

Feb. 20, 1962

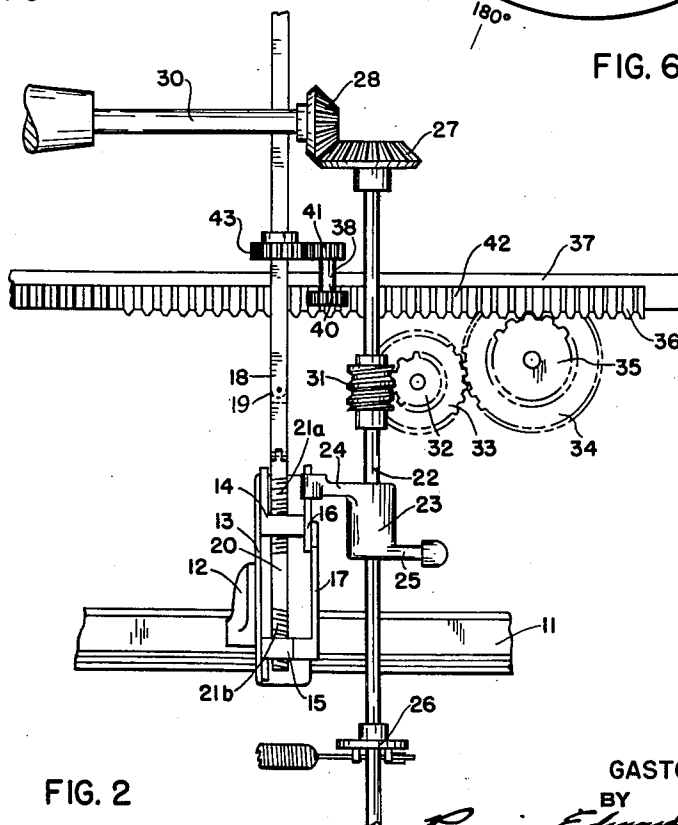
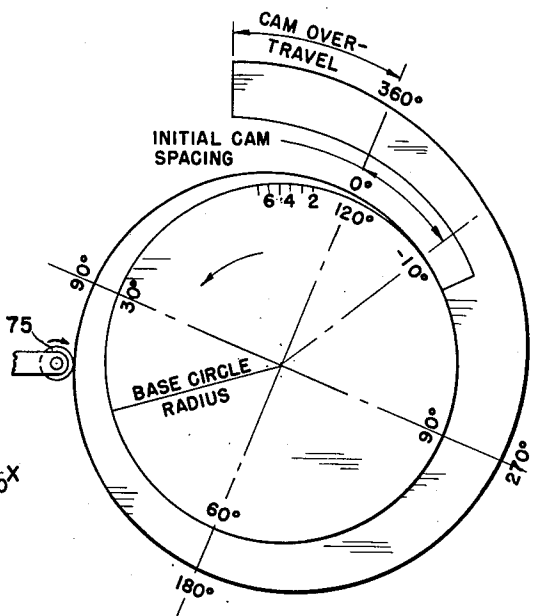
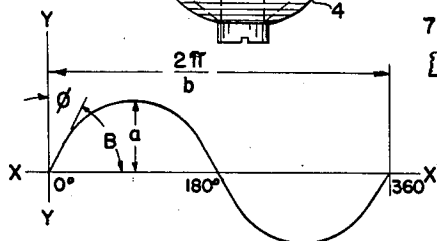
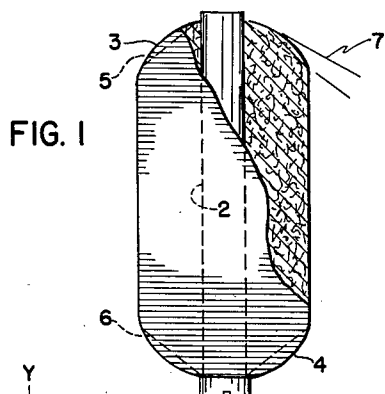
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3,021,664

APPARATUS FOR WINDING PACKAGES OF ROVING

Filed Nov. 3, 1959

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

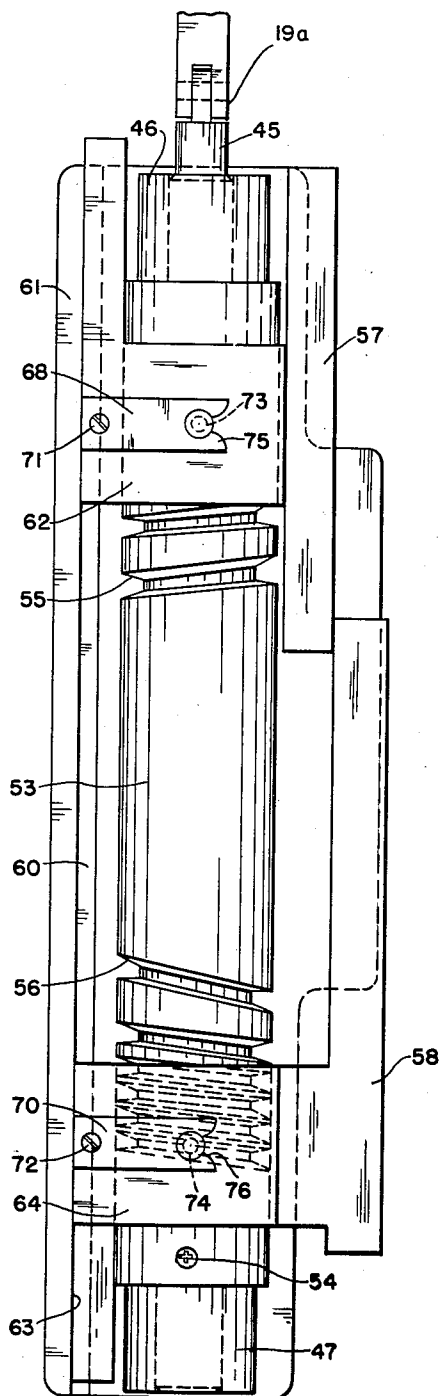


FIG. 3

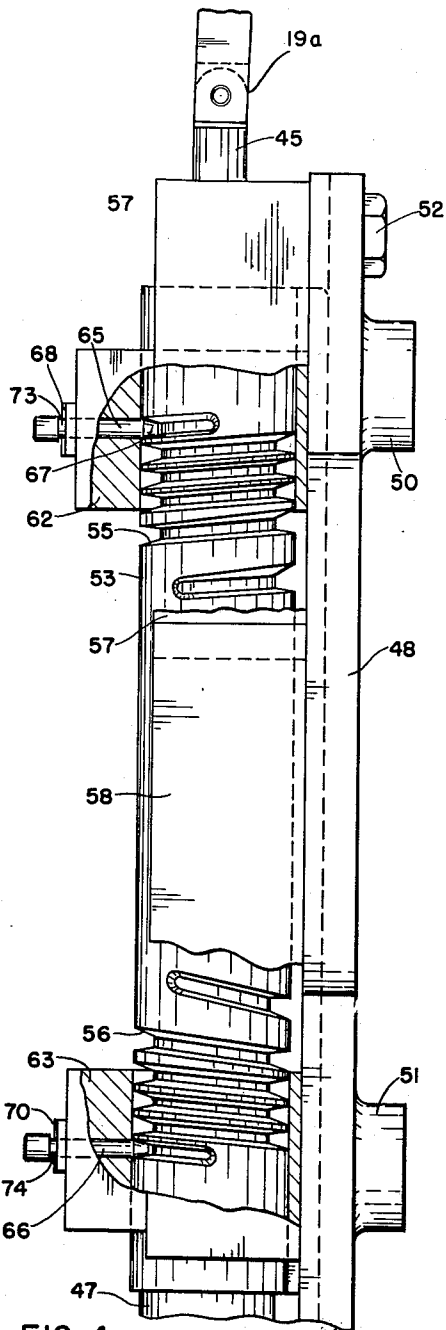


FIG. 4

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3,021,664 APPARATUS FOR WINDING PACKAGES OF ROVING

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7 Claims. (Cl. 57—99)

This invention relates to the production of textile yarns and, more particularly, to apparatus for winding packages of roving and the like to produce a package having greater density and stability.

Packages of textile roving are formed by winding roving on bobbins in successive, closely-wound layers so that the fully wound bobbin is substantially cylindrical. It is the conventional practice to form the packages with straight, conical ends to insure the stability of the ends of the package, that is, to prevent the end coils of the layers of the wound bobbin from uncoiling due to lack of support from the underlying layers and becoming so tangled that the package must be discarded, or unwound with difficulty.

Economic considerations dictate that as much roving yardage as is practical be wound on each bobbin. Greater yardage per bobbin means that the roving frame may be run longer without shutdown to change bobbins; hence, fewer operators are required to attend a given number of spindles. Moreover, the machinery which subsequently takes the roving from the packages can be kept running longer without shutdown to replace empty bobbins with full ones.

Ideally, the conventional method of winding the package would result in a straight, conical taper at each end, for that method consists of shortening each succeeding layer by a constant amount. This shape imposes very definite limitations on the amount of roving that can be wound on a bobbin because roving frames of given size are limited to winding roving packages to a certain maximum diameter and because there is a maximum cone angle—measured between the axis of the bobbin and an element of the cone—for which the roving is stable on the bobbin. This maximum angle varies with the amount of tension with which the roving is wound on the bobbin; that is, there is a greater tendency for the tapered ends to break down as the winding tension is increased. To minimize this tendency and to insure stability, the taper angle must be held to a definite maximum for any given set of winding conditions. Moreover, as a practical matter, a true straight taper is difficult to obtain because, as the winding progresses, the underlying layers are compressed by varying amounts which results in an irregularly concave or convex profile along the taper. This irregularity of profile is quite uncontrollable when bobbins are wound by conventional methods, and it necessitates a reduction of the taper angle or a reduction of the winding tension if the roving is to remain stable on the bobbin.

Because roving frames are limited to winding roving to a certain maximum diameter on the bobbin, the simplest way to increase the yardage of roving in a package has been to wind the roving under greater tension so that the roving is compressed to a greater degree, and, therefore, makes room for more layers to be wound on the bobbin. As previously stated, however, if the wound roving is to be stable at these higher densities, the end-taper angle must necessarily be reduced. This is worked directly con-

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trary to the purpose of winding with greater tension because the volume of the wound bobbin decreases as the taper angle is decreased. For these and other reasons, the attempts to increase the yardage of roving in a package merely by increasing the winding tension in otherwise conventional winding methods have met with indifferent success.

It has recently been proposed to build roving packages by a new method which forms packages having convex, rather than straight, end tapers. The immediate benefits of this method are that packages have greater volume, and the ends of the package are more stable. At the same time significantly greater winding tension may be used. All of these factors combine so that packages having much greater yardage may be formed. According to this new method, each successive layer is decreased in length, not by uniform increments which results in a conventional, straight taper, but by progressively greater increments. Moreover, the increments by which the length of the initial layers are reduced are less than the increments conventionally used in forming straight tapers. This results in an initially large taper angle—again measured between the axis of the bobbin and tangent to the end of the roving wound on the bobbin. This forms a curved end contour of relatively large radius at the start of the winding. As the winding progresses beyond the initial layers, the increments by which the lengths of successive layers are reduced become progressively greater so that the taper angle is decreased, and the radius of the end contour is decreased.

In practice, the initial large taper angle approximates a conventional, straight taper. However, as the winding proceeds, the winding tension in the latter half of the package, particularly with the higher-than-normal winding tension which may be used with this new method, compresses the layers in the underlying layers of the package so that the approximately straight taper first produced becomes convex, and the overall final end profile approximates a definite geometric curve, such as a parabolic curve.

For an illustration of a bobbin wound in accordance with this new method, the reader is referred to FIG. 1 which shows roving 1 wound on a bobbin 2. There it is seen that the profiles of the opposite ends 3 and 4 of the fully wound package have a pronounced convex shape. A typical straight conical tapered profile is shown in dotted outline at 5 and 6 to provide a graphic comparison of the substantial increase in volume of the package wound according to the new method. In FIG. 1 it can also be seen how, because of the greater taper angle 7 nearest the bobbin and the thereafter decreasing taper angle, the ends of the package wound according to the new method are more stable.

Apparatus has been devised for winding bobbins according to the new method, and it performs admirably. The apparatus is, however, quite complex and substantial modification of conventional roving frames is required when the new apparatus is to be incorporated in it.

The present invention provides new and greatly simplified apparatus which may be incorporated in an otherwise conventional roving frame without substantial modification of any portion of the frame with the exception that the new combination of components is simply substituted for certain parts of an otherwise conventional frame.

As is well known, a conventional roving frame com-

prises a plurality of drafting rolls for attenuating each of a large number of ends of sliver so that the number of fibers in cross section is reduced. The ends of roving are then passed to another part of the frame which puts a substantially uniform twist per unit length in the roving and then winds each end onto its own bobbin. The winding operation consists in laying the end of a roving on a bobbin in successive layers, each layer consisting of a plurality of relatively closely-spaced coils wound around the bobbin.

As is also well known, the twisting and winding are both accomplished by the differential rotation between the rotating bobbin and a so-called flyer which rotates about the same axis as the bobbin. The roving is led by the flyer to the bobbin and, in order that the coils be laid on the bobbin side by side and in successive layers, the roving frame is provided with means which cause the bobbin to reciprocate axially with respect to the flyer. Conventionally, a roving frame is also provided with means which reduce the amplitude of each successive reciprocation of the bobbin with respect to the flyer by a fixed and constant amount so that successive layers of roving wound on the bobbin have shorter lengths. The apparatus by which the amplitude of reciprocation of the bobbin with respect to the flyer is governed is called the builder, the construction of which is well known. Ordinarily, the builder is actuated by and in direct proportion to the motion of the tension gearing.

According to the present invention, the conventional builder mechanism is replaced by a new combination of elements which comprises a cylindrical builder cam mounted on the roving frame and adapted to be rotatably driven about its longitudinal axis by the same or a similar control shaft such as that conventionally used to drive a builder screw. This cylindrical cam member has on a first portion thereof a first helical camming surface and also has on another portion thereof a second helical camming surface. These first and second camming surfaces are oppositely directed, and each has continuously varying pitch. Further according to the invention, there is provided a pair of builder jaws mounted adjacent the cam member and adapted to be reciprocally moved with respect to the cam member along paths parallel to the axis of the cam. One of the builder jaws is provided with a cam follower which engages the first camming surface of the cam member, and the other builder jaw is provided with a cam follower which engages the second camming surface. Each builder jaw is provided with a tumbler arm bearing surface of predetermined length and extending in the direction of reciprocation of the control shaft. The remainder of the frame is entirely conventional, and the cooperation between the new combination of elements according to this invention and the conventional elements of the frame is not unlike the cooperation between the conventional elements which the new elements replace and the other elements of the frame. There is, however, a markedly different result achieved, and this by substantially simpler means than have been suggested previously.

A complete description of a preferred embodiment of the present invention is given in the following specification, together with a full description of means for making the essential elements according to the invention. In the course of the description, reference is made to the accompanying drawing, in which:

FIG. 1 is an elevation of a package of roving;

FIG. 2 is a schematic illustration of a portion of a roving frame incorporating the present invention;

FIG. 3 is a front elevation of a builder mechanism according to the invention;

FIG. 4 is a side elevation, partly broken away, of the mechanism shown in FIG. 3;

FIG. 5 is a diagram showing the mathematical relations between variables upon which the shape of the helical cam is based; and

FIG. 6 is a diagrammatic illustration of a cam which may be employed in the construction of the mechanism shown in FIGS. 3 and 4.

Inasmuch as the construction and operation of conventional frames are well known, it will not be necessary to describe the entire machine to illustrate the operation of apparatus according to the present invention. A typical roving frame is fully described and illustrated in Hill: Cotton Drawing, Combing and Fly Frame Processes, published by International Textbook Company of Scranton, Pennsylvania. The relevant portions of a typical roving frame are also described in the patent to Hill et al., No. 2,870,597, issued January 27, 1959. Accordingly, there will be described here only so much of a typical roving frame as is necessary to enable those skilled in the art to comprehend the detailed features of a preferred embodiment of the apparatus.

In FIG. 2 there is shown at 11 a portion of the bobbin rail of a roving frame which, as is well known, carries the bobbin-rotating mechanism. The bobbin rail and all the mechanism mounted on it is driven up and down so that the bobbins on which roving is being wound are reciprocated axially with respect to the flyers. Flyers rotate with respect to the bobbins to put a uniform twist per unit of length in the roving and then wind it on the bobbin in successive layers, each of which layers consists of closely wound coils.

In order that the successive layers of roving wound on the bobbins are each shortened by a predetermined amount to form the appropriate tapered end necessary for stability of the finished package of roving, a mechanism known as a builder is used. To orient the reader and to facilitate understanding of the invention and the manner in which one embodiment of it is constructed and operated, there will first be given a description of part of a conventional roving frame.

A conventional builder mechanism comprises a suitable bracket 12 mounted on the bobbin rail 11 which moves up and down as indicated in FIG. 2. This bracket has a part 13 in which there are suitable vertical tracks or other guiding means for an upper jaw 14 and a lower jaw 15. Jaw 14 is provided with a vertical camming surface 16, and jaw 15 is provided with a similar camming surface 17. These camming surfaces are elongated and substantially parallel.

A square builder screw shaft 18 is connected by a suitable universal joint 19 to a builder screw 20 which is provided with two oppositely threaded portions 21a and 21b, the pitch of the threads being uniform throughout. The upper jaw 14 is provided with internal threads which mate with the threaded portion 21a on the screw 20 as a nut on a bolt. Similarly, the lower jaw 15 is provided with internal threads which mate with the threaded portion 21b. Thus, because the threads on the portions 21a and 21b are oppositely directed, rotation of the screw 20 in one direction or the other will either close or open the jaws upon each other to the extent permitted by the length of the threaded portions 21a and 21b.

Adjacent and parallel to the shaft 18 there is a tumbler shaft 22 suitably mounted for rotation about its axis on a stationary part of the machine frame. A so-called builder dog, indicated at 23, is fixed to the tumbler shaft and has oppositely extending arms 24 and 25 which are of sufficient length in a radial direction so that the arm directed toward the builder shaft at any given time will engage one of the vertical camming surfaces 16 or 17.

The tumbler shaft is also provided with a spring-loaded camming mechanism 26 arranged to urge the tumbler shaft to rotate in a counterclockwise direction as viewed from the bottom of FIG. 2, thereby insuring that one or the other of the arms on the builder dog will bear on one of the camming surfaces.

The tumbler shaft 22 is also positively, but intermittently, driven by the bevel gear 27 fixed to the upper end of the shaft 22 and the bevel gear 28 fixed to the main

drive shaft 30 of the roving frame. As is well known, the gear 27 is a sector gear having teeth in two opposite sectors and having no teeth in the other two opposite sectors. The gear 27 is so oriented on the tumbler shaft 22 that when one or the other of the arms on the builder dog is rotated into position to engage the camming surfaces on the builder jaws, a toothless sector on the gear 27 is adjacent or under the gear 28 on the main drive shaft so that there is no driving torque transmitted to the tumbler shaft.

Now, as the bobbin rail 11 is driven upward or downward to the end of its stroke, the arm of the builder dog in engagement with the camming surfaces on the jaws will overrun the end of the camming surface so that there is no longer any resistance to the turning moment exerted on the tumbler shaft by the spring-loaded camming mechanism 26. This mechanism then causes the tumbler shaft to turn enough to bring a toothed sector of the gear 27 into engagement with the gear 28, and the tumbler shaft is positively and rapidly driven through nearly a half revolution before the next toothless sector of the gear 27 comes under the gear 28. By this time, however, the spring-loaded camming mechanism 26 is again in control of the tumbler shaft 22 and causes the shaft to complete the half revolution and bring the other arm of the builder dog to bear on the camming surfaces of the builder jaws. Thus, to illustrate, if the bobbin rail is being driven downward while the arm 24 engages the camming surfaces, the tumbler shaft cannot turn until the arm 24 overruns the end of the camming surface 16 on the upper jaw 14. The mechanism 26 and the gears 27 and 28 will then cooperate to turn the tumbler shaft through 180 degrees so that the other arm 25 on the builder dog, which is axially displaced with respect to the arm 24, engages the cam surface 17 on the lower jaw 15.

Those who are acquainted with textile machinery know that the half revolutions of the tumbler shaft also actuate a mechanism which determines the direction in which the bobbin rail is driven. At the same time that the arm 24 overruns the end of the surface 16 and the tumbler shaft 22 turns through a half revolution, the driving mechanism of the bobbin rail is reversed by conventional means so that the bobbin rail is then driven upward. The upward travel will continue until the arm 25 on the builder dog overruns the lower end of the surface 17 on the lower jaw 15, whereupon the tumbler shaft will again be turned by the camming mechanism 26 and the gears 27 and 28. The bobbin rail driving mechanism will be reversed and the bobbin rail will again be driven downwardly. These changes in direction of the bobbin rail travel result in the bobbins on all the spindles of the roving frame being driven up and down with respect to their respective flyers which are axially stationary. Each time the bobbin rail changes its direction of travel, a new layer of roving is wound on each of the bobbins.

As has been previously described, each successive layer of roving wound on the bobbin by a conventional roving frame is shortened by a predetermined and constant amount so that when the bobbin is fully wound the ends of the bobbin have a straight tapered shape. In conventional roving frames this is accomplished by turning the builder shaft by a predetermined amount in the direction which causes the upper and lower jaws 14 and 15 to close upon each other, thus bringing the upper and lower ends of the camming surfaces 16 and 17 closer together by successively equal amounts. Obviously, the upward and downward strokes of the bobbin rail are then shortened by a corresponding amount, for either the arm 24 will overrun the upper end of the surface 16 sooner than before or the arm 25 will overrun the lower end of the surface 17 sooner than before, thereby causing the direction of travel of the bobbin rail to be reversed.

The conventional way of turning the builder screw by the necessary amount is to drive the builder screw from the tumbler shaft through a gear train which causes the

builder screw to rotate through an angle which is in fixed and direct proportion to the 180° angle through which the tumbler shaft rotates each time. This gear train, known as the tension and taper gearing, comprises a worm gear 31 fixed to the tumbler shaft and spur gears 32, 33, 34, and 35. The gear 32 in engagement with the worm gear 31 is fixed to a shaft which is common to the gear 33. The latter gear engages the gear 34 which is fixed to a shaft common to the gear 35. The gear 35 engages the teeth 36 on the underside of an elongated rack gear 37. The rack gear is mounted on suitable guides so that it may be moved from side to side in FIG. 2.

Merely to orient the reader, it is well to state here that the rack gear is also the driving element of a belt shipper mechanism for an endless belt which runs between two conical pulleys in the power train of the roving frame. The purposes of this power train are not directly relevant to this invention and need not be described in detail. However, the rack gear itself is also an element in the train of gears between the tumbler shaft and the builder screw.

A suitably mounted vertical shaft 38 carries the taper gear 40 and gear 41, the former of which engages the teeth 42 along the side of the rack gear 37 as seen in FIG. 2. The other gear 41 engages a gear 43 fixed to the builder screw shaft 18. The gear 43 and screw shaft 18 rotate together, but the screw shaft is of square cross-section and must be free to slide axially in a square axial aperture in the gear as the shaft oscillates with the bobbin rail 11.

A mechanism of this kind can only build packages having straight tapered ends, although the taper angle may be changed by changing the various gear ratios within the mechanism.

According to the present invention, the members 13, 14, 15, 16 and 17, as well as the builder screw 20 having the threaded portions 21a and 21b of uniform pitch are removed and replaced by a new combination of elements shown in FIGS. 3 and 4. In those figures, a shaft similar to shaft 18 in FIG. 2 is similarly adapted to be driven and to slide up and down within the gear 43 as the bobbin rail 11 moves up and down. The universal joint 19a in FIGS. 3 and 4 couples the shaft to a central shaft 45. This shaft 45 is rotatably journaled in upper bearing block 46 and lower bearing block 47 which are mounted on a bed plate 48. Internally threaded mounting bosses 50, 51 on the back of the bed plate 48 provide for mounting the bed plate directly on the bobbin rail 11 or on a bracket similar to the bracket 12 in FIG. 2 which is in turn fixed to the bobbin rail. One of the bearing blocks, for example, the lower bearing block 47, may be integral with the bed plate 48, but at least one of the bearing blocks, for example, the upper bearing block 46, should be removably mounted on the bed plate as by bolt 52, which passes through the bed plate and is threaded into the bearing block. The lower bearing block 47 may be fabricated separately from the bearing plate and fixed thereto by a similar bolt.

A cylindrical cam member 53 in the form of a sleeve adapted to fit over the central shaft 45 and of a length to be received between the upper and lower bearing blocks 46, 47 is fixed to the central shaft 45 for rotation therewith by any suitable means such as a pin or a set-screw 54. This cylindrical cam member has two helical cams 55 and 56 machined into its outer surface. As best seen in FIG. 4, the helices 55 and 56 are oppositely directed, and the pitch of each helix varies in a definite pattern from turn to turn throughout its length from its outermost or initial end to its innermost or terminal end. The principles by which the helices are formed, the detailed characteristics of a preferred form of helices, and one suitable means for forming such helices will be described later in the specifications.

A pair of dog-arm camming members 57 and 58 are slidably mounted on the bed plate 48 so that they may be

reciprocally driven parallel to the axis of the cam 53. The upper camming member 57 is located nearer the axis of the cam member than is the lower camming member 58 so that the two members may pass side by side as they slide along their mounting grooves. The lengths of these camming members 57, 58 are proportioned similarly to the lengths of the camming members 16 and 17 of a conventional builder apparatus such as that shown in FIG. 2 and their function is similar—that is, the upper arm of a builder dog bears on and slides along the surface of the upper camming member 57, and the lower arm of a builder dog slides along the camming surface of the lower camming member 58.

In this illustrative embodiment a single guide groove 60 is cut along the full length of the bed plate parallel to and to the left of the axis of the shaft 45 as seen in FIG. 3. A guide member 61, having a groove-engaging portion along its lower edge, is fixed to and adapted to cooperate with the upper camming member 57 by means of a bridging portion 62 which is fixed between the upper edges of the guide member 61 and the camming member 57 adjacent their upper edges. Similarly, a guide member 63 is made to cooperate with lower camming member 58 by means of a bridging portion 64. Each of the guide members 61 and 63 has a longitudinal groove-engaging portion along its lower edge. The cross-section of the groove 60 and the groove-engaging portions may be of any suitable shape so that the guide members are positively guided and retained in position on the bed plate by the slot. The camming members 57 and 58 could also be positively guided by means of grooves cut in the bed plate and cooperating slot-engaging portions on the lower edges of the camming members; however, this is not necessary, and in this illustrative embodiment the camming members merely bear along their lower edges on the bed plate. The pressure of the dog arms bearing on the camming surfaces of the members 57 and 58 is sufficient to maintain the camming members properly seated on the bed plate.

It is readily apparent that, because of the variations in pitch from turn to turn of the two helical cams 55 and 56, the internally-threaded members used in conventional builder apparatus to engage a constant pitch builder screw cannot be used in my new apparatus. Therefore, I provide cam-engaging members which are adapted to engage and track the cams. In this embodiment, the cam-engaging members are the pins 65 and 66 mounted in holes passing through the bridging members 62 and 63 respectively. The cam-engaging ends of these pins are tapered, as indicated at 67 on the upper pin 65, the angle of taper being substantially the same as the angle of the side walls of the camming surfaces so that the contact between the tapered end of the pin and the side wall of the cam groove is essentially a line contact. In other words, while the cam followers may extend over the cam surface for a substantial distance more or less radially of the cam body, the cam followers should not contact the cam surface over any substantial distance in the direction along the length of the cam surface if the cam follower is to track the cam accurately. In some of the claims this condition is expressed as "engaging each of said camming surfaces along an element of substantially zero length along the length of said surface."

The pins are positively held in contact with the helical cam's surfaces by means which permits ready removal of the pins when necessary. These means comprise metallic leaf springs 68 and 70, the former leaf spring being secured at one end to the guide member 61 by a screw 71 and the latter leaf spring being secured at one end to the guide member 63 by a screw 72. Each of the pins 65 and 66 has a circumferential groove in a portion which protrudes beyond the bridging member. The groove in pin 65 is shown at 73, and the groove in pin 66 is shown at 74. The end of each leaf spring op-

posite the end fixed to the guide member is provided with a suitable slot into which the grooved portion of the pin may be received. For example, the spring 68 has a slot 75, and the spring 70 has a slot 76.

As will readily be understood from the foregoing description, when the shaft corresponding to shaft 18 in FIG. 2 is turned by the gearing of the roving frame, the helical cam member 53 is also turned. The pins 65 and 66 engaging their respective cam grooves effectively follow the grooves and cause the camming members 57 and 58 to be driven closer together or farther apart depending on the direction in which the screw is turned. When packages of roving are being wound, the screw is turned so that the camming members are driven together, thereby shortening the length of travel of the bobbin rail necessary to permit the dog arms to overrun the ends of the camming members and cause the frame to commence winding the next layer of roving on the bobbins.

The package end profile which the builder screw forms in this illustrative example of my invention is a mathematically exact curve and is based on the following considerations. The taper angle for a convex curve can be much larger than that for a straight-line profile or a concave profile at the beginning, or initial layers, of the wound package. There is a limit, however, to how large a taper angle can be successfully used, and this angle limits the selection of curves which will produce a convex contour and at the same time permit the building of a high-density package.

The circle, ellipse, parabola, cycloid, involute and sine wave all have convex contours. My study of the properties of these curves showed that the sine curve permits the use of a reasonable taper angle at the beginning or innermost layers, and it requires only moderate increments in the slope as the package is built. This contributes to the high volume of packages in accordance with my invention and is a very real advantage.

I will now describe the properties of a helical builder screw according to my invention and one means for constructing such a screw.

Referring now to FIG. 5 in the drawing, I will describe the mathematical basis by which the particular sine curve is derived. In the figure,

β equals the initial taper angle.

$y_{\max} = a = \text{effective radius of the package} = \text{amplitude of the sine curve.}$

$$\frac{2\pi}{b} = 2 \text{ (length of first layer minus length of last layer)}$$

β varies with the size of the bobbin and desired length of the last layer of roving.

The value of $y_{\max}$ is limited by the roving frame flyers, where, as in this description, the builder mechanism of my invention is incorporated in an otherwise standard roving frame. For the same reason, the length of the first layer is limited by the amplitude of the bobbin rail motion. For example, using a 10" x 5" roving frame, the length of the first layer of roving is ten inches, and the maximum diameter of a full package is five inches, assuming a standard flyer is on the frame.

In order to apply these considerations to a specific design of builder screw, it is evident that the largest volume of roving on the package may be obtained if the initial taper angle β is made as large as practically possible. From actual mill experience with conventional straight profiles, constant taper angles were found to vary from 30° to 60°. I have found that by manually controlling the convex contour on a 10" x 5" roving frame the approximate upper limit for the initial taper angle is about 60°, and this initial taper angle may be used for regular operation if the roving frame is in good mechanical condition. As previously stated, the larger the taper angle, the greater the volume of the resulting package. It will be recognized that the angle designated ϕ in FIG. 5 and used in the following calculations is actually the com-

plement of the taper angle as measured between a tangent to the profile of the end of the package and the longitudinal axis of the package.

I have found from my experimental investigation, that initial angles of $\phi=30^\circ$, $\phi=32^\circ$, and $\phi=35^\circ$ will provide an adequate range for practical operation. For example, $\phi=30^\circ$ could be used for high-tension winding of medium weight roving, and $\phi=35^\circ$ could be used for high-tension winding of heavy roving. $\phi=32^\circ$ appears to be a good value for general purpose work and has been used to produce a 48 oz. roving package of 1.25 hank roving.

Continuing with the illustrative example, the wooden bobbin of a 10" x 5" roving frame has 1.5 inch outside diameter. Accordingly,

$$\frac{5.0'' - 1.5''}{2} = 1.75''$$

is the effective wound package radial thickness. Assuming that for a constant β equals 45° , one cycle would equal

$$\frac{2\pi}{b} = 4(1.75) = 7.00''$$

and $1/b = 1.1140819''$. The radial thickness of 1.75" is divided by 120, which is a convenient division resulting in 3° increments. Then y_1 has a value of

$$1\left(\frac{1.75}{120}\right) = 0.01485''$$

and x_1 has a value calculated from the expression $y = a \sin bx$. It follows that $y_{\max} = a = 1.75''$ and $y_{120} = 1.75''$. Table I illustrates the successive calculations which are made.

Table I

Y	y, in	y/a	Arc Sin° y/a	Radians	Calculated X ins. (Radians X 1/b or 1.1140819'')
1-----	0.01458	0.008333	0.483	0.0083334	0.00928
2-----	0.02917	0.016667	0.950	0.0016667	0.01856
3-----	0.04375	0.025000	1.438	0.0025002	0.0279
120-----	1.7500	1.0000	90°	1.570231	1.7494

By conventional drafting means, a drawing of the sine curve was made to a scale of 10"=1" based on the calculated values of x and y. As this sine curve approaches tangency with the outside surface of the bobbin, the outer portion of the sine curve has a rapidly decreasing radius of curvature. A modification is made here to prevent this by drawing a 60° line tangent to the sine curve. This means that from y_{112} onward an increment of 0.0252" is added to successive values of x as set forth in Table II below. To provide for adjusting the cam, the sine is started five increments ahead and to permit the use of small taper gears the 60° tangent is extended to 140 increments for y. The initial angle of ϕ can also be checked with a protractor on the drawing. In this illustrative example, the initial value is $\phi=32.5^\circ$.

The values shown in Table II are used to generate a disc cam shown in FIG. 6. This is the controlling cam for the machine tool on which the helical builder screw is cut. The base circle of this disc cam should be as large as possible, and for accurate results, it should have a base circle radius of not less than 3 inches. The cam and its basic layout is shown in FIG. 6. For brevity, Table II includes only every tenth value of X and the corresponding values of x. It should be clearly understood, however, that the intermediate nine values between each of the values actually shown should be calculated and used in the layout of the cam. These values are accurately scribed on any suitable type of sheet metal, and the cam may be rough cut on a band saw. The final shaping of the cam may be done by hand with a file, ribbon sander, or other type of fine cutting tool.

Table II

X	Length x	X	Length x
-5-----	2.9536	50-----	0.4788
-4-----	2.9629	60-----	0.5833
-3-----	2.9724	70-----	0.6939
-2-----	2.9814	80-----	0.8130
-1-----	2.9907	90-----	0.9448
0-----	3.0000	100-----	1.0975
10-----	0.0929	110-----	1.2920
20-----	0.1866	120-----	1.5425
30-----	0.2815	130-----	1.7945
40-----	0.3786	140-----	2.0465

The disc or master cam just described is used in cutting the cylindrical helical groove in the builder screw. Although several other precision machine tools could be used to cut the helical cam, I have used a conventional, high-precision ten-inch lathe to turn the cam body and a milling attachment to cut the grooves in the body. The master cam is suitably mounted and rotated in coordination with the rotation of the cam body into which the helical grooves are cut. A small roller indicated at 75 in FIG. 6 is rigidly connected in any suitable way so that the motion of the cross-slide of the lathe in the direction parallel to the axis of the workpiece is accurately controlled in accordance with the increase in diameter of the master cam. Because the detailed steps of the cam-cutting process will be apparent to a skilled machinist, there is no need to describe them at great length. It need only be noted that the two grooves in the complete cam have identical variations in pitch from point to point along the axis of the cam, but they are of opposite hand and are oppositely directed along the axis of the cam body. Accordingly, the same disc cam may be used as a master to cut back grooves.

The helical cam constructed according to the foregoing description could be used, for example, in a conventional 10" x 5" Saco-Lowell F.S. 2 roving frame. If a 19-tooth taper gear is used in such a machine, a highly-acceptable end profile may be formed on the wound bobbins, although taper gears having anywhere from 17 to 21 teeth could be used.

In the foregoing description, I have set forth in detail one embodiment of my invention and the manner in which it may be constructed. Of course, many variations on this particular embodiment will occur to those skilled in the art; accordingly, I do not propose to be limited to the details of the particular embodiment. My invention is defined in the following claims.

I claim:

1. In a roving frame having a builder screw driving mechanism, means for building packages of roving having curved end profiles, which means comprises a builder cam body having on a first portion thereof a first helical camming surface and having on another portion thereof a second helical camming surface, said first and second camming surfaces being oppositely directed and each of said camming surfaces having continuously varying pitch from one end thereof to the other, means for engaging each of said camming surfaces along an element of substantially zero length along the length of said surface, said engaging means being mounted for motion relative to said cam body in a direction substantially parallel to the axis thereof, the builder screw driving mechanism of the frame being adapted to drive said builder cam body through equal successive increments and thereby displace said engaging means by successively different increments, and means responsive to the position of said engaging means along said camming surfaces for determining the lengths of successive layers wound on the packages.

2. In a roving frame having a builder screw driving mechanism, means for building packages of roving having convexly curved end profiles, which means comprises a cylindrical builder cam body having in a first portion of the length thereof a first helical camming groove and hav-

ing in a second portion of the length thereof a second helical camming groove, the directions of said camming grooves being of opposite hand and each of said grooves having a major portion thereof which has continuously varying pitch, means for engaging the surface of each of said camming grooves along an element of substantially zero length along the length of said camming groove, said engaging means being mounted for motion relative to said cam body in a direction substantially parallel to the axis thereof, the builder screw driving mechanism of the frame being adapted to drive said builder cam body through equal successive increments and thereby displace said engaging means by successively different increments, and means responsive to the position of said engaging means along said camming grooves for determining the lengths of successive layers wound on the packages.

3. In a roving frame having a builder screw driving mechanism, means according to claim 2 for building packages of roving and which means are further characterized by the fact that a portion of each of said grooves varies in pitch along its length by increments which are related to the incremental changes in slope of a curve which is convex with respect to an axis in a system of rectangular coordinates.

4. In a roving frame having a builder screw driving mechanism, means according to claim 3 for building packages of roving and which means is further characterized by the fact that the convex curve is a major portion of a sine wave.

5. In a roving frame having a builder screw driving mechanism, means according to claim 2 for building packages of roving and which means are further characterized by the fact that a major portion of each of said grooves varies in pitch along its length by increments which are related to the incremental changes in amplitude of a curve which is convex with respect to an axis in a system of rectangular coordinates.

6. In a roving frame having a builder screw driving mechanism, means according to claim 5 for building packages of roving and which means is further characterized by the fact that the convex curve is a major portion of a sine wave.

7. In a roving frame having rotatably driven flyers and rotatably driven bobbin spindles, said bobbin spindles also being mounted to be reciprocally driven along a path in a direction parallel to the axis of said flyers, a builder control shaft mounted for rotation in a member of said frame which reciprocates in synchronism with said bobbin spindles, the axis of said control shaft extending in the direction of reciprocation of said member, a tumbler shaft mounted in said frame for rotation about its axis and having mounted thereon for rotation therewith a builder

dog provided with a pair of oppositely-extending arms, and means for reversing the direction of motion of said frame member upon each successive rotation of said tumbler shaft, the improvement which comprises a cylindrical builder cam member mounted on said frame and adapted to be rotatably driven about its longitudinal axis by said control shaft, said cylindrical cam member having on a first portion thereof a first helical camming surface and having on another portion thereof axially spaced from said first portion a second helical camming surface, said first and second camming surfaces being oppositely directed and each of said camming surfaces having continuously varying pitch, a pair of builder jaws mounted adjacent said cam member and adapted to be reciprocally moved with respect to said cam member along paths parallel to the longitudinal axis thereof, one of said builder jaws having thereon a cam follower for engagement with said first camming surface and the other of said builder jaws having thereon a cam follower for engagement with said second camming surface, and each of said builder jaws also having a tumbler arm bearing surface of predetermined length in the direction of reciprocation of said control shaft, means for rotating said control shaft through angles which are proportional to angles of rotation of said tumbler shaft, and means for driving said tumbler shaft through an angle of rotation sufficient to bring one of said tumbler arms to bear on the arm bearing surface of one of said jaws upon the other of said tumbler arms overrunning the end of and becoming disengaged from the arm bearing surface of the other of said jaws due to relative motion between said control and tumbler shafts, the direction of motion of said frame member being reversed upon each successive rotation of said tumbler shaft, whereby the extent of the reciprocating motion in one direction or the other of the frame member and control shaft which is required to cause a tumbler arm to overrun the end of the bearing surface engaged by the arm is successively changed by progressively different amounts due to the builder jaws' changing their positions with respect to each other by successively different amounts upon each successive rotation of the cam member.

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