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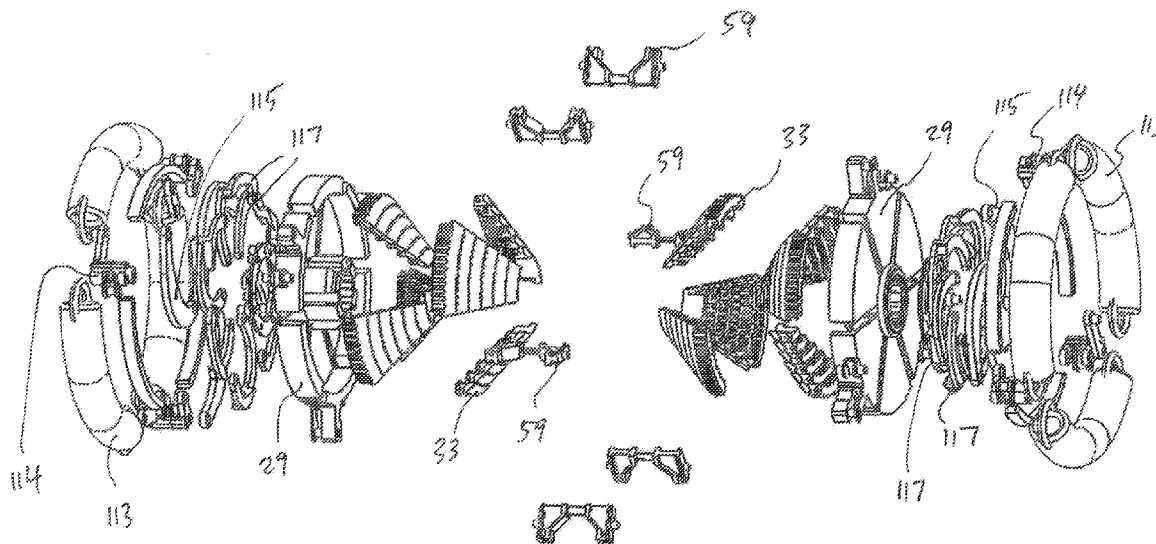


Figure 3

(57) Abstract: The present invention provides a transmission system (12) comprising a first pulley (211) connected to an input (11) by a cable (40) such that movement of the input causes rotation of the first pulley. The first pulley comprises an annular recess (25) between a first side (17) of the first pulley and a second side (19) of the first pulley. The annular recess is adapted to receive the cable such that the cable is supported by the first pulley. The first pulley also comprises a pair of support surfaces (31) located in the annular recess, which are moveable in a lateral direction relative to the sides of the pulley between a spaced condition, wherein the first pulley is at a first diameter and the pair of support surfaces do not engage the cable, and a meshed condition, wherein the first pulley is at a second diameter and the pair of support surfaces support the cable, the second diameter being larger than the first diameter.



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A Pulley and Transmission System

TECHNICAL FIELD

[0001] The present invention generally relates to a pulley. In particular the present invention relates to a pulley which is capable of presenting a variable diameter. The present invention also relates to a transmission system, or pulley driven system, which incorporates the pulley.

BACKGROUND ART

[0002] The following discussion of the background art is intended to facilitate an understanding of the present invention only. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

[0003] Transmission systems are used in various vehicles and industrial equipment to transfer power from a power source to an output, typically to a drive wheel to move the vehicle. One such vehicle which employs a drive train is a bicycle.

[0004] The transmission system of a bicycle is typically in the form of a centrally located chain ring integrating two crank arms. A rider engages the crank arms to rotate the chain ring. The chain ring is spaced from a rear sprocket but is interconnected using a chain which spans between the chain ring and the sprocket. As a result the torque exerted on the chain ring is transferred to the rear sprocket, which is also caused to rotate. The rear sprocket is secured to the axle of the rear wheel of the bicycle such that as the rear sprocket rotates the rear wheel will simultaneously rotate.

[0005] The transmission system of a bicycle will typically further comprise a gearing system to enable a rider to manipulate the effect the rotational force of the chain ring has on the rear wheel. This gear system generally comprises a plurality of co-axially mounted rear sprockets of different diameter and a plurality of co-axially mounted chain rings (usually between one and three) of different diameter. By activating a gear mechanism the rider can cause the chain to move to different sprockets or chain rings, enabling the rider to choose the gear ratio which best suits the conditions.

[0006] Current gearing systems are limited in the gear range they can achieve. A bike can either be set up with a large gearing range thereby not featuring the smallest possible gears, or with a small 'compact' gearing range thereby not featuring the largest possible gears. Therefore when setting up a bicycle it is necessary to choose one of the subset ranges.

[0007] A large gearing range is used for relatively flat terrain but inevitably leads to undesirable limitations when sections of the predominantly flat terrain lead uphill at a notable gradient, as these cannot be ridden with the preferred small gearing. This in turn leads to rider fatigue and a competitive disadvantage. A small gearing range is used for relatively steep uphill terrain but leads to undesirable limitations when riding downhill as large gearing to facilitate pedalling downhill at high speeds is not available. This leads to lower than possible speeds and hence a competitive disadvantage.

[0008] On a practical level the gear ratio range limitations of existing state of the art chain driven derailleur systems mean that riders and mechanics have to make a call on whether to install a large or small gear range. This not only compromises riding efficiency but also means a constant mechanical effort in changing and replacing the systems on the bike between race days of any tour event. The same applies to recreational riders who have to go through the effort of replacing drive trains depending on their intended type of riding if they want to expend riding energy efficiently.

[0009] While chain driven derailleur systems are highly efficient in transferring rider energy from the crankset to the rear wheel, this efficiency is significantly diminished when the chain is not set in a straight line between the plane of the front chain sprocket and the plane of the rear sprocket, i.e. all three elements are not in the same plane. Due to the inherent limitation of this type of drivetrain, straight line chain setting is only achievable for a small subset of gear settings of the drive train gearing range.

[0010] When a gear setting is chosen that causes the chain to deviate from the straight line between the chosen front chain ring and the chosen rear sprocket, the resultant strains and friction within the chain, and between chain and the chain ring and sprocket cause drive train efficiency to drop markedly. This means that up to 20% of the rider's energy provided at the crank set does not arrive at the rear wheel. The rider has no choice but to select terrain induced gear settings that feature this inefficiency because it would be even less desirable to force the rider's body to cope with too high or too low gear settings just for the sake of drive train efficiency.

[0011] An issue for chain driven derailleur or any discrete gearing systems is that the process of changing gears results in a temporary loss of power transmission for the time it takes the chain to relocate from one chain ring or sprocket to another one. This results in notable loss of rider energy in particular when riding uphill at steep gradient, as the resulting loss of momentum during gear change requires additional effort to bring the bicycle back to the speed before the gear change. It also leads to a time delay in the opportunity to respond to another rider's sprint during a race situation, all of which constitutes a competitive disadvantage and may make the difference between winning or not winning a road race.

[0012] Chain driven derailleur systems also feature inherent discontinuous gearing when changing chain rings which result in the need to simultaneously change sprockets. This compounds the loss of momentum problem. It also presents a significant challenge to fatigued riders and frequently leads to inefficient riding.

[0013] Another disadvantage of conventional chain driven derailleur systems is the inability to change gear when stationary. Chain driven systems require a pedalling cadence to be applied in order to facilitate gear change. When a rider unexpectedly has to come to a stop or slow down there is a loss in rider energy and ultimately chain drive train efficiency, as the rider must first change to a smaller gear starting from a much too large gear. This consumes a disproportionate amount of energy and the cumulative effect of that over long rides leads to reduced rider endurance.

[0014] Chain and derailleur driven bicycle drive trains have been refined over several decades but still feature unavoidable weight in their components, particularly the chain itself which can only practically be manufactured from heavy steel.

[0015] Chain driven derailleur systems are sensitive to physical shocks to the bike, lack of mechanical calibration quality or other misalignment, componentry mismatch, and lack of sensible rider operation. If any of the above exceeds the limitation of their operational design, the chain will come off the chain ring or the sprocket and, in the worst case, the chain can break. Chain derailment is common in recreational cycling and even regularly occurs during professional road racing even though great care is taken to provide equipment in peak condition. Other mechanical failures for conventional chain drives include blockage of some of the gear ratios by dirt ingress or ice formation.

[0016] Conventional chain driven systems and also other hub gearing systems require lubrication in order to operate at peak efficiency possible. The systems are very sensitive to suboptimal lubrication which leads to regular maintenance requirements that are an operational overhead as well as a cost. Furthermore, new chains only become efficient after a 'break in' period that removes friction inefficiencies resulting from manufacturing processes. They then need to be regularly cleaned at short intervals or significant inefficiencies are introduced.

[0017] Chain driven derailleur and also hub planetary gearing systems are subject to high wear rates between the two metallic surfaces interacting, i.e. either the steel chain and the teeth on a sprocket or chain ring, or the planetary gear sprockets in a hub. This reduces part life cycles and means the entire drive train needs regular replacement in order to provide efficient power transfer.

[0018] The above discussion of the background art is intended to facilitate an understanding of the present invention only. While the discussion focusses on transmission systems of bicycles, it would be readily understood that similar problems exist in transmission systems used in other applications.

SUMMARY OF INVENTION

[0019] It is an object of this invention to provide a pulley and a transmission system comprising the pulley which ameliorates, mitigates or overcomes, at least one disadvantage of the prior art, or which will at least provide the public with a practical choice.

[0020] While the invention has been shown and described with particular reference to a bicycle, the invention is equally applicable in many other applications. For example the invention has application in most cable/chain/belt/pulley driven systems which currently use different gear ratios to achieve a particular outcome. These other applications include, but are not limited to transmission systems in vehicles, motorcycles, lawn mowers, quadbikes, pumps, generators, manufacturing equipment including cnc machines, and other industrial mobile equipment, as well as fixed cable/belt driven machinery. These other applications, as well as those which would be obvious to the person skilled in the art, are considered to be included in the scope of the invention as defined herein.

[0021] Throughout the specification the term 'cable' is used to describe a rope, a belt, a chain, webbing or any other rope-like device which may be used to assist in transmitting force from a pulley to another object. Furthermore the term 'cable' can denote a single unitary cable, or a cable made from many smaller cables entwined, joined in an end to end arrangement or otherwise formed to provide a substantially unitary member.

[0022] The present invention provides a transmission system, the transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the first pulley input causes movement of the first pulley, the first pulley comprising:

- a first side assembly spaced from a second side assembly, the first side assembly and second side assembly are rotatably fixed together;

- a variable annular recess defined between the first side assembly and the second side assembly, the annular recess being adapted to receive the cable;

- each of the first side assembly and the second side assembly providing a support surface for supporting the cable, the support surface is laterally movable between a first position and a second position, the first position being spaced outwardly from the second position, the support surface of the first side assembly and the support surface of the second side assembly co-operate to engage the cable when the support surface of each side assembly is

in the second position, whereupon the cable moves from a first diameter to be supported at a second diameter;

at least one actuator apparatus for moving each support surface between the first position and the second position;

a movement mechanism comprising a biasing means, the biasing means applies a constant force or near constant force to each of the at least one actuator apparatus, the movement mechanism being reactive to the force exerted thereon by the cable;

wherein the width of the first pulley remains constant as the support surface moves between the first diameter and the second diameter, and vice versa.

[0023] Preferably the at least one actuator apparatus moves radially relative to the first side assembly and the second side assembly.

[0024] The at least one actuator apparatus may move radially relative to an axis of rotation of the first pulley.

[0025] The at least one actuator apparatus may be variably positioned along a radial extent of the first pulley.

[0026] Preferably the at least one actuator apparatus comprising a first actuator and a second actuator connected therebetween by a bridge member.

[0027] Preferably the first actuator co-operates with the support surface of the first side assembly and the second actuator simultaneously co-operates with the support surface of the second side assembly to move each support surface between the first position and the second position.

[0028] The bridge member maintains the first actuator and the second actuator in a fixed relation. This ensures each support surface, when engaged by the at least one actuator apparatus, is held in position by the at least one actuator apparatus and not caused to move laterally outward due to the force exerted thereon by the cable.

[0029] At least one or both of the first actuator and the second actuator provides a first guide means to cause the support surface to move to the second position. The first guide means may comprise a first guide surface which engages the support surface.

[0030] At least one or both of the first actuator and the second actuator provide a second guide means to guide the support surface to the first position. The second guide means may comprise a second guide surface which causes the support surface to move to the first position. The second guide surface may comprise an actuator channel which cooperates with a portion of the support surface to cause the support surface to move to the first position.

[0031] The pulley may comprise a control means to control the movement of the at least one actuator apparatus. The control means may constrain the at least one actuator apparatus such that the at least one actuator apparatus is limited to radial movement relative to each side assembly.

[0032] The control means may comprise at least one support channel which engages the at least one actuator apparatus to limit movement along the at least one support channel. The at least one support channel may extend in a radial direction relative to each side assembly such that the at least one actuator apparatus is limited to radial movement relative to each side assembly. The at least one actuator apparatus may be variably positioned along the radial extent.

[0033] The control means may comprise a support housing which supports the at least one actuator apparatus. The support housing may comprise a backing plate and the movement mechanism. In one embodiment the backing plate may be located at a position between the support surface and the movement mechanism. The backing plate may support the support surface and the movement mechanism. The backing plate may have a central hub adapted to receive a shaft or axle.

[0034] The backing plate may incorporate the at least one support channel for restricting the movement of the at least one actuator apparatus to a radial direction. The at least one support channel may extend from the hub radially outward. The at least one support channel may be closed at an end near the hub and open at an end distal the centre of the backing plate. Alternatively the at least one support channel may be open at an end near the hub and closed at an end distal the centre of the backing plate. The open end assists with assembly of the first pulley. The opening may have a closure to prevent the at least one actuator apparatus from departing the at least one support channel.

[0035] The movement mechanism may cause the at least one actuator apparatus to move along the radial extent.

[0036] The movement mechanism may be reactive to the force exerted thereon by the cable. In this regard the first pulley will react to ensure the tension in the cable is maintained. If the tension in the cable was to decrease the movement mechanism will cause the first pulley to support the cable at a larger diameter. If the tension in the cable was to increase the movement mechanism will cause the first pulley to support the cable at a smaller diameter.

[0037] When there is no tension exerted on the first pulley by the cable (or there is no cable fitted thereto) the movement mechanism may cause the first pulley to be in a normal condition wherein the first pulley is at its largest diameter. Preferably the first pulley is biased to its normal condition.

[0038] The movement mechanism may bias each of the at least one actuator apparatus to an outer position.

[0039] Preferably the biasing means applies a constant force or near constant force to each of the at least one actuator apparatus regardless of the radial position of the at least one actuator apparatus.

[0040] The movement mechanism may further comprise a set of lever arms to transfer the force of the biasing means to each of the at least one actuator apparatus. The number of lever arms required may depend on the number of the at least one actuator apparatus. The number of lever arms required may depend on the biasing means selected.

[0041] The set of lever arms may comprise one or more first lever arms and one or more second lever arms.

[0042] In another aspect of the invention the movement mechanism comprises a plurality of biasing mechanisms. Preferably each side assembly has a number of biasing mechanisms such that the number of biasing mechanisms on the first side assembly is equal to the number of biasing mechanisms on the second side assembly. Each biasing mechanism comprises a biasing means in the form of at least one spring, and a set of lever arms preferably comprising a first lever arm and two second lever arms.

[0043] The first lever arms may transfer the force from the biasing means to one or more second lever arms. The second lever arms may have a first end rotatably secured to the at least one actuator apparatus such that movement of the first end of the second lever arm causes movement of the at least one actuator apparatus along the at least one support channel.

[0044] The one or more first lever arms may have a first end connected directly or indirectly to the biasing means, and a second end connected directly or indirectly to a second end of the one or more second lever arms.

[0045] Preferably the movement mechanism further comprises a ring rotatably secured to the backing plate. The ring may be coaxially positioned in proximity to a central hub of the backing plate. The second end of the one or more first lever arms may be rotatably secured to the ring. The second end of the one or more second lever arms may also be rotatably secured to the ring. Preferably the second end of each of the lever arms is secured at a different angular position to each other.

[0046] The biasing means may be in the form of one or a plurality of springs. The springs may be variable force springs. Alternatively, the springs may be fixed force springs. The springs may be supported around the outer periphery of the backing plates. Each spring may have an end which is connected to the first end of one of the first lever arms. Preferably a linkage assembly connects the first end of the first lever arm to the end of the spring.

[0047] In an alternative embodiment the biasing means may be provided by one or more magnets, hydraulics or any system/device which would provide a biasing force, as would be understood by the person skilled in the art.

[0048] The end of the at least one actuator apparatus may provide a spigot, wherein the first end of the one or more second lever arms may be rotatably secured thereto.

[0049] In one aspect of the invention the support surface comprises a plurality of support segments arranged in a circular configuration wherein the overall appearance of each support segment is that of a truncated pie segment. The number of support segments may depend on the diameter of the pulley.

[0050] Each support segment comprises a plurality of support surface units. One or more of the support surface units define the support surface. Considering a single support segment, each support surface unit is stacked one on top of the other wherein, in one embodiment, the support surface unit positioned closest to the rotational axis of the pulley is the smallest inner support surface unit, with each support surface unit thereafter increasing in length.

[0051] Preferably each support surface unit is restricted to axial movement relative to adjacent support surface units. Each support surface unit may be configured to prevent tangential movement between adjacent support surface units. Each support surface unit may have a spline arrangement therebetween, wherein the spline arrangement prevents tangential movement between adjacent support surface units.

[0052] Each support surface unit may comprise a limiting mechanism to limit axial movement between adjacent support surface units. The limiting mechanism may prevent axial movement of each support surface unit beyond a certain distance from the central plane of the first pulley. The limiting mechanism may comprise a projection incorporated in each support surface unit wherein the projection is adapted to co-operate with a recess in an adjacent support surface unit. The limiting mechanism at least maintains the support surface units in the second position until the at least one actuator apparatus allows the support surface unit to move back to the first position.

[0053] In another aspect of the invention each support surface comprises a plurality of support surface units. Each unit is independently movable between the first position and the second position. Each unit is restricted to movement between the first position and the second position.

[0054] Each support unit is adapted to co-operatively engage the at least one actuator apparatus wherein the at least one actuator apparatus causes each support unit to move between the first position and the second position.

[0055] Preferably the at least one actuator apparatus engages the support surface units to cause the support surface unit to move between the first position and the second position as the at least one actuator apparatus moves radially outward along the at least one support channel.

Preferably the first guide surface of the at least one actuator apparatus engages the one or more support surface units.

[0056] Preferably the at least one actuator apparatus engages one or more support surface units to cause the support surface unit to move between the second position and the first position as the at least one actuator apparatus moves radially inward along the at least one support channel. Preferably the second guide surface of the at least one actuator apparatus engages the one or more support surface units.

[0057] The present invention further provides a transmission system, the transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

- a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

- an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley at a first diameter;

- each of the first side assembly and second side assembly comprising a support surface comprising a plurality of independently mounted support surface units adapted to engage the cable, each support surface unit being laterally movable between at least a first position, wherein the cable is at a first diameter, and a second position, wherein the cable is at a second diameter, the second position being spaced inwardly from the first position;

- a movement mechanism comprising a biasing means, the biasing means applies a constant force or near constant force to each of a plurality of actuator apparatus, the movement mechanism being reactive to the force exerted thereon by the cable.

[0058] The present invention further provides a transmission system, the transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

- a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

- an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

- each of the first side assembly and second side assembly comprising a support surface, the support surface is laterally movable, the support surface is selectively movable between at least a first position and a second position, the second position being spaced inwardly from

the first position, wherein all or any part of the support surface can be in the first position or the second position, the support surface being adapted to engage the cable wherein when the entire support surface of each side assembly is in the first position the cable is supported at a first diameter of the first pulley, when the entire support surface of each side assembly is in the second position the cable is supported at a second diameter, when a first portion of the support surface of each side assembly is in the first position, and a second portion of the support surface is in the second position the cable is supported on the first pulley which is at a third diameter, the third diameter being a diameter between the first diameter and the second diameter;

wherein the first pulley reacts to the movement of the support surface of the second pulley, the first pulley comprising a biasing means which biases the support surface of the first pulley to be at its largest diameter when the cable is at the smallest diameter on the second pulley or when the cable is not present.

[0059] The support surface may be selectively positioned such that the third diameter is any sized diameter between the first diameter and the second diameter.

[0060] The first diameter may be the largest diameter possible for the first pulley.

[0061] The second diameter may be the smallest diameter possible for the first pulley.

[0062] The movement of the support surface of the first side assembly between the first position and second position may be just after or just before the movement of the support surface of the second side assembly between the first position and second position.

[0063] The support surface may comprise a plurality of support surface units, each support surface unit being laterally movable between at least a first position and a second position. The first side assembly may be connected to the second side assembly. The plurality of support surface units may co-operate to provide the support surface whereby selective movement of the support surface units causes the cable to transition to be positioned between different diameters of the first pulley.

[0064] The first side assembly and the second side assembly may be co-axially mounted.

[0065] Preferably during movement of each of the support surface units from the first position to the second position the cable is supported on the first pulley which is presenting a constantly increasing diameter.

[0066] Preferably during movement of each of the support surface units from the second position to the first position the cable is supported on the first pulley which is presenting a constantly decreasing diameter.

[0067] Preferably the support surface comprises a plurality of support surface segments wherein each support surface segment provides one or more support surface units. The support

surface segments may take the shape of a pie segment, such that the combined configuration of the plurality of support surface segments is circular.

[0068] Each support surface unit provides at least one contact surface adapted to engage the cable. Each contact surface extends laterally from the support surface unit in a generally central direction. That is to say that each contact surface of each support surface unit extends towards a central plane of the first pulley wherein the central plane is substantially perpendicular to the first pulley's axis of rotation.

[0069] Preferably the contact surfaces of the first side assembly are offset from corresponding contact surfaces of the second side assembly.

[0070] The contact surfaces of the first side assembly may be offset from corresponding contact surfaces of the second side assembly such that the contact surfaces of the first side assembly may be at a different diameter/radial position to corresponding contact surfaces of the second side assembly.

[0071] The contact surfaces of the first side assembly may be offset from corresponding contact surfaces of the second side assembly such that when the contact surfaces of the first side assembly are in the second position and the contact surfaces of the second side assembly are in the second position, the contact surfaces overlap.

[0072] Preferably movement of each of the support surface units to the second position causes a portion of the contact surface of the first side assembly to be received between radially adjacent contact surfaces of the second side assembly. With this arrangement the support surface units effectively mesh together to provide a substantially continuous recess for supporting the cable.

[0073] The first pulley may provide a support cradle for supporting the cable when the cable is at a position corresponding to the smallest possible diameter of the first pulley.

[0074] In one aspect of the invention the support cradle is fixed. The support cradle may be in the form of one or more support surface units fixed in the second position.

[0075] In another aspect of the invention the support cradle may be movable. The support cradle may be provided by the innermost support surface units wherein the innermost support surface units are prevented from moving to their first position, instead being movable between an intermediate position and the second position, the intermediate position being between the first position and the second position. The backing plate may also comprise a cradle portion which forms part of the support cradle.

[0076] The cable may connect the first pulley and the input. The cable may extend between the first pulley and the input such that the cable loops partially around the first pulley and partially around the input.

[0077] The cable may be in the form of a continuous belt which frictionally engages the first pulley. The cross section of the belt may be V-shaped, and may be truncated.

[0078] The cable may have a face which is adapted to be supported by the support surface of each of the first side assembly and second side assembly, wherein the cross section of the belt is V-shaped, and may be truncated. Preferably at least 50% of the vee-shaped face is supported by the support surface. Preferably at least 75% of the vee-shaped face is supported by the support surface. Preferably at least 80% of the vee-shaped face is supported by the support surface. Preferably at least 85% of the vee-shaped face is supported by the support surface.

[0079] The belt may comprise a plurality of wedge shaped segments depending from a belt portion. Preferably the cross sectional profile of the belt changes between a tensioned state wherein the profile represents a narrow V-shape, and a relaxed state wherein the profile represents a broader V-shape. The belt may adopt the tensioned state when it spans between the pulley and the output. The belt may adopt the relaxed state when the belt engages the pulley and when the belt engages the output. When the belt is in the relaxed state the broader V-shaped cross section presents a greater surface area to engage the annular recess of the pulley, and the output. In this regard the V-shape complements the annular recess. When in the tensioned state the narrower V-shape presents a reduced surface area such that the cross section is narrower than the cross section of the annular recess. As a result the belt does not engage with the pulley until further around the pulley, and disengages from the pulley earlier than if the belt only had one state. This configuration reduces friction losses encountered at the transition of the belt engaging and disengaging from the pulley.

[0080] In one aspect of the invention the frictional forces between the belt and the pulley are the same when considered from all directions.

[0081] In another aspect of the invention the ratio of the friction between the belt and the pulley in the belt driving direction to the friction between the belt and the pulley in a direction at or near normal to the driving direction is as high as possible, being higher than 1:1, in that the driving direction friction is lower than the normal friction. When friction between the belt and the pulley in the belt driven direction is high, and the friction between the belt and the pulley in a direction normal to the driven direction is low, power transmission is possible without belt slip. It also allows for improved shifting of gearing to overcome non-drive directional friction between belt and pulley.

[0082] In one aspect of the invention the surface of the belt and/or the surface of the pulley may comprise surface irregularities such as projections and/or knurls, to increase friction between the belt and the pulley.

[0083] In another aspect of the invention the surface of the belt and/or the surface of the pulley may comprise surface irregularities such as projections, knurls, grooves, and/or patterns to assist in increasing the ratio of the friction between the belt and the pulley in the belt driving direction to the friction between the belt and the pulley in a direction at or near normal to the driving direction.

[0084] The cable may be in the form of a composite material. The cable may have a core. The core may be formed from a non-yielding material such as aramid or carbon fibre. While the core is flexible the length of the core, once formed into the belt, does not significantly yield.

[0085] Preferably the input is in the form of a second pulley. The second pulley may generally be larger than the first pulley. However, it is to be understood that it could also have a smaller diameter. The second pulley may have similar elements to those of the first pulley. The second pulley may comprise a first side assembly and a second side assembly spaced from each other, the first side assembly being connected to the second side assembly such that the first side assembly and second side assembly are co-axially mounted. Preferably each of the first side assembly and second side assembly of the second pulley comprise a support surface.

[0086] In one aspect of the invention the second pulley comprises an activation means to cause movement of the support surface units of each side assembly between the first position and the second position. Using the activation means the second pulley controls the position of the cable, effectively determining the gearing of the transmission system. Preferably the first pulley reacts to the movement of the at least one ring of each side assembly of the second pulley. In this regard the first pulley is a passive pulley.

[0087] The first pulley has a biasing means which biases the support surface of the first pulley to be at its largest diameter when the cable is at the smallest diameter on the second pulley (or when the cable is not present).

[0088] The biasing means may comprise a plurality of springs which interact with a set of lever arms to reactively move the support surface units between the first position and the second position.

[0089] The biasing means may allow at least one actuator apparatus to move the support surface units between the first position and the second position. The at least one actuator apparatus may comprises a first actuator head and a second actuator head held in fixed relation. Each actuator head may provide the at least one guide means.

[0090] The at least one guide means may be in the form of a first guide means and a second guide means. The first guide means may cause the support surface to move to the second position. The first guide means may comprise a first guide surface which engages each support surface unit of the support surface.

[0091] The second guide means may guide the support surface to the first position. The second guide means may comprise a second guide surface which causes the support surface to move to the first position. The second guide surface may comprise an actuator channel which cooperates with a portion of each support surface unit to cause the support surface to move to the first position.

[0092] The first pulley may comprise a control means to control the movement of the at least one actuator apparatus. The control means may constrain the at least one actuator apparatus such that the at least one actuator apparatus is limited to radial movement relative to each side assembly.

[0093] Preferably the transmission system is arranged such that as the second pulley moves from the first diameter to the second diameter, the first pulley moves from the second diameter to the first diameter. As the belt is fixed in length, the belt must move relative to the first pulley in order to compensate for movement of the belt relative to the second pulley. Therefore, as the belt is positioned to rotate about the larger second diameter of the second pulley, the belt is caused to move to rotate about the smaller first diameter of the first pulley or vice versa.

[0094] The present invention further provides a transmission system, the transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

each of the first side assembly and second side assembly comprising a support surface provided by a plurality of rings wherein the rings on the first side assembly are at different diameters to the rings on the second side assembly, and the rings on the second side assembly have an offset corresponding ring on the first side assembly wherein corresponding rings move between at least a first position and a second position, the second position being spaced inwardly from the first position, corresponding rings being adapted to engage the cable wherein when the corresponding rings are in the second position the cable is supported by the first pulley at a different diameter to the diameter defined by the adjacent corresponding rings, each ring comprises a plurality of support surface units, each support surface unit of each ring being independently movable by at least one actuator apparatus.

[0095] The present invention provides a transmission system, the transmission system comprising a first pulley connected to an input by a cable such that movement of the input causes rotation of the first pulley, the first pulley comprising:

an annular recess between a first side of the first pulley and a second side of the first pulley, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

a pair of support surfaces located in the annular recess, the pair of support surfaces being moveable in a lateral direction relative to the sides of the pulley between a spaced condition, wherein the first pulley is at a first diameter and the pair of support surfaces do not engage the cable, and a meshed condition, wherein the first pulley is at a second diameter and the pair of support surfaces support the cable, the second diameter being larger than the first diameter.

[0096] The present invention provides a variable diameter pulley, the pulley comprising:

an annular recess for receiving a cable such that the cable is supported by the pulley at a first diameter of the pulley;

a pair of support surfaces located in the annular recess, the pair of support surfaces being moveable in a lateral direction between a spaced condition, wherein the pair of support surfaces do not engage the cable, and a meshed condition, wherein the pair of support surfaces support the cable at a second diameter of the pulley, the second diameter being larger than the first diameter;

wherein the pulley comprises a biasing means to bias the pulley to present the largest diameter.

[0097] The present invention provides a variable diameter pulley, the pulley comprising:

an annular recess adapted to receive a cable at a first diameter of the pulley;

the annular recess providing a support surface for supporting the cable when received therein, the support surface being movable to present the first diameter and a second diameter;

wherein the support surface is positionable to present any diameter between the first diameter and the second diameter;

wherein the pulley comprises a biasing means to bias the pulley to present the largest diameter...

[0098] Preferably the thickness of the pulley remains constant as the pulley moves between the first diameter and the second diameter.

[0099] Preferably the support surface presents a substantially continuous surface to the cable when received on the pulley. The cross sectional profile of the support surface may be complementary to the cross sectional shape of that portion of the cable which engages the support surface so that the cable is retained in the annular recess.

[00100] Preferably as the support surface moves between the first diameter and the second diameter, the cable, when supported thereon, remains in the same radial plane.

[00101] Preferably the support surface is formed from a first set of support surface units and a second set of support surface units.

[00102] The first set of support surface units and the second set of support surface units may mesh together or overlap with each other to form the support surface.

[00103] The first set of support surface units and the second set of support surface units may be moveable in a lateral direction between a spaced condition, wherein the cable may be supported at the first diameter of the pulley, and a meshed condition, wherein the cable may be supported at the second diameter of the pulley, whereby during movement of the set of support surface units between conditions the cable may be supported on the support surface which is presenting a changing diameter.

[00104] Circumferentially adjacent support surface units may define a ring. Each ring may not be continuous. Preferably a gap is defined between adjacent support surface units of the same ring.

[00105] Each ring of the first set of support surface units has a complementary ring of the second set of support surface units, whereby complementary rings are in a staggered relation to each other to provide a ring pair. Meshing of each ring pair provides the support surface for engaging the cable.

[00106] Each ring pair may move between a first position and a second position.

[00107] In the first position the complementary rings of a ring pair may be spaced away from each other in the axial/lateral direction. In this position the cable cannot be supported by the ring pair.

[00108] In the second position the complementary rings of the ring pair may be in the meshed condition to provide the support surface. In this position the cable is supported by the ring pair.

[00109] Each ring pair may move to a third position which is between the first position and the second position.

[00110] Each ring of support surface units may be arranged so that as a ring approaches the second position the adjacent upper/outer ring thereto commences moving towards the second position.

[00111] Each ring of each set of support surface units may be arranged so that as a ring approaches the first position the adjacent lower/inner ring thereto commences its movement towards the first position.

[00112] Each support surface unit may be wedge shaped to provide a sloped contact surface which engages the cable.

[00113] The pulley may comprise a first side housing for housing the first set of support surface units.

[00114] The pulley may comprise a second side housing for housing the second set of support surface units.

[00115] The first side housing and the second side housing may be co-axially mounted with respect to each other to define the annular recess therebetween.

[00116] The pulley may comprise a biasing means to bias the pulley to present the largest diameter. In this regard the biasing force of the biasing means must be overcome before the pulley is able to move to a smaller diameter. Once this force is removed the pulley will return to present its largest diameter as a result of the biasing means. In this regard the pulley is passive/reactionary in that it reacts to forces exerted thereon.

[00117] The pulley may comprise a plurality of actuator apparatus. Each actuator apparatus may be movable in a radial direction between a first position, central of the pulley and a second position, adjacent the outer diameter of the pulley. Each actuator apparatus may have at least one head adapted to cause movement of the support surface units as each actuator apparatus moves between positions. Preferably each actuator apparatus has a first head, adapted to cause movement of the support surface units of the first side assembly, and a second head, adapted to cause movement of the support surface units of the second side assembly as each actuator apparatus moves between positions.

[00118] The first head and second head may be interconnected by a bridge extending therebetween such that they are held in fixed relation to each other.

[00119] Each actuator apparatus is supported in corresponding channels in the first side housing and second side housing. The plurality of actuator apparatus may be spaced from each other radially in a spider web type arrangement.

[00120] As the first head and second head of the actuator apparatus move from their first position radially outward towards their second position they cause the support surface units to successively move from their first position to their second position.

[00121] Preferably as and after the heads of each actuator apparatus successively engages each support surface unit when moving in a radially outward direction each support surface unit moves to its second position.

[00122] Preferably as and after the heads of each actuator apparatus successively pass each support surface unit when moving in a radially inward direction each support surface unit moves back to its first position.

[00123] Preferably the biasing means comprises a plurality of springs which interact with a set of lever arms. Preferably, the plurality of springs interacts with the lever arms to bias each of the actuator apparatus towards their outmost position such that when the biasing force of the biasing means is greater than the force acting on the support surface units the pulley presents its largest diameter, When the force exerted thereon is greater than the force of the biasing means the pulley presents a smaller diameter.

[00124] The present invention provides a transmission system, the transmission system comprising a variable diameter pulley as herein before described connected to an input by a belt.

BRIEF DESCRIPTION OF THE DRAWINGS

[00125] Further features of the present invention are more fully described in the following description of a non-limiting embodiment thereof. This description is included solely for the purposes of exemplifying the present invention. It should not be understood as a restriction on the broad summary, disclosure or description of the invention as set out above. The description will be made with reference to the accompanying drawings in which:

[00126] Figure 1 is a perspective view of a rear pulley assembly of a transmission system of a bicycle according to a first embodiment of the invention;

[00127] Figure 2 is a side view of the rear pulley of figure 1;

[00128] Figures 3, 4, 5 are a series of exploded views of figure 1;

[00129] Figure 6 is a cross sectional end view of figure 1 taken through a central plane

[00130] Figure 7 is a perspective view of the rear pulley of figure 1 with a side assembly removed;

[00131] Figure 8 is a side view of figure 7;

[00132] Figure 9 is a perspective view of a backing plate of the rear pulley shown in figure 1;

[00133] Figure 10 (a, b, c) are various views of a support surface unit segments of the rear pulley shown in figure 1;

[00134] Figure 11 is a side view of a plurality of support surface units with a plurality of actuator apparatus of the rear pulley shown in figure 1;

[00135] Figure 12 is a perspective view of figure 11;

[00136] Figure 13 (a, b, c) are various views of one of the support surface units shown in figures 10 to 12;

[00137] Figure 14 (a,b) are enlarged views of one support surface unit engaging an adjacent support surface unit;

[00138] Figures 15 (a to d) are various views of one of the support surface units according to an alternate embodiment to those shown in fig 13;

[00139] Figure 16 (a, b) are views of an actuator apparatus;

[00140] Figure 17 is a perspective view of a portion of a biasing means of the rear pulley shown in figure 1;

[00141] Figure 18 is a view similar to figure 17 with the backing plate;

[00142] Figure 19 is a perspective view of different portions of the biasing means of the rear pulley shown in figure 1 with the backing plate;

[00143] Figure 20 is a perspective view of different portions of the biasing means of the rear pulley shown in figure 1 with the backing plate

[00144] Figure 21 is a perspective view of the biasing means of the rear pulley shown in figure 1 interacting with the plurality of actuator apparatus;

[00145] Figure 22 is a view similar to figure 21 with the backing plate;

[00146] Figure 23 is a side perspective view of the rear pulley of figure 1 wherein the orientation of the biasing means relates to the pulley at its largest diameter;

[00147] Figure 24 is a view similar to figure 23 showing a portion of the biasing means with the backing plate;

[00148] Figure 25 is a side perspective view of the rear pulley of figure 1 wherein the orientation of the biasing means relates to the pulley at a diameter between its largest and smallest diameters;

[00149] Figure 26 is a view similar to figure 25 showing a portion of the biasing means with the backing plate;

[00150] Figure 27 is a side perspective view of the rear pulley of figure 1 wherein the orientation of the biasing means relates to the pulley at its smallest diameter;

[00151] Figure 28 is a view similar to figure 27 showing a portion of the biasing means with the backing plate;

[00152] Figure 29 is a cross sectional perspective view of the rear pulley of figure 1 without the biasing means taken through a vertical plane, the rear pulley presenting the smallest diameter;

[00153] Figure 30 is a schematic view of the upper section of figure 29 with the actuator apparatus shown;

[00154] Figure 31 is a view similar to figure 30 but with the actuator apparatus partially shown;

[00155] Figure 32 is a schematic representation of the transmission system of the first embodiment when at the smallest/lowest gear ratio (one side of each pulley being removed for illustrative purposes);

[00156] Figure 33 is a schematic representations of a section of the rear pulley showing the position of the plurality of support surface units of the pulley of figure 1 when supporting the cable at its lowermost position, representing the smallest diameter;

[00157] Figures 34 to 38 are schematic representations of a section of the rear pulley showing the change in position of the plurality of support surface units as the actuator apparatus moves outwardly relative to the central region of the first pulley; and

[00158] Figures 39 and 40 are schematic representations of the transmission system (one side of each pulley being removed for illustrative purposes – fig 39) and a section of the first pulley (fig 40) showing the change in position of the plurality of support surface units as the actuator apparatus is at its outermost position relative to the central region of the rear pulley to represent the largest diameter.

[00159] Figure 41 is a perspective view of a backing plate according to an alternate embodiment;

[00160] Figure 42 is a close up view of a portion of figure 41; and

[00161] Figure 43 is a cross-sectional view of support surface units interacting with the backing plate shown in figure 41.

DESCRIPTION OF EMBODIMENTS

[00162] The present invention according to a first embodiment of the invention, as depicted in the figures, is in the form of a transmission system 12 comprising a first pulley in the form of a rear variable diameter pulley 11. The pulley 11 is particularly adapted for use with a transmission system which functions in a similar/same manner as a continuously variable transmission (CVT).

[00163] As will be highlighted in the below discussion, a difference between the present invention and CVT's of the prior art is that the pulley of the present invention is configured to maintain a relatively narrow gauge. This enables the pulley and associated transmission system to be used in applications which have minimal space to accommodate a transmission system, such as, for example, bicycles including conventional bicycles, e-bicycles and pedelecs.

[00164] Previous CVT's comprise relatively thick front and/or rear pulley arrangements which could not be readily utilised in applications which have limited space to house the pulley arrangement. For example, prior art CVTs could not be applied to bicycles as it would impede the pedal action and/or required a wide rear axle, not provide a sufficient range in gear ratios, place significant stress on the chain and/or are too heavy. The relatively narrow pulley of the

present invention provides the transmission system with a practical and efficient drive train geometry. When applied to a bicycle the thickness of the pulley of the present invention is similar to or narrower than the thickness of a rear cassette of sprockets or hub gearing system of a conventional geared bicycle.

[00165] The present invention also allows the diameter of the pulley to be increased with minimal or no change in the width of the pulley. This provides for a large range of gear ratios. This further enhances the vast array of applications the present invention is suited.

[00166] The below embodiment discusses the present invention as applied to a bicycle. However, there are many more applications in other types of driven equipment. These include applications in vehicles, lawnmowers, motorised scooters, quad-bikes, snowmobiles, mobile or industrial equipment such as generators, pumps, conveyors and chainsaws. Other applications as would be understood by the person skilled in the art are considered to be within the scope of this invention.

[00167] In the present embodiment the pulley 11 is adapted to be positioned on the rear wheel of a bicycle. The rear pulley 11 has a central hub 13. As best shown in figure 1 the central hub 13 has a plurality of ribs 15. As shown in figure 2, the hub 13 receives an axle 21 of the bicycle (not shown) wherein the axle 21 has a set of complementary ribs to those in the hub 13 such that the rear pulley is rotatably fixed relative to the bicycle when fitted thereto.

[00168] The pulley 11 comprises a first side assembly 17 and a second side assembly 19. The first side assembly 17 and the second side assembly 19 are co-axially mounted.

[00169] The first side assembly 17 and the second side assembly 19 are spaced a distance from each other such that when the pulley 11 is assembled the first side assembly 17 and second side assembly 19 define an annular recess 25 therebetween. The annular recess 25 being adapted to receive a cable in the form of a v-shaped belt 40, as best shown in figure 33.

[00170] Each side assembly 17, 19 comprise a backing plate 29 and a support surface 31. As the configuration of the second side assembly 19 is largely identical to that of the first side assembly 17 only one of the side assemblies is described below. For ease of reference, similar components of the side assemblies are suffixed with 'a' when associated with the first side assembly 17, and are suffixed with 'b' when associated with the second side assembly 19.

[00171] As best shown in figure 6, the annular recess 25 is defined by the first side assembly 17, the second side assembly 19 and the support surface 31. The support surface 31 is moveable in a lateral direction between a first/spaced condition, wherein the support surface 31 does not engage the belt 40, and a second/meshed condition, wherein the support surface 31 supports the belt 40.

[00172] Each support surface 31 comprises a plurality of support surface units 33. When arranged the support surface units 33 are in a circular configuration divided into a plurality of

support surface segments 35. Each support surface segment 35 has a gap 37 therebetween for reasons which will be described below.

[00173] As shown in figure 10, each support surface segment 35 comprises a set of the plurality of support surface units 33 arranged to be one on top of the other. In this embodiment each support surface segment 35 comprises one support surface unit 33 stacked on another support surface unit 33. In other embodiments each support surface segment 35 may have two or more support surface units 33 in a side by side relation, with one or more support surface segments 35 stacked thereon.

[00174] Each support surface unit 33 provides a contact surface 39 which, when in position extends at a sloped orientation towards a central plane of the pulley. The contact surface 39 co-operates with the contact surface 39 of other support surface units 33 to provide the support surface 31 which directly engages and supports a cable in the form of a v-shaped belt 40, as will be described in further detail below.

[00175] An upper surface 41 of each support surface unit 33 is shaped to engage a complementary shape in a lower surface 43 of the adjacent support surface unit 33. As shown in figures 13 and 14 the complementary shape of the upper surface 41 and the adjacent lower surface 43 provide a spline type arrangement 45 whereby movement of adjacent support surface units 33 is restricted by the spline arrangement 45 to lateral movement with respect to each other, as depicted by arrow 'A' in figure 10(b).

[00176] In one arrangement the lower surface 43 of each innermost support surface unit 33c also engages with the backing plate 29a, 29b in the spline arrangement 45 to restrict lateral movement with respect to each other. Similarly the upper surface 41 of each outermost support surface units 33d engages with the backing plate 29 in the spline arrangement 45 to restrict lateral movement with respect to each other. (The splines on the backing plate 29 are not shown).

[00177] In another arrangement, as shown in figures 41, 42 and 43 the support channels 183 in the backing plate 129 are closed at the outermost end and open at the innermost end. On the section of the backing plate 129 between each support channel 183 there is provided a rib 130. Each rib 130 co-operates with an indent 134 on the rear of each support surface unit 33. As shown in figure 43, the rib 130 is received in each indent 134 to prevent lateral movement of the support surface unit 33 relative to the backing plate 129.

[00178] In this embodiment the backing plate 129 also comprises an annular spacer (not shown) which is adapted to fit between the inner surface 138 of the outer periphery 140 of the backing plate 129, and the upper surface 41 of the outermost support surface units 33d. The spacer is adapted to adjustably co-operate with a plurality of apertures 136 in the outer periphery of the backing plate 129, such as with screws, to adjust the distance between the

spacer and the inner surface 138 of the outer periphery 140. This adjustability enables the support surface units 33 to be held firmly in place relative to the backing plate 129..

[00179] The lower surface 43 of each support surface unit 33 also comprises a projection 47. While each upper surface 41 comprises an indent 49 for receiving the projection 47 of the adjacent support surface unit 33. As best shown in figures 13 and 114 the projection 47 and indent 49 are located at a position distal from the contact surface 39. When adjacent support surface units 33 are in a second position, the projection 47 is received in the indent 49 of the adjacent support surface unit 33. Figure 14 illustrates two adjacent support surface units coming together wherein the projection 47 of one support surface unit 33 is being received in the indent 49 of an adjacent support surface unit. The cooperation of the projection 47 and the indent 49 restricts the lateral movement of the lower support surface unit 33 such that the lower adjacent support surface unit 33 cannot return to a first position. Before the support surface unit 33 can return to the first position, the upper adjacent support surface unit 33 must first commence its return journey to the first position.

[00180] Each support surface unit 33 has a pin 51 at each end. The pin 51 is used to move the support surface unit 33 between the first position and the second position as described below.

[00181] Each support surface unit 33 also has a guide surface 53 at each end. The guide surface 53 is located between the pin 51 and the contact surface 39. In this embodiment the guide surface 53 is parallel to the contact surface 39.

[00182] Each support surface unit 33 is arcuate in shape whereby support surface units 33 in adjacent support surface segments 35 at the same diameter define a ring, the ring being discontinuous as a result of gaps 37.

[00183] The pin 51 is utilised to move the support surface unit 33 between the first position and the second position as described below.

[00184] The guide surface 53 is utilised to move the support surface unit 33 between the first position and the second position as described below.

[00185] Figure 15 shows an alternate support surface unit 133 to that shown in figures 10 to 14. The alternate support surface unit 133 still have a spline type arrangement 145 but has less splines in its upper surface 141 and therefore requires less spline receiving recesses in its lower surface 143. The alternate support surface unit 133 also incorporates two projections 147 in its upper surface 141 as well as corresponding indents 149 in its lower surface 143. These provide the same limitation to lateral movement as the support surface unit 33, as described above.

[00186] The pulley 11 also comprises a movement mechanism which provides a biasing force to the first pulley 11 such that the support surface 31 is biased to, or towards the largest diameter.

[00187] The first pulley 11 also comprises a plurality of actuator apparatus 59 and a control means to controls the movement of each actuator apparatus 59. Each actuator apparatus 59 is movable in a radial direction in relation to the pulley 11. When each actuator apparatus 59 moves radially outward, the support surface 31 is caused to move from the first position to the second position. When each actuator apparatus 59 moves radially inward, the support surface 31 is caused to move from the second position to the first position. The position of the actuator apparatus 59 is dependent on the force exerted on the first pulley 11 by the belt. If the force is less than that provided by the movement mechanism then the movement mechanism retains each of the at least one apparatus 59 at their most outward position relative to the backing plate 29a, 29b. In this position the first pulley 11 presents its largest diameter.

[00188] When the force exerted on the first pulley 11 is greater than the force of the movement mechanism each of the at least one apparatus 59 move inwardly. As this occurs the diameter of the first pulley 11 decreases. The extent to which each of the at least one apparatus 59 travels to their most inward position, and therefore the extent of the decrease in diameter the first pulley presents, will depend on the size of the force exerted on the first pulley 11 through the belt 40.

[00189] As best shown in figure 16 each actuator apparatus 59 comprises a first head 61a and a second head 61b which are held in spaced relation by a bridge 63 extending therebetween.

[00190] Each head 61a, 61b provide a first guide means 65 to cause the support surface units 33 to move to the second position. The first guide means 65 comprises a first guide surface 67 which is adapted to glidingly engage the guide surface 53 of each support surface unit 33.

[00191] Each head 61a, 61b also provides a second guide means 69 to guide the support surface 31 to the first position. The second guide means 69 comprises a second guide surface 71 on each side of the head 61a, 61b which engages the pin 51 of each support surface unit 33 to move it to the first position. The second guide surface 71 is in the form of an actuator channel 73 which receives and cooperates with the pin 51 of the support surface unit 33 to move the support surface 31 to the first position.

[00192] The actuator channel 73 has a first opening 75 in an upper part of the head 61a, 61b which is of a sufficient width to receive the pin 51. As each actuator apparatus 59 moves radially outward, the pin 51 of each side of the support surface unit 33 is received in the respective first opening 75. Further outward movement of the actuator apparatus 59 results in the first guide surface 67 of the actuator apparatus 59 engaging the guide surface 53 of each support surface unit 33. At this point the support surface unit 33 is caused to move towards its second position. As the support surface unit 33 begins to move towards its second position the pin 51 traces along the second guide surface 71 which, in this embodiment is in the form of a sloped wall. Once the support surface unit 33 has reached its second position the pin 51 enters a second opening 77.

[00193] In order to move the support surface unit 33 from the second position to the first position the actuator apparatus 59 is caused to move radially downward. As the actuator apparatus 59 approaches the support surface unit 33, the pin 51 is received in the second opening 77. Further downward movement of the actuator apparatus 59 results in the pin engaging the sloped wall of the second guide surface 71. This forces the support surface unit 33 to move from the second position to the first position. Once the actuator apparatus 59 has moved sufficiently downward so that the support surface unit 33 is in the first position, the pin 51 exits the actuator channel 53 through the first opening 75.

[00194] The control means also comprises a plurality of support channels 83 which restricts movement of the plurality of actuator apparatus 59 to movement in the radial direction. The plurality of support channels 83 are formed in each backing plate 29a, 29b, as best shown in figure 9. Each end of each actuator apparatus 59 is positioned in its respective support channel 83 such that the backing plate 29 is received between the side of the actuator head 61 and the lever arms 115, 117.

[00195] In the present embodiment the movement mechanism comprises a plurality of biasing mechanisms 111. In this embodiment each side assembly 17, 19 has three biasing mechanisms 111, as shown in figures 1 to 5. The number of biasing mechanisms 111 required is dependent on the size of the pulley and the force which will be exerted thereupon.

[00196] Each biasing mechanism 111 comprises the biasing means in the form of a spring 113, a linkage assembly 114 and a set of lever arms. The set of lever arms comprises a first lever arm 115 and two second lever arms 117.

[00197] The spring 113 is a variable force spring and is supported at the outer periphery of the backing plate 29. The spring 113 has an end connected to the linkage assembly 114 and another end connected to a post 121 extending from the backing plate 29. The linkage assembly 114 is also rotatably connected to a first end 119 of the first lever arm 115. The linkage assembly 114 transfers movement of the spring 113 to the first lever arm 115 and vice versa.

[00198] The movement mechanism also comprises a ring 123 which is coaxially mounted relative to the backing plate 29 such that the ring 123 is rotatably movable relative to the backing plate 29.

[00199] As shown in figures 17 and 18 the first lever arm has a second end 120 which is rotatably secured to the ring 123.

[00200] As shown in figure 21, each second lever arm 117 has a first end 125 rotatably secured to one of the plurality of actuator apparatus 59. Each second lever arm 117 also has a second end 126 rotatably secured to the ring 123

[00201] In operation the force of the spring acts on the set of lever arms to influence the position of each of the actuator apparatus 59, and therefore the position of the support surface 31 and the diameter the first pulley 11 presents.

[00202] When the force exerted on the first pulley 11 is equal to or less than the force of the movement mechanism, as provided by the springs 113, the pulley presents the largest diameter. This configuration can be considered the normal condition of the first pulley 11 and is the condition the pulley 11 presents when there is no force exerted thereon.

[00203] In this condition the set of lever arms holds each of the actuator apparatus 59 in their most outward position relative to the backing plate 29, this is best shown in figures 23 and 24.

[00204] When the force exerted by the belt 40 on the pulley 11 is greater than the biasing force of the movement mechanism, the belt 40 causes the diameter of the support surface 31 to decrease. In particular, the belt forces the support surface units 33 to move outwardly away from the central plane of the pulley 11. This causes each actuator apparatus 59 to move radially inward towards the central hub 13 of the pulley 11.

[00205] As represented in figures 26 and 27 the inward movement of the actuator apparatus 59 causes the ring 123 to rotate via the transfer of motion by each second lever arm 117. The rotation of the ring 123 causes the first lever arm 115 to move to expand the springs 113 via the linkage assembly 114.

[00206] If the force exerted on the first pulley reaches a point which is equal to the biasing force of the movement mechanism, the diameter of the support will be maintained.

[00207] If the force exerted on the first pulley remains greater than the biasing force of the movement mechanism, the diameter of the support surface 31 will continue to decrease. If the exerted force remains greater, then the diameter of the support surface 31 will continue to decrease until the smallest diameter is reached, as represented in figures 27 and 28. In this arrangement the actuator apparatus 59 are at their most innermost position being adjacent to the hub 13. Furthermore, each spring 113 is at its maximum expansion, taking into account the structural limitations of the pulley 11.

[00208] When the force exerted by the belt on the pulley decreases the reverse happens allowing the diameter of the support surface to increase. When this happens the spring 113 of the movement mechanism contracts to move the set of levers in a manner which causes each of the actuator apparatus 59 to return towards their outermost position. This causes the support surface unit 33 to sequentially move towards their innermost position.

[00209] When considering the plurality of support surface units 33 which are in a circumferentially adjacent arrangement, the adjacent support surface units 33 are in a circular configuration having gaps 37 located therebetween. Each support surface unit 33 is movable in a lateral direction relative to its side assembly 17, 19, between the first position, wherein the

support surface unit 33 is adjacent the backing plate 29a, 29b, and the second position wherein the support surface unit 33 is spaced away from the backing plate 29a, 29b.

[00210] The support surface units 33 are arranged so that support surface units 33a on one side are offset relative to the corresponding support surface units 33b on the other side. In this arrangement the support surface units overlap, when in the second position, to provide the support surface 31 to support a minimum of approximately 75% of the belt 40.

[00211] As shown in figure 31, the first pulley 11 comprises a support cradle 95 for supporting the belt 40 when the belt 40 is at a position corresponding to the smallest possible diameter of the first pulley 11. The support cradle 95 is in the form of support surface units 33c closest to the central axis of the pulley 11 and a cradle portion 101 of the backing plate. When the belt 40 is supported by the support cradle 95 the remaining support surface units are in their first position and the belt 40 is supported by the pulley 11 at the systems smallest diameter.

[00212] The belt 40 can be supported by the pulley at any diameter between the smallest diameter and the largest diameter and is dependent on the force exerted on the pulley which determines the position of the actuator apparatus 59.

[00213] The first variable diameter pulley 11 can be combined with a second variable diameter pulley 211 to complete the transmission system 12. As can be noted in the figures, the belt 40, which is a continuous loop, extends between the two pulleys 11, 211 to transfer movement between the pulleys 11, 211.

[00214] The first pulley 11 acts as a slave pulley whereby it reacts to changes of the second pulley 211. In this embodiment the second pulley 211 is a larger version of the first pulley 11.

[00215] Owing to the configuration of the plurality of support surface units 33 the pulley presents a substantially continuous support surface to the belt 40 as the belt 40 moves relative to the pulley 11 between the smallest diameter and the largest diameter. In the present embodiment approximately 75% of the belt 40 is supported the plurality of support surface units 33 at any one time.

[00216] Figures 32 to 40 show various schematic views of the transmission system. The transmission system 12 comprises the first variable diameter pulley 11, and the second variable diameter 211 interconnected by the belt 40. The various views show the belt 40 at various positions of the transmission system 12 wherein the various positions correspond to various gear positions of a conventional bicycle chain driven derailleur system.

[00217] Referring to figures 32 to 34, the transmission system 12 is shown at a position relating to the largest/highest gear ratio wherein the actuator apparatus 59 are at their innermost position, whereby the first guide surface 67 of each actuator head 61a, 61b engages the guide surface 53 of the support surface unit 33. In this position the innermost support surface units 33a of the first side assembly 17 of the first pulley 11, and the innermost support surface units

33b of the second side assembly 19 of the first pulley 11 are each in their second position. When in this position the remaining support surface units 33 of the first pulley 11 are in their first position.

[00218] When the belt 40 is supported by the first pulley 11 in the smallest diameter, the belt 40 is supported by the second pulley 211 in the largest diameter. In this position the outermost support surface units 33 of the first side assembly 17 of the second pulley 211, and the outermost support surface units 33 of the second side assembly 19 of the second pulley 211 are each in their second position, with the remaining support surface units 33 also in their second position.

[00219] As the head 61a, 61b of the actuator apparatus 59 of the first pulley 11 moves outwardly the pin 51 of the next adjacent support surface unit 33 enters the first opening 75 of the actuator channel 73. Further outward movement causes the first guide surface 67 of the head 61a, 61b to engage the guide surface 53 of the support surface unit 33. At this point the support surface unit 33 starts to move towards its second position. Further outward movement of the actuator apparatus 59 will result in the support surface unit 33 reaching its second position. Once in this position the pin 51 is in alignment with, and able to exit the second opening 77 of the actuator channel 73, allowing the actuator apparatus 59 to continue its outward movement.

[00220] This sequence continues for subsequent adjacent support surface unit 33 as the actuator apparatus 59 are caused to move further outward.

[00221] Once the actuator apparatus 59 has passed the support surface unit, whereby the support surface unit 33 is in its second position, the projection 47 in the lower surface 43 of the support surface unit, aligns with and is received in the indent 49 of the upper surface 41 of the lower adjacent support surface unit. This retains the lower adjacent support surface unit in the second position until the actuator apparatus 59 returns inwardly and causes the upper adjacent support surface units to return to their first position. This co-operation ensures the support surface units remain in their second position and do not unintentionally return to their first position until caused to do so by the actuator apparatus 59.

[00222] Referring to figures 35 and 36, the transmission system 12 is shown at a first intermediary position. In these figures the actuator apparatus 59 have commenced movement in the radially outward direction. The support surface unit 33c on the right hand side has been allowed to move to the second position, while the support surface unit 33c on the left hand side has moved further towards its second position. This has caused the support surface 31 to move outwardly to a larger diameter, to continue to support the belt 40 as the force exerted thereby decreases.

[00223] Referring to figure 37, the transmission system 12 is shown at a second intermediary position. Referring to figure 38, the transmission system 12 is shown at a third intermediary position. In these sets of figures the transmission system 12 moves away from the largest/highest gear ratio. This occurs as the force exerted by the belt on the pulley decreases, allowing the movement mechanism 85 to move the actuator apparatus 59 outwardly towards their outermost position.

[00224] Referring to figures 39 and 40, the transmission system 12 is shown at a position relating to the smallest/lowest gear ratio wherein each actuator head 61a, 61b is at its the outermost position. This is also represented by figure 6 which shows each actuator apparatus 59 at their most outermost. In this position the first guide surface 67 of each actuator head 61a, 61b engages the guide surface 53 of the outermost support surface units 33d of each side assembly 17, 19. In this position all support surface units 33 are each in their second position to support the belt 40 at the largest diameter.

[00225] When the belt 40 is supported by the first pulley 11 in the largest diameter the configuration of the pulley ensures that the recess 25 which receives the belt limits the ability of the belt 40 to disengage from the pulley 11.

[00226] When the belt 40 is supported by the first pulley 11 in the largest diameter, the belt 40 is supported by the second pulley 211 in the smallest diameter, as shown in figure 39.

[00227] In this embodiment the second pulley 211 is a driver pulley which is actively caused to move to a new operative position. Any resulting change in tension in the belt 40 causes the first pulley 11 to react to support the belt 40 in a new position.

[00228] In reverse operation, the support surface units 33 of the first pulley 11 are caused to return to their first position. As the head 61a, 61b of the actuator apparatus 59 moves inwardly the pin 51 of the below adjacent support surface unit 33 enters the second opening 77 of the actuator channel 73. Further inward movement causes the pin 51 to engage the second guide surface 71. With further inward movement, the sloping face of the second guide surface 71 acts on the pin 51 to cause the support surface unit 33 to return to its first position. When the support surface unit 33 is in the first position the pin 51 aligns with the first opening 75 of the actuator channel 73 before exiting the actuator channel 73, allowing the actuator apparatus 59 to continue its inward movement.

[00229] This sequence continues for subsequent support surface unit 33 as the actuator apparatus 59 are caused to move further inward.

[00230] Similarly, the support surface units of the second pulley 211 are caused to move such that the belt 40 is supported at larger diameters.

[00231] As can be seen by the operation of the present embodiment, the transmission system 12 presents a substantially continuous support surface on both the first pulley 11 and the

second pulley 211 as the transmission system moves between the largest/highest gear ratio and the smallest/lowest gear ratio. Furthermore, the biasing means operates such that the actuator apparatus 59 may be positioned anywhere between their lowermost and outermost position (inclusive) and may be held in that position. As such the surface which supports the belt can be at any diameter between the largest diameter and smallest diameter.

[00232] Considering bicycles, prior art chain driven derailleur systems have been prone to mechanical malfunction or even failure. These include chains coming off sprockets or chain rings when bicycles are subject to shock (e.g. riders going through holes in the road or over edges) or excessively aggressive gear change events. At best these failures lead to considerable inconvenience, distortion of race results, or at worst it leads to rider injury.

[00233] The reason why this malfunction or failure is possible is due to the design and construction of prior art derailleur driven cassette and chain ring systems which do not physically force the chain to be retained in place. The present invention is designed such that it is relatively impossible for the belt to come off the rear or front pulley because no jockey wheels are in use and the edge perimeters of the pulleys physically constrain the belt under any load including shocks induced by road conditions. This increases the safety for the ride and, in competition, levels the playing field.

[00234] The present invention mitigates loss of power during gear ratio changes as it provides continuous power transmission during those gear ratio changes. This does not apply to derailleur systems or any other discrete gearing systems of prior art bicycles which suffer from loss of momentum during gear (chain ring or sprocket) changes

[00235] Loss of momentum is particularly significant for prior art derailleur systems when changing between chain rings requiring associated multiple sprocket (typically 3-4) changes in the cassette at the same time in order to avoid excessive gear ratio adjustments from the current setting.

[00236] The present embodiment can be activated by single trigger up or down shifting (using existing or dedicated handle bar mounted shifter hardware) on the front crank set. The rear wheel gearing adjusts automatically to the crank setting. Prior art derailleur drive trains require the rider to separately coordinate shifting of rear sprockets as well as front chain rings to achieve continuous gearing during up or down shifts which is not only inefficient as it leads to loss of momentum as between 3 and 4 gears have to be traversed when chain rings are changed, but it also places a strain on the riders in a state of fatigue or needing to respond to race situations without warning.

[00237] The present embodiment removes the manual coordination requirement of rear (cassette) and front (chain ring) changes making shifting much simpler. This is particularly desirable when riders are fatigued. The present embodiment also removes gear ratio duplication

which exists in all prior art chain ring and cassette combinations, thereby simplifying the system further.

[00238] The present embodiment eliminates the need for drivetrain lubrication which reduces maintenance and does not compromise drive efficiency.

[00239] The present embodiment also expands on the largest as well as the smallest gear ratios available from prior art derailleur systems.

[00240] As the present embodiment is continuously variable riders are no longer forced to use comparably energy sapping large gear steps inherent in prior art drive trains.

[00241] The efficiency of the present embodiment is superior to that of the prior art systems as traditional systems suffer from inefficiencies when using smallest sprockets and when using cross chain gear settings. The efficiency of the present embodiment ensures more rider energy input at the crank set arrive at the rear wheel.

[00242] Many of the abovementioned advantages of the present embodiment are also realised in one form or another in other applications/embodiments of the present invention. For example changing between gears is no longer associated with a loss of/drop in power as the gears change. The present invention allows for the smooth transition between gear ratios whereby the transfer of power is maintained at all times. It also allows gear changes at load.

[00243] The present invention provides a transmission system having one or more relatively narrow, fixed width, pulleys which are capable of being designed to have near unlimited gear ratios. This is in contrast to current variable diameter pulley systems which must increase in width as gear ratios increase.

[00244] Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[00245] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a”, “an” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprise”, “comprises,” “comprising,” “including,” and “having,” or variations thereof are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or

addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[00246] When an element or layer is referred to as being “on”, “engaged to”, “connected to” or “coupled to” another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly engaged to”, “directly connected to” or “directly coupled to” another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., “between” versus “directly between,” “adjacent” versus “directly adjacent,” etc.). As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[00247] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[00248] Spatially relative terms, such as “inner,” “outer,” “beneath”, “below”, “lower”, “above”, “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

Claims

1. A transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes movement of the first pulley, the first pulley comprising:

a first side assembly spaced from a second side assembly, the first side assembly and second side assembly are rotatably fixed together;

a variable annular recess defined between the first side assembly and the second side assembly, the annular recess being adapted to receive the cable;

each of the first side assembly and the second side assembly providing a support surface for supporting the cable, the support surface is laterally movable between a first position and a second position, the first position being spaced outwardly from the second position, the support surface of the first side assembly and the support surface of the second side assembly co-operate to engage the cable when the support surface of each side assembly is in the second position, whereupon the cable moves from a first diameter to be supported at a second diameter;

at least one actuator apparatus for moving each support surface between the first position and the second position;

a movement mechanism comprising a biasing means, the biasing means applies a constant force or near constant force to each of the at least one actuator apparatus, the movement mechanism being reactive to the force exerted thereon by the cable;

wherein the width of the first pulley remains constant as the support surface moves between the first diameter and the second diameter, and vice versa.

2. The transmission system according to claim 1 wherein the at least one actuator apparatus is variably positioned along a radial extent of the first pulley.

3. The transmission system according to claim 1 or 2 wherein the at least one actuator apparatus comprising a first actuator and a second actuator connected therebetween by a bridge member.

4. The transmission system according to claim 3 wherein the bridge member maintains the first actuator and the second actuator in a fixed relation.

5. The transmission system according to claims 3 or 4 wherein the first actuator co-operates with the support surface of the first side assembly and the second actuator simultaneously co-operates with the support surface of the second side assembly to move each support surface between the first position and the second position.

6. The transmission system according to claim 3, 4 or 5 wherein at least one or both of the first actuator and the second actuator provides a first guide means to cause the support surface

to move to the second position, the first guide means may comprise a first guide surface which engages the support surface.

7. The transmission system according to any one of claims 3 to 6 wherein at least one or both of the first actuator and the second actuator provide a second guide means to guide the support surface to the first position, the second guide means comprises a second guide surface which causes the support surface to move to the first position.

8. The transmission system according to claim 7 wherein the second guide surface comprises an actuator channel which cooperates with a portion of the support surface to cause the support surface to move to the first position.

9. The transmission system according to any one of claims 1 to 8 wherein the pulley comprises a control means to control the movement of the at least one actuator apparatus, wherein the control means constrains the at least one actuator apparatus such that the at least one actuator apparatus is limited to radial movement relative to each side assembly.

10. The transmission system according to claim 9 wherein the control means comprises at least one support channel which engages the at least one actuator apparatus to limit movement along the at least one support channel, the at least one support channel extends in a radial direction relative to each side assembly such that the at least one actuator apparatus is limited to radial movement relative to each side assembly the at least one actuator apparatus being variably positioned along the radial extent.

11. The transmission system according to claim 9 or 10 wherein the control means comprises a support housing which supports the at least one actuator apparatus, the support housing comprises a backing plate and the movement mechanism, the backing plate located at a position between the support surface and the movement mechanism, the backing plate supports the support surface and the movement mechanism.

12. The transmission system according to claim 11 wherein the backing plate has a central hub adapted to receive a shaft or axle.

13. The transmission system according to claim 11 or 12 wherein the backing plate incorporates the at least one support channel for restricting the movement of the at least one actuator apparatus to a radial direction, the at least one support channel extends from the hub radially outward.

14. The transmission system according to claim 13 wherein the at least one support channel is closed at an end near the hub, and open at an end distal the centre of the backing plate.

15. The transmission system according to claim 13 wherein the at least one support channel is open at an end near the hub and closed at an end distal the centre of the backing plate.
16. The transmission system according to claim 14 or 15 wherein the opening has a closure to prevent the at least one actuator apparatus from departing the at least one support channel.
17. The transmission system according to any one of claims 11 to 16 wherein the movement mechanism causes the at least one actuator apparatus to move along the radial extent the movement mechanism being reactive to the force exerted thereon by the cable.
18. The transmission system according to any one of claims 1 to 17 wherein the first pulley is biased to its normal condition.
19. The transmission system according to any one of claims 11 to 18 wherein the movement mechanism bias each of the at least one actuator apparatus to an outer position.
20. The transmission system according to claim 19 wherein the biasing means applies a constant force or near constant force to each of the at least one actuator apparatus regardless of the radial position of the at least one actuator apparatus.
21. The transmission system according to claim 20 wherein the movement mechanism further comprises a set of lever arms to transfer the force of the biasing means to each of the at least one actuator apparatus.
22. The transmission system according to claim 21 wherein the set of lever arms comprise one or more first lever arms and one or more second lever arms.
23. The transmission system according to claim 19 wherein the movement mechanism comprises a plurality of biasing mechanisms.
24. The transmission system according to claim 23 wherein each side assembly has a number of biasing mechanisms such that the number of biasing mechanisms on the first side assembly is equal to the number of biasing mechanisms on the second side assembly.
25. The transmission system according to claim 24 wherein each biasing mechanism comprises a biasing means in the form of at least one spring, and a set of lever arms, the set of lever arms comprising a first lever arm and two second lever arms.
26. The transmission system according to claim 25 wherein the first lever arms transfer the force from the biasing means to one or more second lever arms.
27. The transmission system according to claim 25 or 26 wherein the second lever arms have a first end rotatably secured to the at least one actuator apparatus such that movement of

the first end of the second lever arm causes movement of the at least one actuator apparatus along the at least one support channel.

28. The transmission system according to claim 25, 26 or 27 wherein the one or more first lever arms have a first end connected directly or indirectly to the biasing means, and a second end connected directly or indirectly to a second end of the one or more second lever arms.

29. The transmission system according to any one of claims 11 to 28 wherein the movement mechanism further comprises a ring rotatably secured to the backing plate, the ring is coaxially positioned in proximity to a central hub of the backing plate, the second end of the one or more first lever arms is rotatably secured to the ring, the second end of the one or more second lever arms is rotatably secured to the ring.

30. The transmission system according to claim 28 or 29 wherein the second end of each of the lever arms is secured at a different angular position to each other.

31. The transmission system according to any one of claims 25 to 30 wherein the biasing means is in the form of one or a plurality of springs, the springs are supported around the outer periphery of the backing plates, whereby each spring has an end connected to the first end of one of the first lever arms.

32. The transmission system according to claim 31 wherein a linkage assembly connects the first end of the first lever arm to the end of the spring.

33. The transmission system according to any one of claims 1 to 32 wherein the support surface comprises a plurality of support segments arranged in a circular configuration wherein the overall appearance of each support segment is that of a truncated pie segment.

34. The transmission system according to claim 33 wherein each support segment comprises a plurality of support surface units, whereby one or more of the support surface units define the support surface.

35. The transmission system according to claim 34 wherein each individual support segment has each support surface unit stacked one on top of the other wherein each support surface unit is restricted to axial movement relative to adjacent support surface units and is configured to prevent tangential movement between adjacent support surface units.

36. The transmission system according to claim 34 or 35 wherein the support surface unit comprise a limiting mechanism to limit axial movement between adjacent support surface units, the limiting mechanism prevents axial movement of each support surface unit beyond a certain distance from the central plane of the first pulley the limiting mechanism comprise a projection incorporated in each support surface unit wherein the projection is adapted to co-operate with a recess in an adjacent support surface unit the limiting mechanism at least maintains the support

surface units in the second position until the at least one actuator apparatus allows the support surface unit to move back to the first position.

37. The transmission system according to any one of claims 1 to 32 wherein each support surface comprises a plurality of support surface units each unit is independently movable between the first position and the second position, each unit is restricted to movement between the first position and the second position, each support unit is adapted to co-operatively engage the at least one actuator apparatus wherein the at least one actuator apparatus causes each support unit to move between the first position and the second position.

38. The transmission system according to claim 37 wherein the at least one actuator apparatus engages the support surface units to cause the support surface unit to move between the first position and the second position as the at least one actuator apparatus moves radially outward along the at least one support channel.

39. The transmission system according to claim 34 or 37 wherein the at least one actuator apparatus engages one or more support surface units to cause the support surface unit to move between the second position and the first position as the at least one actuator apparatus moves radially inward along the at least one support channel.

40. A transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley at a first diameter;

each of the first side assembly and second side assembly comprising a support surface comprising a plurality of independently mounted support surface units adapted to engage the cable, each support surface unit being laterally movable between at least a first position, wherein the cable is at a first diameter, and a second position, wherein the cable is at a second diameter, the second position being spaced inwardly from the first position;

a movement mechanism comprising a biasing means, the biasing means applies a constant force or near constant force to each of a plurality of actuator apparatus, the movement mechanism being reactive to the force exerted thereon by the cable.

41. A transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

each of the first side assembly and second side assembly comprising a support surface, the support surface is laterally movable, the support surface is selectively movable between at least a first position and a second position, the second position being spaced inwardly from the first position, wherein all or any part of the support surface can be in the first position or the second position, the support surface being adapted to engage the cable wherein when the entire support surface of each side assembly is in the first position the cable is supported at a first diameter of the first pulley, when the entire support surface of each side assembly is in the second position the cable is supported at a second diameter, when a first portion of the support surface of each side assembly is in the first position, and a second portion of the support surface is in the second position the cable is supported on the first pulley which is at a third diameter, the third diameter being a diameter between the first diameter and the second diameter;

wherein the first pulley reacts to the movement of the support surface of the second pulley, the first pulley comprising a biasing means which biases the support surface of the first pulley to be at its largest diameter when the cable is at the smallest diameter on the second pulley or when the cable is not present.

42. The transmission system according to claim 40 or 41 wherein the support surface is selectively positioned such that the third diameter is any sized diameter between the first diameter and the second diameter.

43. The transmission system according to claim 40, 41 or 42 wherein the support surface comprise a plurality of support surface units, each support surface unit being laterally movable between at least a first position and a second position the plurality of support surface units co-operate to provide the support surface whereby selective movement of the support surface units causes the cable to transition to be positioned between different diameters of the first pulley.

44. The transmission system according to claim 40, 41 or 42 wherein the support surface comprises a plurality of support surface segments wherein each support surface segment provides one or more support surface units, wherein each support surface unit provides at least one contact surface adapted to engage the cable, each contact surface extends laterally from the support surface unit in a generally central direction, the contact surfaces of the first side assembly are offset from corresponding contact surfaces of the second side assembly, such that the contact surfaces of the first side assembly may be at a different diameter/radial position to corresponding contact surfaces of the second side assembly, wherein when the contact

surfaces of the first side assembly are in the second position and the contact surfaces of the second side assembly are in the second position, the contact surfaces overlap.

45. The transmission system according to claim 44 wherein the movement of each of the support surface units to the second position causes a portion of the contact surface of the first side assembly to be received between radially adjacent contact surfaces of the second side assembly.

46. The transmission system according to any one of claims 1 to 45 wherein the cable extends between the first pulley and the input such that the cable loops partially around the first pulley and partially around the input.

47. The transmission system according to any one of the preceding claims wherein the input is in the form of a second pulley, the second pulley comprises a first side assembly and a second side assembly spaced from each other, the first side assembly being connected to the second side assembly such that the first side assembly and second side assembly are co-axially mounted, each of the first side assembly and second side assembly of the second pulley comprise a support surface.

48. The transmission system according to claim 47 wherein the second pulley comprises an activation means to cause movement of the support surface units of each side assembly between the first position and the second position.

49. The transmission system according to any one of claims 41 to 48 wherein the biasing means comprises a plurality of springs which interact with a set of lever arms to reactively move the support surface units between the first position and the second position.

50. The transmission system according to claim 49 wherein the biasing means allows an at least one actuator apparatus to move the support surface units between the first position and the second position.

51. The transmission system according to claim 50 wherein the at least one actuator apparatus comprises a first actuator head and a second actuator head held in fixed relation, each actuator head provides the at least one guide means, the at least one guide means is in the form of a first guide means and a second guide means the first guide means causes the support surface to move to the second position, the first guide means comprises a first guide surface which engages each support surface unit of the support surface, the second guide means guides the support surface to the first position, the second guide means may comprise a second guide surface which causes the support surface to move to the first position.

52. The transmission system according to claim 51 wherein the second guide surface comprises an actuator channel which cooperates with a portion of each support surface unit to cause the support surface to move to the first position.

53. The transmission system according to any one of claims 40 to 52 wherein the first pulley comprises a control means to control the movement of the at least one actuator apparatus the control means constrains the at least one actuator apparatus such that the at least one actuator apparatus is limited to radial movement relative to each side assembly.

54. The transmission system according to any one of claims 47 to 51 wherein the transmission system is arranged such that as the second pulley moves from the first diameter to the second diameter, the first pulley moves from the second diameter to the first diameter.

55. A transmission system comprising a first pulley and an input which is spaced therefrom, a cable extends between the first pulley and the input such that movement of the input causes rotation of the first pulley, the first pulley comprising:

a first side assembly and a second side assembly spaced from each other, the first side assembly and second side assembly are co-axially mounted and rotatably fixed together;

an annular recess between the first side assembly and second side assembly, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

each of the first side assembly and second side assembly comprising a support surface provided by a plurality of rings wherein the rings on the first side assembly are at different diameters to the rings on the second side assembly, and the rings on the second side assembly have an offset corresponding ring on the first side assembly wherein corresponding rings move between at least a first position and a second position, the second position being spaced inwardly from the first position, corresponding rings being adapted to engage the cable wherein when the corresponding rings are in the second position the cable is supported by the first pulley at a different diameter to the diameter defined by the adjacent corresponding rings, each ring comprises a plurality of support surface units, each support surface unit of each ring being independently movable by at least one actuator apparatus.

56. A transmission system comprising a first pulley connected to an input by a cable such that movement of the input causes rotation of the first pulley, the first pulley comprising:

an annular recess between a first side of the first pulley and a second side of the first pulley, the annular recess being adapted to receive the cable such that the cable is supported by the first pulley;

a pair of support surfaces located in the annular recess, the pair of support surfaces being moveable in a lateral direction relative to the sides of the pulley between a spaced condition, wherein the first pulley is at a first diameter and the pair of support surfaces do not engage the cable, and a meshed condition, wherein the first pulley is at a second diameter and the pair of support surfaces support the cable, the second diameter being larger than the first diameter.

57. A variable diameter pulley comprising:

an annular recess for receiving a cable such that the cable is supported by the pulley at a first diameter of the pulley;

a pair of support surfaces located in the annular recess, the pair of support surfaces being moveable in a lateral direction between a spaced condition, wherein the pair of support surfaces do not engage the cable, and a meshed condition, wherein the pair of support surfaces support the cable at a second diameter of the pulley, the second diameter being larger than the first diameter;

wherein the pulley comprises a biasing means to bias the pulley to present the largest diameter .

58. A variable diameter pulley comprising:

an annular recess adapted to receive a cable at a first diameter of the pulley;

the annular recess providing a support surface for supporting the cable when received therein, the support surface being movable to present the first diameter and a second diameter;

wherein the support surface is positionable to present any diameter between the first diameter and the second diameter;

wherein the pulley comprises a biasing means to bias the pulley to present the largest diameter.

wherein the thickness of the pulley remains constant as the pulley moves between the first diameter and the second diameter.

59. The pulley according to claim 57 or 58 wherein the support surface presents a substantially continuous surface to the cable when received on the pulley.

60. The pulley according to claims 57, 58, or 59 wherein the support surface is formed from a plurality of support surface units comprising a first set of support surface units and a second set of support surface units wherein the first set of support surface units and the second set of support surface units mesh together and/or overlap with each other to form the support surface.

61. The transmission system according to any one of claims 57 to 60 wherein the first set of support surface units and the second set of support surface units are moveable in a lateral direction between a spaced condition, wherein the cable is supported at the first diameter of the pulley, and a meshed condition, wherein the cable is supported at the second diameter of the pulley, whereby during movement of the set of support surface units between conditions the cable is supported on the support surface which is presenting a changing diameter.

62. The transmission system according to claim 60 or 61 wherein circumferentially adjacent support surface units define a discontinuous ring.
63. The transmission system according to claim 62 wherein a gap is defined between adjacent support surface units of the same ring.
64. The transmission system according to claim 62 or 63 wherein each ring of the first set of support surface units has a complementary ring of the second set of support surface units, whereby complementary rings are in a staggered relation to each other to provide a ring pair.
65. The transmission system according to claim 64 wherein each ring pair move between a first position and a second position, in the first position the complementary rings of a ring pair are spaced away from each other in the axial/lateral direction wherein the cable cannot be supported by the ring pair, in the second position the complementary rings of the ring pair are in the meshed condition to provide the support surface wherein the cable is supported by the ring pair.
66. The transmission system according to any one of claims 57 to 65 wherein the pulley comprises a plurality of actuator apparatus, each actuator apparatus is movable in a radial direction between a first position, central of the pulley and a second position, adjacent the outer diameter of the pulley, each actuator apparatus has at least one head adapted to cause movement of the support surface units as each actuator apparatus moves between positions.
67. The pulley according to claim 66 wherein each actuator apparatus has a first head, adapted to cause movement of the support surface units of the first side assembly, and a second head, adapted to cause movement of the support surface units of the second side assembly as each actuator apparatus moves between positions, the first head and second head are interconnected by a bridge extending therebetween such that they are held in fixed relation to each other.
68. The pulley according to any one of claims 66 to 67 wherein the biasing means comprises a plurality of springs which interact with a set of lever arms, the plurality of springs interacts with the lever arms to bias each of the actuator apparatus towards their outmost position such that when the biasing force of the biasing means is greater than the force acting on the support surface units the pulley presents its largest diameter, when the force exerted thereon is greater than the force of the biasing means the pulley presents a smaller diameter.
69. A transmission system comprising a variable diameter pulley according to any one of claims 57 to 68 connected to an input by a cable.

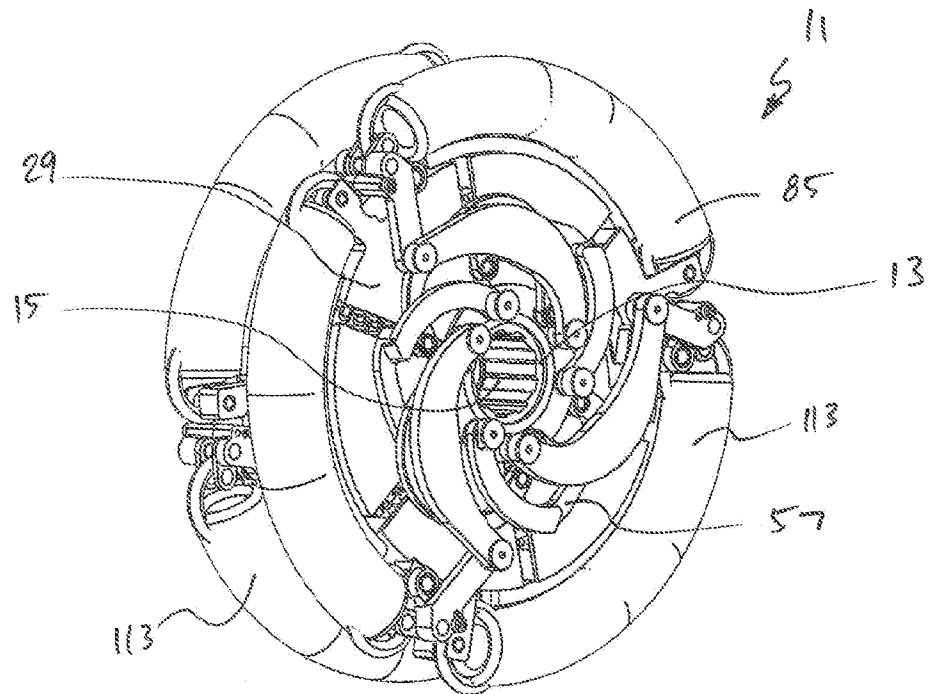


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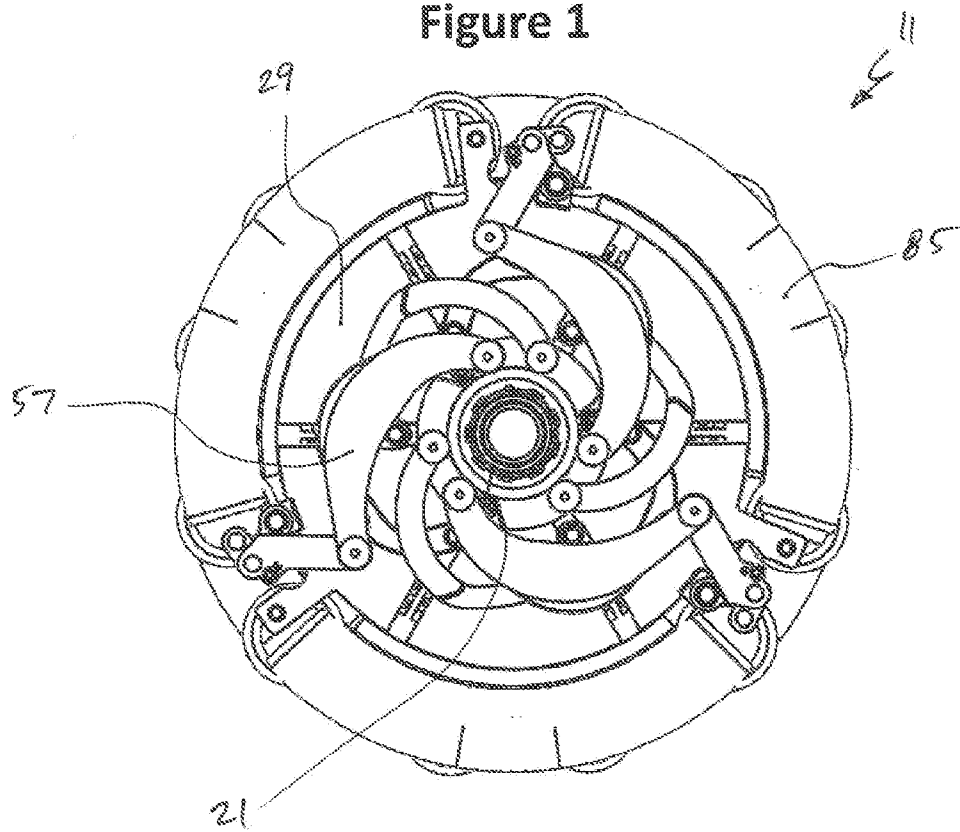


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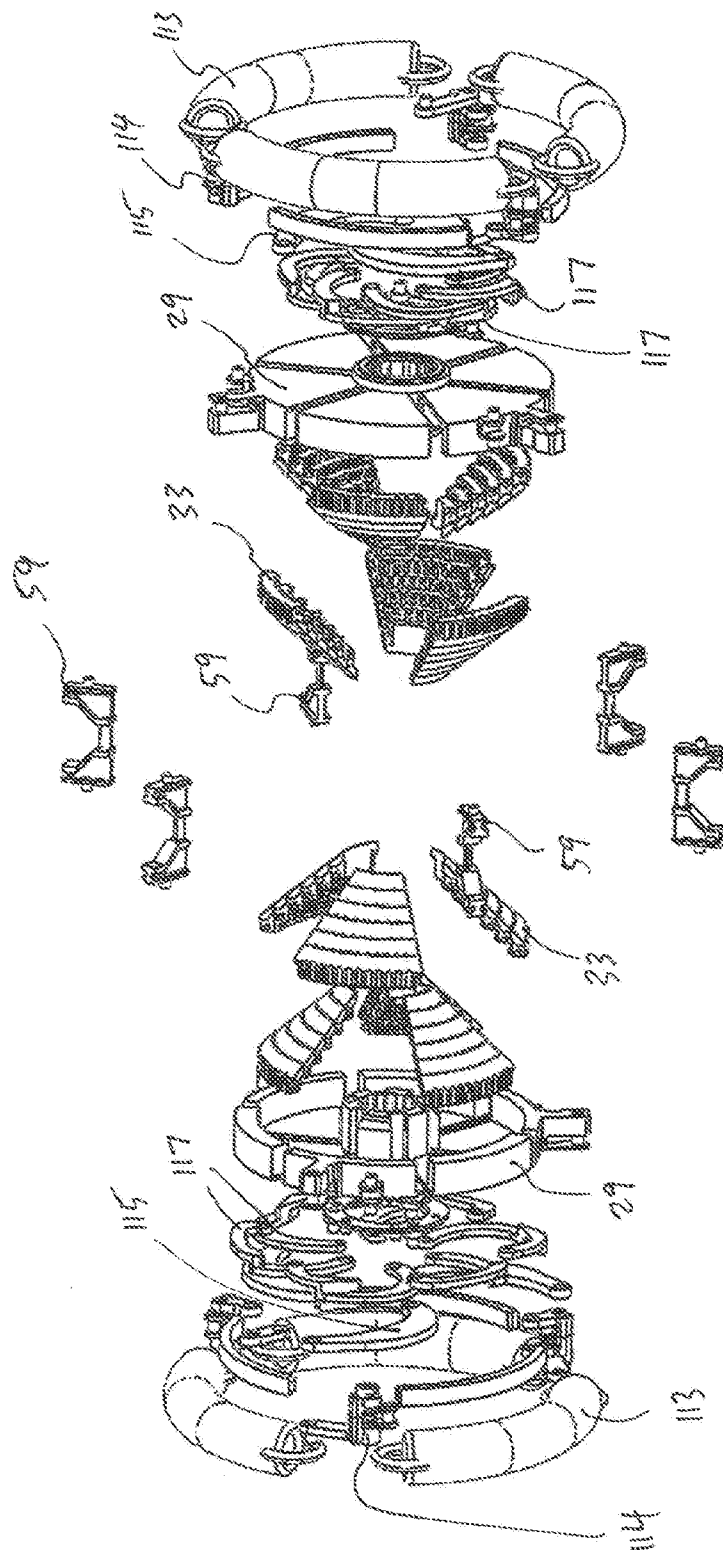


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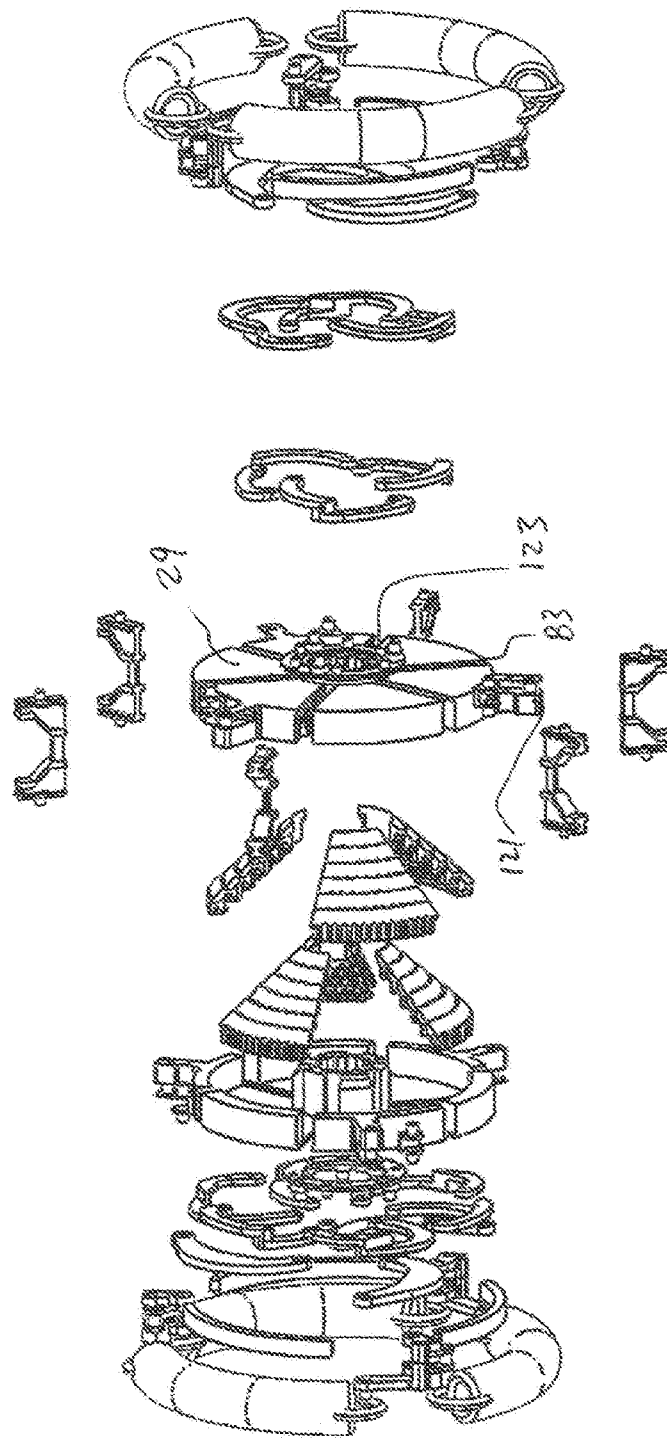


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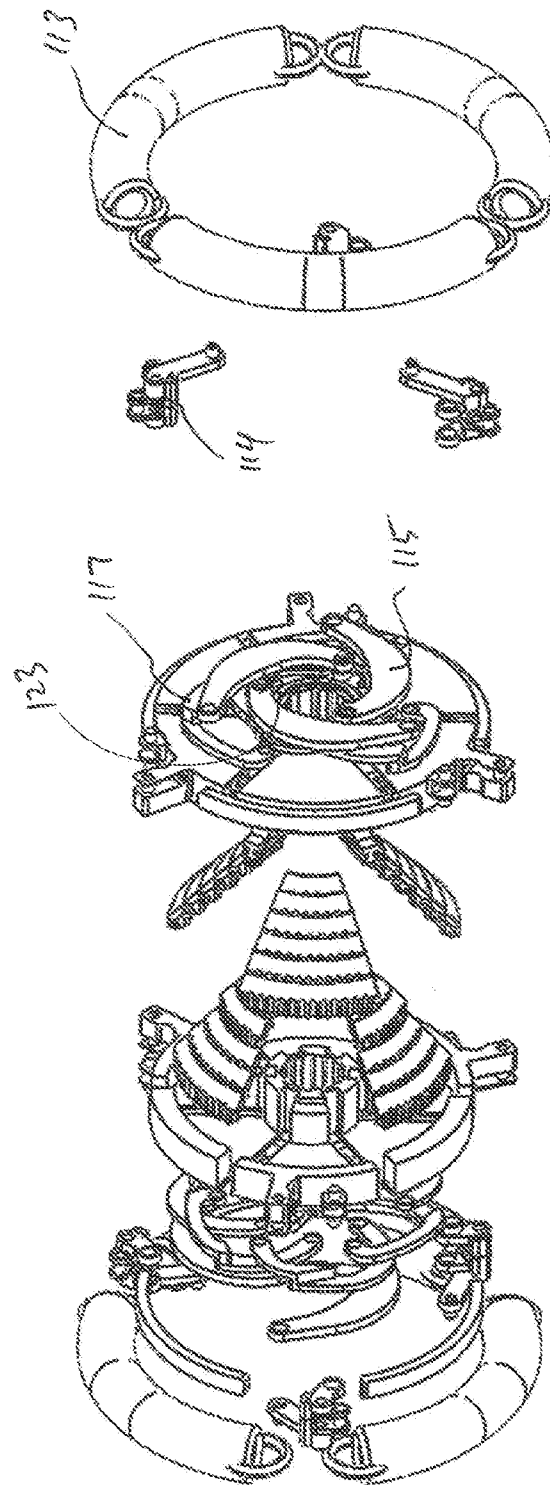


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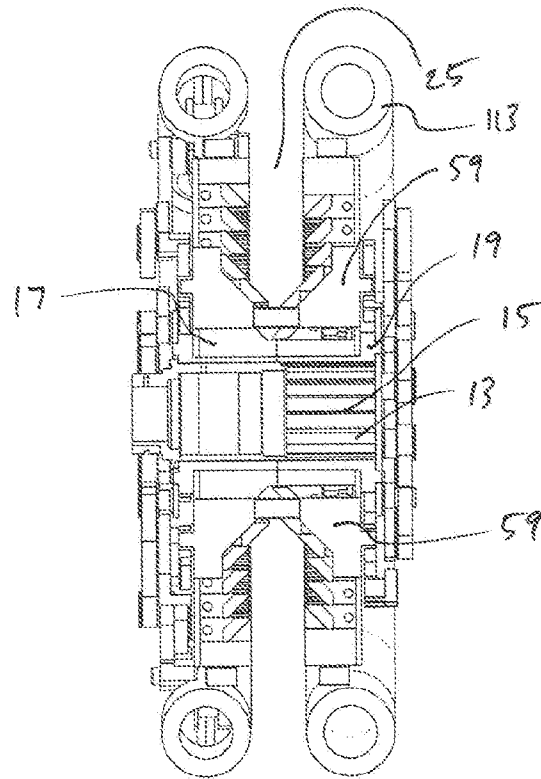


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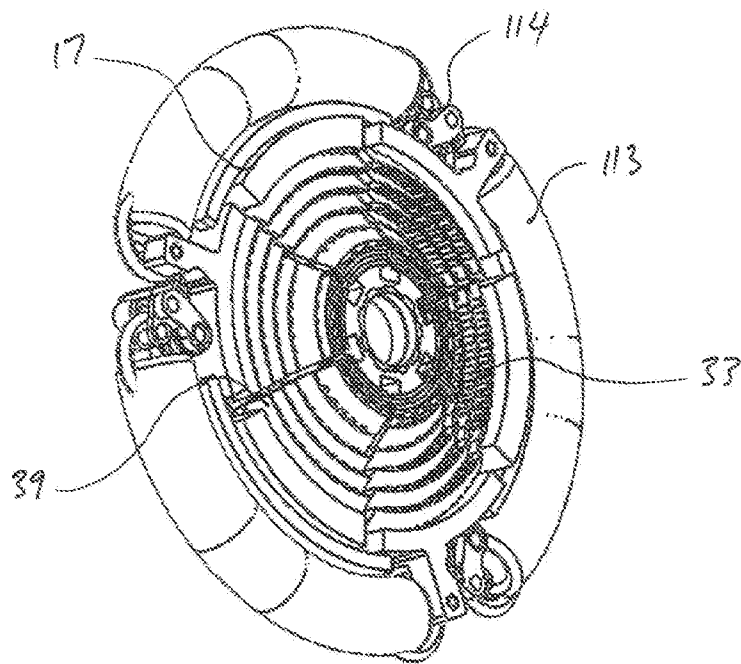


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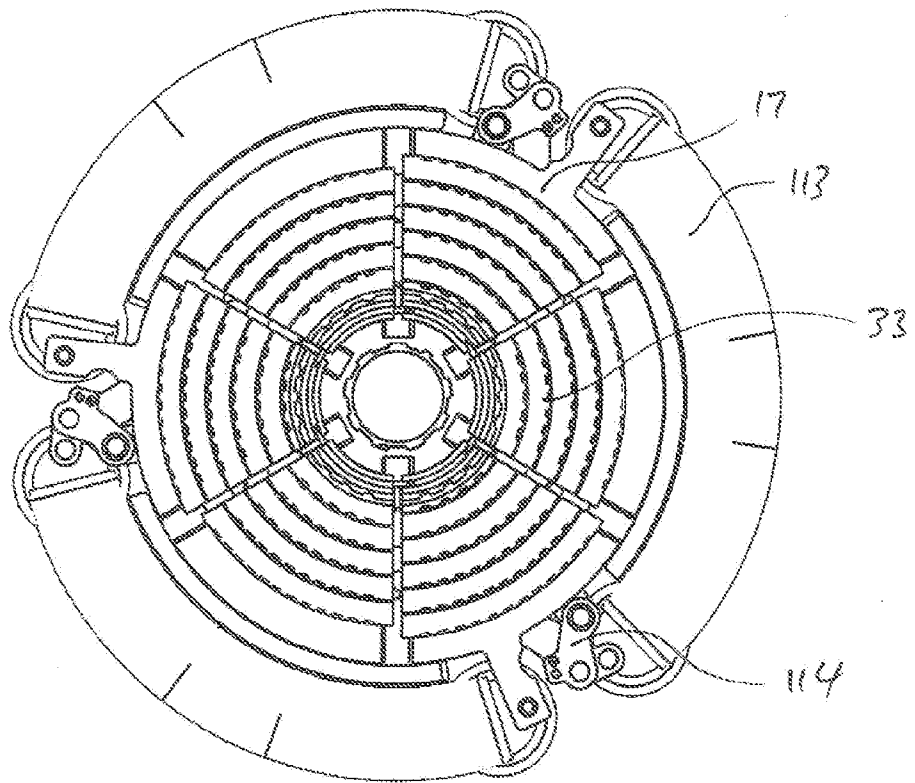


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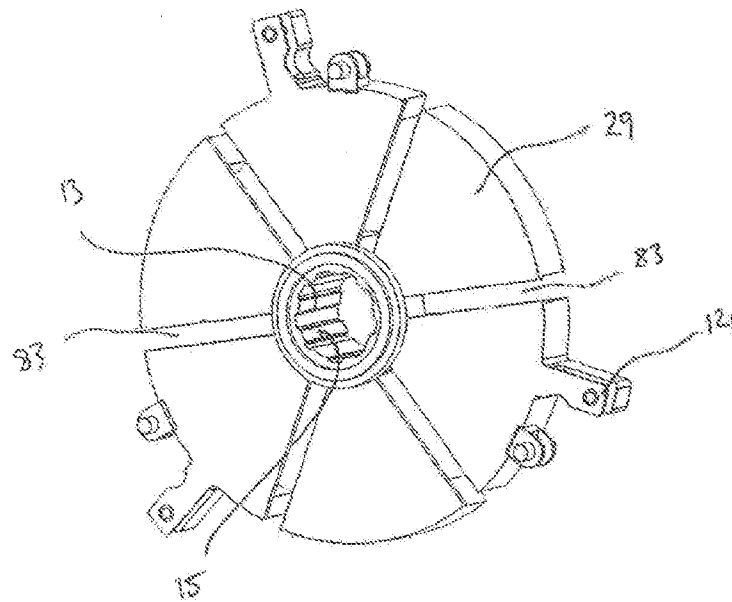


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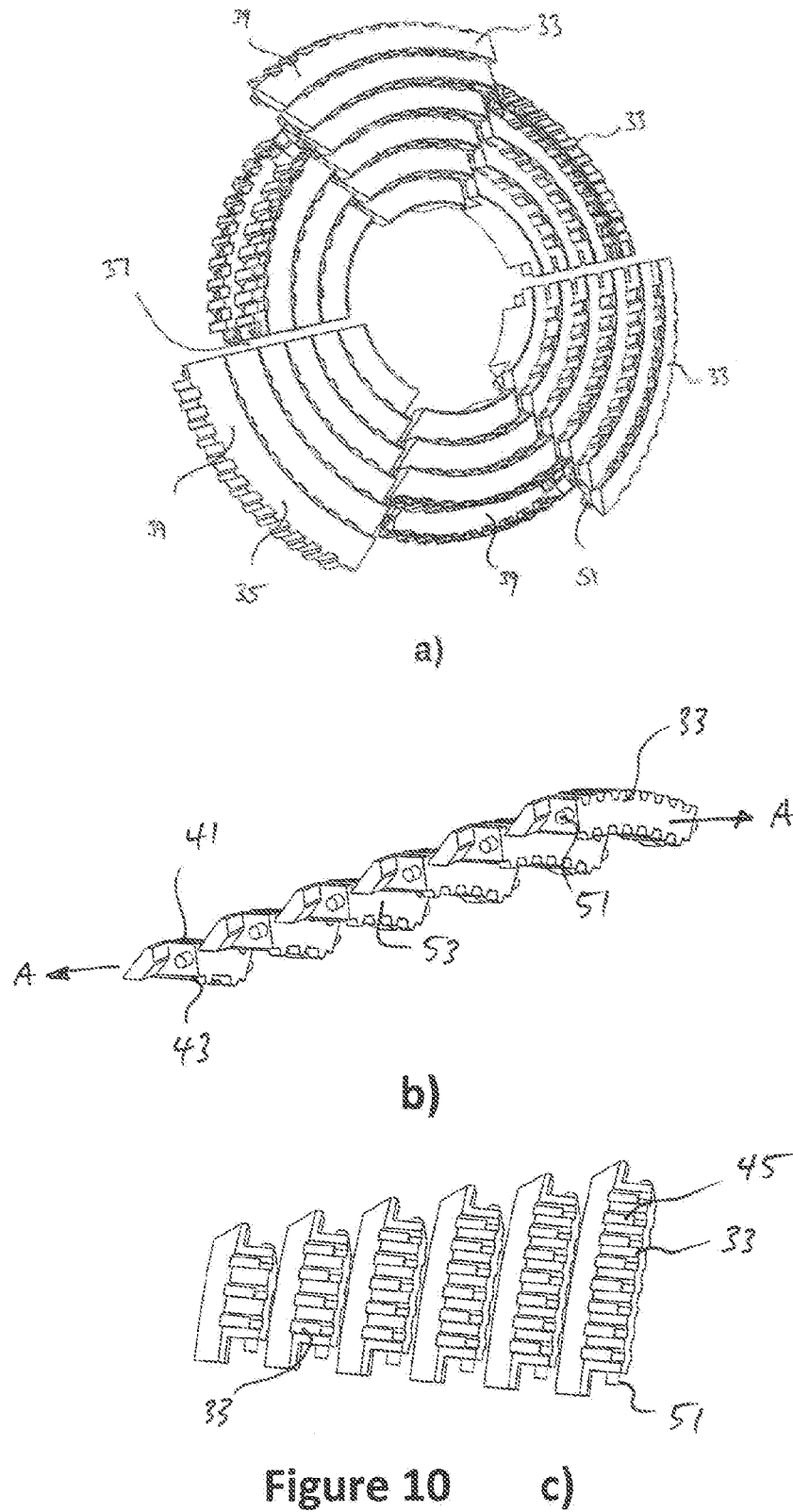


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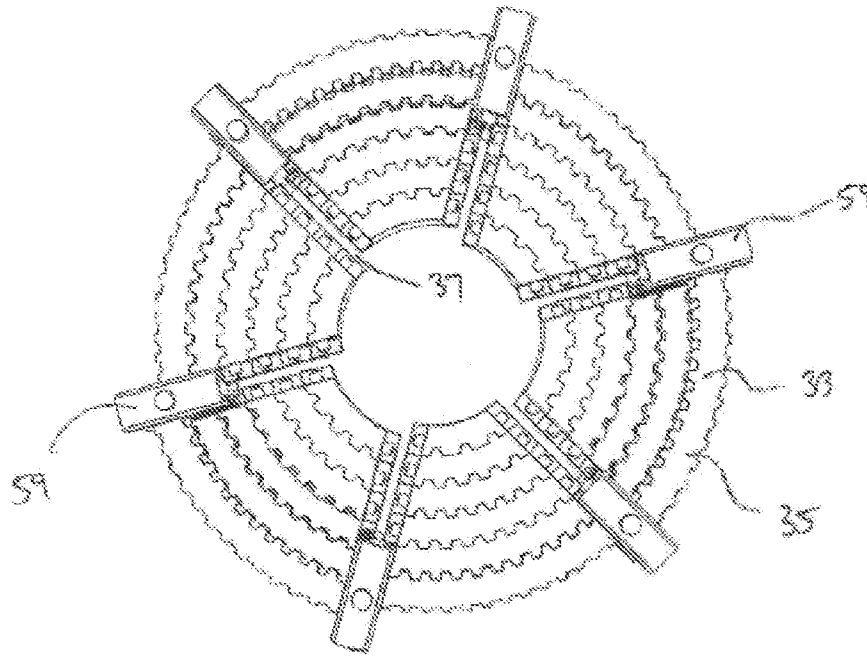


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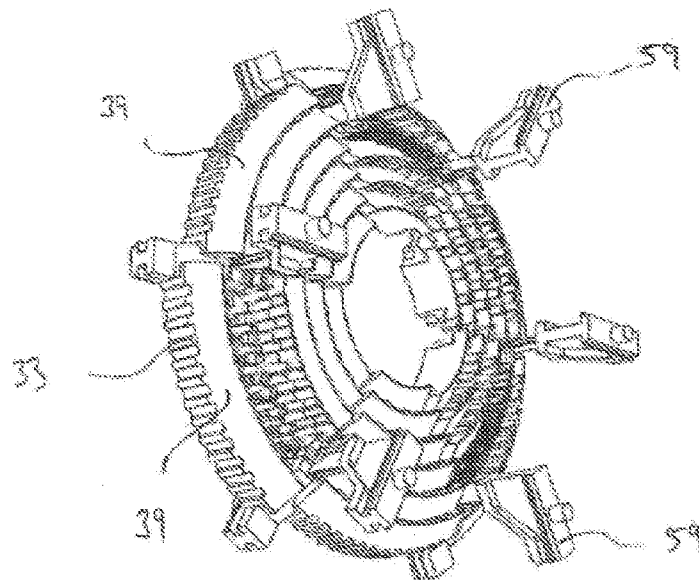


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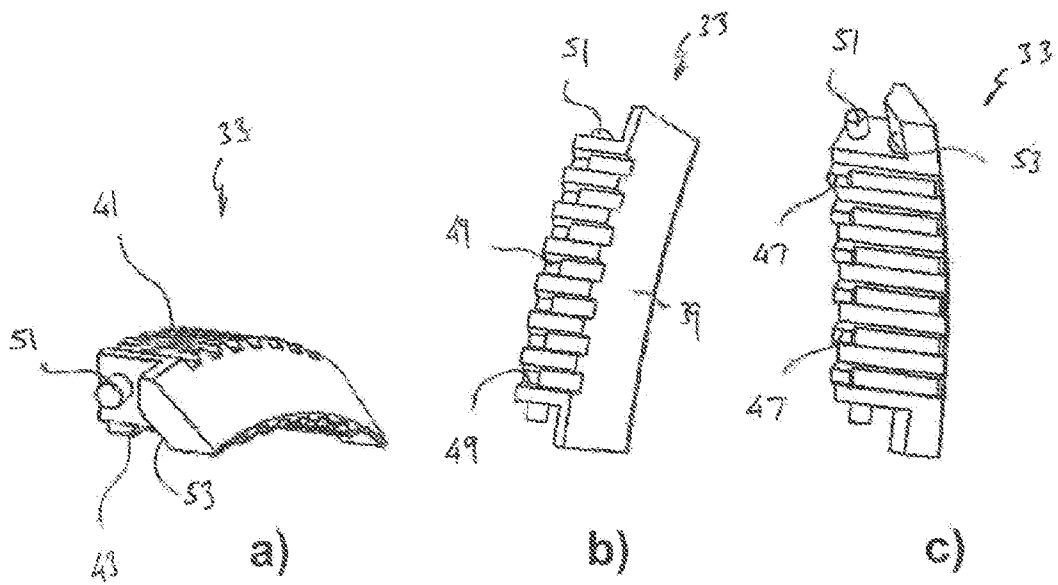
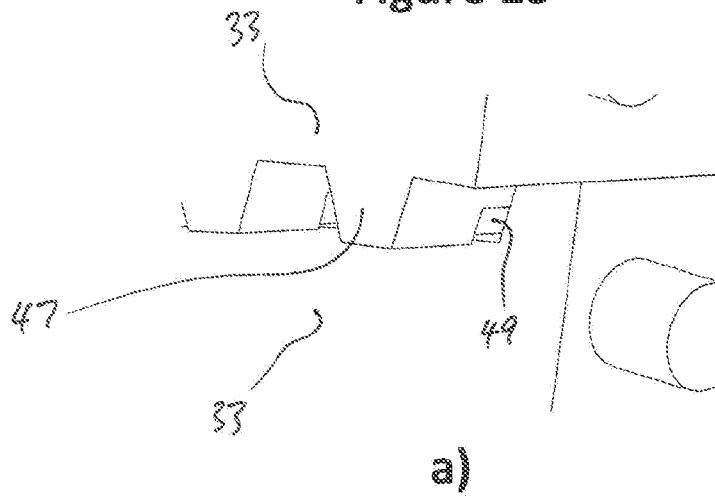


Figure 13



a)

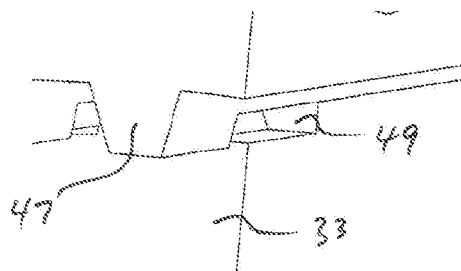


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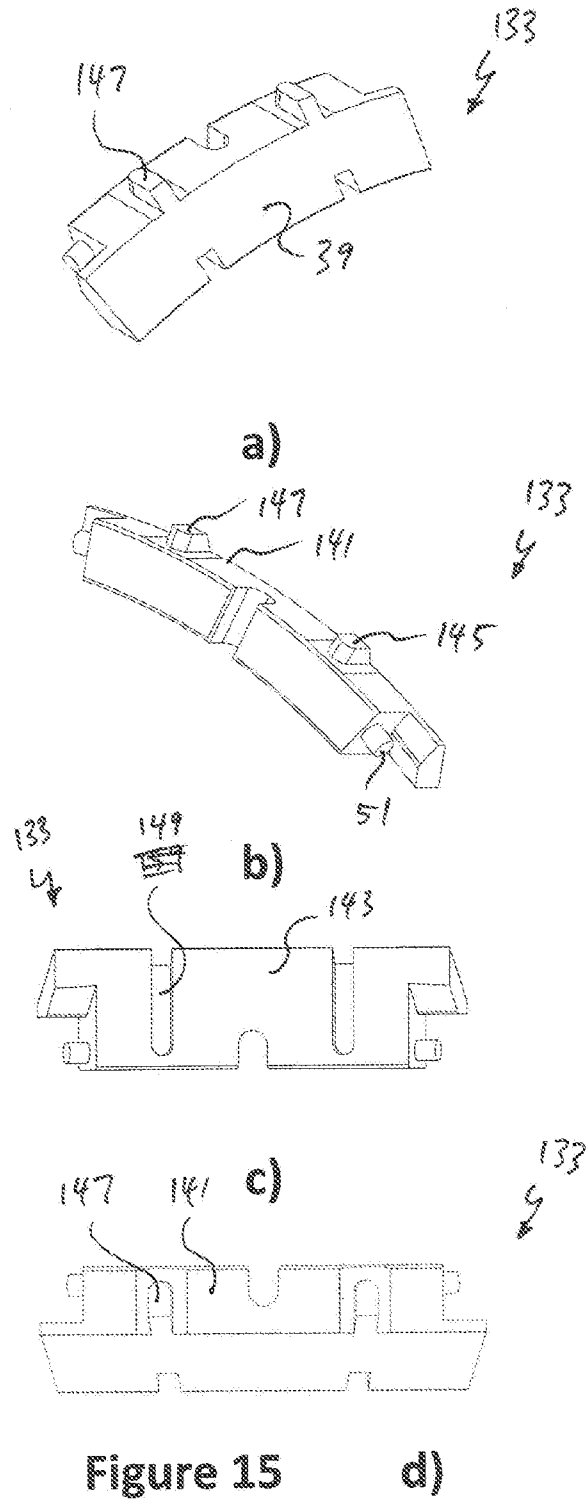


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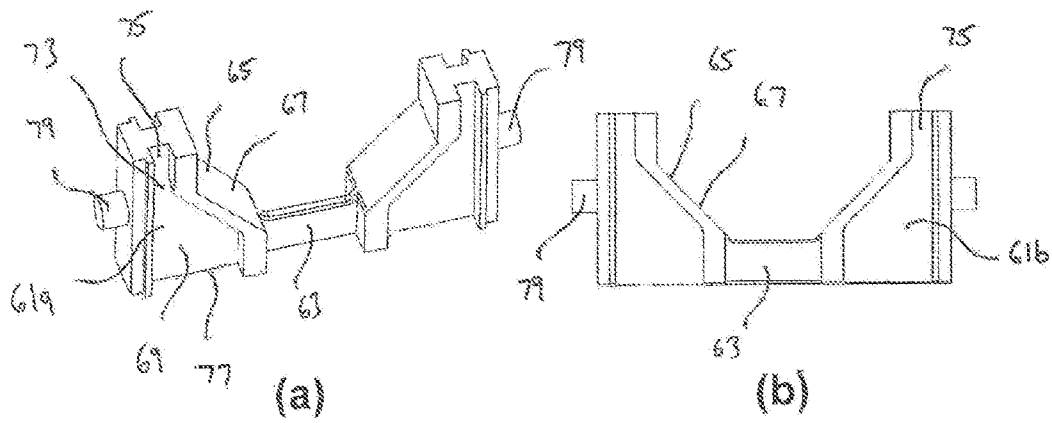


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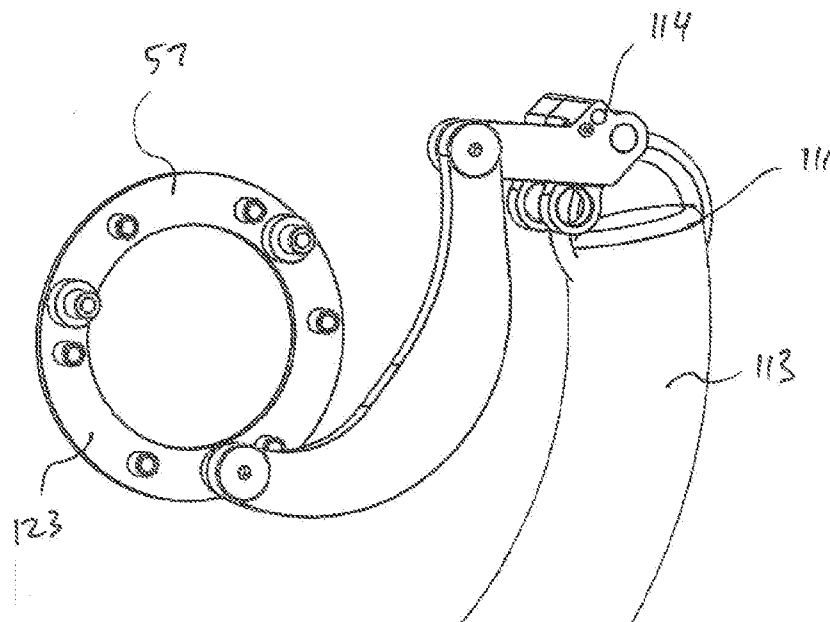


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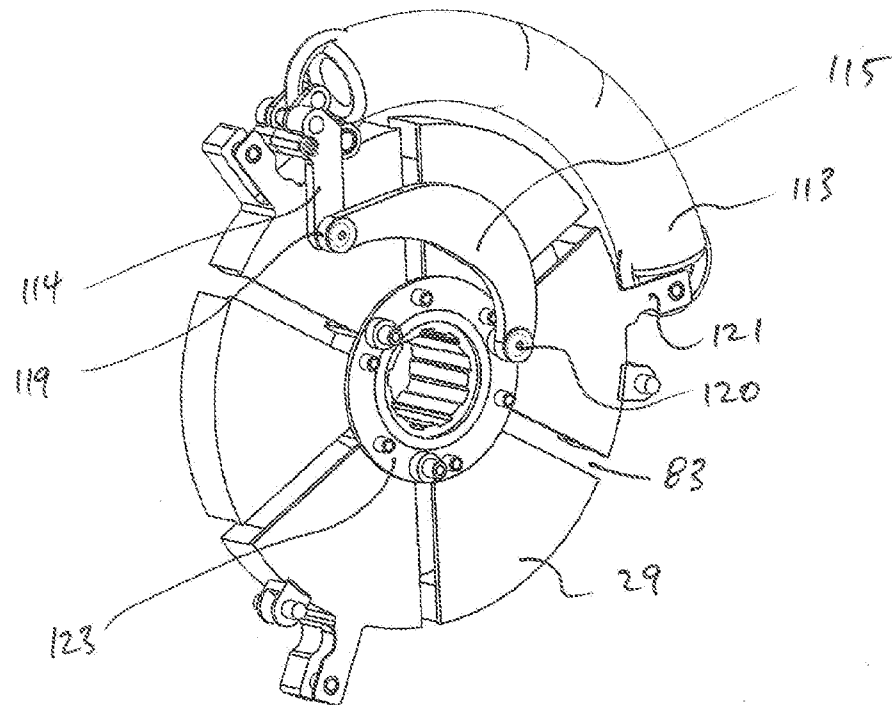


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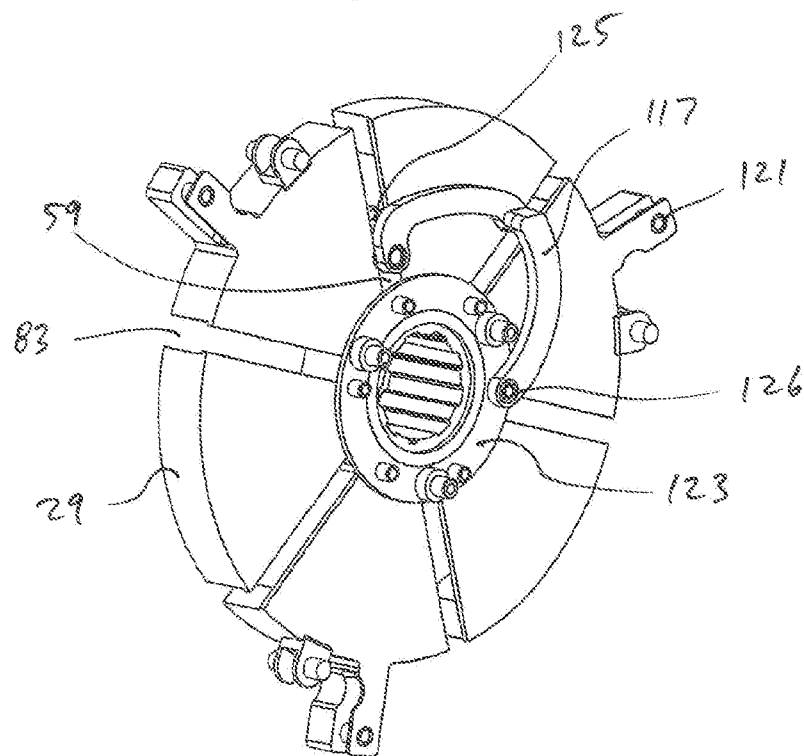


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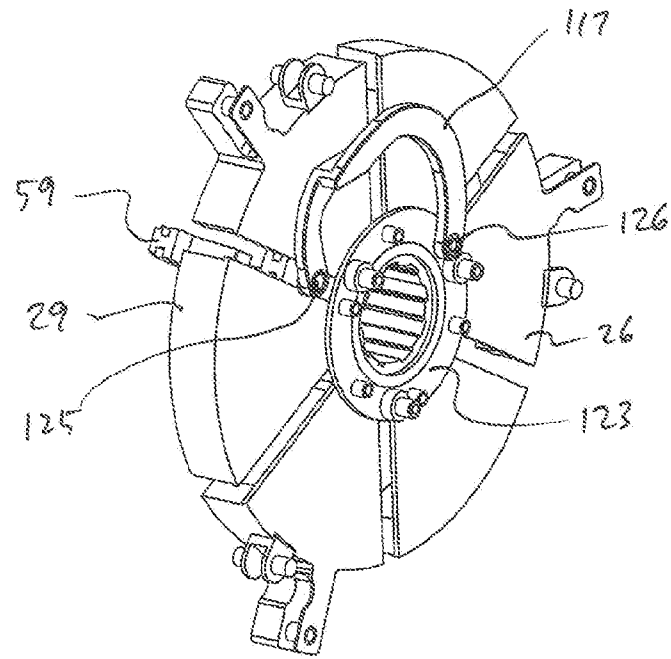


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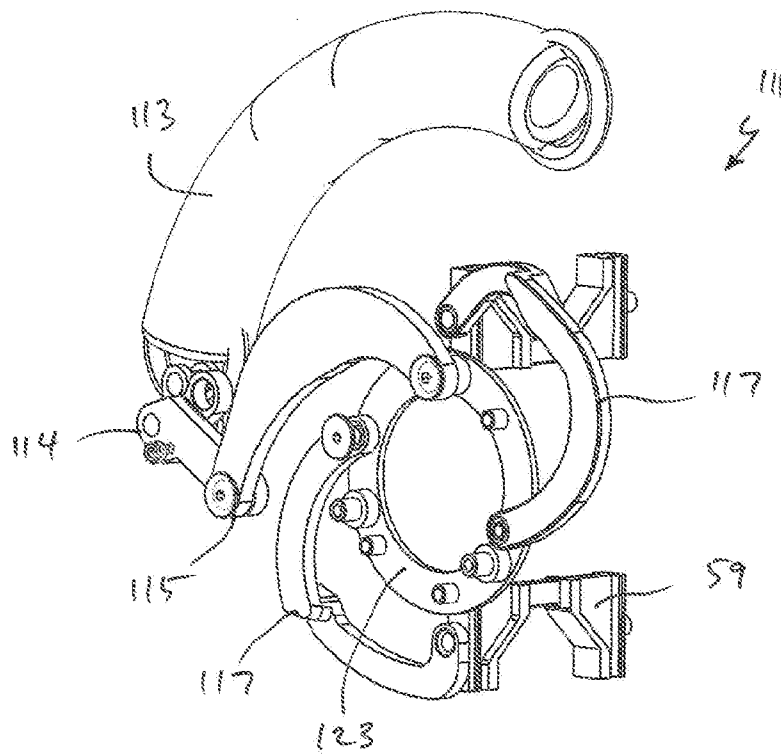


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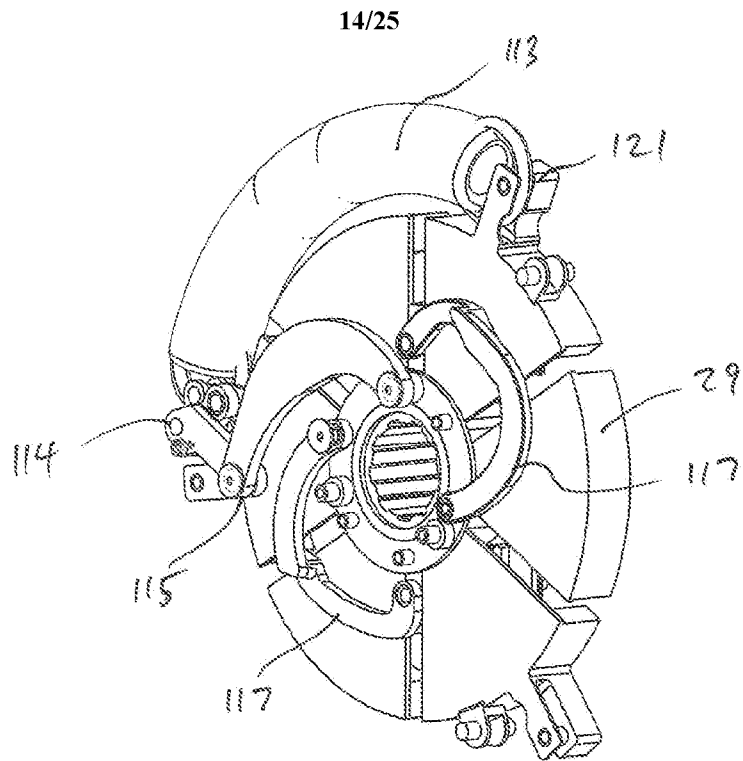


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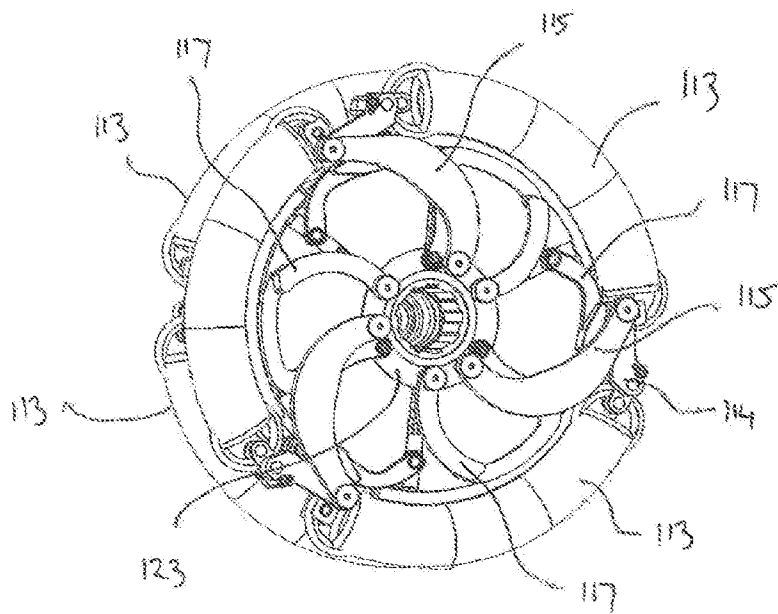


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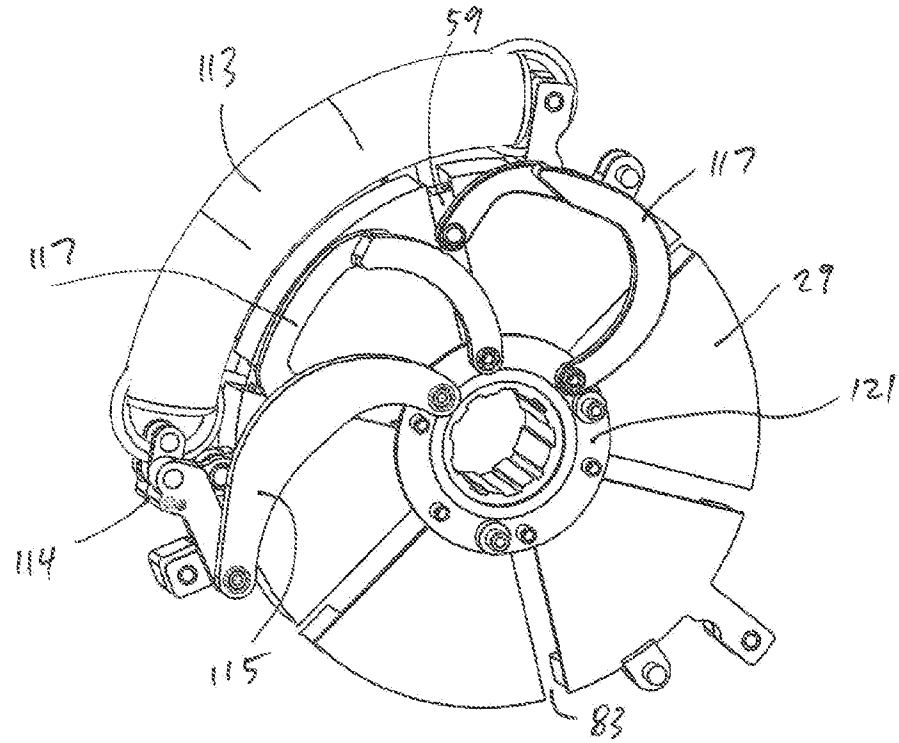


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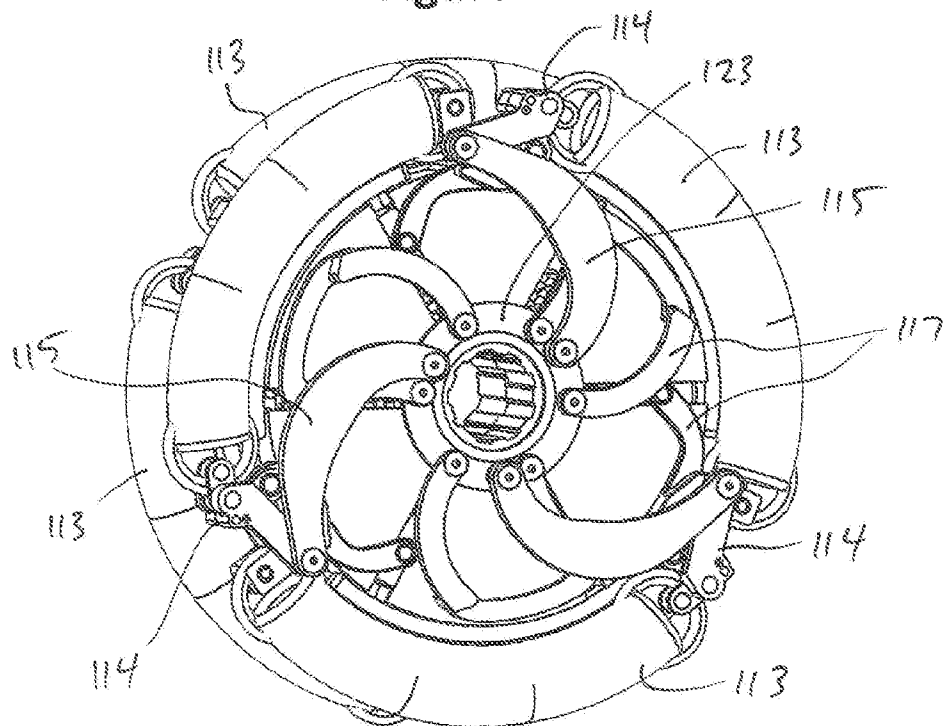


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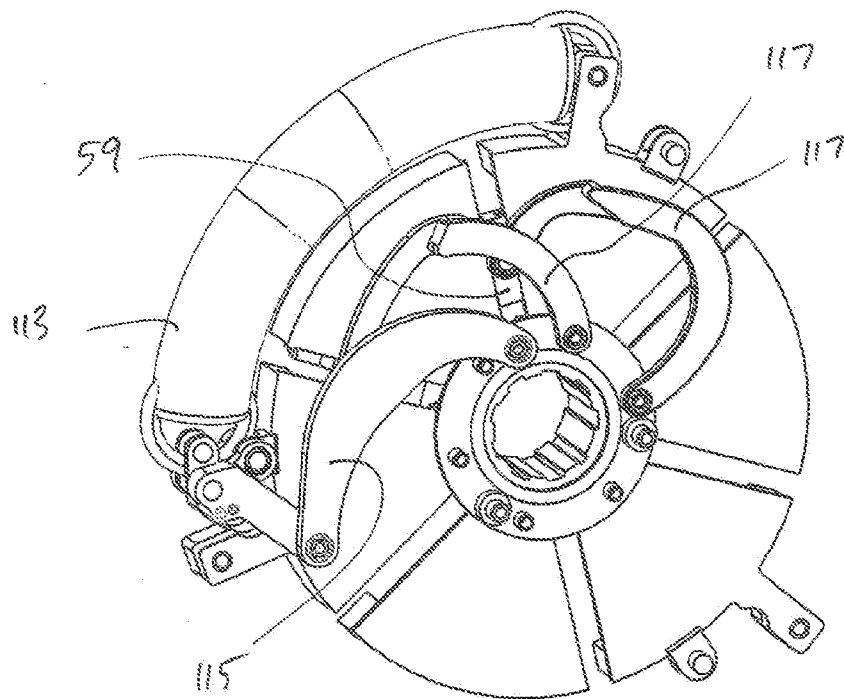


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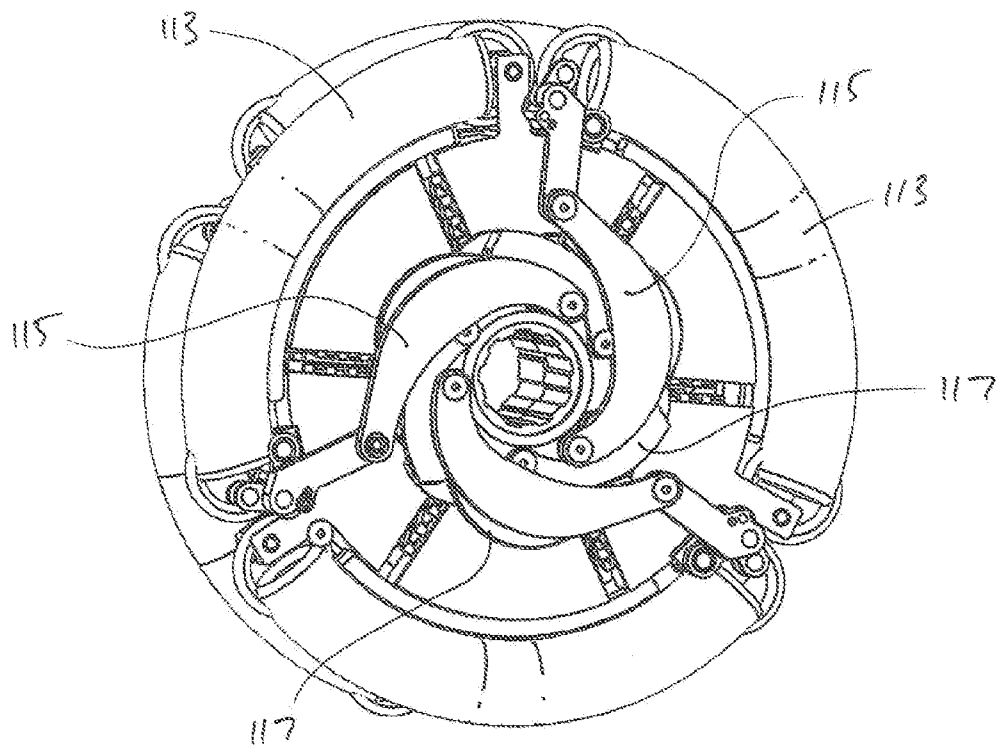


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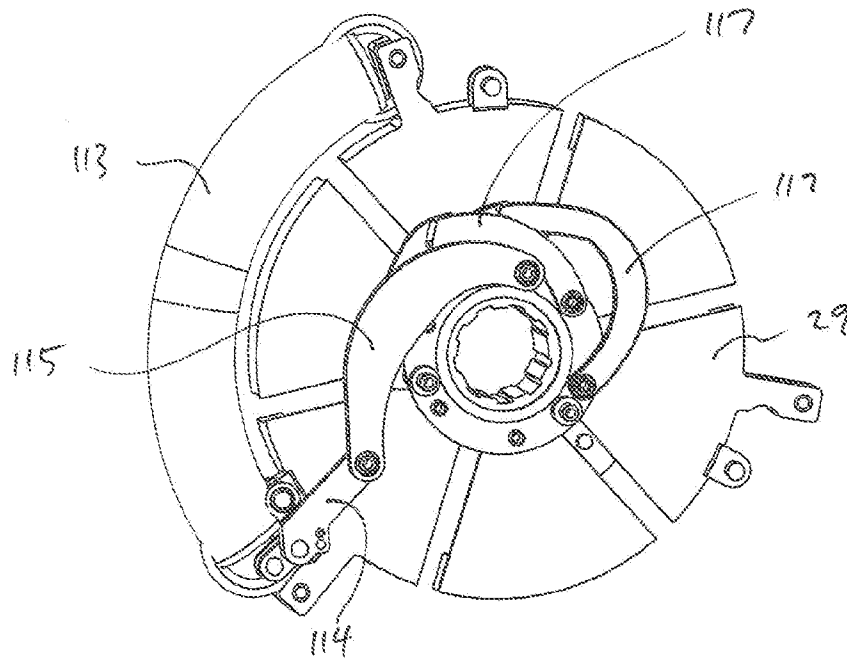


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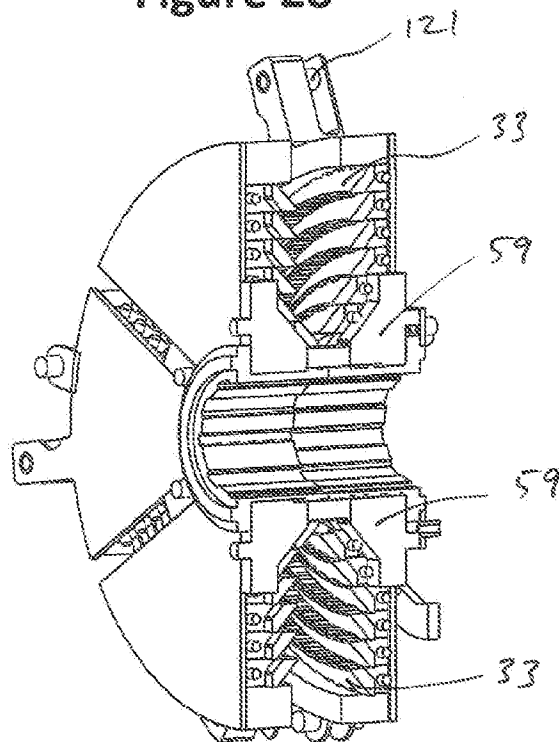
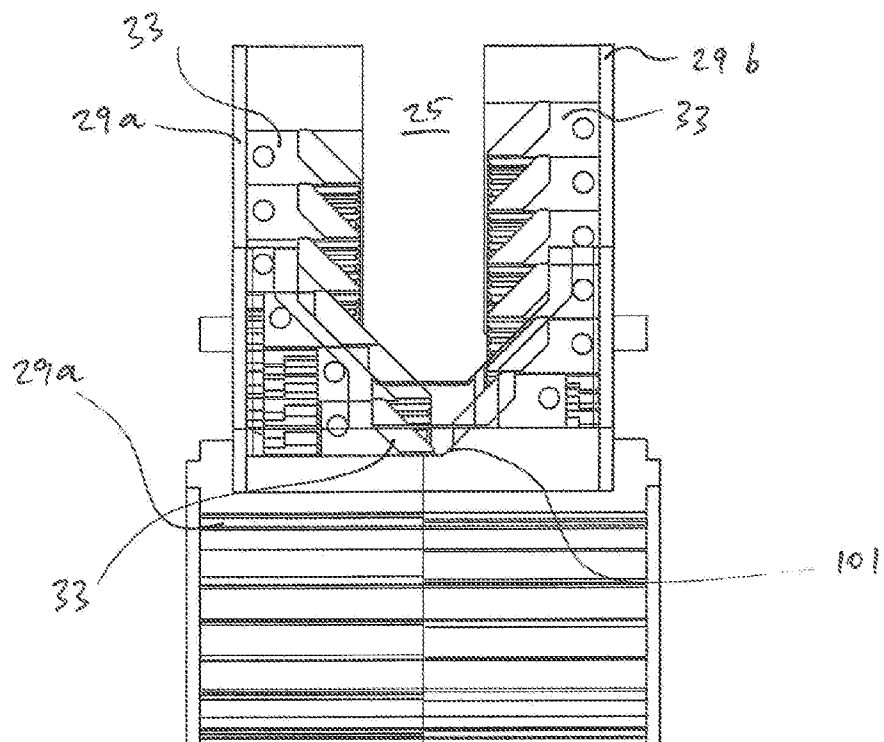
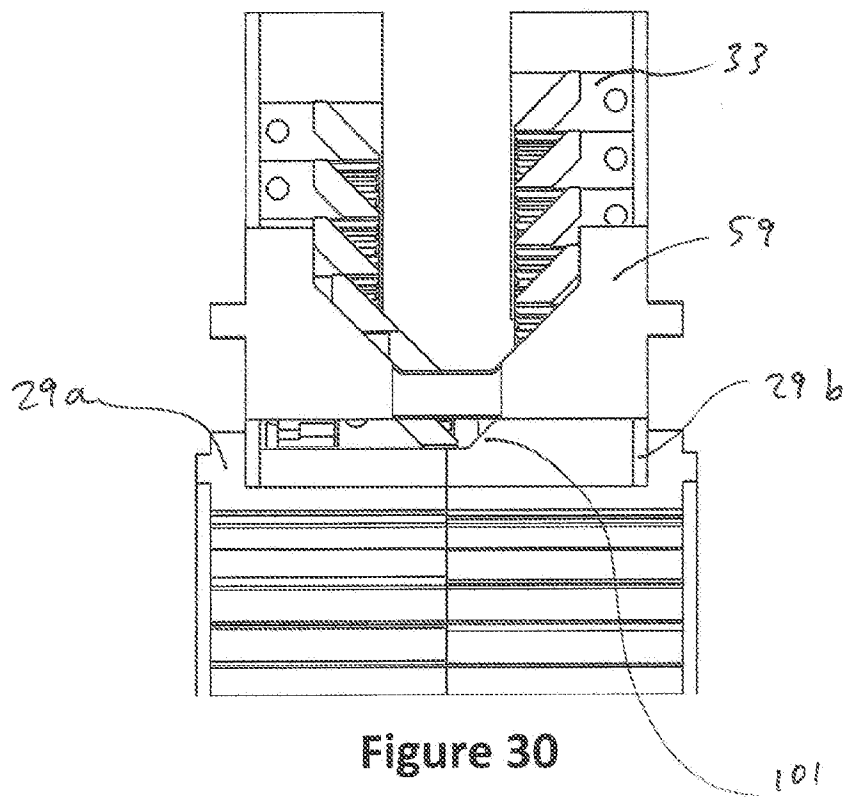


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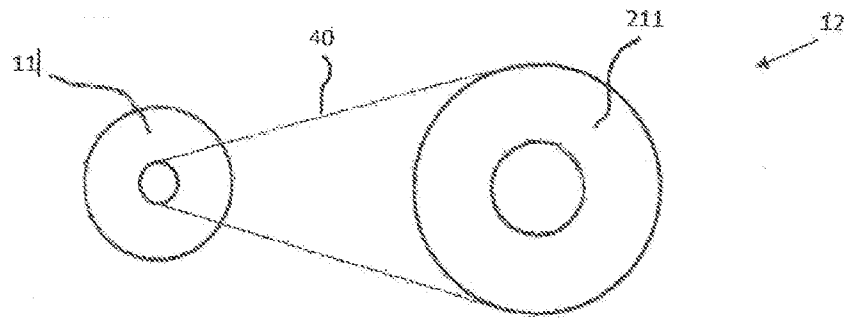


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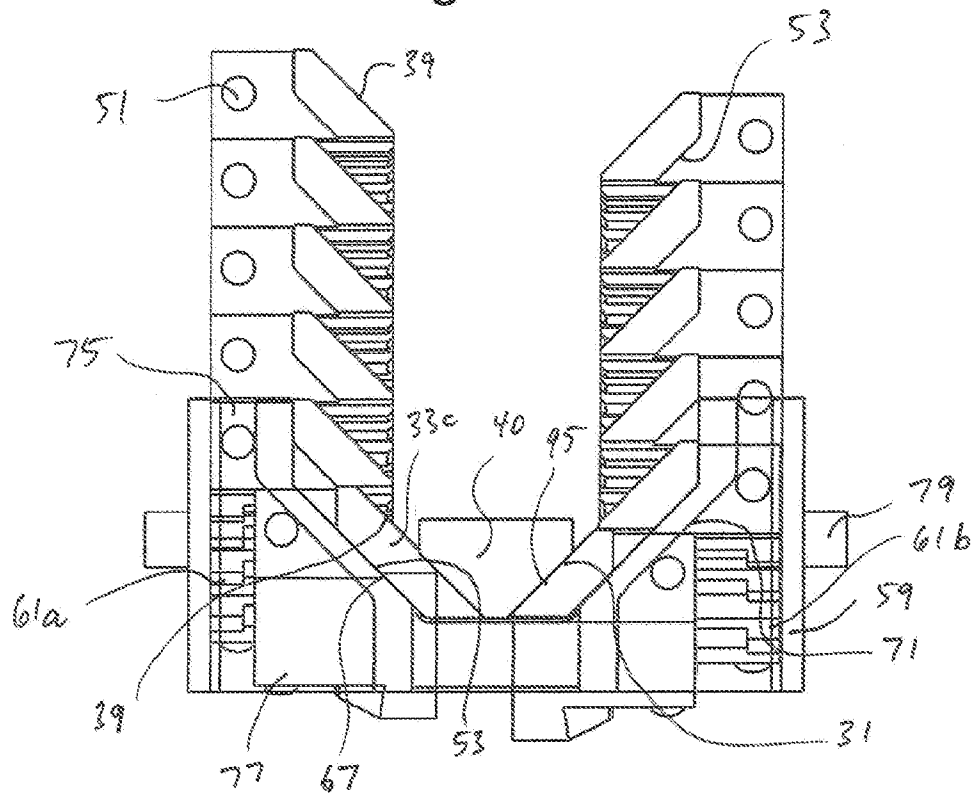


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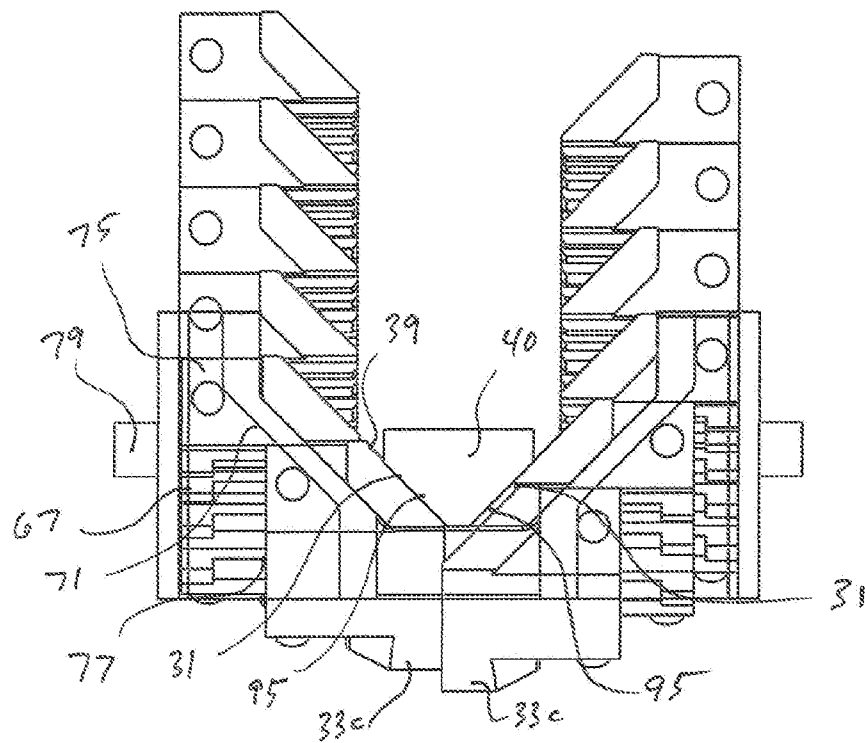


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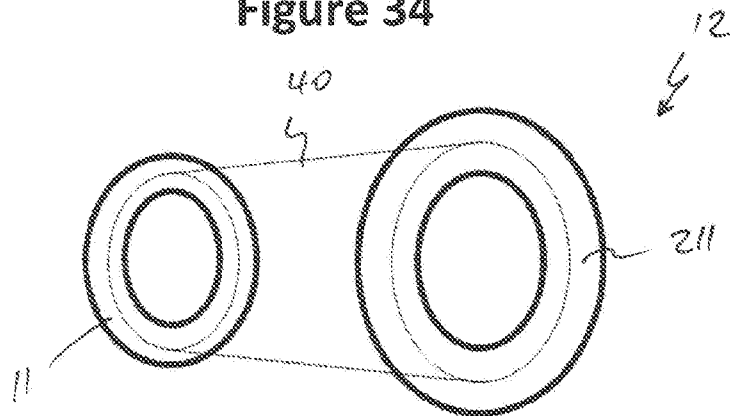


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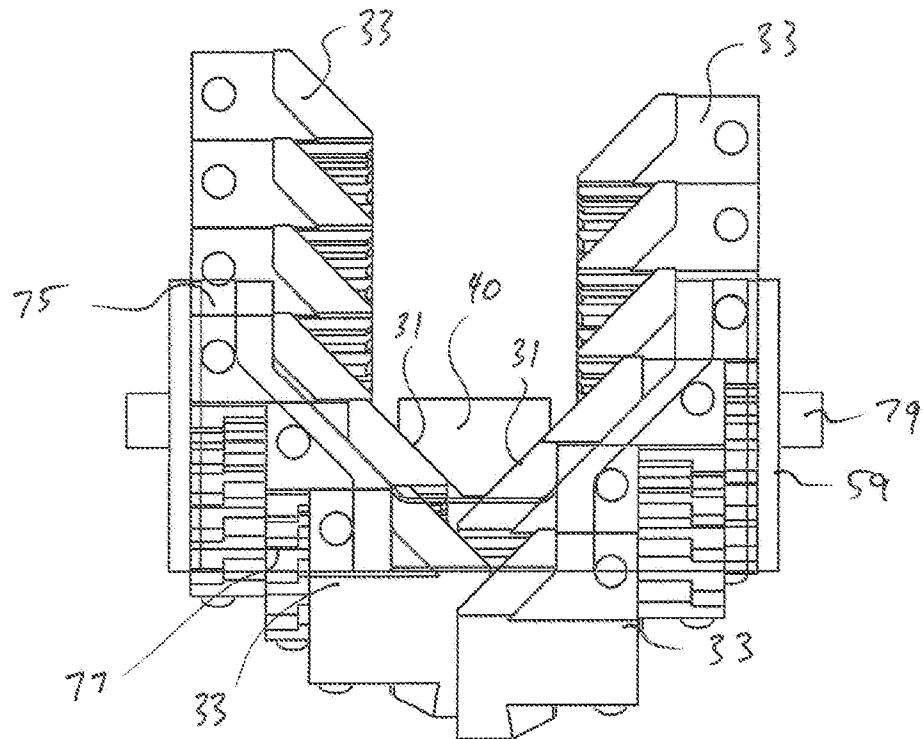


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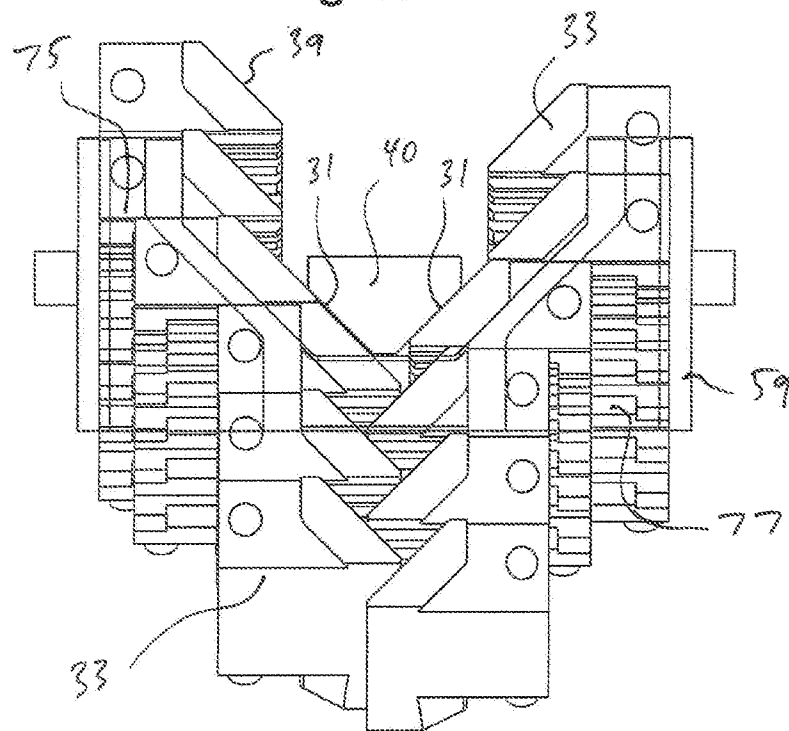


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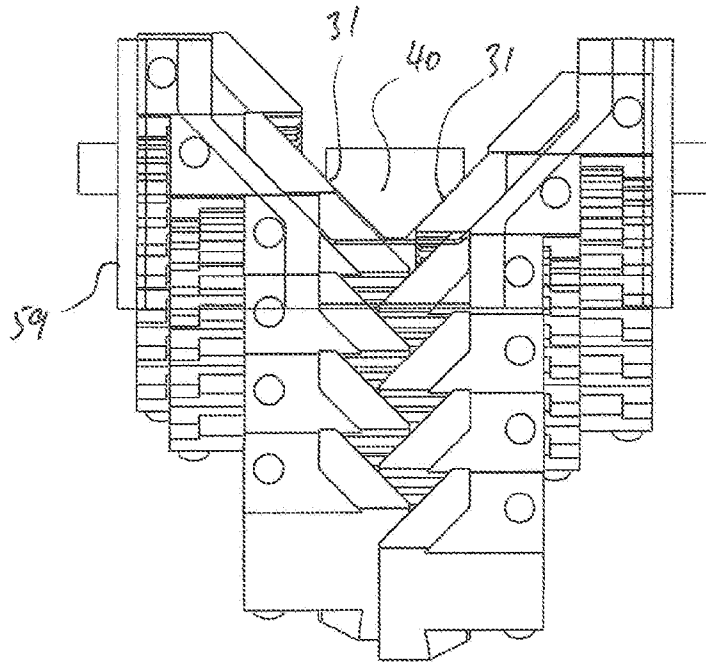


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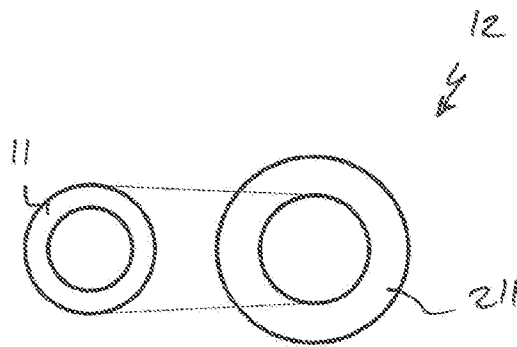


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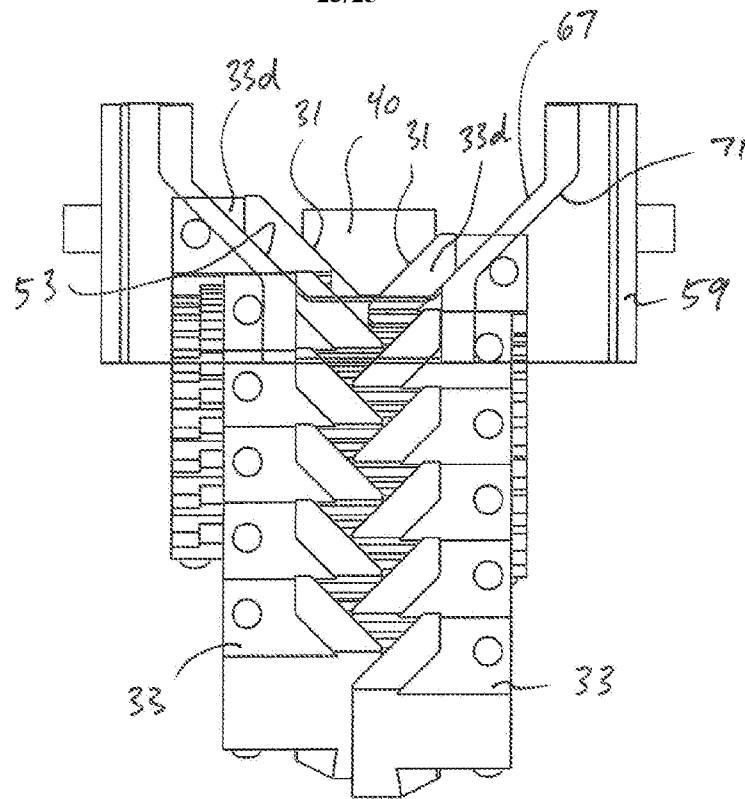


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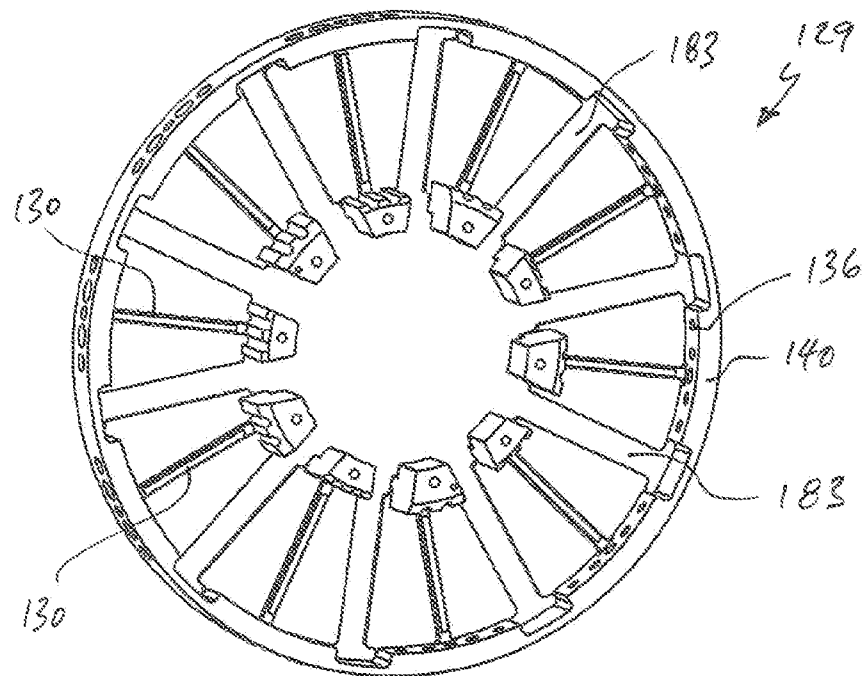


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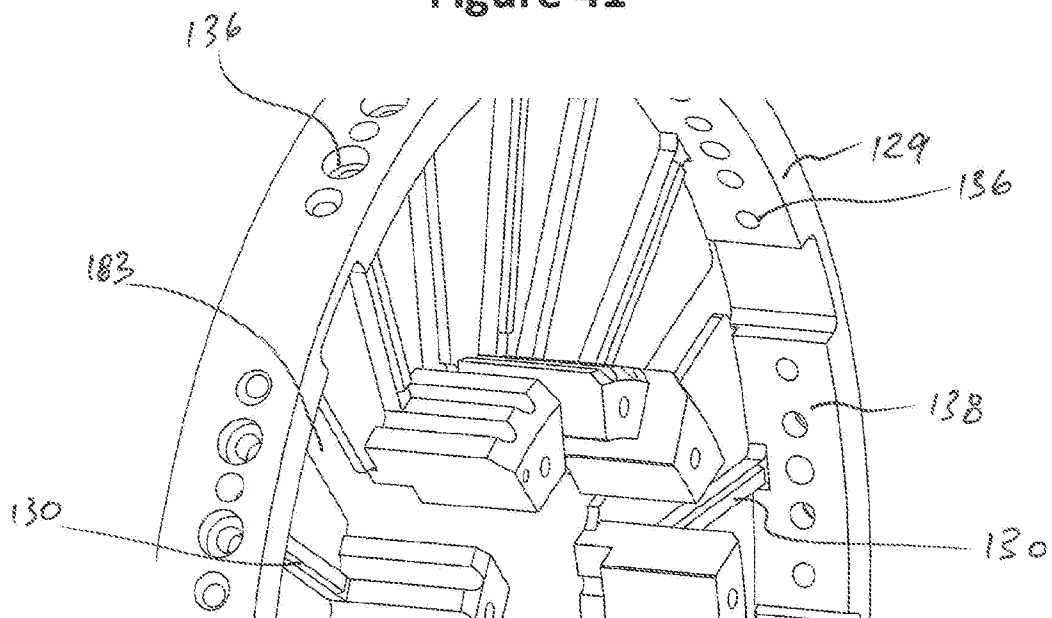


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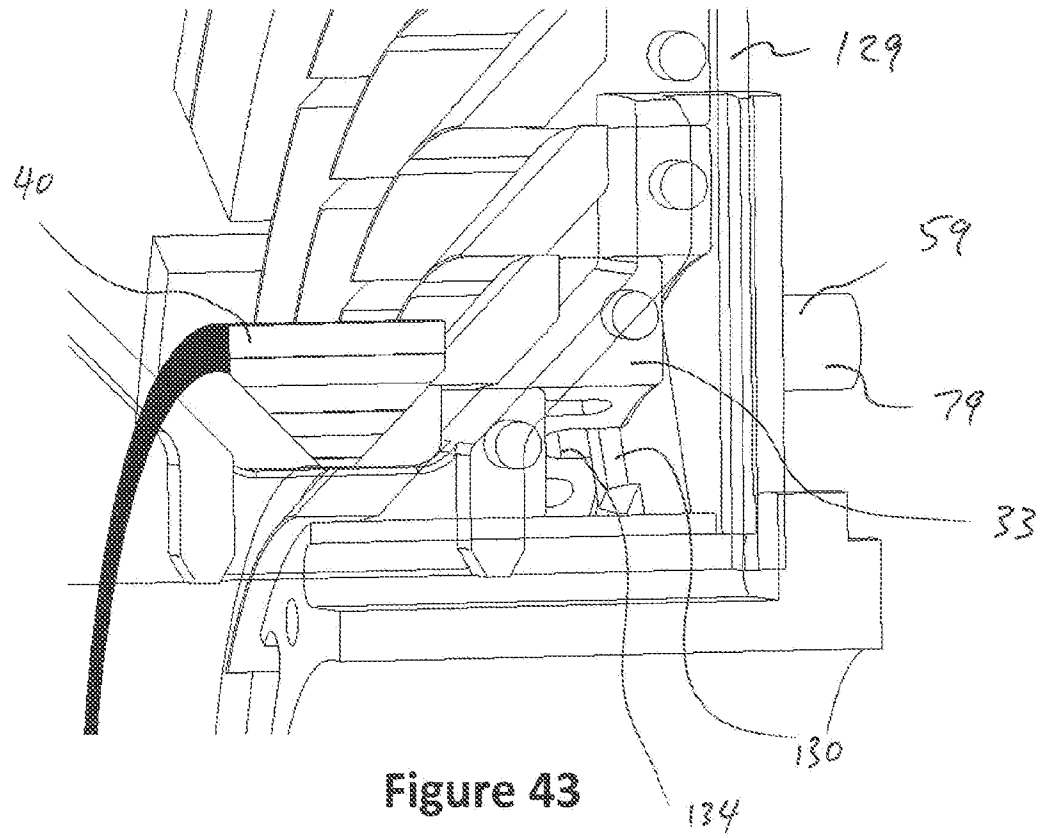


Figure 43

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2018/050728

A. CLASSIFICATION OF SUBJECT MATTER

F16H 55/54 (2006.01) B62M 9/06 (2006.01) F16H 9/10 (2006.01) F16H 9/12 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases: PATENW, Google patents, Espacenet, Google.**Keywords:** Variable, adaptable, decrease, increase, alter, pulley, sprocket, diameter, width, size, ratio, gear, tension, force, torque, load, cadence, respond, react, auto, counter, cvt, belt, cable, chain and similar terms.**Symbols:** F16H9/12, F16H9/10, F16H55/54, B62M9/06.

Applicant(s)/Inventor(s) name searched in Espacenet, AusPat and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 21 September 2018		Date of mailing of the international search report 21 September 2018	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au		Authorised officer Clive Gaskin AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262256108	

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2018/050728
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017/070736 A1 (TREADLIE ENGINEERING PTY LTD) 04 May 2017 Figures 1 - 36 and paragraphs [0041], [0043], [0049], [0068],[0082], [0097], [00115], [00142].	1 - 69
X	US 5405158 A (WILDING ET AL) 11 April 1995 Figures 1 - 12, column 9, lines 1 - 58 and column 7 lines 15 - 15.	40 - 57, 59 - 65, 68, 69
X	US 4652250 A (RESWICK) 24 March 1987 Figures 1 - 9, column 1, line 59 – column 2, line 40 and the corresponding text in the description.	56 – 60, 62, 63, 69
X	US 5468191 A (MONAHAN) 21 November 1995 Figures 1 - 13, column 4, lines 5 - 26 and the corresponding text in the description.	40 – 43, 46 – 48, 54, 56, 57, 59 – 65, 69
A	US 5582555 A (MILLER) 10 December 1996	
A	CN 106379479 A (ZHU AIXIA) 08 February 2017	
A	JP H01299355 A (SAKAMI HIROYUKI) 04 December 1989	

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2018/050728	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
WO 2017/070736 A1	04 May 2017	WO 2017070736 A1	04 May 2017
		AU 2016345061 A1	14 Jun 2018
		EP 3368793 A1	05 Sep 2018
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US 5582555 A	10 December 1996	US 5582555 A	10 Dec 1996
CN 106379479 A	08 February 2017	CN 106379479 A	08 Feb 2017
JP H01299355 A	04 December 1989	JP H01299355 A	04 Dec 1989
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