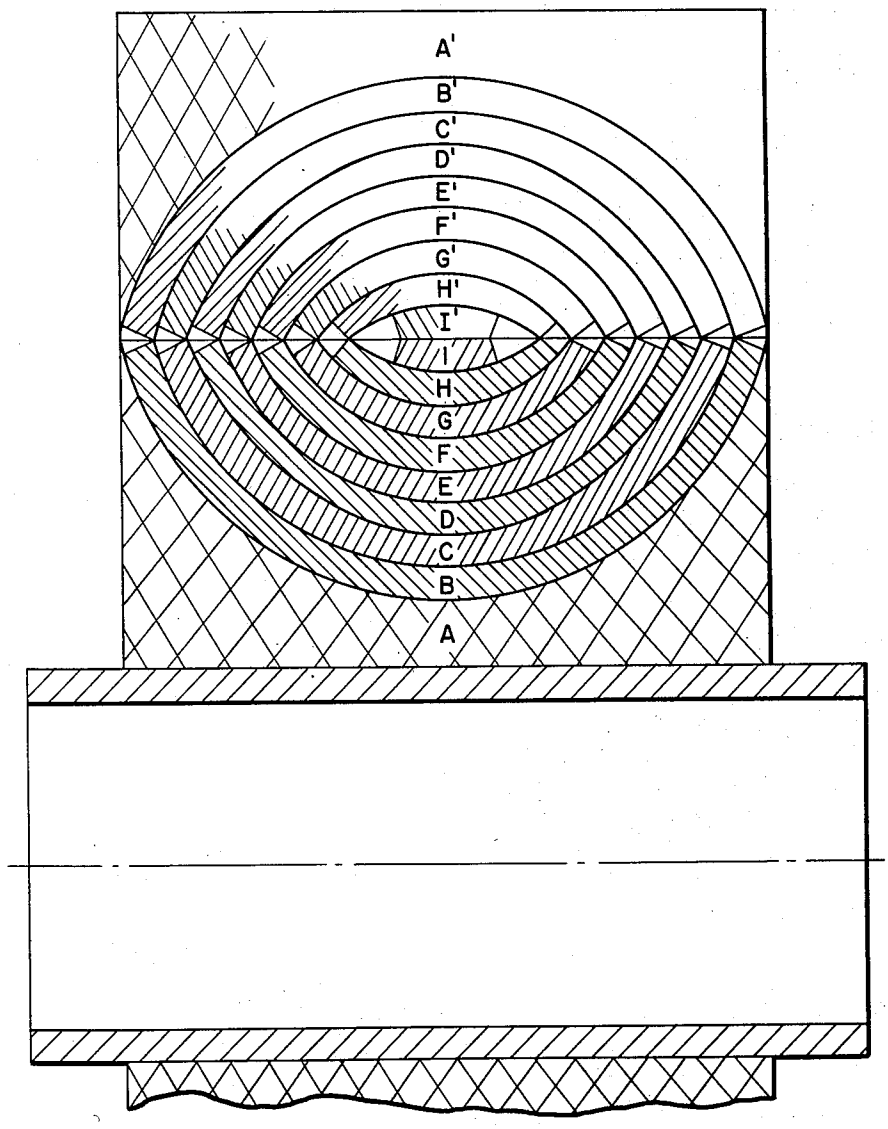
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METHOD AND APPARATUS FOR YARN TRAVERSE

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Fig. 1



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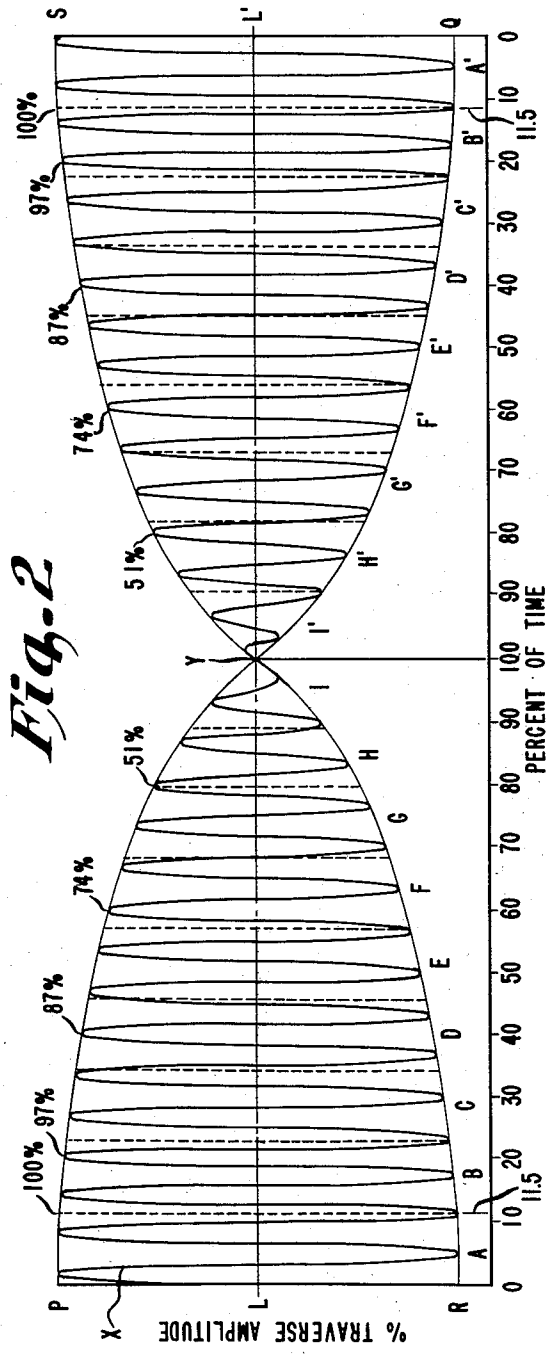


Fig. 2

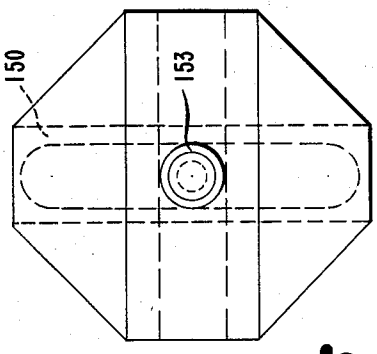


Fig. 16

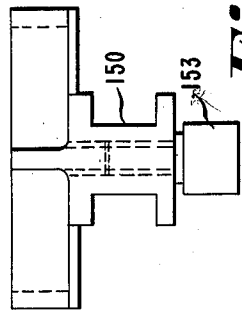


Fig. 15

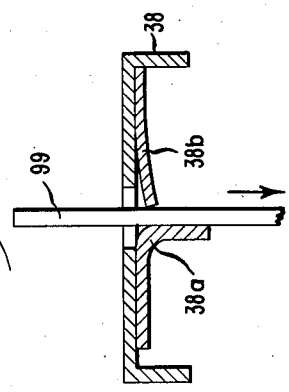


Fig. 8

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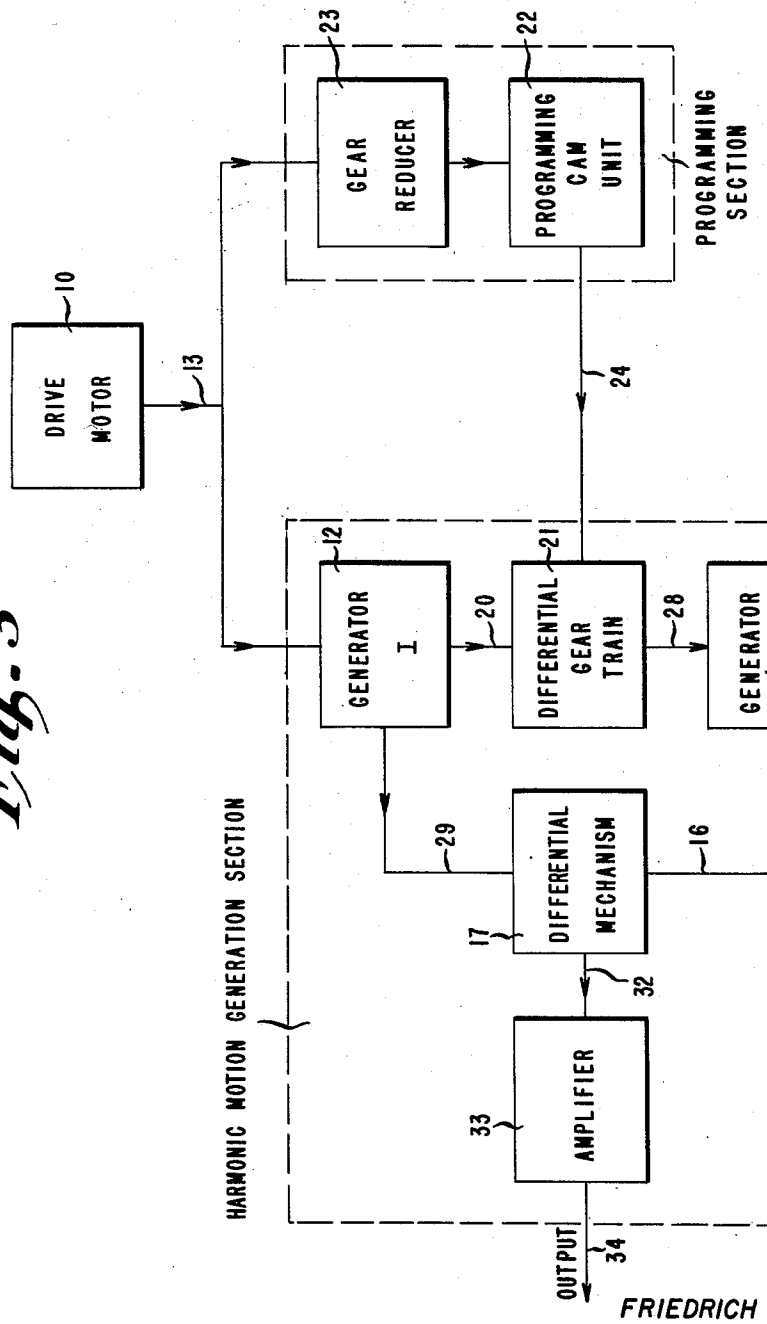


Fig. 3

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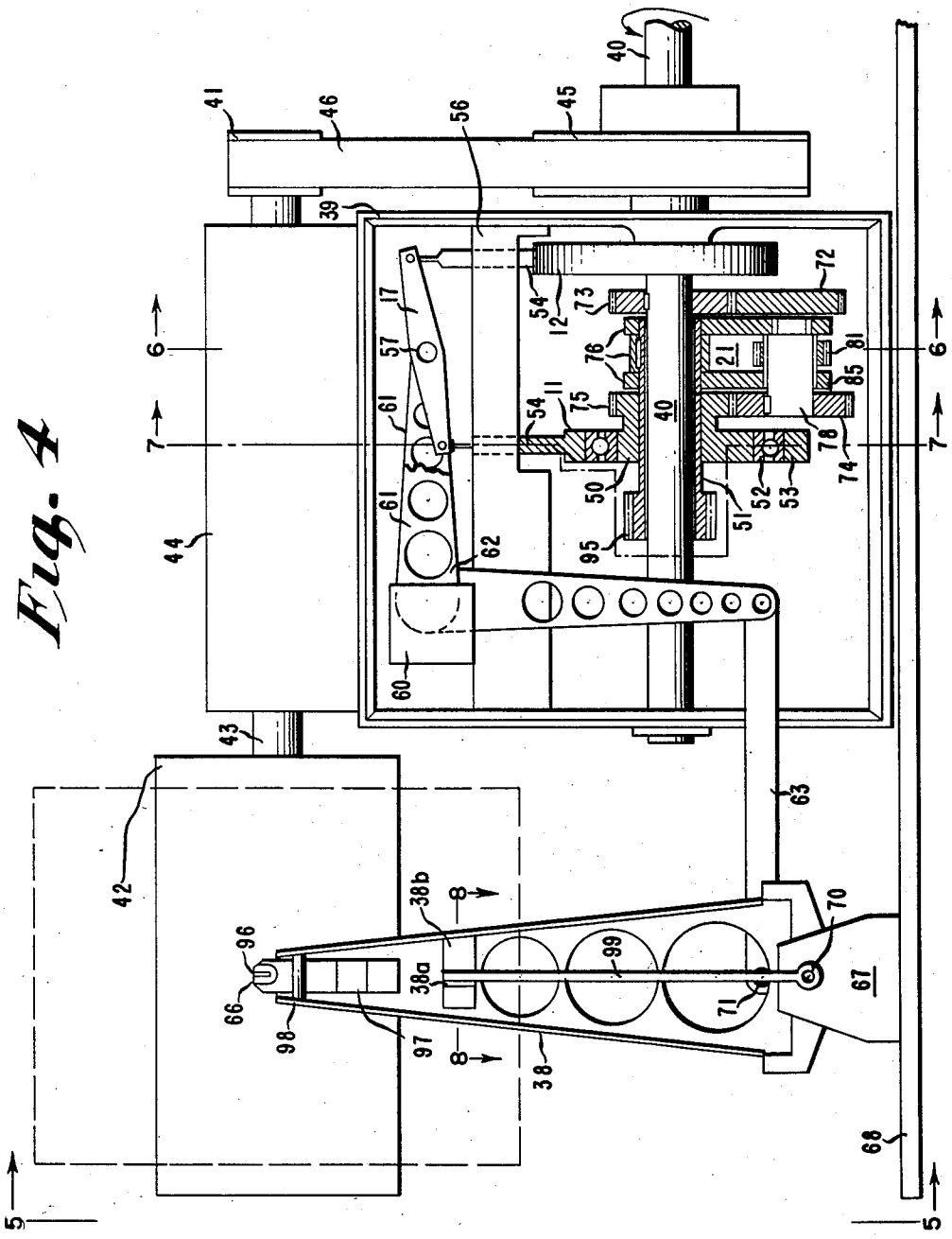
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Fig. 4



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Fig. 6

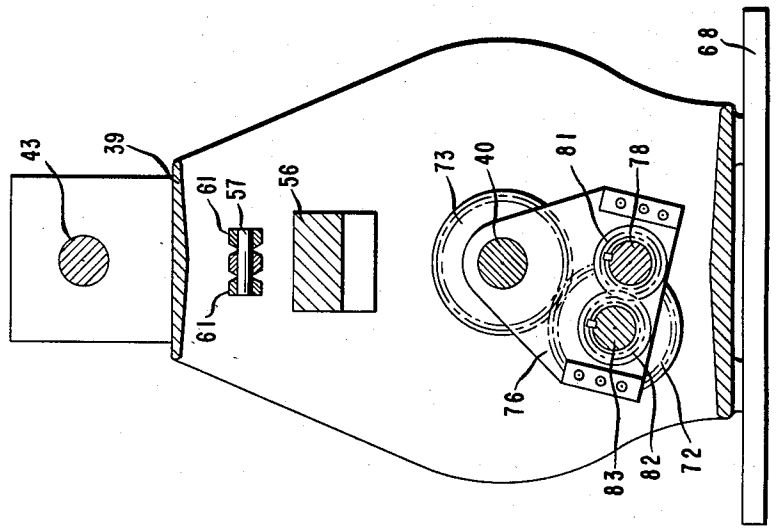
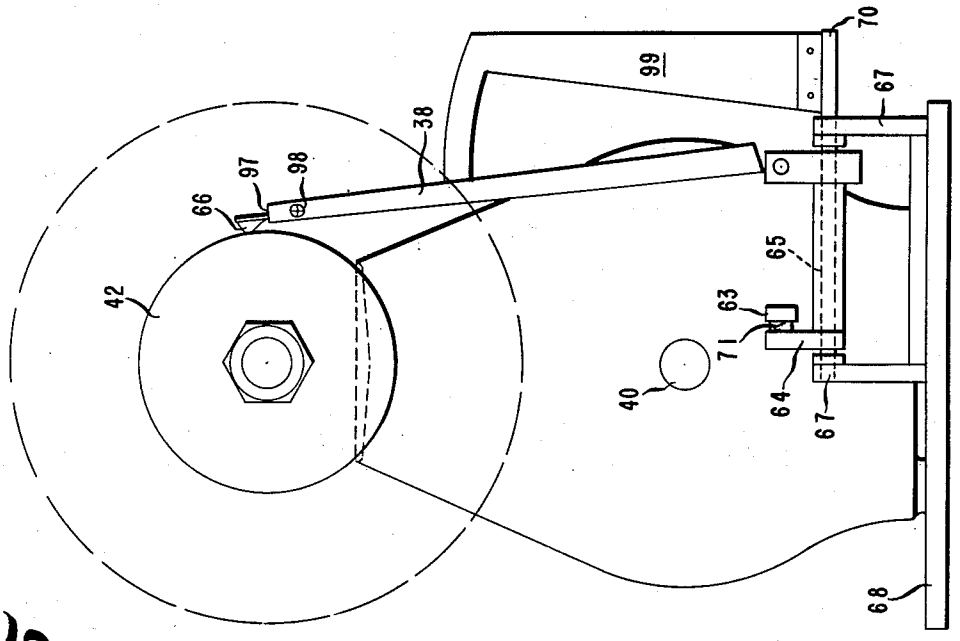


Fig. 5



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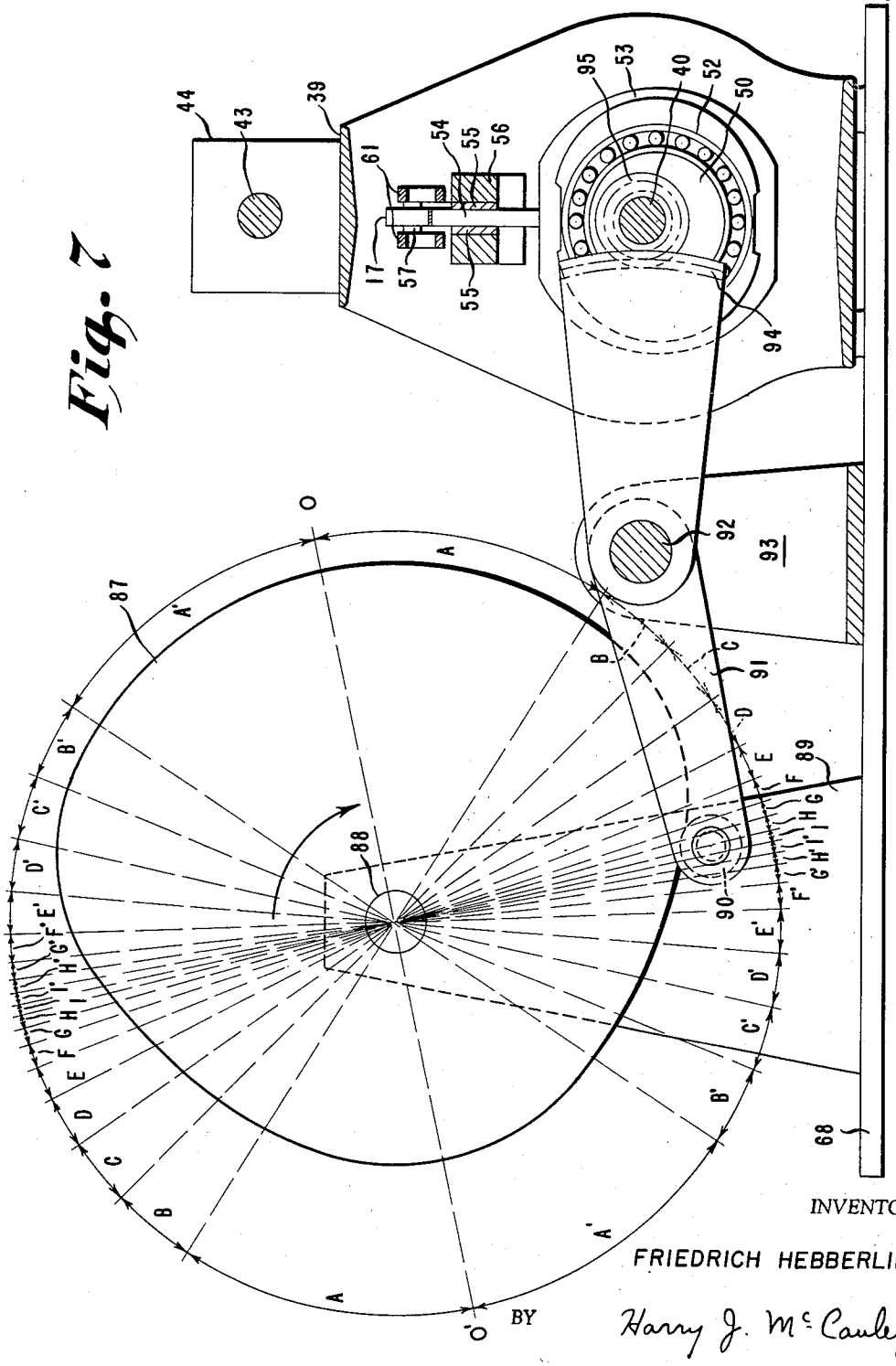
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Fig. 7



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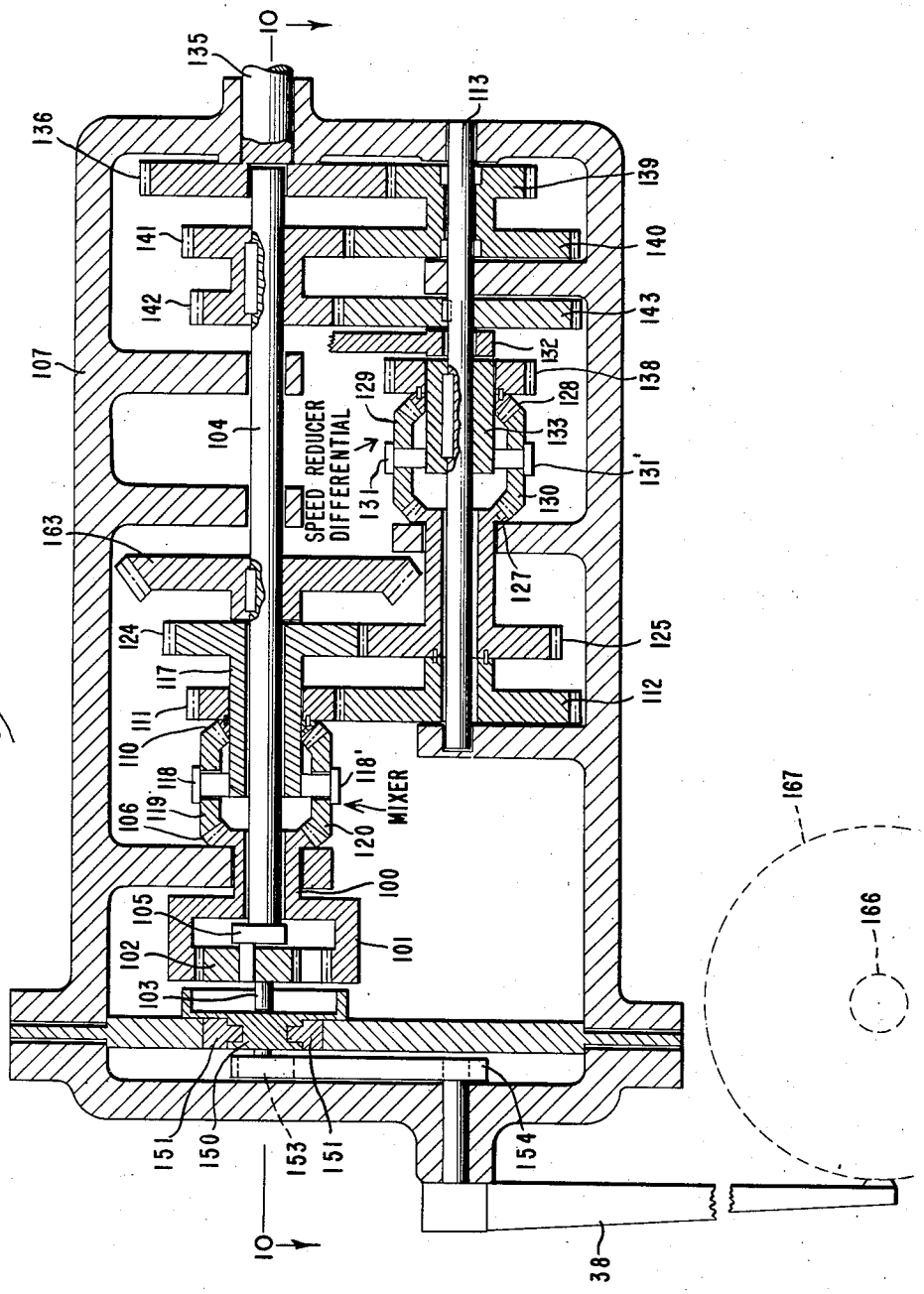
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Fig. 9



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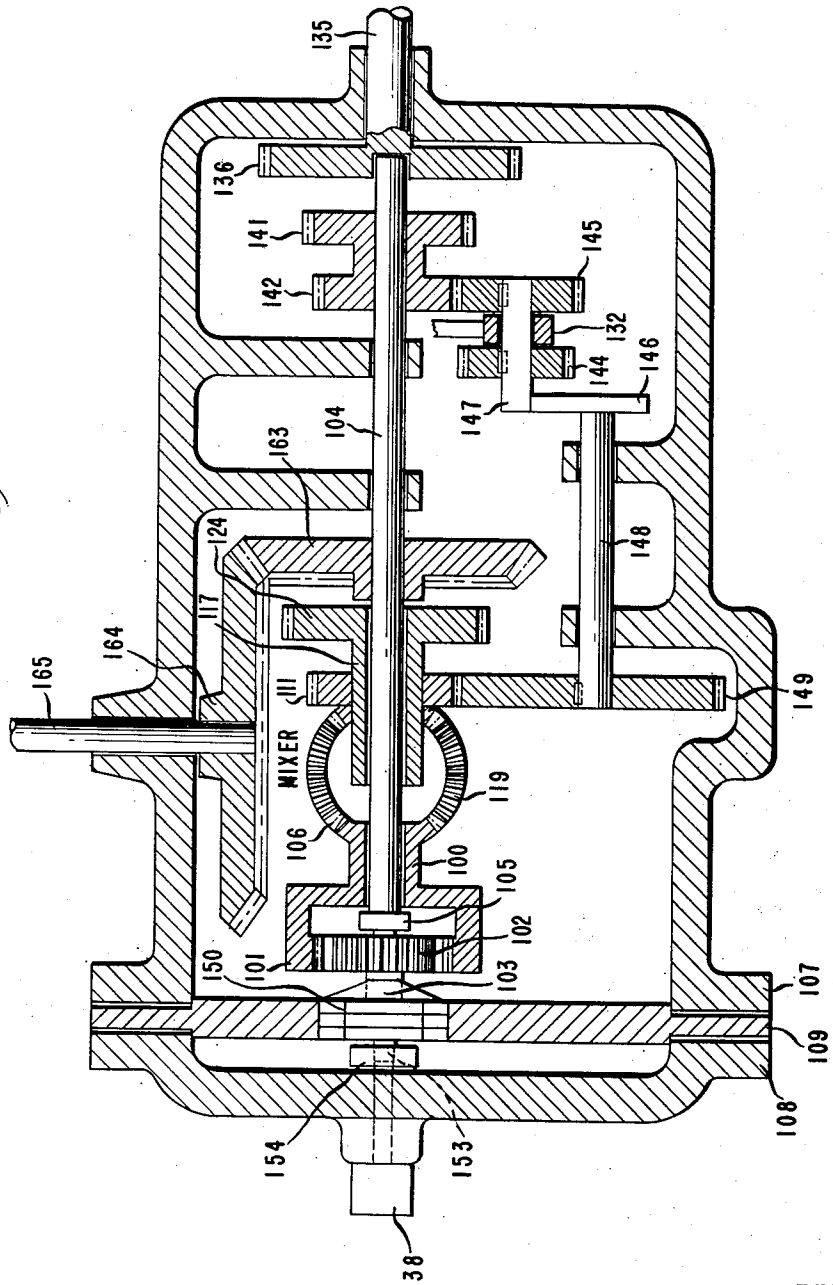
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METHOD AND APPARATUS FOR YARN TRAVERSE

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Fig. 10



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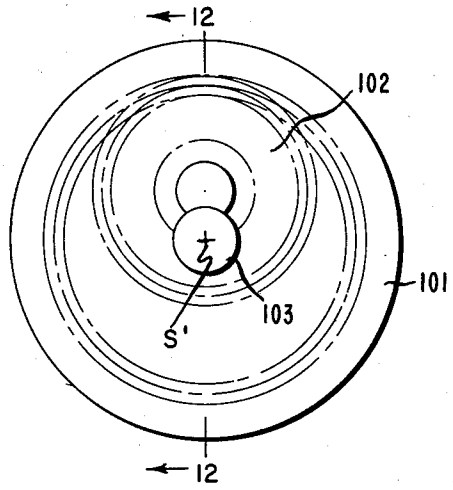


Fig. 11

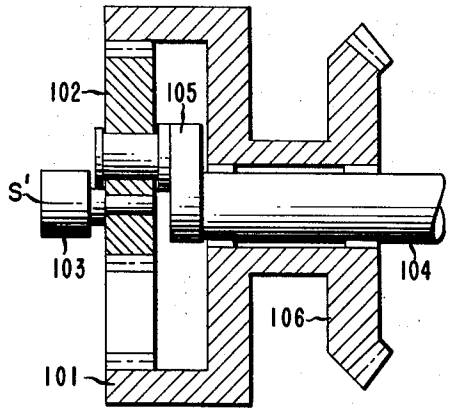


Fig. 12

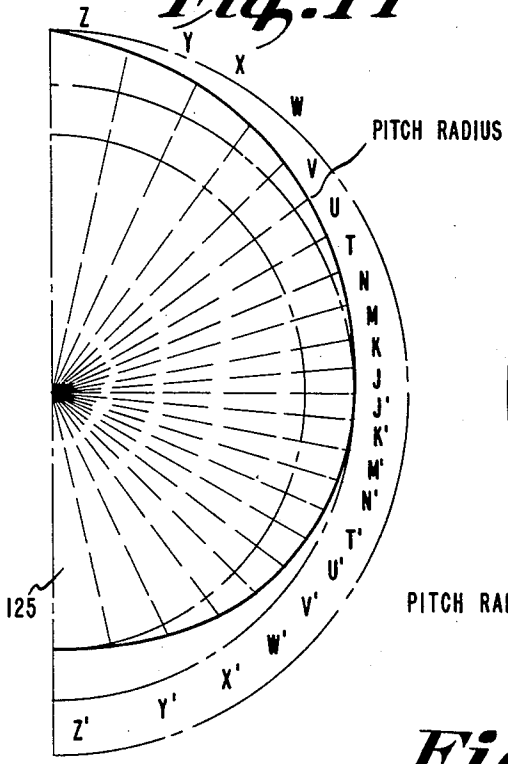


Fig. 13

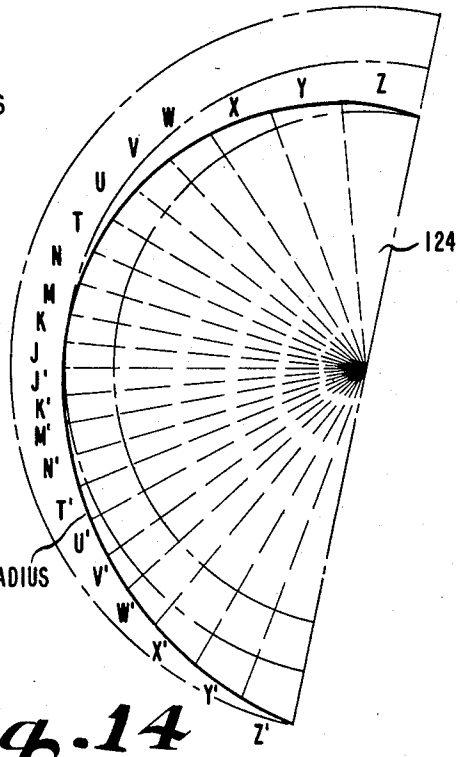


Fig. 14

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United States Patent Office 2,848,173
Patented Aug. 19, 1958

2,848,173

METHOD AND APPARATUS FOR YARN TRAVERSE

Friedrich Hebberling, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Application September 5, 1956, Serial No. 608,158

10 Claims. (Cl. 242—43)

This invention relates to a method and apparatus for the traverse of filamentary materials during windup, and particularly to a method and apparatus for effecting the traverse of a filamentary material such as a textile yarn which is adapted to operate at very high processing speeds up to about 6000 yards per minute with the obtainment of improved yarn packages or cakes, and also improved lay down.

The manufacture of synthetic textile yarns has been improved by advances in technology to the point where spinning and drawing speeds of the order of about 6000 yards per minute are feasible; however, actual production is limited to considerably lower processing rates due to the fact that available yarn traverse methods and mechanisms are incapable of operation at these high speeds. Conventional yarn traversing during windup is incapable of producing satisfactory packages at high speeds because of inherent deviation from the ideal wind pattern. This ideal wind pattern can be defined as one which, on traversal of yarn lay down, will lay a uniform amount of yarn at each increment across the width of the receiving package. Such a wind pattern may be visualized as a zigzag line wherein traverse reversals are accomplished in an infinitely short time. This is necessarily an idealized conception, because it is impossible to effect an instantaneous reversal of traverse. Also, most existing apparatus which has been devised to reverse traverse at very high speeds possesses the disadvantage that relatively high wear occurs during service. This has imposed a ceiling on efforts at speed-up of most traverses and actual mill processing speeds are today very much less than 6000 yards per minute.

An object of this invention is to provide a traverse method and apparatus adapted to wind yarn or other filamentary material in high quality packages at supply speeds up to 6000 yards per minute, and above. Other objects of this invention comprise the provision of a traverse method and apparatus which is adapted to wind yarn packages onto cylindrical or tapered tubes, with either precision or random-wound operation, at the option of the operator, while obtaining a minimum of degradation of the yarn product. Other objects of the invention include the provision of a yarn traverse method and apparatus adapted to wind zero-twist yarns, and to give packages having a high maximum wind angle up to about 36°, all while reducing both wear and the noise encountered in traverse drive. The manner in which these and other objects of this invention are obtained will become apparent from the detailed description and the following drawings, in which:

Fig. 1 is an exaggerated schematic representation in cross section of the sequence of yarn windup according to this invention,

Fig. 2 is a diagrammatic representation of the general traverse wind pattern of this invention,

Fig. 3 is a schematic representation of one embodiment of this invention wherein programming of the traverse is obtained by utilization of a cam.

Fig. 4 is a sectional elevation through the differential gear train of the apparatus depicted in Fig. 3, showing also the harmonic motion generators, the output lever, the transmitting mechanism for the traverse guide, and the traverse guide itself,

Fig. 5 is a side elevation view of the yarn traverse guide arm and associated elements looking in the direction of 5—5, Fig. 4,

Fig. 6 is a section taken on line 6—6 of Fig. 4,

Fig. 7 is a section taken on line 7—7 of Fig. 4, showing also the associated programming cam and the cam follower connection,

Fig. 8 is a section on line 8—8 of Fig. 4 showing details of a friction trap auxiliary,

Fig. 9 is a sectional front elevation of a second embodiment of traverse apparatus according to this invention,

Fig. 10 is a section taken on line 10—10 of Fig. 9, with shaft 113 and its appurtenances, which lie behind shaft 104, omitted for clarity in representation,

Fig. 11 is a side elevation view of a generator adapted to effect programming of traverse for the embodiment of Figs. 9 and 10,

Fig. 12 is a sectional view taken on line 12—12 of Fig. 11,

Fig. 13 is a half development of the pitch radius profile of the driver gear of the non-circular gear pair 124—125 of Figs. 9 and 10,

Fig. 14 is a half development of the pitch radius profile of the driven gear of the non-circular gear pair 124—125 of Figs. 9 and 10,

Fig. 15 is a plan view of the slide assembly connecting the drive and traverse mechanisms of the embodiment of Figs. 9 and 10, and

Fig. 16 is a side elevation of the slide assembly of Fig. 15 looking toward the drive mechanism.

Generally, the method and apparatus for yarn traverse according to this invention comprises a controlled sequence of winding which employs a basic harmonic motion at maximum amplitude of the traversing guide for the lay down of yarn followed by successive stages of amplitude-modulated winding, also in harmonic motion, by which the package is filled in and thereafter built up to the point where a reverse basic lay down is again achieved, following which the entire cycle is, in effect, repeated as many times as required to obtain the desired package diameter.

Reciprocation of the yarn traverse element in harmonic motion according to this invention has the important advantage that accelerations and decelerations at the points of reversal of the traverse element are very much lower than with other motions. This advantage enables the employment of exceedingly high average traverse velocities which permit the windup of yarn at much higher speeds than is now possible.

Referring to Figs. 1 and 2, a schematic representation of the method of lay down according to this invention is set forth in exaggerated showing to facilitate understanding of the interrelationship between yarn lay down and traverse wind pattern. As represented to greatly magnified scale, traverse with basic harmonic motion is accomplished with build up of yarn in the generally concave cross section depicted at A. Windup in the basic step A occurs over about 11.5% of a single traverse half cycle, as indicated in Fig. 2, which is a plot of traverse amplitude versus time. The trace X of Fig. 2, is the true yarn lay and the area within the envelope can be considered the developed area within which winding is effected on the bobbin on which the package is built, it being understood that, for clarity in representation, only a very small number of yarn traverses is shown

for each traverse step such as depicted in Fig. 2, as will be hereinafter described in detail.

It is apparent from Fig. 1 that the dished yarn build-up of the basic period A, if utilized by itself and without anything more, would be objectionable because of resulting instability of the package, inability to unwind properly, and also because of the peculiar form thereof, even though very satisfactory traverse action is obtainable when the traversing guide is driven with harmonic motion. This inadequacy is cured by employing a multiplicity of winding stages progressively modulated in amplitude to fill in the concavity and thereby give a uniform diameter package throughout. The succeeding steps of the build-up therefore comprise filling in by lay down of a plurality of other yarn increments, only eight of which (B to I) are shown by broken line division in Figs. 1 and 2, although it will be understood that in practice there are a great many more, so that all voids in the package are completely filled and uniform yarn density is obtained throughout.

The successive yarn layers depicted as B through I are laid down as represented in Figs. 1 and 2 by an amplitude-modulated harmonic motion which narrows the traverse progressively to the zero point indicated at Y of Fig. 2, after which the reverse takes place with progressive widening of traverse as indicated from I' through B'. The final step comprises the reversely oriented basic harmonic motion denoted A', following which the entire cycle is, in effect, performed again for as many times as desired, depending on requirements. It will be particularly understood that, with the progressive modulation indicated by the smooth envelope of the curve of Fig. 2 there are no voids between the ends of opposed layers such as appear in the simplified showing of Fig. 1, and that a package of uniform density is obtained in the practice of this invention. The entire cycle of winding from A through A' deposits at most only about 1/16" of yarn on the bobbin, and it will therefore be apparent that the showing of Fig. 1 is very greatly exaggerated in a radial sense to facilitate illustration of the principles involved. In this connection it should be mentioned that it is not necessary to commence yarn windup at the beginning of, or at any other specific point in the cycle, due to the fact that yarn lay down during individual cycles is relatively so small that the effect is of no practical consequence.

As in conventional practice, the yarn input to the traverse mechanism is usually fairly constant speed, within about ±3% at least, but greater variations than this can be tolerated without deleterious results to the packages obtained. The embodiment of this invention shown in Figs. 3–8 is not adapted for as high operating speeds as the embodiment of Figs. 9–16 hereinafter described due to the inertia loads present in the machine elements, which cause objectionable vibrations at high speeds unless great care is taken in the design to compensate for these loads; however, the embodiment of Figs. 3–8 is capable of giving an improved yarn package over those obtainable with conventional traverse mechanisms and is, therefore, a completely practical embodiment of my invention.

Referring to Fig. 3, which is a schematic representation of the embodiment of Figs. 4–8, it will be seen that the apparatus as a whole can be considered as made up of two separate assemblies, which are supplied with power from a common motor **10**. The two assemblies constitute, first, a harmonic motion generation section and, second, a programming section adapted to effect the predetermined wind-up pattern control of the harmonic motion generation section by modulation of the amplitude of the traverse drive output.

In general, the harmonic motion generation section consists of a first harmonic motion generator **12** which may be considered the independent generator of the pair of which generator **11** is the other. As indicated by the line representation **13**, generator **12** is powered from motor **10** and transmits its output through the drive connection represented schematically at **29** to differential mechanism **17**. Generator **12** is at the same time connected through drive connection **20** to one of the three power connections of differential gear train **21**. Programming is achieved by direct connection of the programming cam **22**, driven from motor **10** through gear reducer **23**, by connection **24** with a second of the three drive connections of differential gear train **21**. The output from differential **21** is introduced into generator **11** through drive connection **28**. Generator **11** may thus be considered the dependent generator of the pair comprising **12** and **11**, and its output is delivered through drive connection **16** to differential mechanism **17**. Harmonic motion generators **11** and **12** are independent of each other as regards phase through the agency of the programming section acting on one of the generators only. The resultant output from **17** is delivered through drive connection **32** which may, optionally, drive a displacement amplifier **33** which, in turn, drives the traverse guide by direct connection therewith, indicated at **34**.

The apparatus of Fig. 4 constitutes a complete design, inclusive of all of the individual elements of Fig. 3, details being elaborated on in Figs. 5–8. As shown in Fig. 4, the entire drive apparatus is conveniently mounted within a common housing **39** and is supplied with power through drive shaft **40**, to which is keyed drive pulley **45**. The yarn bobbin is indicated at **42** and is disposed on spindle **43** journaled in bearings **44** and driven by pulley **41** connected to pulley **45** with timing belt **46**. Such a drive permits precision windup and is a convenient arrangement from this standpoint.

Drive shaft **40** extends through housing **39** and is journaled thereon.

The independent harmonic motion generator **12** of Fig. 3, which is the right-hand generator of Fig. 4, is driven by direct connection with drive shaft **40**, whereas generator **11**, the left-hand generator of Fig. 4, is driven in part from generator **12** and in part from programming cam **22** (not shown in Fig. 4) through the differential gear train indicated generally at **21** in Fig. 4.

Harmonic motion generators **11** and **12** are identical in construction and are detailed in Figs. 4 and 7. The generators consist of a circular plate **50** journaled eccentrically on drive shaft **40**, in the case of generator **12**, and eccentrically on hollow shaft **51**, journaled concentrically on shaft **40**, in the case of generator **11**. As shown most clearly in Fig. 7, although also in the sectional showing of generator **11** in Fig. 4, each plate element **50** is fixedly mounted within a concentric ball bearing assembly **52**, the outer race of which is snugly fitted within yoke strap **53**, sufficient clearance being provided between the inside periphery of the yoke strap and bearing **52** to permit lateral movement therebetween. The construction of the generators is thus that of a Scotch yoke which is adapted to convert rotary motion into simple harmonic motion through the agency of reciprocating rod **54** fixedly secured to yoke strap **53**. Rods **54** are guided in ways **55** provided in frame cross member **56**. The output motions of generators **11** and **12** are taken off by pinned connections at opposite ends of differential mechanism **17** which, in this construction, is simply a centrally fulcrumed lever. The lever of **17** is journaled on pin **57**, which is attached at the ends to the two arms **61** (Fig. 7), making up one element of the bell crank indicated generally at **62** pivotally supported on bracket **60**. The other arm of bell crank **62** is joined by pin connection with transmitting link **63**, which is in turn pinned at **71** to the end of crank **64** (refer Fig. 5), which drives the yarn traverse guide **66** through annular extension **65**, pinned to shaft **70**, which is journaled in bracket **67** attached to the common base **68** of the apparatus. Yarn traverse guide arm **38** is pinned or otherwise fixedly attached to shaft **70**. If desired, a suitable

displacement amplifier (33 of Fig. 3), such as a multiplying linkage or the like, may be interposed between link 63 and yarn traverse guide arm 38, the details of which are not further described herein because of the conventional nature of the construction.

The details of construction of differential gear train 21 of Fig. 3 are shown most clearly in Figs. 4 and 6. The gear train is of the conventional type, including the gear pairs 72—73 and 74—75, and the cage 76 integral with hollow shaft 51, which is provided with a shaft 78 journaled at the ends in the two cage arms. Gear 81 is keyed to shaft 78 and is driven by gear 82 keyed to shaft 83, which is hidden from view in Fig. 4 due to its disposition behind shaft 78, but which is shown in Fig. 6. Shaft 83, together with gear 82, is driven by gear 72 (Fig. 4), keyed to shaft 83 and in mesh with gear 73.

The programming section of Fig. 3 incorporates an amplitude modulation cam 87, shown in Fig. 7, which is driven by a gear reducer 23 (Fig. 3) at constant rotational speed, the reducer not being detailed herein because of the conventional design. Cam 87 is keyed to the output shaft 88 of reducer 23, the shaft being journaled on support stand 89 mounted on base 68. The cam profile is cut to obtain, in sequence, the yarn build-up motions depicted through the range from A to I, and thence from I' to A' (Figs. 1 and 2) in completion of the cycle, the two halves of which are perfectly symmetrical about a vertical line drawn through point Y of Fig. 2. The profile of the cam detailed in Fig. 7 was developed by laying out, from the reference line O—O' as base, the individual points in succession at the following angular spacings:

Interval	Angle (in degrees)	Radius (in inches)
	0	12.00
A	44.8	12.00
B	57.2	11.84
C	67.0	11.48
D	74.5	11.12
E	80.3	10.72
F	84.2	10.44
G	87.0	10.28
H	88.5	10.12
I	90	10.00
I'	91.5	9.88
H'	93.0	9.72
G'	95.8	9.56
F'	99.7	9.28
E'	105.8	8.88
D'	113.0	8.52
C'	122.8	8.16
B'	135.2	8.00
A'	180	8.00

The foregoing tabulation is descriptive of one-half of the cam, the other half being the mirror image of the determined half, and thus merely a copy.

Programming motion is communicated from cam 87 to differential gear train 21 via cam follower 90, pinned on one end of rocker arm 91, which is journaled on pin 92 carried by support stand 93. The other end of rocker arm 91 is provided with a sector gear element 94 which meshes with driver gear 95 integral with hollow shaft 51 hereinbefore described.

Referring to Figs. 4, 5 and 8, the yarn traverse guide arm per se is quite conventional in design, except that steps have been taken to reduce the mass of the parts as much as practicable while still retaining high structural rigidity. This is accomplished by providing an arm 38 which is of generally channel-like cross section, as shown in Fig. 8, and which is cut away circularly across the central web to reduce the mass. Yarn traverse guide 66 is conventional, having a slit 96 for reception of the yarn, the guide being carried on the end of outwardly biased leaf spring support 97 attached at its other end to arm 38, the clearance with respect to bobbin 42 of which can be adjusted by selective rotational disposition of eccentric cross-section bolt 98. It is desirable to provide the traverse mechanism with a friction trap which permits free movement of arm 38 away from bobbin 42 but which resists reverse movement of the arm which might do damage to the yarn cake. A suitable friction trap may consist of a strut 99 fixedly secured to shaft 70, the upper curved end of which is slidably disposed between oppositely biased spring ears 38*a* and 38*b*, welded or otherwise securely attached to the inside of arm 38. These ears permit relatively free movement of traverse guide arm 38 in the direction of the arrow of Fig. 8, while barring reverse movement.

In operation, it will be understood that drive shaft 40 drives generator 12 by direct connection therewith and also drives gear 73, which is keyed to shaft 40. The input to the differential gear train 21 is thus through gear 73 to gear 72, thence via shaft 83 to gear 82, which drives gear 81, and also shaft 78 keyed therewith. Gear 74 is keyed to shaft 78 and drives gear 75, which is integral with plate 50 of generator 11. Thus, generator 11 is driven by differential gear train 21 as represented in Fig. 3 by a line drive, such as that indicated by line 20 of Fig. 3, direct from generator 12.

The control effected by the programming section is imposed through gears 94—95, hollow shaft 51, and cage 76 integral therewith, thence to the output of gear train 21, which is reflected in the output of generator 11 and thus in the resultant with generator 12 taken out by the lever of 17. As hereinbefore described harmonic motion generators 11 and 12 are actuated independently of each other as regards phase, due to the fact that generator 11 is responsive to cam 87 whereas generator 12 is directly connected to drive shaft 40. Therefore the resultant output at the center of pin 57 supporting the lever of 17 is one-half of the sum of the instantaneous displacements of the rods 54. The variation in phase between harmonic motion generators 11 and 12 occurs progressively and cyclically and develops the traverse envelope depicted in Fig. 2.

Programming with a cam 87 of the profile detailed develops an envelope in accordance with Fig. 2 included within the curves extending from P to Y and R to Y which are symmetrical with respect to the longitudinal axis L—L' and which, referred to axis L—L', each have the following time-displacement relationship:

Cumulative Time (Percent)	Amplitude (Percent)
0	100
11.5	100
20	97
40	87
60	74
80	51
100	0

This half of the cycle corresponds to cam movement, as shown in Fig. 7, moving follower 90 through the regions A to I. Curves of the same profile, but extending from Y to S and Y to Q, are developed simultaneously upon continuing movement of the cam from I' to A', thus completing the traverse envelope, which is then repeated cyclically, each rotation of cam 87 corresponding to two complete modulation cycles of traverse operation.

Figs. 9–16 detail a second embodiment of this invention which is particularly adapted to high speed yarn windup of the order of 6000 yards/minute, or higher, without difficulties from inertial loads. The second embodiment of the invention dispenses with linear harmonic motion generators, such as 11 and 12 and utilizes, instead, a beat generator, indicated generally at 100 in Figs. 9 and 10, which may be of the type shown in Figs. 11 and 12. Beat generator 100 comprises a ring gear 101 provided with a single planet gear 102, the output of which is applied to a conventional Scotch yoke mechanism through roller 103, eccentrically journaled a distance of about 15/32" from the center of rotation of planet gear 102.

Gear 102 is driven by constant speed shaft 104 through crank 105.

The Scotch yoke mechanism receiving the output from roller 103 is an essential part of beat generator 100 and consists of a slide 150 provided with a roller follower 153, the slide being reciprocably mounted in ways 151. The slide converts the rotary motion to oscillatory motion, which is transmitted to yarn traverse guide arm 38 through crank arm 154 provided at its end with a slot receiving roller follower 153.

It can be established by kinematic analysis that, if the pitch diameter of planet gear 102 is half of the pitch diameter of ring gear 101, and gear 101 is held stationary, then the travel of point S', the center of roller 103, will describe a linear harmonic motion with respect to a horizontal plane through S'. Kinematic analysis further discloses that, if the pitch diameter of planet gear 102 is made a small percentage larger (e. g., about 1–10%) than one-half the diameter of ring gear 101, the projection of point S' on a horizontal plane will be a repetitive motion which yields a time-displacement curve with an envelope which corresponds to what, in physics, is denoted a common beat. Such an envelope approaches the complete cycle envelope of Fig. 2 from the beginning of period A through to the end of period A', but must be compensated for deviations therefrom, both in the basic period and in the remainder. This compensation is effected by the programming gear system hereinafter described, thus giving an envelope which is a duplicate of the pattern of Fig. 2.

It should be mentioned that proportioning the diameters of gears 101 and 102 at a ratio of less than precisely 2 in effect causes a slow rotation of the plane along which linear harmonic motion is described and thus develops the beat hereinbefore mentioned. The envelope of the beat can be compensated at will by control of the rotation of the plane in which the linear harmonic motion is described. This can be readily effected by programmed counterrotation of ring gear 101 a sufficient amount to, during the period in time corresponding to A of Fig. 2, preserve a constant amplitude harmonic motion and, during each subsequent discrete period, to yield amplitude modulation calculated to duplicate the other periods extending from B through I. Such counterrotation is impressed on gear 101 by integral connection of the gear with side gear 106 of the differential gear train denoted the "mixer" in Figs. 9 and 10. The elements of the mixer gear train are mounted for free rotation on shaft 104 which extends nearly the full length of housing 107.

The primary input for the mixer differential is supplied from side gear 110 which is integral with spur gear 111, journaled on spider shaft 117 and in mesh with spur gear 112, which is journaled on reducer shaft 113 and pinned to non-circular gear 125 hereinafter described.

The secondary input to the mixer differential is supplied through spider shaft 117 provided with stub shafts 118 and 118', upon which are journaled spider gears 119 and 120, respectively. Spider shaft 117 is supported in freely rotatable relationship with respect to shaft 104 and is provided with non-circular gear 124 integral with spider shaft 117. Gear 124 is driven by non-circular gear 125 which is integral with the output side gear 127 of the differential denoted "speed reducer differential" in Fig. 9. Use of non-circular gears with the embodiment of Figs. 9–16 is necessary to achieve variation in velocity as the parameter upon which programming is based. This is in distinction from the embodiment of Figs. 4–8 wherein displacement was the governing parameter for the programming and conventional cams could therefore be employed.

Development diagrams for the non-circular gears are shown for one-half of each in Fig. 13, as regards driver gear 125, and in Fig. 14, as regards driven gear 124, it being understood that the other half of each of the gears is the mirror image of the half that is detailed. The center-to-center spacing of the gears in this instance was 3", under which conditions the tabulated characteristics upon which Figs. 13 and 14 are based are as follows:

Driver Gear 125			Driven Gear 124		
Increment	Angle (Degs.)	Pitch Radius (Inches)	Increment	Angle (Degs.)	Pitch Radius (Inches)
	0	1.75		0	1.25
Z	13.2	1.705	Z	17.1	1.295
Y	25.9	1.662	Y	32.3	1.338
X	37.0	1.622	X	45.4	1.378
W	45.7	1.602	W	55.0	1.398
V	53.2	1.565	V	63.4	1.435
U	60.2	1.548	U	70.8	1.452
T	66.6	1.532	T	77.8	1.468
N	72.7	1.518	N	83.8	1.482
M	78.7	1.507	M	90.0	1.493
K	84.3	1.50	K	96.0	1.50
J	90	1.50	J	101.7	1.50
J'	95.9	1.50	J'	107.5	1.50
K'	101.6	1.493	K'	113.2	1.507
M'	107.6	1.482	M'	119.2	1.518
N'	113.7	1.468	N'	125.2	1.532
T'	120.0	1.452	T'	131.2	1.548
U'	126.9	1.435	U'	137.6	1.565
V'	134.3	1.398	V'	144.4	1.602
W'	143.1	1.378	W'	152.0	1.622
X'	154.3	1.338	X'	161.2	1.662
Y'	167.0	1.295	Y'	170.9	1.705
Z'	180	1.25	Z'	180	1.75

The elements of the speed reducer differential are mounted for free rotation about reducer drive shaft 113 and comprises spider gears 129 and 130 driven by spider shafts 131 and 131', respectively, integral with hollow shaft 133. Spur gear 138, fixedly attached to side gear 128 of the speed reducer differential and journaled on shaft 133, is driven by gear 144, Fig. 10, as gear 144 and the follower 147 to which it is keyed are displaced by correction cam 146, hereinafter described.

As shown in Fig. 9, power is introduced to the apparatus through main drive shaft 135 provided with drive gear 136. Gear 136 is drilled to support the right-hand end of shaft 104 in freely rotatable relationship therewith. Driving power for shaft 104 is transmitted through the conventional gear train consisting of gear 136, gear 139 integral with gear 140, which is journaled on shaft 113, and two-part gear 141—142 keyed to shaft 104. Shaft 113 is driven through gear 143 in mesh with gear 142.

Practicable design of non-circular gears 124 and 125, particularly as regards feasible low pressure angles, necessitates the independent introduction of a cyclic speed component to the non-circular gear pair which is adapted to anticipate a portion of the speed changes synchronously encountered during the rotation of the non-circular gears. This is accomplished by use of a correction cam 146 and follower 147 combination, as shown in Fig. 10, which reciprocates arm 132 and thereby introduces the anticipatory component into the speed reducer differential. Cam 146 is circular in profile but disposed at an eccentricity of about ¼" with respect to the axis of shaft 148 to which 146 is attached. Shaft 148 is driven by gear 149, keyed thereto, which is in mesh with side gear 111, the arrangement being such that the anticipatory component pickup is subordinated to gear 112, also in mesh with gear 111, and therefore non-interfering therewith.

Follower 147 has keyed thereto gears 144 and 145, between which is journaled the lower end of reciprocatory arm 132. The upper end of arm 132 is journaled on shaft 113 and oscillation of arm 132 occurs about the axis of shaft 113 as center. Arm 132 together with follower 147 and gears 144 and 145 move in concert and transmit the anticipatory velocity component to non-circular gear 125 through gear 144 in mesh with gear 138 via the speed reducer differential. It will be understood, of course, that a constant speed input is simultaneously and continuously supplied to the mixer from

gear **112**, pinned to gear **125**, which is introduced as one input to the mixer differential, the other input of which derives from the non-circular gear **124**. The output of the mixer differential drives ring gear **101** and duplicates the envelope of Fig. 2, through the Scotch yoke output mechanism, by controlled counterrotation of gear **101** with respect to planet gear **102**.

The apparatus shown in Figs. 9–16 is provided with a power takeoff for precision winding consisting of drive gear **163**, which is keyed to shaft **104** and meshes with gear **164** keyed to bobbin shaft **165**, some of the elements of the cooperating gear train making connection with bobbin spindle **116** being omitted for simplicity of representation in Fig. 9. The bobbin **167** is mounted on spindle **166** in conventional manner, and is not further described herein because it is not related to this invention.

From the foregoing, it will be understood that this invention provides a method and apparatus for winding yarn on a package which employs a basic simple harmonic motion upon which is superposed a progressively decreasing amplitude modulated fill-in traverse motion, following which the exact pattern is repeated, but in reverse order to complete the cycle. In practice, it appears that up to approximately 1% deviation in terms of radial yarn lay down from that obtainable with true harmonic motion can be tolerated, and this is also true for about the same percentage departure from shape as regards the modulation envelope. Thus, control of the wind pattern according to this invention is quite critical.

It will be understood that each of the cycles occurs within a very short period of time and, even with high yarn supply speeds, the thickness of yarn lay down during any one cycle is very small and is actually of the order of 1/16". The advantages inherent in utilizing harmonic motion as the basis of windup is that gradual deceleration is a natural accompaniment of the mode in approaching points of reversal, making it possible to wind yarns at very high average speeds without encountering inertial loads so great as to impose unsupportable stresses on the apparatus component while, at the same time, not demanding excessive power for operation.

The cam-controlled embodiment of Figs. 4–8, and the positively gear-driven embodiment of Figs. 9–16, represent two basic types of apparatus which can be utilized to achieve windup according to the invention; however, it will be understood that a great number of devices and modifications are adapted to achieve the invention's objectives without departure from the essential spirit, wherefor it is intended to be limited only by the scope of the following claims.

What is claimed is:

1. A method for yarn traverse in the winding of a length of yarn consisting in sequence and cyclically of winding said yarn in a first stage with a traverse action in harmonic motion at maximum amplitude, then winding said yarn with a traverse action in harmonic motion of progressively modulated amplitude during which the package is filled in and thereafter given a yarn lay down reversed in sense to the yarn configuration built up during the interval when said package is filled in, and then completing the cycle by winding said yarn with harmonic motion at maximum amplitude in reverse order to said first stage but for approximately the same time duration.

2. A method for yarn traverse in the winding of a length of yarn consisting of building a substantially constant diameter yarn cake by sequentially and cyclically winding yarn in a symmetric pattern over the full cake length with a traverse action in harmonic motion at maximum amplitude, continuing said winding with harmonic motion modulated in amplitude so as to fill in the concavity created during said winding over the full cake length, thereafter winding with a harmonic motion reversely modulated in amplitude to said harmonic motion modulated in amplitude so as to fill in said concavity, and then completing the cycle by winding said yarn over the full cake length with a traverse action at maximum amplitude but in reverse order to the first-mentioned said harmonic motion at maximum amplitude.

3. A method for yarn traverse in the winding of a length of yarn consisting in sequence and cyclically of winding said yarn with a traverse action in harmonic motion at maximum amplitude for approximately 11.5% of the duration of a half cycle, then winding said yarn with a traverse action in harmonic motion of progressively modulated amplitude so that the following percentage amplitudes correspond approximately to the following percentages of the period of said half cycle:

Percentage Amplitude	Cumulative Percentage of Period of Half Cycle
97	20
87	40
74	60
51	80
0	100

and then completing the cycle by repetition of the complete half cycle but in the reverse order to that first detailed.

4. A method for yarn traverse in the winding of a length of yarn consisting in sequence and cyclically of winding said yarn with a traverse action in harmonic motion at maximum amplitude for approximately 6.75% of the duration of the cycle, then winding said yarn with a traverse action in harmonic motion of progressively modulated amplitude from said maximum amplitude to zero so that the following percentage amplitudes correspond approximately to the following percentages of the period of said cycle:

Percentage Amplitude	Percentage of Period of Cycle
97	10
87	20
74	30
51	40
0	50

thereafter winding said yarn with a traverse action in harmonic motion of progressively modulated amplitude from zero to said maximum amplitude but in the reverse order to the first-mentioned winding at modulated amplitude so that the following percentage amplitudes correspond approximately to the following percentages of the period of said cycle:

Percentage Amplitude	Percentage of Period of Cycle
0	50
51	60
74	70
87	80
97	90

and then completing said cycle by winding said yarn with a traverse action at maximum amplitude for the final 6.75% of the duration of said cycle.

5. An apparatus for yarn traverse in the winding of a length of yarn comprising in combination a yarn traverse guide arm provided with a yarn traverse guide, drive means for said yarn traverse guide arm developing a harmonic motion output, programming means cyclically and sequentially controlling said harmonic motion output of said drive means from maximum amplitude through progressively decreasing amplitude to zero and then in the reverse sense from zero through progressively increasing amplitude to maximum amplitude, and a drive connection between said drive means and said yarn traverse guide arm.

6. An apparatus for yarn traverse in the winding of a length of yarn according to claim 5 wherein said programming means cyclically and sequentially controlling said harmonic motion output causes said drive means to drive said yarn traverse guide arm at substantially the following percentage amplitudes in harmonic motion at the following percentages of the period of the yarn winding cycle:

Percentage Amplitude	Cumulative Percentage of Period of Winding Cycle
100	0
100	6.75
97	10.0
87	20.0
74	30.0
51	40.0
0	50.0
51	60.0
74	70.0
87	80.0
97	90.0
100	93.25
100	100

7. An apparatus for yarn traverse in the winding of a length of yarn comprising in combination a yarn traverse guide arm provided with a yarn traverse guide, drive means for said yarn traverse guide arm consisting of a pair of harmonic motion generators each delivering its output to a differential mechanism, programming means progressively and cyclically varying the phase difference between the outputs of said harmonic motion generators to displace the output element of said differential mechanism with the following percentage amplitudes at the following percentages of the period of the winding cycle:

Percentage Amplitude	Cumulative Percentage of Period of Winding Cycle
100	0
100	6.75
97	10.0
87	20.0
74	30.0
51	40.0
0	50.0
51	60.0
74	70.0
87	80.0
97	90.0
100	93.25
100	100

and a drive connection between said output element of said differential mechanism and said yarn traverse guide arm.

8. An apparatus for yarn traverse in the winding of a length of yarn according to claim 7 wherein said programming means is a unidirectional rotating cam.

9. An apparatus for yarn traverse in the winding of a length of yarn comprising in combination a yarn traverse guide arm provided with a yarn traverse guide, drive means for said yarn traverse guide arm consisting of a beat generator, programming means progressively and cyclically controlling the output of said beat generator to circumscribe harmonic motion referred to the longitudinal axis of the output pattern of said beat generator to give the following percentage amplitudes of said harmonic motion at the following percentages of the period of the winding cycle:

Percentage Amplitude	Cumulative Percentage of Period of Winding Cycle
100	0
100	6.75
97	10.0
87	20.0
74	30.0
51	40.0
0	50.0
51	60.0
74	70.0
87	80.0
97	90.0
100	93.25
100	100

and a drive connection between said beat generator and said yarn traverse guide arm.

10. An apparatus for yarn traverse in the winding of a length of yarn according to claim 9 wherein said programming means comprises a gear differential wherein a constant speed input is combined with a variable speed input to give an output progressively and cyclically controlling the output of said heat generator.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,848,173 August 19, 1958

Friedrich Hebberling

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 73, for "bracket" read -- brackets --; column 8, line 34, for "shaft 133" read -- shaft 113 --; column 9, line 13, for "spindle 116" read -- spindle 166 --; line 40, for "component" read components --.

Signed and sealed this 28th day of October 1958.

(SEAL)

Attest:

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