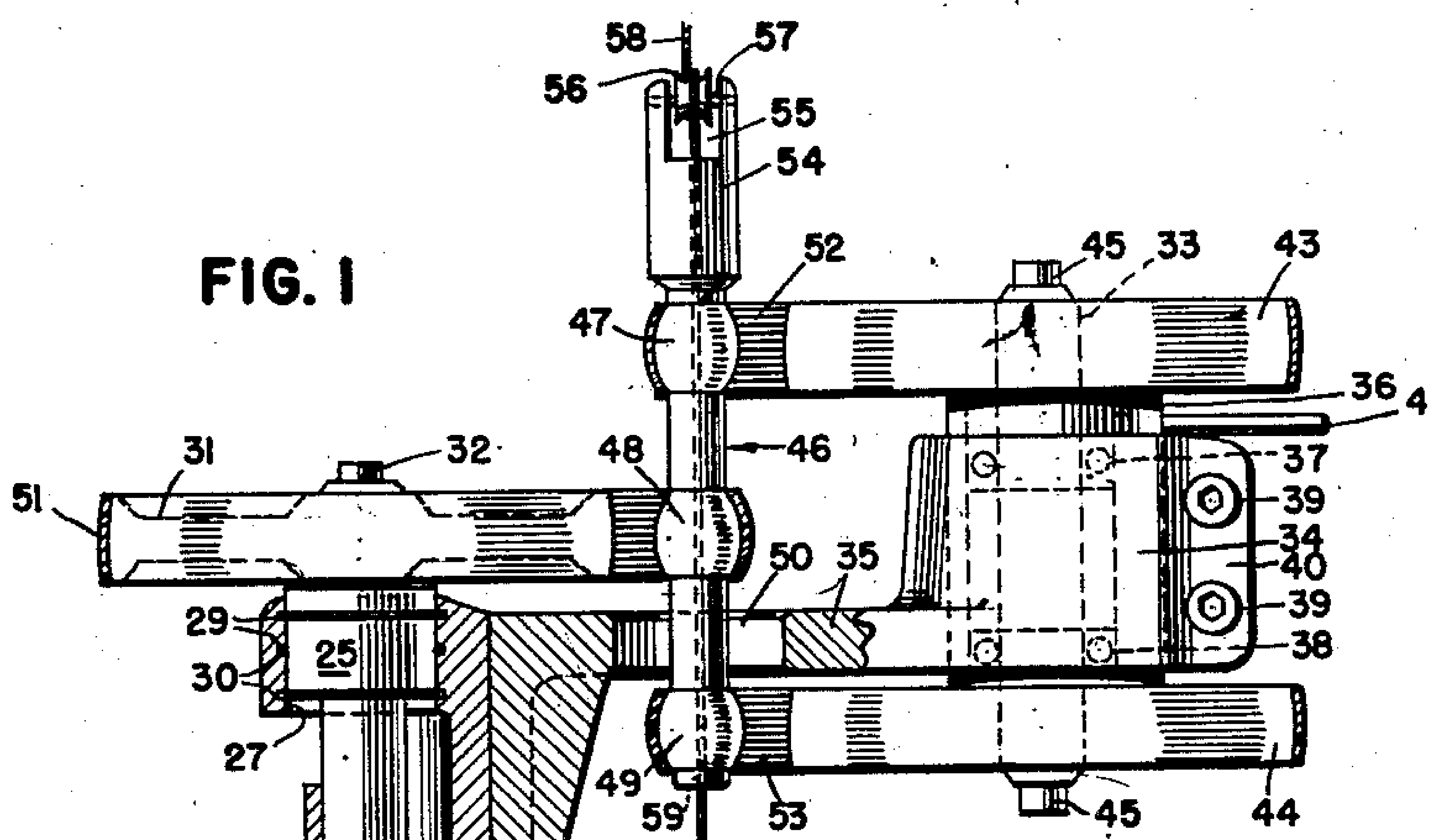
April 27, 1965 J. F. SMITH 3,180,074

HIGH SPEED SPINDLE APPARATUS

Filed April 4, 1956 2 Sheets-Sheet 1

FIG. 1



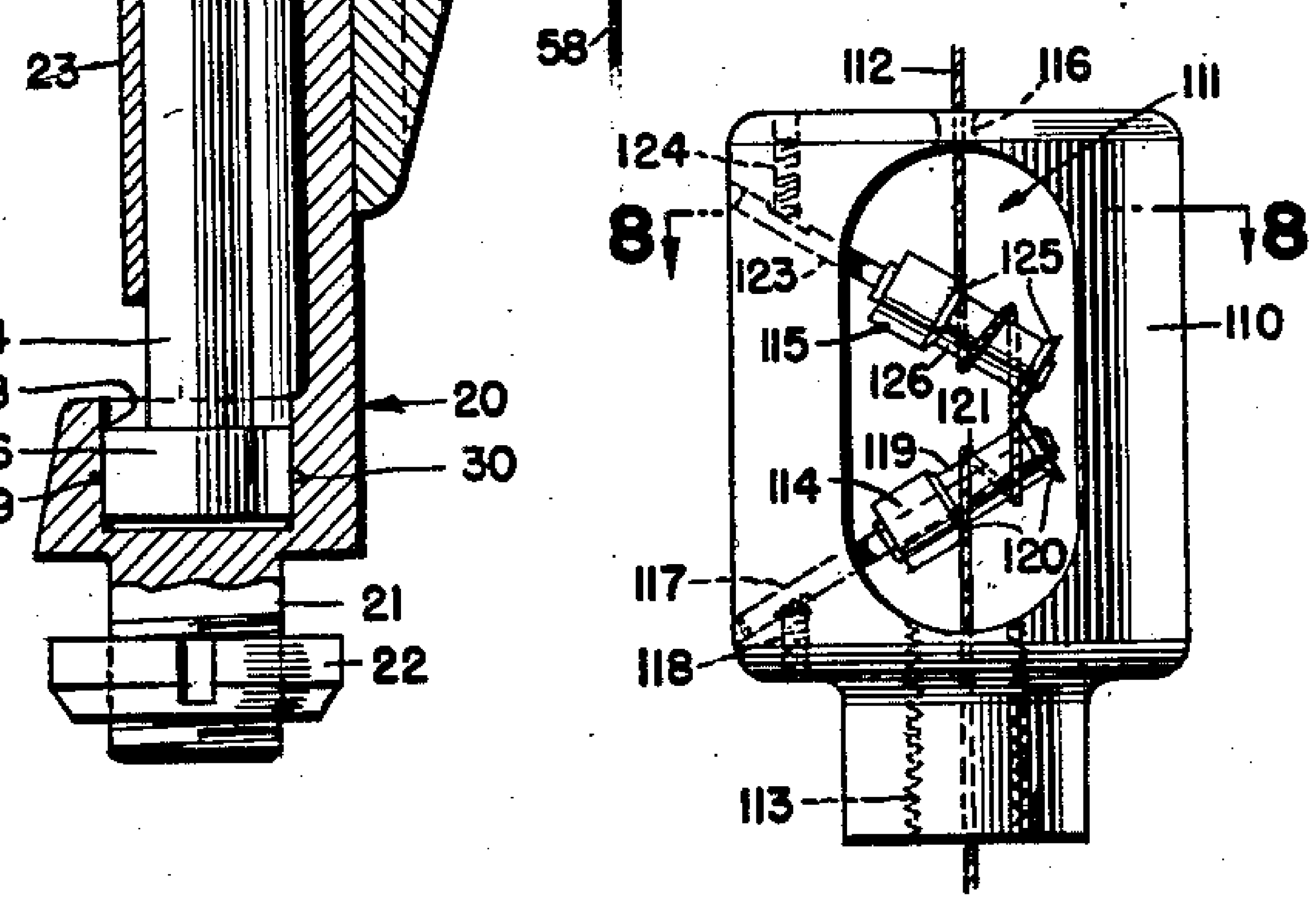


FIG. 7

FIG. 2

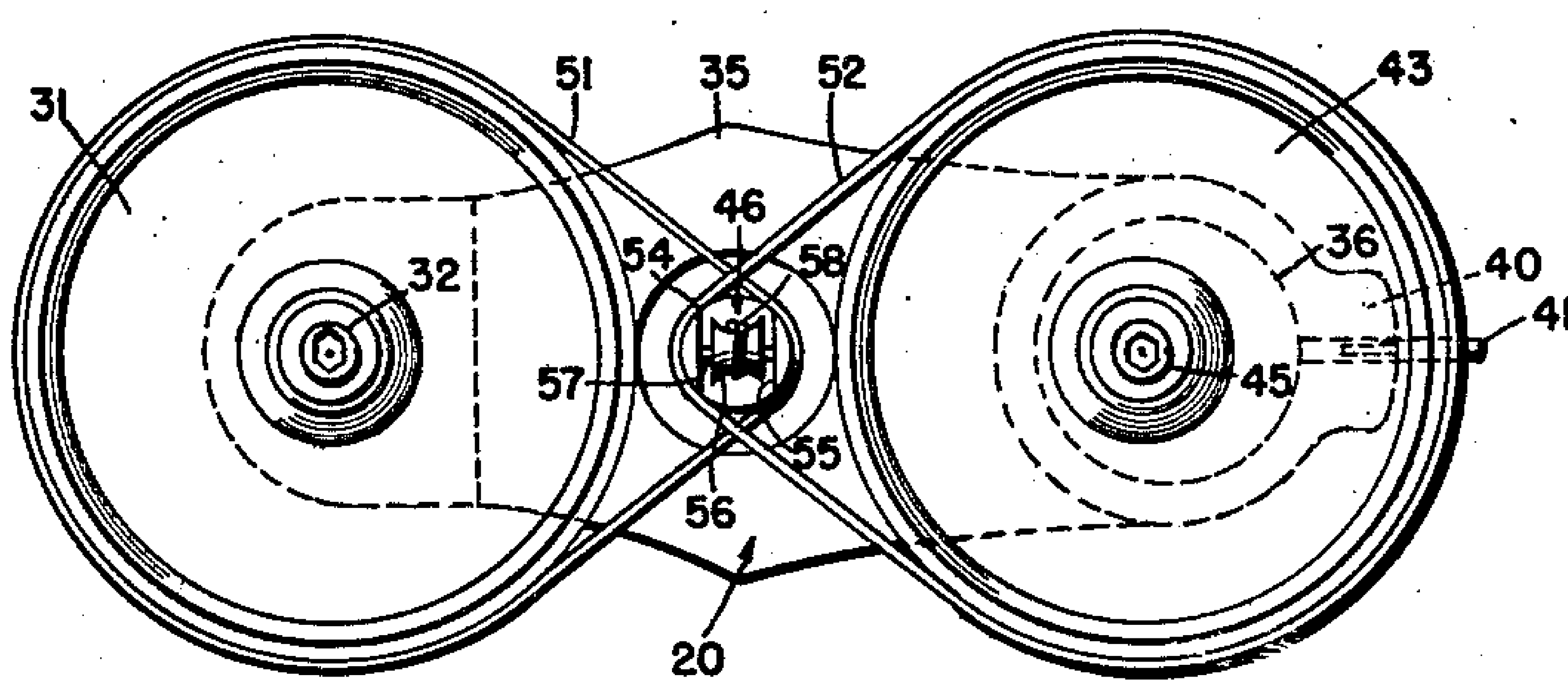


FIG. 8

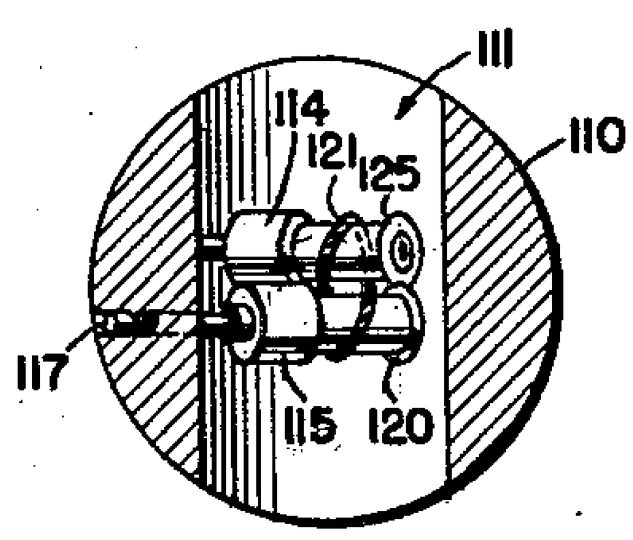


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FIG. 4

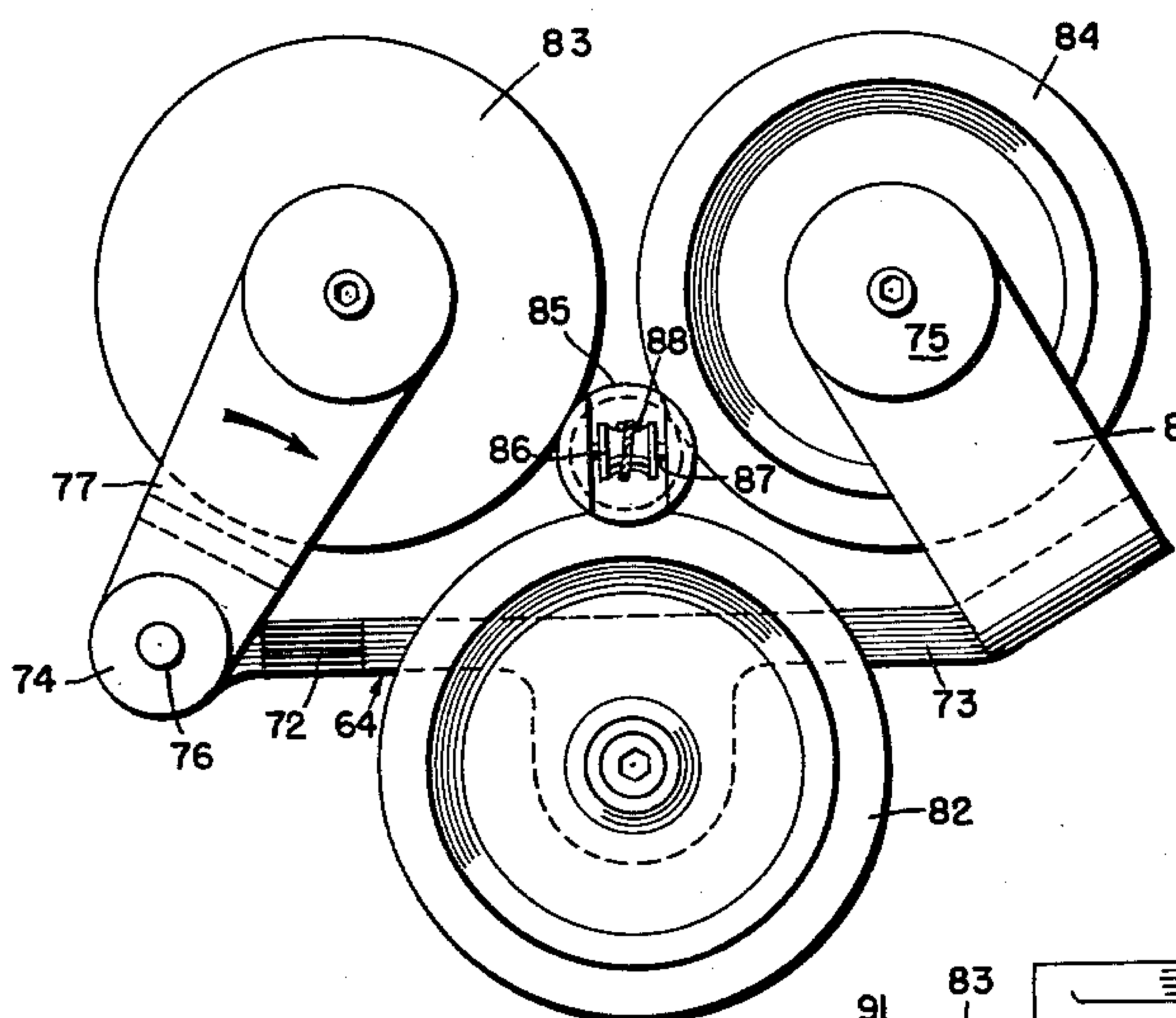


FIG. 6

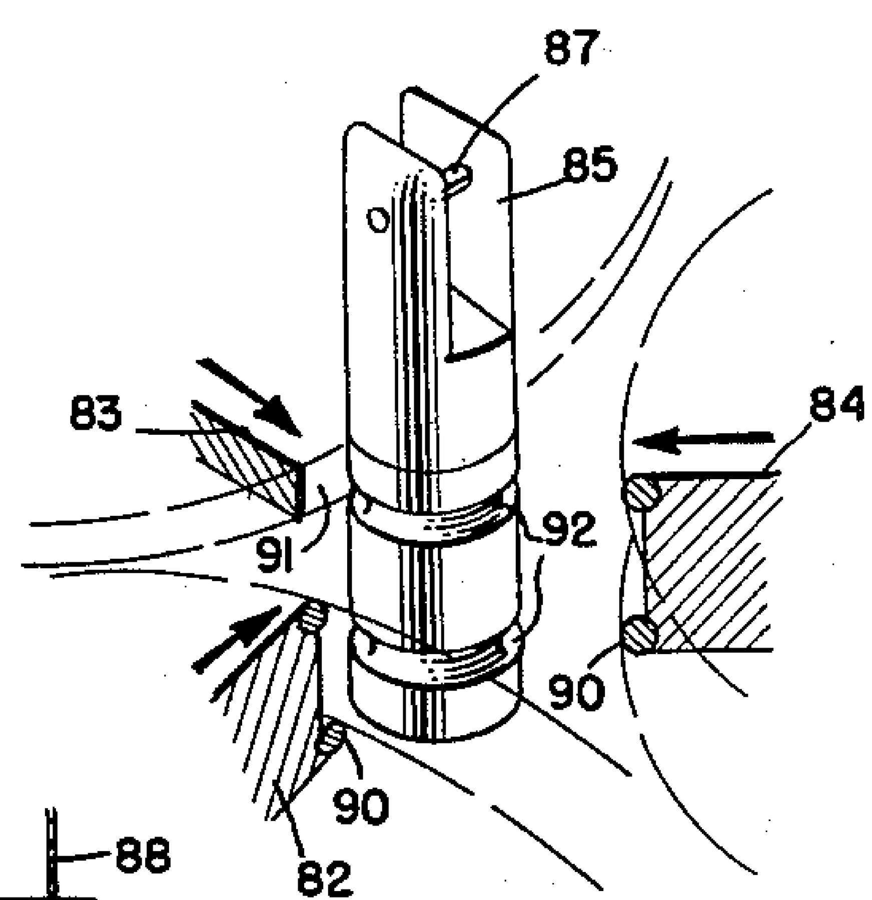


FIG. 5

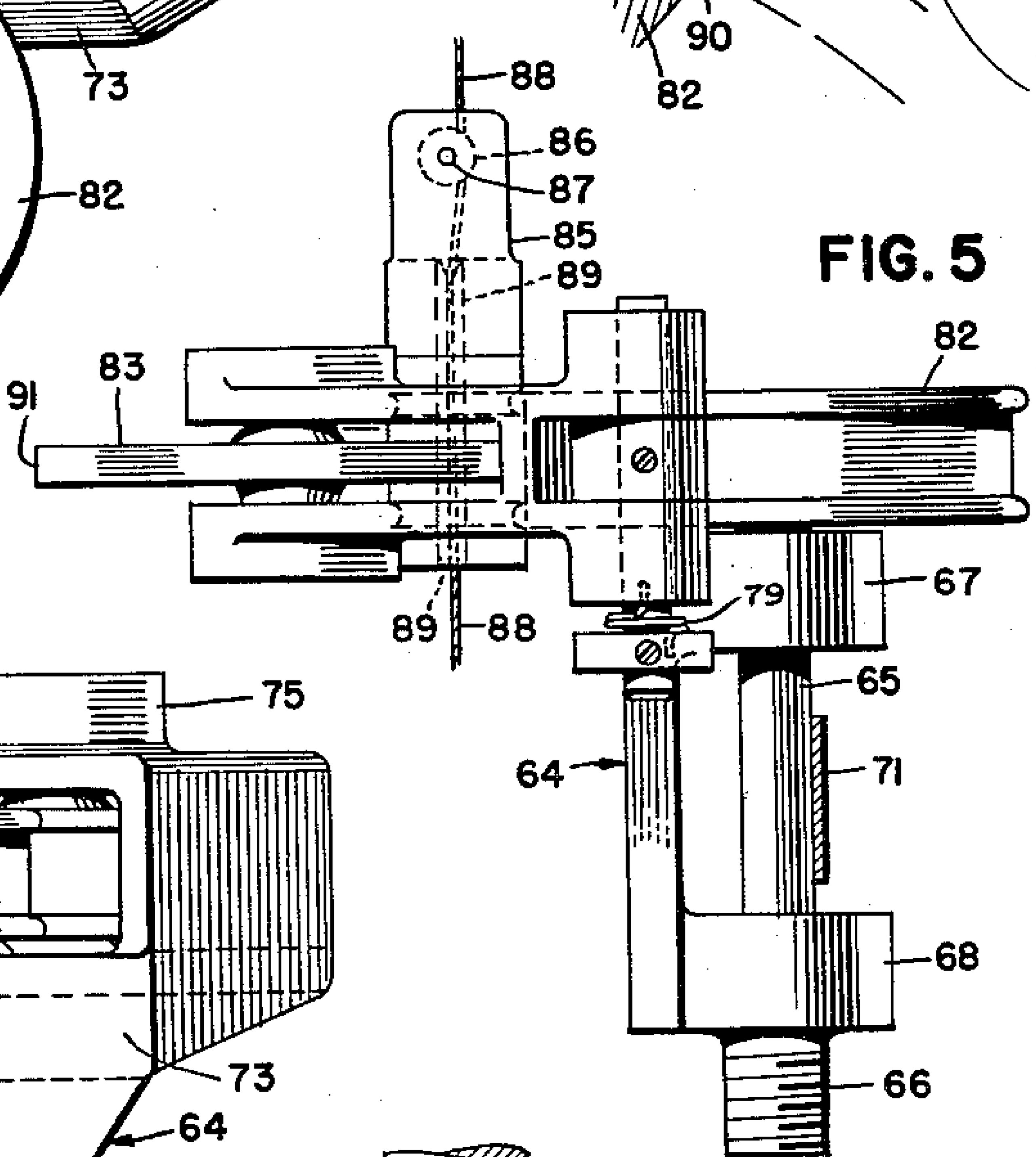


FIG. 3

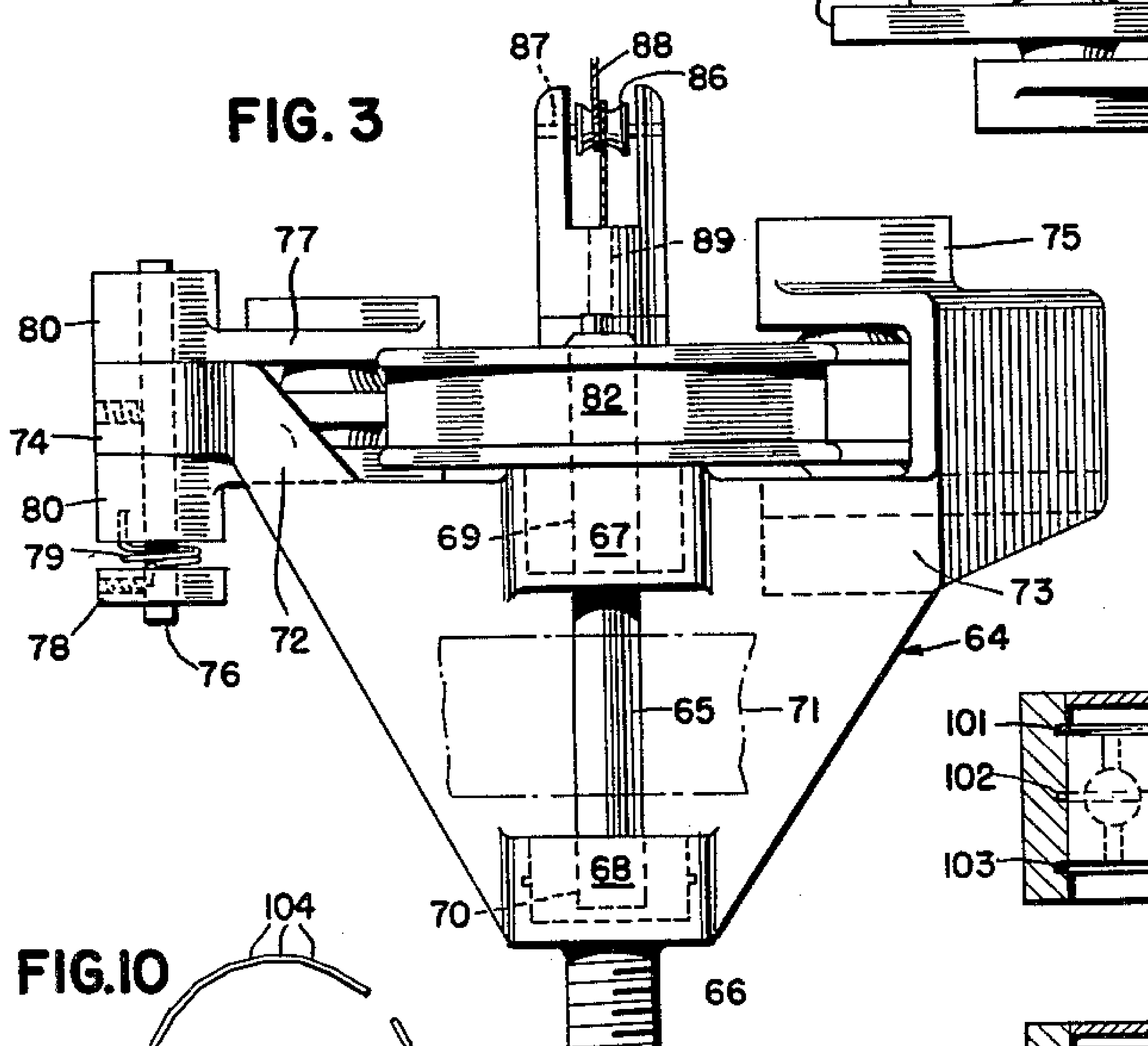


FIG. 9

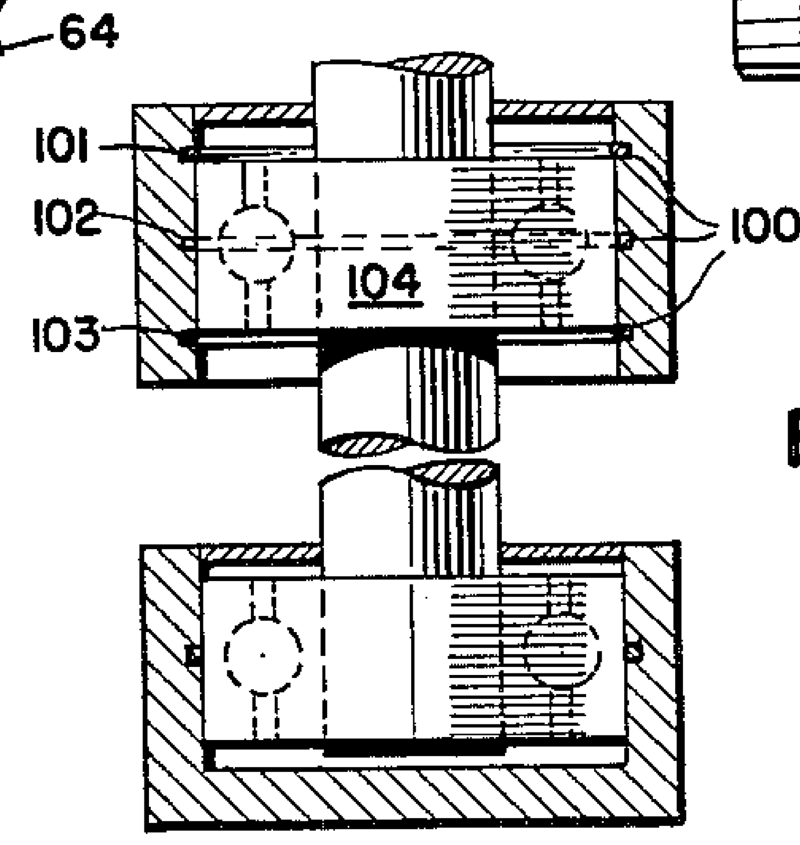


FIG. 10

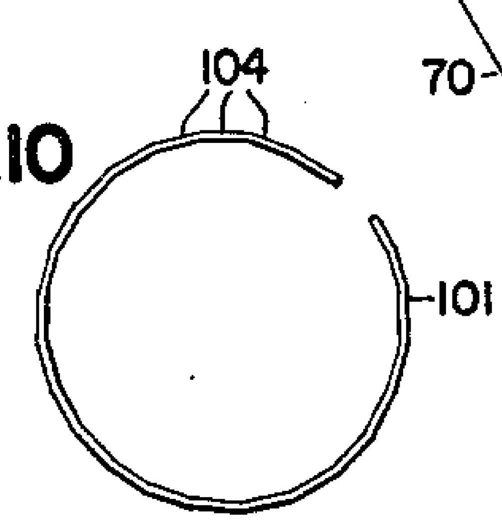


FIG. 11

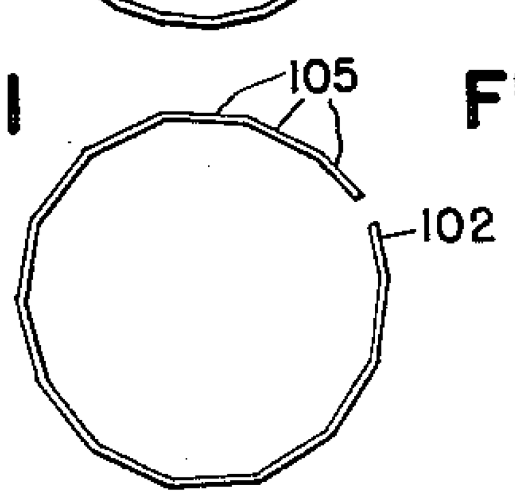
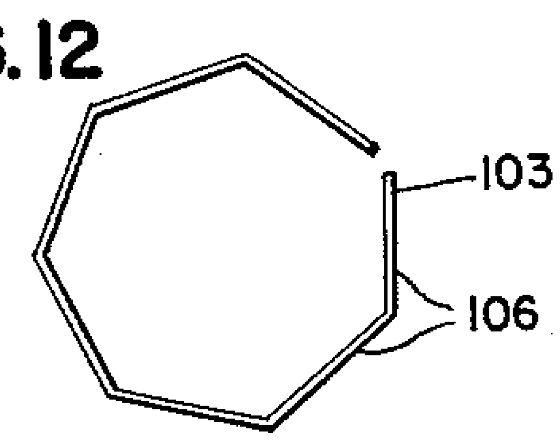


FIG. 12



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3,180,074
HIGH SPEED SPINDLE APPARATUS
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Filed Apr. 4, 1956, Ser. No. 576,004
5 Claims. (Cl. 57—77.45)

The present invention relates to high speed spindle apparatus and more particularly to high speed floating spindle apparatus for imparting a false twist to a continuously traveling yarn.

The physical and textural properties of many of the synthetic yarns produced at the present time may be improved by various treatments subsequent to yarn fabrication. In this respect not only may the synthetic yarns be improved but also the property of many of the yarn blends containing both natural and artificial fibers may be improved similarly. One such process for imparting certain desirable characteristics to a yarn, such as nylon, is to apply a very high false twist by employing a conventional false twisting means to a continuously linearly traveling yarn and subjecting the traveling twisted yarn to a heating zone in order to heat "set" the twist in the yarn. When the yarn is drawn from the false twist apparatus the set twist will remain in the yarn.

The prior art false twisting devices employed for imparting a suitable false twist to the yarn are usually driven by direct belt contact or other means so as to have a hollow false twist spindle rotate about a fixed axis in suitable stationary high speed bearings of various types. Due to the high yarn production rates required and the very high rotational speeds demanded of the spindles, the useful life of a spindle bearing operating under very high speeds is appreciably reduced. While ball and other type bearings have been designed to accommodate for these very high rotational speeds, bearing life has been shortened very appreciably particularly in the range of speeds exceeding 40,000 revolutions per minute. Furthermore, at the very high rotational speeds presently demanded of conventional and even some modified bearing structures, the heat generated by the high speed rotating apparatus presents a very difficult problem for proper lubrication of the bearings since most lubricants do not have the wide range of lubricating properties required. Vibrational effects as well as safety problems present additional causes for necessary concern in running spindles at these very high rotational speeds.

Although bearing failures are a constantly reoccurring problem at high speeds of rotation, linear yarn travel along a directed path without objectionable ballooning as the yarn leaves the false twist apparatus also presents a serious problem. Reduction of the ballooning action produced by the centrifugal forces acting on the traveling yarn in order to contain the yarn with some degree of confinement is vitally necessary. Yarn tracking which produces non-uniform travel and frayed filaments is also a major problem.

It is a known principle in kinematics of machines that the transmission of motion from a driver shaft to a driven shaft may be accomplished by direct contact as in pure rolling contact with circular or non-circular surfaces provided that: (1) sufficient pressure is applied between the surfaces to produce the necessary friction between the rolling surfaces, (2) the surface condition between the rolling friction surfaces is not too highly polished or lubricated, and (3) one of the surfaces is made of some soft material in order to have a higher coefficient of friction. The contacting friction surfaces may be on parallel shafts, intersecting shafts or on non-intersecting and non-parallel shafts. In rolling contact the velocity ratio of a pair of bodies is inversely proportional to the distance from their point of contact to the respective centers of rotation or pivot points. Therefore, when two bodies are in direct rolling contact, the angular velocities of the bodies are inversely proportional to the corresponding radii of rotation. The relationship that exists in direct rolling contact between angular velocities is similar between the radii of rotation for rotating bodies interconnected by a flexible connector in which the rotational speed of one body may be transmitted to another body.

Therefore, an object of the present invention is the provision of a high speed floating bearingless driven spindle.

Yet another object of the present invention is to provide a floating bearingless spindle for producing a false twist in a continuously traveling yarn.

Still another object of the present invention is to provide a driven floating spindle in rolling contact with a relatively slower rotating driving body in order to produce a false twist in a linearly traveling yarn.

A further object of the present invention is to provide a high speed driven floating bearingless spindle means that is driven by a relatively slowly rotating driven means for imparting a high false twist to a traveling yarn which may be drawn through the rotating spindle means.

A still further object of the present invention is to provide a hollow floating driven spindle through which a traveling yarn may be passed to envelop a transverse yarn supporting means for imparting a false twist to the yarn as the driven floating spindle rotates and whereby the floating spindle may be rotated at very high rotational speeds by means of an appreciably slower driving rotating means either by direct rolling contact between the slower rotating means and the driven hollow spindle or by means of a flexible connector link interposed between the driving means and the driven floating spindle.

A further object of the present invention is to provide freely rotatable yarn guide roller means supported on a high speed spindle for imparting a false twist to a traveling yarn about which roller means one or more turns of the yarn may be wrapped and the yarn prevented from tracking on itself.

Yet another object of the present invention is the provision of a yarn guide roller means that may be mounted in the head of a rotating hollow spindle through which spindle a traveling yarn may be drawn and wrapped about the roller means to guide the yarn substantially in straight-line travel into the hollow spindle to the point of yarn departure from the roller means so that the yarn will not track on itself thereby avoiding fraying of the yarn filaments and ballooning as much as possible.

Another object of the present invention is to provide novel bearing locking means for maintaining bearing alignment and retaining a bearing raceway within a bearing housing without the raceway creeping or rotating with a rotating shaft.

Other and further objects and many of the attendant advantages of this invention will become more readily apparent as the invention becomes better understood from the following detailed description taken in conjunction with the accompanying drawings in which like characters of reference designate corresponding parts throughout the several views and wherein:

FIG. 1 is a front elevational view with portions and sections removed of one embodiment of the present invention;

FIG. 2 is a top plan view illustrating the embodiment of FIG. 1;

FIG. 3 is a front elevational view of another embodiment of the present inventive concept;

FIG. 4 is a top plan view illustrating the embodiment of FIG. 3;

FIG. 5 is a side elevational view of the embodiment illustrated in FIGS. 3 and 4;

FIG. 6 is a partial perspective view of a false twist hollow spindle and the related driving and idler components of the embodiment of FIGS. 3 to 5, in a disengaged relationship;

FIG. 7 is an enlarged front elevational view of a modified false twist head for mounting on a hollow spindle;

FIG. 8 is a transverse sectional view taken substantially along the plane of line 8—8 of FIG. 7;

FIG. 9 is an enlarged partial sectional view of a bearing housing illustrating the bearing raceways and anti-creep rings in position; and

FIGS. 10, 11 and 12 illustrate various anti-creep bearing rings employed with the present invention.

As is well understood in the art a crimp or torsional twist may be imparted to a continuously traveling yarn to incorporate a stretch or crepe effect by subjecting the traveling yarn to a false twist and then applying a suitable heat treatment to the yarn while it is in the twisted condition. In producing stretch nylon yarns the thermoplastic yarn is subjected to a high twist by means of a false twist apparatus along a traveling linear increment and that portion having the twist imparted is subjected to a yarn twist-setting atmosphere. Upon leaving the false twist apparatus some of the twist imparted may be removed leaving the yarn in a crimped or torsionally distorted condition as it is collected into a yarn package. With the introduction of the continuous process of producing stretch nylon yarns as well as other superpolyamidic yarns, the rate of yarn production is controlled to a large extent by the degree of twist impartation to the traveling yarn. At present the rotational speeds of false twist apparatus is limited primarily by the type of bearings employed as the bearings are not designed for speeds in excess of 30 to 50,000 r.p.m. The lubricants available are inadequate to dissipate the very high heat generated by the rotating spindle in the bearings at the very high speeds of rotation or to provide adequate lubrication for the bearings thus resulting in frequent bearing failures.

The apparatus of this invention is concerned with a means for increasing the production of crimped yarns by imparting a false twist in a fast moving continuously linearly traveling yarn without the ever present limitations experienced by bearing seizure or freezing and other bearing failures. The apparatus utilizes the principle known in mechanics and kinematics that the angular velocities of two rotating bodies in direct contact or connected by a flexible connector are inversely proportional to the corresponding radii of rotation.

Referring initially to FIGS. 1 and 2 there is illustrated a supporting spindle framework **20** that may be mounted in a suitable manner to a twister base frame through the threaded stud **21** and locking nut **22**. The spindle framework **20** will be positioned on the twister base frame so that the linearly traveling driving tape or belt **23** will engage an exposed portion of the vertical shaft or whorl **24** with sufficient frictional contact to rotate the shaft within the bearings **25** and **26**. The bearings **25** and **26** are retained in the aligned bored openings **27** and **28**, respectively, in the spindle framework and prevented from rotating by means of anti-creep bearing retainer rings **29**, to be described hereinafter, which rings are seated in peripheral ring grooves **30**. A crowned driving pulley **31** is keyed to the top exposed portion of the driving shaft **24** and locked to the shaft by the cap screw **32** so as to rotate with the shaft **24**.

An idler shaft **33** is supported for rotation in the auxiliary bearing housing **34** which is mounted on the cantilever platform **35** of the spindle framework. Bearing housing **34** is bored to receive an eccentrically bored sleeve member **36** in which the bearings **37** and **38** are retained in a manner similar to the construction illustrated in FIG. 8 and described above. Clamping screws **39** are passed through the housing wing bosses **40** in order to compress the housing bore sufficiently to prevent rotation of the sleeve member **36** within the housing **34**. The eccentrically bored sleeve member **36** is provided with a lever **41** for rotating the sleeve member with the shaft **33** in order to displace the shaft **33** in the housing **34** with respect to the shaft **24**, as will be described more fully below.

Shaft **33** projects both from the top and bottom of the housing **34** sufficiently to have fastened at either end a crowned idler pulley **43** and **44**. Idler pulleys **43** and **44** preferably have the same diameter as the driving pulley **31** and each of the idler pulleys are secured to the ends of the shaft **33** by means of fastening screws **45**.

A hollow spindle **46**, also referred to as a hollow tube, provided with axially spaced crowned rings **47**, **48**, and **49**, which rings may be integrally formed on the spindle, is suspended through the spindle framework opening **50** and between the pulleys **31** and **43**, **44** by means of the flexible belt connectors **51**, **52**, and **53**. The driving belt **51** encircles pulley **31** and the intermediate spindle crown ring **48** with the idler or supporting tension flexible connector belts **52** and **53** encircling the spindle crowned rings **47** and **49** and pulleys **43** and **44**, respectively.

An enlarged spindle head **54** is provided at one end of the spindle with an opening **55** in which to mount the yarn roller guide **56**. Roller guide **56** may be positioned on the roller guide shaft **57** for rotation transversely across the path of travel of a yarn **58** emerging axially through the longitudinal core **59** in the hollow spindle. As illustrated in FIG. 1, the yarn **58** will enter at the lower end of the spindle **46** through the longitudinal core and emerge at the top of the spindle opening and one or more convolutions of the yarn may be wrapped around the roller guide **56** before the yarn will be conducted to a bobbin or other yarn packaging device above the spindle. It will be evident that in some applications the guide roller **56** may be located at the bottom of the hollow spindle. Obviously care must exercised to prevent the yarn that is moving continuously through the hollow spindle from being drawn over the guide roller in such a manner as to track back on itself thereby fraying or severing the yarn filements. This feature will be described in further detail below.

It will be readily apparent that when required suitable flanges may be incorporated with the crowned portions of the pulleys as well as the crowned rings on the hollow spindle. In installing the unit for operation, the hollow spindle may be mounted between the pulleys by initially rotating the lever **40** so as to position the idler shaft **33** as close to the shaft **24** as the structure will permit. With the belts mounted in position on the pulleys and the hollow spindle, the lever **41** may be rotated to apply a suitable tension to the individual belts after which the housing locking screws **39** may be tightened to secure the sleeve **36** in the desired position.

The linear velocity of the pulley **31** may be transmitted to the spindle crown **48** in order to rotate the floating spindle **46**. Obviously with sufficient tension applied to the belts **52** and **53** the spindle **46** may be maintained in a vertical upright position. Assuming there is no loss in the transmission with the use of flexible belt connectors, the velocity ratio relation for the inner surface of the belt as well as for direct contact surfaces which will be set forth hereinafter will be as follows:

$$NsRs = NdRd$$

$$\text{Velocity Ratio} = \frac{Ns}{Nd} = \frac{Rd}{Rs}$$

Where in FIG. 1:

Ns=r.p.m. of the driven spindle **46**

Nd=r.p.m. of the driving pulley **31**

Rs=radius of the driven spindle **46**

Rd=radius of the driving pulley **31**

(Crown dimensions have been neglected.)

Although it is recognized that the actual value of the velocity ratio will be less than obtained by the above equation this loss will be due primarily to slip and creep of the belt and in most applications this loss will vary from 2 to 4 percent, thus in this application it will be neglected.

A further embodiment of the present inventive concept is illustrated in FIGS. 3 through 6 in which the supporting spindle framework **64** may be fastened to a twister base frame through the threaded stud **66** and a suitable locking nut, such as the nut **22** shown in the first described form. Framework or housing **64** is provided further with axially spaced bosses **67** and **68** which are bored to receive the bearings **69** and **70** therein in a manner to be described below. The medial portion of the shaft or whorl **65**, supported in the bearings **69** and **70**, is exposed to be contacted by the linearly traveling belt **71** which is driven by a conventional twister driving mechanism (not shown).

Framework **64** is formed with laterally extending and upwardly projecting wing sections **72** and **73** from which extend the pulley arm supporting bosses **74** and **75**. Roller-supporting arm boss **74** is drilled to receive the roller arm shaft **76** which in turn will pivotally support the roller arm **77** and the spring retaining disk **78** in fixed relation. A helical spring **79** encircles the shaft **76** with one end of the spring being fixed to the bottom boss **80** of the roller arm **77**. The other end of the helical spring **79** is fixed to the disk **78** so that the roller arm will be biased to pivot in a clockwise direction as shown in FIG. 4. The right roller arm **81** is fixed to the framework and the end of the arm recahes toward the roller arm **77** in a counter-clockwise direction forming an acute angle with the central portion of the framework.

A driving roller **82** is securely fastened at the top end of the shaft **65** and idler rollers **83** and **84**, having substantially the same diameter as the roller **82**, are rotatably mounted on the roller arms **77** and **81**, respectively. It will be quite evident that rollers **82** and **84** will remain in fixed positions for rotation while the roller **83** will rotate at the end of the roller arm **77** which arm will normally urge the roller **83** into tangential contact with the rollers **82** and **84** as the rollers rotate in substantially the same plane about different vertical axes.

A hollow continuous uninterrupted wall spindle **85** having a grooved yarn roller guide **86** which is rotatably mounted on a roller guide shaft **87** is positioned for substantially tangential contact and support by the rollers **82**, **83**, and **84**. A yarn **88** is drawn vertically through the longitudinal opening **89** in the hollow spindle and is wrapped about the yarn guide roller **86** to provide sufficient tension in the vertical reach between the roller and a yarn tension device (not shown) as the yarn is false twisted during its vertical travel. The yarn is removed from the guide roller continuously to be wound on a bobbin to form a suitable yarn package.

It has been found desirable in some forms of this embodiment wherein direct rolling contact is employed to provide the periphery of the rollers **82** and **84** with a raised peripheral contact surface, such as the ring or tire formation **90**. In some applications the rings **90**, shown as being axially spaced from each other on the roller periphery, may be made of rubber or other suitable material having a high coefficient of friction. The roller **83** is illustrated as a cylindrical disk having a straight peripheral surface **91** for engaging the periphery of the spindle **85** intermediate the grooves **92** on the spindle in order to urge the spindle into tangential engagement with the other rollers **82** and **84**.

When the rollers **82** and **84** are used with the ring contact surfaces, the spindle **85** is preferably provided with ring receiving circumferential grooves **92** into which grooves the rings **90** will register loosely as the spindle is supported by the rollers in driving relationship.

During operation sufficient bias will be exerted by the spring **79** connected to the pivoted arm **77** to urge the roller **83** into constant contact with the spindle periphery so that the spindle may be floatingly supported without bearings by tangential contact with the rollers **82**, **83**, and **84**. Furthermore, the inverse velocity ratio relationship of the previously described apparatus will be equally applicable to this form of the invention.

Frequently the outer bearing raceways have a tendency to turn within a bearing housing during high speed rotation of the spindle particularly when the tolerance between the two is not controlled accurately. In high speed apparatus the raceways may tend to rotate within the housing quite rapidly and gradually some wear will occur. It is only after a shaft becomes misaligned or binds will this condition become noticed. Normally it is necessary to shut down the apparatus while repairs are being made to the bearings and to the housings. To eliminate relative raceway rotation the bearing housings, such as the bosses **67** and **68**, similar to the bored bearing openings **27** and **28**, clearly shown in FIG. 9, are provided with circumferential grooves **100** that are axially spaced from each other to seat the anti-creep split resilient rings **101**, **102**, and **103** therein before insertion of the bearings **104** into the bearing housings. Each split ring may be made of a resilient wire and is provided with substantially uniform chord lengths which tend to protrude partially beyond the wall of the bearing receiving bore. One combination of rings found to be very satisfactory for use is the series of rings shown in FIGS. 10, 11, and 12. The ring **101** is provided with flats or chords **104** which may be on the order of $\frac{3}{32}$ inches, ring **102** will have a chord length **105** in the order of $\frac{1}{8}$ inch, with the ring **103** having a chord length **106** of $\frac{3}{8}$ inch. The circumferential grooves **100** are positioned so as to receive a ring therein with the edge of the outer raceway seated directly against the ring. When a bearing is seated into the bearing opening the individual rings being of resilient material tend to spread radially outwardly sufficiently while still engaging the surface of the bearing outer race to prevent relative rotation within the bearing housing. The chord lengths **106** of ring **103** project sufficiently into the bearing opening to limit axial displacement of the bearing once the bearing is positioned into the bearing opening.

At the very high rotational speeds that are employed in the false twisting art there is a tendency for the traveling yarn which encircles the roller guide **56** to track on itself, due primarily to the high centrifugal action incurred at the high spindle speeds. There is also a tendency for a large ballooning arc to be produced when the traveling yarn is introduced to the guide roller off-center and leaves the roller from an off-center position, as is clearly shown in FIG. 4. Some ballooning effect may be eliminated by mounting the guide roller in an offset position from the longitudinal axis of the spindle in order to permit the yarn to engage the roller tangentially in a direct straight linear path of travel. Also, with the yarn being wrapped about the yarn roller with the desired number of convolutions, the yarn may leave the roller in substantially the same linear path as the initial contacting yarn. Although displacing the guide roller from the center position may reduce ballooning and frayed filaments due to tracking at the lower speeds of rotation, unbalance and some ballooning will continue to be major problems at greatly increased speeds of spindle rotation.

FIG. 7 illustrates one means found to be efficacious for reducing yarn tracking, filament fraying and ballooning at reduced or increased speeds of spindle rotation. The guide roller head **110** is threadably fastened to the upper end of a hollow spindle such as **46** or **85**. A transverse opening **111** in the spindle head facilitates threading the yarn **112** as it leaves the longitudinal opening **113** of the hollow spindle and tangentially engages the periphery of the lower yarn guide roller **114** of the vertically spaced yarn guide **114** and **115**. Lower yarn guide roller 114 is rotatably mounted on the upwardly inclined shaft 117 which shaft is fastened to the head by means of the fastening set screw 118. Shaft 117 is mounted so as to present the cylindrical yarn contacting surface 119 of the lower roller 114 in surface tangential contact with the upwardly traveling yarn without having the yarn deviate from its linear course of travel. Limit flanges 120 are provided on the roller 114 to confine the yarn within the reduced cylindrical surface of the roller. A single yarn convolution 121 is made about the roller surface 119 with the yarn convolution making an helical turn to the right with the yarn leaving the roller on the same side as the yarn was introduced to the lower roller. A second or upper roller 115 is spaced vertically above the first roller 114 and rotatably mounted on the downwardly inclined shaft 123. Shaft 123 may be displaced out of the vertical plane of the first roller on the opposite side of the yarn, that is, on the other side of the longitudinal axis of the spindle as the yarn enters the head 110 with the roller shaft 123 being secured to the head by means of the fastening screw 124. Roller 115 is also provided with limit flanges 125 and a cylindrical surface 126, similar to roller 114.

The yarn 112 leaving the front side of the roller 114 is introduced directly to the rear side of the forwardly displaced roller 115. A single open helical yarn convolution about the cylindrical surface 126 to the left will return the yarn to the original center of the yarn travel permitting the yarn to leave the rear side of the roller 115 directly in line with the longitudinal opening 113 in the spindle and the discharge passageway 116 at the top of the spindle head. As is quite evident the directional sense of roller rotation is in opposite directions to each other.

It is contemplated that the axis of shafts 117 and 123 will intersect at some point beyond the spindle and the included angle therebetween will be less than 180° to provide the requisite pitch of the helical yarn convolution. In some applications the yarn guide rollers may be replaced by similar elements of a tubular or other configuration and affixed to the spindle head without any rotation. Furthermore the yarn guide rollers or similar means may be displaced on the same side of the spindle axis with both helical yarn convolutions wrapped in the same direction.

Obviously when the spindle head having the double yarn rollers is employed at high rotational speeds the spindle head may require accurate initial balancing in order to eliminate any possible vibration effects which may be encountered.

One illustrative example of the dimensions employed in each of the embodiments without intending in any manner to limit the infinite number of combinations possible is as follows:

For the belt driven spindle: A 3 inch diameter driving roller rotating at 15,000 r.p.m. will rotate a hollow spindle 3/8 inch in diameter at the rate of 120,000 r.p.m.

For the direct driven spindle: A 3 inch diameter roller rotating at 20,000 r.p.m. will rotate a hollow spindle 1/4 inch in diameter at the rate of 240,000 r.p.m.

Thus there has been described a high speed false twist apparatus in which the spindle may be driven either by means of a flexible connector or by a direct rolling contact with a driving roller with the spindle being rotated in a floating or freely suspended manner without being supported in a roller or other type bearing. The driving and driven relationship conforming in an inverse angular velocity relation whereby the speeds of rotation are related to each other inversely as the radii of the driving roller and the driven spindle.

Obviously, many modifications and variations may be made in the construction and arrangement of the driving and idler rollers as well as the positioning of the floating bearingless spindle located between the driving roller and the idler rollers whether in direct contact or in open or closed flexible connector relation in the light of the above teachings without departing from the real purpose and spirit of this invention. It is, therefore, to be understood that within the scope of the appended claims many modified forms of the present inventive concept as well as the use of alternatives and mechanical equivalents may be reasonably included and modifications are contemplated.

What is claimed is:

1. A high speed spindle apparatus for imparting a positive twist to a rectilinearly traveling yarn for individual mounting on a twisting apparatus in which a whorl driving belt provides the driving power for the spindle apparatus comprising: a framework to be mounted adjacent to a driving belt, a belt-engaging whorl rotatably supported on a fixed axis in said framework between axially spaced apart bearings, a circular member mounted on said whorl at one end thereof for rotation therewith, axially spaced apart circumferential twist tube engaging elastic ribs mounted on the circular member, a shaft bearingly mounted to revolve about a fixed axis in spaced parallel relationship to said whorl on the framework, a circular member mounted to rotate with said shaft and having axially spaced apart circumferential twist tube engaging elastic ribs thereon, a continuous tubular wall member substantially smaller in diameter than the diameter of either of said circular members, said tubular member having means for positively twisting a rectilinearly traveling yarn and for supporting a convolution of said yarn thereon passing through said tubular member, said twist tube member having axially spaced apart circumferential recesses for cooperatively receiving the circular member ribs therein, and means for urging said twist tube member into cooperative rotatable relationship with said circular members, said means for urging said twist tube member into driving relationship with said circular members including a circular member mounted for rotation on said framework and biasing said twist tube member into engagement with said circular members.

2. A high speed spindle apparatus for imparting a positive twist to a rectilinearly traveling yarn for individual mounting on a twisting apparatus in which a whorl driving belt provides the driving power for the spindle apparatus comprising: a framework to be mounted adjacent to a driving belt, a belt-engaging whorl rotatably supported on a fixed axis in said framework between axially spaced apart bearings, a circular member mounted on said whorl at one end thereof for rotation therewith, axially spaced apart circumferential twist tube engaging ribs mounted on the circular member, a shaft bearingly mounted to revolve about a fixed axis in spaced parallel relationship to said whorl on the framework, a circular member mounted to rotate with said shaft and having axially spaced apart circumferential twist tube engaging ribs thereon, a continuous tubular wall member substantially smaller in diameter than the diameter of either of said circular members, said tubular member having means for positively twisting a rectilinearly traveling yarn and for supporting a convolution of said yarn thereon passing through said tubular member, said twist tube member having axially spaced apart circumferential recesses for cooperatively receiving the circular member ribs therein, and means for urging said twist tube member into cooperative rotatable relationship with said circular members.

3. A high speed spindle apparatus for imparting a positive twist to a rectilinearly traveling yarn for individual mounting on a twisting apparatus in which a whorl driving belt provides the driving power for the spindle apparatus comprising: a framework to be mounted adjacent to the driving belt, a belt-engaging whorl rotatably supported on a fixed axis in said framework, revolving means mounted on said whorl having

axially spaced apart circular twist tube engaging frictional surfaces, revolving means mounted about a fixed axis on said framework in spaced relationship to said whorl having axially spaced apart circular twist tube engaging frictional surfaces, a tubular twist tube member having uninterrupted inner and outer walls and having a diameter less than one-fifth the diameter of the said revolving means, said twist tube member having a longitudinally extending core through which a traveling yarn passes and means for supporting a convolution of yarn thereon fixed adjacent to one end of said member, said twist tube member having means for restricting axial displacement thereof, and means urging said twist tube into driving relation with said twist tube engaging frictional surfaces.

4. A high speed spindle apparatus as claimed in claim 3 and wherein said twist tube urging means is a rotatable roller pivotally mounted on said framework.

5. A high speed spindle apparatus as claimed in claim 3 wherein said yarn supporting means has a yarn-receiving groove therein.

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