WINDING TENSION CONTROL MECHANISM
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Claims. (Cl. 57—95)

This invention relates to the production of textile yarns and, more particularly, to apparatus for providing improved tension control during winding of materials such as roving and the like to produce packages having greater density and yardage.

Packages of textile roving are usually formed on roving frames or fly frames by winding roving on bobbins in successive closely wound layers so that the body of the fully wound bobbins is substantially cyindrical with the ends tapered or in the shape of truncated cones. It is conventional practice to provide limited roving tension control during winding by decreasing the speed of rotation of the bobbins after completion of each layer of roving. To do this, a gear arrangement is selected to limit roving tension, consistent with other factors, so that tension breaks are minimized. The gear arrangement can be changed only when the frame is shut down.

With this arrangement, a generally constant tension is maintained and maximum roving tension is not provided for each layer of roving. Rather, a relatively low tension is used at the inner layers in order that tension during winding of the outer layers will not cause breakage before the roving packages are completed. Full bobbins are thus wound with a minimum of troublesome tension breaks but the roving packages produced have relatively low average density and low yardage.

As is well known, the conventional roving frame comprises a plurality of drafting rolls for attenuating each of a large number of ends of slivers 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.

Also, as is 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 will 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 speed of rotation of the bobbin upon completion of each successive layer of roving. Thus, the rate of displacement between the flyer and the surface of the bobbin winding is progressively reduced, as the circumference of roving layers increases.

The apparatus by which the speed of rotation of the bobbins is governed is called the cone drive. A first rotatable cone which has decreasing diameter over its length is arranged in the frame parallel to a second rotatable cone which has increasing diameter over its length. A belt is arranged on the cones to transmit the rotating motion of the first cone to the second. Suitable gearing arrangements transmit the rotary motion of the second cone to the bobbin spindles. Upon completion of each layer of roving on the spindles, the belt is moved in a direction parallel to the longitudinal axis of the cones so that the speed of rotation of the second cone and consequently of the bobbin spindles is reduced.

In a conventional roving frame a tumbler shaft is arranged so as to make a half revolution upon completion of each layer of roving. By means of a so-called tension gear train which is driven in successive equal increments by the half-revolutions of the tumbler shaft, a rack is longitudinally displaced in successive equal increments. This rack is connected to a belt shipper. Thus each time the tumbler shaft makes a half-revolution, upon completion of each layer of roving, the belt-shipper pulls the cone belt along the cone a certain distance. The belt is moved along automatically the same distance each time.

The tension gear train mentioned above controls the length of the rack and belt shipper movements in order to vary the length of the belt shipper movements it is necessary to change the tension gear ratio. This is done by substituting tension gears with different numbers of teeth. Such gears can be changed between doffs when the roving frame is shut down.

It has been standard practice in the past to select a tension gear ratio so that full bobbins may be wound with a minimum of tension breaks. The bobbin rotation as controlled by particular tension gears, is adjusted only enough to keep outer layer tension from becoming excessive and inner layer tension is less than the maximum permitted by roving tensile strength.

The winding of roving on a bobbin is affected by many factors. Some of these factors are humidity and temperature, package stability, and size, evenness, stretch and compressibility of the particular roving material being used. Package stability problems relate to the degree of support which outer layers receive from inner layers. Each layer that is wound is affected by the layers previously and subsequently wound. To provide stability, it has been conventional practice in the past to make roving packages with tapered conical ends. In this way the end coils of the layers of the wound bobbin are supported on the underlying layers. Otherwise, the end coils overrun and tangle so that the package must be discarded or unwound with difficulty.

Because roving frames are limited to winding roving to a certain maximum diameter on the bobbins, many attempts have been made to increase package yardage by simply winding the roving under greater tension. It appeared that roving could be compressed to a greater degree leaving room for more layers to be wound on each bobbin. However, to do this, and still maintain package stability, it was found that the taper angle at the end of the packages would have to be reduced. Taper angle reduction directly reduces package volume, contrary to the purpose of winding with greater tension, and results were of indifferent success.

Recently, apparatus has been developed 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 with proper winding tension, the ends of the packages can be made more stable. In conjunction with these developments further investigation has shown that significantly greater winding tensions can be used in making roving packages with the new convex end tapers. All of these factors combine so that packages having much greater yardage may be formed.

The purpose of this invention is to provide automatically operated means for improved tension control during winding of packages of roving or the like. With this invention winding tension is highest during winding of initial layers on the bobbin and is decreased gradually as the package increases in diameter. As a result average winding tension and average package density are increased and stable packages of increased yardage and weight can be produced.
In the present invention, a cam controlled mechanism is used to change the effects of the tension gears on the movement of the belt shipper. The step-movements of the rack can be provided in the conventional equal increments, or they can be provided in constantly increasing, decreasing or exponentially varying increments. All of these steps are cam controlled with the particular variations of the rack movement being dependent upon the axial position and the profile of a particular cam being used.

According to our invention a flat cam is mounted in the roving frame for rotation about an axis. Tension gears are still used but only to limit, in a general way, the range of control of the bobbin rotating speed obtained through use of the cam. The tension gears, which are conventionally displaced in successive equal rotational amounts upon completion of each layer of roving, are utilized to provide successive, equal angular displacements of the flat cam. Thus, the gear ratio provided by the selections of cogs served only to determine the magnitude of the rotational displacements of the cam.

A flexible link such as a cable or chain is adapted to be wound around the profile surface of the cam as the cam is turned. The contour of the camming surface and the axial position of the cam are readily arranged so that the amount of cable wound on the cam increases with each successive displacement. Now, with one end of the flexible link attached to the cam, as the cam is rotated through successive, equal angular displacements, the other end of the link or cable will be longitudinally displaced in successive increasing increments. The other end is then connected in the frame to drive the belt-shipper, likewise through successive increasing longitudinal displacements, to provide controlled, varying tension at the bobbin.

An important feature of our invention is the provision for radial adjustment of the flat cam. This permits changing the position of the geometric axis of the cam with respect to its axis of rotation. By adjusting the offset distance between these two centers or axes, fine control is obtained over the relative magnitude of the successively increasing longitudinal displacements.

For explanation, it may be helpful to consider first the effects of using a circular camming surface. With a circle, of course, equal angles between radii or equal chords subtend equal lengths of arc. Therefore, with the geometric center of a circular cam arranged coincident with the center of its drive shaft (i.e., axis of rotation), successive equal angular displacements of the cam would produce successive equal longitudinal displacements in a cable being wound on the circular surface. With the outer end of such a cable attached to a belt-shipper, successive belt-shipper step movements would be of constant magnitude. In such an arrangement, the belt-shipper would be moved in the same fashion as heretofore with the standard tension gear connections.

By offsetting the center or geometric axis of the cam from the axis of rotation, however, the amount of cable wound on the camming surface would change with each successive angular displacement of the cam. Thus, such a cable can be used to pull a belt-shipper in varying amounts after completion of each successive layer of roving.

To use the offset arrangement described, tension gears are selected to provide a low gear ratio. The cam is arranged for starting with the minimum radius from the rotation axis. With each succeeding cam motion, an increasing amount of cable is wound on the camming surface. As a result, the effects at the belt-shipper, viz., increasingly greater longitudinal displacements, can be compared to the effects which would occur if the tension gear ratio could be increased after each layer of roving.

Various combinations of cam contour, cam offset and tension gears may be employed to effect roving tension during winding. The important result from any combination is that much closer tension control is afforded. Cams can be made to produce any particular variation in rack movement desired. With a given cam, fine control in roving tension for particular materials, package shape, prevailing mill conditions, etc., can be made with the offset center adjustments.

The apparatus of our invention is readily fabricated and assembled. Modern roving frame automation is required for installation. Once installed, the combinations and adjustments possible for control of roving tension provide a wide range of settings to compensate for the many physical factors which affect winding operations.

Therefore, a given set of cone pulleys designed for specific roving and mill conditions, could produce only approximate results in the many off-design situations in which roving frames must function for practical mill operations. With our invention, the effects of poorly designed or constructed cones can be accommodated. With our invention, a single cam for the most part can be used for control of winding tension under diverse operating conditions. But for particular or extraordinary situations, it is a simple matter to provide and install a cam of a different size and contour. High starting tensions can be used and packages of greater average density and much greater weight can be produced.

Greater package density and weight means that the roving frames can be run longer between shutdowns for changing bobbins. Hence, fewer operators are required to attend a given number of spindles. Also, the effects of greater package yardage permit greater economy in other locations in the textile industry. The machinery subsequently used to take the roving from the packages can also be kept running longer between shutdowns to replace empty bobbins with full ones.

These advantages are particularly timely and important now that other recent developments have shown the feasibility of better controlling the volume of roving packages. With new machinery for winding packages having convexly curved ends, increased tension provides packages of greater stability.

However, increased tension for this application must be accompanied by improved tension control in order that correct tension can be provided at each roving layer. This invention is particularly suited for meeting this requirement.

These and other features of the invention are described in the following portions of the specifications. For clarity, reference will be made to the accompanying drawings in which:

**FIG. 1** shows the components which, in a conventional roving frame, provide control of bobbin rotating speed; **FIG. 2** shows a preferred embodiment of this invention installed for use with the apparatus of **FIG. 1**; **FIG. 3** is an enlarged view of a portion of the invention showing details of the device used for adjusting cam offset; **FIG. 4** is a side view of the offset adjustment device of **FIG. 3**; **FIG. 5** shows an alternative embodiment of the invention adapted for operation in another conventional type of roving frame; **FIG. 6** is a plan view of the embodiment of **FIG. 5**; and **FIG. 7** is an elevation view showing further details of the embodiment according to **FIG. 5**. 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 Text Book Company of Scranton, Pennsylvania. 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 com-
prehend the detailed features of a preferred embodiment of the apparatus.

A conventional builder mechanism 10 is shown connected by a shaft and gears to rack 11. As is well known, the builder mechanism 10 is mounted on a part of a roving frame called the bobbin rail or bolster rail which carries the bobbin rotating mechanism. The bobbin rail and all the mechanism mounted on it are driven and down on the bobbin on which roving is being wound are reciprocated axially with respect to the flyer. The flyer 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. Adjacent to the builder mechanism 10 there is a shaft 12 suitably mounted for rotation about its axis on a stationary part of the roving frame. A so-called builder dog, indicated at 13, is affixed to the tumbler shaft 12.

As is well known, co-operating action of the builder mechanism 10 and the builder dog 13 initiates reversal of the direction of reciprocation of the bobbin rail upon completion of each successive layer of roving on the bobbins. The builder mechanism also controls the amplitude of bobbin rail reciprocations.

The tumbler shaft is also provided with a spring-loaded camming mechanism 14 arranged to urge the tumbler shaft to rotate in a counter-clockwise direction viewed from the bottom of FIG. 2, thereby ensuring that one or the other of the arms, on the builder dog will bear on the builder 10. The tumbler shaft 12 is also positively, but intermittently, driven by the bevel gear 15 affixed to the upper end of shaft 12 and the bevel gear 16 affixed to the main drive shaft 17 of the roving frame. As is well known, the gear 15 is a sector gear having teeth in two opposite sectors and having no teeth in the other two opposite sectors. The gear 15 is so oriented on the tumbler shaft 12 that when one or the other of the arms on the builder dog is in position engaging builder 10, a smooth sector of the gear 15 is adjacent or under the gear 16 on the main drive shaft so that there is no driving torque transmitted to the tumbler shaft 12.

Now, as the builder mechanism 10 is driven upward or downward to the end of the stroke of the bobbin rail, the arm of the builder dog 13, in engagement with the builder 10, will overrun the end of the builder so that there is no longer any resistance to the turning movement exerted on the tumbler shaft by the spring-loaded camming mechanism 14. This mechanism then causes the builder dog to bring a toothed sector of gear 15 into engagement with gear 16, and the tumbler shaft is positively and rapidly driven through nearly a half revolution before the next toothless sector of gear 15 comes under gear 16. By this time, however, the spring-loaded camming mechanism 14 is again in control of the tumbler shaft and causes the shaft to complete the half-revolution and bring the other arm of the builder dog to bear on the builder 10.

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 of the builder dog 13 overrun the upper end of the builder 10 and the tumbler shaft 12 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 other arm of the builder dog overrun the lower end of builder 10, whereupon the tumbler shaft will again be turned by camming mechanism 14 and the gears 15 and 16. The bobbin rail will again be driven downward. These changes in direction of the bobbin rail travel cause the bobbins on all the spindles of the roving frame to be driven up and down with respect to their respective flys 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 discussed, upon completion of each successive layer of roving wound on the bobbins, in a conventional roving frame, the speed of rotation of the bobbins is reduced in order that roving tension during the next layer of roving will not be excessive. In the conventional roving frame, this is accomplished by moving belt 18 in successive equal steps longitudinal of belt cones 19 and 20. The first belt cone 19 as shown is mounted for rotation on the main drive shaft 17 of the roving frame. The second belt cone 20 is mounted for rotation on a shaft which is parallel to the main drive shaft 17. The second cone is driven by the belt 18. Rotation of the second cone 20 and its shaft provides, through conventional apparatus, rotation of the bobbin spindles in the roving frame.

The two cones 19 and 20 are oppositely tapered. As shown, cone 19 has decreasing diameter over its length and cone 20, the bobbin drive cone, has increasing diameter over its length. When winding is started, the belt 18 is placed at the large diameter end of cone 19. As the winding progresses and upon completion of each layer of roving, the belt is moved in steps longitudinally of the cones. As the belt is moved along the direction of decreasing diameter on cone 19, the speed of rotation of cone 20, and hence the speed of rotation of the bobbins in the roving frame, is reduced. This action keeps roving tension from becoming excessive as the diameter of the layers of roving on the bobbins increases.

As shown at 21, a fork-shaped member called the belt-shapper is used to provide the step movements in the belt. The belt-shapper 21 is connected to rack 11 for longitudinal displacement upon completion of each layer of roving. The rack and belt-shapper are conventionally driven through successive equal longitudinal displacements by a gear train which is actuated upon each half revolution of the tumbler shaft 12. This gear train, commonly known as the tension gearing, comprises a worm gear 22, fixed to the tumbler shaft, and spur gears 23, 24, 25 and 26. The gear 23, in engagement with the worm 22, is affixed to a shaft which is common to the gear 24. The latter gear engages gear 25 which is affixed to a shaft which is common to the gear 26. The gear 26 engages the teeth on the under side of rack 11.

The rack is mounted on suitable guides so that it may be moved longitudinally. The magnitude of the rack displacements is controlled by the gear ratio of the tension gear train. Tension gears 24 and 25, can be provided in different sizes for changing this ratio. Substitution of different tension change gears can be done when the roving frame is shut down, to change the magnitude of successive step movements of belt 18.

Merely to orient the reader, it is well to state here that the rack gear 11 is also the driving element for a taper gear train which in turn provides successive displacements in the builder mechanism 10 upon completion of each layer of roving. The purposes of this mechanism are not directly relevant to this invention and need not be described in detail. It is sufficient to indicate that this mechanism provides for changing the amplitude of reciprocation of the bobbins and of the bobbin rail as well as initiating the sequence of events which is started upon revolution of the builder dog 13 after each layer of roving is completed.

A tension gear and belt-shripper mechanism of the type shown in FIG. 1 can, in general, provide a constant value of tension throughout winding of the roving. A tension gear ratio is established while the roving frame is shut down. This ratio cannot thereafter be changed during the winding operation. As a result, the tension control, provided by successive equal displacements of belt 18 is approximate at best. The tension gear ratio selected provides for relatively low tension during winding of the initial layers on the bobbin. The principal achievement is that roving tension is kept below a maximum, limited largely by roving tensile strength, so that
full packages of roving may be wound without excessive tension breaks. The packages produce low average density, non-uniform density, and slow total weight and yardage.

According to the preferred embodiment of our invention shown in FIG. 2, the rack 11 is disconnected from the belt shipper 21 and arranged in the roving frame so as not to interfere with belt shipper movements. The tension gear arrangements for displacing the rack, in successive equal longitudinal increments, are generally the same as before. However, instead of driving the belt shipper the rack is now used to drive a flat cam 27 as shown in FIG. 2, through successive equal angular displacements. Cam 27 is mounted on a shaft 28 for rotation about an axis. A wheel gear 29 which engages the rack, is also mounted on cam shaft 28.

As shown in FIG. 2, a rack extension 30 is arranged to engage the wheel gear 29 to drive the cam 27 through successive equal angular displacements upon each successive half revolution of the tumbler shaft 12. Cam 27 is held in place on its shaft by a cam center adjustment assembly 31, details of which are shown most clearly in FIGS. 3 and 4. A cam follower such as a flexible cable, tape or chain is connected from the edge of cam 27 to the belt shipper 21 to provide longitudinal movement of the belt shipper whenever the cam is angularly displaced. In the embodiment of FIG. 2, a cable 32 is connected between the cam edge and the belt shipper.

A tension linkage completes the arrangement. The linkage comprises a counterweight 33 suspended on a cable from the belt shipper 21 so as to exert a force which opposes the force exerted by cam follower cable 32. Counterweight 33 is necessary to keep the belt shipper positively in place between cam movements and to prevent overruns when the belt 18 is displaced in response to rotation of cam 27.

Now, with the one end of cable 32 attached to the edge 34 of cam 27, as the cam is rotated the cable is wound on the cam. As successive amounts of cable are wound on the periphery of the cam, the other end of the cable 32 is longitudinally displaced in successive increments. With the other end of the cable attached to the belt shipper 21, the belt 18 will be displaced in successive step-movements for control of bobbin rotating speed.

For explanation, we will first describe the effects with a cam in which edge 34 comprises a circular arc camming surface. Of course, with such a camming surface, equal angles between successive radii from the center of the cam subtend equal lengths of arc. Therefore by mounting a circular arc type cam with its center or geometric axis coincident with the axis of rotation of shaft 28, equal lengths of cable 32 will be wound on the camming surface edge 34 upon successive equal angular displacements of the cam. This action produces successive, equal stepmovements at belt shipper 21, analagous to the conventional action provided by the apparatus of FIG. 1.

By using the cam center adjustment assembly 31 of the invention, the cam center or geometric axis of the cam can be offset from the axis of rotation. With the cam axis offset, radii from the axis of rotation to the camming surface will be unequal. By offsetting along the cam diameter which connects opposite ends of a semi-circular camming surface, the radii, from the rotation axis to the camming surface, will decrease from a minimum value in one direction along the described diameter to a maximum value along the other diameter direction.

As shown in FIG. 2, an offset semi-circular cam is arranged with the cable 32 attached at the top of the cam tangent to camming surface 34 at the point of intercept by the minimum radius. The maximum radius thus intercepts camming surface 34 at the bottom of the cam, or at the point of last contact between the cam and the cable. As the cam is rotated in the clockwise direction, in successive equal angular increments, successively increasing lengths of cable 32 will be wound on camming surface edge 34.

As a result belt shipper step movements will be of successively greater magnitude. The speed of rotation of the drive cone 19 and hence of the bobbin spindles are automatically adjusted upon completion of each layer of roving to provide a reduced tension for winding of the succeeding layer.

With the cam center adjustment assembly 31, much greater tension control selectivity, than can be obtained through sole use of conventional belt cones and tension gears, is afforded. Changing offset distance or substituting a cam of different profile, or both, is readily achieved when winding conditions are changed. The alternative is modification or substitution of belt cones which is not practical because in production, winding, and mill conditions are changed frequently.

To build packages of increased density and yardage requires continuous step-adjustments in roving tension during winding. Tension control which can be achieved by using the apparatus of the invention. The cam center adjustments and permits use of maximum roving tension consistent with roving tensile strength and package stability, for each layer of roving.

For operation with the offset center arrangement, tension gears 24 and 25 which will provide a low tension gear ratio are selected. This ratio determines the magnitude of successive cam displacements. As increasing amounts of cable are wound on the camming surface at each successive equal angular displacement of the cam, the belt shipper will be displaced by successively increasing increments. The magnitude of these increments depends upon the profile of the particular cam being used, that is, the contour of a particular curved camming surface, and the amount of offset distance between the geometric axis of the cam and the axis of rotation.

With our invention, much more precise tension control is provided. The resulting action can be compared to the effects which would be achieved if the tension gears of the conventional mechanism of FIG. 1 could be changed to provide successively greater gear ratios after completion of each layer of roving. But, as explained in the conventional method, the tension gear ratio can be changed only when the roving frame is shut down and during conventional operation all belt shipper step movements are of constant magnitude.

The cam center adjustment assembly 31 is shown in detail in FIGS. 3 and 4. An oblong slot 35, milled in the cam along the diameter connecting opposite ends of the camming surface edge 34, is provided to permit radial movement of the cam 27 with respect to its shaft 28. A collar 36 is mounted on the shaft 28 for rotation with the same and is held in place on the shaft by a suitable spline, key or lock screw arrangement. A cam slide 37 is positioned over the center of the cam 27 and over the slot 35. The cam slide and cam are held on the shaft by bolts 38 which extend through both cam slide and the cam and into threading holes in collar 36. The cam slide also has two oblong guide slots 39, arranged parallel to slot 35. Slide 37 and cam 27 are held in radial alignment by bolts or studs 40 which extend through guide slots 39 into the cam. A slide flange 41, and a cam flange 42 are also mounted on the slide 37 and the cam 27. Drive screw 43 is arranged in flanges 41 and 42, parallel to the above-mentioned diameter which connects opposite ends of the camming surface edge 34.

As shown, the lower end of the drive screw 43 is turned into and tightened in a threaded aperture in slide flange 41. A thumb nut 44 is arranged to receive the upper end of the cam flange 42 with a hollow shaft projecting through an aperture in cam flange 42. The upper end of drive screw 43 projects through the hollow shaft 45 and the
2,996,870 Thumb nut 44. Drive screw 43 and the inner wall of hollow shaft 45 are threaded so that when thumb nut 44 is turned, the drive screw and hence the cam slide 37 can be displaced along the longitudinal directions of the screw 43.

It is advantageous to provide position indicator means in the cam center adjustment assembly 31. For this purpose a graduated scale 46 shown on the cam in FIG. 3 stops or cam marks 47 on the starting point 48 of the thumb nut 44 and a pointer 48 supported on the cam flange 42 are provided. With the scale and position marks provided, an operator experienced in the use of the cam apparatus of this invention can readily establish a predetermined amount of cam offset. With this apparatus the cams used in this invention are made radically adjustable and very fine adjustments in tension control can be made.

At the end of a doff it is necessary to reset the roving frame for the next run. To do this, the tension gears are thrown out of mesh and the drive cone 20 is raised to clear the drive belt. The rack and belt shipper are moved to the left to a position such as that indicated in FIG. 2 with the flexible link or cable 32 being unwound from the camming surface edge 34. Counterweight 33 pulls the belt and belt shipper to the left so that the belt is placed in its starting position at the left end of cones 19 and 20.

Wheel gear 29 as shown in FIG. 2 is conveniently made a sector gear, since it is of sufficient diameter so that it does not make a complete revolution during a given winding operation on the roving frame. Having a sector with no teeth, gear 29 thereby provides its own stops or limits and thus the starting and terminal positions of the cam are readily controlled.

We have found that use of a semi-circular cam in our invention provides significantly improved tension control. By offsetting the geometric axis of a semi-circular cam from the shaft axis or axis of rotation, roving packages of greater average density and therefore of increased weight and yardage can be produced. For offset adjustments we have used a drive screw such as that shown at FIG. 4, with 40 threads per inch. Thus one turn of the thumb nut 44 moves slide 37 and cam axis 0.025".

With the cam axis offset, as the cam is rotated by step movements of the rack through successive equal angular displacements, camming surface arcs of increasingly greater length are rotated past a reference plane positioned vertically through the axis of rotation. Thus the lengths of cable wound on the cam and the lengths of belt shipper step movements are successively of greater magnitude.

Of course a cam having a camming surface of circular arc contour is by no means the only type of cam which can be used. Other curved cam surfaces can be devised for accommodating particular roving frames and roving winding conditions. A basic criterion for the cam is that the contour of the curved camming surface shall have radius of curvature which, in a reference system of polar co-ordinates where the pole coincides with the geometric axis of the cam, is of increasingly greater length as the radius is rotated through successive equal angles about the pole. Then with the added facility of the cam center adjustment assembly 31 very precise, automatic tension control can be provided for each layer of roving.

With the apparatus of this invention, the belt shipper step movements can be provided in the conventional manner when a circular arc type cam is used without offset. The belt shipper step movements can be varied by the use of cams profiled and therefore offset by a distance between the cam geometric axis and the axis of rotation.

The cam profile can be tailored or custom-made for unusual winding requirements or to accommodate special or unusual roving frames, worn cone drives or cones of special design.

In the embodiment of FIG. 2, the tension regulator apparatus of the invention is shown installed for use with the conventional mechanism of a 10" x 5" Saco-Lowell F.S. 2 roving frame where we have used the following with good results: cam diameter of 19.098"; offset center distance adjustability of from 0" to 13/4" and a sector gear with 19.400" O.D., 10 pitch, 192 teeth. The invention can as well be installed, for example, in a Whitin roving frame where the rack and belt shipper movements are the same, the principal difference for the purposes of this invention being only in the arrangement of the tension gears for driving the rack. The invention has been used in a 12" x 6" Whitin roving frame with the result that standard roving bobbin weight of 50 ounces has been increased to 58 ounces, representing an increase in weight of 14% in each package of roving. This increase has been obtained without causing more than the usual and normal number of tension breaks or over-runs encountered in producing mills.

An alternative embodiment of our invention is shown in FIG. 5 installed for tension control in a conventional Whitin roving frame. Most of the conventional components of the roving frame in FIG. 5 are similar to those which were described in connection with FIG. 1. For ease of reference, identical components in FIGS. 1, 2 and 5 bear the same identifying numerals. The principal distinction to be noted is that tumbler shaft 12 carries a spur gear 49 instead of a worm gear (shown at 52 in FIG. 1) for driving the tension gears. As before, the tension gears are used in this embodiment for providing successive equal angular displacements of a cam upon each successive tumbler shaft half revolution. Tension gears 50 and 51 can be changed so that the tension gear ratio may be varied from time to time to change the magnitude of the angular cam displacements.

In this embodiment, cam 52 is mounted for counter-clockwise rotation on cam shaft 53. The cam 52 is also positioned on shaft 53 by an offset center adjustment assembly 31. In this embodiment, gear 51, which is the last element of the tension gear train, drives an actuating shaft 54 which is the input member of gear box 55. The output member of gear box 55 is the previously mentioned cam shaft 53. This may best be seen in FIG. 6.

According to this embodiment, the rack 11 remains attached to the belt shipper 21. A cable 52 is attached as before to the camming surface edge of cam 53. This cable passes around shafts 56 and 57 mounted on the roving frame, and the outer end of the cable is clamped at 58 at the end of the rack 11.

The operation in this embodiment is as follows. When tumbler shaft 12 is rotated through successive half revolutions upon completion of each layer of roving on the bobbins, the tension gears, actuated by spur gear 49 on the tumbler shaft, are displaced through successive equal angular increments. Thus the actuating shaft 54 and the cam shaft 53, which are connected through the gear box 55, are also rotated through equal successive angular increments for driving the cam. In this case, cam 52 is rotated in the counter-clockwise direction through successive equal angles.

With the cam adjusted for offset center rotation by assembly 31, the amount of cable which is wound on the camming surface increases with each displacement of the cam. The cable and rack, as well as the belt shipper which the rack is connected, are longitudinally displaced in successively greater increments. The belt shipper step movements, as before, control bobbin rotating speed and roving tension.

Specifically for the 12" x 6" Whitin frame mentioned, we have used the following with good results: gear box 55, 10:1; tension gears of from 30 to 50 teeth; offset center distance adjustability of from 0" to 13/4" and a cam diameter of 19.098".

In the remaining components shown and numbered in FIGS. 5, 6 and 7, but not as yet explained, winding shaft 59 is provided for resetting the roving frame.
Winding shaft 59 is mounted in the roving frame connected at its lower end by a series of spur and wheel gears to the rack 11. As the rack is displaced in response to angular cam movements, the winding shaft 59 and the hand wheel 60 affixed at the upper end of the winding shaft, are slowly turned. At the end of the doff, in order to reset the roving frame for the next layer, the tension gears are thrown out of mesh, the bottom cone 20 is raised to clear the drive belt 18 and the winding wheel 60 is manually turned backwards. Thus the winding shaft 59 drives the rack 11 and the belt shipper 21 to the starting position so that belt 18 is returned to the large end of the power cone 19.

It should be noted, of course, that other means can be incorporated for transmitting the successive step movements, which have been described, to and from the cam and follower. As an illustration of that which is within the skill of the art, the cam and follower can be arranged as intermediate members of a gear train. A properly designed gear train would thus permit use of a cam which has smaller physical size than that previously described. This in turn would provide for greater flexibility in locating and mounting the tension control mechanism in a particular frame.

In the foregoing specification, we have described our invention in detail. For ease of understanding we have referred in our description to presently preferred and to alternate embodiments. Of course, many variations of these embodiments will occur to those skilled in the art. Accordingly, we do not propose to be limited to the details which have been set forth. Our invention is defined in the following claims.

We claim:

1. In a roving frame having rotatable bobbins on which roving packages are wound, the bobbins being mounted on a member of the frame for reciprocatory movement, means for variably controlling roving tension which means comprises a cam having an edge camming surface, a cam follower, said follower being mounted in said frame against said camming surface, said follower being movable with respect to said surface, said camming surface having a contour which is prescribed in terms of camming and reference dimensions of the cam wherein, in a reference system of co-ordinates, the reference dimension is an independent variable and the camming dimension is a dependent variable, which camming dimension increases in successively increasing increments as said reference dimension increases in equal successive increments, means connected to said gear mechanism and adapted to drive said cam and said follower relatively and thereby displace said follower in response to reciprocatory movement of said member connecting said follower to said belt shipper whereby the position of said follower is adapted to determine positions of said belt shipper.

2. The roving frame combination of claim 1 in which said cam comprises a rotatable flat disc cam, said cam being mounted in said frame on a shaft for rotation about an axis.

3. The roving frame combination of claim 2 in which said follower comprises a flexible cable, one end of said cable being connected to said cam, said cable being wound on said camming surface by rotation of said cam.

4. The roving frame combination of claim 3 in which said follower comprises a rack extension and a rotatable wheel gear, said wheel gear being mounted on said shaft and engaging said extension.

5. The roving frame combination of claim 4 in which said cam is supported on said shaft by means whereby the distance between the geometric axis of said cam and the axis of rotation of said shaft is adjustable.

6. The roving frame combination of claim 4 in which said cam is supported on said shaft by means whereby the distance between the geometric axis of said cam and the axis of rotation of said shaft is adjustable.

7. The roving frame combination of claim 4 in which said cam is supported on said shaft by means whereby the distance between the geometric axis of said cam and the axis of rotation of said shaft is adjustable.

8. The roving frame combination of claim 4 in which said cam is supported on said shaft by means whereby the distance between the geometric axis of said cam and the axis of rotation of said shaft is adjustable.

9. The roving frame combination of claim 8 in which said means connected to said gear mechanism comprises gear means connected to said shaft and engaging a tension gear member of said mechanism.

10. In a roving frame having rotatable bobbins on which roving packages are wound, the bobbins being mounted on a member of the frame for reciprocatory movement, means including a tumbler shaft for reversing the direction of reciprocatory movement of said member upon completion of each layer of roving on the bobbins, gear mechanism driven by said reversing means in successive equal increments upon said completion of each layer, a pair of belt pulleys and a belt shipper adapted for movement longitudinally of said pulleys for changing the bobbin rotating speed, one end of said rack being connected to said belt shipper, the improvement which comprises a rotatable flat cam having a curved edge camming surface, said cam being supported in said frame on a shaft for rotation about an axis, means connected between said cam and said shaft and adapted for changing the distance between the geometric axis of said cam and its axis of rotation, a cable type cam follower adapted to be wound on said camming surface, one end of said cable being attached to said cam, the other end of said cable being connected to said frame, said camming surface having a particular radius of curvature which, in a reference system of polar coordinates where the pole coincides with the geometric axis of said cam and the initial line coincides with the shortest radius of said cam, increases in length in successively increasing increments as said radius is rotated by equal angular increments, said follower being movable with respect to said surface, said camming surface having a contour which is prescribed in terms of reference and camming dimensions of the cam wherein, in a reference system of co-ordinates, the reference dimension is an independent variable and the camming dimension is a dependent variable, which camming dimension increases in successively increasing increments as said reference dimension increases in equal successive increments, means connected to said gear mechanism and adapted to drive said cam and said follower relatively and thereby displace said follower in response to reciprocatory movement of said member connecting said follower to said belt shipper whereby the position of said follower is adapted to determine positions of said belt shipper.

11. In a roving frame having rotatable bobbins on which roving packages are wound, the bobbins being mounted on a member of the frame for reciprocatory movement, means for variably controlling roving tension which means comprises a cam having an edge camming surface, a cam follower, said follower being mounted in said frame against said camming surface, said follower being movable with respect to said surface, said camming surface having a contour which is prescribed in terms of reference and camming dimensions of the cam wherein, in a reference system of co-ordinates, the reference dimension is an independent variable and the camming dimension is a dependent variable, which camming dimension increases in successively increasing increments as said reference dimension increases in equal successive increments, means connected to said gear mechanism and adapted to drive said cam and said follower relatively and thereby displace said follower in response to reciprocatory movement of said member connecting said follower to said belt shipper whereby the position of said follower is adapted to determine positions of said belt shipper.

12. The roving frame combination of claim 11 in which said cam comprises a rotatable flat disc cam, said cam being mounted in said frame on a shaft for rotation about an axis.
amounts of said cable are wound on said camming surface.

11. In a roving frame having rotatable bobbins on which packages of roving are wound, the bobbins being mounted on a member of the frame for reciprocatory movement, means including a tumbler shaft for reversing the direction of reciprocatory movement of said member upon completion of each layer of roving on the bobbins, gear mechanism, including tension gears, driven by said tumbler shaft in successive equal increments upon said completion of each layer, a pair of belt pulleys and a belt shipper adapted for movement longitudinally of said pulleys for changing the bobbin rotating speed, the improvement which comprises a rotatable flat cam having a curved edge camming surface, said cam being supported in said frame on a shaft for rotation about an axis, means connected between said cam and said shaft and adapted for changing the distance between the geometric axis of said cam and its axis of rotation, a cable type cam follower adapted to be wound on said camming surface, one end of said cable being attached to said cam, the other end of said cable being connected to said belt shipper, a tension linkage connected between a structural member of said frame and said belt shipper, said camming surface being of prescribed contour, said contour having a radius of curvature which, in a reference system of polar coordinates where the pole coincides with the geometric axis of said cam and the initial line coincides with shortest radius of said cam, increases in length in successively increasing increments as said radius is rotated by equal angular increments about said pole, and gear means connected between said tension gears and said shaft for angular displacement of said cam in successive equal increments upon said completion of each layer, whereby successively increasing amounts of said cable are wound on said camming surface.

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