on the drive member and a second chain sprocket is mounted for rotation at the rear wheel.

The heart of the system is the tapered belt. The means for tapering may be accomplished in several different ways. A flexible woven member with plastic beads such as nylon is one form which gives good results and several forms of this system are shown in FIGS. 6-20.

As shown in FIG. 6 the beads are attached to a flexible member such as a woven nylon strap 3. The beads vary in size in a uniform manner and are designated 4a, 4g, 4h, and 4j, as a representative sampling for purposes of illustration. The beads get smaller in thickness as shown by bead 4i and 4j as the radius becomes smaller. There is a rapid decrease in mechanical advantage as the member is drawn off the drum and as the beads in the series 4j become the outside row.

FIGS. 7-10 show one form of attaching the beads to the elongated member. Each bead is formed with edge slots 42 and 43. The beads are attached to strap 3 by fastening straps 46 and 47 which are inserted into the slots 42 and 43 and are attached to the straps along lines 48 and 49 as by sewing.

As shown in FIGS. 6 and 7, a portion 51 of the strap 3 does not have beads attached. This portion of the belt would give the least mechanical advantage and consequently would be used for traveling at higher speeds or on the level or down hill where the amount of torque required is low.

Another method of constructing the tapered belt is shown in FIGS. 14-17. In this form of the invention, the strap is replaced by a pair of cables 52 which are threaded through openings 53 in the beads. As shown in FIG. 14, the beads vary in thickness such as from the large beads 4'a to the small beads 4'j. The beads get progressively smaller as they approach the shaft. Thus the beads in declining thickness are 4'a, 4'g, 4'h, 4'i and 4'j. Note that the openings in the beads 53 may be non-uniform to reduce friction as the strap is wound upon itself. As shown, the openings at the edges are slightly larger than at the center of the opening. As shown in FIG. 14, the entire length of the cable is not furnished with beads and thus the end portion of cable is merely wound upon the drum in the area shown by

the number 54. It is not essential to attach each bead to the cable. Only the end beads need be attached to the cable. This can be accomplished by soldering or swaging.

Another form of the invention is shown in FIGS. 18-20 in which a portion of the elongated member is formed with a cable 52'' and beads 4'' and the other portion by a strap 44''. As in the previous examples, the beads vary in thickness so that the mechanical advantage varies as strap is withdrawn from the shaft. The different portions of the elongated member may be joined as by a coupling shown in FIGS. 19 and 20 with a cylindrical member 56 holding the loop 57 of the cable and a loop 58 being formed in the strap to encircle the cylinder.

Still another form of the elongated member is shown in FIGS. 11-13 in which the beads 4''' are attached to the elongated strap 44''' in a different manner. In this form of the invention, a slot 61 is formed through the bead along the central portion of the bead, and a holding strap 62 is threaded there-through and attached along lines 63 to the main strap as by sewing.

Another feature of the present invention is the ability of the mechanism to change mechanical advantage quickly, easily and independently of the movement of the ground wheels or even the drive assembly.

Essentially, the gear unit for changing the mechanical advantage consists of a control ring 66 mounted for rotation on a take up post 67 connected to the frame. A convenient location for the connection of the take up post is near the upper portion of the seat tube and between the back stays. A snugly fitting clutch spring 68 grips the post and can only be turned by a force applied against a first end 69 or a second end 70 in a direction that tends to "unwind" the spring. The control ring is formed with slots 71 and 72 to receive and engage the respective turned up ends 69 and 70 of the spring. Thus, when slot 72 of the control ring as shown in FIG. 23 moves in a counter-clockwise direction and engages spring end 70, the spring will release from post 67 and the control ring will be permitted to continue to move in a counter-clockwise direction. Spring end 69 will move into circumferential slot 73. Straps 3 and 3L are connected to the spring end 70 by a clip 74 and are wound about storage ring 76. Thus movement of the control ring in a counterclockwise direction as shown in FIG. 21 winds straps 3 and 3L onto the storage ring 76 resulting in a removal of the strap from the drive drums and resulting in a "higher gear" for higher speeds.

To shift to "low gear" for pedaling under load or up hill on a bicycle, the control ring must be moved clockwise as shown in FIG. 21. Slot 71 moves against spring end 69 which unwinds the spring from the post 67 and spring end 70 rides in circumferential slot 77. Return spring 7 withdraws strap 3 from the storage ring and a similar spring connected to a shaft similar to shaft 24 withdraws strap 3L from the storage ring. As shown in FIG. 23, bearing 78 and 79 are interposed between the post 67 and the control ring 66 to permit rotational movement of the control ring without interference with the spring 68 except as previously discussed.

The control ring can be rotated either by direct manual manipulation or by a remote control means. When the invention is adapted to powering a bicycle, it is convenient to place the mechanical advantage controller mechanism on the handlebars. One form of the inven-

tion is shown in FIG. 21 in which one of the handle grips 81 can be mounted for rotation on the end of the handlebar 17. A control cable drum 82 is mounted to rotate with the handle grip. A length of endless control cable 83 is wound about cable drum 82 and also about control ring 66. A fastener 84 on the control ring 66 connects the cable to the control ring and a fastener 86 connects the cable to the cable drum 82. Cable guides 87 on the handle bars and cable guides 88 mounted on the rear stays cause the cable to wind properly on the cable drums.

One means of transferring the rotational energy from the oscillating shaft 24 to the rear wheel is by means of an over-running clutch 35 interposed between the shaft and the drive member 33. Such clutches are in common use and a typical example is the clutch made by Torrington in Connecticut. As above noted, FIG. 3 is only one side of the drive mechanism with a mirror image of the mechanism being present on the other side of the center line 91. The mechanism is duplicated on the other side of the center line except that there is only one sprocket wheel 38. The drive member 33 continues on to the other side of the Figure and there is a duplicate shaft similar to 24. The shafts are not connected. A separate clutch is interposed between this shaft and the drive member 33 so that the power from both pedals is transferred to the drive member 33 and thence through sprocket 38, chain 37 and sprocket 36 to the rear wheel.

While the overrunning clutch shown insures that chain 37 always moves in the same direction, it is possible that if the rear hub includes a ratchet mechanism, the constant movement of the chain during coasting can be eliminated. Thus, the chain would only move when the clutch engages the drive member 33.

The most efficient means of drawing the elongated member from the shaft 24 is by means of leg movement. Obviously, the arm could be used but this would not be as efficient.

When used on a bicycle, pedal arm 101 is pivotally connected by a bearing housing 102 to the seat stay 9 and the rear bottom stay 11a. The pedal arm must be capable of drawing off a length of strap each time it is moved downwardly and it must also pass the strap to the strap-take-up means if a unit for changing the mechanical advantage is used. Preferably the pedal arm is tubular so that the strap can be passed through the inside of the tube. A pedal 103 extends from the front portion of the pedal arm and the rear part holds bearings 104 and 105. The bearings are received by bearing housing 102. The bearing housing only supports each bearing over half of its surface. Note that housing 102a covers a sector from about "5 o'clock" to "11 o'clock", while housing 102b covers a sector from about "7 o'clock" to about "1 o'clock". Under load, each pedal arm is thrust in a rearward direction and torqued. The right pedal arm receives a clock-wise moment viewed from the rear, and the left arm receives a counter-clockwise moment as viewed from the rear. Each bearing is clamped to the bearing housing by an expandable clamp which consists of a spring 107 and a spacer 108 which partially fills the opening in the bearing housing.

A strap guide 109 is mounted on the leading edge of the pedal arm and another strap guide 111 is mounted on the frame just above the pedal arm housing. The guide 111 causes the elongated member to pass

through the pivot point of the pedal arm thereby reducing the sliding friction of the elongated member at this point. The longitudinal opening in the pedal arm is large enough to permit the beads on the strap to pass into the pedal arm. The storage of the beaded portion of the strap in the pedal arm when the drive system is in "high gear" leaves only the unbeaded portion of the strap to be reciprocally drawn from the shaft 24. Thus, the inertia of the reversing belt at the reversing shaft is reduced still further increasing the efficiency of the machine at high speeds.

Another unique feature of the present invention is the fact that all of the power drive mechanism is located on the rear portion of the frame. In adapting the machine to bicycles, this is extremely important since it enables the bicycle to be folded at convenient points making a very small and compact package. By folding the bicycle very compactly, it can be carried on and off public transportation. By providing a suitable case, the entire bicycle can be folded into a small neat case so that instead of storing the bicycle in special storage racks, they can, for example, be carried into office buildings and stored beside the desk of the owner or in a large coat closet. The fact that a bicycle can be folded into a lightweight compact package enabling it to be carried onto a bus or train and stored in an office may be the answer to many who are within a few miles of a suburban station and relatively close to their urban office.

In FIG. 1, a pair of releasable/locked hinges 113 and 114 are provided respectively between the top tube 12A and 12B and the rear bottom stay 11A and front bottom stay 11B. FIG. 31 is a smaller view of the bicycle shown in FIG. 1 for purposes of comparing it with the folded position in FIG. 32. It should be noted that the package can be made even more compact by lowering the handle bars and the seat.

A bicycle capable of being folded into even a smaller package is shown in FIGS. 33 and 34. In this form of the bicycle, a hinge 121 is placed in the upper portion of the seat stay and a second hinge 122 is placed in the lower rear stay behind the seat tube and just ahead of the limit bar 123. A second set of hinges is placed forwardly with one hinge 124 being placed in the head tube and another hinge 125 on the front portion of the lower stay. It should be noted that in the form of bicycle shown in FIGS. 33 and 34, the drive assembly housing 22F is mounted on the rear stay 9F while the unit 66F for changing mechanical advantage is located on the lower portion of the rear stays.

In most applications of the present machine, pedal limit means should be used. As shown in FIG. 1, a hanger 131 extends from the seat tube and is formed with semi-circular T-shaped bars 132 which receive the underside of the pedal 103 thereby preventing the pedals from striking the ground.

OPERATION OF THE MACHINE

Operation of the machine would be as follows: First, the pedal arms 101 and 101L would be drawn upwardly by the return spring 7 and the return spring for elongated member 3L. The operator would place either his right foot on pedal 103 or his left foot on pedal 103L. Normally in starting out from a stop, the operator would want to set the mechanism so that he would obtain the greatest mechanical multiplier or gear ratio. In order to accomplish this, the operator merely rotates

the hand control **81** in a direction that will unwind the elongated member from the storage ring **76**. The take up springs, such as take up spring **7** automatically winds the elongated member onto shaft **24**. In the illustration in FIG. **21** the hand control is rotated clockwise and cable **83** rotates the storage ring in a clockwise direction.

As the foot pushes on one of the lever arms such as **101** downwardly, the strap **3** begins to unwind from shaft **24**. As shown in FIG. **6**, the radial distance from the shaft to the strap is greatest as the strap begins to unwind and therefore the mechanism gives the greatest force multiplying effect at the beginning of the stroke. Since the leg is bent at the beginning of the stroke and therefore at its weakest thrusting position, the need for the greatest gear ratio is met by the present invention. As the leg continues to push downwardly and gradually is capable of more and more thrust power the strap is unwound from the shaft and the radial distance from the shaft to the strap decreases rapidly due to the thickness of the beads. Thus the increasing of the leg force and the decreasing of the mechanical advantage approximately balance one another and in terms of force applied to the out put shaft or rear wheel it remains relatively constant. In terms of applied force, the leg is able to move the pedal downwardly at a nearly constant rate and to the rider, the pedal appears to be as easy to pump at the top of the stroke as at the bottom of the stroke. When the lever reaches the end of the stroke it strikes against stop **132** and pedal **103L** strikes **132L**. As soon as the foot pressure is released, spring **7** draws the pedal arm back up for the next stroke and the strap is wound upon shaft **24**. It may be noted that it is not necessary to push the pedal all the way down until it strikes the stop but it may be pushed down to any convenient point and then the return spring will return the strap. Thus if one wishes to stay at the very highest mechanical advantage, (lowest gear ratio), the operator need only use a series of short strokes.

As shaft **24** is rotated, overrunning clutch **35** locks onto drive member **33** and transmits the force to the sprocket **38** thence through chain **37** to sprocket **36** and finally to the wheel **21**.

An entirely separate drive means is operated by lever **101L**. An elongated member **3L** encased in housings **23L** and **22L** is attached to a shaft similar to shaft **24**. An overrunning clutch similar to clutch **35** is connected to the drive member **33** independently of the shaft and clutch **24** and **35**. Thus it is possible to pump the bicycle by one or the other pedals separately; the pedals may be moved reciprocally or both of the pedals could actually be pumped in unison. The bike could actually be propelled merely by jumping up and down on the pedals. Such a means of propulsion would obviously be quite novel and most enjoyable to children.

While as above explained, the mechanical advantage or gear change occurs on each and every stroke. Greater gear changes may be made by withdrawing varying amounts of strap from the shaft **24**. These gear changes may be made by turning the handle grip **81** while the bicycle is actually stopped; a feat which cannot be accomplished on any multiple geared bicycle today which uses a chain derailleur. It is also possible to change to a higher gear or a mode of less mechanical advantage, or a lower gear or a mode of greater mechanical advantage much more quickly than in present derailleur equipped bicycles.

To change gears in a derailleur equipped bicycle, it is necessary to slip the chain from one size sprocket to another. No torque can be applied to the wheel for a full 180° of the sprocket while the chain is moving from one sprocket to another. On present bicycles, this means that one must anticipate gear changes rather carefully while moving up hill. The inexperienced bicycle rider frequently must get off the bicycle and change the gear by revolving the crank by hand.

In the present invention, it is very simple to change to a mode of greater mechanical advantage (shift to a lower gear). The operator merely turns the control handle **81** and the take up springs unwind strap from the storage ring **76** and wind it onto the shaft **24**. It does not matter whether the operator is pumping the lever arms or not. Thus the change in mechanical advantage takes place rapidly and inexperienced riders never need suffer the indignity of having to dismount to change gears.

I claim:

1. A machine for converting human powered reciprocating leg or arm motion to rotary motion comprising:

- a. a frame;
- b. a rotatable member mounted for rotation on said frame;
- c. a flexible stranded elongated member having a thickness substantially less than its width and having an end connected to said rotatable member and spirally wound upon itself on said rotatable member;
- d. a plurality of non-compressible members of increasing thickness arranged in side by side non-connected relationship and each individually attached to said elongated member along a portion of its length forming a segmented portion of tapering thickness which increase in thickness in proportion to the distance from the end connected to said rotatable member;
- e. foot or hand receiving means engaging said elongated member; and
- f. means connected to said frame and said rotatable member for rewinding said elongated member upon said rotatable member.

2. A machine as described in claim 1 comprising:

- a. said non-compressible members consist of hard beads having single arcuate curved outer faces generally conforming to said spiral and are connected to said flexible member and a width so that the member can be spirally wound upon itself so that a substantial portion of the face of the bead rests upon the adjoining stranded elongated member.

3. A machine as described in claim 2 comprising:

- a. said elongated member consists of a metal cable.

4. A machine as described in claim 2 comprising:

- a. said elongated member consists of a woven material.

5. A machine as described in claim 1 comprising:

- a. a drive member mounted for rotation with said rotatable member;
- b. a driven member having a diameter relatively greater than the diameter of said drive member mounted for rotation on said frame and disposed from said drive member;
- c. a flexible endless member coupling said drive and driven members; and

- d. means operatively connected to said drive and driven members providing unidirectional rotation of said driven member.
6. A machine as described in claim 5 comprising:
- a. said drive member and said driven member having first and second chain sprockets mounted thereon for rotation therewith; and
 - b. said endless member consisting of a chain.
7. A machine as described in claim 1 comprising:
- a. means for changing the mechanical advantage connected to the end of said elongated member for drawing a portion of said elongated member from said rotatable member and storing the end portion of said elongated member.
8. A machine as described in claim 7 comprising:
- a. said means for changing the mechanical advantage consists of a storage ring mounted for rotation on said frame for storing varying amounts of said elongated member.
9. A machine as described in claim 8 comprising:
- a. said means for changing the mechanical advantage includes:
 1. a take-up post mounted on said frame;
 2. a clutch spring mounted in surrounding frictional releasable sliding grip with said take-up post; having a first and second end;
 3. a spring engaging control ring having slotted openings for engaging the ends of said spring; and
 4. said storage ring being mounted on said control ring.
10. A machine as described in claim 9 comprising:
- a. control means for varying the amount of said elongated member stored on said storage ring including:
 1. a rotatable control member remotely located from said storage ring adapted for manual engagement; and
 2. an elongated cable member attached to said control member for winding receipt thereon and connected to said control ring for winding thereon.
11. A machine as described in claim 1 comprising:
- a. said non-compressible members are attached to substantially the entire length of said elongated member thereby forming a segmented belt which tapers substantially its entire length.
12. A machine as described in claim 1 comprising:
- a. said segmented portion of said elongated member having a tapering thickness is located adjacent the distal end of said elongated member; and
 - b. a substantial portion of said elongated member located adjacent the end connected to said rotatable member is free of said non-compressible members of varying thickness.
13. A machine having a frame and output member comprising:
- a. a rotatable member mounted for oscillating rotation on said frame;
 - b. a flexible elongated member having a portion of tapered thickness connected to said rotatable member and spirally wound upon itself thereon;
 - c. foot adaptable means engaging said elongated member for drawing said member from said rotatable member;
 - d. means to rewind said elongated member on said rotatable member;

- e. a storage ring mounted on said frame connected to and for receiving the free end of said elongated member;
 - f. control means connected to said storage ring for rotating said storage ring and storing varying lengths of said elongated member;
 - g. driven power train means connected to said rotatable member and including a driven member; and
 - h. means interposed between said driven member and said rotatable member for transmitting unidirectional rotation only to said driven member.
14. A machine as described in claim 13 comprising:
- a. said foot means including:
 1. an arm pivotally connected to said frame; and
 2. said arm engaging said elongated member for drawing off a portion of said elongated member from with each reciprocating cycle of said arm and permitting said means to wind said member back on said rotatable member with each cycle.
15. A machine as described in claim 14 comprising:
- a. said arm being tubular for receiving said elongated member through a portion thereof;
 - b. said output member including a ground engaging wheel connected to said driven member; and
 - c. said driven power train including an endless flexible member connected to said rotatable member and to said driven member.
16. A machine as described in claim 13 comprising:
- a. said frame being divided into A and B sections and being pivotally connected together for a first rigid driving position and a second folded stored position;
 - b. said members described in claim 11, all being mounted on said A section of said frame;
 - c. a rear ground engaging wheel mounted for rotation on said A section of said frame and operatively connected to said drive member;
 - d. a seat mounted on said A frame section;
 - e. a front ground engaging wheel mounted for rotation on said B frame section and mounted for pivotal steering movement;
 - f. steering means connected to said front ground engaging wheel mounted on said B frame section for pivotal movement; and
 - g. manually engaging locking means connected to said A and B frame sections for locking and releasing said frame members permitting the rigid driving position and the folded storage position.
17. A machine as described in claim 13 comprising:
- a. said frame being divided into A, B and C sections and being pivotally connected together for a first rigid driving position and a second folded stored position;
 - b. said members described in claim 11, all being mounted on said A section of said frame;
 - c. a rear ground engaging wheel being mounted on said A section;
 - d. a seat and seat tube being mounted on said B section; and
 - e. the handle bars, fork and front wheel being mounted on said C section.
18. A machine as described in claim 13 comprising:
- a. said foot adaptable means consisting of a pedal arm pivotally connected to the frame of said machine;
 - b. a pair of spaced bearings mounted on the pivot end of said arm;

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- c. a pair of bearing housings mounted on said frame consisting of approximately half circles for receiving said spaced bearings;
- d. a pair of spring clamps enclosing said bearing housing and said bearings;
- e. a spacer member mounted on each of said spring

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- clamps enclosing said bearings in annular registration with said bearing housings; and
- f. guide members mounted on said frame for guiding said flexible elongated member through the approximate center of said pedal arm pivot point.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,889,974

DATED : June 17, 1975

INVENTOR(S) : CHARLES A. KALLANDER

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 12, line 17, after "from" insert ---said rotatable member---

Column 12, line 37, change "drive" to ---driven---

Signed and Sealed this

thirteenth Day of January 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks